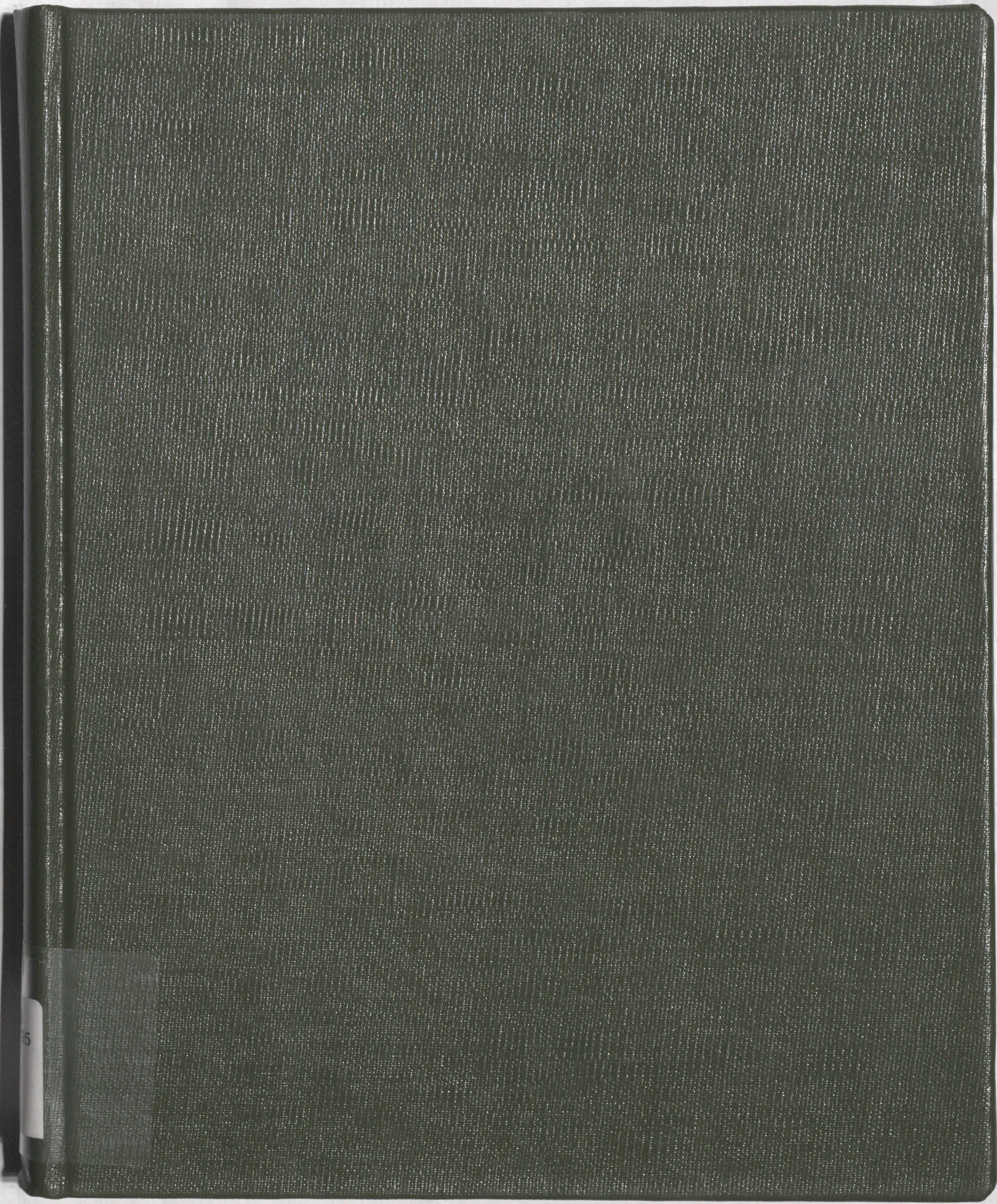




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A DAIRY PRODUCTS PLANT FOR THE GALLATIN VALLEY

Part I

Undergraduate Thesis in Architectural Design

by

Dennis R. Hulsing

Submitted to the School of Architecture as partial
fulfillment of the requirements for the degree of
Bachelor of Architecture

at

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INTRODUCTION

A large consolidated dairy plant for the Gallatin Valley is based on economic considerations and does not consider the length of time it will take to occur. Many small plants are going out of business each year because of the higher costs of production and only the larger plants are surviving. This trend toward fewer and larger plants is apparent also in other states such as North Dakota, Minnesota, and Wisconsin. It is for this reason that this large scale problem was undertaken.

CONDITIONS CREATING A NEED

CONDITIONS CREATING A NEED

At the present time there are twenty-two milk processing plants in Montana. Every year the number of plants decreases and the capacity of each plant increases. If this trend continues, as is predicted, the smaller plants will be consolidated into two large plants, one located in the Gallatin Valley and the other in Stevensville, Montana.¹ Considerable study has been done in this field and economic factors point to consolidation in milk processing plants.

Each of the smaller plants now in operation processes between 25,000 and 30,000 pounds of milk a day. Many of these plants have equipment that could handle more milk, but because of the competition among buyers, the lack of marketing facilities, and the cost of operation, the equipment is not fully utilized. In the pasteurizing process, for example, most plants are using the high temperature short time pasteurizer. This unit requires very little floor space and can pasteurize milk very quickly. However, in the smaller plants it stands empty a great percentage of the day because of the small amount of milk received to process.

Another area of increasing cost to the smaller plant is that of the staff. A minimum staff is needed for the smallest operation. For example, one plant superintendent is needed for the small plant as well as the large. One sales manager is needed for the small plant as well as the large. There are many other

cases where the personnel cannot be omitted in the small plant. The cost of labor or man-hours goes down proportionately as plant capacities increase to a point of maximum utilization of resources.

Possibly the most important point in relation to the size of operations is the larger plant's ability to handle a greater surplus of milk for processing. Surplus milk is that not used in Grade A packaging. If more milk is received than can be utilized for Grade A milk packaging, it must be sent to another dairy plant, as is done at Yellowstone Dairy in Bozeman², or it must be used in auxiliary functions which are only partly incorporated in small plants because of cost. The larger plant can have auxiliary operations such as cottage cheese, cheddar cheese, and novelty items to use the surplus milk.

The greatest problem in a consolidated plant in Montana is the cost of transporting the milk to the processing plant and marketing it from that point. Since Montana has four major geographic areas of production, points of origin and delivery must be analyzed. The Stollsteimer theory, as applied to Montana by J. H. Cothorn, showed Bozeman to be one of the two most economical sites for a consolidated dairy products plant if there were two major plants in the state.³ The research also showed that by lowering the costs of production and by making use of surplus milk, the cost of transportation would not negate the increase in savings with the larger plant.

Assuming consolidation will occur immediately into two large operations, the Gallatin Valley plant would serve the southern regions of the state. The areas surrounding Billings, Great Falls, Butte, Helena, and Havre would transport milk to the Gallatin Valley. In addition, there is a possibility that eastern areas around Miles City, Glendive, and Plentywood could be included if feeder routes were used into the main lines from Billings and Great Falls. In this proposal the feeder routes would haul every two days, which is practical with the present milk handling techniques. The total amount of raw milk produced in the foregoing areas is listed in Illustration 1 for the third quarter of 1968.⁴ With the total figures projected for the four quarters, it can be seen that this plant could receive 146,000,000 pounds of milk a year.

Although this is not a complete economic study, the major economic factors of under utilization of equipment and staff, the increase in use of surplus milk, and the off-setting of transportation and marketing costs are the major areas pointing toward consolidation.

Illustration 1

<u>Production Area</u>	<u>Total Pounds of Raw Milk Produced</u>
Bozeman	13,173,830
Billings	5,524,031
Great Falls	7,935,145
Butte	2,798,972
Helena	1,622,078
<u>Havre</u>	<u>2,358,398</u>
Total	33,412,454
Miles City	1,378,786
Plentywood	124,554
Glendive	1,495,240
<u>Lewistown</u>	<u>28,009</u>
Total	3,026,589

F U N C T I O N S O F A D A I R Y P L A N T

FUNCTIONS OF A DAIRY PLANT

It is critical in the design of a dairy plant to know the processes involved in the treatment of milk from the dairy farm to the manufacturing plant and finally to the consumer's table. Although there are many different methods of processing and transporting the raw milk, in each case certain basic operations are followed.

Transportation

In a large plant it is the common practice to transport the raw milk in bulk to the plant in order to save the cost of extra equipment such as can washers, can conveyors, and the added labor cost of can milk inspection. This method of milk handling is more convenient for the dairyman, the trucker, and the plant. The raw milk is pumped directly from the milker to a storage tank on the farm and from there directly into the tank truck, never coming in contact with the air.

The tank trucks vary in size from the small five hundred gallon truck to one capable of carrying over five thousand gallons, the larger trucks being semi-trailer or two-tank trailers. When the large trucks arrive at the plant, they drive to the receiving area. In this area the milk is pumped from the truck, then the truck is washed, rinsed, and sanitized by one of the laborers in the plant. The entire operation takes a maximum of three hours.⁵

Receiving

The first step for the personnel in the receiving area is to weigh and measure the milk from the truck. There are a number of ways to do this such as weight measurement, volumetric measurement, and flow measurement. The latter two are more accurate than the first. Any method can be justified by accuracy, convenience, or expense, but in every case its primary function is to determine the amount of raw milk bought from the producer.

