PLANT REQUIREMENTS FOR MANUFACTURE OF MILLED RICE

TECHNICAL AIDS BRANCH

INTERNATIONAL COOPERATION ADMINISTRATION

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FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

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TABLE OF CONTENTS

	Page
Introduction	1
General Assumptions	1
World Production in Rice	2
Terminology	5
Weights and Measures	7
Classifications and Grading	10
Grades and Grade Requirements for All Classes of Rough Rice	11
Grades and Grade Requirements for All Classes of Brown Rice	12
Grades and Grade Requirements for All Classes of Milled Rice Except Second Head Milled Rice, Screenings Milled Rice, and Brewers Milled Rice	12
Grades and Grade Requirements for The Class Second Head Milled Rice	13
Grades and Grade Requirements for The Class Screenings Milled Rice	13
Grades and Grade Requirements for The Class Brewers Milled Rice	14
Uses and Characteristics	14
Various Milling Processes	17
Manufacturing Operations	22
Direct Materials	30
Supplies	30
Direct Labor	30
Indirect Labor	31
Production Tools and Equipment	31
Other Tools and Equipment	32
Furniture and Fixtures	33
Plant Layout	33

	Page
Plant Site	34
Buildings	34
Power	35
Water	35
Fuel	35
Depreciation	36
Manufacturing Overhead	36
Manufacturing Costs	37
Fixed Assets	37
Working Capital	38
Capital Requirements	38
Sales Revenue	39
Recapitulation of Costs, Sales and Profits	39
Budget Control	40
Budget Control Accounts	40
Purchase Requisition	41
Voucher Check	42
Engineers	43
Training	44
Safety	45
Other Considerations	46
Materials and Supplies	46
Market Factors	46
Export Market	47
Marketing Problems	47
Economic Factors	48

	Page
Personnel	48
Laws and Regulations	48
Financial Factors	49
Fainancial Requirements of the Project	49
Short Term Bank Credits	49
Financial Plan	49
Bibliography	50
Rice Milling Consultants	50
Abbreviations	50
Flow Chart of Self Contained Rice Mill	51
Sheet Metal Bins for Storage of Rice	52
Handling and Warehousing of Sacked Milled Rice	53
Typical Paddy Rice Cleaner	54
Typical Disc Separator	54
Typical Grading Machine	54
Under Runner Sheller and Typical Paddy Rice Huller or Husker	55
Typical Paddy Separator	55
Typical Brown Rice Huller	55
Typical Rice Polisher Machine	56
Combined Bran Huller and Rice Polisher	56
Typical Grain Aspirator	56
Typical Indented Cylinder Grader	56

M I L L E D R I C E

INTRODUCTION

The purpose of this report is to provide basic information for establishing a plant in a foreign country to process rice.

GENERAL ASSUMPTIONS

In order to make realistic estimates in this report, certain assumptions are made. These are:

1. The costs of the building and general facilities are based on United States prices.

2. Material costs are based on sizes and specifications of materials used in the United States.

3. Labor costs are based on the average for the industry as recently published by the United States Bureau of Labor Statistics.

4. Adequate power and water are available at the plant site.

5. Adequate transportation facilities are available at the plant site.

6. The plant operates eight hours a day, five days a week, and fifty weeks per year.

7. No special provision is made for the training of new personnel. It is assumed that learner's rates are paid in such cases.

8. The following items cannot be estimated realistically:

   A. Land value.
   B. Distribution and selling costs.
   C. In-freight and out-freight.
   D. Administrative costs.
   E. Taxes.

   While general estimates will be made of each of these items, for the purpose of completing cost estimates, adjustment should be made in accordance with actual local costs.

   In fact, all cost estimates contained in this report should be adjusted to conform to local conditions.

9. Columns are provided in the tables included in this report to facilitate the conversion of cost figures to conform with local costs.

WORLD PRODUCTION OF RICE

Statistics of world rice production for 1955-1956 reveal the following variables in productive yield per acre:

Area	High	Low	Average	Acres Cultivated	Total Production by Area (Short Tons)
North America			1239 lbs.	2,963,000	3,549,000 tons
United States	2932 lbs.			1,822,000	
Honduras		900 lbs.		30,000	
Europe			3848 lbs.	1,036,000	1,940,000 tons
Spain	5428 lbs.			420,000	
Yugoslavia		2750 lbs.		20,000	
Asia			1585 lbs.	182,173,000	195,724,000 tons
Japan	4273 lbs.			16,000,000	
Laos (Indo-China)		733 lbs.		1,800,000	
India				78,000,000	
Syria				10,000	
South America			1853 lbs.	7,506,000	5,453,000 tons
Uruguary	3500 lbs.			40,000	
Venezuela		1100 lbs.		150,000	

Area	High	Low	Average	Acres Cultivated	Total Production by Area (Short Tons)
Africa			822 lbs.	8,109,000	4,408,400 tons
Egypt	3291 lbs.			715,000	
Belgian Congo		---			
French Morocco		---			
Madagascar		---			
Oceania			2237 lbs.	114,000	134,000 tons
Australia	4474 lbs.			42,000	
Fiji		---			
Total -- World			1930 lbs.	201,901,000	221,208,500 tons

Botanically, there are at least 7,000 varieties of rice and possibly several thousand more. Commercially, there are but two types, white and red. Classification-wise there are three general groups, commonly referred to as short-grain, medium-grain and long-grain. Usually the short-grains are soft and chalky and the long-grains, hard and translucent. The long-grain type carries premium prices.

Wheat generally is considered the food of the world, for in the total acreage of the land masses devoted to its cultivation and growth, it surpasses all other grains. Rice, however, is the most important food in the world, for the volume of food produced by the world rice crop is 10% to 20% greater than that of wheat. This paradox is due to the wider adaptation of the rice plant to varying climatic and soil conditions, and the resulting high yield per acre, which is usually two to three times that of wheat. Rice supplies the major food requirements for more than one-half of the world's population, and this single food item comprises 70% to 80% of the entire calorie intake in many countries.

Rice is produced under a wider variety of conditions and by more varied methods than any other major crop. Although it is considered by many to be a tropical, hot weather crop only, it is grown in Northern Japan and Korea, at the foothills of the Alps, in Northern Italy, and lower reaches of the Andes, under climatic conditions too severe for the production of corn and similar temperate-climate crops. Even though it is thought to be primarily a sea-level, marsh-land crop, it is planted at altitudes of 4,000 feet in Peru, 6,000 feet in the Philippines, and 10,000 feet in the Himalayas. Further, in spite of the fact that it is considered to be an irrigated crop only, produced under completely flooded conditions, more than half of the world's annual production is without artificial or controlled irrigation of any kind. Much of it is cultivated on rolling to hilly lands which would be considered unsuitable for tilled crops.

Approximately 95% of the world rice production is in Asia. South America is second in importance, with Africa third, North America fourth, and Europe, Russia and Australia following.

The average rice farm in China and Japan is less than three acres, whereas in the United States a 300-acre farm is considered small and 1,000-acre farms are quite normal. Within this wide range, there obviously are economic factors affecting labor needs, areas from which a mill can draw upon for its supply, transportation problems and innumerable other factors to consider from a mill viewpoint when processing rice into finished grain.

There is also within such wide range, varied methods of land preparation, seeding, transplanting, irrigation, weeding, cultivating, harvesting, marketing and final processing. For example, the rice farmer of the United States plows 25 to 30 acres of land in 10 hours with mechanized methods, and frequently operates such equipment 24 hours during emergency requirements. On the Argentine pampas, a 5-horse hitch with steel mouldboard takes three times as long to plow the same acreage. In the Orient, five workers, using hand tools, average about one acre per day or one-fifth acre per man-day.

When seeding fields in the United States, the larger rice producer stands in the field with a tall pole to which is attached a brightly-colored flag and his co-worker flies over at low level in an airplane, using the flag at different intervals as a marker, and seeds 200 to 400 acres per day. In the upper reaches of the Amazon, the native walks across a freshly burned area, punches a hole in the ashes at irregular intervals and drops three to five rice seeds in each hole before stepping on the hole with his foot. Then he walks off and forgets the crop until time to harvest. In the Orient, the farmer carefully prepares a seed bed of ashes, manure and mud, spreads the seed over this surface in a thick layer, covers the nursery bed with a light layer of finely-pulverized top soil, and approximately 40 days later, pulls up the plants, transplants them in clumps of three to five plants, eight inches apart in a previously prepared flooded field.

Less than a year later, rice from the United States, Brazil and the Orient are all together in a retail store in Brussels or Stockholm, competing in a world market.

In other areas of the world, methods vary still further, and in fertilizing, irrigation and final harvesting, there are innumerably wide variations of operations.

Consequently, the economics of establishing milling operations to convert rice harvests into commercially salable grain present cost factors and problems that vary with location, source and availability of raw materials, climatic conditions, type and class of labor, methods

of cultivation and production, transportation facilities, marketing of the end product and finally, the uses to which the milled grain is to be put. The prospective investor in such an enterprise is cautioned to secure the services and advice of a reputable firm of consulting management engineers, who would prepare a complete administrative, operative and financial analysis commensurate with local conditions involved, before embarking on as complex an enterprise as a rice mill.

TERMINOLOGY

As mentioned previously, there are thousands of variations and kinds of rice. This situation has led to much confusion among rice producers and merchants throughout the world when applying terminology to various kinds of rice. In March, 1949, the International Rice Commission held its first session in Bangkok, Thailand, and formulated a set of common terms to describe rice in the husk and at different stages of the milling process, and treatment prior to marketing and consumption. In this report, it will be frequently essential to use such nomenclature, and to preclude any confusion in the mind of the reader as to what it meant by certain terms with reference to rice, the following "common terms," "definitions," and "accepted and recommended terms" are set forth. This report will adhere to the "accepted and recommended terms."

Common Terms	Definitions	Accepted and Recommended Terms
Stalk paddy	Unthreshed rice in the husk, harvested with part of the stalk.	Stalk paddy
Paddy; unhusked rice; rough rice	Rice in the husk after threshing.	Paddy
Husked rice; shelled rice; hulled rice; brown rice; silver skin rice; cargo rice; whole rice	Rice from which the husk has been been removed; it still retains the bran layers and most of the germ.	Husked rice
Home pounded rice; hand pounded rice	Rice from which the husk, germ and bran layers have been partially removed without use of power machinery.	Home pounded rice

Common Terms	Definitions	Accepted and Recommended Terms
Undermilled rice; lightly milled rice	Rice from which the husk, germ and bran layers have been partially removed by power machinery.	Undermilled rice
Milled rice; machine milled rice; highly milled rice; white rice; clean rice	Rice from which the husk, germ and bran layers have been substantially removed by power machinery.	Milled rice
Polished rice; coated rice	Rice milled to a high degree and then coated with a foreign substance such as glucose or talcum, called polished rice in Europe, whereas in the United States the term refers to rice that has been milled to a high degree and which has gone through the brush. In other countries the same term is used for highly milled rice treated with polishing powders. The term "polished" therefore causes some confusion.	Coated rice
Parboiled rice; converted rice; malekised rice	Rice obtained by pounding or milling from paddy which has been steeped in water, steamed or heated, and subsequently dried.	Parboiled rice
Whole grain rice; whole rice	Rice which does not contain broken grains, smaller than three-quarters of the whole grain.	Whole grain rice
Broken rice	Rice consisting of broken grains, smaller than three-quarters of the whole grain.	Broken rice
Brewers rice	Very small broken rice, generally used for industrial and feeding purposes.	Brewers rice

Common Terms	Definitions	Accepted and Recommended Terms
Rice polishing	A by-product from the milling of rice consisting of the inner bran layers of the kernel with part of the germ and a small percentage of the starchy interior.	Rice polishing
Husks; hulls;	A by-product consisting of the outer bran layers of the kernel with part of the germ.	Bran

WEIGHTS AND MEASURES

Another factor leading to much confusion throughout the world is the standard of weights and measures particularly applicable to rice. Inasmuch as this report may be read by interested peoples of different countries, the subject requires some clarification as to the units of measurement and weight used.

