# REQUIREMENTS FOR PROCESSING OF DAIRY PRODUCTS

**DEPARTMENT OF STATE**

AGENCY FOR INTERNATIONAL DEVELOPMENT
COMMUNICATIONS RESOURCES DIVISION
Washington 25, 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 Agency for International Development, but merely a citation that is typical in its field.

This report was prepared by Fehmerling Associates, Consultants to Food and Allied Industries, Bridgeton, New Jersey, in May 1962 for the technical aids program through the facilities of the Office of Technical Services, U. S. Department of Commerce.

Technical information and equipment illustrations, as well as review of this brochure, were provided by William Giebel, President, Rainier's Dairies, 2 East Commerce Street, Bridgeton, New Jersey.

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For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Agency for International Development.

July 1962

Code Number
PR-118

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## INTRODUCTION

This manual provides information on the processing of milk and other dairy products for human consumption. It is primarily intended to give the reader a basic understanding of production and marketing methods.

## GENERAL ASSUMPTIONS

There are certain minimum requirements that must be considered in a venture of this kind, all of which are absolutely essential. Without any one of them, the plan can proceed no further. In this manual, the following assumptions are made:

1. Anyone interested in establishing a dairy enterprise will either have a sound knowledge of the basic principles of dairy manufacturing or will avail himself of the services provided by engineers, consulting firms or equipment suppliers who specialize in this field.

2. A steady, plentiful supply of raw materials and supplies are available.

3. A dependable supply of potable water, abundant enough for all processing and cleanup operations, is available.

4. Facilities are available for sewage disposal which will not violate local laws or ordinances.

5. An adequate power supply, supplemented by auxiliary emergency equipment, is available.

6. Transportation is available to deliver both raw materials and finished products.

7. A market for the products already exists or the entrepreneur is prepared to develop a market.

8. The costs of buildings, facilities, materials and labor are based on current United States prices.

9. Operations, involving the largest number of employees, such as filling, bottle washing, casing and stacking cased bottles in the cooler occur five days a week, fifty two weeks a year. Receiving operations are generally carried on seven days a week, fifty two weeks a year. Retail deliveries of milk are made six days a week, fifty two weeks a year.

10. Where items must be estimated, the estimates are based on the most realistic figures available, applicable to the area in the United States where a plant such as the one described in this report might feasibly be located. These items are:

    A. Land value.
    B. Selling costs, including advertising allowances.
    C. Administrative costs.
    D. Taxes, social security and insurance.

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

## PRODUCT SPECIFICATIONS

A milk processing plant usually produces a number of different or related products. Packaging may be in several different sizes and types of containers.

The items produced in the plant from which economic data for this report were gathered, are pasteurized, homogenized whole milk in quart bottles, cream in bottles, butter and cottage cheese.

Obviously the cost figures on all of the various products, packaged in various types and sizes of containers, cannot be shown in this report.

For this reason, all cost figures contained in this report are based on the production of one product packed in one size container, in order to supply annual production figures. The product used for this purpose is pasteurized, homogenized whole milk packed in one quart returnable glass bottles.

It is estimated that this product will comprise 50% of the total annual production of the plant.

## PRODUCTION CAPACITY

The production capacity of this plant is based on a single product as stated above. The annual production is 1,872,000 one quart bottles of pasteurized, homogenized whole milk. Of this total, seventy five percent (1,404,000 quarts) is sold to retail consumers, delivered to the door. Twenty five percent (468,000 quarts) is sold wholesale to stores for retail sales.

## MANUFACTURING UNIT

The manufacturing unit is a one quart bottle.

# HANDLING MILK ON THE FARM

Milk is an excellent medium for the growth of many organisms. Because of the unavoidable time lag between production of the milk and its ultimate consumption, it is imperative that extreme care is taken to prevent the milk from becoming contaminated during this period.

Many diseases, such as tuberculosis, typhoid fever, diptheria, scarlet fever, septic sore throat, brucellosis and various intestinal disturbances may be transmitted to man through contaminated milk. Some of these may come from infected cows, while others may come from diseased workers who have come in contact with the milk.

It is obvious that to ensure a safe, clean milk supply, good sanitation practices must begin on the farm.

## Barn Construction

Floors and gutters of barns should be made of impervious material such as concrete, and should be sloped so that all liquid material will drain promptly. There should be a minimum of ledges to prevent the accumulation of dust, and ceilings should be tight to prevent dust from filtering down from the floors above. Stalls should be of proper length so that the excrement of the cows falls into the gutters and the gutters themselves should be so designed that they can be easily and thoroughly cleaned. Every effort should be made to keep rodents and insects out of the barn and adequate ventilation and lighting should be provided.

## Cows

Dairy cows should be free of any infectious or contagious diseases. They should be tested regularly for tuberculosis and brucellosis and any infected cows removed from the herd. The udders should be checked regularly for mastitis or other abnormalities and the animals should not be used for milk production until the condition is corrected. Milk should not be used from any animals with actinomysis or running sores of any kind. Cows should be kept as clean as possible, especially around the udder section and flanks.

## Milking

When cows are milked by hand, there are several important sources of external contamination that must be considered:

1. Bacteria and dirt may get into the milk from the coat of the animal, stable air, dirty milking pails and from the milker himself. The bacterial and dirt content of milk can be considerably reduced by the use of small-mouthed or hooded pails which prevent a good portion of airborne foreign material and dirt from the cow's body from getting into the milk.

2. Dirty milk pails are another important source of contamination. They should be washed after use and checked regularly for deposits of milkstone, corrosion and rough areas which harbor bacteria.

3. Milkers with slovenly personal habits may also be responsible for the contamination of raw milk and should not be employed in a dairy operation. Such persons are quite likely to be careless about sanitation in the cleaning of the animals and stables, the sanitizing of equipment and other necessary procedures. Personnel employed on dairy farms and elsewhere in dairy operations should be free from contagious or infectious diseases, running sores, etc. They should also be checked regularly in the performance of their duties.

When hand milking, it is a good policy to first wipe the udder section clean with a damp cloth. "Wet-milking," the undesirable practice of moistening the hands with milk before grasping the teats also contributes large numbers of bacteria. Employees should avoid sneezing, coughing, and talking over open milk pails since this practice may contaminate the milk with pathogenic organisms.

Although the machine milking of cows is a great labor saver, it may also be one of the main sources of bacterial contamination. The complicated construction of milking machines makes cleaning difficult unless special methods are used. Particular attention should be given to the teat cups and rubber tubes both in washing and drying. Milking machines should be cleaned as soon as milking is completed. The parts should be rinsed in cool or lukewarm water, then washed in hot water and finally sterilized with the aid of special chemicals.

Straining

Straining milk does little to reduce the bacterial count. It may, in fact, greatly increase the numbers of bacteria if the filter cloths are not clean. Although straining milk will remove sediment, the practice is frequently responsible for a breakdown in sound sanitation practices and results in the producer making little effort to keep foreign material out of the milk because he knows he can remove it by straining.

Cooling

Inasmuch as milk produced under the very best conditions contains some bacteria, it must be cooled as quickly as possible to check their growth.

Cans of milk should be covered and immersed to the neck in a tank of cold water. Although stirring during this period facilitates cooling, the utensils used are also an additional source of contamination. If the final cooling temperature will be 40° Fahrenheit or lower, it is probably better not to stir the milk.

Care of Milk Cans

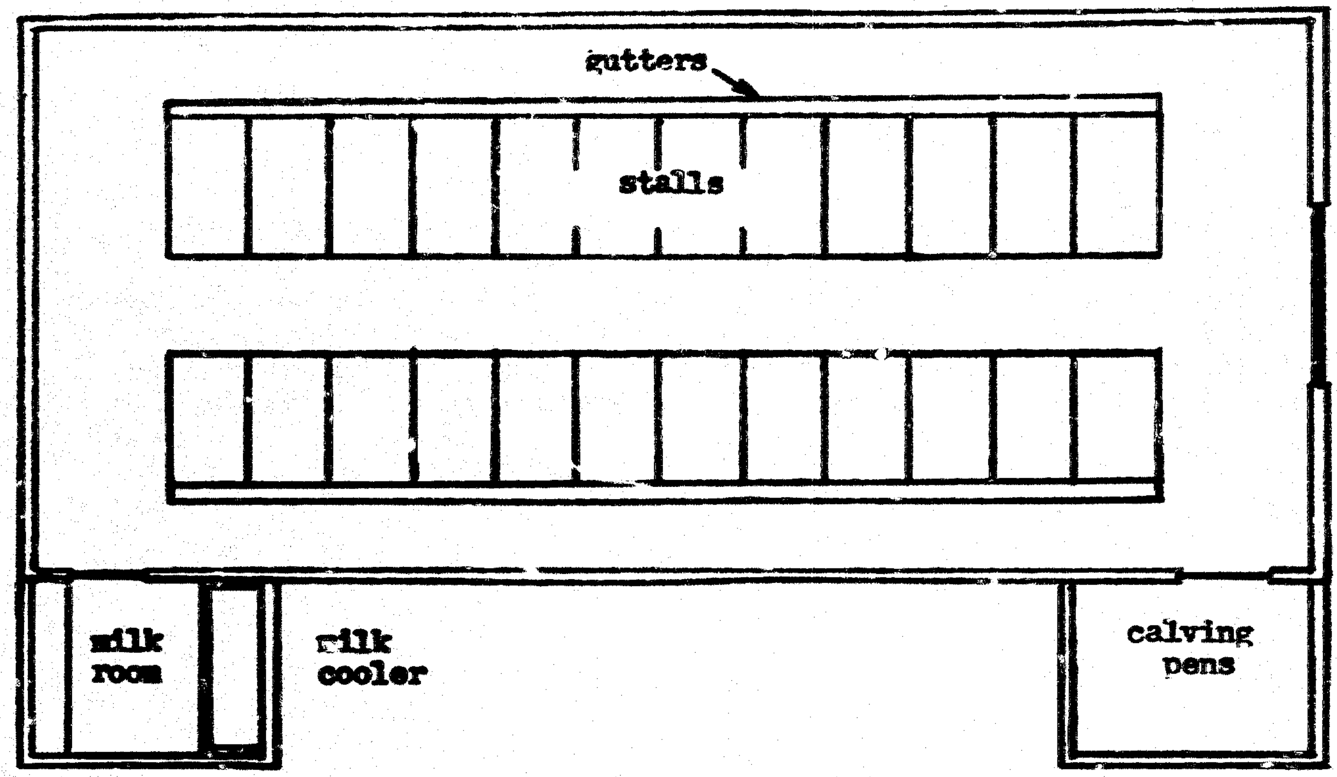
Milk cans are a very important source of bacterial contamination. Many milk producers pay little attention to their cans because they feel that the dairy plant operator takes care of this for them. This is definitely not true. It is the responsibility of every dairy farmer to check his milk cans regularly. The washed cans should be examined for milkstone deposits, rust, faulty seams and entrapped moisture, and the condition corrected or the can withdrawn from service.

Transportation

Even though it is cooled, milk should not be allowed to accumulate on the farm. It should be delivered to the dairy plant daily and provision should be made for keeping it cool enroute, if the trip is several hours or longer.

## Milking Parlors

Very high quality milk is usually obtained from farms with milking parlors. Floors should be of an impervious material and the entire room should be tight and easy to clean. It should be located close to the dairy barn but separated from it. It may be large enough to hold from one to several cows and facilities should be provided for washing the udder section of the cows at milking time.




LAYOUT OF MODERN DAIRY BARN

The drawing above is an example of a simple barn layout. The actual layout and size of a dairy barn will be determined by the terrain, drainage, number of cows to be milked, type of feed to be utilized, frequency of milk pickup, method of manure removal, whether or not a bull is to be maintained and other important factors. Adequate lighting, ventilation and door openings are essential. The barnyard should drain away from the barn. Manure should be removed frequently and either applied to the soil immediately or stored away from the barn area. Feed may be stored in either a silo or on the floor above, depending on the type of feed being used. Cows may face in either direction, with gutters located appropriately, depending on which arrangement is most convenient for milking and feeding.

<u>Supplemental Equipment</u>

Small-mouthed milk pails, or milking machine
Water pails
Milking stools
Manure forks
Manure shovels
Curry combs and brushes
Insect spraying equipment
Milk and cream cans
Cooling facilities
Cream separator (optional)

# THE PHYSICAL PLANT

## Location

Ideally, a dairy manufacturing plant should be located both close to a raw milk supply and close to a market for the products. In a practical sense, however, this is rarely possible. Consequently, the costs of transporting raw materials to the plants as opposed to delivering the finished products must be carefully weighed.

A plant which manufactures butter, cheese, concentrated or dried milks should be situated in a milk producing area, if not, it will be competing with market milk producers for a supply of raw milk.

Plants which distribute milk on retail routes are better located in city areas because of the lower delivery costs.

Ice cream plants should be located near the point of consumption since the raw materials are generally concentrated and have good keeping qualities if properly handled.

## Construction

The nearer an approach is made toward a square design, the more floor space will be obtained from a given amount of wall structure. The plant may be a single-story building, which requires more land area, or a multiple-story building, which requires heavier construction and supporting members. Provision should be made for future growth.

Floors should have a concrete base with strength enough to support heavy equipment. They should be surfaced with a wear-resistant, slip-proof, waterproof, easy to clean material that is impervious to lactic acid, grease and cleaning solutions. They should be properly pitched for rapid draining and have full rounded corners at all wall joints and pedestals for equipment.

Walls and ceilings should be waterproof and sanitary. The lower portion of the walls should be glazed tile.

Adequate lighting and ventilation are necessary. Windows should be screened and the frames made of aluminum or steel. Doors must be self closing, screened and tight fitting. Ample space should be provided for the storage of raw materials, containers and finished products.

## Equipment

The choice of equipment will depend on the type of dairy enterprise and the anticipated volume to be handled.

The capacities of the various processing units should be coordinated to avoid unnecessary expense and all metal parts which come in contact with the products should be made of stainless steel or monel.

Many types of multipurpose units are available which have special advantages. Again, the choice will be determined by the type of operation being considered.

The capacity and number of pumps and storage tanks will be determined by the layout of the plant and its anticipated volume. A steam generator will also be required.

## Sanitation

Proper sanitation practices are probably more important in the dairy industry than in any other food processing enterprise. The very nature of the raw ingredients makes them an ideal medium for the growth of microorganisms. Therefore, it is essential that every surface with which the products come in contact are cleaned and sterilized after each use. Large washing sinks must be provided for this purpose.

The amount of time required to clean and sanitize has a direct bearing on plant earnings, not only because of the man hours required, but also because of the time the equipment is out of production.

In many instances, equipment and pipelines will have to be completely dismantled for cleaning. A well planned arrangement of units will reduce the number of fittings and shorten pipelines. Complicated hookups should be avoided and equipment should be cleaned immediately after use.

Modern plants use cleaning-in-place methods so that the pieces of equipment are not dismantled but sanitizing agents are flushed through them. It is not possible to do this with all equipment but wherever it is, cleaning time can be reduced up to 50%.

There are many cleaning agents available that have been formulated specifically for dairy use. Some of these combine a bactericide with a detergent compound so that cleaning and sterilizing are done simultaneously. Chlorine and quaternary ammonium compounds are frequently used. They are effective bactericides and leave no objectionable odor. In all cases, the manufacturer's directions should be carefully followed and the cleaning agents should be completely rinsed from the equipment.

## RECEIVING OPERATIONS

Milk may be purchased from the producer in several ways. It may be paid for by measure, that is, by the gallon or can, by total weight, by weight or measure with minimum standards for milk fat and a premium for additional milk fat, on the basis of the actual milk fat content, or by a basic price per hundred weight of milk plus a straight price per pound of milk fat. The method of payment will vary with local custom, competition in the area and the purpose for which the milk is intended.

### Inspecting and Weighing

The cans of milk are unloaded from the trucks onto a roller or drag-chain conveyor and are transported into the receiving room.

The can lids are removed and the milk is checked for visible filth and undesirable odors. Sediment testing may also be done at this point.

If the milk is rejected the lid is replaced and a conveyor transports the can back to the truck. If it is accepted, it moves on to the weigh tank.

Depending on the size of the operation, the weigh tank may have either one or two compartments with sloping bottoms leading to 6 - 10 inch discharge gates. The tanks are connected to a scale with easily read calibrations. The tops of the tanks are covered except for the opening into which the milk is dumped and a sampling hole. The main opening is fitted with a hopper to prevent spillage and a 3/16 inch screen to strain out gross filth.

The hoppers should be fitted with baffles which aid in mixing the milk and also help prevent splashing. Many dumping units are equipped with cradles in which the can rests as it is tipped. These are so arranged that the milk can be dumped in either tank.

When a tank is full or all of the milk from a producer has been received, it is weighed and recorded.

## Sampling for Butterfat

At this point, the milk is sampled for the butterfat test. Some modern dairies have semi-automatic sampling devices attached to the weigh tank, but in most cases, the thoroughly mixed milk is sampled by means of a long handled dipper. A small portion is removed from the weigh tank and placed in a jar. The jar should be given a gentle rotary motion as the milk is added. It is not necessary to test every producer's milk every day. Many dairies sample milk for testing only 2 or 3 days during three or four test periods each month. Frequency of testing will be determined by the method of payment and the laboratory facilities available.

In the receiving room it will be necessary to have shelves or racks on which to store the sampling bottles. The bottles themselves should have a wide mouth and tight closure to prevent evaporation. They usually have a rubber stopper which is chained to the neck. They should be identified with the same number that appears on the producer's can. The bottles are stored on trays and the trays kept in racks. Most operators add a mercuric chloride tablet to each bottle so the resulting color will show that the milk is not for human consumption. The Babcock Test is discussed in the chapter entitled "Quality Control".

After the weight of the milk is recorded, the discharge gate is opened and the milk flushes out to a drop tank below. The advantage of a double compartmented weigh tank is that receiving operations can continue while one of the tanks is draining.

## Can Washing

It is the practice in some dairies to hold the cans upside down for several seconds after they are dumped to drain them. A faster method involves the use of a drainage pan and rack. This unit is so arranged that the cans may be dumped, placed immediately on the rack in an inverted position, and carried automatically to the can washer. On the way to the washer, milk draining from the cans falls into the pan and is channeled into the weigh tank while another can is being dumped.

Can washing is extremely important as it is a major source of contamination. Cans should be inspected regularly for milkstone deposits and other faults. Such deposits become progressively more serious since the rough surface makes thorough washing less effective, provides an ideal surface for additional accumulations and makes complete drying difficult. Although washing is still done by hand in some very small dairies, mechanical washing is necessary in most operations.

There are two general types of washers, the straight-away and the rotary. In either case the washing is accomplished by passing the cans over a series of spray jets under pressure. Some machines are so designed that the can lid and can enter the machine together. They are both washed and dried and the lid is replaced on the can at the discharge end.

The first jets in the machines provide a pre-rinse with cold or tepid water. The next series of jets spray a hot washing solution into the cans. The solution usually contains a wetting agent and may be either an alkaline preparation such as trisodium phosphate and sodium metasilicate, or one of the newer acid detergents. The alkalinity should not exceed 0.05% because of the corrosive effect on the tinned surface of the cans.

The washing is followed by a fresh water post-rinse, which is followed by a rinse of hot water at 180° Fahrenheit. In the last step, a blast of hot air is blown into the can to dry it. Thorough drying is very important since a dry surface affords little opportunity for the growth of bacteria. Some machines provide for a blast of cold dry air as the last step. This procedure eliminates the possible condensation of moisture inside the cans.

