PLANT REQUIREMENTS FOR MANUFACTURE OF BREWERS FLAKES

TECHNICAL AIDS BRANCH
INTERNATIONAL COOPERATION ADMINISTRATION
Washington, D. C.

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.

Industrial reports prepared for ICA under special contract are customarily reviewed and edited before publication. This report, however, like other technical inquiry replies, has not been reviewed; it is the sole responsibility of the firm that prepared the report.

This brochure was prepared in March 1960 by Arthur Associates, Inc., Stamford, Connecticut. Technical information, as well as a review of the brochure, was provided by A. K. Robins and Company, New York, New York.

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For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Code Number
43

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BREWERS FLAKES

INTRODUCTION

Beer is essentially a mildly alcoholic beverage resulting from the fermentation of various starchy cereal grains by yeast. Because yeast cannot utilize starch directly, it must first be converted to some form of sugar.

When cereal grains are permitted to germinate, large quantities of enzymes (amylases) are produced. These enzymes have the ability to convert starch into maltose. The germination is stopped in the initial stages by drying, and the resulting "malt" is the principal raw material used in brewing.

In order to reduce costs or to obtain the pale "dry" beers popular today, a part of the malt is replaced by unmalted cereal starches from various sources, such as corn or rice. These unmalted starches must be given a pretreatment to permit rapid conversion to sugar by the enzymes present in the malt. Such pretreated products made from corn are known as Brewers Flakes.

RAW MATERIAL CHARACTERISTICS

The art of brewing consists of several careful steps, the most important of which is the mashing process, where the characteristic flavor is developed and the final quality of the beer is determined.

To reduce costs, and sometimes to modify the composition of the beer, some of the malt can be replaced by adjuncts such as unmalted cereals or raw grains, or by the addition of sugar to the boiling wort in the copper.

These materials are principally starch and contain little or no protein content. The malt enzymes which act on the malt also act on the adjunct starch yielding a pale and very stable beer. Hence, adjuncts are used as a source of additional alcohol and to correct the composition of the mash, to reduce costs, and to obtain the paler, snappier, less filling beer preferred today. Since adjuncts contain practically no nitrogen, they may be used to correct a condition of excess nitrogen (e.g. from a high nitrogen barley).

Too much adjunct can spoil the quality of a beer; however, a 10-15% replacement of the malt has little effect on beer quality. In some countries (e.g. Germany), adjuncts cannot be used in beer for local consumption but their use is permitted in export beers. Other countries (e.g. Belgium) use a moderate amount of unmalted cereals as adjuncts (10-20%), while the United States and France use up to 50% adjuncts.

Cereal grains high in oil cannot be used as adjuncts and are generally undesirable as the oil may affect the foam stability. Moreover, the oil may go rancid and give off undesirable odors or flavors. Thus, while whole corn as such cannot be used as a beer adjunct, corn products from which the oil has been removed are of great importance for this use.

The following materials are useful as adjuncts:

1. (a) Corn refined grits from wet corn milling. This is probably the highest yielding and purest adjunct.

   (b) Corn (white or yellow) grits from dry milling. The germ, which contains the oil, is removed during milling. Beers

using corn are more mellow than when other adjuncts (e.g. rice) are used. Corn finds special use in top beers and is used as grits, meal, flakes, refined grits, sugars, and syrups.

2. Rice. The grain is used as grits (i.e. broken grains obtained during the process of dehulling and polishing. The maximum lipid content is 0.5-0.7%. Rice is especially good for pale bottom beers as it gives a dry palate and helps bring out the hop flavor.

3. Milo grits (sorghum) and cassava (manioc). These are acceptable substitutes for the more valuable grains during shortages. They are used by grinding them to a medium fine grist and then using them in the same manner as corn grits.

4. Wheat - used as flakes for over 50 years. Low protein wheat is moistened and passed through hot rolls and dried to below 12.5% moisture (to prevent mold and heating in bags). The best wheat for this process is the large berry mealy type of wheat containing less than 11% protein (best: 8.5-9.5%). Wheats with high (12-16%) protein are hard and flinty and hence cause conversion and run-off difficulties. Also, the high protein may cause trouble with clarification.