At this writing, there is no international uniformity in weights and measures, and in many highly civilized areas of the world, the use of pounds, tons, acres, and bushels means nothing to the reader. This is particularly true of rice, for, unlike any other grains in the world, units of weight and measurement for rice are as variable as currencies.

A general table of equivalents follows, to give the reader some of the ready conversion factors. It must be borne in mind, however, that there are approximately 275 distinct variations, internationally, in weights and measures which are impractical to include herein. For example, there are deviations which, to the local populace of an area, are entirely common to that area, but to the stranger mean nothing. The Quental, which in the United States equals 100 pounds, in Argentina (adapted from the Spanish) equals 101.28 pounds (Imperial), and in Brazil (adapted from the Portuguese) equals 129.54 pounds (Imperial) In Spanish Morocco, a Spanish ton equals 2271.64 pounds (Imperial), whereas in most of Latin America, the metric ton (2204.622 pounds) is used. In the United States, a foot equals 12 inches, whereas in parts of Africa, deviating entirely from metric or anything else, a French foot equals 12.1 inches (Imperial), and a South Africa Cape foot equals 12.375 inches. (Imperial)

In weights and measurements of rice, harvested rice is known as paddy, rough raw or unhusked. After the rice grains have been removed it is

called cargo or brown rice. When put through a milling process, the result is called white rice. Therefore, when referring to 100 pounds of rice, the statement always must be qualified.

The following weights and measurements are those used generally in international trade.

100 tons brown rice	=	88 tons milled rice
100 tons paddy rice in:		
British Borneo	=	62 tons milled rice
Burma	=	67.9 tons milled rice
Ceylon	=	68 tons milled rice
Formosa	=	70 tons milled rice
India	=	68 tons milled rice
Indo China	=	64 tons milled rice
Indonesia	=	68 tons milled rice
Korea	=	73 tons milled rice
Japan	=	73.7 tons milled rice
Malaya	=	63 tons milled rice
Pakistan	=	68 tons milled rice
Philippines	=	64 tons milled rice
Thailand	=	65 tons milled rice
United States	=	66 tons milled rice
All others (average)	=	65 tons milled rice

Measures of paddy rice --

1 bushel (United States - British)	=	45 pounds
1 bushel - Australian	=	42 pounds
1 bushel - Ceylon	=	50 pounds
1 cask - United States	=	672 pounds
1 bag or pocket - United States	=	100 pounds
1 barrel - United States	=	162 pounds
1 bag - East Indian	=	168 pounds

Linear

United States - British	Metric	United States - British
1 inch = 2.54 centimeters	1 centimeter	= 0.393701 inches
1 foot = 0.3048 meters	1 meter	= 3.28084 feet
1 yard = 0.9144 meters	1 meter	= 1.09361 yards
1 mile = 1.609344 kilometers	1 kilometer	= 0.62137 miles

Square Measure

1 sq. in.	= 6.4516 sq. centimeters	1 sq. centimeter	= 0.15500 sq. in.
1 sq. ft.	= 0.092903 sq. meters	1 sq. meter	= 10.7639 sq. ft.
1 sq. yd.	= 0.83613 sq. meters	1 sq. meter	= 1.19599 sq. yd.
1 acre	= 0.404686 hectares	1 hectare	= 2.47105 acres

Cubic Measure

1 cu. in.	= 16.3871 cu. centimeters	1 cu. centimeter	= 0.061024 cu. in.
1 cu. ft.	= 0.028317 cu. meters	1 cu. meter	= 35.31467 cu. ft.
1 cu. yd.	= 0.76455 cu. meters	1 cu. meter	= 1.30795 cu. yd.

Capacity Measure

1 gal.(Imp.)	=4.54596 liters (Imp.)	1 liter (Imp.)	=0.219975 gals.(Imp)
1 gal.(U.S.)	=3.78533 liters	1 liter	=0.264178 (US)gals.
1 gal.(Imp.)	=1.20095 (U.S.) gals.	1 (U.S.) gals.	=0.83267 (Imp)gals.
1 bu.(Imp.)	=0.363677 hectoliters	1 hectoliter	=2.74969 (Imp.)bus.
1 (U.S.) bu.	=0.352383 hectoliters	1 hectoliter	=2.837819(U.S.)bus.
1 (Imp) bu.	=1.03206 (U.S.) bu.	1 (U.S.) bu.	=0.96894 (Imp.)bus.

Weights

1 pound	= 0.453592 kilograms	1 kilogram	= 2.204622 pounds
1 long ton	= 2240 pounds	1 pound	= 0.0004464 tons
1 short ton	= 2000 pounds	1 metric ton	= 2204.622 pounds

Frequently, varas are used in acreage measurements, particularly in Latin America, but even this old Spanish measurement is variable from 32.5 inches in Guatemala to 34.09 inches in Argentina, and in Portugal it is 43.31 inches (Imperial equivalents). The confusion is further compounded when United States standards come into the picture. The international comprehension of weights and measures in world trade vacillates from complete chaos to regimented forms of confusion, particularly in a world commodity such as rice.

In this report, United States standards are used as they apply to rice, and the reader should carefully analyze any compilation of figures before any conclusions.

CLASSIFICATIONS AND GRADING

There are no international standards of grades and qualities of rice. In the absence of such standards, international rice business has to be conducted on the basis of samples requiring personal inspection before transactions are made, which, in turn, means that what one country might consider as Grade I, would, in another country be considered Grade III, for in many countries, the mixing of high quality rice with inferior types is common practice.

In the United States and some other countries, legislative measures have been taken to prescribe well-defined standards of grade and quality, and the mills separate and grade their rice production into controlled grades as to quality, size, type and variety. The factors usually taken into consideration in judging the quality and grades of rice are:

(1) shape; (2) slenderness or ratio of length to breadth; (3) color, degree of milling, polishing and rooting, if any; (4) percentage of broken grain; (5) damaged grains, discolored grains; (6) grains damaged by weevils or other insects; (7) presence of grains of other rice varieties; (8) foreign matter content such as weed seed, soil particles; (9) weight per unit of volume; and (10) age and aroma.

Rice, unlike any other grain in the world, is a highly complex commodity, and is the only grain which has a completely distinctive set of classifications and grades which are too involved and lengthy to fully set forth herein. However, to acquaint the reader with a relatively condensed format of the classification and grading formulae, the following is outlined.

The United States Department of Agriculture established standards which divide rough rice (paddy) into classes, and the subsequent rough, brown, milled, second head milled, screenings, brewers, unpolished, parboiled, and coated, into grades.

Rough rice consists of 50 per cent or more of kernels from which the hulls have not been removed.

Classifications

Class I	Rexoro (incl. Rexark)	Class VII	Magnolia
Class II	Patna	Class VIII	Zenith
Class III	Blue Bonnet	Class IX	Calrose
Class IV	Nira	Class X	Early prolific
Class V	Fortuna	Class XI	Pearl
Class VI	Blue Rose (and variations of)	Class XII	Mixed

Grades

The foregoing classes are further segregated under the following standards of grades:

Figure 1 - Grades and grade requirements for all classes of rough rice.

Grade[1]	Maximum limits of—				
	Seeds and heat-damaged kernels		Red rice and damaged kernels (singly or combined)[2]	Chalky kernels[2]	Rice of contrasting classes[3]
	Total (singly or combined)	Heat-damaged kernels and objectionable seeds (singly or combined)			
	Number in 500 grams	*Number in 500 grams*	*Percent*	*Percent*	*Percent*
U. S. No. 1	2	1	0.5	1.0	1.0
U. S. No. 2	4	2	1.5	2.0	2.0
U. S. No. 3	7	4	2.0	4.0	3.0
U. S. No. 4	15	10	3.0	8.0	5.0
U. S. No. 5	30	30	6.0	10.0	10.0
U. S. No. 6	75	75	[4] 15.0	15.0	10.0
U. S. sample grade	U. S. sample grade shall be rough rice which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 6, inclusive, or which contains more than 18.0 percent of moisture, or which is musty, or sour or heating, or which has any commercially objectionable foreign odor, or which is otherwise of distinctly low quality				

[1] Color and general appearance, minimum requirements: U. S. No. 1 shall be white or creamy. U. S. No. 2 may be slightly gray. U. S. No. 3 may be light gray. U. S. No. 4 may be gray or slightly rosy. U. S. No. 5 may be dark gray or rosy. U. S. No. 6 may be dark gray or rosy.

[2] The rice in grade U. S. No. 1 of the class Pearl rough rice may contain not more than 2.0 percent, in grade U. S. No. 2 not more than 4.0 percent, in grade U. S. No. 3 not more than 6.0 percent, and in grade U. S. No. 4 not more than 8.0 percent of chalky kernels.

[3] These limits do not apply to the class Mixed rough rice.

[4] The rice in grade U. S. No. 6 may contain not more than 6.0 percent of damaged kernels.

Brown rice consists of more than 50 per cent of kernels from which the hulls only have been removed, and these in turn are segregated under the following standards of grades.

Figure 2 - Grades and grade requirements for all classes of brown rice.

Grade [1]	Maximum limits of—							
	Seeds and heat-damaged kernels			Red rice and damaged kernels (singly or combined)	Chalky kernels	Broken kernels		Rice of contrasting classes [2]
	Total (singly or combined)	Heat-damaged kernels	Objectionable seeds			Total	Through 6½/64 sieve	
	Number in 500 grams	*Number in 500 grams*	*Number in 500 grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
U. S. No. 1	25	1	2	1.0	1.0	5.0	1.0	1.0
U. S. No. 2	50	2	10	2.0	3.0	10.0	2.0	2.0
U. S. No. 3	75	4	20	4.0	5.0	15.0	3.0	5.0
U. S. No. 4	100	8	35	8.0	8.0	25.0	4.0	10.0
U. S. sample grade	U. S. Sample grade shall be brown rice which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 4, inclusive, or which contains more than 14.0 percent of moisture, or which is musty, or sour, or heating, or which has any commercially objectionable foreign odor, or which contains more than 0.1 percent of foreign material, or which contains live or dead weevils or other insects, insect webbing, or insect refuse, or which is otherwise of distinctly low quality.							

[1] The brown rice in grade U. S. No. 1 may contain not more than 1.0 percent, in grade U. S. No. 2 not more than 3.0 percent, and in grades U. S. No. 3 and U. S. No. 4 not more than 10.0 percent of milled rice.
[2] These limits do not apply to the class Mixed brown rice.