Washed cans should be inspected regularly and any defects brought to the producer's attention.

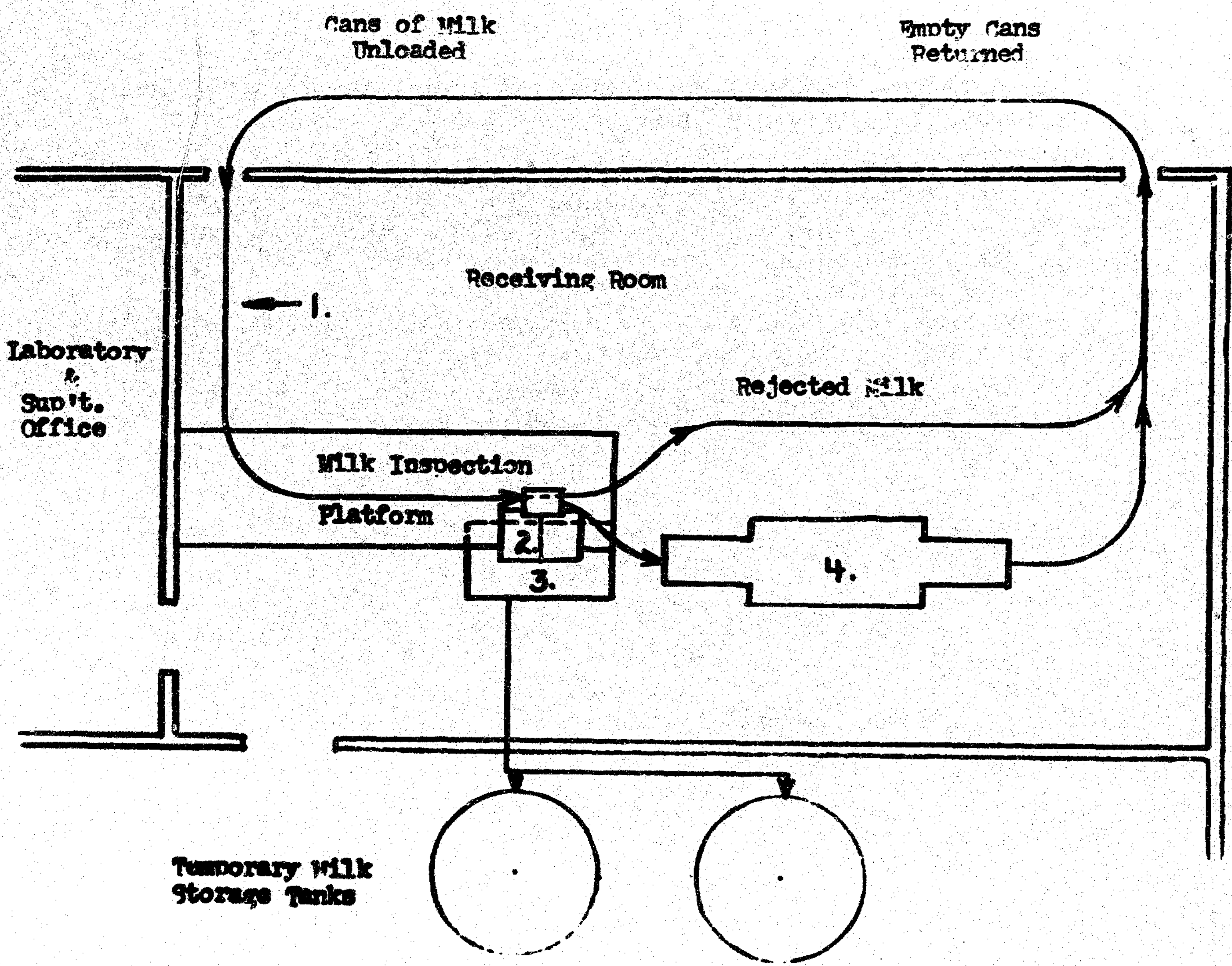
Empty cans come out of the washer onto a conveyor which carries them back to the truck. The conveyor should discharge the cans at a point far enough from the intake conveyor so that it does not interfere with incoming trucks.

## Temporary Storage Tanks

From the drop tank the milk is generally pumped to temporary storage tanks. In some cases, such as some cheese plants, the milk is allowed to flow directly into the cheese vats. In most operations, however, temporary storage tanks are used because they assure a steady flow of milk after operations begin, and the milk is thoroughly mixed.

The raw milk may or may not be cooled. This will be determined by the temperature of the incoming milk, its quality, and the period of time which will elapse before it receives pasteurization or other processing.

Cooling involves the double expense of first lowering the temperature and later reheating the milk. Consequently, cooling prior to processing should be avoided whenever this can be done without sacrificing quality in the finished product.




LAYOUT OF RECEIVING OPERATIONS

Racks for milk samples should be located near the weigh tanks and ample space should be provided for the temporary storage of full cans in the event milk is unloaded faster than the equipment can handle it.

Equipment Illustrated

1. Can conveyor
2. Weigh tanks with scale
3. Drop tank
4. Can washer

## MARKET MILK PROCESSING

There is much disagreement among dairy operators concerning the treatment of milk and the arrangement of the processing equipment. There are probably more than a dozen different methods for processing market milk in use today, all of which differ from the others in some detail of the operation. This chapter will be concerned only with the various steps necessary for the production of a high quality product. The order in which they take place will be a matter of personal judgment, within certain limits, or may be dictated by local health laws.

### Preheating

The viscosity of milk decreases as the temperature is raised. Consequently, the practice of preheating facilitates the filtration or clarification processes which follow. Preheating may, however, initiate rancidity if the milk is not pasteurized quickly.

The raw milk is generally passed through a tubular heater which raises the temperature to $90^{\circ}$ - $95^{\circ}$ Fahrenheit. Plate heaters may also be used in this process.

### Clarifying or Filtering

Clarifying removes suspended foreign particles by centrifugal sedimentation. Filtering removes particles by straining them out. Both methods will remove visible particles quite efficiently.

Filters employ pads or cloths through which the milk is pumped. A frame holds the edges of the cloth or pad in such a way that the milk can only pass through it. The center is supported by a screen or perforated metal support so that the pressure of the milk will not tear or burst the material. The cloths or pads may be reused if properly sterilized but it is a common practice in modern operations to use them only once.

Clarifiers are similar in appearance and operating principle to cream separators. They differ mainly in the size of the bowls, which are larger in clarifiers, and in the absence of any device to separate the cream.

As milk is pumped into the rapidly spinning bowl of the machine, the heavier particles are driven by centrifugal force to the walls of the bowl. This results in a grayish slime which contains various kinds of dirt that has fallen into the milk, body cells, bacteria, particles of casein, fat and other materials. This material must be cleaned out regularly. The amount of clarifier slime obtained from milk is variable and depends largely on the amount of dirt and number of body cells in the milk when it is received.

Although filtration will remove particles down to 0.05 mm., clarification removes even finer particles. Clarification will also remove a portion of the body cells and some bacteria from the milk which would ordinarily pass through a filter.

While clarification removes more bacteria than filtration, the number of bacteria in clarified milk, as determined by the plate method, is frequently higher. The apparent increase is due to the breaking up of clumps of bacteria in the machine. Clarifiers are gradually replacing filters in most modern operations in spite of their higher initial cost.

## Homogenizing

Essentially, homogenized milk is simply milk that has been treated to break up the fat globules to the point where a cream line will no longer form. The product has received wide consumer acceptance in recent years.

Some advantages of homogenizing are:

1. The fat is finely divided and remains uniformly distributed in the milk.
2. The flavor and color are richer.
3. It is easier to digest.
4. It produces superior results in cooking.

Some disadvantages are:

1. Increased production costs.
2. The equipment may be an additional source of contamination.

3. Possibility of sediment in the bottled product.

4. Problems in utilizing returned homogenized milk.

5. More rapid flavor deterioration.

The homogenizer is a triplex pump which forces milk through a restricted opening at high velocity. Extremely high pressures are achieved which cause the break-up of the fat globules.

There is some disagreement on the ideal location for the homogenizer in the flow of milk. Some contend that pasteurization should follow homogenization which would kill any organisms picked up in the homogenizer. Others claim that milk should be homogenized before it is clarified since more bacterial cells will be removed during clarification. A modern, widely used system is to incorporate homogenization in the pasteurizing operation. In the high-temperature short time (HTST) system of pasteurization, the milk is homogenized as it comes from the regenerator unit and before it enters the final heater.

Higher pasteurization temperatures may be used on homogenized milk since the creaming qualities of the milk do not have to be considered.

Tests have shown that homogenized milk deteriorates much more rapidly than regular milk at temperatures near 70° Fahrenheit but that it holds well under refrigeration.

The sludge which sometimes forms in the bottom of bottled homogenized milk may be largely avoided through the use of a clarifier.

Returned homogenized milk may present some problems in efficient utilization. If homogenization has been thorough, the fat can not be removed efficiently for use in butter production. If the returned milk is of good quality, however, it may be used in cultured buttermilk, chocolate milk, ice cream or in standardizing sweet cream.

Separation and Cream Production

A cream separator is used to separate whole milk into skim milk and cream. Cream of almost any desired fat content may be obtained by properly adjusting the machine. The cream may be used for whipping, as table cream or in the manufacture of butter and ice cream. The skim milk may be marketed as such, used for cheese or chocolate drink, or made into condensed or dried skim milk. Raw milk is usually separated at 90° Fahrenheit.

Cream which is to be sold as sweet cream should be standarized, and pasteurized. It may also be homogenized during the HTST method of pasteurization. Recommended pasteurization times and temperatures are 155° Fahrenheit for not less than thirty minutes or 180° Fahrenheit for fifteen seconds. The pasteurized cream should be promptly cooled to 45° Fahrenheit and stored at 40° Fahrenheit or less. Cream which is to be sold for whipping purposes should not be homogenized.

## Pasteurizing

Pasteurizing is 100% efficient in destroying the common disease causing organisms frequently found in milk. Consequently, most health regulations require it. A number of methods have been used through the years but two are now generally accepted.

The batch method employs a minimum temperature of 140° Fahrenheit for a period of at least thirty minutes. It is generally used by small processors for market milk and by large processors for cream, chocolate milk and other products which are produced in small amounts. Higher temperatures are often used.

In this system the milk is heated, held and partially cooled in a water or steam jacketed tank or vat. The pasteurizer is equipped with agitators to keep the milk in motion. For cooling, the hot water or steam in the jacket is replaced with cold water.

The high temperature-short time method, generally referred to as HTST pasteurization, is a continuous process which is now used almost universally in the larger milk plants. A minimum temperature of 160° Fahrenheit for a period of fifteen seconds is required.

This process employs plate heaters for rapid heat transfer. A series of thin plates are joined together but separated by gaskets. The gaskets are so arranged that no leakage can occur when the milk flows across one side of a plate while the medium which is heating it flows along the other side. The milk and heating medium enter the unit from opposite ends and tend to equalize in temperature. The capacity of the unit can be increased by merely adding more plates.

The most efficient units of this type have a regenerative feature. As cold raw milk enters the regenerator section, it flows along plates on the other side of which the hot milk is leaving the pasteurizer. This cools the milk leaving the unit and heats the raw milk which is entering it. The warm raw milk is then pumped to the final heater where it is raised to 160° Fahrenheit and passes into the holding section. This section is so designed that it takes fifteen seconds for the milk to pass through it. The hot milk is conducted to the regenerator where it gives up most of its heat to the cold milk coming into the unit and finally it flows into the cooling section where refrigerated water reduces the temperature to 40° Fahrenheit or less. Over 80% of the heat used in pasteurizing by the HTST method is recovered in the regenerator.

Quick cooling of pasteurized milk encourages the formation of large fat globule clusters which give unhomogenized milk a deep cream layer.

## Cooling

Batch pasteurized milk is usually pumped to a surface cooler, a cabinet cooler, an internal tube cooler or a plate cooler, where the temperature is reduced with ammonia or ice water. In HTST pasteurization, the last section of the pasteurizing unit is a cooler. In either method, the milk is usually conducted to a surge tank or accumulation tank to await bottling. This tank should be located above the bottle filler so that gravity filling is possible.

## Bottling and Capping

After cooling, the milk flows to the bottler supply tank which is part of the machine. Bottle fillers range in size from single, hand-operated units to large automatic machines with a capacity of well over 100 bottles per minute. The milk may flow into the bottles by gravity or be drawn into them by vacuum. The machines should be able to handle containers of several sizes.

Thoroughly washed bottles are fed to the filler on a conveyor from the bottle washing and storage room. The fillers are rotary in design and the bottles are filled on their trip around the machine. In one type of machine, the bottles are filled by gravity, the milk entering through valves, and the air in the bottles escaping through vent tubes which are inserted into the bottles and extend above the level of the milk in the tank above. In the vacuum-type machine, the milk does not enter the bottle until the air has been removed. Loss of milk due to cracked or chipped bottles is eliminated with this system since the milk will not enter the bottles unless a vacuum exists.

The capper is generally a part of the filling machine. There are several types of caps ranging from a simple treated cardboard plug or disc cap to metal foil caps which extend part way or all the way over the roll at the top of the bottle. Many times disc caps are covered by hoods. The filled bottles are cased and placed in cold storage where the temperature should be maintained at 40° Fahrenheit or less.

## Bottle Washing

Thorough washing of bottles is one of the most important operations in a dairy plant. Since all returned bottles have been exposed to contamination from pathogenic organisms, it is not only imperative that all gross filth be removed from them but that they be sterilized as well.

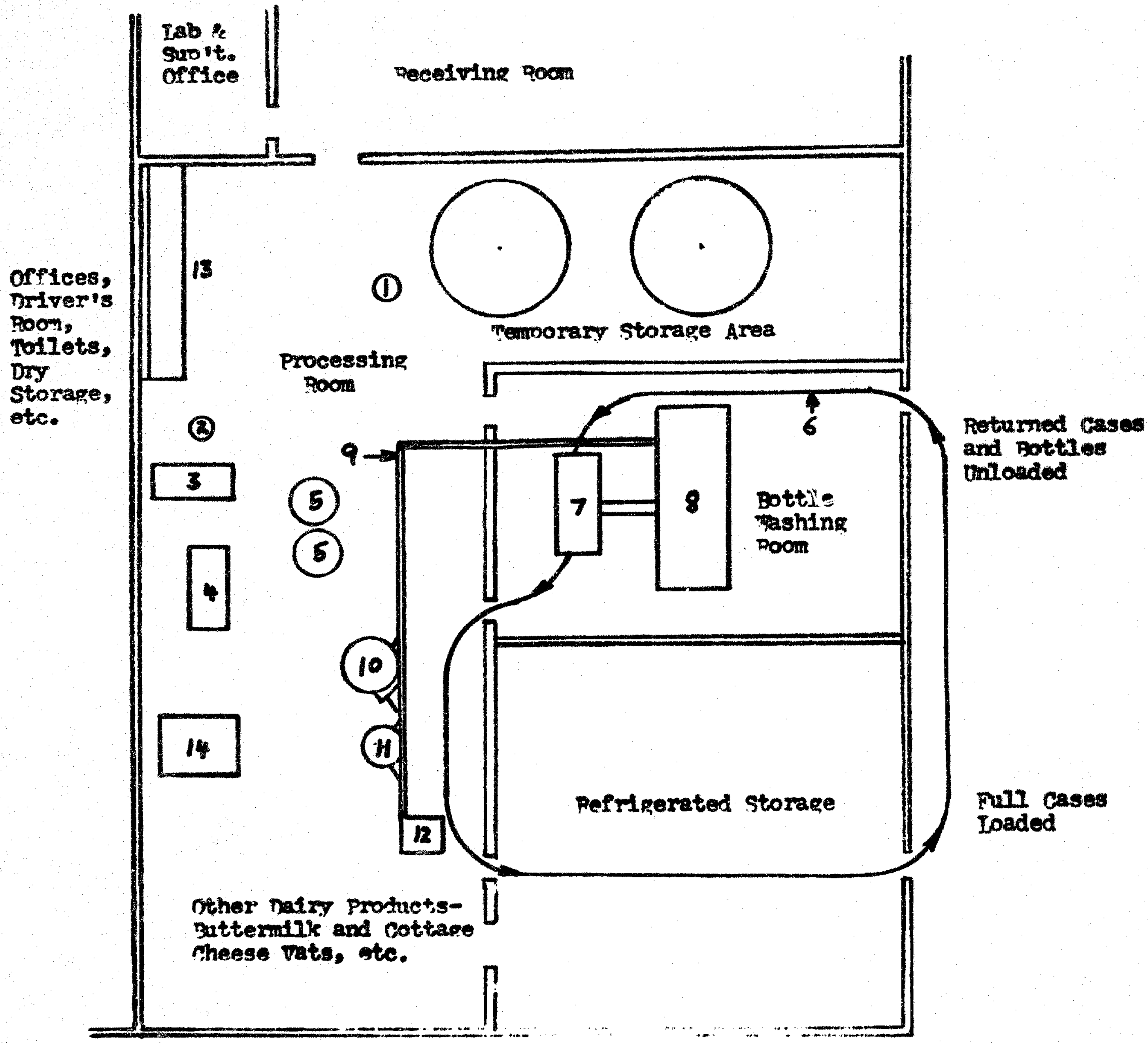
Among the most efficient washers in current use are the soaker type washers. In the newer machines of this kind bottles may receive as many as 18 treatments as they pass through it.

As bottles enter the machine they are pre-rinsed and tempered with warm water. It may be plain water or contain an alkaline solution and the loosening of filth and old milk may be accomplished by jet action or soaking. The bottles are conveyed to one or more soaking compartments containing caustic solutions maintained at relatively high temperatures. They are rinsed by jet action both inside and outside and receive a final rinsing with highly chlorinated water.

The washed and sterilized bottles should be inspected and all damaged or unclean bottles removed. Many firms now use electronic detection devices to supplement manual inspection.

The open bottles should be protected from splashing, dripping and airborne contamination on their trip to the filler. This may be accomplished by installing a shield over the entire length of the conveyor.

Provision should also be made to wash the bottle cases regularly.




LAYOUT OF MARKET MILK PROCESSING PLANT

The exact arrangement of equipment will vary with the type of milk being bottled, the number of other dairy products manufactured, local laws, etc.

Equipment Illustrated

1. Clarifier
2. Separator
3. Short-time pasteurizer with regenerator
4. Homogenizer
5. Holding tanks
6. Case conveyor
7. Case washer
8. Bottle washer
9. Washed bottle conveyor
10. Filling machine
11. Bottle capper
12. Casing operation
13. Equipment wash sink
14. Vat pasteurizer

# CONCENTRATED MILKS

The removal of a portion of water from whole or skim milk is known as condensing or evaporating, but the resulting products are all considered "condensed" milks by the trade.

The degree of concentration can be controlled and will be determined by the ultimate use of the product. The composition of concentrated milks is expressed in terms of (1) fat percentage, (2) total milk solids, (3) total solids, and (4) sugar content (if it has been added).

A listing of some relatively important concentrated milk products follows:

| Name | Approximate Ratio of Concentration |
|---|---|
| 1. Condensed whole milk (plain) | 2.75-1 to 4-1 |
| 2. Condensed whole milk (sweetened) | 2.5-1 |
| 3. Condensed skim milk (plain) | 2.22-1, 3-1, 3.78-1 |
| 4. Condensed skim milk (sweetened) | 2.5-1 to 3-1 |
| 5. Superheated, condensed whole or skim milk | 5-1 |
| 6. Evaporated whole or skim milk | 2.25-1 |

Dried milk products are discussed in a later chapter of this report.