5. Unmalted barley. Used in limited amounts. Barley as an adjunct is best used in a crushed or flaked form and is added directly to the mash. The barley should be very mellow and contain high extract, but low protein content. Husks should be clean (not stained) and the barley should be sound, clean, and not too moist or plump.

6. Potato starch - not used very much.

7. Soybeans. Can be used in small amounts. They aid nourishment of the yeast and hence improve the fermentation. They are processed as follows: First, the dried raw soybeans are dehulled; then the oil is

extracted with solvents (e.g. naphtha); and the product flaked between rolls. Inasmuch as the bean may contain about 42% protein, only about 0.25 lbs. is used per barrel of finished wort.

8. Tapioca - inasmuch as tapioca has an alkaline reaction, it is seldom used as an adjunct. It can be used if the material is neutralized.

9. Oats - during World War II, English brewers used flaked oats as a brewing adjunct along with flaked barley and flaked rye. Difficulties were encountered due to the high (5%) oil content, and the relatively high husk to starch ratio. However, in practical use (90 parts malt and 15 parts of flaked oats, with water containing 14 grains per gallon of calcium carbonate), all the oil remained in the spent grains producing a beer normal in every way. It was necessary to reduce the moisture content of oat flakes to 6-8% to achieve good storage. The oats are flaked in the same manner as other grains such as corn.

10. Sugars and syrups. The so-called brewing sugars are very useful if iron-free. The corn syrup is made by an acid-catalyzed high pressure, high temperature hydrolysis of corn starch. It consists of a mixture of dextrins and sugars and contains no unchanged starch. The invert sugars and syrups are often obtained from wheat, but other grains may be used. Inasmuch as the sugars and syrups are outside the scope of this report, their use will not be further discussed.

Of all the adjuncts mentioned, rice and corn are the principal unmalted cereals used in brewing, but the starches of these two cereals saccharify very slowly when added directly to the mash and must be pregelatinized by boiling with water before being added. The preferred way is to heat the starch to boiling with a little malt. The heat gelatinizes the starch which is then attacked by amylitic enzymes from the malt. As a result, the

gelatinized starch is liquified without its being converted to sugar. The heating is done in stages in order to give the enzyme time to act. For some grains, the conversion to a useful state is particularly difficult. Thus, for rice, it is necessary to heat the raw grains in water to 85-90°C. to achieve gelatinization. The mixture is then cooled to 70-75° (in order not to destroy the α-amylase) and malt added. After a few minutes, the starch is properly liquified and can now be heated to boiling without danger of scorching.

In order to avoid this extra preboiling step in the brewing process, corn may be added in the form of flakes. These flakes are commonly known as "Brewer's Flakes". Essentially, the Brewer's Flakes are made by passing de-germed moistened ground meal between heated rolls. The meal must be low in fat content (below 1%) and the small amount of fat actually present must not be rancid. Commercial corn flour or flakes made for brewing contains about 12 - 13% moisture, 63% starch, 9% protein, and up to 1% fat. Whole corn meal cannot be used as an adjunct as the grain must first be de-germed to remove the oily embryo. The reason for this is the high oil content of corn - as much as 4 - 5% fatty material which is harmful to the quality of the beer. The low amount of oil remaining in the corn flakes has no effect on the quality of the finished beer.

CORN MILLING

The separation of the germ, and preparation of corn grits or flour is a large scale milling operation, involving several processing steps which are carried on in a series of special machines. Either a wet process or dry process may be used, and many steps, such as regulation of corn flow, water flow, drying and separation of the products are entirely automatic.

The "dry" process is the simpler of the two, and will produce grits of less than 1% oil content, suitable for Brewer's Flakes. The actual process is as follows: the corn is first cleaned and separated from foreign matter. It is then subjected to a tempering process, in which the grains are moistened and allowed to stand for 1-2 hours. The grains are then crushed and de-germinated to release the now toughened germ and shell from the cracked kernel. The added moisture must now be removed from the mixture before screening. The drying process is at 170°F and is used not only to make the separation easier, but to destroy harmful molds, yeasts, and insect eggs.

