A HANDBOOK FOR DAIRYMEN

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THE RELATION

OF

TEMPERATURE, HUMIDITY AND PRESSURE

TO

DAIRY OPERATIONS

A HANDBOOK FOR DAIRYMEN

By

WALTER W. FISK, M.S. IN AGR.

Professor of Dairy Industry, New York State College of Agriculture, Cornell University

FOXBORO, MASS.

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FOREWORD

THE object of this book is to provide authoritative and up-to-date information on the relation of temperature, humidity and pressure to the manufacture of dairy products.

Because of his professional standing and wide experience with every phase of the dairy industry, Professor Walter W. Fisk, of Cornell University, was asked to prepare the material.

Professor Fisk is in no way connected with The Foxboro Co., Inc., and no restriction of any kind was imposed upon him. He was at liberty to write what he wished. Each branch of the dairy industry has been analyzed from the standpoint of temperature, humidity and pressure, and discussed in the light of the best practices of the most successful dairymen. No theories that have not proved to be commercially practical are presented.

The result is an unbiased, authoritative treatise on some of the most significant phases of dairy operation.

With the hope that we have contributed to dairy improvement and progress this book is dedicated to the dairy industry.

THE FOXBORO CO., INC.

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A typical installation of recording thermometers on pasteurizing equipment. Foxboro Thermom
gallon Elyria Pasteurizers at the Newton

CHAPTER I

INTRODUCTION

It is only recently that the importance of temperature, pressure and humidity in relation to milk handling has been fully realized. Authorities are now agreed that the successful manufacture, handling and storage of milk and milk products of prime quality depend upon the knowledge and the careful regulation of these factors. Cleanliness is not to be minimized, but it is taken for granted in this discussion that every right-thinking dairyman has the welfare of his community enough at heart to use the utmost care in keeping his plant clean and sanitary. Our aim is to give to the manufacturer, superintendent and operator certain suggestions regarding the relation of temperature, humidity and pressure to dairy operations, which will not only enable him to raise the standard of his product and eliminate needless wastes, but in the end will be of assistance to the whole industry.

Temperature has two influences on dairy operations: it regulates the growth of micro-organisms, and it has a physical effect on certain operations and on the quality of the finished product.

The Influence of Temperature on the Growth of Micro-Organisms.

Every dairyman knows that in milk and milk products there are many micro-organisms: bacteria, yeasts and molds. Because these are really tiny plants, their growth depends upon a readily available food supply and proper temperature. Milk and milk products furnish their food, but high temperature will kill them and low temperature will retard their growth.

Professor W. A. Stocking in an interesting experiment shows the effect of temperature on the development of bacteria in milk. A sample of milk was thoroughly mixed and divided into six equal parts. The six bottles were placed in water at different temperatures for twelve hours, at which time the germ content of each lot was determined. The bottles were then all placed together in a temperature of 70° F. and allowed to remain until they curdled. As each sample curdled, the time was recorded. Results show what may happen easily in milk which is allowed to stand overnight without thorough cooling.

Effect of Different Temperatures, Maintained for Twelve Hours, on the Growth of Bacteria and on the Keeping Quality of Milk

I	II
Kept at 45 degrees Number of bacteria, 9300 Curdled in 75 hours	Kept at 50 degrees Number of bacteria, 18,000 Curdled in 72 hours
III	**IV**
Kept at 55 degrees Number of bacteria, 38,000 Curdled in 49 hours	Kept at 60 degrees Number of bacteria, 453,000 Curdled in 43 hours
V	**VI**
Kept at 70 degrees Number of bacteria, 8,800,000 Curdled in 32 hours	Kept at 80 degrees Number of bacteria, 55,300,000 Curdled in 28 hours

In cheese and butter making, the growth of certain types of organisms, especially the lactic acid type, is essential. In other dairy operations, such as the handling of market or fluid milk, condensed milk and evaporated milk, the growth of organisms invariably causes the product to spoil.

All dairymen and milk producers probably make use of these facts, and the most successful cool the milk as soon as it is drawn from the cow. Regardless of how clean the milk may be produced, there is certain to be some micro-organisms in it. Of course some of these are beneficial and others are harmful, but as the producer cannot distinguish between them, the development of all should be retarded by cooling and holding cold.

The Influence of Temperature on the Quality of the Finished Product.

The quality of the finished product is judged by its flavor, body, texture and appearance.

Flavor is affected by bacterial growth, and this growth in turn is regulated by the temperature. A high temperature will cause a bad or undesirable flavor. A low temperature may cause a lack of flavor.

The body and texture and appearance are determined by the moisture content and the process of manufacture. Both are largely regulated by temperature. For example, if cheese is heated too high, it will be dry, hard and crumbly, while ice cream that is not frozen sufficiently will be watery and grainy. The churning of cream into butter depends upon the correct churning temperature. If the cream is too warm, the butter will be too soft and will have a very poor body; if too cold, it will not churn at all, or very slowly.

The successful manufacturer must make a product that is uniform from day to day. Uniformity depends upon many factors, but the important one, as will be pointed out in detail later, is that of the correct temperature.

The Influence of Temperature on the Storage of Dairy Products.

The keeping quality of milk or milk products depends largely upon a uniform holding temperature. If the temperature is allowed to go too high or to fluctuate from day to day, the product will not keep as long as when held constantly at the proper temperature.

When butter and cheese are held in a refrigerator and the temperature rises, they not only deteriorate in flavor and body and texture, but molds grow rapidly and injure the quality. Bad flavors and poor body and texture in practically all dairy products quickly develop under poor storage conditions.

Many losses can be positively attributed to improper storage temperatures. For example: The writer knows of one case in which an ice-cream manufacturer lost his entire business because of the poor quality of his ice cream. The ice cream was of good quality when it left the freezer, but became grainy and icy during the hardening process, due to uneven and, at times, too high a temperature.

Another case of loss is that of the storage of butter. A thousand tubs of butter were held in a storage which occasionally became too warm and damp so that molds rapidly grew. In this case, each tub had to be stripped and the mold scraped off. The butter sold at a loss of ten cents a pound, or about six dollars a tub, because of the moldy flavor. A loss of six thousand dollars could have been avoided if only a very small fraction of that sum had been invested in a recording thermometer.

There is no definite length of time that a product may be held in storage without deteriorating. Time of deterioration depends upon the quality of the product when put in and the temperature of storage. Whenever the temperature rises during storage, if conditions are right, it gives the lactic acid-forming bacteria a chance to develop. This is especially true of fluid or liquid milk and unsweetened condensed milk. These products sour quickly in a refrigerator that is not held at a uniform cold temperature.

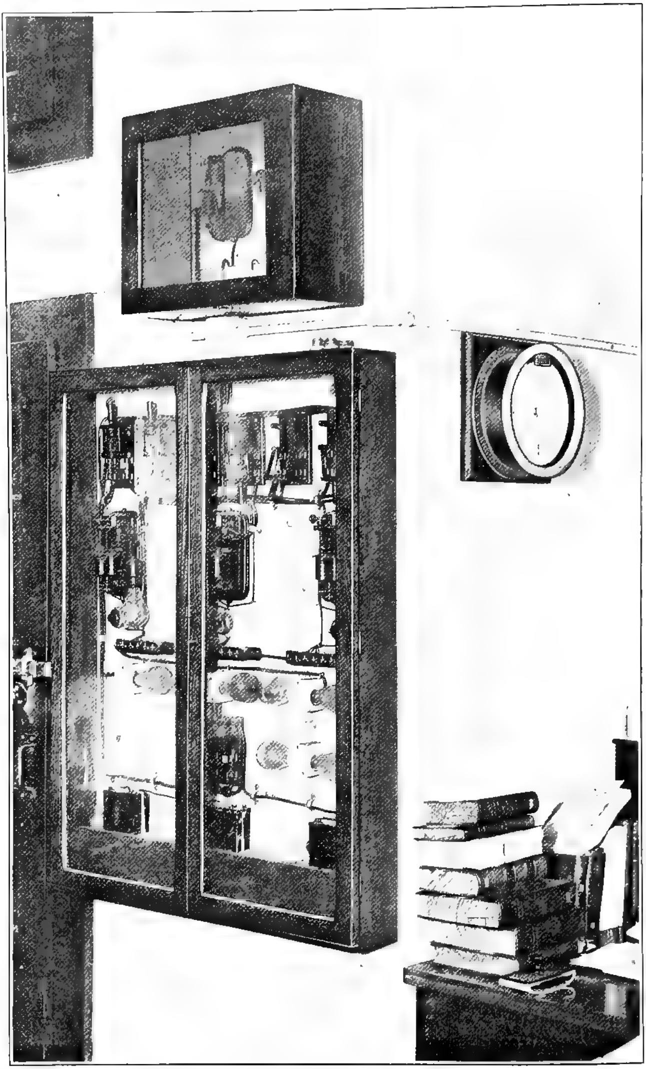
The Influence of Humidity on Dairy Products.

Humidity is most important in the ripening of cheese, the manufacture of milk powder and the storage of products not hermetically sealed. The correct humidity is necessary for the proper functioning of the ripening agent during cheese curing. If the humidity is too low, there will be too much evaporation, which will cause unnecessary losses. If too high and accompanied by the correct temperature, molds will grow and spoil the product. If the humidity is too high, it is impossible to make good milk powder after certain processes.

The Influence of Pressure on Dairy Products.

It is very necessary to have a constant steam pressure for the successful operation of many machines. For example: the centrifugal separator. If there is not sufficient steam pressure, the efficiency of the machine is reduced. It is also important to have different materials put through machines at a given pressure. For example: ice cream mixed through the homogenizer. If the pressure is reduced, the intended results are not accomplished. The important subject of power-plant efficiency will be discussed in a separate chapter.

As stated above, the quality and salability of dairy products depend upon a careful regulation of temperature, pressure and humidity. Manufacturing and storage losses can be traced directly to a lack of knowledge, or to inadequate means of controlling these factors. Savings can be made in formerly wasted materials, steam and water. Losses can be turned into profits. The vital relationship of temperature, pressure and humidity to each dairy product will be discussed in the following chapters.



View of one of six temperature-control boards with recording thermometers for incubation rooms in Pathological Division, Bureau of Animal Industry, U. S. Dept. of Agriculture. Foxboro Thermometers of the continuous seven-day type are used.

CHAPTER II

BACTERIOLOGY

The control of temperature within close limits is very important in laboratories where bacteriological investigations of the micro-organisms of dairy products are conducted. In many instances the success in the maintenance of cultures depends upon the ability continuously to maintain a constant temperature.