Testing

Several tests are made on the raw milk when it is received. The most important test is that which determines the amount of butterfat present in the raw milk. Since milk is priced on this basis (the higher the butterfat content, the higher the price paid), much attention is given to this test. The butterfat test is also important to the manufacturer who produces whole milk having a standard amount of butterfat. Other tests given at this time include those for temperature, acidity, sediment, bacteria, and taste and smell. Upon completion of these tests the milk is ready to undergo its first processing.

Pumping and Measuring

The milk is pumped from the truck by a positive displacement pump. These pumps come in a variety of sizes with the size depending on the amount of milk received per hour. The pump is located adjacent to the receiving area because it pumps the milk from the

tank trucks into the plant storage tanks. The pump draws the milk from the truck through a measuring system except when the milk-weighing method, which is a gravity system, is used.

In some plants a cooler is located between the pump and the cold storage tanks which insures that the milk is between 40° and 45° F. when it is pumped into the cold storage area. In this case an auxiliary by-pass valve circulates the milk around the cooler when the milk received is the required temperature.

Cold Storage

There are several types and sizes of storage tanks. In the last few years plants have installed a type of cold storage tank having the refrigeration unit located within the walls of the tank. Milk can be kept in this tank at least two days before processing. The storage tanks can be either rectangular or cylindrical. The rectangular tanks take up less space but are more expensive. The cylindrical tanks are usually built into the wall leaving only the inlet, breather, manhole and sample cock, and the thermometer exposed for easy access.

Clarification

In large plants which homogenize their milk, a clarifier is used to remove all but the very light extraneous materials from the milk. It does this by means of a centrifugal force principle with the heavier particles forced to the outside of a spinning

bowl and deposited there. The clarifier is usually placed between the cold storage tanks and the pasteurizer.

Separation

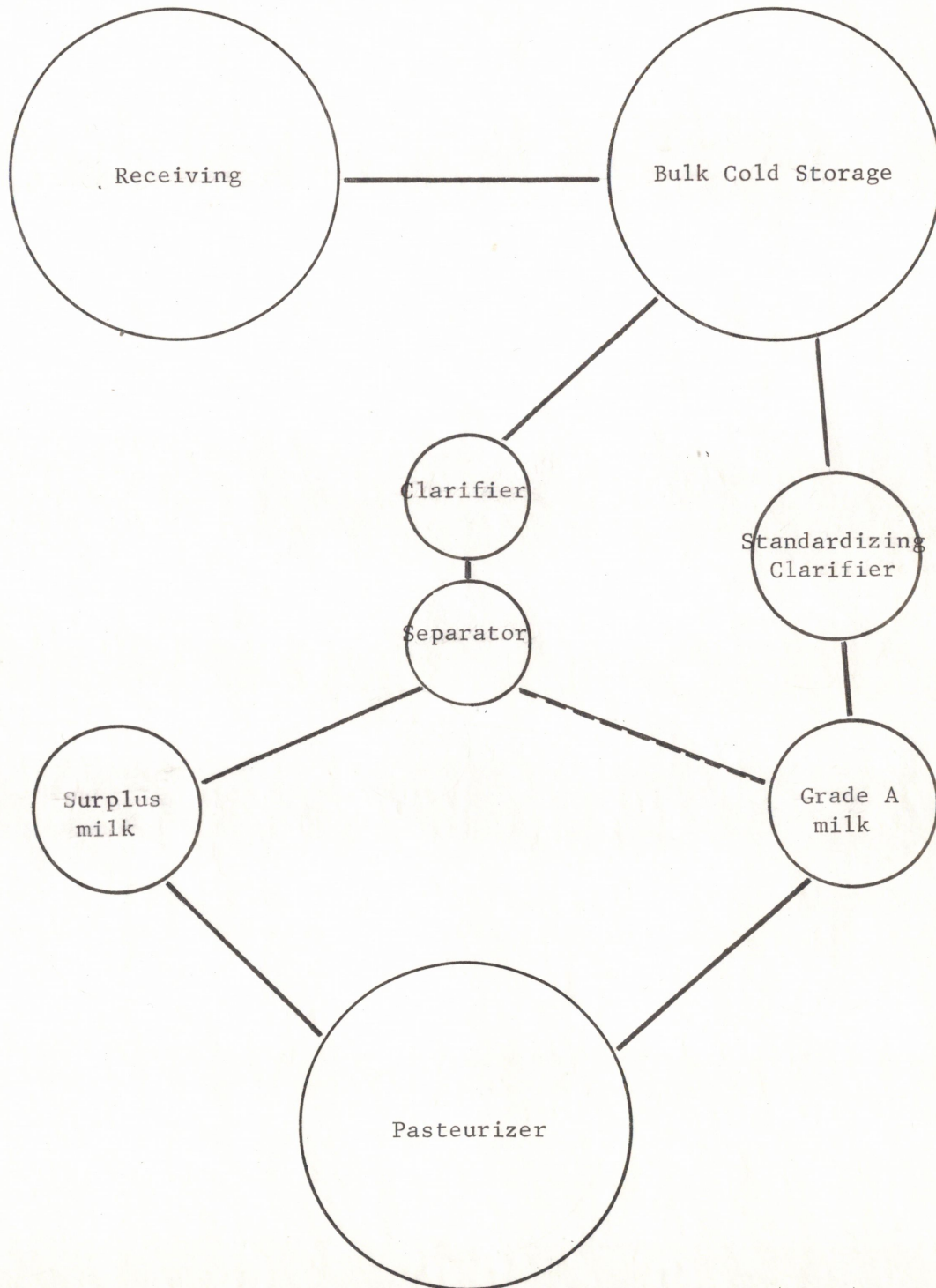
From the clarifier the milk goes to the separator where the butterfat content is regulated. Milk for Grade A processing is standardized, which means the excess butterfat is removed giving the milk a constant percentage of butterfat. Surplus milk is separated to reach the butterfat ratio required for each specific product. Separating is also used to produce skim milk and cream for packaging and use in other dairy products. The principle involved in separating is the same as that in clarification: the heavier cream is forced to the outside wall of a spinning bowl and collected.

Standardization

A standardizing clarifier is used in large plants in addition to the separator. This is a device that cleans the milk and at the same time removes excess butterfat for standardization. This machine cannot be used for the complete separation of milk and cream, and therefore functions only in reducing butterfat content. It does, however, reduce the time and labor involved in mixing the milk and cream for standardization, which must be done when the milk is completely separated. A second advantage is making standardization and clarification a one-step operation. (For a diagram of processes, see Illustration 2.)

ILLUSTRATION 2

DIAGRAM OF INITIAL PROCESSES



Grade A Milk Processing

Up to this point all of the raw milk has undergone the same processes with the exception of standardization. Beyond this point the greater amount of milk will go into processes involved in packaged milk and the surplus milk will go into other supplementary milk products which use different processing methods. Therefore, the discussion of processing must be divided into two sections.

Fortifying of Grade A Milk

The raw milk designated for Grade A drinking milk, after being standardized and clarified, is piped to a holding tank where it is fortified by the addition of concentrated vitamins. After this it is pumped into a float tank to await homogenization.

Homogenization of Grade A Milk

The milk goes indirectly from the float tank into the homogenizer. This indirect path is a result of pumping the milk through the regenerator of the pasteurizer where the milk is heated by the latent heat of the pasteurized milk to 136° F. before it enters the homogenizer. (See Illustration 3.) The milk is then forced through the many fine nozzles of the homogenizer causing the fat particles to be broken up. When the milk leaves the homogenizer, it is ready for pasteurization.