Milled rice, in addition to the 12 classes enumerated previously, has three additional classes; namely, Second head, Screenings and Brewers, and milled rice is further defined as whole or broken kernels from which (1) the hulls and practically all of the germs and bran layers have been removed, (other than "special grade unpolished milled rice") or, (2) in the case of milled rice of the "special grade unpolished milled rice" the hulls, a part of the germs and the outer bran layers, but not the inner bran layers have been removed, and which contains not more than 10 per cent of seeds or foreign materials, either singly or combined.

Figure 3 - Grades and grade requirements for all classes of milled rice, except Second Head milled rice, Screenings milled rice, and Brewers milled rice.

Grade [1]	Maximum limits of—						
	Seeds and heat-damaged kernels		Red rice and damaged kernels (singly or combined)	Chalky kernels [2]	Broken kernels		Rice of contrasting classes [3]
	Total (singly or combined)	Heat-damaged kernels and objectionable seeds (singly or combined)			Total	Through 6/64 sieve	
	Number in 500 grams	*Number in 500 grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
U. S. No. 1	2	1	0.5	1.0	4.0	0.1	1.0
U. S. No. 2	4	2	1.5	2.0	7.0	.2	2.0
U. S. No. 3	7	5	2.0	4.0	15.0	.5	3.0
U. S. No. 4	15	10	3.0	6.0	25.0	.7	5.0
U. S. No. 5	30	30	6.0	10.0	35.0	1.0	10.0
U. S. No. 6	75	75	[4] 15.0	15.0	50.0	2.0	10.0
U. S. sample grade	U. S. Sample grade shall be milled rice of any of these classes which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 6, inclusive, or which contains more than 15.0 percent of moisture, or which is musty, or sour, or heating, or which has any commercially objectionable foreign odor, or which contains more than 0.1 percent of foreign material, or which contains live or dead weevils or other insects, insect webbing, or insect refuse, or which is otherwise of distinctly low quality.						

[1] Color and general appearance, minimum requirements. U. S. No. 1 shall be white or creamy, and shall be well milled. U. S. No. 2 may be slightly gray, and shall be well milled. U. S. No. 3 may be light gray, and shall be reasonably well milled. U. S. No. 4 may be gray or slightly rosy, and shall be reasonably well milled. U. S. No. 5 may be dark gray or rosy, and shall be reasonably well milled. U. S. No. 6 may be dark gray or rosy, and shall be reasonably well milled.
[2] The milled rice in grade U. S. No. 1 of the class Pearl milled rice may contain not more than 2.0 percent, in grade U. S. No. 2 not more than 4.0 percent, in grade U. S. No. 3 not more than 6.0 percent, and in grade U. S. No. 4 not more than 8.0 percent of chalky kernels.
[3] These limits do not apply to the class Mixed milled rice.
[4] The milled rice in grade U. S. No. 6 may contain not more than 6.0 percent of damaged kernels.

Figure 4 - Grades and grade requirements for the class Second Head milled rice.

Grade [1]	Maximum limits of—					
	Seeds and heat-damaged kernels		Red rice and damaged kernels (singly or combined)	Chalky kernels	Broken kernels	
	Total (singly or combined)	Heat-damaged kernels and objectionable seeds (singly or combined)			Through 6/64 sieve	Through 5½/64 sieve
	Number in 500 grams	*Number in 500 grams*	*Percent*	*Percent*	*Percent*	*Percent*
U. S. No. 1	15	5	1.0	3.0	3.0	15.0
U. S. No. 2	20	10	2.0	5.0	5.0	25.0
U. S. No. 3	35	15	3.0	10.0	7.0	35.0
U. S. No. 4	50	25	5.0	15.0	10.0	50.0
U. S. No. 5	75	40	10.0	20.0	10.0	50.0
U. S. sample grade	U. S. sample grade shall be milled rice of this class which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 5, inclusive; or which contains more than 15.0 percent of moisture or which is musty, or sour, or heating; or which has any commercially objectionable foreign odor; or which contains more than 0.1 percent of foreign material; or which contains live or dead weevils or other insects, insect webbing, or insect refuse; or which is otherwise of distinctly low quality.					

[1] Color and general appearance, minimum requirements: U. S. No. 1 shall be white or creamy, and shall be well milled. U. S. No. 2 may be slightly gray, and shall be well milled. U. S. No. 3 may be light gray, and shall be reasonably well milled. U. S. No. 4 may be gray or slightly rosy, and shall be reasonably well milled. U. S. No. 5 may be dark gray or rosy, and shall be reasonably well milled.

Figure 5 - Grades and grade requirements for the class Screenings milled rice.

Grade [1]	Maximum limits of—				
	Seeds		Chalky kernels	Broken kernels	
	Total	Objectionable seeds		Through 5½/64 sieve	Through 6/64 sieve
	Number in 500 grams	*Number in 500 grams*	*Percent*	*Percent*	*Percent*
U. S. No. 1	30	20	5.0	4.0	20.0
U. S. No. 2	75	30	8.0	6.0	30.0
U. S. No. 3	125	90	12.0	8.0	40.0
U. S. No. 4	175	140	20.0	10.0	50.0
U. S. No. 5	250	200	30.0	15.0	60.0
U. S. sample grade	U. S. sample grade shall be milled rice of this class which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 5, inclusive; or which contains more than 15.0 percent of moisture; or which is musty, or sour, or heating; or which has any commercially objectionable foreign odor; or which has a badly damaged or extremely red appearance; or which contains more than 0.1 percent of foreign material; or which contains live or dead weevils or other insects, insect webbing, or insect refuse; or which is otherwise of distinctly low quality.				

[1] Color and general appearance, minimum requirements: U. S. No. 1 shall be white or creamy, and shall be well milled. U. S. No. 2 may be slightly gray, and shall be well milled. U. S. No. 3 may be light gray, or slightly rosy, and shall be reasonably well milled. U. S. No. 4 may be gray or rosy, and shall be reasonably well milled. U. S. No. 5 may be dark gray or very rosy, and shall be reasonably well milled.

Figure 6 - Grades and grade requirements for the class Brewers milled rice.

Grade	Seeds (maximum limits)		Color and general appearance, minimum requirements
	Total	Objectionable seeds	
	Percent	*Percent*	
U. S. No. 1	0.5	0.05	Shall be white or creamy, and shall be well milled.
U. S. No. 2	1.0	1	May be slightly gray, and shall be well milled.
U. S. No. 3	1.5	2	May be light gray or slightly rosy, and shall be reasonably well milled.
U. S. No. 4	3.0	4	May be gray or rosy, and shall be reasonably well milled.
U. S. No. 5	5.0	1.5	May be dark gray or very rosy, and shall be reasonably well milled.
U. S. sample grade	U. S. sample grade shall be milled rice of this class which does not meet the requirements for any of the grades from U. S. No. 1 to U. S. No. 5, inclusive, or which contains more than 15.0 percent of moisture, or which is musty, or sour, or heating, or which has any commercially objectionable foreign odor, or which has a badly damaged or extremely red appearance, or which contains more than 0.1 percent of foreign material, or which contains live or dead weevils or other insects, insect webbing, or insect refuse, or which is otherwise of distinctly low quality.		

In addition to the foregoing, there are further classifications and grading in unpolished, parboiled and coated milled rice. Those are special grades of milled rice, and are, likewise, controlled by specific grade requirements. The United States Government has established rice-inspection stations in all rice producing and milling areas and under legislative requirements enforces strict adherence to classification and grading standards. To describe full definitions and procedures of controlled classifications and grading would require a separate section too lengthy to include herein.

USES AND CHARACTERISTICS

This report will deal only with the processing of rice as the end product to be marketed, and will not introduce the many specialized ramifications in the use of the grain by-product nor the husks, hulls and rice straw, the latter of which comprises major industries in some countries.

The organic composition by per cent of the grain, is as follows:*

Item	Field Products		Polished Rice	Milled Products		Rice Hulls
	Rough Rice	Rice Straw		Rice Bran	Rice Polish	
Water	9.6	7.5	12.3	9.5	10.0	9.3
Ash	4.9	14.5	.5	11.3	4.8	16.9
Crude protein	7.6	3.9	7.4	10.9	11.9	3.3
Carbohydrates:						
Fiber	9.3	33.5	.4	15.8	1.9	35.4
Nitrogen-free extract	66.7	39.2	79.0	42.7	62.3	34.0
Fat	1.9	1.4	.4	9.8	9.1	1.1
Total	100.00	100.00	100.00	100.00	100.00	100.00

* W. A. Henry and F. B. Morrison: "Feeds and Feeding"

The nutritive value of rice is as follows:

Per 100 grams -- Edible Portion

	Brown Rice	Polished Rice
Food energy, calories	360.0	362.0
Protein, grams	7.5	7.2
Fats, grams	1.7	.3
Carbohydrates, grams	77.7	79.4
Fiber, grams	.6	.2
Ash, grams	1.1	.4
Calcium, milligrams	39.0	24.0
Phosphorous, milligrams	303.0	136.0
Iron, milligrams	2.0	.8
Vitamin A	negligible	negligible
Thiamine, milligrams	.32	.07
Riboflavin, milligrams	.05	.03
Niacin, milligrams	4.6	1.6

The bran layers surrounding the rice kernel are the best natural source of Vitamin B^1, and were discovered in the aleurone layers of rice. Rice is the most easily digested of all human foods. The human body digests it within one hour, whereas most other foods require two to four hours. The digestive co-efficient of rice is 98, and allergy to rice is extremely rare.

The term "wild rice" is greatly misunderstood for it is a reed-like water plant, or aquatic grass and not rice. It is native to North America and, while it slightly resembles real rice, is unknown in other parts of the world. Its origin likewise is unknown. It was and still is used as a food, first by American Indians, and now it is considered a delicacy by the American housewife. It is not harvested or milled as is regular rice and is not to be confused with the subject matter of this report. Wild rice retails for about $2.25 per pound, whereas real rice is about $0.15 per pound.

It is not the intention of this report to dwell upon the dietary aspects of rice, but there are certain misconceptions relative to its animal and human food use worthy of mentioning, so that the reader may have a better understanding of the reasons for some of the milling processes.

The rice hull or the outer covering of the grain, is tasteless, tough and woody, and contains a large volume of silica and sand. It has sharp, roughened, flinty edges and needle-like points (35 per cent fiber) which, because they do not soften in the digestive tract, are dangerous to the stomach and intestines, hence paddy rice is little used as food by livestock and never by humans. Rice straw, on the other hand, is used.

Polished rice dry matter is 90 per cent nitrogen-free extract, almost exclusively starch. It contains a total of 78 per cent digestible nutrients. The protein averages about seven per cent and is the major cause of nutritional deficiencies of populations using polished rice as their major food. In most of the Asiatic areas, however, where rice constitutes daily food, they do not follow the practice of milling highly-polished rice. They consume brown rice (husked, but not polished) or "undermilled" rice containing most of the bran layer with a higher protein content.