The micro-organisms of dairy products are grown on various food materials known as media. To secure the proper temperature for growth they are usually placed in an insulated box known as an incubator, and the temperature is regulated by an electric thermostat, fan and ice.

Each incubator is usually fitted with a seven-day recording thermometer. The recording elements are mounted on the wall outside of the incubator and the capillary tube passes through the wall, the bulb being located near the top and in the center of the incubator. The charts taken from the recorder are examined and any variations in temperature beyond the prescribed limits are noted, with the time at which the variations occurred.

The value of a continuous temperature record in the process of incubating cultures lies in the fact that such records not only show the temperature at all times throughout the period of incubation, but they are dated and can be filed for reference. It is thus possible to determine with accuracy the temperature maintained in the incubating process on any previous date.

If the temperature in the incubator is too low, the growth of the organism will be very slow, or it will not grow at all. Also if the temperature is too high, the organism may not grow. In either case if it does grow, it will not give a strong type and contaminations are likely to appear.

Starter.

A practical application of bacteriology to dairy operations is the preparation of starter.* The lactic acid starter used in the making of butter and cheese is the most common. Other starters are the molds of Camembert and Roquefort cheese, Bulgaricus for Swiss cheese, the eye-forming culture for Swiss cheese, and the starter for ripening cream for Hebrew trade.

The Lactic Acid Starter.

Since cultures must be prepared by a bacteriologist, commercial laboratories have developed a large business in their production, usually under trademarked names. Some of these cultures represent races of lactic bacteria cultivated and cared for efficiently, hence uniformly valuable over long periods of time. Others, carelessly produced, are worthless, or even a peril to the user.

The organisms are usually shipped in small quantities in bottles of liquid or powder, or in capsules of uniform size. The contents may be either the culture medium upon which the organisms grew, or an inert substance designed merely to hold the bacteria in active form. In either solid or liquid form, the producer of the culture should guarantee its activity up to a plainly stated date.

*Starter is a culture of desired organisms in a living or active state.

It is the problem of the cheese or butter maker first to keep the organisms pure, and second to increase them to such numbers and in such an active condition that they are commercially useful. The common practice is to allow them to develop in some material, usually whole milk or skimmed milk, or even dissolved milk powder.

The manufacturer's directions apply to average conditions and must be varied to suit the individual case. The directions should state the amount of milk necessary for the first inoculation, usually one or two quarts.

Suggestions for Selecting Starter Milk.

As the flavor of the starter will be the same as that of the milk from which it is made, great care should be used in its selection. The following suggestions are offered to aid in this selection: only clean-flavored sweet milk, free from undesirable micro-organisms, should be used. Choose the morning milk because the bacteria have not had much chance to develop. In no case should mixed milk be used, as this eliminates all opportunity for selection. Choose the milk from a producer who maintains high standards and whose milk is usually in good condition. The quality of the milk can be determined by the fermentation test.

Pasteurization.

Pasteurization kills most of the micro-organisms in the milk and makes a clean seed-bed for the pure culture. The temperature of pasteurization recommended for starter making differs with the authority. A temperature of 180° F. for thirty minutes or longer seems to be very satisfactory because under these conditions nearly all the micro-organisms are killed.

The small amount of milk needed for starter making may be pasteurized by placing the container in water heated to the desired temperature. A very satisfactory arrangement is to cut off a barrel and place a steam pipe in it. Two or three extra bottles should be prepared, as some of them may be broken. Fill the bottles about two-thirds full so that there will be room enough for the mother starter and for later examination. To avoid possible contamination, it is desirable not to have the milk or starter touch the cover. It is a good plan when pasteurizing to have one bottle of water as a check. Test the temperature for all the bottles by inserting a thermometer in the bottle filled with water. Never put a thermometer in the starter bottles. Uniform temperature may be obtained by shaking.

Cleanliness.

A successful starter can only be made if all utensils coming in contact with the milk are sterile. Keep the covers on the containers at all times. Don't put thermometers into the bottles. When examining the starter, pour it out — never dip into it. If the cover is removed from the container, put it in a sterile place. It is easy to spoil the culture if the cover becomes contaminated.

Glass fruit jars, or quart milk bottles, or tin containers may be used for starter making. The first two are more easily cleaned and their content is always visible, but they break easily. The tin container does not break, but it is hard to keep clean and the chance for contamination is exceedingly great.

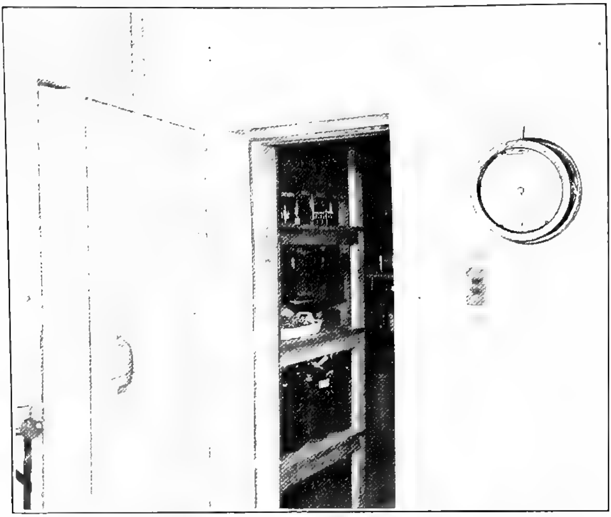
Adding the Culture.

After being pasteurized, the milk should be cooled to a temperature of 80° F. — a suitable temperature for the development of the lactic acid-forming organisms. The commercial or pure culture is added to the milk and mixed thoroughly by shaking the bottle. The shaking should be repeated four or five times every fifteen or twenty minutes. The milk should be placed in a room or incubator with a temperature as near 80° F. as possible. A uniform temperature is necessary for the growth of the organisms. The bacteria in the pure culture are more or less dormant, so that this higher temperature is necessary to stimulate their activity. The milk should be coagulated in eighteen to twenty-four hours, depending largely on the uniformity of the temperature maintained in the incubator.

"Mother" Starter, or Startoline.

The thickened sour milk obtained by inoculating the sweet pasteurized milk with the pure culture of lactic acid-forming bacteria is known as "Mother" starter, or Startoline. Its physical properties, odor and taste should be examined carefully.

Sometimes the first few inoculations from a new culture will show signs of gas, but ordinarily this will quickly disappear and have no injurious effect on the starter. It should have a clean sour-cream odor and be smooth, thick and creamy, entirely free from lumps, whey, and gas pockets. This starter may have an objectionable flavor, due to the media in which the organisms were growing when shipped. In such cases it is necessary to carry one or two propagations to overcome the flavor, to enliven the micro-organisms and to secure the quantity desired.



A Foxboro Recording Thermometer installed on the exterior of a bacteriological cold storage vault. The tube connecting the bulb passes through the wall. Permanent records of the exact temperature are thus maintained and unnecessary opening of the door to the vault is eliminated.

The Second Day's Propagation.

For the second day, the milk for the starter is selected as on the first day. It is pasteurized, and this time is cooled to 70° F. because the organisms have become more active, and hence do not require so high a temperature to grow. Instead of inoculating with powder, as was done the first day, the mother starter already prepared is thoroughly mixed with the milk. Only a very small amount is required, perhaps a tablespoonful to a quart bottle. Since this starter may have the flavor of the media used in the laboratory culture, it may be necessary that it be carried one or two days more to eliminate it. After the flavor has become normal, the mother starter is ready for use.

Preparation of Larger Amounts of Starter.

Determine the quantity of starter required, select the milk as carefully as before, pasteurize, cool and add the mother starter.

The milk should be pasteurized at a temperature of 180° F. for thirty minutes if possible. A good incubation temperature is 60° to 65° F. However, this temperature may be varied so that the starter will be ready at a given time — the higher the temperature the less time is required to ripen the starter.

Pasteurization and incubation can be carried on in a starter can or a milk can. The former requires mechanical power to operate the agitator. The latter may be used where mechanical power is not available, and the milk and starter is stirred by hand. This kind of apparatus is more often used in cheese factories.

Amount of Mother Starter to Use.

Use the mother starter prepared the day before. The amount depends upon the following factors:

1. Temperature of milk when mother starter is added.
2. Average temperature at which the milk will be kept during the ripening period.
3. Time allowed for the starter to ripen before it is used.
4. Vigor and acidity of the mother starter added.

The amount of starter may vary from 0.5 per cent to 10 per cent, depending upon the above conditions.

Some operators prefer to add the mother starter while the milk is at a temperature of about 90° F., before it has been cooled to the incubating temperature. This reduces the amount of mother starter necessary.

If an even incubating temperature can be maintained, less mother starter is needed than if the temperature goes down.

If the ripening period is short, it will require a larger amount of mother starter. If the starter has a low acidity or weak body, indicating that the organisms are of low vitality, more will be required.

The starter, when ready for use, may or may not be coagulated. A good idea of the quality of the starter may be gained by the condition of the coagulation. It should be jelly- or custard-like, close and smooth, entirely free from gas pockets, and should not be wheyed off.

When broken up, the starter should be of a smooth, creamy texture and entirely free from lumpiness or wateriness. It should have a slightly pronounced acid aroma. The flavor should be clean, mildly acid and free from all undesirable taste.

Bulgaricus Starter.

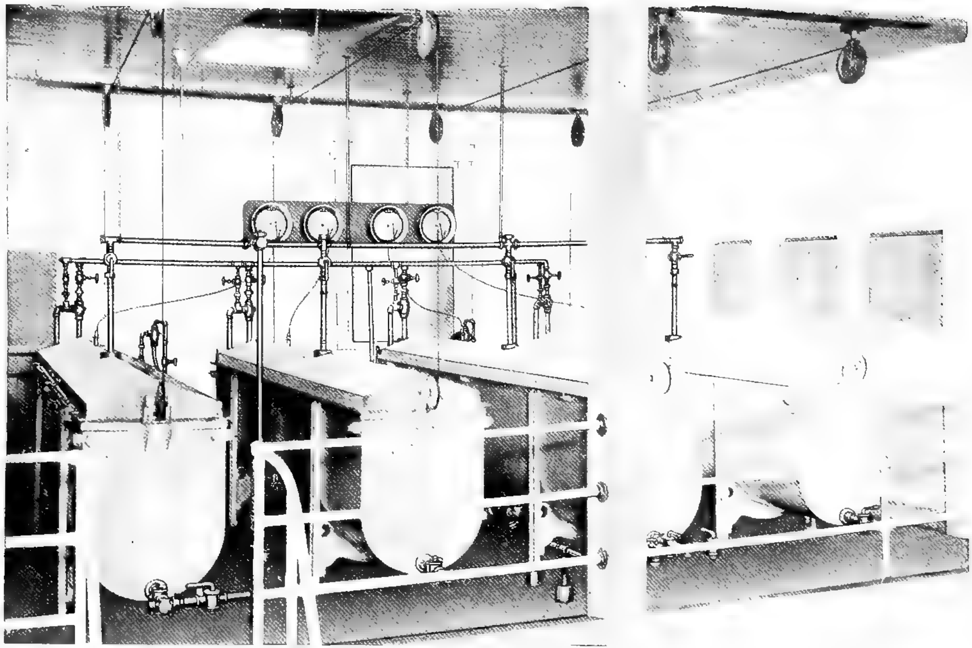
The Bacillus Bulgaricus Starter for Swiss cheese is carried in about the same way as the lactic acid starter, except that whey is a more desirable medium than milk. This organism requires a temperature of 100° F. for growth.