When the product is dried to about 15% moisture, classifiers separate the product into (a) a mixture of intermediate grits and the germ portion, (b) fines, and (c) the so-called coarse "hominy grits".

The fines may be further purified to produce finer grits, and breakfast foods, or may be used directly as livestock feed. The germ portion is used as livestock feed, or if the scale of operations is large, may be pressed to recover the oil.

The minimum size dry-milling equipment suitable for the de-germing and milling operation has a capacity of about 2 tons per hour, and costs in the neighborhood of $150,000. Such equipment is manufactured by the Allis Chalmers Co., and consists of several units which would be selected according to the complete line of finished products desired.

For the small Brewer's Flakes plant proposed, such equipment is not included. The plant is designed to use a coarse grade of hominy grits as raw material, and de-germing and milling equipment is optional for larger scale plants.

BREWER'S FLAKES PLANT

A small plant for the production of Brewer's Flakes is set up in the following fashion.

The raw materials consist of the coarse grade of hominy grits which is quite inexpensive and readily available.

These grits are normally packed in multiwall sacks of 100 lbs. each, and upon arrival are stacked on pallets until ready to use. The quality control necessary on this material is a visual examination to uncover the possible presence of weevils, miscellaneous dirt or infestation. A chemical analysis for fat is important in order to ascertain that the fat content of the corn grits is less than 1.0%. The lot should be rejected if more than 1.0% oil is found.

The acceptable corn grits are then loaded into metal storage bins having a capacity of 2,000 lbs. each. From the bins, the corn grits are dropped onto a vibratory feeder and fed into a continuous cooker where they are tempered with live steam at 140-160°F.

Large plants design and have their own continuous cookers fabricated to process huge amounts of material. The grits, together with the regulated addition of water, are pushed by a paddle-type conveyer through the continuous cookers at an adjustable rate while simultaneously being cooked by controlled steam pressure heat at 140-160°F. to assure proper geltinization of the starch.

For this small plant, specially fabricated equipment is not necessary. A Robins Rotary Continuous Blancher can be used. The corn grits are fed to the blancher drum through the feed hopper, at which point it is picked up by the spiral in the blanching drum and positively conveyed through the length of the drum to the discharge. During its passage through the drum, the product is heated by perforated steam pipes running throughout the length of the tank. The temperature is held constant by means of temperature control equipment. The product moves through the spiral drum at a specified rate, varying with the speed of the drum. By means of a vari-speed drive connected to the drum, the speed and time of heating can be easily changed or adjusted.

The cooked gelatinized grits are discharged onto a vibratory feeder which in turn conveys and feeds the grits to the flaking mill. For the small plant, a conventional double drum flaker is used. A good unit of this type is the Buflovak Double Drum Flaker with 24" x 36" cast iron drums mounted in self-aligning bearings on fabricated steel frames, cooled by internal spray nozzles with rotary joints for entrance and exit of the coolant. A spring type adjustment on one of the drums allows them to spread when excessive pressure is developed and original clearance to be reestablished automatically when pressure returns to normal. Stops prevent drums from being pushed too closely together.

For larger plants, a Blaw-Knox 36" x 60" Flaking mill is available, which has the following advantages:

1. An optimum "bite angle" so that the grit instantly passes between the rolls instead of riding the rolls.

2. A spacer between the rolls which prevents them from running metal to metal.

3. Hydraulic pressure preloading of the rolls which assures a uniform average flake thickness of ± .001"

4. A safety feature whereby if any foreign matter that enters the rolls and builds up pressure beyond the required rolling pressure, the rolls automatically separate allowing the foreign matter to pass between the rolls and then automatically reset themselves to their original operating position.

5. Whenever power is shut off, the feed gate closes automatically.

This machine is practically automatic continuously running after once being put in operation. One operator can operate several of these units, and it is only necessary to check the quality of the product periodically.

After flaking, the flakes are lifted by conveyor to a conventional hammer-mill equipped with knives, and ground to proper size.