## Vacuum Pan Condensing

In order to be condensed, milk must be boiled, but the use of a temperature of 212° Fahrenheit would be injurious to the finished product. For this reason, the condensing operation is usually performed in a vacuum pan.

By placing milk under twenty five inches of vacuum, its boiling point is reduced from slightly above 212° Fahrenheit to 140° -145° Fahrenheit.

The vacuum pan is so constructed that the milk is caused to boil violently, surge upward in a fine mist, and drop back into the bottom of the unit. This process continues until the desired concentration is obtained. At the top of the cycle, vapors of the boiling milk are drawn from it and removed by condensation. There are several types of vacuum pans available which differ mostly in the design of the heating unit.

There is a very wide variation in processing temperatures which may range from 140°-230° Fahrenheit. The ideal temperature will be determined by the type of pan being used and the type of condensed milk desired.

Standardizing

Condensed milk is left in the pan until the proper concentration is reached. This is determined from the specific gravity by means of a Baume hydrometer. By making frequent analysis of the condensed milk and by taking frequent Baume readings at definite temperatures, it is possible to determine the exact point at which to withdraw the product from the vacuum pan.

Because of the widespread use of condensed milks as an ingredient of other products, such as ice cream and candy, buyers insist on a uniform, standardized product. For this reason the condensed milk manufacturer must pay particular attention to the ratio of butterfat to non-fat solids and make adjustments by the addition of butterfat or non-fat milk solids where indicated. This is usually done by the addition of sweet cream or sweet cream butter to raise the fat content, or by the addition of skim milk or dried skim milk to raise the non-fat solids. This may be done after the milk is condensed except in the case of sweetened condensed milks. The viscous nature of the finished product makes it imperative to standardize the normal milk before condensation.

Cooling Condensed Milks

There is considerable variation in the systems used to cool sweetened and unsweetened condensed milks. Sweetened condensed milk must be cooled quickly with slow, gentle agitation to avoid the incorporation of air in the finished product. Extreme care must be taken to avoid crystallization of the sugar. Unsweetened condensed milk may be cooled in coil vats or surface coolers.

Packaging and Marketing

Unsweetened condensed milk, commonly called evaporated milk when used in the home, is generally homogenized after cooling. It is filled into hermetically sealed cans and sterilized, after which it may be stored at room temperatures. It may be necessary to place the canned milk in shaking machines to break up the coagulated casein.

Sweetened condensed milk is also packed in hermetically sealed tins for either home or industrial use.

Such condensed products as plain condensed whole or skim milk and superheated condensed whole or skim milk are most frequently sold for use in the manufacture of human foods. For bulk shipments to other processors various size containers are used. The 10 gallon milk can and 50 pound lard tin are popular for this purpose. Sweetened condensed whole and skim milk are frequently sold in 30 or 50 gallon steel drums.

Canned milk is sold directly to wholesale grocers who supply the retail stores.

Bulk condensed milks are generally sold to bakers, confectioners or ice cream manufacturers.

Because of the great variety of condensed products on the market, detailed information on processing methods is beyond the scope of this report. Excluding dried milk products, there are at least 15 different condensed products which may be marketed in an infinite number of concentrations for special purposes.

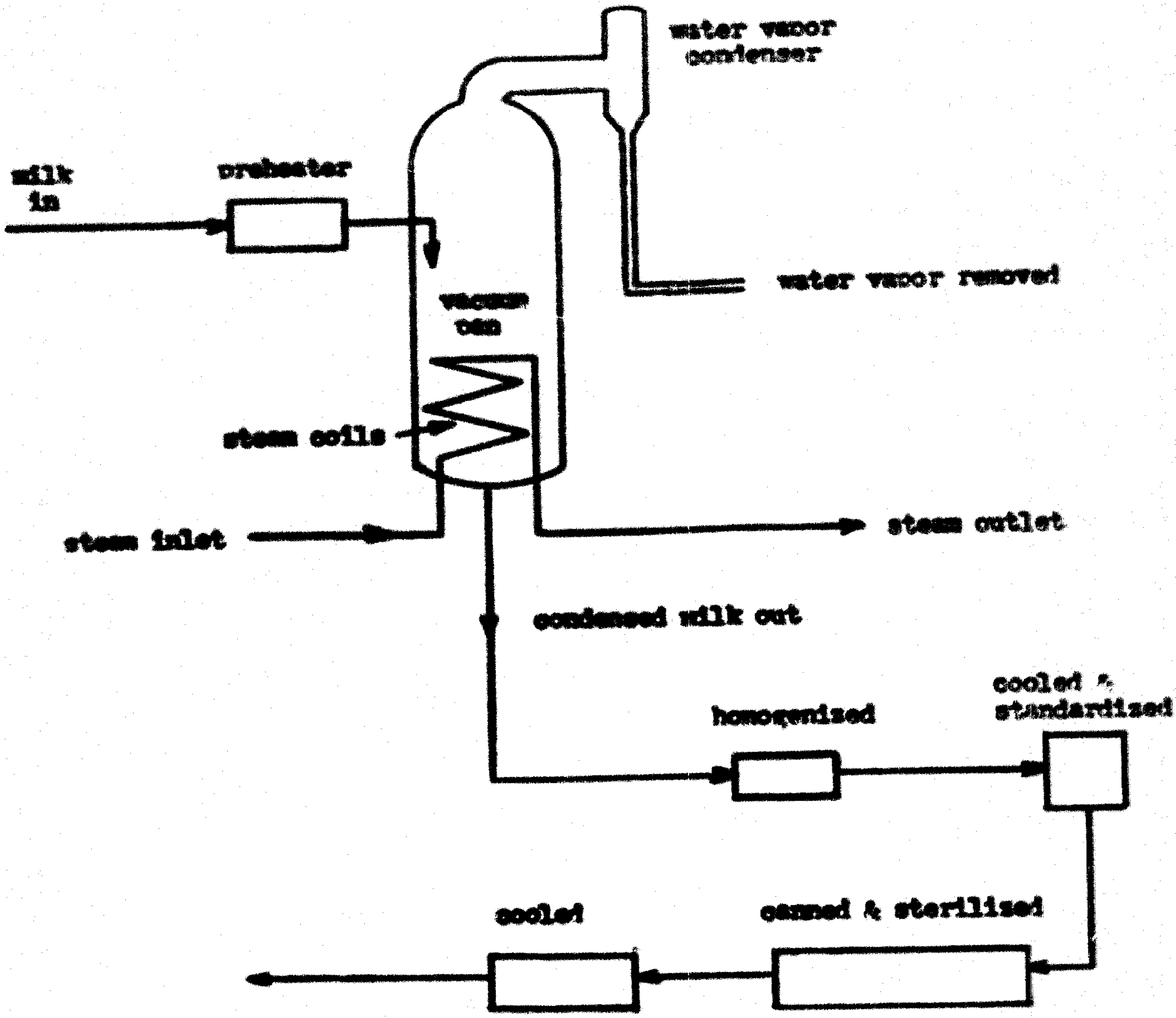



DIAGRAM OF VACUUM PAN USED FOR
MANUFACTURE OF CONDENSED MILKS

Butter may be made from either sweet or sour cream. The cream may be received in the form of whole milk or may have been separated on the farm or at another processing plant.

If received in the form of whole milk, the steps discussed in the chapter entitled "Receiving Operations" are followed and the cream is diverted to the butter making process after a separation. If the cream is received in cans, the procedure is similar, with some exceptions. The cream is usually weighed in the producer's can and the weight of the can subtracted from the gross weight. It is then poured into the dump tank and the can is steamed to remove any remaining cream. In order to avoid weighing the cans every time, the weight is painted or stamped on each can. During the receiving operation, much attention is devoted to the detection of off-flavors and odors in the cream.

The butter making process is begun when there is enough cream in storage vats to make a churning.

## Neutralizing

If the cream is sour, the acidity must be adjusted to prevent the loss of fat during pasteurization. If only sweet cream is used, this step is not necessary.

Neutralization is accomplished by the addition of an alkaline compound such as calcium oxide or magnesium oxide, sodium or calcium hydroxide, sodium bicarbonate, etc. Two very important points which must first be determined are the exact amount of cream to be neutralized and the percentage of acid in the cream. Without this information, the quantity of neutralizer to be added could not be calculated. The cream should be retested after neutralization.

## Pasteurizing

Pasteurization of cream for butter making is done primarily to free it of potentially harmful organisms and to increase the keeping qualities of the butter.

Smaller creameries generally use a vat system where the cream is heated to a minimum of 150° Fahrenheit and held for at least thirty minutes. The holding time may be shortened if the temperature is increased. Most larger modern dairies use flash pasteurization methods which allow a continuous flow of cream through the unit. Temperatures of 180°-240° Fahrenheit are used for periods of one to fifteen seconds. Vacuum pasteurizers heat the cream under vacuum and remove volatile substances which may cause off-flavors.

Cooling - Ripening

After leaving the pasteurizer, cream should be cooled immediately to 40-50° Fahrenheit. The cooling unit may be a part of the pasteurizer or a separate unit. Some butter making plants make a practice of ripening cream by adding a starter culture to it as it is cooling, mixing it thoroughly and allowing the cream to stand undisturbed for an extended period. Whether or not this is done depends on the quality of the cream and the type of butter to be made from it. Other processors do not use a starter and may allow the cream to ripen for only two or three hours. There are unlimited variations of the ripening process and the one chosen will ultimately be dictated by consumer preference, for it is at this point that most of the flavor of butter is developed.

Churning

The ideal butterfat content of cream entering the churn is 33-35%. Both the fat content and temperature of the cream should be adjusted so that churning is completed in 45-60 minutes.

The churn may be in the form of a cylindrical drum, an inclined cone or an irregularly shaped cube. It may or may not have agitators or baffles inside but it is designed to agitate the cream violently. It is usually filled about half full and color is added if necessary and allowed under existing laws.

During the churning process, butter granules begin to form. When they build up to about the size of a pea or kernel of corn, the churn should be stopped and the buttermilk drained from the bottom of the churn.

## Washing

A sufficient quantity of potable water is added to the churn to float the bulk of the butter granules. The unit is closed and rotated for a short period to wash the milk solids from the butter. This liquid is drained off and a larger quantity of chilled water is added. The rotating is repeated and the water again drained. The second washing removes any remaining milk solids and firms the granules.

## Salting

Salt is added to butter to prolong its keeping quality and to impart flavor. Some butter is not salted at all. The amount of salt added, if any, will be determined by consumer demand. Quantities up to 3% are commonly used. It is generally added in granular form, either sprinkled over the butter or put in a trench made in the butter and the churn started again.

## Working

The purpose of working the butter is to bring the granules together in a compact mass and to distribute the salt evenly. During the working process moisture is firmly and uniformly incorporated into the butter in the desired proportion. The amount of water and fat is checked several times during the working process and the churn is stopped when no free moisture or droplets are visible or can be pressed from the butter.

There are several continuous butter making systems on the market which are efficient but quite expensive. They are economically feasible only in plants where a large supply of cream is available and a large volume of production is anticipated.

## Packaging

Butter is not always sold immediately after it is made. Frequently, it is removed from the churn and placed into parchment lined tubs or boxes which hold quantities from 50 - 65 pounds.

The containers are then placed in cold storage. This is especially true during the months when there is a surplus of milk.

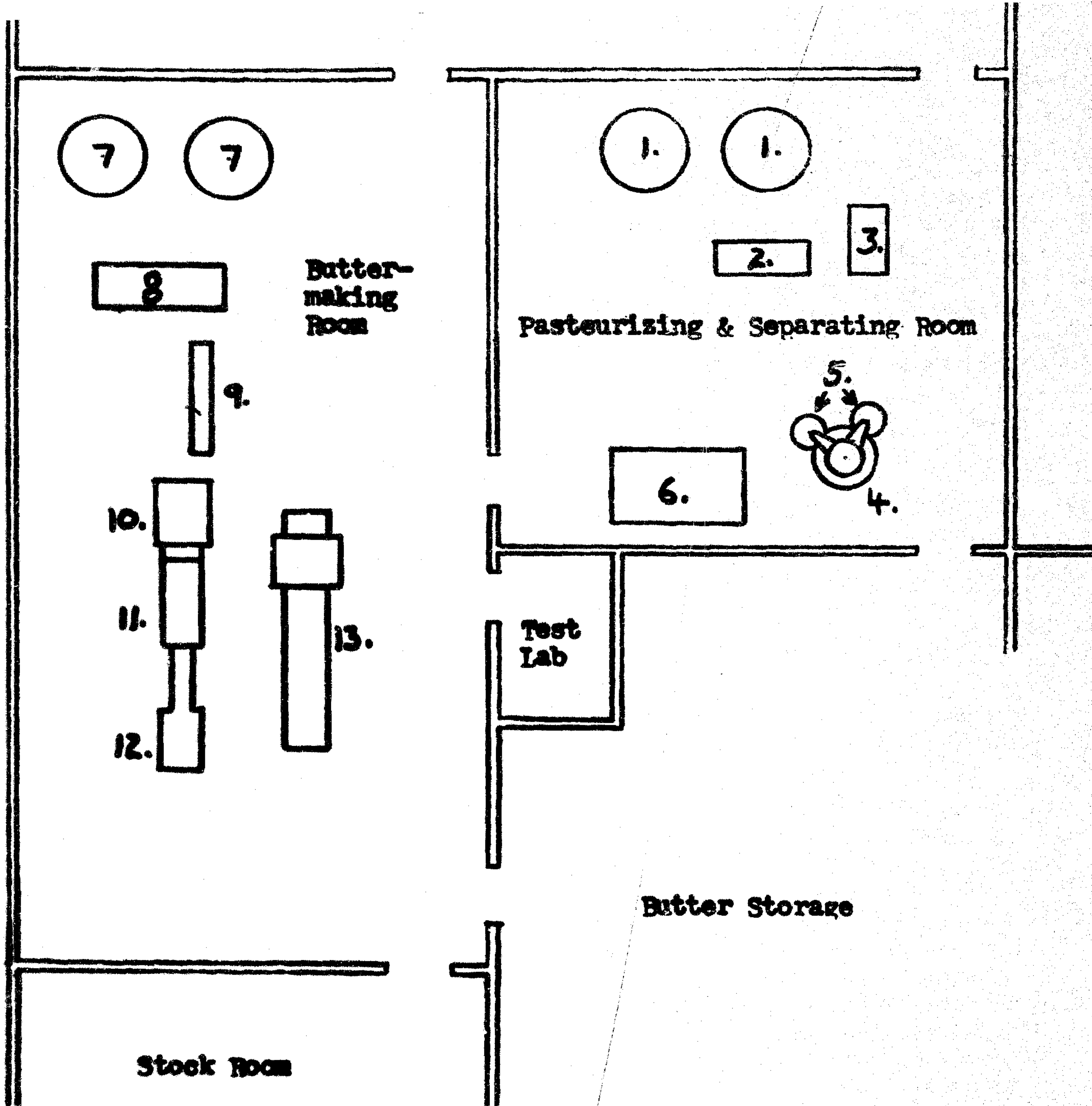
The butter may be held in storage at the plant or sold to wholesalers. It is removed from storage and repacked for distribution during the period of low milk production.

The treatment butter receives after churning will depend upon the form in which it will ultimately be sold (retail or wholesale), how long it is to remain in storage and the type of printing machine through which it will eventually be run.

If butter is to be made into prints relatively soon after manufacture, it may be stored at 35-40° Fahrenheit and after packaging, at 40° Fahrenheit. If it is to be sold several weeks after manufacture, a storage temperature below 0° Fahrenheit is necessary. For very long periods of storage, the temperature should be 10° Fahrenheit.

Some butter printers require that the butter be in the form of a block which is forced through a series of wire cutters spaced an appropriate distance apart. Other types of cutters work on the principle of a meat grinder. The thoroughly chilled butter is placed into a hopper and forced by a worm screw through an opening the size of the print desired. It comes from the opening in a continuous stream and is cut into suitable lengths.

Butter prints are wrapped in parchment, foil or one of the newer laminated materials, packed in waxed cardboard cartons, and returned to cold storage until sold.




LAYOUT OF BUTTER MAKING PLANT

If whole milk is received instead of cream, additional equipment will be required to utilize the skim milk.

Equipment Illustrated

1. Receiving vats
2. Centrifugal heater
3. Cream filter
4. Separator
5. Separation tanks
6. Vacreator pasteurizer
7. Standardizing vats
8. Chiller
9. Texturator
10. Print former
11. Wrapping machine
12. Packaging machine
13. Bulk butter packaging machine with scale

# ICE CREAM

Ice cream varies more in composition and methods of preparation than any other dairy product. There are innumerable combinations of ingredients, a wide variation in consumer preference and many conflicting local and state laws and ordinances. As a result, there is no single definition of the product. It is a very important dairy product and has received almost universal acceptance throughout the world.

Where **standards for** ice cream have been established, the only universal point of agreement is that the most significant quality factor is a minimum butterfat content. This may range from 6-14% in the case of ice cream, or 1-5% for ice milk and sherbert.

In general, the manufacturing processes fall into four major groups:

1. Receipt of raw ingredients.

2. Mix preparation.

3. First freezing.

4. Hardening.

The final choice of equipment should be made only after consultation with an equipment manufacturer who will be able to give detailed, technical advice based on the purchaser's specific needs. Individual pieces of equipment may be designed to perform a single operation or may be multipurpose units which are capable of performing several operations. Dairy operators who manufacture several products may be able to utilize certain pieces of equipment they already own for ice cream manufacture and also other products. For these reasons, emphasis will be placed on steps in the production of ice cream rather than items of equipment which may be used to accomplish them.

## Receiving Raw Materials

Ice cream plants receive raw materials in many different forms. They may be dry, liquid or frozen and may be packed in barrels, cans, boxes, bags, bottles or other containers. The receiving department of an ice cream plant must necessarily be set up to handle any product in any form. This will also include storage facilities, since the raw materials received may not be used for several days or longer.

Where whole or skim milk and cream are used, they should be inspected, tested and weighed as outlined in the chapter entitled "Receiving Operations". Many multiproduct plants use much of the whole milk which is returned from retail routes in the manufacture of ice cream if it is of good quality.

Dry ingredients may arrive in bags, barrels or drums and a cool dry storage area should be provided for them.

Frozen raw materials such as frozen cream or frozen condensed milk may be taken to a special storage room or kept in the hardening room.

Other ingredients, such as the various condensed milks which are not hermetically sealed and sterilized, should be stored under refrigeration if they are not to be used immediately.

Some of the dairy ingredients which may be used in ice cream manufacture are: Fresh whole milk, fresh skim milk, dry whole milk, dry skim milk, unsalted butter, anhydrous milk fat, fresh cream, plain condensed skim milk, sweetened condensed skim milk, plain condensed whole milk, sweetened condensed whole milk, evaporated milk, frozen cream, frozen condensed milk, plastic cream (80% B.F.), superheated condensed skim milk.

The following ingredients may be used as sweetening agents: Cane sugar, beet sugar, corn syrup, corn syrup solids, corn sugar, invert syrup.

The combination of ingredients used in ice cream will depend almost entirely on their availability. This is especially true of the dairy ingredients.

## Mixing

Mixing may be done on a batch basis or in a continuous process. Frozen raw materials may be thawed before mixing or passed through a comminuter which enables them to thaw quickly while being mixed.