The growing of the molds for Camembert and Roquefort cheese is somewhat similar, except that Camembert is aërobic and grows on the outside of the cheese, while the Roquefort is anaërobic and grows on the inside of the cheese. The Camembert mold may be grown on a media of whey agar or on sterile crackers. It grows spores more rapidly when held at a temperature of 60° to 70° F. It should also be kept very moist. The Roquefort molds grow best when inoculated into a fresh loaf of bread that has been paraffined as it comes from the oven. As soon as cooled, it is ready for inoculation. This can be done by drawing the mold spores with sterile water into a sterile pipette and then forcing them into the bread. The loaf should be sealed and held at a temperature of 60° to 70° F.

Experiments are now being conducted on the eye-forming culture for Swiss cheese. The fact is known that such a culture exists, but definite information is lacking as to its preparation and handling.

Commercial Buttermilk.

Commercial buttermilk is the term applied to lactic acid starter used for drinking. It is often sold as buttermilk or prepared buttermilk, and under many trade names, such as Lactic Culture, Bulgazoon and the like. It is made in the same way as any starter up to the time it begins to coagulate. As soon as it is coagulated and before the coagulation becomes too hard it must be broken up. If allowed to become too hard, the buttermilk will be lumpy and will whey off very rapidly — a great objection to it. As soon as coagulated the starter should be churned. The flavor is improved if 10 or 15 per cent of sweet whole milk is added and churned with the starter. As soon as churned, it should be placed in a ripener or other suitable container and rapidly cooled to 40°–50° F. and held at this temperature. If allowed to warm up and cool again, it will whey off much more rapidly. As soon as cooled it is ready for consumption. It may be sold in bulk in 40-quart cans or put up in various-sized milk bottles. Commercial buttermilk should have a desirable mild acid flavor, a smooth, creamy body and texture, and should not have free whey.



An installation of Foxboro Recording Thermometers on four pasteurizers at the Columbia Dairy, San Francisco, Cal.

CHAPTER III

BUTTER MAKING

The A B C's of butter making are separating the cream from the milk, preparing the cream for churning or ripening, churning, packing and storing; five simple steps full of pitfalls for the unwary. What are the precautions to be taken? How can losses be avoided? How can savings be made by the proper regulation of temperature and pressure? After studying the manufacturing methods of many of the most successful butter makers of the country, a few of the factors which enable the butter maker to manufacture consistently a uniform product of high quality will be set forth.

Separating the Cream.

If the cream separator is working efficiently there should not be more than .01 to .02 per cent of fat left in the skimmed milk. The efficiency of the machine depends upon the following factors:

1. Temperature of milk being separated. If the separator is set up properly, temperature is the factor which is most likely to affect the efficiency of the machine. If the temperature is below 85°–100° F. the separator will not remove all the fat.
2. Speed of the separator. If belt driven, keep the belt tight. If turbine driven, the proper speed can be insured by placing a pressure gauge in the steam line. It must be remembered that if the separator is not operated at the specified speed, it will not skim clean.
3. Rate of flow of milk. Operate the separator to

capacity and keep the feed cup filled to the level indicated by the maker.

4. Percentage of fat in the cream. Sometimes a cream rich in fat will not be skimmed clean. Butter makers differ as to the desirable fat content but a cream testing 30–35 per cent fat will give satisfactory results. The separator will not always deliver cream containing exactly the same percentage of fat, even if the cream screw is adjusted properly. If an exact percentage of fat is desired, it can only be secured by standardizing. (For method of standardizing, see page 31.)
5. Amount of slime in bowl.

Most butter makers install a pre-heater to heat the milk to the proper separating temperature. It is desirable to connect a recording thermometer to the pre-heater. This gives the operator an accurate working guide and the management a check on operating conditions.

Pasteurization.

There is no "best practice" in regard to pasteurization. There are pro-pasteurizers and those who are against it. Those that favor pasteurization base their judgment on the fact that it eliminates the possibility of disease and that it usually improves the flavor of the butter. A temperature of 145° F. for thirty minutes has proved to be very satisfactory. However, if cream is pasteurized at too high a temperature, the butter is likely to have a cooked flavor. After pasteurization the cream should be cooled to the ripening temperature of 60° to 75° F.

Preparing the Cream for Churning — Ripening.

Good judgment of the butter maker and the taste of the consumer usually determine the method of preparing the cream for churning. The various methods of preparation are as follows:

1. The cream may be pasteurized, if sweet, held cold and churned sweet.
2. Pasteurized, starter added and churned.
3. Neutralized and not pasteurized, starter added and churned.
4. Neutralized, pasteurized, starter added and churned.

Sweet cream should be pasteurized before churning, or there will be a large fat loss in the butter-milk. Cream that is churned sweet makes a milder-flavored butter and keeps better in storage.

Amount of Starter.

No definite rule can be stated as to the amount of starter to add, as it will vary from 1 to 30 per cent. The proper amount depends upon the length of time the cream is ripened, the ripening temperature, the acidity of the starter and the acidity desired in the cream at the time of churning. The amount of acid or degree of ripeness is determined largely by the amount of fat in the cream. The more fat the less acid is required. The cream when ready to churn should have 0.3 to 0.65 per cent acidity.

There is no definite time when the starter is added. Some butter makers prefer to add it when the cream is partially cooled, usually from 75° to 90° F. The cream must be cooled below the temperature at which the lactic acid organisms are killed before the starter is added or its effect will be lost. Others prefer to add it after the cream is partially cooled. Lumps of starter cause white specks in the butter. Therefore, the starter should be strained.

After being ripened the cream should be cooled to the churning temperature or slightly below and held for at least three or four hours. This allows the fat globules to congeal.

It is obvious that successful ripening and pasteurization hinge upon the careful regulation and control of temperature while the cream is in the coil-ripening vat. Even the experienced operator should have an accurate guide at this critical stage. Regardless of the size of the creamery, it has been proved that the installation of a recording thermometer not only helps to standardize the quality of the product, but points the way to savings worth many times the cost of the instrument.

Churning.

If the butter is to be colored, it is desirable to add the coloring to the cream either just before or immediately after placing the cream in the churn. Some makers prefer to add the color to the salt. However, it is difficult to obtain a uniform color by this method. The amount of color to use varies from 1 to 3 ounces per 100 pounds of fat.

Churning time is determined by the temperature of the cream. The churning temperature varies from 48° to 65° F. according to the season of the year, being lower in summer than in winter. If churned too warm, the butter will come very quickly and will be too soft. If too cold, it will come very slowly and the granules will not gather easily. The butter should be churned until the granules are about the size of kernels of wheat. This should require thirty to sixty minutes.

After the buttermilk is drawn off, the butter should be washed with water at the same temperature as the buttermilk. If the butter is very soft, colder water may be used to make it firm. It is advisable to wash the butter in two waters to remove any remaining buttermilk. The churn should be given several revolutions in each water.

Butter may be marketed either with or without salt. That without salt is known as sweet butter, and is demanded especially by the Hebrew trade. The amount of salt to add varies from 1.5 to 5 per cent, depending upon the taste of the consumer. It is advisable to add the salt while the butter is yet in the granular condition.

Working distributes the salt evenly, presses out the free buttermilk, gives the butter a solid body, the desired texture or grain and a uniform color, and also incorporates the moisture. If worked too much the butter will be greasy or salvy and the texture injured. If not worked enough, the color will not be uniform and the body will not be solid.

The increase of the butter over the butter fat is due to the incorporation of moisture and is known as over-run. It is the aim of every butter maker to secure as large an over-run as possible. The legal limit of moisture is 15.99 per cent.

The incorporation of the moisture should be studied in relation to the following factors:

Temperature of cream and wash water.
Amount of cream in churn.
Percentage of fat in cream.
Amount of working.
Pasteurized or raw cream.
Degree of ripeness of cream.
Churning butter in wash water.
Working butter in wash water.

The secret of moisture control lies in regulating the churning temperature and in adjusting the working process according to the firmness of the butter as determined by the chemical, physical and mechanical properties of the butter fat, and in the constant use of a reliable moisture test. This shows the vital relation of temperature to over-run. In many plants the cost of manufacture, marketing and profits must come from the over-run because the fat is paid for at the same price per pound as the butter.

As a large percentage of butter is made during the short season when there is a large production of milk, it has to be held to supply the demand during the rest of the year. Quality is maintained by storing the butter in very cold refrigerators — 0° F. or below. If the quality of the butter is to be maintained, the temperature of the refrigerator must not fluctuate. The refrigerator should be equipped with a recording thermometer with the recording element located on the outside. This saves opening the door to observe the temperature, and also gives a record of the temperature. It is especially desirable if butter is stored for some one else. Then, if it deteriorates in storage, the operator can produce his records of the temperature, which at once show whether the deterioration is due to temperature or to some other cause. The value of such an installation was pointed out in Chapter I.

Whey Butter.

Whey, or the liquid portion of the milk left after cheese making, contains a small amount of fat. The amount varies with the variety of cheese made, usually from .8 to .3 per cent. Special separators have been devised to separate this fat from the whey. Cream rich in fat (60 to 75 per cent) is desirable.

This cream should be reduced with milk to the correct percentage for churning. It may be made into butter the same as any cream. It is best to pasteurize it and add a larger percentage of starter. Because the whey naturally contains the softer fats, whey butter is apt to be soft-bodied. For this reason, it should be churned at as low a temperature as possible. If the milk from which the whey is obtained was of good quality, the cream separated as soon as the whey was drawn and the directions above followed, whey butter should be of good quality.