The first by-product in the milling process is rice bran. This product is an important livestock feed in all areas. Digestible nutrients are 62 per cent with 11 per cent protein and 10 per cent fat. The final by-product of the polishing process in which the inner layers of the endosperm cover are removed is termed rice polish. It has a total of 82 per cent digestible nutrients including 12 per cent protein, nine per cent fat, 62 per cent nitrogen-free extract and only two per cent fiber. In the Western Hemisphere and surplus rice areas of Asia, the major use of this product is hogfeed. Unlike the heavy consuming rice areas of the world, the United States and Europe are the only areas where they mill off most of the bran layer to meet consumer demand for highly polished rice. In fact, the natural polished rice is subsequently coated with a glucose and talcum to obtain even a higher polish.

Rice products, after the milling process, fall into five basic categories:

1. Whole kernels
2. Broken kernels
3. Bran
4. Polish
5. Hulls

The by-products of rice are not too numerous, and a few may be considered in the following categories:

A. Human Foods

1. Grain and rice flour
2. Wines - beverages
3. Margarines

B. Animal Foods

1. Rice bran
2. Rice polish

C. Industrial

1. Hulls (fuel) (adobe-type bricks) (insulation)
2. Bran (oils)
3. Soaps
4. Powders

D. Pharmaceuticals

1. Grain and bran - vitamin preparations
2. Powders

VARIOUS MILLING PROCESSES

Rice growers generally sell their harvested crop direct to mills. The methods of harvesting are as varied as those of production, ranging from the most primitive of hand operations in cutting, shocking and threshing to highly mechanized methods. The end result, however, is the same; namely, the acquisition of as many bushels of paddy rice as can be obtained.

Before discussing the various stages in the process of rice milling, it may be helpful to point out the structure of rice as a grain, because

milling is concerned essentially with separating the whole grain, or paddy rice, into its three basic categories; namely, (1) husked, (2) brown or bran rice, and (3) milled rice.

As previously mentioned, the paddy grain has an outer hull or husk, is hard and covered with needle-like hairs, high in silica content and consists of two ridged inner glumes and two outer glumes. It has little or no value other than that of fuel, the ash of which is sometimes used in conjunction with powdered fats to produce an admixture for cleansing soaps and lye.

Inside the husk is found the rice kernel covered with bran layers. It usually is light brown in color, hence the term brown rice or husked rice. At one end of the kernel, and lying within the bran layers, is the germ, or embryo, which nearly always is removed with the bran in milling. Rice bran, including the germ, is high in nutritive value and valuable for livestock feeding. Next to the bran, there lies a layer of appreciably different material, known as the aleurone layer, which is rich in nutrients.

The starchy core of the kernel, after substantial and variable removal of the layers described above (dependent upon the milling process), is the white or creamy grain used as food. This is termed milled rice.

There are many variations in the milling process and in the machinery and supplementary equipment used. In many countries, large amounts of rice are produced for domestic consumption by home-pounded, or primitive, devices. In the more developed areas, however, the rice produced is processed in both small and large-scale cooperatives and commercial mills which have installed machines and other equipment to carry out the necessary operations in obtaining the finished product, white rice.

In most parts of the world, the design of rice mills has not advanced for many years, and a large proportion of mills in existence are obsolete, worn out or require either extensive repair, renovation, modification or modernization. On the other hand, the adaptation of modern mechanized methods is relative to the economics of the location involved, productivity of the raw material, market availability and innumerable economic ramifications about which the reader has already been cautioned.

In this report, consideration is given to a modern mill of modest capacity which most likely will be applicable to the average economic location other than in the United States. While the principles and concepts of modern milling operations are adhered to, the economics are based on the smaller capacity mill which will normally suit the average requirement.

Further, unlike any other grain, the processing of rice, especially milling, is linked with local habits, traditions, nutrition requirements,

customs, demands and other problems, many of which are not easy to alter. For example, the modernized parboiling process is unknown in many areas of the world, and the end product would not be acceptable if it were used.

In world trade, however, although far from being standardized, the parboiling process is gaining some acceptance such as in India and British Guiana. The vitamins and other nutrients in the bran layers are forced into and fixed in the endosperm, it is less attractive to insects than undermilled or hand-pounded rice, the partial gelatinization of the starch during parboiling toughens the grains and reduces breakage during milling, and the parboiled rice keeps for several days after cooking, whereas the raw milled rice usually spoils in two days.

On the other hand, most millers feel that the net cost of parboiling rice is higher than that of producing raw rice and the relative higher yield of whole grains (10 per cent to 20 per cent) and other benefits do not offset the added processing costs. In other areas, the opposite is claimed.

Consumer acceptance is also a highly variable factor, for parboiled rice has a distinctive odor which to some is a highly objectionable feature. A modified process recently has been developed which consists of soaking the raw rice in a hot dilute solution of calcium chloride. The product is known as calcured rice and retains the appearance of highly milled raw rice, but possesses all the desirable features of parboiled rice.

It is claimed to be even less susceptible to insect attack and to supply additional calcium. Cost factors, however, are highly variable and the product was developed too recently to determine consumer acceptance.

The patterns of change in world rice consumption from raw rice to parboiled and chemically treated rice will be slow because of habits and customs. Superstition, religions and many other elements also play a part in this world rice picture. For example, in the Orient, practically starving consumers discarded free gifts of parboiled rice rather than eat their normal staff of life. To them it just did not look or taste like good food.

In the United States, where the annual per capita consumption is five pounds, rice is rice. In the Orient, where the per capita consumption is 400 pounds, rice is life. It is necessary, therefore, for the reader to utilize considerable elasticity in his thinking when considering the relative economics of milling operations described herein.

When the rice grain is broken down in the successive stages of the milling process, about 25 per cent by weight, of the original rough

rice is hulls or husks. The balance is the husked kernel or brown rice. In the milling process thereafter, 75 per cent comprising the husked kernel or brown rice is graded after subsequent milling into first heads (completely whole grain milled rice) and second heads (broken grains), the percentage of one to the other finally determining grade and price as outlined in preceding tables on grades.

It will be noted that Grade U.S. No. 1 contains no more than four per cent of broken grains by weight, whereas Grade U.S. No. 6 can contain as much as fifty per cent of broken grains. Again, considering the milling results from the original rough rice with 25 per cent by weight constituting hulls or husks, 57 per cent of the remaining is generally first head. This, however, is entirely relative and dependent upon mill efficiency in equipment and management.

In the United States, a general milling rule which can be applied is 25 per cent hulls, 50 per cent first heads, 15 per cent second heads, eight per cent bran and polish, and two per cent debris. The reader must bear in mind, however, that yields in milling are very variable throughout the world. In Burma, for example (world's largest exporter), where the parboiling process is accepted practice, 71.6 per cent is first head average, 0.5 per cent second head and 2.45 per cent bran. Husks are the same, 25 per cent In Burma, however, only about 25 per cent of the rice production is of the parboiled process, a decline from 40 per cent prior to World War II.

When we speak of milling plants or rice mills, we again are confronted with a paradox, for more than half of all the rice produced in the world never leaves the farm where it is grown. In such instances, standard practice, with but minor variations, is to process only the amount needed for one week's consumption by the farm-stead and neighbors. The milling machinery consists of the mortar and pestle principle.

In intermediate contrast to this are the simple rice mills, which are similar to the old type manual or belt-driven coffee-grinding machine, and which, in many areas of the world, still serve as the commercial millers' process. In both methods, the net result is the same - undermilled rice and a single commodity output, rice and hulls.

In contrast to both the foregoing are two classes of the commercial steam or electric powered mills. The first of these two classes does not operate efficient separators to divide the final milled product into classes of head rice and the many different types of broken grain, but produces one type of edible rice, one grade of broken grain and one type of by-product feed, usually termed rice bran.

The second class of commercial mill is the type with which this report is concerned but of a capacity commensurate with the average requirement

of an economy less developed and mechanized than that of the United States.

Milling plant capacities in the United States generally are rated in terms of barrels or pounds per hour or day and operate by steam-generated power using rice hulls as fuel. These are much the same as those found in Burma, Siam, French Indo-China, Italy, Brazil and Argentina.

The major mills in the United States have capacities of 65,000 pounds to 3,500,000 pounds per 24-hour day. Many other countries of the world use small electrically operated mills capable of processing 1,000 to 5,000 pounds of rough or paddy rice daily. As previously mentioned, these mills are not equipped with separation machines for producing different grades of milled and broken rice. They sell [illegible] and broken rice containing everything from the unmilled grains, which slipped through the huller, to weed seeds.

For such operations, the quality of the product depends almost entirely on the quality of the rough rice milled. The hulls are discarded into nearby streams, dumped on unused lands or burned in piles. Such mills produce just as much edible food per unit of rice milled but not of the types and qualities demanded by consumers in the Western Hemisphere. Since their customers are mostly in the low-income brackets, price-conscious and not quality-conscious, these mills are as efficient for the areas they serve as are most of the elaborate mills in the United States.

In the economic aspects of milling and in the interest of adhering to a commercial enterprise that is neither in the category of the small village type electrically-operated mill, with a single end product (ungraded rice), nor the large commercial type with its innumerable grades and by-products, this report is confined to the modest, small capacity mill which is fully modern and can meet all the normal market requirements of the large mills as to grades and qualities on an adequate, competitive basis.

The economics of any mill depend upon what it actually produces. Two thousand hours per year is generally the economic minimum, whereas 4,000 hours per year are the technical maximum. One of the basic elements adhered to herein is that the principles and concepts of modern milling operation are fully followed at the lowest reasonable economic levels.

This report is, therefore, based on an hourly milling capacity of two tons of paddy rice and has an end product of 2,800 pounds of top grade milled rice. It is a 2,000-hour annual operation which would accommodate the average annual yield of 42 bushels per acre from 4,232 acres (4,000 pounds of paddy rice x 2,000 hours = 8,000,000 pounds ÷ 45

pounds per bushel = 177,777 bushels). The mill, of course, could be operated on an eight, 16 or 24-hour basis, or 250, 125 or 82 days per year.

The mill described herein also is designed to be operated by electric, Diesel or steam power. Obviously, without specific data relative to location, power, labor, and productivity, it is impossible to do other than generalize on such factors.

There are seven major considerations to be studied in planning a new mill:

1. The mill should be housed in a building of minimum size to keep that portion of capital investment as low as possible.

2. Automatic features should be incorporated into mill operations to the greatest extent possible for ease of control. This relieves operators of many menial tasks associated with nonautomatic mills.

3. Sanitation problems must be minimized.

4. Service factors of equipment must be high if mill is to operate continuously. Shutdowns due to breakdowns can be more costly than the original price of a piece of equipment.

5. Maximum flexibility should be incorporated into the flow so that uniformity in products can be maintained and adjustments in specifications readily made.

6. Economy of power consumption must be considered.

7. Low maintenance expenditures will contribute immeasurably to low cost operations.

MANUFACTURING OPERATIONS

The complete milling function involves seven basic operations:

1. Storage
2. Cleaning

3. Hulling or husking
4. Separating
5. Brown rice hulling
6. Polishing
7. Grading and sacking

1. Storage

Unlike other grains requiring milling, there is much on-farm storage of paddy rice, and, excepting the larger cooperative mills and big milling companies, the rice mill operator generally maintains storage facilities for only a fraction of his annual volume, purchasing the paddy rice in quantities commensurate with his schedule of definite orders for the milled product.