Pasteurization of Grade A Milk

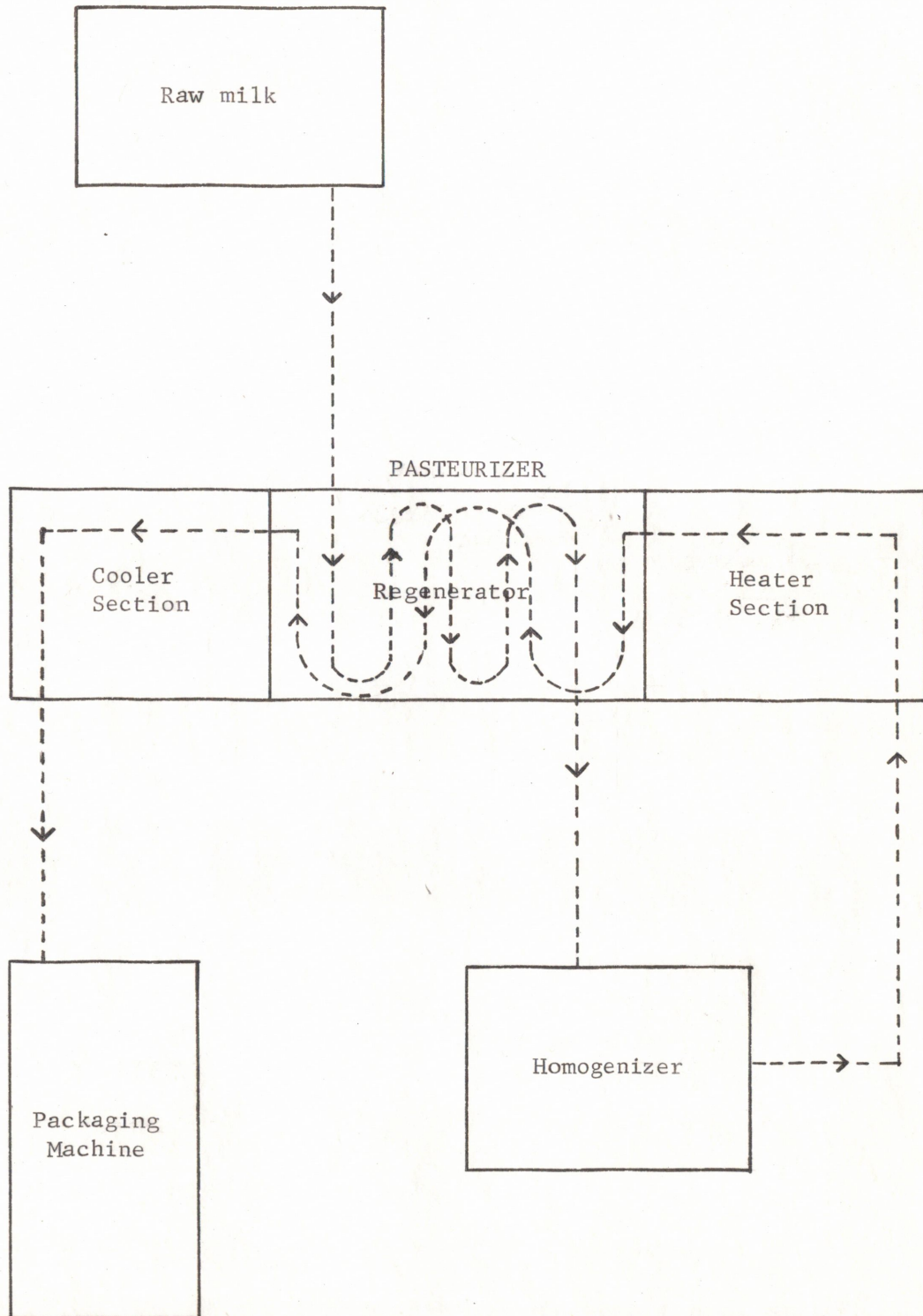
Practically all market milk today is pasteurized by the high-temperature short time pasteurizer. These machines can handle up to 35,000 pounds of milk per hour and take up very little floor space. The pasteurizer is divided into three parts: the heater, the regenerator, and the cooler. When the milk enters the pasteurizer from the homogenizer, the heater raises the temperature of the milk another 25° to approximately 161° F. It is held at this temperature for sixteen seconds and then pumped back through the regenerator to give its latent heat to milk starting its journey to the homogenizer.⁶ (See Illustration 3.) From here the pasteurized milk is cooled to 38° F. by a cooler which circulates cold water around the milk pipes. Having reached this temperature the milk is ready to be packaged and is piped into a large surge tank where it remains until it enters the filler of the packaging machine.

Packaging of Grade A Milk

The packaging machine, after unfolding and bonding each carton, allows a predetermined amount of milk to flow into the carton by gravity. A vacuum nozzle removes any foam from the top of the milk before the carton is sealed.⁷ The cartons are placed manually into a case; then they are conveyed by mechanical means into the plant coolers. The milk is now ready to be loaded and transported

ILLUSTRATION 3

MILK FLOW THROUGH PASTEURIZER AND HOMOGENIZER



to the distributing points.

Other Grade A milk products including 2% milk, chocolate milk, skim milk, half and half, and whipping cream also use the same equipment and packaging machines as the whole milk. These products are stored in individual holding tanks and pasteurized and packaged periodically.

Surplus Milk Processing

Milk not needed for Grade A packaging is used for the manufacture of ice cream and fermented dairy products such as cheddar cheese, butter, cottage cheese, yoghurt, and sour cream. This milk does not follow the same path as that of the packaged milk.

Ice Cream Processing

In the larger plants, the ice cream processes are the most detailed of all because of the great number of additives such as flavorings, fruit, and nuts. During these processes the milk travels from the standardizer and clarifier directly to the ice cream mix tank. The ice cream mix is made up of the by-products from Grade A milk production including skim milk, cream, butter, whole milk, dry mix (a commercially-made combination of stabilizers and solidifiers), sugar, water, and condensed milk.⁸ It is stored in a mix tank in regulated proportions and agitated to combine the ingredients. It is then pumped through the pasteurizer and homogenizer at a higher temperature and for a longer time than that

for milk. After being pasteurized it is stored in aging tanks, where all liquid flavorings are added, and awaits the freezing operation. The ice cream mix may be aged up to 24 hours in these tanks before entering the freezer.

Most plants today use the continuous freezer. The mix is pumped into the freezer where it is "whipped" and is cooled by a liquid coolant which surrounds the tank. It is then forced out of the freezer and into a machine that mixes in solid flavorings such as fruits and nuts. Then the ice cream is pumped either into large bulk packages or into a packaging machine. The larger packages are taken immediately to the hardening room to continue the freezing process. This hardening process can take several different forms. In a large plant a hardening room maintained at a temperature of -10° F. to -50° F. is used for the larger packages, while the smaller packages and ice cream novelties are hardened in a tunnel which surrounds the product with a -30° F. to -50° F. air blast and hardens it within one hour. After hardening the ice cream is stored in a palletizing room at 0° F. where it is made ready for shipping.⁹

The ice cream area usually has the additional function of manufacturing products known as novelties. These include ice cream bars, ice cream sandwiches, and different flavors of sherbet. The processes used are similar to those for ice cream, and additional equipment and area are the only requirements for this operation.

Fermented Dairy Products

Cheddar Cheese

If surplus milk is to be used for cheddar cheese it is stored and pasteurized as all milk, but not homogenized. It is then piped into the cheese vats, usually in a separate enclosed area. Once in the vats, the milk is kept at a constant temperature of 88° F. and a lactic starter is added to it. Rennet is added after about twenty minutes and the cheese milk is agitated to mix in the rennet. It is then allowed to set until it form a curd. The curd is cut into small pieces and stirred with the whey as the temperature is increased to 100° F. in order to "cook" the curd.

Following this process the curd is allowed to settle in the vat, and the whey is drained off. This causes the curd to mat so that it can be cut into small blocks and allowed to dry. The cheddaring process has now begun. Every fifteen minutes for about two hours these blocks are turned and stacked double or even triple until the end of the cheddaring period when a certain acidity has been reached in the cheese.¹⁰ Finally, the blocks are "milled" or cut into small pieces by a rotary blade and salt is added to the curd.

The next step is placing the milled curd into a mold and pressing it hydraulically. There are different types of molds, but in each the curd must be compressed, wrapped in a salted muslin cloth, and then recompressed. This entire process takes about one and

one-half hours under a pressure of twenty to twenty-five p.s.i.¹¹ The cheese is removed from the press, stamped with the date, type of cheese, and vat number, and then it is placed in a drying room for three to four days where it is turned daily. The cheese is then removed, coated with paraffin, and stored in boxes at a constant temperature and humidity for nine to twelve months before it is ready to be shipped to the distributors.

Other fermented milk processes in a large plant tend to balance each other. Some of these use skim milk while others use cream, complementing each other so that all milk products are used efficiently.

Butter

The buttermaking process uses both cream that has been removed from whole milk during standardization and that separated from skim milk. The cream is stored in a tank adjacent to the separator where alkalais are added, neutralizing it to the required acidity. It now awaits processing, usually done only a few times a week. At that time it is pasteurized at a temperature higher than that for milk and pumped into a holding tank where "starter" is added and the cream is allowed to ripen.¹² After this process the cream is pumped into either a continuous buttermaking machine, used for large volumes of cream, or a churn, which is used for smaller quantities. In the latter case, the cream is pumped through a filter and into the drum of a stainless steel churn. The churn

operates by a rotary motion at different controlled speeds with rotating wooden blades inside to agitate the cream.

After the butter is churned into small granules, the churn is stopped and the butter washed to remove all buttermilk, which is then drained from the churn. At this time salt is added to the butter to help preserve and flavor it. The churn is again started and the butter is "worked" by being pressed between wooden rollers in the churn, or in some cases simply by tumbling and rolling. After the butter is worked thoroughly with the salt, fully mixed, and air and excess moisture removed, it is taken from the churn and fed into a "printing" machine which cuts the butter into the desired sizes for packaging. When packaged it is placed in a storage area at approximately -20° F. before being shipped to the distributing points. Butter can be kept at this temperature up to nine months to be sold during the slack season.