CHAPTER IV

MILK AND CREAM

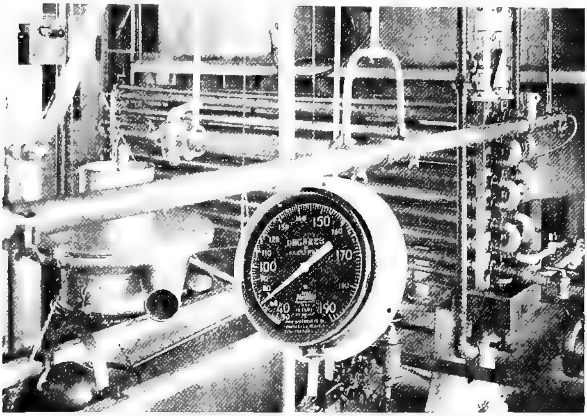
It has been estimated that the total annual production of milk in the United States is valued at approximately two billion dollars. Of this huge amount 45.7 per cent is consumed as fluid or whole milk. In brief, these figures show the tremendous importance of this one branch of the dairy industry.

Market milk not only is of importance from the standpoint of its production value, but it has become a vital factor in the life and well-being of every community. Boards of Health in a great many localities enforce stringent regulations in regard to the source of the milk supply and the pasteurization of the milk. But progressive dairymen exercise greater care than is even prescribed by the Boards of Health.

In the last analysis the successful handling of market milk depends upon the careful regulation of temperature. The growth of bacteria, pasteurization, storage and the efficient operation of the plant are all influenced by temperature. The dairyman knows that temperature influences these processes, but is that knowledge accurate and is it used to make his business more profitable? As one superintendent of a large Boston dairy said: "Until I kept a record of temperatures, a careless employee, in the Pasteurizing Department alone, could waste his wages in steam and water several times a day."

Pre-Heating and Clarifying.

As the milk is delivered to the dairy at a lower temperature than is required for proper handling



View of the pre-heater and clarifier at the Turner Centre System, Somerville, Mass. The Foxboro Long Distance Dial Type Indicating Thermometer inserted is commonly used on pre-heaters.

(often 40° F. in winter time) a pre-heater is usually necessary. The heating may be accomplished by running the cold milk counter-current to hot water, or by other methods. A temperature of 85° to 100° F. has proved satisfactory for the subsequent process of clarifying. It is almost necessary to install a recording thermometer on the pre-heater in order to save heat and to prevent the milk from scorching.

The centrifugal clarifier strains the milk at any temperature, but works more efficiently when the milk is heated 85° to 100° F. The clarifier removes the dirt, pus cells, blood corpuscles, etc., without separating the whole milk and aërates the milk, which improves its flavor. The machine may be belt or turbine driven, and if the latter a pressure regulator in the steam line will insure a uniform pressure. The clarifier will not operate efficiently unless it is run at the prescribed speed.

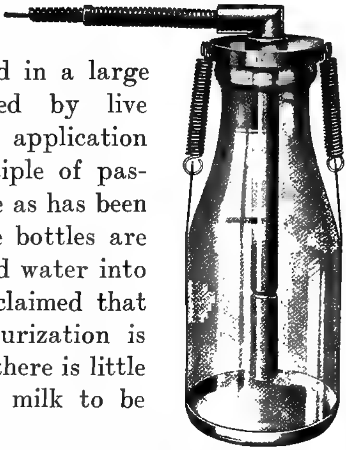
Pasteurization.

There are two general methods of pasteurization, — the Holding and the Flash methods. A more recent development is the pasteurization of the milk after it has been bottled. However, this method is not used so generally as the first two.

The Flash Method: The milk or cream is heated to a temperature of 170° to 180° F. for an instant, and then cooled. Unless great care is exercised the high temperature is likely to impart a cooked flavor to the product.

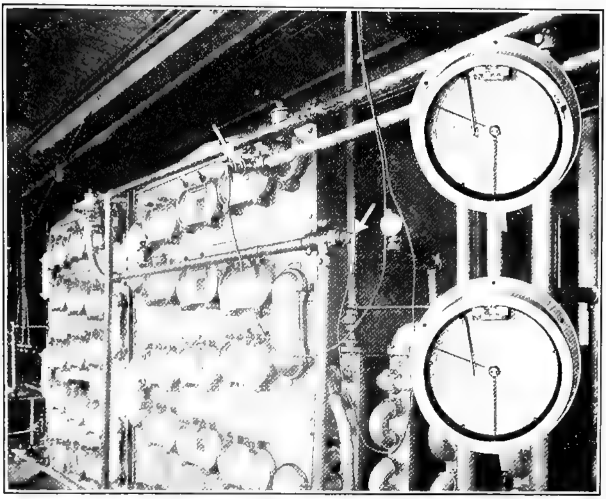
The Holding Method: The milk is heated to a temperature of 142° to 145° F. and held at this temperature for thirty minutes.

Bottle Method: After the milk is packaged, it is placed in a large container and heated by live steam. Although the application is different, the principle of pasteurization is the same as has been described above. The bottles are cooled by running cold water into the container. It is claimed that this method of pasteurization is more efficient because there is little or no chance for the milk to be contaminated.



Special Foxboro bulb and fitting for the Bottle Method of Pasteurizing.

Pasteurization is the critical stage in the handling of market milk. Temperatures in the pasteurizer should be known and carefully regulated at all times. Even the most experienced operator cannot be so efficient or so vigilant as a recording thermometer or a temperature con-



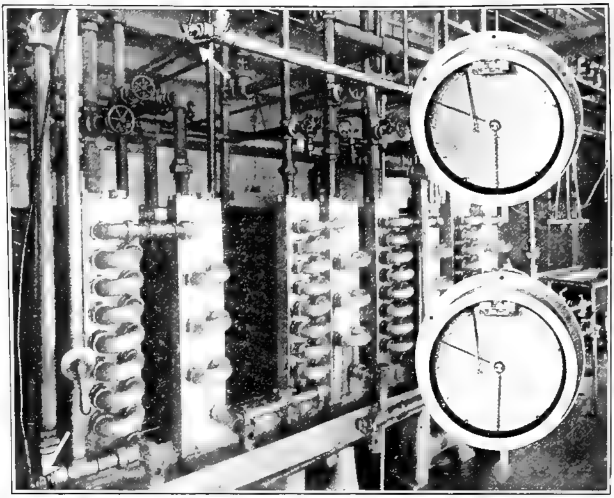
Installation of Foxboro Recording Thermometers on Burrell continuous pasteurizer at the Turner Centre System, Somerville, Mass. The arrows indicate the location of the thermometer bulbs.

troller-recorder. The only way a superintendent can check the efficiency of his plant is to keep a record of the operations involving temperature. The regulations set down by most Boards of Health require that a record be kept each day showing the temperature at which the cream or milk is heated and the time it was held at this temperature.

Three thousand dollars were saved the first year by one medium-sized dairy after four recording thermometers and two temperature controllers were installed in the Pasteurizing Department. The installation paid for itself during the first two weeks of operation.

Cooling

After pasteurization, the milk should be cooled rapidly with as little contamination as possible, to a



Installation of Foxboro Recording Thermometers on coolers at the Turner Centre System, Somerville, Mass. Arrows show where thermometer bulbs are connected to the coolers.

temperature of about 40° F. At this temperature the growth of any organisms which may have survived pasteurization is very slow. The ease of cleaning the cooling device should not be overlooked. The milk may be cooled by running it counter-current to cold water, or by other equally effective methods. A recording thermometer should be used as a check on the efficiency of the cooler.

The milk is often held in large glass-lined holding tanks until it can be packaged. The tanks are equipped with brine pipes for cooling and an agitator to keep the cream evenly distributed throughout the milk. The operator will find a recording thermometer a great aid in maintaining a uniform cool temperature in the tanks. If the milk or cream warms up, it is very likely to sour.

As it is customary to prepare the milk and cream one day and to deliver it the next, it is necessary to refrigerate the milk for several hours. The refrigerator temperature should be held uniformly at 40° F. and the milk should not be allowed to freeze. Here, too, the only practical precaution for the dairyman is a recording thermometer. With the recording elements on the outside of the refrigerator, the temperature may be observed and maintained uniformly without the loss otherwise incurred by frequent opening of the door for temperature observation.

Standardizing Milk and Cream.

To satisfy the consumer, cream or milk containing the same percentage of fat should be sold every day. Because a separator will not deliver cream testing the same percentage of fat every day the cream must be standardized.

Standardizing milk or cream consists of raising or lowering the fat content to a fixed standard.

In standardization, there are two classes of problems involved: first, a certain fixed amount of milk is to be made up or a certain amount of standardized milk is desired. Second, a certain amount of milk or cream is to be used and enough of another product added to make the mixture test a certain percentage of fat. In the latter case the amount of the mixture is indefinite.

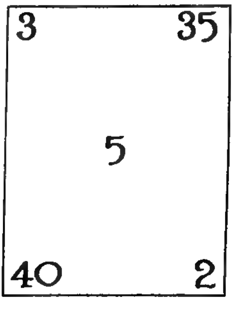
The original method of computing problems in standardization is long and difficult, but a scheme has been devised that is simple. The method is as follows:

Draw a rectangle and place in the center of it the percentage of fat desired. Place at the left-hand corners of the rectangle the percentage of fat in the materials to be mixed. Subtract the number in the center from the larger number at the left of the rectangle. Place the remainder on the diagonally opposite right-hand corner of the rectangle. Subtract the smaller number on the left-hand corner from the number in the center and place the remainder on the diagonally opposite right-hand corner of the rectangle.

The two numbers on the right-hand corners of the rectangle represent the number of pounds of material required. If these two numbers are added, they will express the number of pounds of the mixture, which will contain a percentage of fat expressed by the number in the center of the rectangle. In each case the number on the right-hand corner corresponds in fat test to the number on the left-hand corner directly opposite.

Problem.

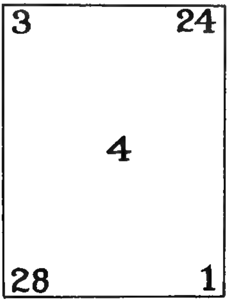
How many pounds of 40 per cent cream and 3 per cent milk must be mixed to make milk testing 5 per cent? Using the diagram as described, the following result is obtained:



This means that if 2 pounds of 40 per cent cream are mixed with 35 pounds of 3 per cent milk, the result will be a 37-pound mixture testing 5 per cent.—*Answer.*

Problem.