On the other hand, rice is highly susceptible to deterioration in storage at both farm and mill, and proper prevention is more effective than any type of efficient cure. Because of the tough exterior of the rice kernel, paddy rice is more resistant to pest damage than other grains.

Despite this, however, infestation does occur, and the only preventive is fumigation which ordinarily is not required for paddy rice but is necessary frequently for milled rice if it is not moved to market immediately after milling. The principal pest infestation comes from rodents, insects and fungi, and storage presents a dual problem since proper controlled storage facilities must be maintained for both the paddy rice and the end product, the milled rice.

In addition to these storage problems, there is the matter of moisture content. In the humid regions of southeast Asia, moisture content must be controlled within 10 to 12 per cent, whereas in other parts of Asia, Europe and the Western Hemisphere 12 to 14 per cent is desirable for paddy rice. Milled rice in storage, however, must maintain 10 to 12 per cent moisture control.

Where the moisture content exceeds the above limits, stored rice develops heat which causes discoloration and objectionable odors. The interior of the grains becomes soft and subject to excessive breakage resulting in substantial losses in salability.

The large milling companies in the United States usually deal with separate cooperative or company driers. They purchase their paddy rice, dried and ready for milling from these sources and send their milled rice to sack dryer plants and warehouses. In many instances, these operations are not separate companies but integrated parts of large mill operations and cooperatives. Mechanical drying or any other method of moisture control is based on the same principle - blowing hot air through or over the rough rice until the excessive

moisture has been removed. Milled rice in storage, whether sacked or bulk, is dried similarly.

The solution to the storage problem appears to be drying and maintaining proper moisture controls of the paddy rice prior to storage or doing so in properly designed, constructed and operated elevators and driers, and warehousing milled rice in rodent and insect-proof, moisture-proof, dust-proof and well ventilated storage facilities.

Although mechanical driers appear to be necessary for producing a final milled product of top grade, the economic efficiency of establishing such facilities in all rice milling operations is highly questionable. In many areas of the world, paddy rice is dried in open drying yards and covered each night with burlap and canvas as protection against dew or rain. In other areas, climatic conditions are such that the drying is done in the fields before harvesting. Like all other economic elements involved in this subject, the factors are relative and vary with location, and market.

In this report, however, the assumptions previously given involved storage at mill, of 40,000 bushels of paddy rice which, in terms of the physical facilities necessary, means elevator (or flat) storage silos (or bins) of concrete, steel or wood. The most recent estimates for construction costs of the three types are from $0.65 to $1.25 for each bushel stored, including the head house and auxiliary equipment for receiving, drying and elevating (or conveying) the grain.

Converting this requirement to availability in production would equal the normal yield from approximately 1,000 acres. This, in turn, would mean that, in 250 days of mill operation, such storage facilities would be filled four times to accommodate the mill described in this report.

Whether the storage facilities for the paddy rice are built of concrete, steel or wood, each has its advantages and disadvantages. Wood, being a bad conductor of heat, permits maintaining a fairly even temperature inside the bins. Further, interlacing of timers and planking make walls, particularly corners, strong, elastic and resistant to bursting stresses.

On the other hand, steel and concrete permit maintaining better rodent and pest control, are easier to clean and require less maintenance. Bulk storage also can be accomplished by flat grain storage, in lieu of elevators, and in buildings containing sheet metal bins as shown in Figure 8.

The foregoing should give the reader the relative factors to consider in relation to storage requirements, location, and crop availability.

Fumigation ordinarily is not required in rough rice storage facilities of the better construction. However, some fumigation should be done at least twice a year and regularly where milled rice is stored when each major quantity is moved out.

2. Cleaning

Paddy rice received from the fields, whether sacked or in bulk, contains quantities of dust, stubble straw, weed seeds and other foreign materials which are removed either before going into storage or at the mill before entering processing.

The assumption herein is that from the elevators or flat storage facilities, the paddy rice is conveyed to the mill receiving hoppers in its field condition (or partially cleaned) after having received proper artificial drying at temperatures of 110 degrees to 120 degrees Fahrenheit. The cleaning is accomplished by a combination of screening and blowing, with the paddy rice passing through sifter screens and discharging into ducts or conduits and the foreign matter being sucked through cyclone dust and refuse collectors. (See Figure 10)

The cleaned paddy or raw rice then passes to batch scales from where it is conveyed pneumatically to graders and separators before entering the shellers or hulling process. (See Figure 11)

The grading and separating machines enable uniform grain sizes to reach the huller or sheller so that the machinery can operate at prolonged periods before second adjustment runs. It also permits handling of other similar grains requiring similar processing with minor adjustment. Further, the grading of the rice grain before it reaches the hulling or husking operation insures a minimum of grain breakage and, hence, a higher yield of the whole grain grades. Many separators also are equipped with magnetic devices to remove any metal particles which might cause damage to machinery.

3. Hulling or Husking

The historic methods of husking the rice grain or removal of the outer covering by mortar and pestle, pounding, old-fashioned husking stones, and coffee grinders, have been described in a general way. As previously mentioned, the old methods still are followed in many areas of the world, but modern practice employs machinery of various types.

These are nothing other than machines containing two metal discs, or stones as they are sometimes called, coated on their opposite surfaces with a durable abrasive composition which can be renewed readily when necessary. The upper plate remains stationary, with the lower one

revolving at speeds of 200 to 600 revolutions per minute. The upper plate is adjustable to fit the husking of the size grains being handled and the revolving motion of the lower plate tends to keep the grains of rice on end and cracking the husk without breaking the grain.

Other techniques involve the use of horizontal rubber rolls revolving at different speeds so that the compression action is rather gentle, the grains enter in a flat position, and the husks are pressed off the kernel, so to speak. Still other types employ a rubber belt under pressure to the shelling roller, and the shelling surfaces consist of a wide rubber belt of uniform thickness throughout its length.

Figure 12 illustrates the under runner disc type of sheller.

When the grain has passed through the shellers or huskers, the husked product processed is composed of husked grains, unhusked grains, unripe grains, broken rice crumbled during the husking, some bran meal and a quantity of empty husks. This mixture then passes to the next stage of processing.

4. Separating

The brown rice grain must be separated from the unusable residue and the unhusked and unripe grains reclaimed. This is done by separators, one known as the paddy and the other as the chaff separator.

The chaff or husk separator, in reality, is a sifting machine or cleaner, the same as described and illustrated under Cleaning (Figure 11). This machine removes the brown rice, both whole and broken, along with bran meal, unhusked and unripe grains, exhausting the useless husks and chaff through cyclone suction to refuse piles and sending the processed materials remaining to the paddy separator.

This latter machine carrying the brown rice residue is designed to separate the paddy remaining in the mixture after husking from the cleaned husked rice. It consists of a large, inclined, mechanically operated shaker, the surface of which is interrupted at regular intervals by small vertical metallic plates which divide the rice.

As the shaking proceeds, the paddy grains, being lighter, gradually move upward from the center feed and pass over the high side of the machine into a trough, while heavier husked grains are collected under the lower side. The separation may be varied by changing the speed of shaking, the angle of incline of the table or the rate of feed. Figure 13 illustrates such a machine.

After separating, the paddy leaving the machine on the high side is returned to a secondary husker, while the husked brown rice is passed

on for further processing. This secondary husker, or huller, is generally smaller and the husking stones are adjusted at shorter distances apart, since the grains which were not husked in the first husker are smaller. After the second husking, the remaining mixture again flows through the paddy and chaff operations.

5. Brown Rice Hulling

Brown rice, when free from its outer coating, still is covered with the silver grey or vari-colored inner bran layers. It must, therefore, be milled several times, dependent upon its origin and the standards of the finished product desired. This is done in a machine or machines known as white rice hullers. These machines scour the bran and rub the germ from the shelled rice grain.

This process differs considerably from the old type pearling cones, inverted, truncated cones covered with a mixture of emery and cement, which revolved inside a steel wire screen encased in an iron casting with openings for the grain to enter and leave as the cone was spinning. By raising or lowering the revolving cone, the distance between the cone and screen was adjusted and the amount of scouring regulated.

The machine illustrated in Figure 14 is the type used in this report. It consists of a horizontal cylinder with large helicoidal fluting, turning in an iron perforated cylinder (lineal holes through which the bran husks pass) or in half stippled and half smooth cylinder. The fluting, horizontal in the stippled part and inclined in the smooth part, first whitens, then carries the rice to the exit.

In larger mills machines operating on a different principle are used. Here the bran is peeled off the grain by the action of a specially grooved rotor having machine-cut shallow grooves running parallel to the axis.

From these machines, the shelled rice passes to the polisher with the bran conveyed to storage piles or sacks for use in by-products.

6. Polishing

After milling, rice has to be brushed or polished in order to improve its appearance and to remove the bran produced during milling. This is usually accomplished by the use of a rice polisher machine. Figure 15 illustrates such a machine showing the outer casing open.

It consists of revolving rollers, or drums, encased in fine wire mesh with an inner covering of sheepskin. In some machines leather strips are used on wooden staves mortised into solid cast iron heads to

compress the cylinder. In some mills the bran huller and polisher are combined in one machine as illustrated in Figure 16.

The by-product of the milled and polished rice is known as rice polishings and is commonly mixed with rice bran or meal and marketed for livestock feed.

7. Grading and Sacking

In most modern mills, rice is cleaned and graded following the milling process to standards of the finished product and the requirements of the market. In achieving this an intermediate step known as aspiratoring generally is taken. The residue and polished grain are received in the aspirator machine from the polisher, and the whole rice, broken kernels, immature rice (grains varying in length and thickness and a certain quantity of bran) pass through the machine which separates rice, brewers rice and surplus bran and dust and flakes in conjunction with a vibrating screen. Figure 17 illustrates an aspirator.

The vibrating screens described in this report are of the single deck type and principally are for the extraction of the brewers grain.

The foregoing is generally the first step in the grading process. A second grading by length and class of grain is then required, and the milled rice passes to a disc grader. This machine is similar to that illustrated in Figure 11 and separates the whole grain, number one grade rice from broken and brewers, gravity feeding the head rice to bins.

Finally, a third grading by thinness and secondary grades is accomplished by an indented cylinder grader similar to that illustrated in Figure 18. This machine is little more than a roller with varying sizes of cylinder wall openings joined in multiple combinations.

It must be borne in mind that in the particular field of cleaning and grading rice, no set rule is available. It appears that rice millers use a certain series of machines according to experience, processing techniques and the market to be supplied.

The general rule, however, is that a good paddy stock will yield the following after a high degree of milling and grading:

Milled rice and coated rice	51%	
Broken rice and brewers rice	18%	
Total yield of edible grain		69%
Bran	10%	
Rice Polishings	1%	
Total by-products		11%
Husks (including invisible milling shrinkage)		20%
		100%

After the final grading, the finished product moves by conveyors to the various surge or storage bins from which it is gravity fed, weighed and sacked.

Note: This report does not cover any of the phases of mill operations involved in the processing of coated rice (treatment by glucose and talcum), modern testing devices employed in larger mills, parboiling process, consumer packaging, shipping or marketing. Such information can be furnished in separate reporting but is too extensive to include herein.