The final product is then packed into multiwall sacks by a screw packer. Usually 40 to 100 pounds per sack is packed depending upon the density of the flakes.

A flow sheet of the process is shown in Figure 1.

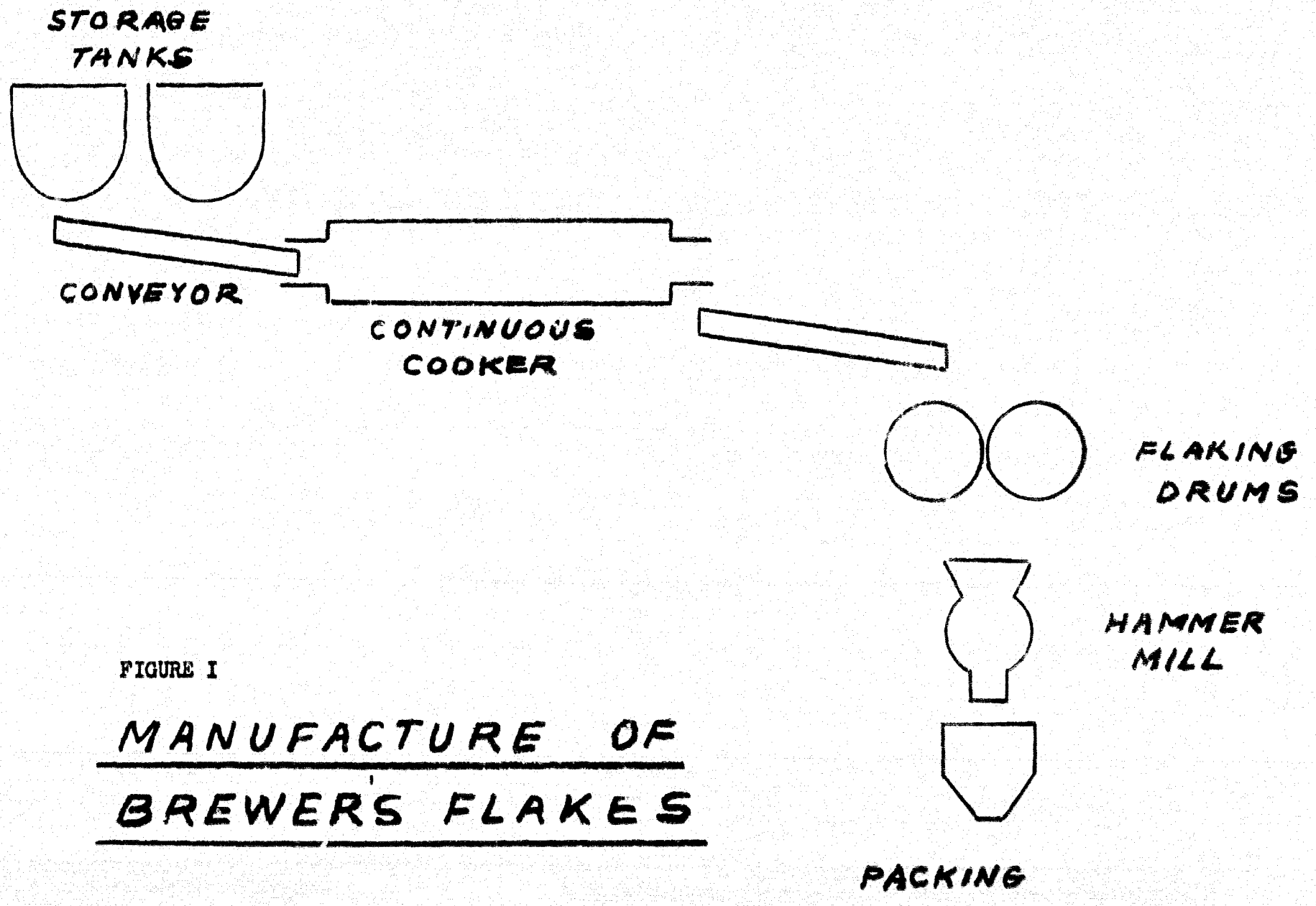

FIGURE I

MANUFACTURE OF BREWER'S FLAKES

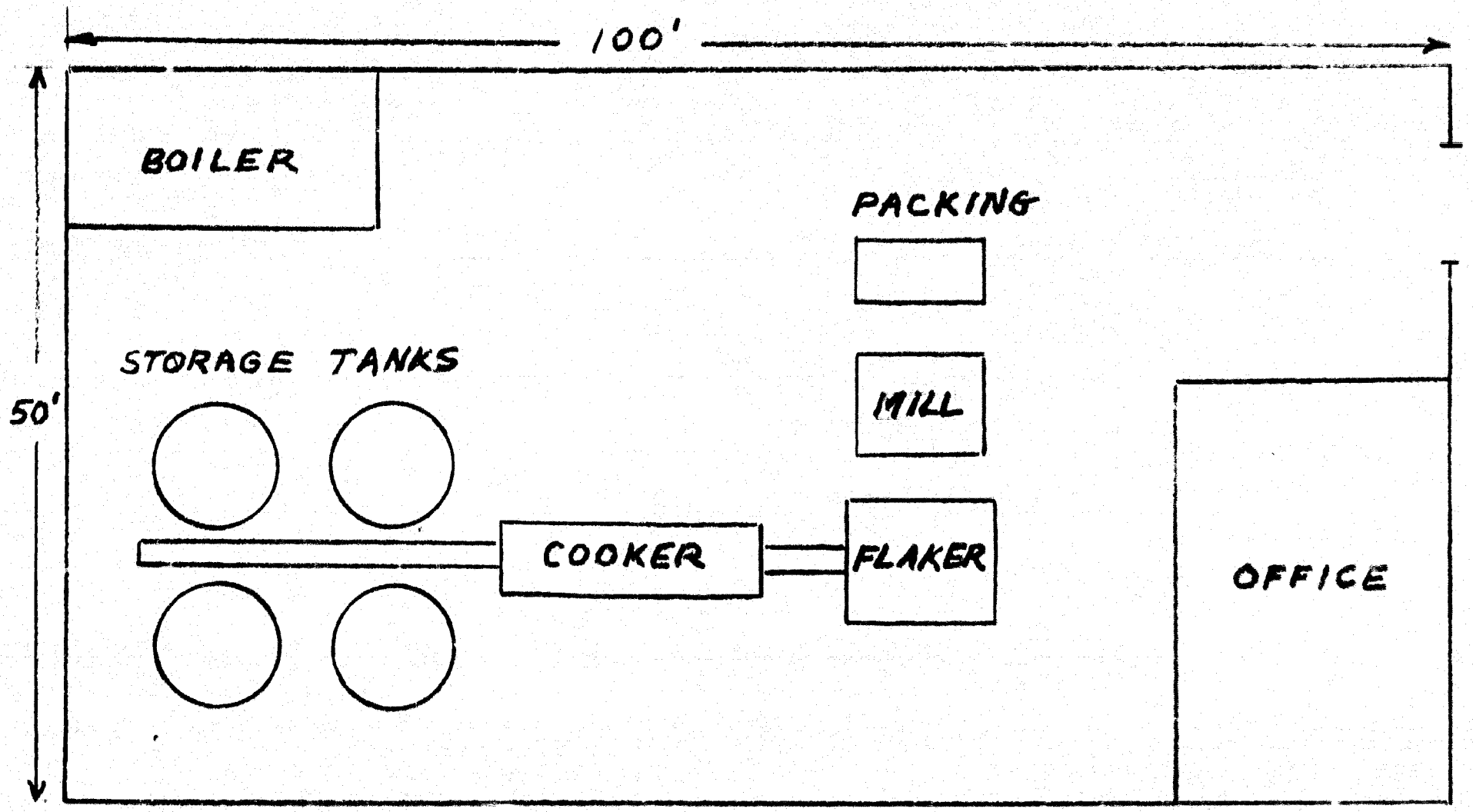