How many pounds of 28 per cent cream and 3 per cent milk will be required to make 500 pounds of a mixture testing 4 per cent? In this problem a definite number of pounds of the mixture is required.



According to the diagram, 1 pound of 28 per cent cream is required to every 24 pounds of 3 per cent milk to make a mixture testing 4 per cent. This would make 25 pounds of the mixture, but 500 pounds is the amount desired. In other words, the number of pounds desired is 20 times larger than the number of pounds on hand ($500 \div 25 = 20$). The amounts must be kept in the proportion of 1:24. Therefore, in order to get 500 pounds of mixture, it is necessary to multiply both the 1 and the 24 by 20. This would give a result of 20 pounds of 28 per cent cream and 480 pounds of 3 per cent milk, which mixed will equal 500 pounds of 4 per cent milk.—*Answer.*

This problem may also be worked by simple proportion:

$1 : 25 :: x : 500$
$25x = 1 \times 500$
$25x = 500$
$x = 20$, number of pounds of 28 per cent cream there will be in the 500-pound mixture. — *Answer.*

If there are 20 pounds of 28 per cent cream in the 500-pound mixture, the remainder will necessarily be 3 per cent milk.

Therefore, $500 - 20 = 480$, number of pounds of 3 per cent milk. — *Answer.*

The number of pounds of 3 per cent milk can be found directly by simple proportion:

$24 : 25 :: x : 500$
$25x = 24 \times 500 = 12{,}000$
$x = 480$, number of pounds of 3 per cent milk. — *Answer.*

Proof.

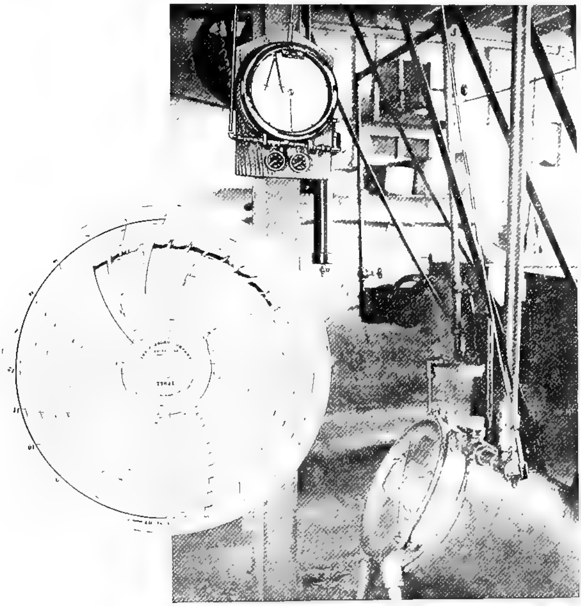
In working problems in standardization, it is always wise to prove the answer and check for mistakes. According to the conditions of the problem, there would be 500 pounds of 4 per cent milk. This amount of milk would contain 20 pounds of fat ($500 \times .04 = 20$). According to the results the 480 pounds of 3 per cent milk would contain 14.4 pounds of fat ($480 \times .03 = 14.4$). The 20 pounds of 28 per cent cream would contain 5.6 pounds of fat ($20 \times .28 = 5.6$).

$$14.4 + 5.6 = 20$$

Since the 500 pounds contain 20 pounds of fat and the materials of which the 500 pounds is made up furnish the 20 pounds of fat, the answer is correct.

Problem.

How many pounds of 3 per cent milk must be mixed with 150 pounds of 28 per cent cream to make a mixture testing 4 per cent? In this problem the number of pounds to be made up is not definitely known.



Foxboro Automatic Temperature Recorder-Controller installed on a flash pasteurizer at Schlosser Bros. Creamery, Plymouth, Indiana. This one instrument does the work of both controller and recorder. The chart shown is a facsimile of an actual chart from this instrument. The heavy lines show how close the temperature was held within the allowable limits. The momentary high and low temperatures were caused by the cream supply being changed from one fore-warmer to another.

Working the problem by the rectangle method (see page 32), 1 part of 28 per cent cream is required for 24 parts of 3 per cent milk. According to the terms of the problems, 150 pounds of 28 per cent cream must be used, and the 3 per cent milk must be increased 150 times. This would give 150 pounds of 28 per cent cream (1×150), and 3600 pounds of 3 per cent ($150 \times 24 = 3600$), making in all 3750 pounds ($150 + 3600 = 3750$) of a 4 per cent mixture.

This problem may also be worked by simple proportion:

$24 : 1 :: x : 150$
$x = 3600$, the number of pounds of 3 per cent milk required.

Proof.

The 3750 pounds of 4 per cent milk will contain 150 pounds of fat ($3750 \times .04 = 150$). If the 150 pounds of 28 per cent cream and 3600 pounds of 3 per cent milk furnished 150 pounds of fat, the problem is correct.

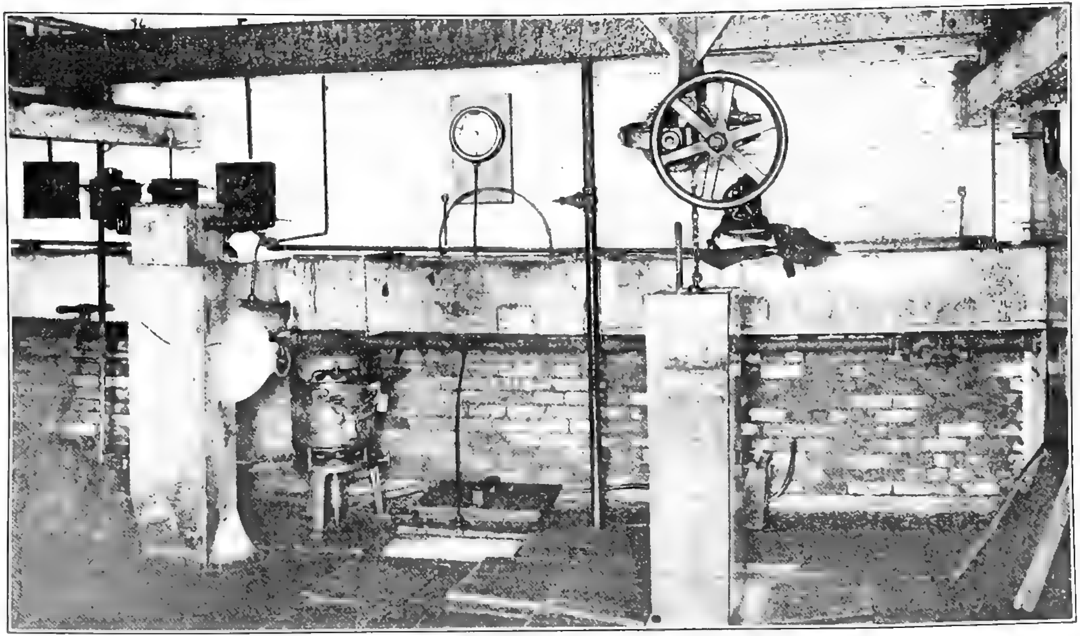
$3600 \times .03 = 108$, number of pounds of fat in milk.

$150 \times .28 = 42$, number of pounds of fat in cream.

$108 + 42 = 150$, number of pounds of fat in mixture. — *Answer.*

Specific Gravity and Weight of Milk and Cream at a Temperature of 68° F.

	Per cent of fat	Specific gravity	Weight of one gallon in pounds
Skim	.025	1.037	8.6295
Milk	3	1.034	8.6045
Milk	3.5	1.033	8.5962
Milk	4	1.032	8.5879
Milk	5	1.031	8.5796
Milk	6	1.030	8.5713
Mixed Milk, Cream	10	1.025	8.5297
Mixed Milk, Cream	15	1.018	8.4714
Cream	18	1.015	8.4564
Cream	20	1.013	8.4298
Cream	22	1.011	8.4132
Cream	25	1.008	8.3882
Cream	28	1.006	8.3715
Cream	30	1.004	8.3549
Cream	32	1.002	8.3383
Cream	35	.999	8.3133
Cream	38	.997	8.2966
Cream	40	.995	8.2800



Interior of the freezing room at the Turner Centre System, Somerville, Mass. Recording thermometer gives a permanent continuous record of brine temperature.

CHAPTER V

ICE CREAM

No milk product varies so much in quality as ice cream. This is largely due to the fact that the federal standard which requires that a vanilla mixture contain 14 per cent of fat and a fruit or nut mixture 12 per cent is not enforced. In many states ice cream may be sold either very low or very high both in fat and in milk solids not fat depending upon the amount the manufacturer wishes to spend for materials. Many concerns make an ice cream containing 8 to 10 per cent of fat and 30 to 35 per cent of total solids.

The common milk products used in ice cream are cream, whole milk, skimmed milk, whole or skimmed condensed milk, whole or skimmed powdered milk and butter.

The Importance of Refrigeration.

One of the most essential parts of an ice-cream plant is its refrigerator. Because the demand for ice cream fluctuates with weather conditions, manufacturers must carry a sufficient amount of raw materials to meet any emergency. These raw products should be kept in a refrigerator at a uniform temperature and as near freezing as possible — but not frozen. Without such a refrigerator manufacturers either run short of raw materials and cannot supply a sudden demand that would mean a large increase in profits, or certain of the raw products spoil before they are manufactured. Sour ice cream is more often due to faulty refrigeration of raw materials than to anything else.

Many ice-cream plants have a fruit storage room. This is similar to the storage for raw-milk products and in many cases is a small refrigerator partitioned off from the larger one. Fruits should never be allowed to freeze.

Pasteurization of Milk Products.

Some manufacturers pasteurize their milk products while others do not — there is no uniform practice. It is a known fact that pasteurization reduces the viscosity, so that after being pasteurized the product must be held for some time to regain its viscosity. As will be pointed out later, the viscosity is very important in relation to swell. Products should be pasteurized at as low a temperature as possible, not above 145° F., to prevent a cooked flavor. Any of the milk or cream pasteurizers may be used.

Basic Recipes for Ice Cream.

Here are two basic recipes which make ten gallons of ice cream:

No. 1. Without condensed milk.

40 lbs. cream.	4 oz. gelatine in 4 lbs. water.
8 lbs. sugar.	Flavoring.

The percentage of fat in the cream governs the percentage of fat in the ice cream.

No. 2. With condensed milk.

30 lbs. cream.	4 oz. gelatine in
10 lbs. condensed milk.	4 lbs. of water.
7 lbs. sugar.	Flavoring.