Sacking operations are dependent entirely upon the market involved. For the purpose of this report, it is assumed that finished products are sacked in cloth or muslin bags of the weights commensurate with the locale and tables of weights and measures previously itemized.

* * * * * * * * * *

DIRECT MATERIALS

Item	Annual Requirements	Unit Cost	Annual Cost Estimated	Annual Cost Actual
Rice	4,000 tons	$90.00 a ton	$ 360,000	_____
Packaging material	---	---	3,000	_____
TOTAL			$ 363,000	_____

SUPPLIES

Item	Annual Cost Estimated	Annual Cost Actual
Lubrication and hand tools	$ 200	_____
Maintenance materials and spare parts	2,000	_____
Office supplies	200	_____
TOTAL	$ 2,400	_____

DIRECT LABOR

Occupation	Number Required	Hourly Rate	Annual Cost Estimated	Annual Cost Actual
Miller	1	$2.25	$ 4,500	_____
Miller's helper	1	1.60	3,200	_____
Elevator, warehousing and sacking	1	1.60	3,200	_____
TOTAL	3		$ 10,900	_____

INDIRECT LABOR

Occupation	Number Required	Annual Cost Estimated	Annual Cost Actual
Manager and office	1	$ 8,000	_____
Maintenance	1	5,000	_____
TOTAL	2	$ 13,000	_____

PRODUCTION TOOLS AND EQUIPMENT

Description	Number Required	Cost Estimated	Cost Actual
No. 3 Rough rice cleaner	1	$ 2,500	_____
Automatic rough rice scale	1	1,000	_____
Rough rice disc grader	1	2,000	_____
Disc seed separator	1	2,000	_____
48 Inch under runner rough rice sheller	1	3,000	_____
20 Inch under runner rough rice sheller	1	1,500	_____
Chaff separator	1	1,500	_____
High capacity paddy separator	1	4,000	_____
Huller	4	8,000	_____
White rice polisher	1	2,000	_____
Centrifugal exhause fan	1	400	_____
Aspirator	1	500	_____
Vibrating screen	1	1,000	_____

PRODUCTION TOOLS AND EQUIPMENT (Continued)

Description	Number Required	Cost Estimated	Cost Actual
Disc white rice grader	1	$ 2,000	_____
Uniflow indented cylinder grader	1	1,000	_____
Cyclone dust collectors	3	3,000	_____
TOTAL		$ 35,400	_____

OTHER TOOLS AND EQUIPMENT

Description	Number Required	Cost Estimated	Cost Actual
Double elevators	4	$ 5,000	_____
Motorized elevators	2	9,500	_____
Screw conveyor	1	1,500	_____
Steel floor structure 45 feet long, 17 feet wide, 12 feet high	1	3,600	_____
Starters, switch, wiring, bins, spoutings, gutwork, mill feed hopper		2,000	_____
TOTAL		$ 21,600	_____

FURNITURE AND FIXTURES

Item	Number Required	Unit Cost	Cost Estimated	Cost Actual
Desks and chairs	2	$150	$ 300	_____
File cabinets	2	75	150	_____
Typewriter	1	150	150	_____
Adding machine	1	150	150	_____
TOTAL			$ 750	_____

PLANT LAYOUT

In rice milling operations, the flow chart is the miller's constant guide. It is on this sheet that all details of the milling process (machinery and flow) are noted in operational order. It must be kept up to date without fail if losses in operating costs are to be avoided.

Normally, the flow sheet should indicate all equipment, that is, the number of the various machines, sizes, differentials, revolutions per minute, capacity controls, and auxiliary equipment, such as proportioning and blending equipment, conveyors, scales, cleaning equipment, and ducts.

The various machines are represented by squares, rectangles, circles, cylinders and other symbols, and the flow of stock from one piece of equipment to another is represented by connecting lines with arrows indicating direction of flow.

The flow sheet is mandatory in a well run plant. In the past, mills were inclined to allow uncontrolled expansion, and not infrequently management awakened too late to the fact that it had developed many unnecessary conveyors, that gravity had not been taken advantage of, all contributing to increased operating costs and lower profit returns.

Figure 7 shows the flow sheet for the mill covered in this report.

PLANT SITE

In order to provide for future expansion, a plant site of one acre would be required. The plant site should be as advantageously located as possible with respect to transportation, power, water, fuel, raw materials, sources of labor and markets.

The estimated cost of the plant site is $1,000.

BUILDINGS

In rice mill design, for the type mill covered herein, a two-story structure is recommended, with an adjoining one-story warehouse for the milled product. The mill building should be 40 feet x 50 x 36 feet, and the warehouse adjoining, in the form of lean-to, gable or flat roofed construction, should be approximately 25 feet x 40 feet x 10 feet clear. The ground floors should be concrete. The structures themselves can be steel frame, sheet metal, wood, brick or concrete. Regardless of the type of building, the principle considerations are cleanliness, efficient equipment placement, and operating and storage housing that is rodent, insect and moisture protective to as great a degree as is economically feasible.

The cost of the building is estimated at $30,000.

Storage Elevator and Auxiliary Equipment

For a mill of the above stated capacity, provision should be made to store 40,000 bushels of paddy rice. This would require four elevators 20 feet in diameter and 65 feet high, or flat storage silos or bins of concrete steel or wood.

The reader's attention is directed to the comments under the heading "Storage," page 25. As previously mentioned, the most recent estimates for construction costs of the types of storage mentioned are from $0.65 to $1.25 for each bushel stored, including head house and auxiliary equipment, for receiving, drying and elevating (or conveying) the grain. For the purpose of an estimate, however, a cost of $1.00 per bushel is used in this report.

Calculation: $1.00 x 40,000 = $40,000.

POWER

The connected load requirements amount to 90 horsepower.

Based on an 80 per cent load factor the annual cost of power is estimated at $1,000.

WATER

The annual cost of water for heating, sanitary purposes, and fire protection is estimated at $200.

FUEL

It is estimated that the annual cost of fuel for heating and sanitary purposes will amount to about $400.

* * * * * * * * * * *

DEPRECIATION

Description	Estimated Cost	Years Life	Annual Cost Estimated	Annual Cost Actual
Buildings	$ 30,000	20	$ 1,500	_____
Storage elevators and equipment	40,000	15	2,666	_____
Machinery and equipment	35,400	10	3,540	_____
Other tools and equipment	21,600	10	2,160	_____
Furniture and fixtures	750	10	75	_____
TOTAL			$ 9,941	_____

MANUFACTURING OVERHEAD

Item	Annual Cost Estimated	Annual Cost Actual
Depreciation	$ 9,941	_____
Indirect labor	13,000	_____
Power	1,000	_____
Water	200	_____
Fuel	400	_____
Supplies	2,400	_____
TOTAL	$ 26,941	_____

MANUFACTURING COSTS

Item	Annual Cost Estimated	Actual
Direct materials	$ 363,000	_____
Direct labor	10,900	_____
Manufacturing overhead	26,941	_____
TOTAL	$ 400,841	_____

FIXED ASSETS

Item	Cost Estimated	Actual
Land	$ 1,000	_____
Buildings	30,000	_____
Storage elevators and equipment	40,000	_____
Machinery and equipment	35,400	_____
Other tools and equipment	21,600	_____
Furniture and fixtures	750	_____
TOTAL	$ 128,750	_____

WORKING CAPITAL

Item		Cost Estimated	Cost Actual
Direct material	60 days	$ 60,300	_____
Direct labor	30 days	900	_____
Manufacturing overhead	30 days	2,200	_____
Reserve for sales collections	30 days	42,600	_____
TOTAL		$ 106,000	_____

CAPITAL REQUIREMENTS

Item	Cost Estimated	Cost Actual
Fixed assets	$ 128,750	_____
Working capital	106,000	_____
TOTAL	$ 234,750	_____

SALES REVENUE

Annual milling capacity of 8,000,000 pounds of paddy rice equals the following annual product yields and sales revenue based upon the foregoing percentages:

51% of 8,000,000 lbs. = 40,800 cwt at $10.00		$408,000
18% of 8,000,000 lbs. = 14,400 cwt at $6.00		86,400
10% of 8,000,000 lbs. = 400 tons at $38.00		15,200
1% of 8,000,000 lbs. = 40 tons at $43.00		1,720
Total annual sales revenue		$511,320

RECAPITULATION OF COSTS, SALES AND PROFITS

Item	Estimated Cost		Actual Cost
Direct materials	$ 363,000		_____
Direct labor	10,900		_____
Manufacturing overhead	26,941		_____
Total manufacturing cost		$400,841	_____
Interest on loans	6,000		_____
Insurance	500		_____
Legal	600		_____
Auditing	1,200		_____
Unforeseen expense	2,859		_____
Total administrative costs		11,159	_____
Sales commissions		8,000	_____
Travel, bad debts, discounts and allowances, freight-out		4,000	_____
Profit before taxes		87,320	_____
Total annual gross sales		$511,320	_____

BUDGET CONTROL:

A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on the following page.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk below) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

Following the requisition form, a sample voucher check is shown. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a break-down of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS:

Account Number		Monthly Expense	Monthly Budget	Annual Budget	Actual
10	Administrative	$_____	$ 691	$ 8,300	$_____
20	Sales	_____	666	8,000	_____
30	Direct Materials	_____	30,250	363,000	_____
40	Supplies	_____	200	2,400	_____
51	Power*	_____	83	1,000	_____
52	Water*	_____	17	200	_____
53	Fuel	_____	33	400	_____
60	Unforeseen Expense (Reserve Account)	_____	238	2,859	_____
71	Direct Labor*	_____	908	10,900	_____
72	Indirect Labor*	_____	1,083	13,000	_____
80	Depreciation (Reserve Account)	_____	828	9,941	_____

PURCHASE REQUISITION	COMPANY NAME	DATE

- ☐ 10 ADMINISTRATION
- ☐ 20 SALES
- ☐ 30 MATERIALS
- ☐ 40 SUPPLIES
- ☐ 50 UTILITIES
- ☐ 60 UNFORESEEN EXPENSE

INDICATE BELOW THE USE OF MATERIALS

- ☐ DIRECT MATERIALS
- ☐ MAINTENANCE MATERIALS
- ☐ MAINTENANCE SERVICES
- ☐ OPERATING SUPPLIES

	PLEASE ORDER THESE MATERIALS OR SERVICES	DELIVERY WANTED	
QUANTITY	DESCRIPTION	UNIT	TOTAL

QUOTES FROM		REQUISITIONED BY	
QUOTES FROM		APPROVED BY	
QUOTES FROM		ORDER NO.	ORDER DATE

R. W. MITCHELL MANUFACTURING COMPANY
1422 BOSWORTH STREET, S. E.

65-22
514

ANYWHERE, U. S. A. _____ 19____ No. 10000

PAY _____ DOLLARS $ _____
TO THE ORDER OF

R. W. MITCHELL MANUFACTURING COMPANY

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

BY SAMPLE CHECK
VICE PRESIDENT

ACCOUNT NUMBER

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.

R. W. MITCHELL MANUFACTURING COMPANY

ENGINEERS:

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D. C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice, who are willing and able to provide appropriate consulting services.

TRAINING:

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.

SAFETY:

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

OTHER CONSIDERATIONS

There are other important subjects, shown below, that should be fully investigated and considered. Information on these subjects is usually available from such sources as banks, government agencies, exporters and importers, wholesalers, retailers, transportation companies and manufacturers.