Batch mixing may be done in a jacketed vat which is also used for pasteurization. The liquid ingredients are first placed in the vat and the mixture is heated with continuous agitation. Dry ingredients are added while the agitation continues. Certain dry ingredients, such as dry milk solids, are particularly difficult to get into solution without lumping. Sometimes this difficulty is overcome by putting the material into solution before it is added to the vat. Gelatin and sugar are generally added before the mix becomes too warm. Gelatin may also be dissolved in hot water and added when both the gelatin and the mix reach a temperature of approximately 145° Fahrenheit. Liquid or soluble dry flavors are added at this point. Insoluble materials, such as fruits and nuts, are added after freezing.

The continuous mixing process is based on the use of liquid ingredients which are stored in separate tanks. As needed, they are conveyed to a weigh can where each item is added in a measured quantity. The order of assembly is the same as for batch mixing.

Even though raw ingredients are tested and formulations are predetermined, the ice cream mix may need some adjustment. Testing of the mix should be done before pasteurization and any defects corrected at that time. If the mix does not contain the exact proportions required, it will interfere with subsequent processing operations and yield a lower quality product.

## Pasteurizing

Ice cream mixes require more intense heat treatment than milk. Temperatures of 160° Fahrenheit for thirty minutes or 175° Fahrenheit for twenty five seconds are adequate.

If the batch system is used, heavier agitators are necessary because of the higher viscosity of the liquid. In continuous processing, higher pressures and more plates are required. Other than this, pasteurization is carried on in the same general manner as described in the chapter entitled "Market Milk Processing".

## Homogenizing

It is common practice to filter the mix after pasteurization. This is done to remove any lumps and also to eliminate any foreign material which may have been accidently introduced during previous operations.

Homogenization is done to obtain a uniform product, to reduce curd tension and to produce an apparent creaminess. It also aids subsequent whipping and helps to prevent butterfat from separating out. A homogenizer makes the use of certain fat containing ingredients possible which could not properly be incorporated into the mix by agitation alone.

Homogenization should be done at temperatures of 145° Fahrenheit or higher. Although it may be done immediately after pasteurization, it is frequently done during pasteurization as described in the chapter entitled "Market Milk Processing".

## Cooling and Aging

The rapid cooling of ice cream is extremely important. This prevents bacterial growth and keeps the mix from becoming more viscous.

Cooling may be done in a cabinet or plate cooler. A big advantage of the use of a plate cooler in conjunction with the pasteurizer is the savings in heat which is described in the chapter entitled "Market Milk Processing". The mix should be cooled to approximately 36° Fahrenheit and aged at temperatures below 40° Fahrenheit and above freezing.

Ice cream mix is aged to permit the protein and gelatin in the mix to soak up free water, thereby preventing the formulation of ice crystals. Aging periods vary from 4-48 hours, but it is generally believed that a period of not more than 24 hours is adequate.

## First Freezing and Packaging

This operation is done to partially freeze the mix and incorporate air into it by whipping. The increase in volume due to the entrapped air bubbles is called the overrun. This process may also be done on either a batch or continuous basis.

In the batch system, the mix is usually allowed to freeze to the proper consistency after which the refrigeration system is turned off and the product whipped until the maximum overrun is obtained. It is removed at 24° - 26° Fahrenheit.

In the continuous system, whipping is done as air is introduced under pressure. This generally yields a smoother ice cream. It is drawn from the freezer at 20° - 22° Fahrenheit.

After first freezing, every effort should be made to get the ice cream into the hardening room as quickly as possible. Partial melting at this point results in a coarse ice cream.

If the ice cream is to be transported in bulk containers to a packaging machine for filling into small retail units before being hardened, it is advisable to subject the packages to a cold air blast of -30° Fahrenheit to -50° Fahrenheit which freezes them very rapidly. The continuous system eliminates most of this problem since the packaging operation is geared to the capacity of the freezer itself and the packages are filled almost immediately.

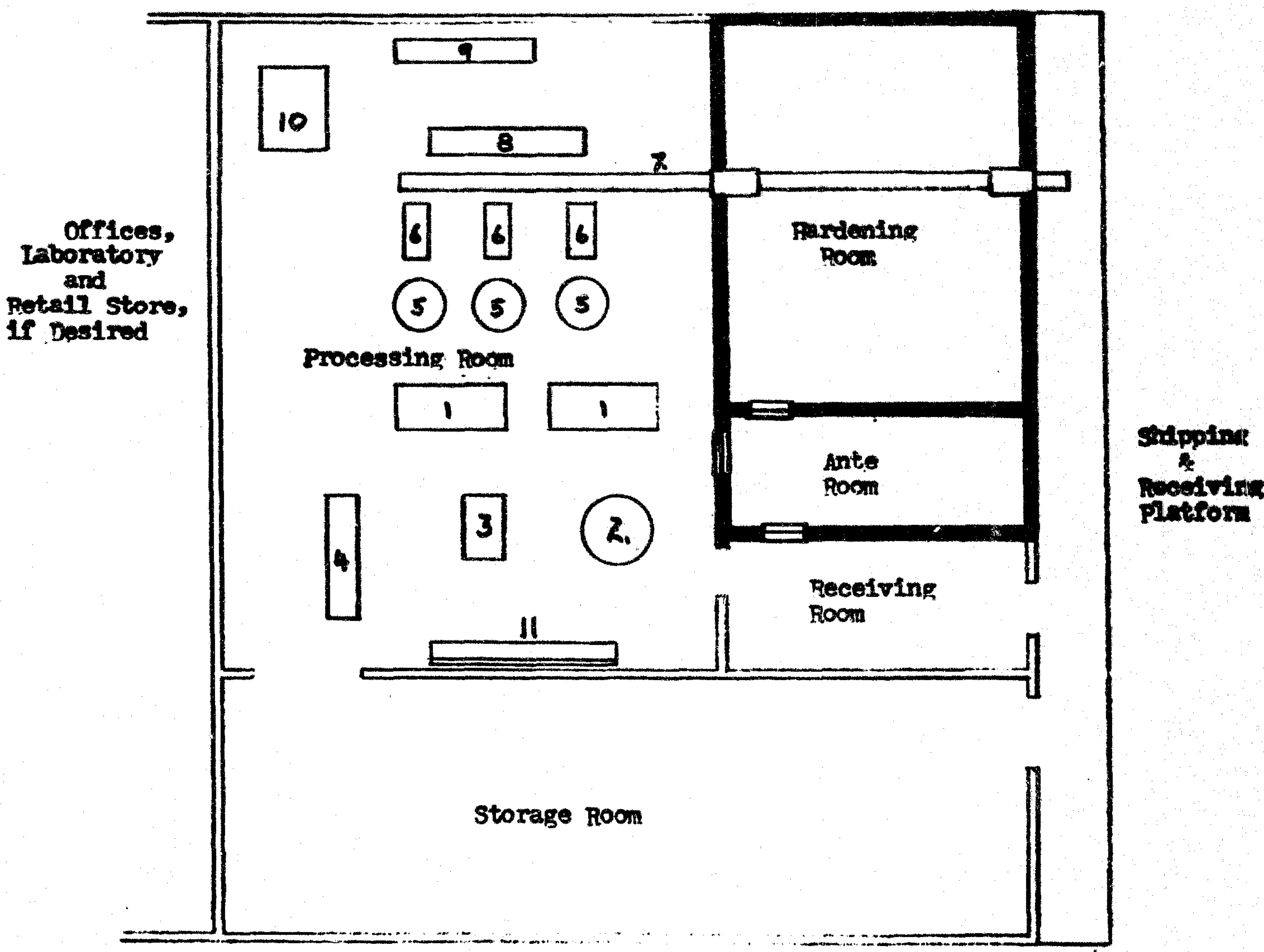
Most bulk containers are made of paper or metal. Recently plastic and laminated plastic containers have come into use. They are filled directly from the freezer in the continuous system. Batch operations require the use of special filling machines.

## Hardening

Ice cream in bulk containers and retail packages is taken to the hardening room and stored there until shipped. The temperature of the hardening room should be maintained at -10° to -25° Fahrenheit and it should be automatically controlled so that it does not fluctuate. Hardening should be completed within 24 hours.

## Delivery

Ice cream is usually shipped from the hardening room in refrigerated trucks. Solid carbon dioxide is used widely as a refrigerant but some trucks use cold salt brine in wall and overhead tanks. While this system may be necessary where dry ice is not available, the corrosive effect of the brine on the trucks is serious and becomes quite a problem. For long distance hauling, trucks with complete mechanical refrigeration systems should be used.




LAYOUT OF ICE CREAM PLANT

A plant similar to that shown above is capable of manufacturing 200,000 gallons of ice cream per year. Smaller plants will require the same types of equipment but fewer units and less storage space.

<u>Equipment Illustrated</u>

1. Storage vats
2. Round processing tank
3. Homogenizer
4. Cooler
5. Vats for mix
6. Freezers
7. Conveyor with special can pass doors
8. Work table
9. Chocolate dip tank
10. Popsicle brine tank
11. Sanitary wash sink

## COTTAGE CHEESE

Cottage cheese is the unripened curd of skim milk which is obtained primarily by acid development but may be aided by the addition of rennet or a special coagulating enzyme. Creamed cottage cheese is curd to which sweet cream has been added. Dry cottage cheese, sometimes called pot cheese, contains no additional ingredients except salt. The product can be made from either fresh skim milk or reconstituted low heat skim milk powder. Many times it is made from a blend of the two. Solids are kept near 9% although they are sometimes increased by the addition of dry milk to get more production from each vat. Cottage cheese is an excellent outlet for surplus skim milk. It is nutritious and requires little equipment to manufacture. Variations in some of the manufacturing operations can alter the size of the curd, firmness, dryness and flavor, which allows the plant operator to adjust his product to consumer preference.

### Receiving

Fresh raw milk is received, inspected and tested as discussed in the chapter entitled "Receiving Operations". It is then separated before being pumped to the processing room.

### Pasteurizing

Fresh skim milk is pasteurized by either the LTLT or HTST method. The latter is generally preferred because it shortens the operation when vats are to be set. When using reconstituted skim milk powder, further pasteurization is not necessary. Excessive pasteurization is detrimental to both the body and texture of the curd. Care must also be taken to prevent recontamination of the milk or the curd, especially by gas forming organisms which cause an undesirable flavor. Efficient pasteurization is essential, since any surviving organisms in the milk may grow during acid development and seriously influence the flavor, body and texture of the product. After pasteurization, the milk is cooled to setting temperature and pumped to open, steam jacketed vats.

Starter Culture

The greatest hazard in cottage cheese manufacture is the use of an inadequate starter culture. Since the acid development in the curd must be reasonably rapid in order to obtain high quality cheese, the use of old, slow cultures should be avoided. There are tests to determine the activity of a culture.

The starter culture is derived from a mother culture which may be obtained from commercial sources in a liquid or powder form. The mother culture is propagated in sterilized skim milk by asceptically inoculating the cooled milk with it and incubating the mixture in sterile, covered containers. New batches should be propagated regularly. Each day a small amount is used to inoculate the next batch, and the remainder is used to inoculate the starter. The mother culture will not have to be replaced unless it becomes contaminated.

A safeguard against the loss of a culture by contamination is to keep duplicate or triplicate samples of the culture.

The skim milk used for the starter should be of the highest quality with the lowest possible bacterial content. It is necessary that it be pasteurized at very high temperatures to assure this. After cooling to 70° Fahrenheit it is inoculated with the mother culture and incubated at that temperature until it has coagulated. It is removed from the incubator and held at 50° Fahrenheit or lower until used. Since the cultures contain two or more fermentation organisms, some of which ferment the by-products of others, incubation temperatures should be carefully controlled to prevent one organism from outgrowing another. This condition would affect the flavor and other qualities of the cheese.

Setting

The starter and rennet or special coagulator are added to the pasteurized skim milk in the vats and completely distributed by mixing. The mixture is then permitted to stand without further disturbance until it has reached the proper degree of coagulation. It is during this period that the flavor is developed.

The amount of starter which is added depends on whether the long or the short set method is to be used. In the short set method, the milk is held at a temperature of 85-92° Fahrenheit for three to five hours and the starter is added at the rate of 2-5% depending on how active it is. If the long set method is used, the milk is held for twelve to sixteen hours at 70-80° Fahrenheit in which case less starter is used. The setting time is often regulated to fit conveniently into other plant activities.

## Cutting

The curd has reached the proper degree of coagulation when it does not shatter or produce milky whey when distributed or cut. At this point the whey acidity should be checked.

Cutting is done by hand with curd knives in two operations. The spacing of the cutting edges will be determined by the size curd desired in the finished product.

A horizontal curd knife is run back and forth the length of the vat, overlapping cuts as little as possible. A vertical curd knife is then run from end to end crosswise.

## Cooking or Firming the Curd

To produce the desired whey separation and firming of the curds, heating with constant agitation is necessary. During the initial phase, agitation must be very gentle. If the capacity of the vat permits, warm water (110°-120° Fahrenheit) in amounts up to 50% of the volume of skim milk is added and the cheese mechanically stirred. If the vat is not large enough the temperature is slowly raised while the curds are stirred by running a cheese rake over the bottom and sides of the vat. As the temperature rises, the curd shrinks and gets firmer. At about 90° Fahrenheit mechanical agitation may be used but not violently enough to break up the curd particles. Free whey is exuded and the heating is continued and held until the curd reaches the desired degree of firmness. The firmness increases if the curd is chilled so it is usually tested after immersion in cold water.

Draining, Washing and Chilling

After the curd settles, it is shoved gently to the upper end of the vat with a curd rake. A strainer is placed in the drain and the valve opened. When the whey has drained to a level below the top of the curd pile a channel is formed down the middle of the mass to facilitate further draining. The strainer should be kept open during this process. Cold water may be added before the drainage is completed to a level where the curd is suspended. The curd is again stirred and after a few minutes it is drained. This may be followed by a second washing but excessive washing causes flavor loss. It may be necessary to squeeze the cheese gently to remove excessive moisture. The final rinse water should be well chilled to further firm the curd.

Salting

The drained cheese is salted by sprinkling dry salt over it and stirring it in thoroughly with a curd fork. Salt is usually added at the rate of one pound to 100 pounds of cottage cheese.

Creaming

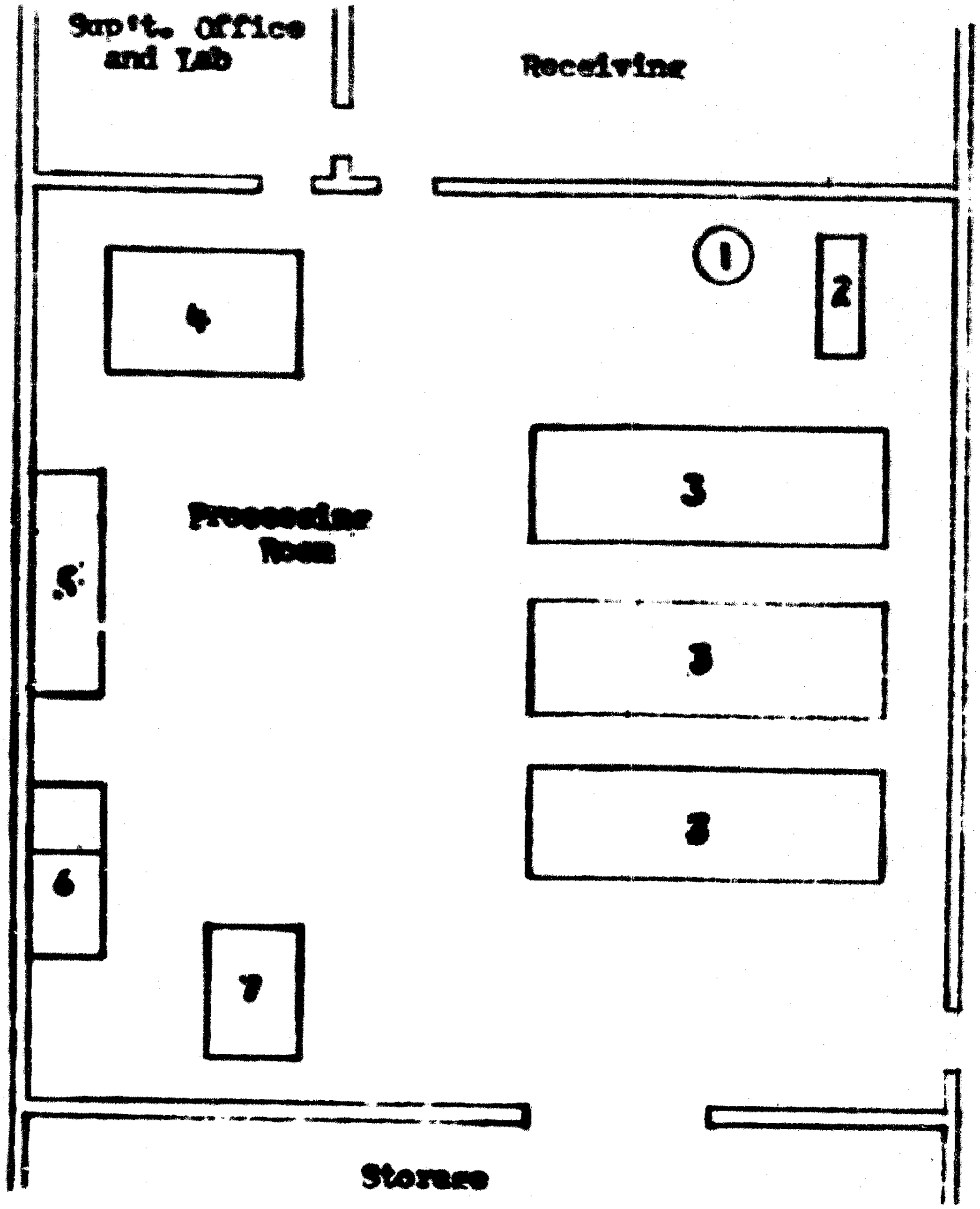
The creamed product may contain from 2 to 6% butterfat depending on food laws and consumer preference. The cream may be added in the form of pasteurized cream, or a pasteurized mixture of cream, milk or skim milk, in order to get the desired consistency. It is mixed with the cheese to get a uniform product in such a way that the size of the curd will not be altered.

Storing

If not packaged immediately, the cheese may be stored in cans. When stored at 35° Fahrenheit it has very good keeping qualities. The dry cottage cheese holds longer than the creamed type and this should be taken into consideration if it is to be stored. The creamed product may be prepared as needed.

## Packaging

Cottage cheese is usually sold in paraffined paper tubs, although many producers pack it in glass containers which may later be used as drinking glasses by the consumer. The containers are either filled by hand or by an automatic filling machine. If hand packed, each unit should be weighed before capping. The average yield of cheese is about 15 pounds per hundred pounds of skim milk.




LAYOUT OF COTTAGE CHEESE PLANT

If whole milk is received, the cream is separated and may be used for butter, ice cream or other dairy products.

<u>Equipment Illustrated</u>

1. Separator
2. Pasteurizer
3. Jacketed cheese vats with covers and mechanical agitators
4. Butter churn (optional)
5. Work table
6. Two compartment wash sink
7. Filling machine with scale

<u>Other Equipment Required</u>

Vertical and horizontal curd knives
Curd fork
Strainer-bottomed dipper
Whey strainers for vats
Curd scoop
Floating thermometer
Storage facilities for starter

## RIPENED HARD CHEESE

There are approximately eighteen distinct varieties of cheese which are called by over 400 different names. For purposes of classification, however, they may be divided into two general types - hard cheeses and soft cheeses. Both types may be ripened by the action of mold or bacteria with the exception of cottage cheese which is an unripened soft curd variety. This chapter will describe the manufacture of cheddar cheese, a typical ripened, hard cheese.