Either whole or skimmed condensed milk may be used. Plain condensed is preferable to sweetened condensed milk. Again, the percentage of fat in the cream may be varied to give the ice cream the desired percentage of fat.

For standardization see page 31. The percentage of fat in the mix is figured by dividing the total pounds of fat by the total weight of the materials in the mix. (The "mix" is the unfrozen ice cream.)

Milk powder is either used to make milk or to bring up the percentage of milk solids not fats or in place of the condensed milk, or the cream or milk may be made by mixing the various milk products mentioned above.

Machines for Mixing Materials.

The mixing process can be accomplished by two types of machines. One is the type in which the materials are forced through very small holes or slots by centrifugal force. It is known as an emulsifier. The other, in which the material is forced between a valve and its seat by a piston pump, or through a very small opening between porcelain discs by a piston pump, is known as a viscolizer and homogenizer. Viscolizers and homogenizers are much more powerful than the emulsifiers and break up the fat globules so finely that the cream can never be rechurned. Many ice-cream makers run the whole mix through these machines, which increases the viscosity which in turn increases the swell.

Mixing.

Opinions differ as to the correct temperature at which the materials should be emulsified. Some manufacturers prefer to pasteurize and then emulsify at the same temperature. A temperature of 120° to 130° F. is satisfactory. The materials must be kept thoroughly mixed or else the fat rapidly separates and comes to the top. This mixing may be accomplished by supplying the machine with the materials from a revolving coil or by an agitator in the supply tank. When butter is used, it should be cut into small pieces and then melted in the milk or water.

Directly from the emulsifier, the material must be cooled as near 40° F. as possible, or the fat may separate.

The preparation of materials to be viscolized or homogenized is the same as stated above. By means of an adjusting screw, the pressure under which the material passes through the machine can be regulated. The pressure may vary from 2000 to 3000 pounds. The only objection to these machines is that inferior products can be made to appear better than they really are. This is especially true of butter. Homogenizers may also be used on market or fluid cream, causing it to appear much richer than it really is.

The next step in the preparation of the mix is the adding of the correct amount of sugar. If an ice-cream powder is used it must be thoroughly mixed with the sugar. Gelatine is added to prevent the separation of water crystals that cause ice cream to be grainy or icy. There are several ways to prepare the gelatine. The following method gives good results: To eight quarts of cold water add one pound of gelatine, or in that ratio, then mix the gelatine and water and let it stand twenty or thirty minutes. In this length of time the gelatine and water mixture will be rather thick. It should then be heated in a water bath to 165°–170° F. While at this temperature it should be added slowly to the mix which is being agitated. The whole mix or each individual freezer can now be flavored.

Showing Properties of Solution of Salt (*Siebly*)*

(*Chloride of Sodium*)

Per cent of salt by weight	Pounds salt per gallon of solution	Degrees or salometer 60° F.	Weight per gallon at 39° F.	Specific gravity at 39° F., 4° C.	Specific heat	Freezing point F.
1	0.084	4	8.40	1.007	0.992	30.5
2	0.169	8	8.46	1.015	0.984	29.5
2.5	0.212	10	8.50	1.019	0.980	28.6
3	0.256	12	8.53	1.023	0.976	27.8
3.5	0.300	14	8.56	1.026	0.972	27.1
4	0.344	16	8.59	1.030	0.968	26.6
5	0.433	20	8.65	1.037	0.960	25.2
6	0.523	24	8.72	1.045	0.946	23.9
7	0.617	28	8.78	1.053	0.932	22.5
8	0.708	32	8.85	1.061	0.919	21.2
9	0.802	36	8.91	1.068	0.905	19.9
10	0.897	40	8.97	1.076	0.892	18.7
12	1.092	48	9.10	1.091	0.874	16.0
15	1.389	60	9.26	1.115	0.855	12.2
20	1.928	80	9.64	1.155	0.829	6.1
24	2.376	96	9.90	1.187	0.795	1.2
25	2.488	100	9.97	1.196	0.783	0.5
26	2.610	104	10.04	1.204	0.771	—1.1

Properties of Solution of Chloride of Calcium (*Siebly*)*

Per cent by weight	Specific heat	Specific gravity at 60° F.	Freezing point in degrees F.
1	0.996	1.009	31
5	0.964	1.043	27.5
10	0.896	1.087	22
15	0.860	1.134	15
20	0.834	1.182	5
25	0.790	1.234	—8

* From Larsen & White's "Dairy Technology," by courtesy of the authors.

Ageing the Mix.

It is desirable, after the mix has been prepared, to "age" it by allowing it to stand. Ageing blends

View of hardening room at the Turner Centre System, Somerville, Mass. It is very important that the temperature be kept even if quality is to be maintained.

the flavors and increases the viscosity. It is usually done in large, insulated brine circulating coil tanks, equipped with recording thermometers. The one great danger of ageing is that the mix is likely to sour. Souring is determined entirely by temperature. If the mix sours, it is practically a loss. It may be neutralized but it never makes a product of as high a grade. If cream is aged and sours while ageing, it can be churned into butter, providing it has not been homogenized. For this reason many manufacturers prefer to age the cream rather than the whole mix.

The temperature at which the mix enters the freezer is an important factor in relation to both quality and swell. The mix should enter the freezer as near 40° F. as possible. This helps to eliminate the danger of churning and of producing an ice cream of greasy texture.

How to Freeze Ice Cream.

The freezer has a dasher with scrapers revolving in the center and a jacket around the outside in which cold brine is circulated. The rate of flow of the brine is determined by the pump, and after it is once regulated should be constant. The temperature of the brine may vary within wide ranges, though the best results are obtained when it is from $+6°$ to $+10°$ F. Temperature is an extremely important factor in connection with the making of ice cream. If the brine is too warm the cream will churn instead of freeze, and there will be chunks of butter in the ice cream. If the brine is too cold, the ice cream freezes too fast and then it is difficult, if not impossible, to obtain the swell.

Care in freezing is of the utmost importance because it affects both the quality of the ice cream and the swell. If the desired swell is not obtained, the business will be a failure. The rate or time to freeze depends upon the following factors:

1. Temperature of brine.
2. Rate of flow of brine.
3. Temperature of materials when put into freezer.
4. Materials in mix.
5. Speed of the freezer.

The first three factors show the important part that temperature plays in the freezing process. It should take from 12 to 20 minutes to freeze a batch of good ice cream.

By "swell" is meant the increase in volume of the ice cream over the mix. This increase is due to the incorporation of the air. The factors affecting swell may be divided into two general classes: kind and preparation of materials used and method of freezing.

Certain combinations of these factors increase the swell, while other combinations decrease it.

To obtain swell:

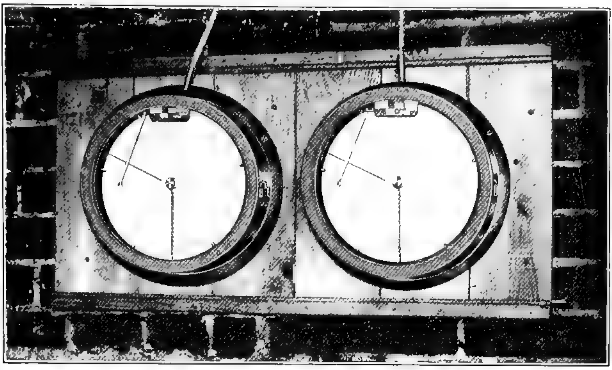
1. Have viscous milk and cream.
2. Age the milk and cream or mix.
3. If pasteurized milk and cream are used, age until viscous.
4. The cream and milk or whole mix should be homogenized or emulsified.
5. Condensed milk in the mix aids in obtaining swell.
6. The mix should contain at least 30 per cent of total solids.
7. The dasher should run at the required speed.
8. Mix should enter freezer as near 40° F. as possible.
9. There should be a sufficient supply of brine from +6° F. to +10° F.
10. The cream should be whipped for a moderate time in the freezer.
11. The mix should fill the freezer half full.
12. It should require 12 to 20 minutes to freeze.
13. The ice cream should not be below 27° F. when drawn from the freezer.

The converse of these conditions will cause a decrease in the amount of swell.

If not enough swell is obtained in freezing, the ice cream will be soggy and heavy, and if too much swell is obtained the ice cream will be fluffy and inclined to be grainy. A swell of 85 to 100 per cent is satisfactory.

The Hardening Process.

When drawn from the freezer the ice cream is in a semi-fluid condition and must be frozen solid or "hardened." This is accomplished by placing the cans of ice cream in a cold room known as a hardening room or by packing them in ice and salt or placing them in a box of cold brine. The usual



Foxboro Recording Thermometers for recording hardening room temperatures at Schlosser Bros. Creamery, Plymouth, Indiana. In this case the recorders are located at a considerable distance from the hardening room, but there is no loss of accuracy.

practice in the large plants is to have a hardening room with a temperature of —20° F. This will harden the ice cream in twenty-four hours. In no case should the temperature be allowed to go above 0° F. A long-distance type recording thermometer shows the temperature of the hardening room at all times and saves loss of refrigeration due to the opening of the doors to learn the temperature. It also gives the engineer and the management a constant record. Much ice cream properly made and of good quality up to the time of hardening has been spoiled during the hardening process, due to fluctuations in the temperature. When the ice cream is allowed to melt and freeze in the hardening room, its body and texture is quickly ruined. It will become grainy and full of ice crystals. After being hardened the ice cream must be properly handled and packed in ice and salt for delivery.

CHAPTER VI

CONDENSED AND EVAPORATED MILK

Condensed milk is milk in which the solids have been condensed by the removal of the water. This is usually accomplished by boiling the milk in a vacuum, although there are concentrators in which a vacuum is not used. Either skimmed milk or whole milk may be condensed, and may be made plain or may be sweetened by the addition of cane sugar.

As a condensing plant usually receives milk much faster than it can be condensed it is usually placed in large holding tanks. These tanks are insulated and often refrigerated in order to keep the milk cold and sweet. It is much easier to standardize the milk in the holding tanks than it is the condensed milk after it has been drawn from the pan. For method of standardization see page 31.

The milk is first heated in large open copper kettles, called fore-warmers or hot wells, in order that cold milk will not be drawn into the vacuum pan. When sweetened condensed milk is made, about 16 to 18 per cent of cane sugar is added to the milk in the hot well. Sweetened milk is heated to 180°–200° F. to dissolve the sugar, and the plain milk to 130°–150° F.

The boiling is done in a large copper container called a pan. The size is spoken of in terms of the diameter, *i. e.*, a four-foot pan or a five-and-a-half-foot pan.