Cottage Cheese

Upon separation the skim milk designated for cottage cheese goes through a pasteurizer, as did the cream, but at a lower temperature and a much faster rate of speed. The procedure is quite similar to that for cheddar cheese, with the milk being pumped directly into vats. This processing area, too, should be enclosed, as temperature control is important in this process. First starter is added to the milk in the vats, then the rennet. The mixture is agitated and allowed to stand, as did the cheddar mixture, but for

a longer period of time. When it is fully coagulated it is cut into pieces and heated to finish the curding process. After the curd is firm, the whey is drained off and the curd is washed with water and cooled. Immediately following the curd is pushed to the sides of the vat and salt and cream are poured on it to obtain the proportions desired for cottage cheese. The curd is then mixed mechanically and is ready to be packaged. Usually this operation can be done in six hours and is one of the simplest processes in a plant.¹³

Yoghurt

Yoghurt is a standardized milk product of 1.7% butterfat. It is pasteurized at 190° F. and homogenized under 1,000 p.s.i., then cooled to 45° F. and pumped into holding tanks where starter and bacteria are added. The "inoculated" warm milk is then packaged and allowed to incubate in special walk-in incubation rooms for approximately four hours. After incubation it is removed to the chill room, where the yoghurt is cooled by cold air circulation to 36° F. and is then ready for distribution.

Sour Cream

Sour cream processing is much the same as that for yoghurt; however, the temperature of pasteurization and the pressure of homogenization are changed. Starter is added and after the cream is agitated it is incubated in large cans at 72° F. for sixteen hours. Then the sour cream is emptied into a mechanical filler

and packaged. Sour cream dip is made by mixing a flavoring into the xour cream before packaging. Botheyoghurt and sour cream use the same packaging equipment as the previously mentioned milk products and for this reason are easily included in a large operation.¹⁴

Although this is by no means a detailed account of the various milk processes, it does explain the most essential operations performed on milk products and give some insight into the mechanical procedures of a dairy products center.

REQUIREMENTS OF THE BUILDING

REQUIREMENTS OF THE BUILDING

In a dairy products plant the building functions can be divided into three parts: primary, secondary, and supplementary. The sanitary production of dairy goods to meet set standards is the primary function. This function takes place in the processing areas. The secondary functions of the building are those which relate directly to the primary, for example plant offices and shipping and receiving areas. Finally, the supplementary functions of the building are those which are not necessary for the operation of the plant, but are desirable for public and employee satisfaction such as lounges and observation areas.

Primary Function Areas

Since the primary function of this building is the production process, the areas required for production should receive first consideration.

Milk Area

The milk production area should have adequate space for the necessary equipment. This includes the standardizing clarifier, the separator, the pasteurizer and homogenizer, the surge or holding tanks, the packaging machines, and a conveyor system. (See Illustration 4 for spatial requirements.) There also must be enough space to work around each piece of equipment, to allow access to the stainless steel piping system, to take milk samples,

ILLUSTRATION 4

SPATIAL REQUIREMENTS FOR EQUIPMENT

<u>Equipment</u>	<u>Floor Area</u>	<u>Square Feet</u>
Standardizing clarifier	4 ft. x 4 ft.	16
Separator	4 ft. x 4 ft.	16
Pasteurizer	10 ft. x 14 ft.	140
Homogenizer	4 ft. x 4 ft.	16
Surge tank (large cylindrical)	8 ft. x 8 ft.	64
Packaging machine (quart and half gallon)	7 ft. x 20 ft.	140
Packaging machine (gallon)	10 ft. x 16 ft.	160
Cold storage tank (2500 gallon)	10 ft. x 20 ft.	200
Holding tank (rectangular)	varies	
Mix tank	8 ft. x 16 ft.	128
Flavor tank	4 ft. x 8 ft.	32
Ice cream freezer	6 ft. x 9 ft.	54
Ice cream packager	16 ft. x 20 ft.	320
Novelty packing table	12 ft. x 24 ft.	288
Cheese vat	5 ft. x 28 ft.	140
Hydraulic press	5 ft. x 16 ft.	80
Cottage cheese packager	4 ft. x 16 ft.	64
Butter churn	12 ft. x 20 ft.	240
Butter printing machine	4 ft. x 12 ft.	48

and to allow employees to pass unhampered. Parallel flow patterns should be maintained through the area to eliminate congestion. Temperature and air pressure in this area do not have to be kept at a constant level.

Ice Cream Area

The ice cream production area should have adequate space for the mix tanks, the flavor tanks, the ice cream freezer, the holding tanks for sherbet, the packaging machines for ice cream and novelties, a novelty packing table, and a conveyor system. Since the tasks performed in this area are varied and the flow is non-directional, ample space should be provided to work around all pieces of equipment. This area should be divided from other processing areas because the operations rely on special equipment not common to the other areas. The temperature and air pressure do not need to be exactly controlled, although the ventilation should be good and the area should give a feeling of spaciousness.

Cheddar Cheese Area

The cheddar cheese area must have adequate space for the cheese vats, the separator, the molds and hoops, and the hydraulic press. Usually the vats are located parallel to each other with main aisles running past the ends. There must be enough room to work between the vats when cutting the curd and when cleaning. This area should also be separated from other areas and maintained at a constant temperature and air pressure. Since it is separated,

local storage must be included for the cheese cloths, starter, and rennet.

Cottage Cheese Area

The equipment needed for the cottage cheese processing is similar to that for cheddar cheese; however, rather than a hydraulic press, the cottage cheese area needs a packaging machine. It must be kept at a constant temperature and air pressure and therefore can be included in the same area as cheddar cheese. The vats are laid out in much the same manner as those for cheddar cheese, but must be somewhat separated to allow for the different operations performed such as washing the curd and packaging.

Cultured Cream Area

The cultured cream area includes the processing of different varieties of sour cream and yoghurt. This area is usually divided into many sections with the holding tanks located near the pasteurizers, the incubation rooms near the other cooling rooms, and the packaging machines located in still another area. Holding tanks for yoghurt and sour cream are similar and should be located near the pasteurizer. There must be ample room in this area around the holding tanks to wash and test the products. Areas near the packaging machines should be expansible to include a pasteurizer and homogenizer as the fermented milk processes grow in volume.

Butter Area

The area for butter processing requires very little floor

space. The needed equipment is a holding tank for cream having the correct butterfat content, a churn or continuous buttermaking machine, and a packaging machine. Space is required for one to three people to operate the equipment. The butter area is usually located adjoining the milk production area because of the close proximity of the cream collection tanks. It does not need to have closely controlled temperature or air pressure, but it should be well-ventilated. There must be sufficient room surrounding the equipment for sampling and cleaning.

Secondary Function Areas

The secondary function areas are those which serve the primary function areas.

Receiving Area

The receiving area must have adequate space to pump milk from two trucks at the same time. It should be enclosed and have facilities for washing the tank trucks. The area should include toilet facilities and a lounge for the truck drivers' convenience.

Sampling Room

The sampling room should be located adjacent to the receiving area. It contains testing equipment for the milk just received. It requires enough room for storage and for one person to conduct the various tests.

Bulk Storage Area

The bulk storage area occupies a large space, as it must be

able to contain 400,000 pounds of milk at one time from one day's receipts. These four 15,000 gallon tanks can be close together, but must be accessible from the front for sampling, cleaning, and operating the valves.