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Is satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   - A. Who are the principal consumers?
   - B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   - A. By local production? If so, what is the volume of annual production?
   - B. What percentage of consumption is filled by local production?
   - C. By imports? If so, what is the volume of annual imports?
   - D. What percentage of consumption is met by imports?
   - E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   - A. How were such estimates made?
   - B. By reference to official figures on population growth, family budgets, imports, etc.?
   - C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?

4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

EXPORT MARKETS:

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

MARKETING PROBLEMS:

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?

ECONOMIC FACTORS:

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies:
   - A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment of royalties and technical services?
   - B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   - C. What are estimated annual foreign exchange earnings and in what currencies?
   - D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   - E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   - F. What benefits would the new business bring to the economy in the use of local raw materials: in employment and in technology?
   - G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
     - (1) If not, can existing deficiencies be eliminated satisfactorily?
     - (2) What would be the cost to do so?

PERSONNEL:

1. Is there an adequate labor supply near the plant location?
   - A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   - A. Also, the training of skilled labor?
   - B. Is technical advice available in the locality?
   - C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS:

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   - A. If not, can existing obstacles be removed?
   - B. If so, how and when?

FINANCIAL FACTORS:

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT:

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS:

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN:

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?

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Simmons Press
New Orleans, Louisiana

RICE MILLING CONSULTANTS

A. T. Ferrell and Co.
Saginaw, Michigan

Horner and Wyatt
Kansas City, Missouri

Jones-Hettelsater Construction Co.
Kansas City, Missouri

Henry Simon, Ltd.
Stockport, England

Smico
Oklahoma City, Oklahoma

Sprout-Waldron and Co., Inc.
Muncy, Pennsylvania

Thomas Conveyor Co., Inc.
Burleson, Texas

Wallace and Tiernan, Inc.
Belleville, New Jersey

Wolf Management Engineering Co.
Chicago, Illinois

Barnard and Leas Manufacturing Co., Inc.
Cedar Rapids, Iowa

Woodland Mill Supply Co.
Woodland, California

B. F. Gump Co.
Chicago, Illinois

S. Howes Co.
Silver Creek, New Jersey

Huntley Manufacturing Co.
Brocton, New Jersey

B-I-F Industries, Inc.
Providence, Rhode Island

Ross Machine and Mill Supply, Inc.
Oklahoma City, Oklahoma

Simpson Co.
Cincinnati, Ohio

Superior Separator Co.
Hopkins, Minnesota

Engelberg Huller Co., Inc.
Syracuse, New York

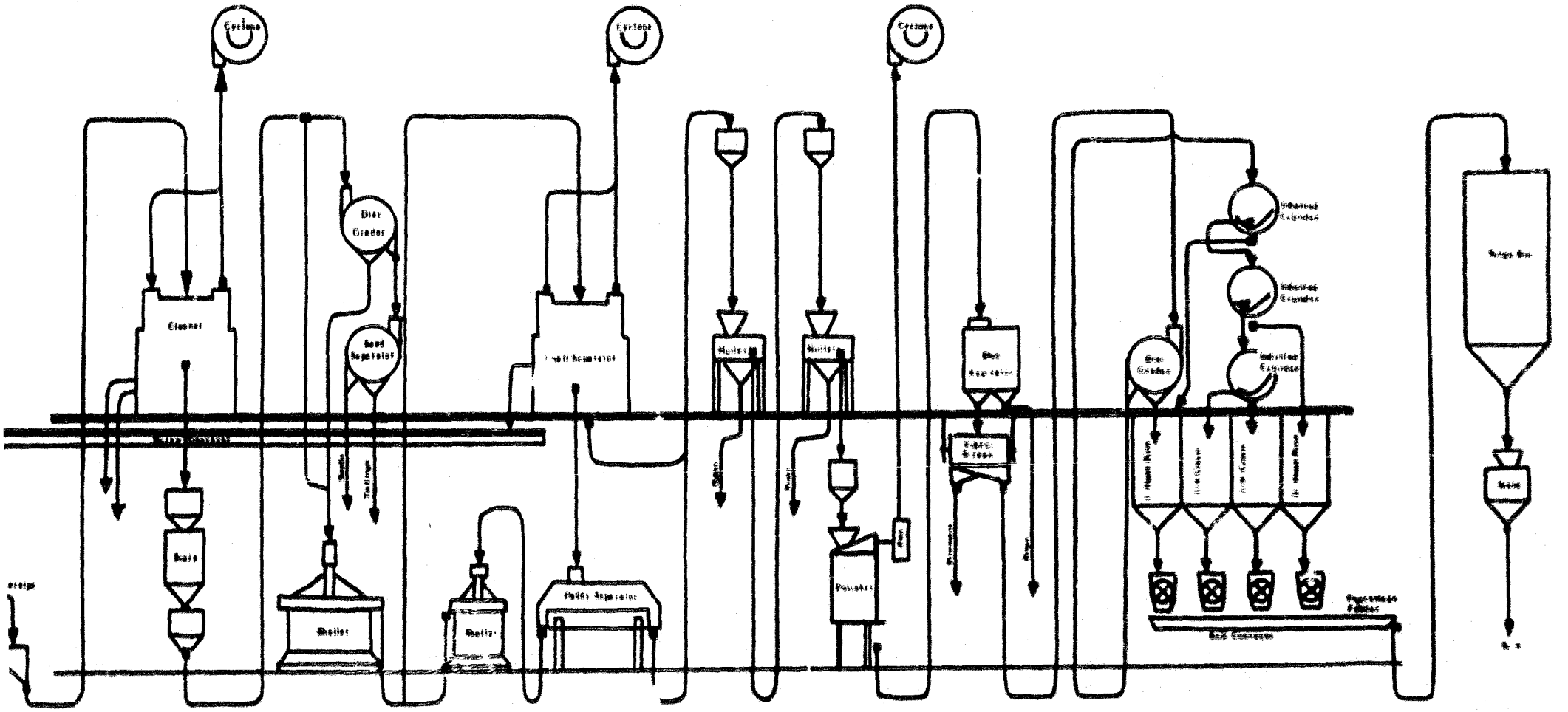
ABBREVIATIONS

LBS.	- pounds	CU. YD.	- cubic yard or yards
%	- per cent	FT.	- foot or feet
SQ. IN.	- square inch or inches	SQ. FT.	- square foot or feet
SQ. YD.	- square yard or yards	CU. IN.	- cubic inch or inches
CU YD.	- cubic yard or yards	U.S. GALS.	- United States gallons
IMP. GALS.	- Imperial gallons	BU	- bushel
NO.	- number	CWT	- 100 pounds

FIGURE 7

FLOW CHART OF SELF-CONTAINED RICE MILL

CAPACITY 2800 LBS. PER HOUR



Courtesy of H. T. McGill Distributors
Houston, Texas

Courtesy The Rice Journal

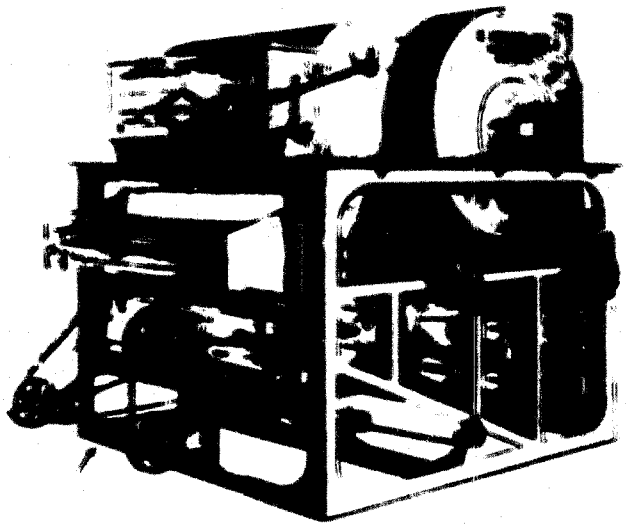
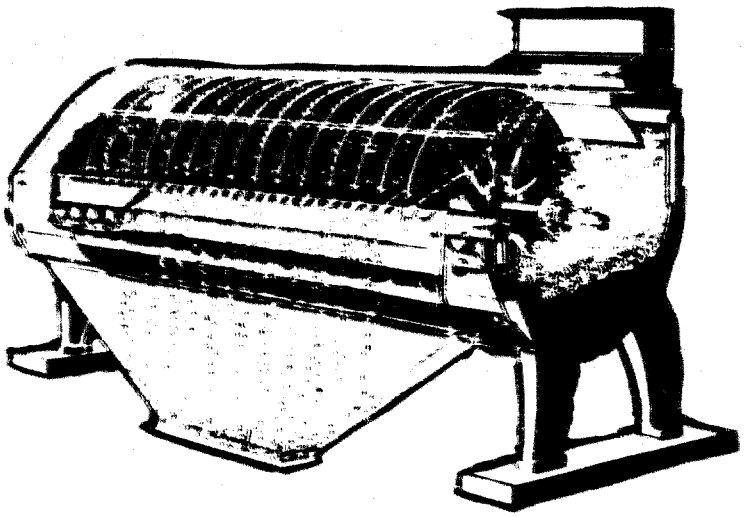