FIGURE II

PLANT LAYOUT

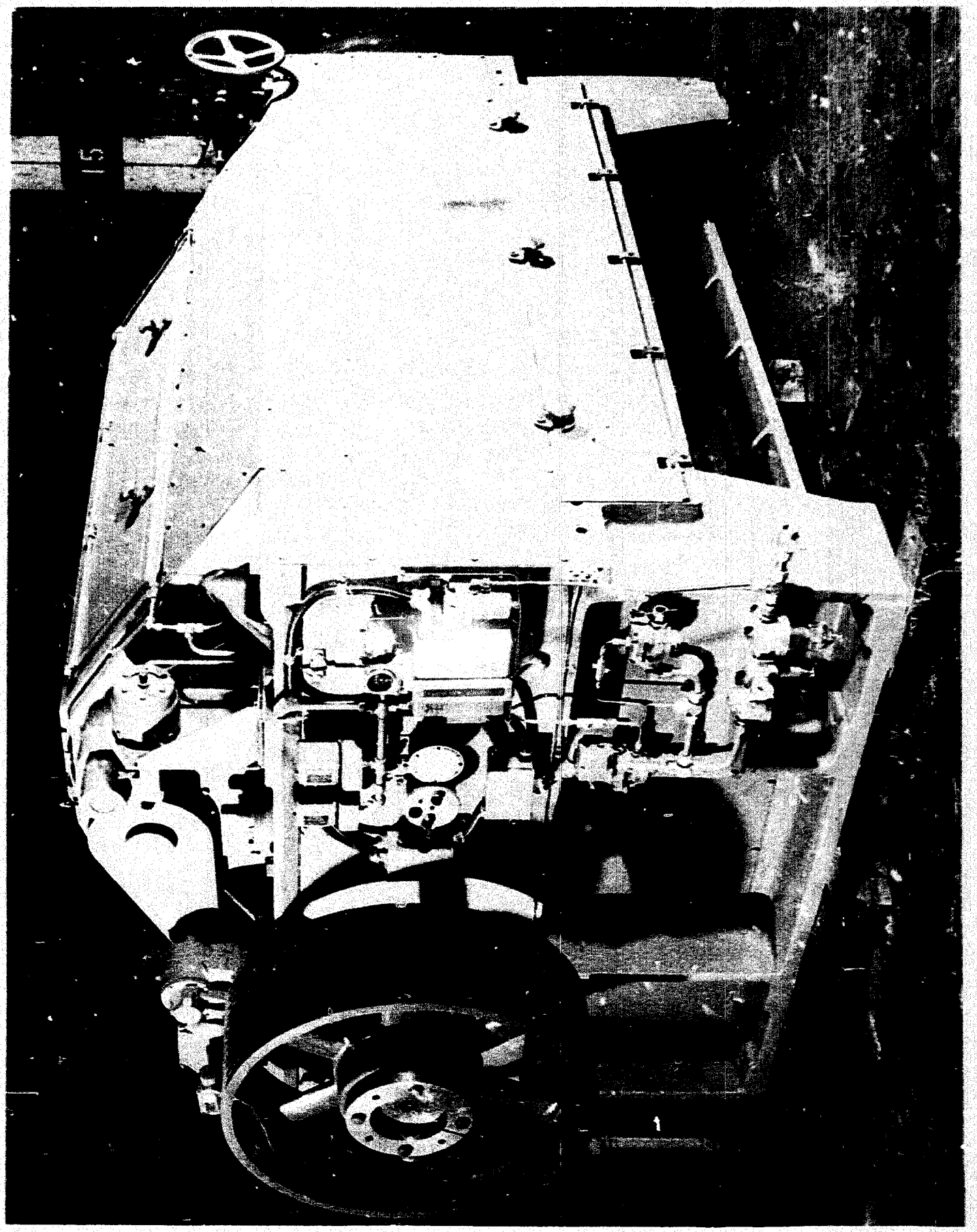

FIGURE III BUFLOWAK DOUBLE DRUM FLAKER

Courtesy

BLAW-KNOX CO. - PITTSBURGH, PA.