Packaged Milk Storage Room

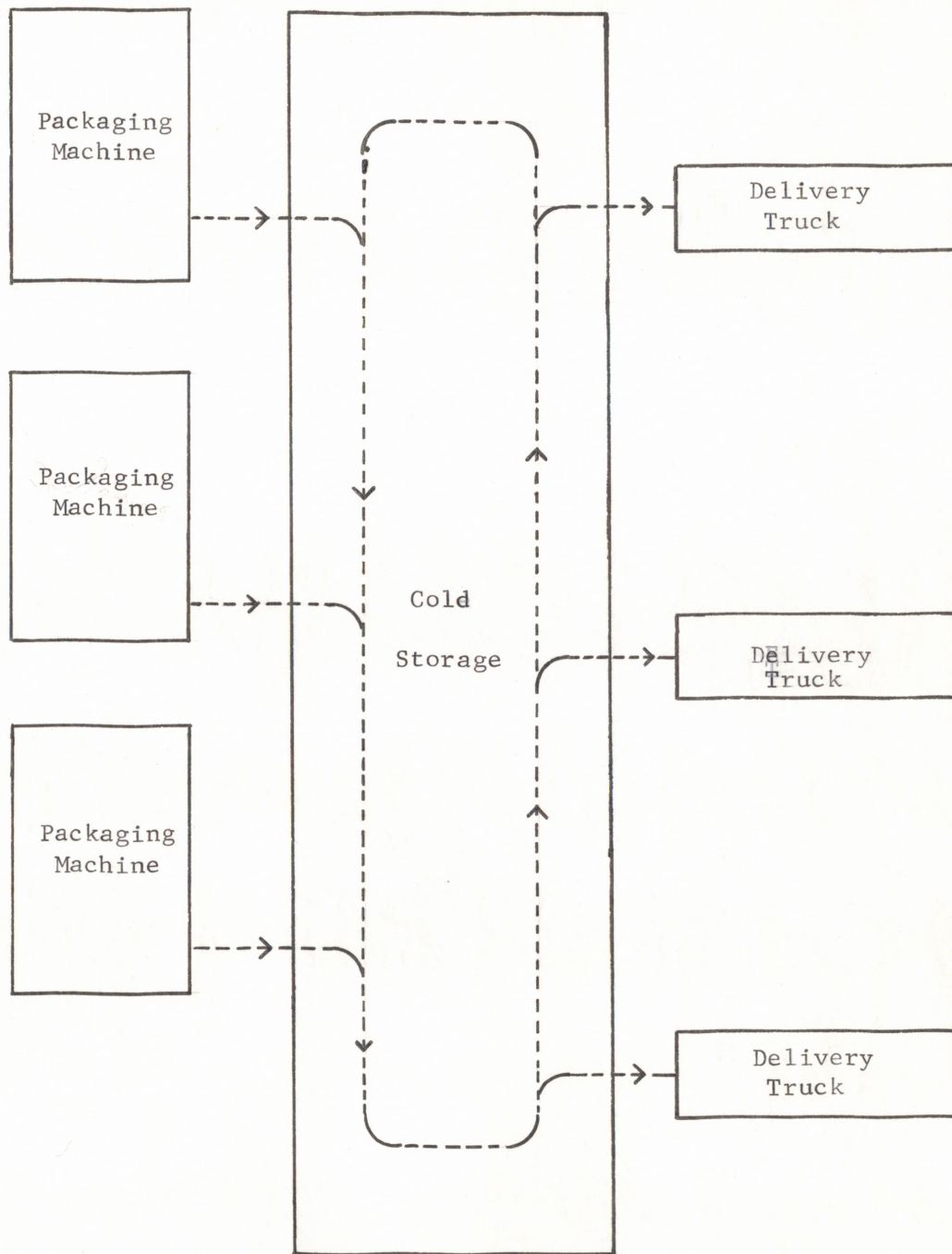
The packaged milk storage room will be located adjoining the milk processing area and also on an outside wall for easy access to shipping areas. It must be spacious and allow room for an electric fork lift to move about and shift the pallets which hold the cases of milk. It constitutes an area large enough to hold the day's production of all carton milk products. Conveyors are used in this area to bring the milk from the packaging area and to move it to the shipping trucks. This area must be kept at a constant temperature and must provide clear flow patterns for the products. (See Illustration 5 for diagram of flow patterns.)

Shipping Area

The shipping area must be a covered space closely related to the cold storage areas. It must be large enough to allow room to load large trailer trucks, smaller single-axle trucks, and the local delivery trucks. A loading dock must be provided to unload empty cases which must be large enough to allow for movement of equipment. An office should also be incorporated into this area where shipping clerks can perform such duties as filing orders, receipts, and other miscellaneous data necessary to the shipping

ILLUSTRATION 5

FLOW PATTERN OF MILK AFTER PACKAGING



department. It is also advantageous to have a drivers' lounge and toilet in the shipping area.

Case Storage and Washing Room

Case storage and washing require a large room directly off the loading dock. The empty cases are taken from the trucks and conveyed into this area where they are stored. When they are to be used, they are washed and conveyed into the packaging room, completing the loop. (See Illustration 6.)

Warehouse

The warehouse must be the largest single area in the plant, constituting approximately 25% of the building. It contains all of the materials used for packaging products plus a supply of additives and starters used in milk processing. This room should be centrally located because of its function and easily accessible from all of the individual production areas of the building.

Mechanical Room

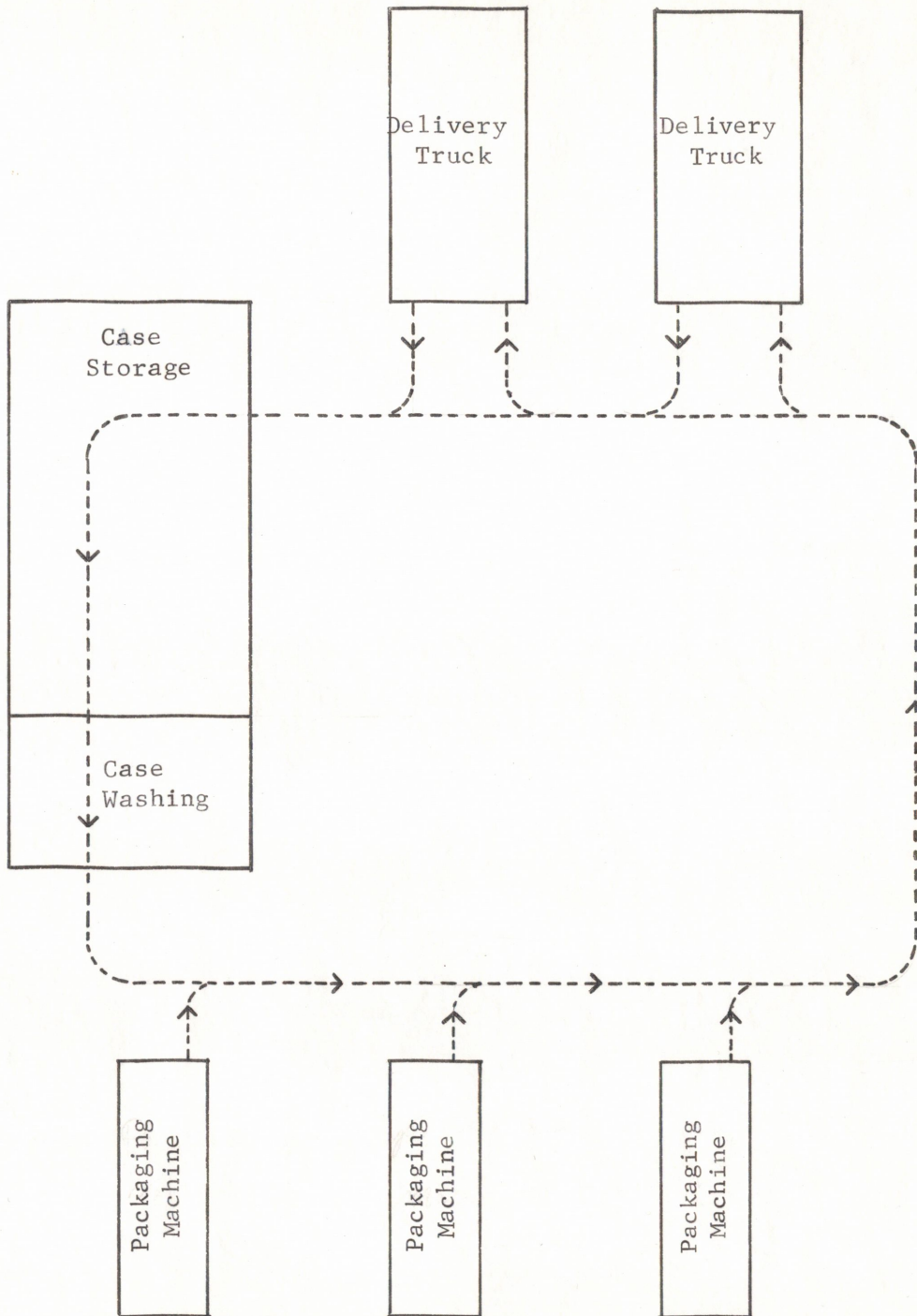
A utilities room or mechanical room must contain the boilers that heat the plant and provide steam for operating equipment and hot water for the sanitary washing of equipment. It also contains such equipment as water purifiers, softeners, and coolers.

Cleaning-in-place Room

The C.I.P. room must contain solution pumps, solution tanks, heater, connecting pipelines, recirculating units, and temperature gauges. This equipment is used to circulate water and a cleaning

ILLUSTRATION 6

CASE FLOW PATTERN



agent through the stainless steel pipes in the plant.

Laboratory

The laboratory must be centrally located to provide access to all milk processing areas. Various milk samples are analyzed by the laboratory technician in this room. The room must contain a desk, files, work cabinets, sink, and storage areas.

Ice Cream Storage Area

The ice cream storage area must be large enough to hold both novelties and ice cream from several days' production. The size of this area will be nearly the same as that of the room needed to process the ice cream. Also a palletizing room must be provided next to the storage area where the ice cream is kept at a slightly higher temperature than in the storage area. The ice cream is mechanically placed on pallets and readied for shipping.

Cheddar Cheese Storage Room

The cheddar cheese storage room and curing room are located adjacent to the cheese production operation. Although curing may not take place at the initial production site, space should be allowed in case this becomes necessary. These areas should have controlled temperature and have parallel flow patterns for individual workers.

Cold Storage Areas

Cold storage areas must also be provided for the cottage cheese and cultured cream products. These rooms are equal to the size of

the production room for these products. In addition, cultured cream requires an incubation space, which is adjacent to the coolers and has controlled temperature and humidity.

Offices

The General Manager's office must have a place for a desk, files, and ample room to receive visitors.

The Plant Manager's activities are centered mainly in production processes and efficient plant operation. His office should have a desk, files, and a large table for working with other people.

The Sales Manager's office should include a desk and filing cabinets. It should be close to the IBM room where the records of the business are kept.

The Office Manager supervises all general office procedures. His office must have a desk and files.

The Plant Superintendent works directly with employees. His office should include a desk, files, a large work table, and enough space for talking with employees and interviewing job applicants.