### Receiving

Raw whole milk is received as described in the chapter entitled "Receiving Operations". Clarification is not essential but yields a higher quality product. Although cheddar cheese may be made from raw milk, there are many advantages to be gained by pasteurization. The use of pasteurized milk makes it possible to standardize the manufacturing method and prevents the growth of detrimental bacteria during the aging process. A modified flash system of pasteurization is commonly used wherein milk is heated to 165° Fahrenheit and held at that temperature for fifteen to twenty seconds. It is then pumped to the cheese vat which should be steam or water heated in its jacket for temperature control. At this point the milk should be standardized to approximately 3.25% butterfat and the acidity determined.

### Ripening the Milk

A starter culture of lactic-acid bacteria, similar to butter starter, is added to the cooled milk at the rate of 0.25-0.50%. The milk is brought to the setting temperature of 84° - 88° Fahrenheit and allowed to ripen until the titratable acidity reaches 0.17-0.20%.

While the milk is being brought to the setting temperature, 1/3 ounce to 2 ounces of cheese color per one thousand pounds of milk may be added, depending on the shade desired. The milk must be stirred thoroughly at this point to ensure even distribution of the color.

### Setting the Curd

When the milk has reached the proper temperature, rennet extract is added at the rate of 2 1/2 - 4 ounces per one thousand pounds of milk and thoroughly mixed in. The rennet coagulates the casein in the milk and a firm curd is formed. Sufficient rennet is added to bring about a firm coagulation in approximately twenty minutes. The extract is usually diluted with water to twenty times its volume and should be added slowly.

## Cutting the Curd

After the curd is formed it is cut with cheese knives into small cubes about 1/4 to 3/8 inches square. This is accomplished by cutting the curd lengthwise with the horizontal knife and both lengthwise and crosswise with the vertical curd knife.

## Heating the Curd

The mass is slowly heated to a temperature of $98^{\circ}$ - $104^{\circ}$ Fahrenheit while the curd particles are kept from matting by agitation with a curd rake or mechanical stirrer. The heating process should take thirty to forty minutes during which time the curd particles eliminate whey and shrink to about one half their original size. The cheese maker decides when to stop heating by the feel and appearance of the curd particles and the increased acidity of the whey. At the proper time, the whey is drained off and the curd is piled on each side of the vat to drain and mat.

## Cheddaring the Curd

During this process the small curd particles mat together and form a solid mass. A large knife is used to cut the long piles into strips 6 to 10 inches wide. The strips are generally 8 to 14 inches long and 2 to 4 inches thick. They are turned at intervals of about fifteen minutes and eventually piled two to six slabs deep. The cheddaring process is completed when the small curd particles are completely fused. Considerable water and whey are eliminated in the process.

## Milling and Salting the Curd

The curd is passed through a curd mill where it is cut into strips 1/2 to 1 inch wide and 2 to 3 inches long. Moisture is also eliminated during this process.

The strips are stirred to prevent matting and salt is sprinkled on at the rate of 1 to 2 1/2 pounds per one thousand pounds of milk.

## Hooping the Curd

Cheese hoops are usually made of heavily tinned steel. They are lined with cheese bandages, a thin woven cotton material known as cheese cloth. A cloth circle is placed in the bottom of the hoop and a lighter, starched circle is placed over it. The curd is filled into the hoop and two or more circles are placed on top of it. The hooped curd is covered by a circular wood or metal disc.

## Pressing the Curd

The hoops are placed in a cheese press where the pressure is increased gradually as the moisture is expelled. The cheese remains in the press up to 24 hours, after which it is removed to straighten out the wrinkles that have formed in the bandages. The hoops are then put back in the press for another 24 to 48 hours. Large modern cheese plants have reduced the pressing time to considerably less time than that mentioned above.

## Paraffining the Cheese

The cheese is removed from the press and placed in a cool, dry place to permit the surface to dry. Drying time is reduced from several days to several hours by the use of fans.

When the cheese is dry, it is dipped in melted paraffine which has been heated to $212^{\circ}$ - $240^{\circ}$ Fahrenheit. This procedure covers the cheese with a thin layer of wax which closes the pores, kills any mold which may be on the surface and checks moisture loss during curing.

Curing

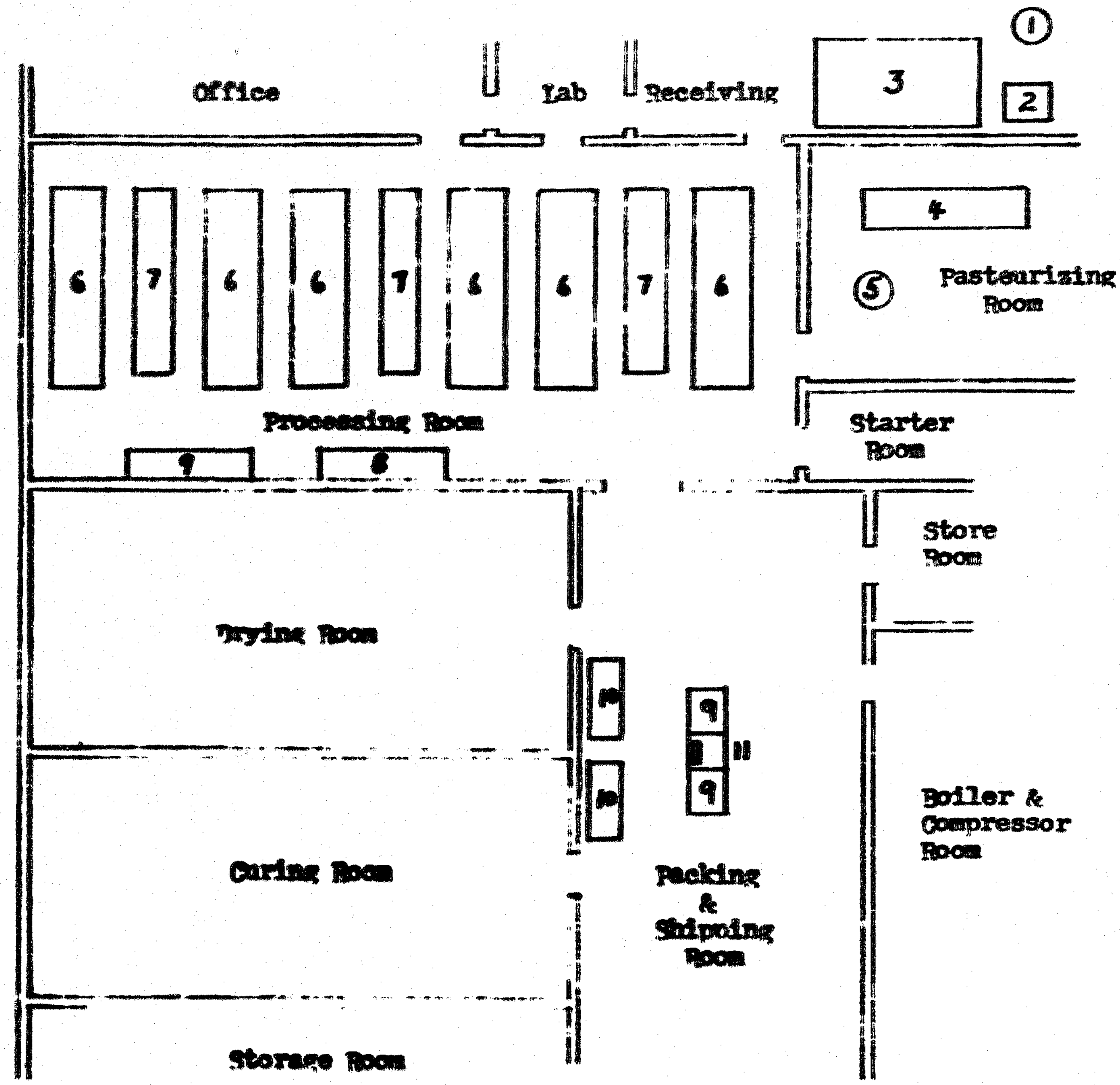
The cheese is placed on shelves in a well ventilated room where the temperature is maintained at 40° - 65° Fahrenheit. The lower the temperature, the slower the curing progress, and slow cure generally yields better quality cheese. The use of pasteurized milk permits the use of higher temperatures, thus shortening the ripening process. If unpasteurized milk is used the cheese must be cured at a temperature of not less than 35° Fahrenheit for a minimum of sixty days to assure the killing off of any pathogenic organisms which may have survived the manufacturing process.

Cheddar type cheese may also be made from skim milk, milk from which part of the cream has been removed, or reconstituted dry milk, but regulations generally require a minimum milk fat content and any cheese falling below the minimum must be so labeled.

Storage and Distribution

If cheddar cheese is to be held for a long period, it should be stored at a temperature of 40° - 50° Fahrenheit. Cheddar is sold in many shapes and sizes and is usually handled through wholesalers. It is frequently cut into consumer-size units and repackaged by the wholesalers before being distributed to retail outlets. Cheese which has been held one to three months is marketed as aged cheddar and brings a higher price.

The whey which results from the manufacturing process may be sold as a swine or poultry feed supplement, made into whey cheese or processed for the recovery of milk sugar.




LAYOUT OF RIPENED HARD CHEESE PLANT

A plant of this type can handle 60,000 pounds of milk per day. The milk is handled as for market milk. If it is not used immediately, it must be clarified and cooled before it is pumped to the temporary storage tank. The size of the curing and drying rooms will be determined by the type of cheese being manufactured.

Equipment Illustrated

1. Clarifier
2. Cooler
3. Temporary storage tank
4. Pasteurizer
5. Separator
6. Cheese vats
7. Cheese presses
8. Wash sink
9. Work tables
10. Paraffine tanks
11. Scale

Other Equipment

Curd knives
Curd rakes
Curd mill
Cheese hoops
Cheese bandages
Cheese circles

# CULTURED BUTTERMILK

Although buttermilk was once merely a by-product of butter churning, consumer demand and other factors have changed this situation until practically all of the buttermilk sold commercially at the present time is of the cultured type.

Cultured buttermilk may be made from skim milk, whole milk or dry milk and combinations of them with or without the addition of butterfat. Buttermilk may be made with the same equipment that is used for sweet milk.

## Receiving

Every effort should be made to use milk of good quality for buttermilk making. The defects of poor quality milk will be magnified in the buttermilk making process since the incubation period through which it must go may also favor the growth of undesirable bacteria. Although the use of poor quality milk may be partially overcome by higher pasteurization temperatures, the increased heat will also have an adverse effect on the flavor and consistency of the finished product. Milk should be received and tested as outlined in the chapter entitled "Receiving Operations".

## Pasteurizing

All milk used for buttermilk should be pasteurized. Recommended pasteurization temperatures are generally higher than for market milk, usually between 160° - 190° Fahrenheit for a minimum of thirty minutes. The milk may also be flash pasteurized but excessive heat should be avoided as it may make the product too thick.

Many smaller plants use a jacketed vat with agitators wherein the entire buttermilk making process may be carried on. The milk can be pasteurized, cooled, inoculated, incubated and recooled before bottling.

The milk may or may not be homogenized.

## Inoculating and Incubating

The milk is cooled to 70° - 72° Fahrenheit for inoculation. A brief description of the handling of starter cultures is given in the chapter entitled "Cottage Cheese". Detailed information concerning the propagation and use of starter cultures should be obtained from the supplier of the original culture. The use of a high quality, vigorous culture is extremely important.

The amount of inoculation required varies with the vigor of the culture, the time to be allowed for incubation and the incubation temperature, but generally 1-2% is used and the milk allowed to incubate for twelve to fourteen hours.

The inoculation of the milk should be so timed and the amount of inoculum so controlled that it will be ready for cooling and bottling at a time which will fit conveniently into other plant activities. After inoculation, the milk should be left in a quiescent state at a temperature of 68° - 72° Fahrenheit until it has coagulated and the coagulum has formed a continuous gel structure. When the acidity has reached 0.80% the curd is gently stirred until a smooth consistency is obtained. Violent or prolonged agitation should be avoided since it may cause a foamy product and whey separation.

The buttermilk is cooled to about 50° Fahrenheit after which it is bottled.

It is common practice to standardize the buttermilk before bottling or otherwise prepare it to comply with consumer preference. Many operators thin the product by addition of whole milk or cream. Others may add butter which has been melted and diluted with water or butter granules. Most manufacturers add salt, after which the buttermilk is stirred, cooled and bottled.

## Bottling

The bottling of buttermilk and the handling of returned bottles are the same as outlined in the chapter entitled "Market Milk Processing Plant". Bottling should be accomplished at 50° Fahrenheit.

# SPECIAL MILKS - CHOCOLATE, FORTIFIED, STERILIZED

## Chocolate Milk

Chocolate milk is an important dairy product and is used by many people who otherwise would not drink milk. When it contains less than 2% butterfat it is generally called chocolate flavored drink or chocolate dairy drink.

It may be made from whole milk, skim milk, condensed skim milk, sweetened condensed milk, reconstituted dry milk or combinations of these. The product is usually flavored with cocoa or chocolate, sugar, a small quantity of salt, vanilla and spices. A stabilizer, such as sodium alginate, gelatin or carrageen is usually added to raise the viscosity and hold the cocoa particles in suspension.

The flavoring ingredients may be added in dry form or made into syrup and mixed with the milk. The product generally contains about 1% cocoa and from 5-7% sugar.

When using dry ingredients, the cocoa and part of the sugar are mixed together in equal proportions and added to the hot ($150^{\circ}$ Fahrenheit) homogenized milk with constant agitation. The stabilizer and another portion of the sugar are blended together and added, followed by the remaining sugar. The mixture is heated to $145^{\circ}$ - $150^{\circ}$ Fahrenheit and held at that temperature for thirty minutes while being stirred constantly. It is then cooled and bottled in the same way as regular milk.

Chocolate syrup may either be purchased or made up at the dairy using a milk or water base. The milk is heated to $140^{\circ}$ - $145^{\circ}$ Fahrenheit and homogenized at fifteen hundred to two thousand pounds pressure. The syrup is added, usually at the rate of one part syrup to nine parts of milk and the mixture held at $140^{\circ}$ - $145^{\circ}$ Fahrenheit for thirty minutes. It is then cooled rapidly and bottled.

## Fortified Milk

Since the diet of most people is deficient in vitamin D, it has become a common practice to add this vitamin to milk.

Vitamin D concentrates may be obtained from commercial laboratories and are usually made from fish liver oils or irradiated ergosterol suspended in edible vegetable oil, sterilized milk or cream. The amount used should be calculated to supply 400 units of vitamin D per quart. The concentrate is added in the holding tank and the milk is then pasteurized and homogenized.

Another method of adding vitamin D to milk is by irradiation. The milk is exposed to direct ultra-violet radiation from carbon arcs or quartz mercury vapor lamps as it flows by them in a thin film. Very large irradiators are able to supply the required 400 units but most operators find it less expensive to use vitamin concentrates.

## Sterilized Milk

Sterilized milk is so treated that it may be held without refrigeration for extended periods. The heat treatment it receives kills all vegetable forms and all but a very few heat resistant spores. The containers are hermetically sealed and the milk has a shelf life of a month or more.

Milk may be clarified, after which it is homogenized at 150° Fahrenheit. It is filled into narrow neck bottles, leaving approximately 2 1/2 inches of headspace. It is then capped with airtight crown closures.

In batch processing sterilized milk, the bottles are placed in crates and the crates put into a large pressure oven or autoclave. The temperature is raised to 220° - 230° Fahrenheit and held there for twenty to forty minutes. After sterilization, the crates are removed and the bottles are allowed to cool naturally.

The equipment used for continuous processing is basically the same as a soaker-type bottle washer. The filled and capped bottles are placed in cradles which move on a continuous conveyor system through a series of tanks containing water of increasing temperature. The speed of the conveyor is so timed that sterilization is effected.

## MANUFACTURING DRY MILK

The use of dried milk products has spread into every food manufacturing industry in which normal milk is used. They are used in the baking industry, in ice cream and candy manufacture, in the meat industry, in prepared cake and biscuit mixes and in many other products. Dry skim milk is becoming increasingly popular for home use where it may be reconstituted for use in foods or drunk as a beverage by itself. Dried milk products are also widely used as livestock and poultry feed.

In addition to dry whole and dry skim milk, this group of products also includes dry cream, dry buttermilk, dry whey and dry ice cream mix. Standards have been established for dry skim milk by the industry itself and also by government regulations. The standards require that the moisture content should not exceed 5%.

The two most widely used methods for drying milk are the spray method and drum, or roller process. There are two general types of drum dryers on the market - "atmospheric" drums and "vacuum" drums.

### Spray Process

Although there are several variations of this process, they all have certain principles in common.

Either skim or whole milk of good quality is pumped from a storage tank to a vacuum pan where part of the water is removed. The condensed milk is sprayed through nozzles into a large drying chamber through which hot air is blown at high velocity. These chambers are generally made of stainless steel.

As the milk enters the chamber in the form of a fine mist, the tiny divided particles are dried as they fall to the bottom. The chamber is so constructed as to prevent the fine particles from leaving the chamber with the outgoing air. The dried milk on the floor of the chamber is subsequently removed by mechanical devices or a vacuum system. In older systems the milk is removed manually with a scoop.

The product is generally packed in hermetically sealed containers because of its hygroscopic properties. Products with a high fat content, such as dry whole milk and cream, are packed in cans containing an inert gas, such as nitrogen or carbon dioxide. This is done first by vacuum creation within the container and then replacing the air with inert gas when releasing the vacuum.

Newer methods have been developed wherein the product is dried in a closed system in the presence of inert gas.

High fat products should be cooled as quickly as possible after leaving the drying chamber. This may be accomplished with currents of cold air or in coil vats utilizing a refrigerant.

Spray driers are used in the processing of dry whole and skim milk, dry cream and dry sweet-cream buttermilk. Advantages of this system over the atmospheric drum process are the increased solubility and the more natural flavor brought about through use of lower temperatures.

## Atmospheric-Drum Process

This type of drier consists of two large, steam heated, horizontal, rotating drums placed side by side. It derives its name from the fact that the milk is continually under atmospheric conditions during drying.

The milk either flows or is sprayed on the surface of the drums and quickly dries. Vapors are removed by means of a large vapor stack. The dried milk is removed from the surface of the drums by sharp, close fitting blades as the drums rotate. It comes from the rollers in a thin sheet which is easily broken into flakes.

Dry skim milk, dry buttermilk and dry whey are commonly made by this system, much of which goes into animal feed. The drying temperatures frequently impart a "cooked" taste to the milk and the finished product is only 60 to 70% soluble as milk dried by the spray process.

## Vacuum-Drum Process

Vacuum-drum driers are similar to atmospheric-drum driers. The main difference is that the drums are encased and the process takes place in a partial vacuum. Thus, lower drying temperatures can be used which give the finished product better solubility and flavor.

The drums may dip into the milk or the milk may be sprayed on them where it dries and is removed by scrapers. This method is commonly used in the manufacture of dry skim milk, dry buttermilk and dry whey.