List of Equipment

Equipment	No. of Units Required	Suppliers	Estimated Cost	Actual Cost
Storage Tanks 2,000 lb. cap.	4	D, E, I	$2,000	
Conveyors	3	L	2,000	
Robins Rotary Continuous Blancher	1	F, J	5,000	
Buflovak Double Drum Flaker, 24 x 36"	1	A, C	10,000	
Hammer Mill, Knife Blade Rotor	1	K, B	2,000	
Screw Packer and Bagger	1	G, H	5,000	
Supplies - Pallets, Tools, etc.		F, J	1,000	
Steam Boiler			5,000	
TOTAL EQUIPMENT			$32,000	

OPTIONAL EQUIPMENT

Allis-Chalmers Vertical Degerminating Mill		A	$150,000

Equipment Suppliers

A. Allis-Chalmers Co.
Milwaukee 1, Wisconsin

B. Bauer Brothers Co.
Springfield, Ohio

C. Buflovak Equipment Division
Blaw-Knox Company
1543 Fillmore Avenue
Buffalo 11, New York

D. Bros, Inc.
1057 Tenth Avenue S. E.
Minneapolis 14, Minnesota

E. Camden Copper Works
559-607 South Second Street
Camden 3, New Jersey

F. Chisholm-Ryder Co., Inc.
Niagara Falls, New York

G. E. D. Coddington Manufacturing Co.
(Augermatic Filler)
5024 North 37th Street
Milwaukee 9, Wisconsin

H. S. Howes and Company
(Eureka Filler)
Silver Creek, New York

I. The Pfandler Company
Rochester, New York

J. A. K. Robins and Company, Inc.
713-729 East Lombard Street
Baltimore 2, Md.

K. Sprout Waldron Company
Muncy, Penna.

L. Syntron Company
Homer City, Penna.

Investment Cost Estimate

	Estimated Cost	Actual Cost
Equipment	$32,000	
Installation and Instrumentation	8,000	
Building (5,000 sq. ft. @ $12)	60,000	
Total Fixed Capital	$100,000	
Working Capital		
Raw Materials (2 months)	11,500	
Product Inventory (1 month)	10,000	
Payroll, etc.	3,500	
Total Working Capital	$25,000	

Labor Schedule

The plant is to operate 8 hours per day, 250 days per year. An unskilled labor force of 6 men is required for processing, packing, receiving and shipping. Two men of supervisory capacity are required for production supervision and office.

Utilities

About 4,000 pounds of steam per day is required for the cooker, and for heating if required. This is supplied by a low-pressure boiler burning No. 2 fuel oil.

Electricity requirements are about 90 KWH per day. About 2,000 gallons process water per day are also required.

Production Cost Estimate

Product: Brewer's Flakes

Capacity: 4 tons per day

Days of Operation per year: 250

	Consumption per 8 hr. day	Unit Price	Estimated Cost	Actual Cost
Raw Materials:				
Hominy Grits, Coarse	8,000 lbs.	$3.18/100 lbs.	$254.40	
Multiwall Bags	160 bags	$204/1000 bags	32.60	
	Total Raw Materials		$287.00	
Labor:				
Direct (6)	48 man-hrs	$1.25/hr.	60.00	
Supervisory (2)	16 man-hrs	$2.25/hr.	36.00	
	Total Labor		96.00	
Utilities:				
Steam (low pressure)	4 M lbs.	$0.80/1000 lbs	3.20	
Electricity	90 KWH	0.015/KWH	1.30	
Water	2 M gal.	0.25/1000 gal.	0.50	
Oil, No. 2 fuel	25 gal.	0.16/gal.	4.00	
	Total Utilities		9.00	
Other Operating Costs:				
Maintenance (5% of labor)			5.00	
Overhead:				
General (based on 50% of labor)			50.00	
Depreciation (based on 7% of fixed capital investment)			26.00	
Taxes and Insurance (based on 5% of capital investment)			19.00	
			95.00	
Total Bulk Production Cost Per Day			$492.00	
Cost per Pound			$ 0.0615	

Analysis of Brewer's Flakes

Physical Tests. The flakes are examined with respect to mold, weevils, rodents, odor, heating, lumps, color, amount of foreign matter and general appearance. The moisture content is measured by heating and re-weighing a ten gram sample. The conditions used are 105°C for four hours. The oil content is measured by extracting a ground ten gram sample with petroleum ether for six hours. The petroleum ether is removed from the oil by evaporation and final drying at 100-105°C for one hour. The residual oil is then weighed.