The General Offices will be housed in a large open area which can accommodate at least ten employees. Each will have a desk and files to handle correspondence. These employees keep the records of the various areas of production for the plant.

Reception Area

A reception area is a necessity for accommodating visitors

and salesmen. A desk having a telephone and seating space are required. This area should be located near the public entrance to the plant.

Toilet Facilities

Toilet facilities are needed for both men and women and will require adequate space for an influx of twenty people at one time during lunch breaks.

Lunch Room

A lunch room must be provided next to the processing rooms for use by all employees. It must be adequate to seat sixty persons at one time and have tables and chairs and a lounge area with vending machines.

Supplementary Function Areas

Data Processing Room

Most modern plants today have their own IBM room for data processing. This room is located apart from the general offices because of noise and traffic flow. It should be located near these offices, however, because of the frequency of its use.

Meeting Room

A meeting room can serve as a community room for advertising purposes, as well as a plant room for staff meetings.

Kitchen

A kitchen area for warming food, making coffee, and serving

the meeting room is also desirable. It would be a minimum facility, having a small refrigerator, range, and sink.

Public Observation Points

Balconies or special observation points serve interested groups and persons who visit the plant to observe its operations. They should be located in an obscure area where they will not affect the operation, but still offer a clear view of activities.

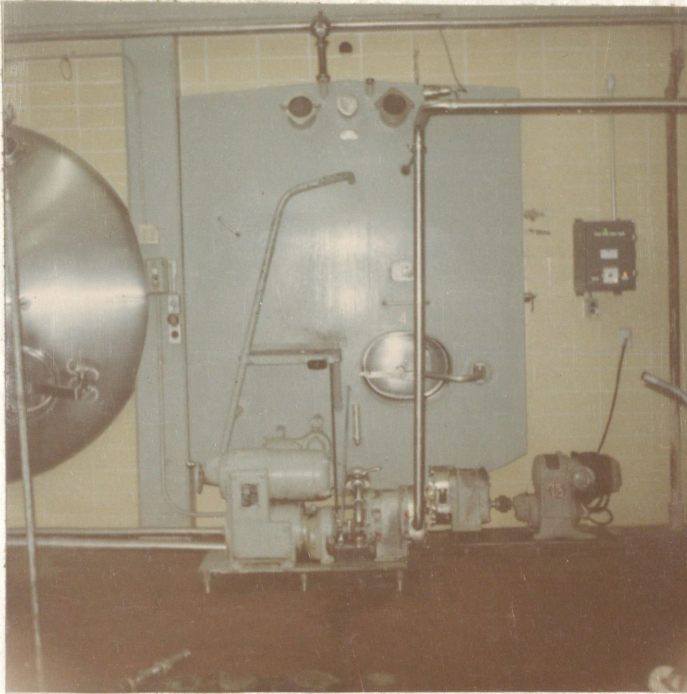
Sales Area

This area is a place to sell products that are made in the plant. The volume of products sold is small and only one person is needed to manage this operation. Its purpose is mainly advertising and requires only showcases and a cash register. An ideal location for this area is near the public entrance.

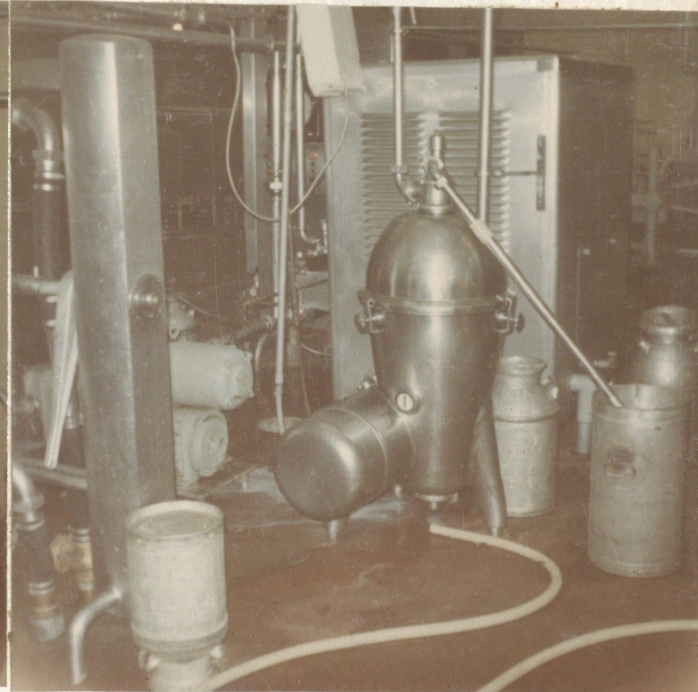
Fountain Area

The ice cream fountain serves only plant-produced products. It requires a small area operated by a single person and has tables to seat thirty people and enough space to include display cases.

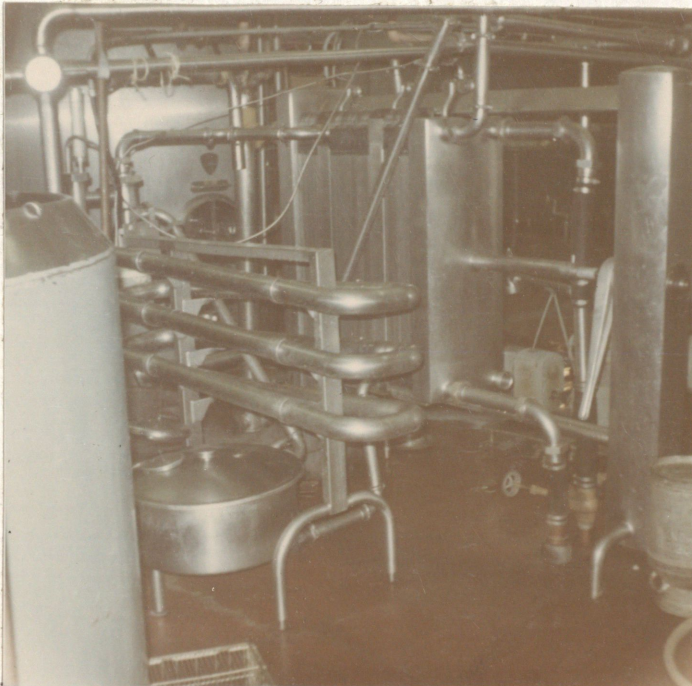
ILLUSTRATION 7



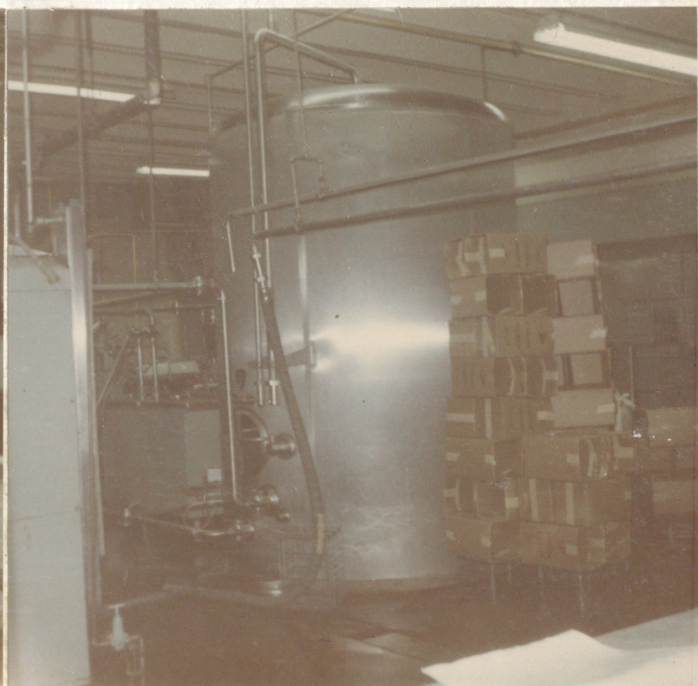
COLD STORAGE TANK



SEPARATOR AND HOMOGENIZER



PASTEURIZER



SURGE TANK

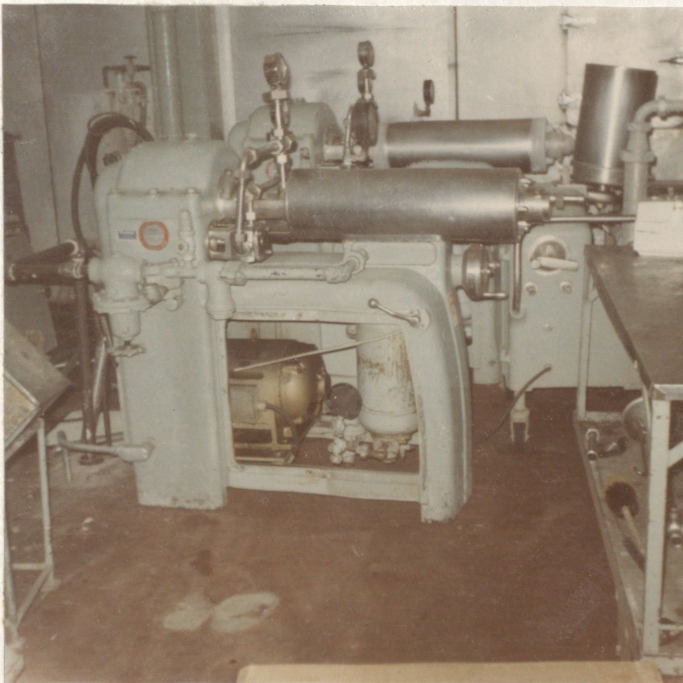
ILLUSTRATION 7 (CONT'D.)