The temperature is regulated by a steam jacket on the bottom and several steam coils inside the pan. The temperature of the pan should be about 130° F. with a vacuum or about 25 to 26 inches of mercury.

It is desirable to have the heating surface in the pan as large as possible in order to make high steam pressure in the jacket and coils unnecessary, and insure complete condensation of the steam. Otherwise too high milk temperatures or waste of steam results. Steam gauges should be placed just after the valves connecting the jacket and coils with the main steam line. Twenty-five pounds' pressure is considered as high as can be safely used, and many condenseries operate with twelve to twenty pounds' steam pressure. Taking into consideration the ordinary water supply, fifteen pounds' steam pressure and twenty-five inches' vacuum are about the best conditions that can be steadily maintained. The temperature is about 135 degrees at this vacuum.

The milk is drawn into the pan by vacuum. After enough has been drawn in to boil well, a constant stream maintains the same volume in the pan. Care must be exercised or the milk will boil over the top. The usual practice is to concentrate a trifle too much and then standardize by the addition of distilled water. This can only be done when the milk has been standardized in the holding tanks.

It is very important for the successful operation of the pan that it be equipped with an accurate thermometer and vacuum gauge. A thermometer which is constructed so that the bulb may be well submerged in the milk is more sensitive to temperature changes and at the same time makes it possible to place the indicator where it is convenient to read. Such a thermometer is known as a long-distance type thermometer.

Boiling Points of Water at Different Vacua*

Absolute pressure per square inch	Vacuum inches of mercury column	Vacuum millimeters of mercury column	Temperatures of boiling point of water, F.	Temperatures of boiling point of water, C.
14.720	0.00	00	212.00	100.00
14.010	1.42	36	209.55	98.5
13.015	3.45	88	205.87	96.8
12.015	5.49	139	201.96	94.3
11.020	7.52	191	197.75	91.9
10.020	9.56	243	193.22	89.5
9.020	11.60	295	188.27	86.75
8.024	13.63	346	182.86	83.7
7.024	15.67	398	176.85	80.5
6.024	17.70	450	170.06	76.8
5.029	19.74	502	162.28	72.5
4.029	21.78	553	153.01	67.2
3.034	23.81	605	141.52	60.8
2.034	25.85	657	126.15	52.3
1.040	27.88	708	101.83	38.7
.980	28.00	712	100.00	37.8
.735	28.50	724	90.00	32.2
.544	28.89	734	80.00	26.7
.402	29.18	741	70.00	21.1
.294	29.40	747	60.00	15.6
.216	29.56	751	50.00	10.0
.162	29.67	754	40.00	4.4
.127	29.74	756	32.00	

* By courtesy of the Buffalo Foundry and Machine Company.

Condensation.

The vapors from the pan are condensed by a spray and column of water. It is desirable for the operator to know the temperature of the water just before and directly after going though the condenser, as the efficiency of the condenser can be determined by the temperature of the water. If the water coming from the condenser is cold, it shows that something is wrong. If the temperature of the condensing water is 55° to 65° F. the water coming from the condenser should be 15° to 20° colder than the temperature of the pan, or about 110° F.; below this temperature there is sure to be much water wasted.

The amount of concentration or the ratio of the condensed to the raw product, *i. e.*, 1 to 3 or 1 to 3.5, etc., is determined by the market demand. The amount of condensation in the pan is determined by sampling and testing with a special hydrometer calibrated in degrees Baumé. When the proper concentration is reached, the milk should be drawn off rapidly and cooled, unless superheated condensed milk is being made. Superheated condensed milk is made by turning live steam directly into the condensed milk as soon as the proper concentration is reached. The temperature is raised to about 210° F. This high heat precipitates the albumin and gives the condensed milk a thick, heavy body, desired by many ice-cream manufacturers.

Cooling the Milk.

Sweetened condensed milk should be cooled gradually. It is placed in large cans, which in turn are placed in tanks. The cans are revolved and stationary paddles stir the milk. The water in the cooling tank is at first fairly warm (about 90° F.) and the milk is about 115° F. to 130° F. After a few minutes cold water is supplied until the milk has reached approximately 70° F. The time for this cooling should be about two hours in all.

Another common practice is to place the condensed milk in large tanks and cool it by pumping it through coils submerged in cold water or brine.

Too rapid cooling must be guarded against in this process, as this causes excessive sugar crystallization.

The sweetened condensed milk, containing enough sugar to preserve it, is usually put in small cans for household use. The plain condensed milk, however, spoils very rapidly unless refrigerated at a temperature of 32° to 40° F. It should not be allowed to freeze. The refrigerator should be held at a uniform temperature, otherwise spoilage is more rapid. Plain condensed milk is used largely by ice-cream and candy manufacturers and bakers. Because the demand for plain condensed is not steady, it is often necessary to hold it for a considerable period. This can be done if the directions above are followed.

Evaporated Milk Processing and Sterilizing.

Evaporated milk is the term applied to sterilized, plain condensed milk. It is made the same as plain condensed but it is not concentrated quite so much; usually the ratio is one to two or one to two and a half. The milk is standardized in the holding tanks and the finished product is standardized by the addition of distilled water. The condensed milk is superheated, otherwise the later heating while sterilizing would give a tough curd. After superheating, the milk is homogenized, which breaks up the milk particles. It is then usually run into holding tanks until it can be packaged.

The package milk is sterilized to prevent it from spoiling. The sealed cans are placed in the rack of a large cast-iron sterilizer heated with steam. The time and temperature may be varied to suit conditions, but the milk should not be heated above 235° F. The cans are revolved in the sterilizer to give uniform heating and to break up the curd.

The sterilizer is equipped with steam and vacuum gauges and automatic temperature controller and temperature recorder. The cans are cooled either by running cold water into the sterilizer or by immersing the cans in cold water. They should be cooled in 15 to 20 minutes to a temperature of 70° to 80° F. They are then placed in a shaker which shakes out the curd which is formed because of the high temperature. The cans are incubated for 20 to 30 days at a temperature of 75° to 85°. Defective cans will swell and bulge.

Federal Requirements.

The federal standards for condensed and evaporated milk are as follows: "Sweetened condensed milk, sweetened evaporated, sweetened concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, to which sugar (sucrose) has been added. It contains, all the tolerances being allowed for, not less than twenty-eight (28) per cent of total milk solids and not less than eight (8) per cent of milk fat.

"Unsweetened condensed milk, evaporated milk, concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean lacteal secretion obtained by the milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains, all tolerances being allowed for, not less than twenty-five and five-tenths (25.5) per cent of the total solids and not less than seven and eight tenths (7.8) per cent of milk fat.

"Sweetened condensed skimmed milk, sweetened evaporated skimmed milk, sweetened concentrated skimmed milk is the product resulting from the evaporation of a considerable portion of the water from skimmed milk to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight (28) per cent of milk solids.

"Unsweetened condensed skimmed milk, evaporated skimmed milk, concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk, and contains, all tolerances being allowed for, not less than twenty (20) per cent of milk solids."

Continuous Evaporators.

Continuous evaporators evaporate the water from the milk by heating the milk at atmospheric pressure. No vacuum is used. With one type of machine the milk is pre-heated and then delivered inside a hollow copper drum. In this drum is a revolving dasher with blades, similar to an ice-cream freezer. Outside the drum is an insulated jacket. Into the small space between the drum and jacket live steam is admitted with 40 to 60 pounds' pressure. This heats the milk and evaporates the water. Scrapers remove the milk from the jacket and so keep it from burning. Any desired concentration may be secured. After being condensed the milk must be cooled. There is a continuous flow of milk into the machine and of condensed milk away from the machine.

Another type of condensing evaporator is somewhat similar, except that air is blown through the hot milk, assisting in the evaporation, and also removing bad odors from the milk.

Condensed Buttermilk.

Condensed buttermilk is used largely for stock and poultry foods. It should be sour and may be condensed after any of the following methods: gravity, centrifugal separation in vacuum pan or concentrator.

CHAPTER VII

MILK POWDER

It is possible to reduce milk to a powder by the elimination of the water and, at some later date, by the addition of water again to turn the powder back to milk. This powder is now commonly made in this country after two different processes. One, the hot-roll or film-drying process, and the other the spray process.

The hot-roll or film-drying processes in common use are the Hatmaker and Ekenberg. Others are Parsburg, Gathsmaun, Just and Buflovak.

The spray processes are the Merrell-Soule and Gray processes. Many of the processes and the necessary apparatus are covered by patents, so that manufacturers who use them are often obliged to pay a royalty.

Description of Standard Processes.

The essential equipment required for the Hatmaker process consists of two horizontal, hollow, steam-heated, revolving metal cylinders. These cylinders are installed sufficiently close to each other so that all the milk comes in contact with the cylinders. The surface of these cylinders is heated to 212° F. and below 270° F. The high temperature reduces the solubility of the finished powder. The patent claims that the treating of the milk with calcium chloride or with the double salt of sodium and calcium citrate, to reduce the acidity of the milk, and with alkaline hypochlorite to preserve the fatty acids in the finished product, causes the milk powder to be more soluble. The milk is delivered into the rolls from a distributing tank with an adjustable discharge. This tank is placed in the center over and between the two rollers. The film of dried milk is removed from the rolls by means of scrapers and falls into receptacles. It has then to be placed on porous racks in a dry kiln in order to dry it completely before it is ground.

The Ekenberg process is a film drier operating in a partial vacuum. The machine which does the drying is called an exsiccator. It consists of a revolving steam-heated drum inclosed in a vacuum chamber. The temperature of drying varies with the steam pressure in the drum. It is claimed that the drying takes place at a temperature of 100° to 120° F. The fact that the milk is dried in a vacuum makes it possible to do it at a low temperature. The milk is first partially condensed by being brought in contact with the concave ends of the rolls. It is then sprayed on the rolls and dried milk is removed by a scraper. Next it falls into a receptacle. This receptacle may be removed when full by means of a special arrangement without breaking the vacuum about the roll.

The films of milk are placed on screen racks and put in a dry kiln and held at a temperature of 90° F. When completely dried the milk is ground and packaged. It may be packed in various sized tin or wood boxes or barrels.

The Merrell-Soule is a spray process of drying. The milk is first partly condensed in an ordinary vacuum pan. Then by means of a pressure pump it is forced into the drying chamber in the form of a fine spray or mist. Air is filtered and blown over radiators in an air-heating chamber and then into the drying chamber. This dry hot air meets the spray of milk and takes up the moisture. The milk falls on the floor of the drying chamber as milk powder and the moisture-laden air escapes from the drying chamber.