Grinding and Milling

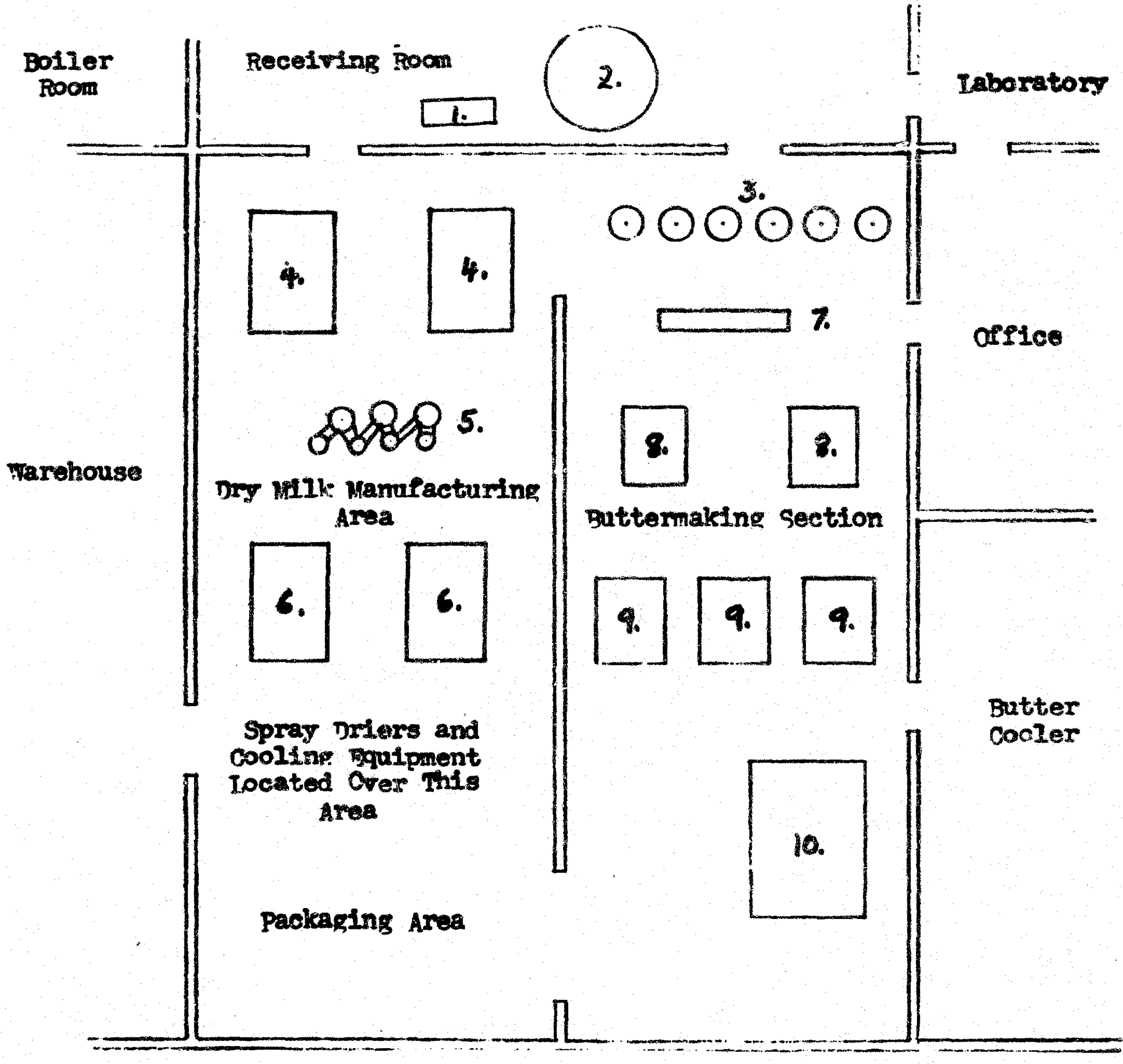
Dried milk made by the drum process may be passed through grinding and bolting machines and milled before being packed in the final container. Frequently, however, it is merely put in sacks and sold as "dried flakes".

Theoretically, spray process products are ready for final packaging immediately after drying, but in many cases they are passed through a bolting machine to avoid lumps.

Packaging and Marketing

There has been a recent surge in the popularity of dry skim milk for home use. Many diet or health conscious persons drink it regularly in preference to whole milk while many other families consume it because it can be obtained for as little as one fourth the cost of fresh, whole milk. Recent improvements in processing have resulted in a more palatable and easily dissolved product which for many years were the two chief reasons for its rejection by consumers.

Dry milk products are shipped and marketed in a variety of containers. For commercial use they are commonly shipped in lined wooden barrels, steel or fiber drums or paper bags.




LAYOUT OF DRY MILK MANUFACTURING PLANT

A plant such as this may profitably run a buttermaking operation in conjunction with the manufacture of dry skim milk. Buttermilk will also be a by-product and may be packed in either liquid or dry form. Milk should be handled as for market milk. It is then cooled and pumped to a temporary storage tank until used.

<u>Equipment Illustrated</u>

1. Cooler
2. Whole milk temporary storage tank
3. Separators
4. Skim milk storage tanks
5. Three stage evaporator
6. Condensed skim milk storage tanks
7. Short-time pasteurizer
8. Cream storage tanks
9. Churns
10. Buttermilk storage tank

## RECONSTITUTED DRY MILK PRODUCTS

The excellent keeping qualities of dry skim milk and anhydrous milk fat make it possible to establish recombining plants to serve areas where a sufficient supply of fresh milk is not available.

Spray process dry skim milk, if properly reconstituted, can hardly be distinguished from fresh skim milk. When combined with anhydrous milk fat, it has almost the same qualities of taste and consistency as fresh whole milk. A variety of other products can also be made in a recombining plant with little extra expenditure. In addition to skim milk, whole milk and cream, such plants may produce buttermilk, chocolate milk drink, tropical fruit milk drinks, sour cream, ice cream, ice milk, yogurt, cottage cheese and local fermented milk drinks.

### Water Supply

The importance of a good quality, safe water supply in an operation of this type cannot be overstressed. In addition to being potable, extreme care must be taken to guard against undesirable flavors and odors which may be caused by minerals or other elements in solution in the water. Since these factors will impart a disagreeable quality to the finished product, it may be necessary to treat the water to avoid this. The method of treatment will be dictated by the specific cause of the condition.

It is also essential that the water source will supply enough water for both manufacturing operations and cleaning. An in-plant chlorination system may be desirable in some cases.

Adequate laboratory facilities and testing equipment for analysis of both the water and the finished products should be provided.

### Raw Materials

The two basic raw materials, other than water, are low-heat, spray dried non-fat dry milk and anhydrous milk fat. Dry skim milk preparation and standards have been discussed earlier in this report. Anhydrous milk fat, sometimes called butter oil, is a product which has had most of the moisture removed and contains 99.8% butterfat. It may be safely stored in airtight containers without refrigeration for two to three months at a temperature below 100° Fahrenheit. The dry skim milk may be stored indefinitely if protected from moisture.

Other raw materials, such as flavor mixes, cocoa, sugar, etc., should be stored in a cool, dry, rodent and insect proof area.

## Blending

Water is heated to at least 100° Fahrenheit at which time the dry skim milk is added. This is done in a blender pump equipped with a hopper, or funnel, to facilitate dumping of the dry ingredients. The mixture is thoroughly agitated in the pump and moves to the pasteurizer. A small quantity of salt may be added to enhance the flavor.

## Pasteurizing and Mixing

Batch pasteurizers are commonly used in plants of this type because they also double as mixing vats in the preparation of some products.

Vat pasteurizers should be equipped so that the product can be subjected to agitation until the vat is completely drained.

When pasteurizing skim milk, the temperature is raised to at least 143° Fahrenheit and held for at least thirty minutes. After pasteurizing, the product should be cooled immediately to 40° Fahrenheit.

In the preparation of fluid whole milk, the steps of heating the water and blending are the same. Anhydrous milk fat is heated until it is in a liquid state and added to the skim milk with thorough agitation. The skim milk should be at least 115° Fahrenheit at this point. The temperature is brought up to 145° Fahrenheit and a small quantity of salt is added if desired. Pasteurization is the same as that outlined for skim milk.

## Homogenizing

Fluid whole milk and mixtures of ice cream are homogenized after pasteurization at 2,000 to 2,500 pounds pressure and cooled.

## Ice Cream

The solids are recombined as for whole milk and the temperature raised to 158° Fahrenheit. Sugar, stabilizer and flavoring, or prepared ice cream mix are added with agitation and the mixture is brought up to a pasteurization temperature of not less than 161° Fahrenheit. It is held for not less than thirty minutes and homogenized at the pasteurization temperature. The mixture is cooled to at least 40° Fahrenheit and should be frozen within twenty four hours. The amount of air incorporated during freezing may be varied to achieve desired texture. The frozen ice cream should be hardened at -10° Fahrenheit.

Ice cream should contain approximately 10% fat and 11% non-fat milk solids. Ice milk mixtures may contain 3 - 6% fat and from 12 - 15% non-fat milk solids.

Special equipment for ice cream manufacture consists of a batch freezer and compressor, a cup filler and freezing facilities capable of maintaining a temperature of -10° to -20° Fahrenheit.

## Cooling

All products should be cooled to approximately 40° Fahrenheit before final packaging, preferably immediately after pasteurization or homogenization. The cooler may be either a cabinet or plate type.

## Bottling

The milk is pumped or flows from the cooler to an accumulation tank before it moves to the filler. The filling machine should be capable of handling bottles of different sizes and have a capper attached.

Bottle washing equipment should be set up as discussed earlier in this report.

The bottles are cased and taken to storage where the temperature is maintained at 35° Fahrenheit.

# QUALITY CONTROL

All tests contained in this section are considered **"official"** by the American Public Health Association, 50 West 50th Street, New York, New York and are published in detail in their book entitled Standard Methods for the Examination of Dairy Products.

The tests described are those considered necessary to establish the quality of the products from a chemical or bacteriological standpoint.

## Acidity

The acid which occurs naturally in milk is lactic and is derived from the milk sugar and lactose. It is produced by action of lactic acid bacteria on the sugar. Milk stored below 50° Fahrenheit develops acidity above 0.17% very slowly. 0.17% is considered normal for fresh milk. Above that temperature, the acid content develops in direct relationship to the storage temperature.

### A. Determination of acidity in milk -

1. Equipment -

    17.6 ml. pipette, delivers 18 grams milk
    100 ml. small mouth Erlenmeyer flask
    50 ml. burette graduated in 1/10 ml.
    Burette stand and clamp to support the burette
    Standard alkali solution, 1/10 normal sodium hydroxide
    1% phenolphthalein in neutral alcohol
    Distilled water

2. Procedure -

    Pipette 18 grams of milk into the flask
    Add 30-40 ml. distilled water to the flask
    Add 3-4 drops phenolphthalein solution to the flask
    Add standard alkali from the burette to the flask slowly while swirling contents of the flask until a faint pink color persists for 30 seconds
    Record the milliliters of alkali used

3. Calculations -

$$\frac{\text{Milliliters of alkali used}}{20} = \%\ \text{lactic acid}$$

This formula is appropriate for milk only when using a 17.6 ml. pipette

Example: 4.8 ml. alkali used - then $\frac{4.8}{20} = 0.24\%$ lactic acid

B. <u>Determination of acidity in cream, ice cream mix, condensed milk or other milk products with high viscosity</u> -

1. Equipment -

The same as for milk except an accurate balance is substituted for the pipette and an electric hot plate is required. Cream and other high viscosity milk products can not be pipetted accurately.

2. Procedure -

Weigh 9 grams of the product into a flask
Add distilled water and shake to mix
Heat mixture to boil and boil for approximately 1 minute to remove carbon dioxide
Allow the flask and contents to cool to room temperature
Add 3-4 drops of phenolphthalein solution and titrate as for milk

3. Calculations -

Using 9 grams of the milk product

$$\frac{\text{Milliliters of alkali used}}{10} = \%\ \text{lactic acid}$$

Example: 2.4 ml. alkali used - then $\frac{2.4}{10} = 0.24\%$ lactic acid

<u>Butter Analysis</u> (Kohman method)

This determination gives the percentage of fat, moisture, curd and salt present.

1. Equipment and reagents -

Moisture test scale and reagents
Aluminum cup approximately 200 ml. capacity
Electric hot plate
17.6 ml. pipette
Graduated cylinder 200 ml. capacity
Burette, burette clamp and burette stand
White porcelain dish 100 ml. capacity
Desiccator with desiccant
Small spatula
Silver nitrate solution (29.062 grams made up to 1 liter with distilled water)
Potassium chromate solution, 10% in distilled water
Petroleum ether, naptha or high test gasoline

2. Procedure -

<u>% Moisture:</u> Sample should be mixed at approximately 70° Fahrenheit until creamy.
Station weight on 10% beam at 10 and the 20% weight on 0.
The scale should be level.
Place the moisture cup on the right hand pan and balance the scale with weights and record the weight if several samples are to be analyzed simultaneously.
If only one sample is to be analyzed the weights may be left on the scale.
Place the 10 gram weight on the left hand pan and accurately balance the scale by adding butter in the aluminum moisture cup.
Heat the sample on a hot plate until foaming ceases and the residue is light tan in color. This indicates removal of all of the moisture.
Cool the cup in the desiccator to room temperature and reweigh by moving the 20% beam from 0 to a point where the scale balances. The reading is direct, that is, the percentage of moisture is the reading on the 20% scale.

<u>% Butterfat:</u> To determine butterfat, add 100 ml. of solvent to the cup and swirl to dissolve the fat. Allow it to stand for five minutes. Pour the solvent off carefully to retain the salt and the curd in the cup.
Add a second portion of 100 ml. of solvent and repeat the swirling and let stand again.
Pour off the solvent and retain for use in the first extraction of the next sample.
Dry the residue in the cup on a hot plate taking care not to burn the curd.

Cool in the desiccator and reweigh. The weighing is done by removing the 10 gram weight from the left hand pan. The 20% scale weight is returned to 0 and the 10% scale weight is moved from 0 to a point on the scale where it balances. The difference between 10 and the reading on the scale indicates the percent salt and curd combined. This percentage plus the percent moisture subtracted from 100 is equal to the percentage of butterfat.

% Salt: Salt is determined by adding 176 ml. of warm distilled water to the cup which dissolves the salt but not the curd. The solution should be thoroughly mixed. Pipette 17.6 ml. of this solution to the white casserole. Add 3-4 drops of chromate solution to the casserole. Add silver nitrate solution slowly from the burette to the casserole until a faint reddish brown color persists for 30 seconds.
The number of milliliters of silver nitrate solution used equal the percent of salt.

% Curd: Curd percentage is obtained by subtracting the percentage of salt from the combined salt and curd percentage.

Butterfat (Babcock method)

This is one of the most important tests to be made since most milk prices are based on the percentage of fat present in the milk. The method described for whole milk may be used, with modifications, for all dairy products.

1. Equipment -

   Babcock centrifuge
   17.6 ml. pipette
   Thermometer
   Pair of dividers
   17.5 ml. acid measuring pipette
   Sulfuric acid (specific gravity 1.82-1.83)
   Babcock milk test bottles
   Water bath, electrically or gas heated

2. Procedure -

CAUTION: Severe burns result from contact of sulfuric acid with skin. Care in pipetting and handling is required.

Add 17.6 ml. of milk (18.0 grams) at 60° - 70° Fahrenheit to Babcock milk bottle (18 gram, 6 inch, 8%)
Add 17.5 ml. acid from pipette slowly with swirling. When all of the acid has been added the mixture is light pink in color.
Place the bottle in the centrifuge and revolve for 5 minutes.
Add hot water (135° - 140° Fahrenheit) until bulb is filled.
Whirl centrifuge for two more minutes. Add hot water until all of the fat is in the neck of the flask. Whirl the centrifuge for one more minute, then place the flask in a water bath for 5 minutes at 135° - 140° Fahrenheit.
Measure the length of the fat column with the dividers measuring from the extreme top to the extreme bottom of the fat. Place the dividers on the 0 mark on the flask and measure the distance up the column. Read the top mark of the divider to the nearest 1/10%. This is the butterfat content.

Experience is necessary to perform the Babcock test properly since temperature, rate of acid addition and amount of mixing influence the ease and completeness of separation and measurement of the fat.

Methylene Blue Test

This test is used by laboratories with very limited laboratory facilities.

It is a qualitative test for estimating bacteria present. Interpretation of the test is based entirely on experience and it is deemed inadvisable to describe the procedure here.

Phosphatase Test

This test is used to determine the efficiency of pasteurization.

The enzyme phosphatase occurs naturally in milk and is readily destroyed by heating at 143° Fahrenheit for thirty minutes or at 160° Fahrenheit for fifteen seconds to inactivate the enzyme.

This test requires special equipment and experience in interpretation of the results and, therefore, is not described here. The procedure must be taught by an instructor directly to the student.

## Sedimentation Test

This test is designed to demonstrate the quantity of solid extraneous and foreign material present in the product. It is an indication of the sanitary condition of the milk producer's dairy.

Many methods are used but they all involve filtering a measured quantity of the milk product through a cotton disk and counting the number of hairs and other material which are trapped by the filter.

Experience can be gained in estimating conditions from this test by observing the sanitary situations in various milking barns and actually correlating the sediment findings with the milking barn conditions

## Bacterial Counts

Samples of milk products are taken under sterile conditions for this test. The viable bacteria are determined by plating dilutions of milk in culture dishes, covering them with melted agar, incubating the dishes for 48 hours at 98° Fahrenheit and counting the colonies which grow on the plates.

1. Equipment -

   1 ml. bacteriological pipettes and cans for sterilizing
   150 ml. dilution bottles and rubber stoppers
   Petri dishes (culture dishes) and cans for sterilizing
   Nutrient agar
   Distilled water
   Pressure cooker
   Dry heat oven
   Thermostatically controlled incubator
   Scale
   Bunsen burner or alcohol lamp
   Spatula

2. Procedure -

Pipettes and culture dishes are sterilized in cans in the oven at 450° Fahrenheit for 4 - 5 hours.
Dilution bottles are filled with 99 ml. of distilled water, stoppered and sterilized in steam pressure cooker for 15 minutes at 15 pounds of steam pressure.
1% nutrient agar solution is sterilized in the same way.
Samples of the dairy product are either taken from the sterile container in which they were collected by measuring 1 ml. of the bluid product by sterile pipette, or if the sample is a solid, by weighing 1 gram, the transfer being made with the spatula which has been flamed in the burner and cooled out of contact with any surface, into the dilution bottle containing 99 ml. of sterile distilled water. This is a 1-100 dilution.
The dilution bottle is closed with its sterile stopper and shaken thoroughly to mix. 1 ml. of this dilution is withdrawn with a second sterile pipette and transferred to a second dilution bottle containing 99 ml. of sterile water, the stopper is replaced and the bottle shaken to thoroughly mix. This is a 1-1,000 dilution.
Another 1 ml. sample is withdrawn from the 1-100 dilution bottle with the same pipette and placed in the culture dish appropriately marked. Dilutions of 1-100, 1-1,000, 1-10,000 and 1-1,000,000 are usually plated on each sample.
Approximately 10 ml. of cooled melted agar is poured in each inoculated plate and swirled gently to mix the dilution and the agar. When the agar solidifies the plates are inverted and incubated for 48 hours.
After incubation the number of colonies are counted on each plate and the count multiplied by the dilution indicates the number of viable bacteria per gram or per milliliter of product.
The counts obtained are useful in estimating the quality of the milk to determine its best possible utilization.
Modifications of the test, such as "little plate" are used when rapid estimation is desired. This involves microscopic examination of the plates after 12 hours of incubation.
Sterile technique must be followed scrupulously throughout the bacterial counting and preparation processes.