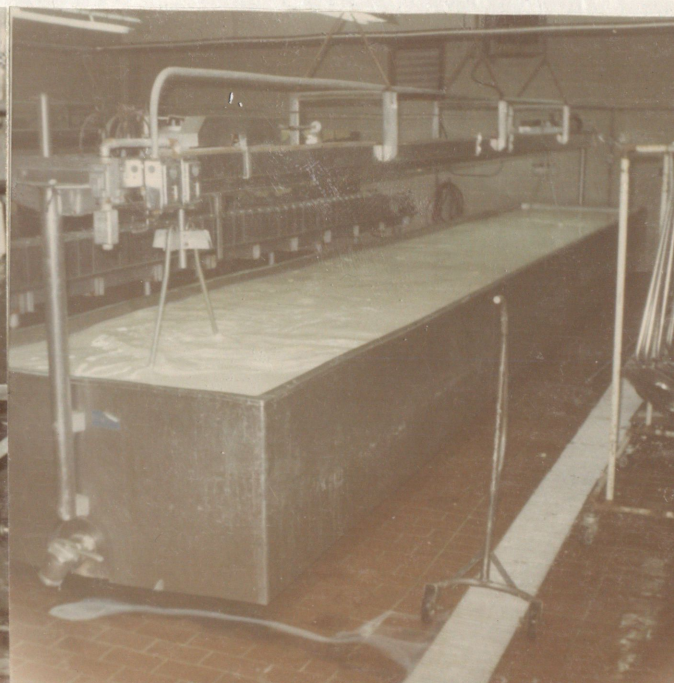
PACKAGING MACHINE



MIX TANKS



ICE CREAM FREEZER



CHEDDAR CHEESE VAT

ILLUSTRATION 7 (CONT'D.)



STARTER VAT



COTTAGE CHEESE VAT



COTTAGE CHEESE PACKAGER



FERMENTED MILK TANK

S I T E C O N D I T I O N S

SITE CONDITIONS

Location

The Gallatin Valley was selected as a site for one of two large consolidated dairy operations by an economic study conducted by J. C. Cothorn as discussed earlier. The exact location is Lots 1 - 5 of the Westlake Subdivision, Bozeman, Montana. (See Illustration 8 for map.) Principal reasons supporting this selection are the close access to major transportation routes, the large land area available, and the easy hookups to city water and sewer.

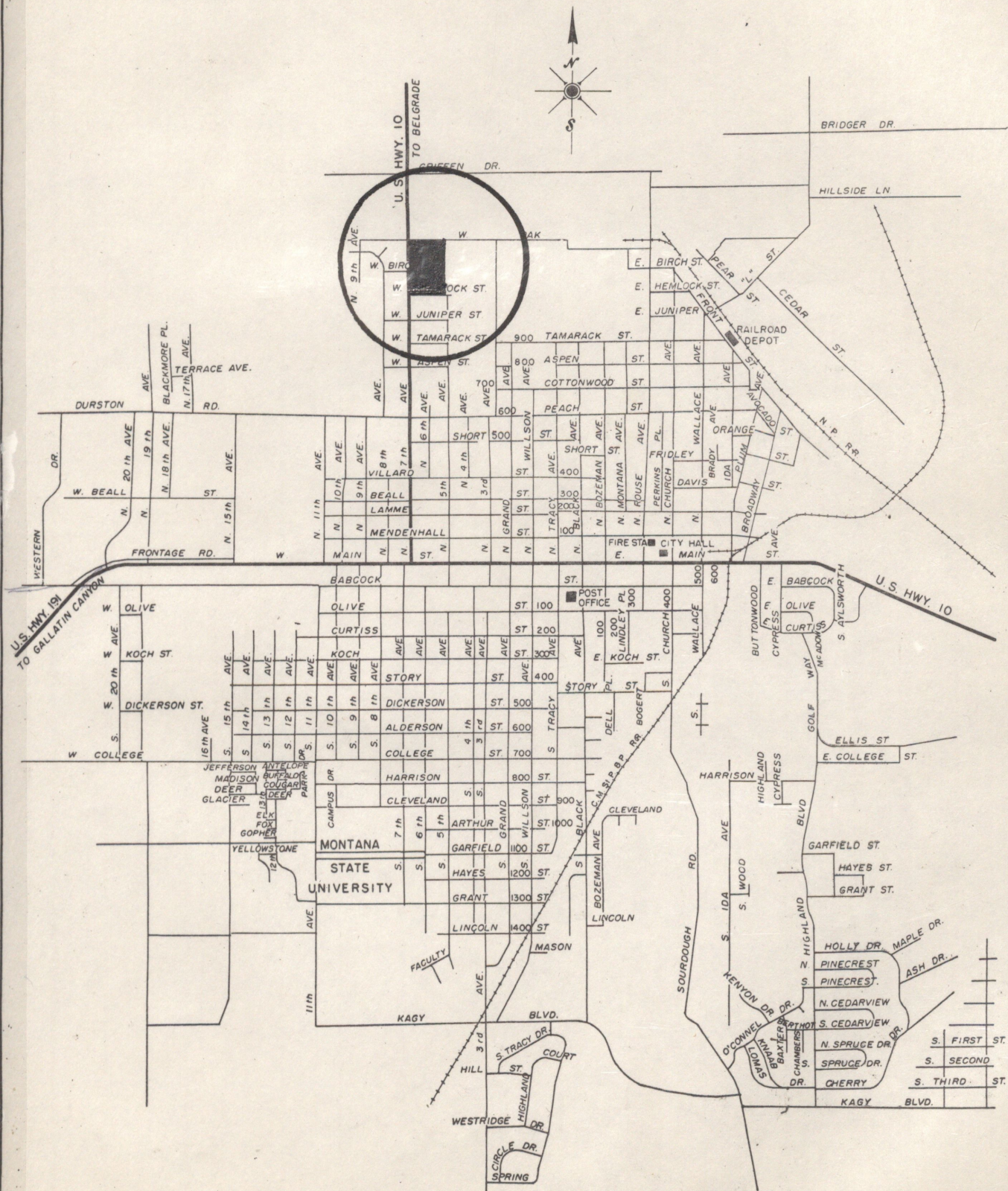
Transportation

This site is particularly good because it is near the interchange on Interstate 94. In this location city traffic can easily get to the site to support the ice cream fountain and sales area. Tourists passing through Bozeman will be able to tour the plant because it can be easily noticed from the two highways. Also egress and ingress are simplified because of the four lane highway presently in use on North Seventh Avenue.

Area

On this site adequate area is available for both employee and visitor parking. With the proper site layout both tank trucks and delivery trucks will have adequate space for turning, loading, and unloading. This site offers open areas to the east for the future expansion of the building.

MAP OF BOZEMAN MONTANA



Water and Sewer

Since this type of plant uses approximately 140,000 gallons of water per day, an important factor in site selection is the availability of city water and sewer connections. City water and sewer lines are already on this site and would simply need to be connected. These systems, if they must be initially installed, are a major expense for a new dairy plant and the savings created in this way will offset the higher cost of land in this location.

Topography

The site is level which is helpful in planning a dairy plant because it decreases cost in the building. The soil is good and there is no standing water present in the area. The site slopes from west to east causing drainage away from the building. (See Illustration 9.)

Zoning

The area of the site is zoned for commercial business. Since the dairy operation is a sanitary business with no air pollution, no restrictions would have to be placed on this particular plant.

Environment

Commercial structures are located on all sides of the site at this time. The site, however, is large enough so that no crowding of buildings will occur. There are no vibration problems

ILLUSTRATION 9



PANORAMIC VIEW OF SITE

because of railroads or pollution problems because of smoke emission in this area.

Orientation

The site is oriented with the major access from the west side. The building must be built with the main entrances in this direction for pedestrian as well as vehicular traffic. (See Illustration 10.)

Climate

The climate at the site is characterized by wide variances in temperature. For example, temperature extremes range from 100° F. to -43° F.¹⁵ This makes expansion and contraction a major consideration in choice of materials and construction. There is also a large snowfall in the area averaging 72.7 inches a year. The rainfall averages 17.65 inches, so the snowfall is the primary consideration concerning precipitation. Prevailing winds blow from the north and northwest usually at less than fifteen miles per hour.



MAJOR ACCESS TO SITE



VIEW OF SITE FACING WEST

BUILDING CONSTRUCTION

BUILDING CONSTRUCTION

The building must be of masonry construction because of sanitary requirements. There must be large open areas inside for equipment layouts, which points to a concrete structural system providing long spans.

Floor Construction

The floors in the milk plant must be smooth and impervious to prevent the collection of moisture and dirt in cracks or crevices. They must be able to withstand the lactic acid which is used in cleaning and also heavy equipment and wear.