The oil contents of a number of cereal products follows:

Sample	Oil Content, %
Corn Flakes	0.2 - 1.2
Malt	1.5 - 2.0
Whole Barley	1.5 - 2.5
Pearled Barley	0.9 - 1.5
Whole Corn	3.5 - 4.5
Corn Meal	0.8 - 4.5
Corn Grits	0.5 - 2.0
Refined Grits	0.01-0.10
Rice	0.5 - 1.8
Whole Wheat	1.5 - 2.5
Whole Meal	0.7 - 1.0
Oats	6.0 - 7.0

Chemical Tests. Protein is determined by weighing out 1.4 g. of the ground sample into a Kjeldhal digestion flask and running a conventional nitrogen analysis. The protein content is estimated as (N)x(6.25) and is calculated from the formula:

$$\% \text{ Protein} = \frac{\left[(\text{ml. } 0.1\text{N } H_2SO_4) - (\text{ml. } 0.1\text{N NaOH})\right] \times 0.0014 \times 6.25 \times 100}{(\text{wt. of sample})}$$

Ash content is obtained by weighing about 2-5 grams of sample into a dish and igniting at 550°C until the ash is white or there is no further change in weight.

Determination of "Extract". The unground flakes (about twenty grams) and 30 grams of ground malt are mashed in 200 ml. of distilled water at 46°C. Good mixing is essential to avoid lumping. The temperature of the mixture is maintained at 45° for exactly 30 minutes after which the temperature is advanced 1°C per minute until 70°C is reached. After adding 100 ml. of distilled water at 70-71°C, the mash is held at 70° for 60 minutes. Drops of sample are tested on a porcelain plate with 0.02N iodine solution every 15 minutes until conversion is complete. At conversion, the test drop and the iodine produce only a yell v stain on the plate two minutes after addition of the iodine. The time of conversion is usually reported in periods, as follows: less than 15 minutes, 15 - 30, 30 - 45, 45 - 60, and incomplete after 60 minutes.

TYPICAL ANALYSES OF CORN FLAKES, OTHER ADJUNCTS, AND RELATED MATERIALS

	Corn Flakes	Brewers' Rice	Rice Meal	Rice Flakes	Corn Grits	Corn Meal	Refined Corn Grits	Ground Yellow Corn***
Moisture, %	10.6	11-13.5	11-14	11-14	12.3	12.3	11.0	14.0
Carbohydrates, % (Starch)	74-82	74-82	73-81	73-83	73-80	71-78	-	-
Protein (Total), %	8.1	6-8.5	7-10	6-8	8.2	8.6	0.3	8.5
Protein (Soluble) %	0.2-0.4	0.1-0.3	0.2-06	0.1-0.3	0.6-0.8	0.7-1.0	-	-
Fats and Oils, %	0.6	0.2-0.8	0.7-1.5	0.2-0.8	0.9	1.4	0.05	3.5
Ash, %	0.3	0.3-0.7	0.5-1.0	0.3-0.8	0.4	0.4	0.14	1.24
Crude Fiber, %	0.4-0.8	0.3-0.7	0.6-1.5	0.3-0.7	0.4-0.8	0.8-1.7	-	-
Lab Yield *								
"As Is", %	82.3	77-84	76-83	78-85	79.1	78.5	92.5	72.5
Lab Yield								
"Dry Basis", %	92.1	87-94	86-93	88-94	90.2	89.5	103.9	84.3
Average Brewery Yield, %	77	78	79	80	74	75	-	-
Boiling Time (Min.)Average	**	20-40	15-30	**	40-50	30-40	-	-

* "Yield" is percent of Dry Extract obtained from the material used.
** No Boiling required.
*** Corn was roughly screened to remove much outer skin and some germs.

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