Figure 10 - Typical Paddy Rice Cleaner



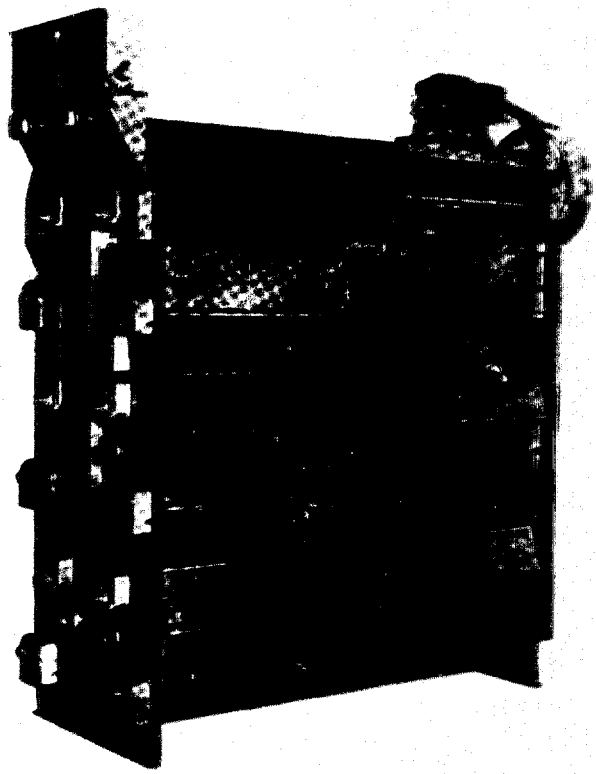


Figure 11 - Typical Disc Separator Typical Grading Machine

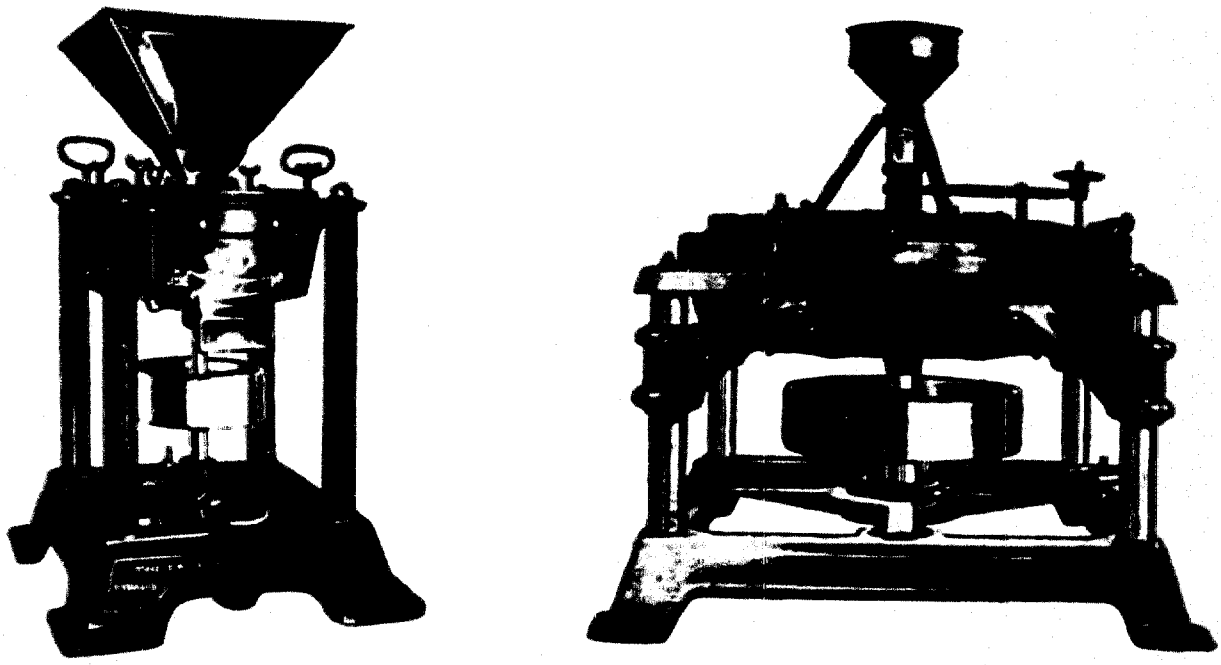


Figure 12 - Under Runner Sheller
Typical Paddy Huller or Husker

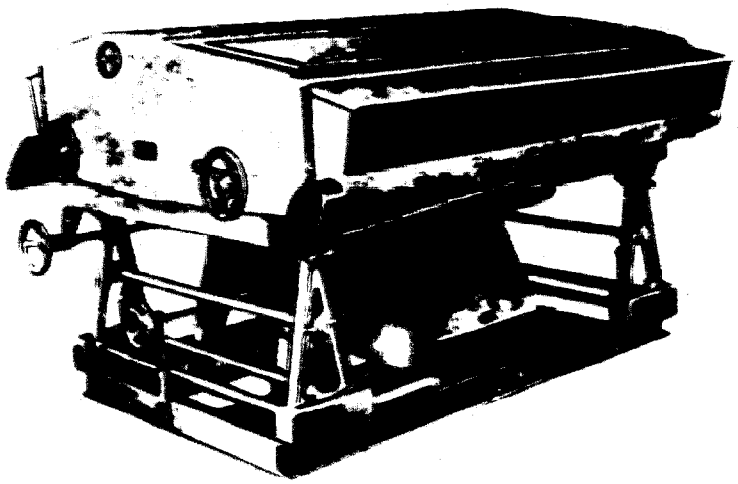


Figure 13 - Typical Paddy Separator

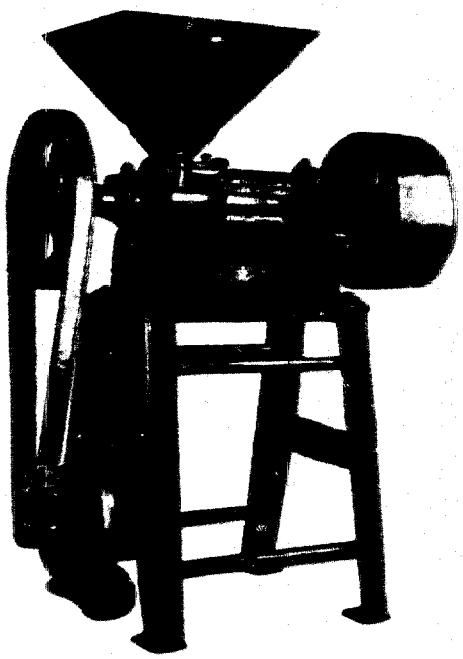


Figure 14 - Typical Brown Rice Huller

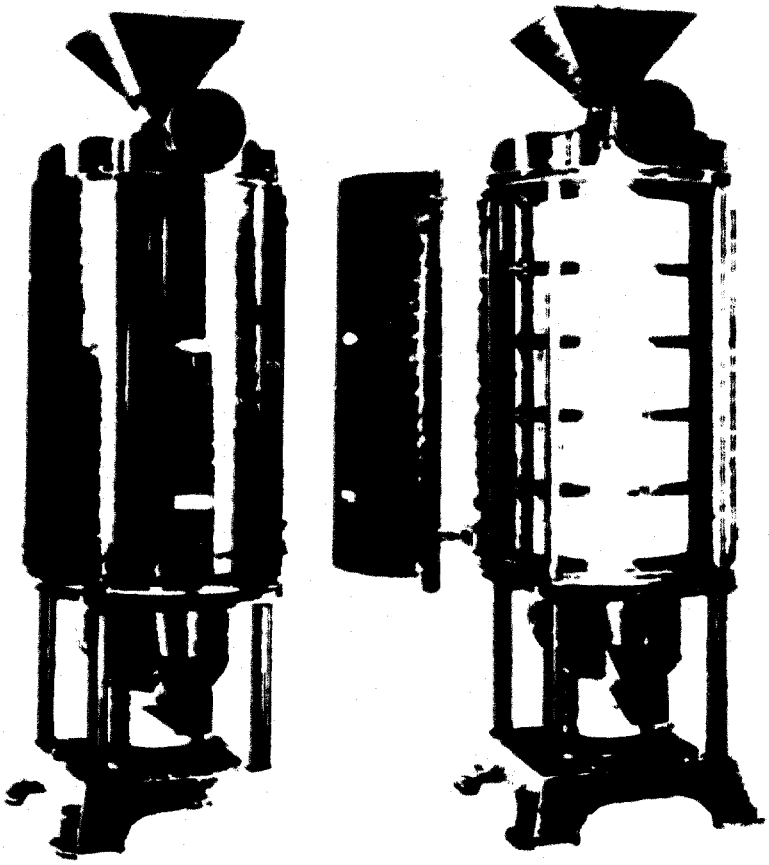


Figure [illegible] - Typical Rice Polisher Machine

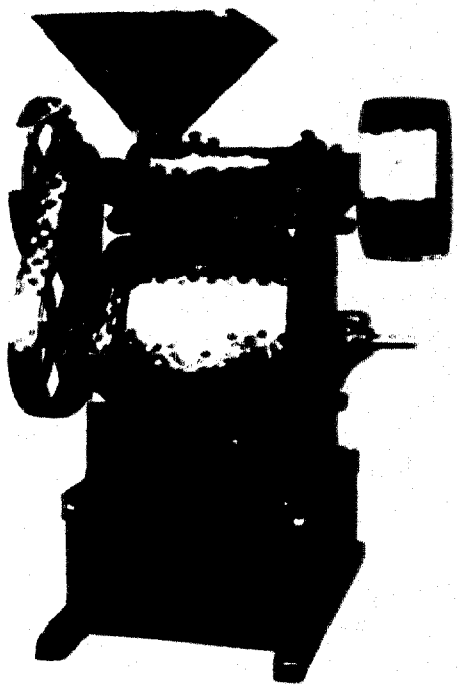
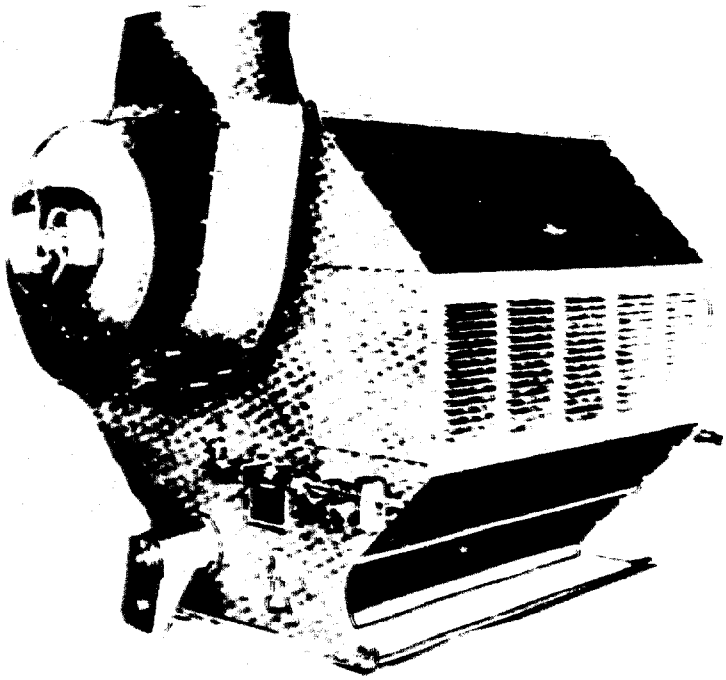
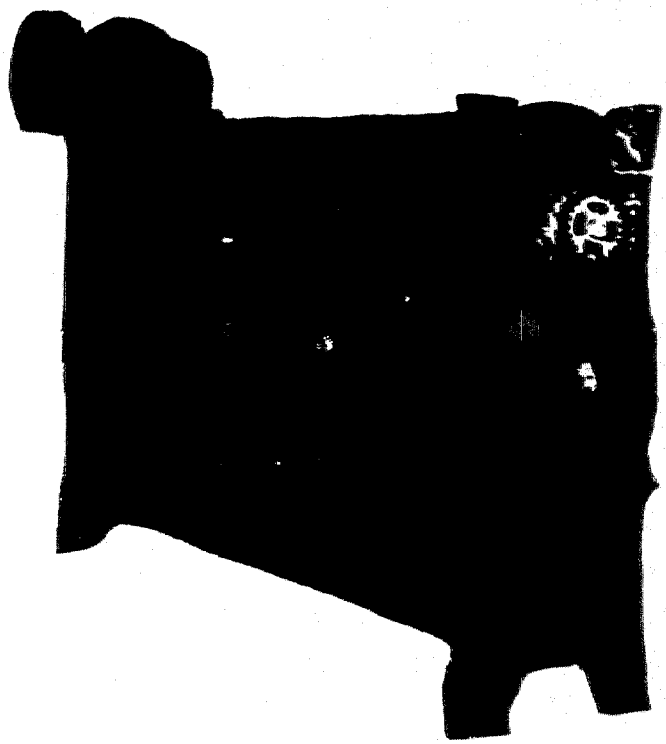



Figure 16 - Combined Bran Huller and Rice Polisher