Wall Construction

The walls should also be of smooth and impervious materials for easy cleaning. This can be done with ceramic tile or cement plaster in most cases. The same material should be applied to all interior wall surfaces.

Ceiling Construction

Ceilings should be easily cleaned and maintained. False ceilings should be avoided because of trapped dirt and debris. Any equipment such as ventilation and mechanical systems in the ceiling should be easily accessible.

Insulated Rooms

The insulated rooms in the plant require the same type of

impervious materials as the other surfaces previously mentioned. Usually sheet metal is used in the floor of this room when an in-floor conveyor system is installed.

Windows

Windows in the dairy plant present a special problem and should be avoided in the processing area as sunlight tends to produce off-flavors in milk. If windows are used in these rooms, special glass or glass block must be incorporated to stop harmful rays.

Lighting and Ventilation

Lighting and ventilation are two primary considerations in the dairy plant and for this reason should be discussed independently. The lighting is important because it increases safety, improves cleanliness, reduces eyestrain, and makes better utilization of all floor space for working areas. The most common form of lighting for the milk plant is incandescent light, which produces a more natural color than fluorescent light. The lighting requirements of the major plant areas are listed in Illustration 11.¹⁶

Ventilation is important to the milk plant because the quality of milk is adversely affected by off-flavors absorbed from odors in poorly ventilated rooms. Another problem is condensation forming on the ceiling and falling into the milk tanks. A system

ILLUSTRATION 11

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION

<u>Location</u>	<u>Footcandles</u>
Boilers	10
Cooling Equipment	20
Filling and Inspection	50
Gages	30 (on face)
Laboratories	50
Loading Platforms	10
Meter Panels	30 (on face)
Offices	
Difficult Seeing Tasks	50
Ordinary Seeing Tasks	25
Pasteurizers	20
Receiving Room	20
Scales	30
Separators	20
Storage Refrigerator	10
Tanks	20
Thermometers	30 (on face)
Vats	50
Weighing Room	10

should be used along the ceiling which picks up the fog and moisture before condensation occurs. It is also advantageous, in construction, to provide an air space between the ceiling and the roof to prevent condensation on the ceiling.

ECONOMIC CONSIDERATIONS

ECONOMIC CONSIDERATIONS

Although economic considerations were discussed earlier in deciding plant location, economics must also be considered for the size of investment needed to build and operate a plant of this size. This dairy plant is designed with the objective of lowering operating costs, but improving working areas and creating more functional spaces to better serve human needs.

Land

A four-acre tract is necessary to provide sufficient space for the buildings and for free movement of vehicles around it. The cost of this land at the chosen site is approximately \$50,000.¹⁷

Building

The cost of a dairy plant varies with the locality; however, in the sixteen plants involved in a study by Johnson Associated International, the average cost per square foot was \$18.48.¹⁸ The areas of construction costs can be divided into three parts: site and building preparation costs, electrical costs, and fees and supervision costs. (See Illustrations 12 and 13 showing a cost breakdown.)

Equipment

The equipment must be selected to minimize processing costs, and includes labor-saving equipment that is economically justified.

ILLUSTRATION 12

AVERAGE CONSTRUCTION COSTS

<u>Construction components</u>	<u>Cost</u>
Building and site preparation	\$13.62 per sq. ft.
Electrical	3.22 per sq. ft.
Fees and supervision	1.64 per sq. ft.
TOTAL	\$18.48 per sq. ft.

ILLUSTRATION 13

<u>Type of area</u>	<u>Average cost per square ft.</u>
Cold storage	\$26.01
Processing	19.51
Storage and service	15.61

To recude the initial investment the equipment is selected for a two-shift operation in the Grade A milk processing area. (See Illustration 14 for an equipment cost schedule.)

Cases constitute a major portion of the investment for a large plant. This cost will total nearly \$111,000 for the 400,000 pounds of milk processed daily. Another factor is that the cases have only a five-year lifetime.

ILLUSTRATION 14

EQUIPMENT INVESTMENT LIST¹⁹

Item	No.	Specification	Investment Required (in place)
<u>Bulk tanks</u>			
Silo tanks	4	15,000 gal. each	\$59,708
Surge tanks	1	10,000 gal.	11,319
	1	5,000 gal.	6,736
	1	4,000 gal.	6,253
<u>Processing equipment</u>			
Separator	2	5,000 lb./hr.	18,852
Clarifier	2	35,000 lb./hr.	42,000
Pasteurizer	2	35,000 lb./hr., HTST	30,745
Homogenizer	2	35,000 lb./hr.	18,002
Blending tank	1	800 gal.	2,709
Blending tank	1	600 gal.	2,300
Vitamin feeder	1		415
<u>Filling equipment</u>			
Paper container filler	2	160 quarts, pints, half pints/minute	161,700
	1	80 half gal./minute	82,950
	1	30 gal./minute	leased
Bulk box filler	1	12-10 qt./minute	7,402
Creamer filler	2	150 half oz./minute	leased
<u>Handling equipment</u>			
Caser-stackers	2	For quarts, pints, etc.	27,546
	1	For half gallons	12,377
	1	For bulk boxes	5,105
Case conveyor and other automatic equipment		For filling room, cold storage, receiving dock	74,811
<u>Cheese equipment</u>			
Vats	7	20,000 lb.	35,000
Culture tank	1	100 gallon	8,500
Cheese press	1	20-case	2,000
Filler	1		8,500
<u>Ice cream equipment</u>			
Continuous freezer	4	Small	12,000
Flavor tanks	4	3-compartment	8,000
Mix storage tanks	3	100 gallon	6,900
Conveyor equipment			42,000

AESTHETICS

AESTHETICS

The aesthetic considerations involved in planning a dairy plant are practically non-existent today and yet this could be one of the most important considerations concerning employee satisfaction, visitor enjoyment, and public advertising. This would involve the total environment of site and building.

The office worker has for some time known the difference a well-designed, comfortable office makes, but this idea has not yet reached the plant employee. His need for personal satisfaction in a working area is just as great as that of the office worker. This idea can be exemplified in a dairy plant by variations in height in the processing areas, the use of more color, and the illuminating of cramped working quarters. All this can be achieved with little extra cost and more consideration to the aesthetics or "feeling" of a space.

A dairy plant should be designed to make a visitor want to enter. If the building form tells the visitor this is his building also and not just another industrial plant, an important idea will be conveyed. People enjoy watching processes if they are comfortable and not in the way of operations. This can be done by the use of observation balconies and glass partitions to give the necessary visual contact. The observations can be educational as well as interesting and should be included in the initial design and not as an after-thought.

Since the objective of the plant is to sell dairy products, a well-designed building will advertise more than a carload of billboards. A building that belongs to the site, that is not obtrusive and yet offers interest, is an asset to the community and to the company which owns it.

Although the aesthetics of a building are probably the most nebulous part of a design, one can at least examine these aspects in considering what is good planning, opposed to bad planning, and what is thought about, opposed to what is ignored.

FOOTNOTES

¹James Harold Cothern, An Economic Study of Milk Produced and Processed for Manufacturing Purposes in Selected Montana Areas, (Bozeman; June, 1968), p. 164.

²Jim King, Plant Superintendent, Yellowstone Dairy, Bozeman, Montana, Personal Interview, February 7, 1970.

³Cothern, p. 183.

⁴State of Montana Milk Control Board, 3rd. Quarter 1968 Quarterly Report of Milk Utilization in Montana, (Helena: October, 1968), p. 5.

⁵Manual for Milk Plant Operators, Plant Operations Committee, Milk Industries Foundation, 1957, p. 235.

⁶Ibid., p. 287.

⁷Hervy Aldrich, Dairygold Company, Bozeman, Montana, Personal Interview, February 12, 1970.

⁸J. H. Frandsen and D. Horace Nelson, Ice Cream and Other Frozen Desserts, J. H. Frandsen, 1950, pp. 27-38.

⁹Emerson Mistelske, Land O' Lakes Dairies, Minneapolis, Minnesota, Personal Interview, September 5, 1969.

¹⁰Art Scherbenske, Manager, Tuttle Cheese, Inc., Tuttle, North Dakota, Personal Interview, June 12, 1969.

¹¹Frank Kosikowski, Cheese and Fermented Milk Foods, Edwards Brothers Inc., 1966, p. 206.

¹²E. L. Fouts and T. R. Freeman, Dairy Manufacturing Processes, John Wiley and Sons, Inc., 1948, pp. 180-183.

¹³Kosikowski, pp. 90-95.

¹⁴King.

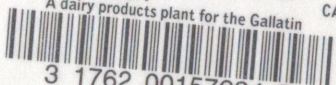
¹⁵Bozeman Chamber of Commerce, Publicity Pamphlet

¹⁶Manual for Milk Plant Operators, p. 36.

¹⁷Representative, Bozeman Realty, Personal Interview, March 7, 1970.

¹⁸Specifications and Costs for a 100,000-Quart-per-Day Model Fluid Milk Processing Plant, Department of Agricultural Economics and Marketing, New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey, April, 1969, p. 10.

¹⁹Ibid., pp. 7-9.

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