NOTES

Due to the perishable nature of most of the milk products, a properly equipped laboratory is essential for quality control.

Ideally, the laboratory should be staffed with a thoroughly trained technician. If this is not possible, an alert employee should be given university or college training or placed in a private laboratory for intensive training in the procedures involved in the tests described above.

## LEGAL REQUIREMENTS

Because dairy products have long been recognized as potential carriers of serious diseases, there has been general acceptance of public control over the conditions under which milk is produced and marketed. In most localities the dairy industry is more closely regulated than any other segment of the economy and enforcement is effected by agencies at all governmental levels.

Most regulations are intended to protect the consumer in two ways. Minimum standards for butterfat content and other constituents help to prevent him from being cheated. Sanitation requirements, which begin on the farm and end when the milk is delivered to the consumer, protect his health.

In areas where there are no regulations to cover the handling of milk on the farm, it is the responsibility of the dairy plant operator to check his producers regularly. This is usually done by field men who visit the farms unannounced. Conditions are inspected and checked off on a prepared form. The penalty for noncompliance may range from simply paying a lower price for the milk to rejecting the milk completely until the undesirable condition is corrected.

Many dairy operators use a bonus plan whereby the producer is paid a premium for high quality milk. Where these plans are in use, the milk is graded on flavor, sediment, bacterial count and non-fat solids.

The primary purpose of a milk ordinance is to protect the public health. Consequently, the requirements should be strict and there should be adequate provisions for enforcement. However, if the requirements are too idealistic and too far ahead of conditions that prevail in the area, a problem is created which defeats the purpose of the law by causing general noncompliance.

A complete milk ordinance will cover every phase of the production and handling of milk. Some of the features which should be included are outlined below.

### Enforcement Provisions

1. Set up an inspection service.
2. Provide for a system of revocable permits to be issued to producers and distributors.
3. Provide penalties for noncompliance.

Milk Quality and Composition

1. Specify maximum bacterial count - standards may range from 200,000 per milliliter for raw milk to 1,000,000 per milliliter in milk for pasteurization.
2. Specify minima for fat and total solids in milk and other dairy products.

Dairy Plant Requirements

1. General - Regular physical examinations for employees, ambulant cases of illness to be kept away from contact with milk, proper sterilization and cleaning of equipment and bottles, protection against flies and other air borne contaminants, use of flush type valves, potable water supply, milk from tuberculin tested cows which are also free of Bang's disease, screens, sanitary floors and walls, separate receiving and processing rooms, personal cleanliness and habits of employees, rapid handling or prompt refrigeration of milk, adequate bacteriological and sediment testing.

2. Pasteurized Milk - Minimum pasteurization temperature and time, accurate recording thermometers, conditions to prevent recontamination of pasteurized milk, precautions to prevent leakage of milk before pasteurization is completed and also that the surface layer and the foam are maintained at pasteurizing temperature.

3. Raw Milk - From certified cows, no mixing of milk from more than one herd prior to receipt, periodic examination of cows.

Dairy Farm Requirements

1. Barn Conditions - Adequate light, ventilation and drainage, frequent manure removal and proper disposal, tight window and door screens, clean floors, walls, ceilings and ledges, fresh bedding and air relatively free from dust and foul odors.

2. Milk Room or Milk House - Separated from barn and contaminated surroundings, clean interior, screened, adequate potable water supply for cleaning and facilities for washing, sterilizing and storing equipment, ample cooling equipment and facilities.

3. Utensils - Construction and condition, hooded milking pails, clean milking suits, thorough washing and sterilization, uncontaminated storage.

4. Milking and Milk Handling - Clean dry hands when milking, clean clothing, wiping of udders and teats with clean damp cloth, prompt removal of milk from barn, exclusion of fore milk and milk from cows within 30 days before and 5 days after parturition, healthy employees.

5. Cows - Periodically tested for tuberculosis and Bang's disease, in good health and with normal udders.

Standards for Dairy Products

The following table is designed to give the reader a general idea of the quantity of butterfat which one would ordinarily expect to find in some important dairy products. The figures represent neither minimum nor maximum standards but have been averaged from those given in the laws and other published material.

| PRODUCT | PERCENT BUTTERFAT |
|---|---|
| Whole milk | 3.25 |
| Skim milk | 0.12 |
| Condensed milk | 7.90 |
| Sweetened condensed milk | 8.50 |
| Condensed skim milk | 0.37 |
| Butter | 83.0 |
| Evaporated milk | 7.90 |

| | |
|---|---|
| Ice cream | 10.0 |
| Creamed cottage cheese | 4.0 |
| Ripened hard cheese | 32.0 |
| Light cream | 19.0 |
| Heavy cream | 36.0 |

It is possible to incorporate less expensive edible oils into some dairy products as a substitute for butterfat with little, if any, change in flavor. If this is done it is important that such products are correctly labeled so that the consumer does not pay a high price for an inferior product. Many localities prohibit the practice entirely.

Most laws regulate the butterfat content of dairy products and at the same time set standards for total milk solids and, in some cases, moisture.

## DIRECT MATERIALS

| Item | Number Required | Unit Cost | Annual Cost Estimated | Annual Cost Actual |
| --- | --- | --- | --- | --- |
| Raw milk | 480,000 gallons | $ 0.48 | $ 230,400 | ______ |
| Bottle caps | 2,000,000 | 0.001 | 2,000 | ______ |
| Bottles* | 93,600 | 0.10 | 9,360 | ______ |
| Total | | | $241,760 | ______ |

*Life expectancy of a bottle is 20 trips, to sell 1,872,000 bottles of milk will require replacement of 93,600 bottles annually.

## SUPPLIES

| Item | Annual Cost Estimated | Annual Cost Actual |
| --- | --- | --- |
| Fuel and oil for trucks | $ 15,000 | ______ |
| Maintenance and repairs for trucks | 8,000 | ______ |
| Cleaning and sanitizing chemicals and salt | 2,000 | ______ |
| Office supplies | 1,500 | ______ |
| Laboratory supplies | 500 | ______ |
| Total | $ 27,000 | ______ |
| 50% Allocated for one product is | $ 13,500 | |

## PLANT LAYOUT

Plant layouts are included in the chapters describing production of various dairy products.

## PLANT SITE

To provide for future expansion and sufficient parking space for vehicles used by the plant, an area of one acre will be required.

| | |
|---|---|
| The estimated cost of this plant site is | $2,500. |
| 50% allocated for one product is | $1,250. |

## BUILDING

A one story building 50 by 100 feet to house processing equipment is required. In addition, a cold storage room, 20 by 50 feet is necessary. A boiler room and space for compressors to furnish refrigeration will require approximately 400 square feet. Office space will require approximately 600 square feet.

| | |
|---|---|
| The cost of the complete structure is estimated to be | $95,000. |
| 50% allocated for one product is | $47,500. |

## POWER

Electrical power required is approximately 85 horse power.

| | |
|---|---|
| The annual cost of the power is estimated to be | $2,800. |
| 50% allocated for one product is | $1,400. |

## WATER

The annual cost of water, providing that the condenser cooling water is recirculated through a cooling tower, is estimated at $1,600.

50% allocated for one product is $800.

## FUEL

The annual cost of fuel for processing and heating buildings is estimated at $3,800.

50% allocated for one product is $1,900.

* * * * * * * * * * * *

## PRODUCTION TOOLS AND EQUIPMENT

| Description | Number Required | Unit Cost | Cost Estimated | Cost Actual |
|---|---|---|---|---|
| Steam generator | 1 | $ 6,000 | $ 6,000 | ______ |
| Pasteurizer and cooler | 1 | 9,600 | 9,600 | ______ |
| Compressor and refrigeration system | 1 | 9,600 | 9,600 | ______ |
| Filler and capper | 1 | 8,400 | 8,400 | ______ |
| Separator | 2 | 3,500 | 7,000 | ______ |
| Homogenizer | 1 | 8,500 | 8,500 | ______ |
| Bottle washer | 1 | 7,000 | 7,000 | ______ |
| Milk scales, blending tank and pump | 1 | 6,500 | 6,500 | ______ |
| Can washer, automatic | 1 | 4,000 | 4,000 | ______ |
| Piston filler | 1 | 3,800 | 3,800 | ______ |
| Conveyors | 5 | Various | 4,500 | ______ |
| Pallets | 200 | 12 | 2,400 | ______ |
| Lift truck | 1 | 3,600 | 3,600 | ______ |
| Sanitary piping and fittings to connect equipment | | 6,000 | 6,000 | ______ |
| Milk storage tanks | 4 | Various | 16,000 | ______ |
| Laboratory equipment | | 4,000 | 4,000 | ______ |
| Metal baskets for bottles | 1,750 | 5 | 8,750 | ______ |
| Milk cans | 900 | 11 | 9,900 | ______ |

| Description | Number Required | Unit Cost | Cost Estimated | Cost Actual |
|---|---|---|---|---|
| Sanitizing tank for fittings and pipes | 1 | $ 1,300 | $ 1,300 | ______ |
| Coagulation and draining vats | 3 | Various | 3,600 | ______ |
| Cheese trucks | 4 | 300 | 1,200 | ______ |
| Pumps | 6 | Various | 9,000 | ______ |
| Churn | 1 | 3,200 | 3,200 | ______ |
| Butter boxes | 40 | 10 | 400 | ______ |
| Butter packer and wrapper | 1 | 7,200 | 7,200 | ______ |
| Total | | | $ 151,450 | ______ |

50% allocated for one product is $75,725.

## OTHER TOOLS AND EQUIPMENT

| Description | Cost Estimated | Cost Actual |
|---|---|---|
| hand trucks | $ 1,000 | ______ |
| Tools | 3,000 | ______ |
| Rubber hose and fittings | 1,750 | ______ |
| Sanitizing equipment | 1,200 | ______ |
| Tables and racks | 2,000 | ______ |
| Total | $ 8,950 | ______ |

5% allocated for one product is $4,475.

## SPECIAL DEPRECIATION ITEM

| Description | Number Required | Unit Cost | Cost Estimated | Cost Actual |
|---|---|---|---|---|
| Refrigerated trucks* | 12 | Various | $ 108,000 | ______ |

*Truck life is estimated at 4 years.

Trucks, 50% allocated for one product is $54,000.

## FURNITURE AND FIXTURES

| Item | Number Required | Unit Cost | Cost Estimated | Cost Actual |
|---|---|---|---|---|
| Chairs | 8 | Various | $ 800 | ______ |
| Desks | 5 | Various | 1,200 | ______ |
| Adding machines | 2 | 250 | 500 | ______ |
| Calculators | 2 | 375 | 750 | ______ |
| Duplicating billing machine | 1 | 1,200 | 1,200 | ______ |
| Typewriters | 3 | 200 | 600 | ______ |
| Filing cabinets | 6 | 100 | 600 | ______ |
| Total | | | $ 5,650 | ______ |

50% allocated for one product is $2,825.

DIRECT LABOR *

| Occupation | Number Required | Hourly Rate | Annual Cost Estimated | Annual Cost Actual |
|---|---|---|---|---|
| Milk receiving | 3 | $ 1.50 | $ 9,000 | ______ |
| Pasteurizer operator | 1 | 1.75 | 3,500 | ______ |
| Homogenizer operator | 1 | 1.75 | 3,500 | ______ |
| Cheese maker | 1 | 2.25 | 4,500 | ______ |
| Butter maker | 1 | 2.00 | 4,000 | ______ |
| Filler operators | 2 | 1.75 | 7,000 | ______ |
| Package machine operators | 2 | 2.00 | 8,000 | ______ |
| Sanitizing crew | 3 | 1.75 | 10,500 | ______ |
| Laborers | 6 | 1.25 | 15,000 | ______ |
| Truck drivers | 12 | 2.25 (average) | 54,000 | ______ |
| Total | | | $ 119,000 | ______ |

50% allocated for one product is $59,500.

*Although wages are calculated on a 50 week per year basis, sufficient hours have been allocated to allow staggered work weeks. In this manner six and seven day week operations, 52 weeks per year, are covered by available workers. (See General Assumptions Number 9).

## INDIRECT LABOR

| Occupation | Number Required | Annual Cost Estimated | Annual Cost Actual |
|---|---|---|---|
| Manager | 1 | $ 15,000 | |
| Sales manager | 1 | 12,000 | |
| Superintendent | 1 | 8,400 | |
| Quality control chief | 1 | 8,400 | |
| Quality control technician | 1 | 5,200 | |
| Sanitizing crew chief | 1 | 5,200 | |
| Bookkeeper | 1 | 6,500 | |
| Clerks | 2 | 6,000 | |
| Maintenance chief | 1 | 6,000 | |
| Maintenance helper | 1 | 3,000 | |
| Total | 11 | $ 75,700 | |

50% allocated for one product is $37,850.

## DEPRECIATION

| Description | Estimated Cost | Years Life | Annual Cost Estimated | Annual Cost Actual |
|---|---|---|---|---|
| Buildings | $ 47,500 | 20 | $ 2,375 | ______ |
| Production tools and equipment | 75,725 | 10 | 7,573 | ______ |
| Other tools and equipment | 4,475 | 10 | 448 | ______ |
| Trucks | 54,000 | 4 | 13,500 | ______ |
| Furniture and fixtures | 2,825 | 10 | 283 | ______ |
| Total | | | $ 24,179 | ______ |

## MANUFACTURING OVERHEAD

| Item | Annual Cost Estimated | Annual Cost Actual |
|---|---|---|
| Depreciation | $ 24,179 | ______ |
| Indirect labor | 37,850 | ______ |
| Power | 1,400 | ______ |
| Water | 800 | ______ |
| Fuel | 1,900 | ______ |
| Supplies | 13,500 | ______ |
| Total | $ 79,629 | ______ |

## MANUFACTURING COSTS

| Item | Annual Cost Estimated | Annual Cost Actual |
|---|---|---|
| Direct materials | $ 241,760 | |
| Direct labor | 59,500 | |
| Manufacturing overhead | 79,629 | |
| Total | $ 380,889 | |

## FIXED ASSETS

| Item | Cost Estimated | Cost Actual |
|---|---|---|
| Land | $ 1,250 | |
| Buildings | 47,500 | |
| Production tools and equipment | 75,725 | |
| Other tools and equipment | 4,475 | |
| Trucks | 54,000 | |
| Furniture and fixtures | 2,825 | |
| Total | $ 185,775 | |

## WORKING CAPITAL

| Item | | Cost Estimated | Cost Actual |
|---|---|---|---|
| Direct materials | 30 days | $ 20,147 | |
| Direct labor | 30 days | 4,958 | |
| Manufacturing overhead | 30 days | 6,636 | |
| Reserve for sales collections | 30 days | 38,610 | |
| Total | | $ 70,351 | |

## CAPITAL REQUIREMENTS

| Item | Cost Estimated | Cost Actual |
|---|---|---|
| Fixed assets | $ 185,775 | |
| Working capital | 70,351 | |
| Total | $ 256,126 | |

## SALES REVENUE

The total annual production capacity of pasteurized homogenized whole milk is 1,872,000 quarts.

Retail sales (75%) are 1,404,000 quarts delivered to door of consumer at $0.26 per quart.

Wholesale sales (25%) are 468,000 quarts delivered to stores for retail sales at $0.21 per quart.

Based on these figures the annual sales revenue would amount to $463,320.

## RECAPITULATION OF COSTS, SALES AND PROFITS

| Item | Estimated Cost | | Actual Cost |
|---|---|---|---|
| Direct materials | $ 241,760 | | ____ |
| Direct labor | 59,500 | | ____ |
| Manufacturing overhead | 79,629 | | ____ |
| Total manufacturing cost | | $ 380,889 | ____ |
| Interest on loans | $ 18,000 | | ____ |
| Insurance | 10,000 | | ____ |
| Legal retainer and fees | 3,600 | | ____ |
| Auditing | 2,500 | | ____ |
| Unforeseen expense | 5,000 | | ____ |
| Total administrative costs | | $ 39,100 | ____ |
| Sales commissions and bonuses | | 12,000 | ____ |
| Travel, entertainment, discounts, bad debts | | 7,000 | ____ |
| Profit before taxes | | 24,331 | ____ |
| Total annual gross sales | | $ 463,320 | ____ |

# BUDGET CONTROL

A requisition form designed to provide accurate records of procurement and indicate the purpose of the 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.

Payment of all expenditures in connection with budget control should be made by uniform vouchers. Each voucher should carry an account number.

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 requisition 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 information 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 | $______ | $ 3,466 | $ 41,600 | $______ |
| 20 | Sales | ______ | 1,000 | 12,000 | ______ |
| 30 | Direct materials | ______ | 20,147 | 241,760 | ______ |
| 40 | Supplies | ______ | 1,125 | 13,500 | ______ |
| 51 | Power* | ______ | 117 | 1,400 | ______ |
| 52 | Water* | ______ | 66 | 800 | ______ |
| 53 | Fuel | ______ | 158 | 1,900 | ______ |
| 60 | Unforeseen expense (Reserve account) | ______ | 417 | 5,000 | ______ |
| 71 | Direct labor* | ______ | 4,958 | 59,500 | ______ |
| 72 | Indirect labor | ______ | 3,154 | 37,850 | ______ |
| 80 | Depreciation (Reserve account) | ______ | 2,015 | 24,179 | ______ |

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

It is suggested that a copy of the manual entitled "Food Processing Feasibility Study" (Code Number ID-14) be obtained and studied to aid in determining the feasibility of establishing a dairy product manufacturing plant. This manual describes, in detail, methods of gathering general information and data required to prepare a feasibility study.

Specific data which may require technical aid in assembling follows:

(a) Labor requirements for various operations. Equipment manufacturers can provide fairly accurate approximations of the number of workers and the skills necessary to operate their machines.

(b) Technical aid will be required, in general, in developing commercial processes for the production of dairy by-products typical of national diets. Preparation of samples and test marketing should be an integral part of this aid.

(c) Selection of by-products which can be manufactured profitably will require technical assistance.

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

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

## PLANT AND OPERATIONAL REQUIREMENTS

Proper safety aids and safety programs; cleanliness and sanitation, are of utmost importance in a food processing plant. These requirements can be met only by proper construction of the buildings and selection of equipment which can be easily cleaned. There must be adequate space provided for the work to be accomplished. Sufficient time and funds must be allocated for safety and sanitation programs of training and inspection.

### A. Sanitation

1. The plant must be so constructed as to meet all governmental requirements and accepted industry standards relative to sanitation. These requirements include; proper drains and waste disposal units; adequate light and ventilation; all doors and windows properly screened against insects, rodents, etc.; proper and adequate storage space; rest room and wash room facilities for personnel.

2. Equipment must be so located and of the type that provide ample room for ease of operation of all pieces, and sufficient free work space for cleaning and sanitizing must be available.

3. In addition to the regular production staff, a thoroughly trained cleaning and sanitation crew must be considered as a part of the production personnel. These people must be supplied with adequate cleaning apparatus and cleaning materials.

### B. Safety

There is always danger of accident and injury in any industrial plant. Because of this, the manager should see that each employee fully understands the importance of safety precautions and intelligent first aid. The following safety features should be included in the plant:

1. All machines with moving parts should contain safety shields and guards in good working condition. The operators should understand their function and make full use of them.

2. Open milk bottles and other containers proceeding to the filling operations must be protected against particles of flying glass. Operations involving products in glass containers must adhere to rigid safety precautions to prevent product contamination from broken glass and injury to personnel.

3. First aid supplies should be readily available throughout the plant. A number of the employees, in addition to the superintendent and foremen, should be trained to use the first aid equipment and supply first aid service.

4. Fire extinguishers should be strategically located throughout the plant, and a number of key employees should be trained to use this apparatus. Additionally, each employee should understand his responsibility in case of fire.

5. Periodic fire drills should be held. Also, regular training in first aid and regular safety inspections should be conducted throughout the plant.

## C. Training

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

In some areas skilled workers and operators may be available locally. In other areas all personnel may have to be trained.

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

1. A contract could be negotiated with the engineering firm which designs the plant, to also train the personnel. The firm could agree to operate the plant for a definite period of time or until the personnel is capable of producing acceptable quality products.

2. Key personnel may be placed in a similar industry in a foreign country for training while the plant is being constructed and made ready for production.

3. 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 train the organization. Private consultants in the field could be retained to train key personnel and to insure the production of quality food products.

4. The general manager should have broad experience in this type of business and be fully qualified in all phases of business and personnel training.

5. Technicians employed by the company must be thoroughly acquainted with legal requirements governing dairy products in the country where the plant is located. They must be capable of operating the plant in accordance with regulations and good sanitary practices. Laboratory personnel must be competent to perform and interpret quality control tests accurately.

## DAIRY EQUIPMENT SUPPLIERS

1. Cherry-Burrell Corporation
   Export Division
   427 West Randolph Street
   Chicago 6, Illinois

2. Mojonnier Brothers Company
   4601 West Ohio
   Chicago 44, Illinois

3. Creamery Package Manufacturing Company
   1243 West Washington Boulevard
   Chicago 7, Illinois

4. Burgess, Smith and Rodgers, Incorporated
   330 West 42nd Street
   New York City, New York

5. Damrow Brothers Company
   196-234 Western Avenue
   Fond du Lac, Wisconsin

6. United Dairy Equipment Company
   West Chester, Pennsylvania

7. Henry R. John and Son, Incorporated
   7 Water Street
   New York City 4, New York

# REFERENCES


1. Dairy Plant Management
   Tracy, Paul H., et al
   McGraw-Hill Book Company, Incorporated
   New York City, New York

2. Dairy Engineering
   Farrall, A. W.
   John Wiley and Sons, Incorporated
   440 Fourth Avenue
   New York City, New York

3. A Dictionary of Dairying
   Davis, J. G. 1955
   Interscience Publishers, Incorporated
   250 Fifth Avenue
   New York City 1, New York

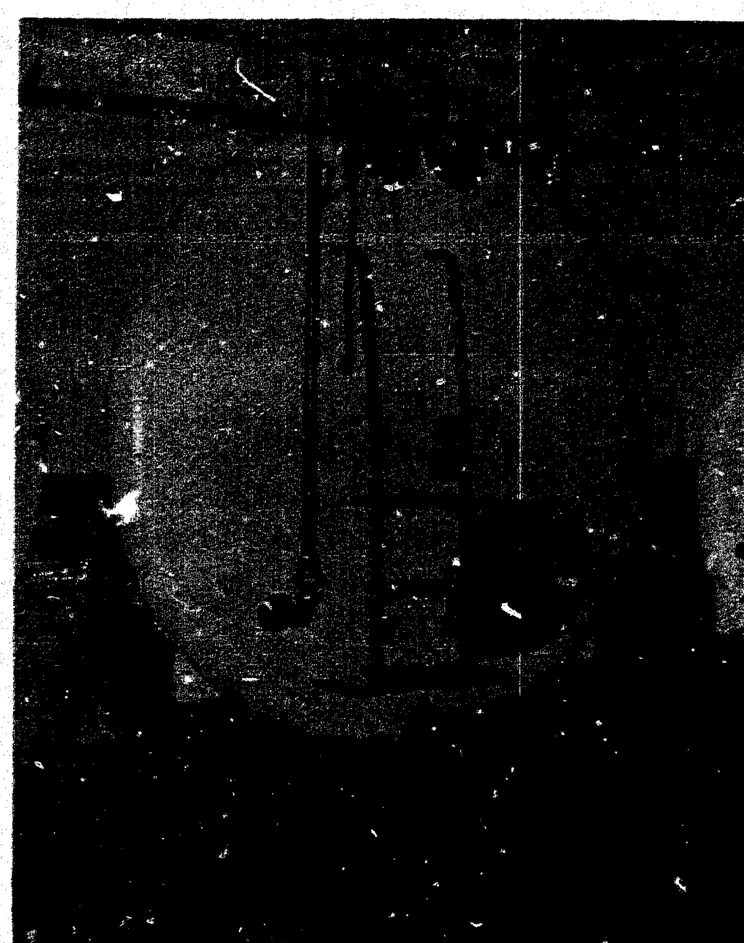
4. Construction and Arrangement of Milk Plants
   United States Department of Agriculture Circular #800
   United States Government Printing Office
   Washington 25, D. C.

5. Operation and Management of Milk Plants
   United States Department of Agriculture Circular #260
   United States Government Printing Office
   Washington 25, D. C.

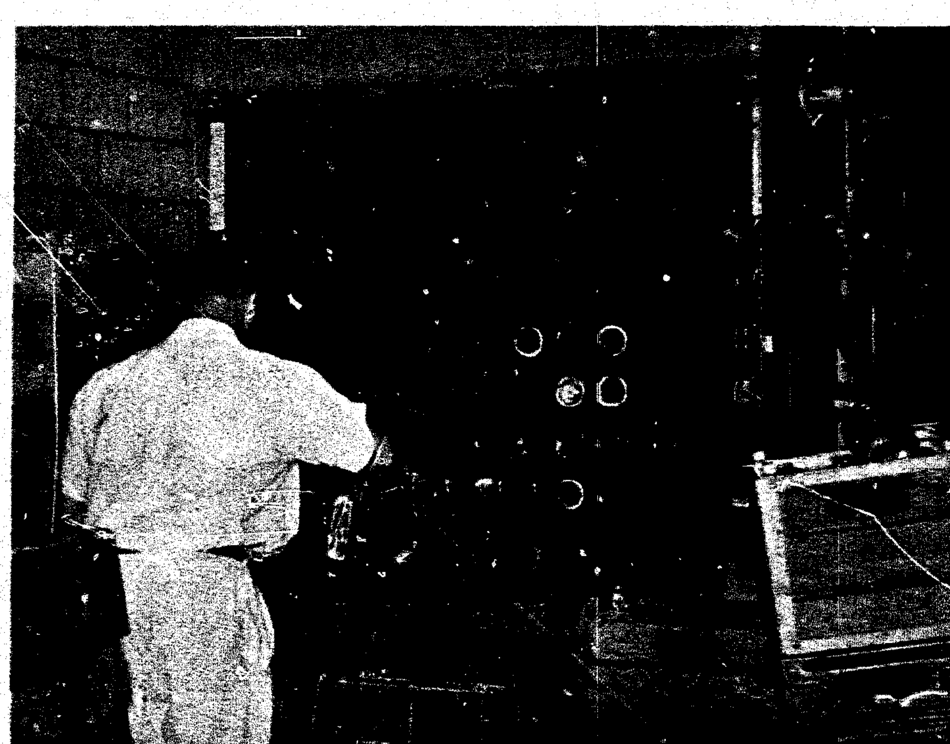
6. Milk Ordinance and Code
   Public Health Bulletin #220
   United States Government Printing Office
   Washington 25, D. C.

7. Definitions and Standards under the Federal Food, Drug and Cosmetic Act
   (Available for cheeses and cheese products, milk and cream, ice cream)
   United States Food and Drug Administration
   Department of Health, Education and Welfare
   Washington 25, D. C.

8. Food Processing Feasibility Manual
   Code Number ID-14
   Publications and Technical Services Branch
   Communications Resources Division
   Agency for International Development
   Washington 25, D. C.



MILK STORAGE TANK



BOTTLE WASHER

CREAM SEPARATOR

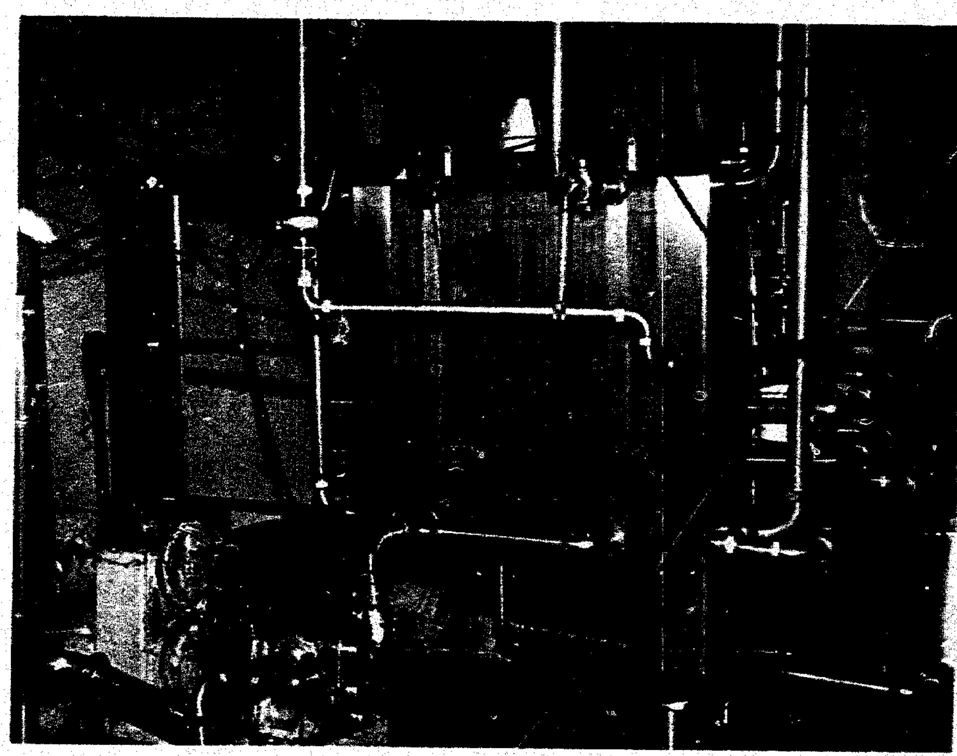
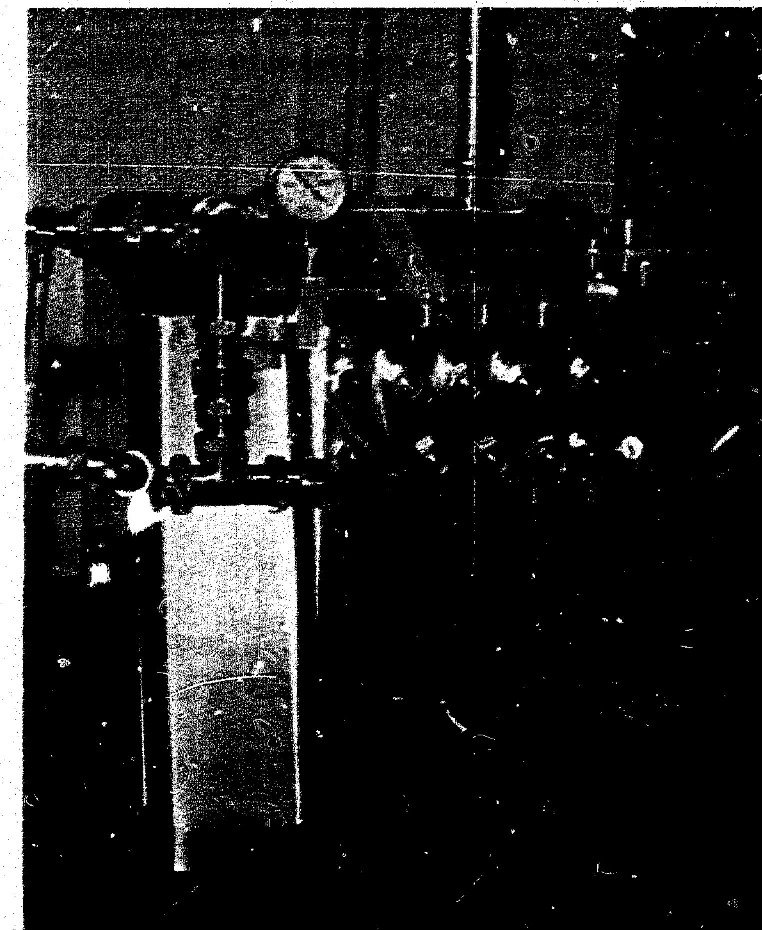
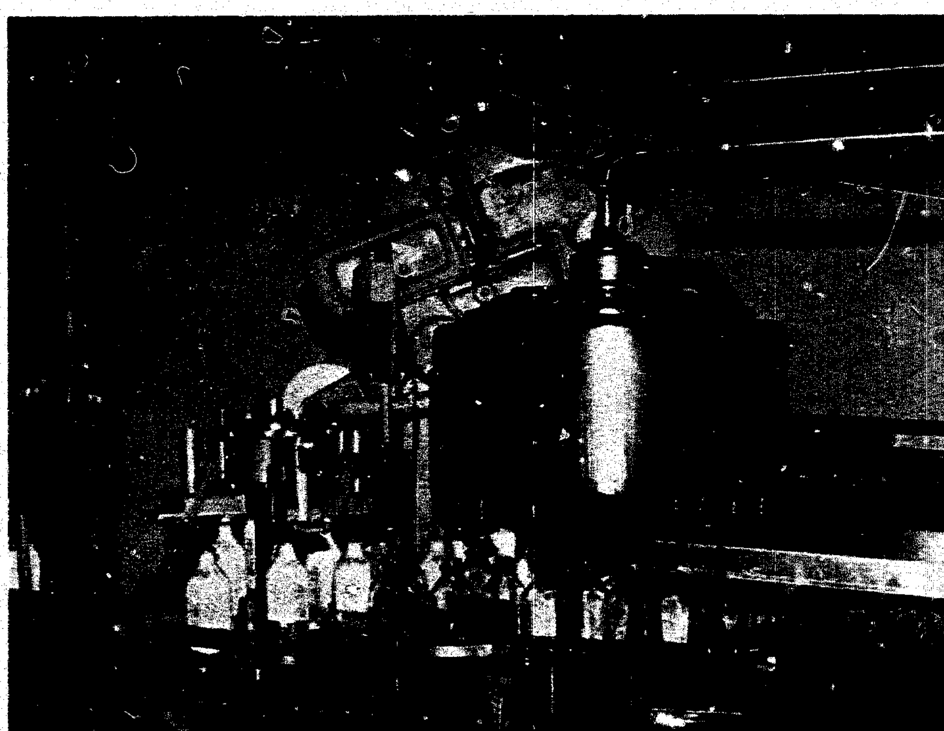


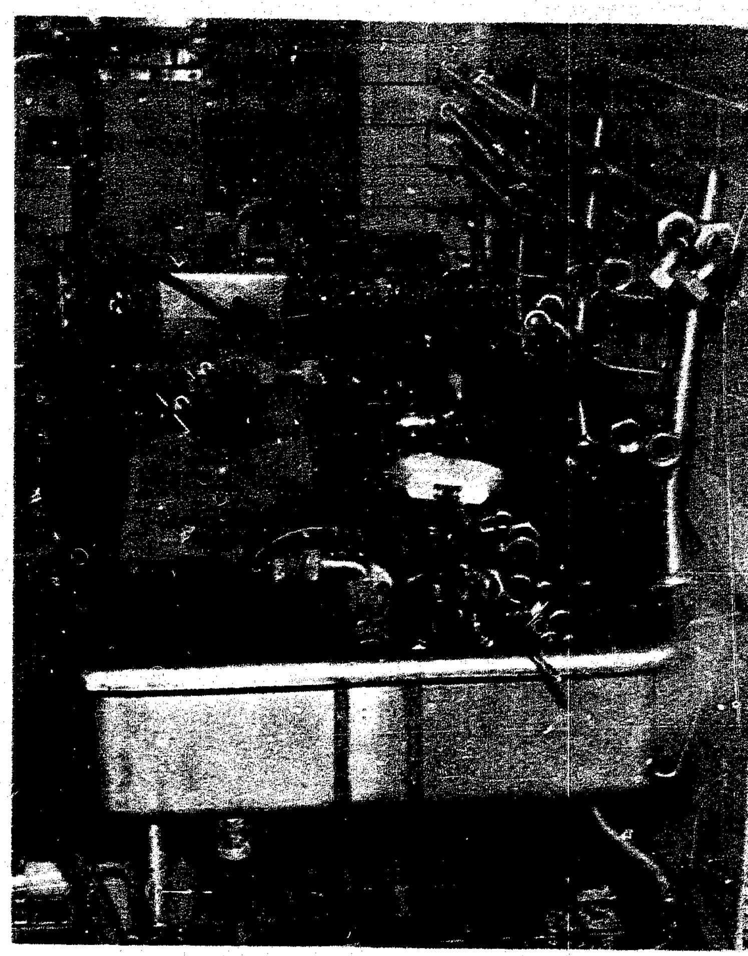
PLATE PASTEURIZER AND COOLER



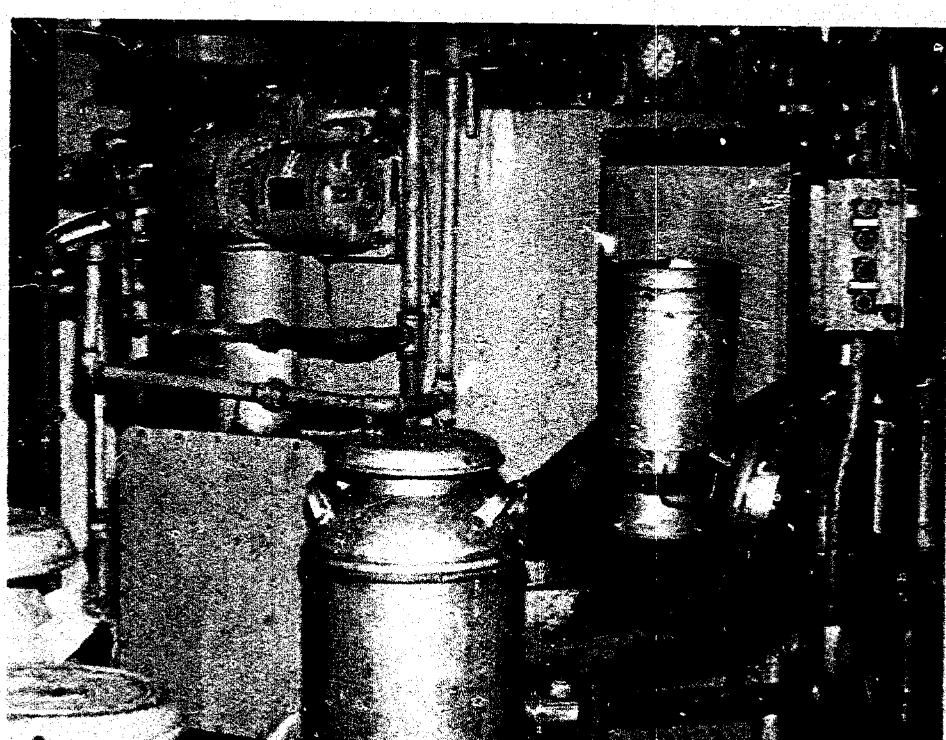
HOMOGENIZER



FILLER



EQUIPMENT SANITIZING TROUGH



MILK CAN WASHER AND STERILIZER