The Gray is also a spray process of drying. This process is covered by several patents and several different desiccating arrangements have been used.

Definition of Milk Powder.

The federal standards of milk powder are as follows: "Dried milk is the product resulting from the removal of water from milk, and contains, all tolerances being allowed for, not less than twenty-six per cent (26.0%) of milk fat and not more than five per cent (5.0%) of moisture.

"Dried skimmed milk is the product resulting from the removal of water from skimmed milk and contains, all tolerances being allowed for, not more than five per cent (5.0%) of moisture."

Much of the milk powder made in this country is used in the warm states, where it is difficult to produce milk. Considerable quantities are exported to tropical countries. Many ice-cream plants use it to standardize the mix. Bakers also use it.

CHAPTER VIII

CHEESE

UNDOUBTEDLY less is known about cheese making than any other dairy manufacturing process. This is probably due to the following facts: the many varieties of cheese, the diversity of the process of manufacture and the complex organic changes which take place during cheese ripening. It is claimed by some authorities that there are 700 known varieties of cheese. The process of manufacture and curing is different for each one.

There are certain varieties which are more extensively made than others. With these, it is known that if certain operations are performed at a definite time in a particular way that a definite result will follow. But the reason is not known. Cheese may be made from whole milk, skimmed milk or partially skimmed milk.

The varieties of cheese commonly made from full skimmed milk are cottage, hoop, pressed, bakers, pot and kosher. Any of the other varieties may be made from either whole milk or partially skimmed milk, although most of them are made from whole milk.

Cheese may be classified in several ways: according to the amount of moisture it contains, the country in which it is made (each country is more or less famous for some special variety of cheese), and the combination of the texture and the method of ripening.

Classification of these according to the amount of moisture it contains:

I. Soft cheese containing 45 to 75 per cent water. They are Cottage Cheese, Pot Cheese, Hoop Cheese, Neufchâtel Cheese, Cream Cheese, Pimento Cheese and Gervais Cheese.

II. Soft cheese, ripened, containing from 40 to 50 per cent water, include Camembert, Brie, d'Isigning, Leiderkranz and Limberger.

III. Hard cheese, containing 30 to 45 per cent water are Edam, Gouda, Cheddar, Brick, Gorgonzola, Swiss, Parmesan and Roquefort.

Classification of cheese according to countries in which they originated, or in which they are commonly and extensively made:

United States	American Cheddar
England	English Cheddar Stilton
France	Camembert Roquefort
Switzerland	Swiss
Holland	Edam Gouda
Italy	Gorgonzola Parmesan

Other countries make a characteristic cheese of their own, but these forms are not commonly known in this country.

Classification according to the method of ripening and the texture:

Hard Cheese All ripened	Cheddar — Close texture Swiss — Large shiny holes Parmesan — Small holes Gorgonzola — Ripened by mold, blue veined Stilton — Ripened by mold, blue veined Edam — Close texture Gouda — Close texture

Soft Cheese
1. Not ripened, eaten fresh
   - Cottage
   - Cream
   - Neufchâtel
   - and the like
2. Ripened by molds
   - (A) Outside the cheese, Camembert
   - (B) Inside the cheese, Roquefort
3. Ripened by bacteria alone
   - Limberger
   - Munster

What is usually termed cheese making may be divided into two parts: one the making of the curd or green cheese, and the other the ripening or developing of the cheese's characteristics, especially the flavor, body and texture.

The making consists of coagulating the solids in the milk, developing the desired amount of acid, and the elimination of the water or whey. When first made, the green curd or cheese is tough, rubbery and tasteless. Due to the changes which take place during the curing, the flavor develops and the body and texture change.

In order to secure a cheese of the best quality, the curd must be properly made and then cured. The process of making any cheese consists of the following operations, which may be varied for each variety of cheese.

For some varieties, such as Swiss and Limberger, it is not necessary to ripen the milk, because the cheese is made from sweet milk. Milk is usually ripened by the addition of starter. The temperature at which the rennet is added and the temperature to which the curd is heated varies with the different cheeses, shown in the following table:

Variety of Cheese	Temperature Rennet added	Temperature Curd is Cooked
Cheddar	84° to 96° F.	98° to 100° F.
Swiss	92° to 96° F.	128° to 135° F.
Limberger	90° to 96° F.	96° to 98° F.
Camembert	84° to 86° F.	Not cooked
Roquefort	82° to 84° F.	Not cooked
Edam	85° to 88° F.	93° to 96° F.
Neufchâtel	72° F.	Not cooked
Cream	72° F.	Not cooked
Munster	84° to 86° F.	98° to 108° F.
Brick	92° to 96° F.	110° to 115° F.

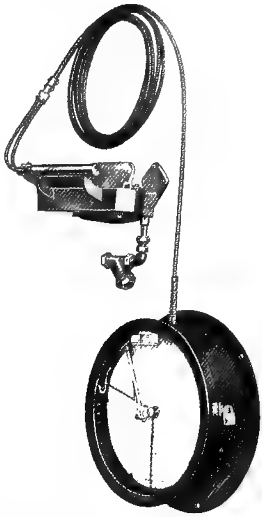
The amount of rennet varies from 2 to 6 ounces per thousand pounds of milk, depending upon the varieties of cheese, the kind of curd desired, and the temperature at which the rennet is added. The length of time of coagulation depends upon the kind of curd desired, and the succeeding operations. Sometimes the curd is cut very soft, and sometimes it is allowed to coagulate very slowly, taking several hours or overnight.

The curd may be either cut or broken. It is usually broken when the coagulated curd is put directly into the draining forms, as in the making of Camembert, Neufchâtel and the like. The size of the pieces into which the curd particles are cut depends upon the rapidity of firming and the dryness desired. The time to remove the whey varies with each kind of cheese. Some varieties may be placed, without heating or cutting, into the draining molds and allowed to drain. A good example of this is Camembert and Neufchâtel. With the other varieties it may be necessary to cut the curd, heat it and allow time for the whey to be expelled or for the curd to become firm. This may take one to three hours from the time of coagulation before it is time to remove the whey.

Some varieties of cheese, such as Cheddar, are salted while the curd is yet in the vat and before it is put to press. Other varieties are salted from the outside after the cheese is entirely formed. This is done by rubbing dry salt on the cheese or soaking the cheese in a very salty brine. Many varieties of cheese do not have to be pressed, for the curd will naturally settle together, but with other varieties the curd must be subjected to very heavy pressure to make it go together.

Many cheeses which have been properly made are ruined by improper methods of ripening. On the other hand, no defects of manufacture can be remedied during the ripening process.

Authorities disagree as to what causes cheese ripening, but it probably is due to a combination of factors, namely, humidity, temperature, micro-organisms, enzymes and chemical agents. In the country where the cheese originated, the ripening is a natural process and does not need any special attention. In a country where the factors of humidity and temperature are different, it is necessary to try to duplicate the proper climate conditions. To do this, humidity and temperature recorders should be installed in the curing rooms. Thus, both humidity and temperature can be accurately judged and a record kept.



Foxboro Recording Psychrometer for recording the room temperature and the wet bulb temperature, thus giving a constant record of humidity. Recorder may be placed outside of the area in which humidity is controlled.

While in the curing room cheese must have constant attention. It must be turned and kept free from mold. Some varieties, such as Limberger, Munster and Swiss, must be rubbed to develop a rind.

If allowed fully to cure or ripen, the commercial life of the cheese is very short. So it is the practice to ripen the cheese partially when packaged and put on the market. The time of packaging and marketing is so arranged that by the time the consumers receive the cheese, it is fully ripe or cured and ready for consumption.

Certain varieties of cheese, such as Cheddar and Swiss, are made extensively during the summer when milk is abundant. These cheeses are then put in storage, after being partially cured. The cheese should be held as near freezing and with as little fluctuation in temperature as possible. There should be a continuous record of the temperature changes. The storage should be dry, so that the cheese will not mold. Some varieties of cheese, especially Cheddar, when partially cured so that they have a firm, dry, smooth rind, are dipped in hot paraffine. This coat of paraffine prevents the evaporation of the moisture, and tends to prevent the entrance of mold. The paraffine is heated to 180° F. and the cheese held in it four to six seconds. If the paraffine is too cold or the cheese is damp the paraffine will not stick.

CHAPTER IX

CASEIN AND MILK SUGAR

THE making of commercial casein is a very simple process, but one which requires strict observance of temperature. Skimmed milk is heated to a temperature of 86° to 90° F., and the casein is precipitated by the addition of sulphuric acid. Hydrochloric acid and rennet are also used. The acid should be diluted by pouring it into cold water. Never pour the water into the acid. Just enough acid should be used to get a clear whey, which shows that all the casein has been precipitated. If too much acid is used, it will cut the casein, causing it to be grainy and chunky. As soon as it is coagulated, the curd should be broken up and the whey drawn off. The curd should then be thoroughly washed and worked in water that is at least 180° F. The washing removes the acid and the working causes the casein to unite. After being worked, the curd will draw out like taffy candy. If too much acid is used, it will not draw out.

Casein may be precipitated as when making cottage or pot cheese. It is then necessary to press this curd to remove the whey, after which it is ground and dried. It is claimed, however, that this method does not give a good grade of casein.

In this condition, the casein is known as green casein or green curd. It contains considerable moisture and will spoil in a short time. It may be dried in the same plant where made, or shipped to jobbers who have drying plants.

The drying is usually done by grinding the green curd and spreading it in thin layers on screen racks.

These racks are placed in a dry kiln and the casein dried for twenty-four hours. The heat for drying is obtained by blowing air over hot radiators. The temperature of the kiln should not be above 115° F. The fan and ventilators are usually connected with a thermostat control and the kiln with a recording thermometer. If the temperature rises too high, it discolors the casein and reduces its solubility. Rotary dryers and vacuum dryers are also used considerably for drying casein.

Casein is used in the making of certain glues, paints, papers, textiles and prepared foods. It is also used for imitation ivory, horn, etc.

Milk Sugar.

Milk sugar is manufactured as follows: Whey, obtained from commercial casein plants or cheese factories, is acidified and heated to its boiling point in large vats, in order to precipitate the albumin. The solution is then treated with calcium hydroxide and evaporated in a vacuum pan until it forms a syrup. It is then filtered and evaporated again at about 100° F. to a thick syrup, which is removed, placed in shallow containers and cooled. After one or two days it has crystallized into the crude yellow sugar. It is then placed in a centrifugal machine provided with sieves and washed to remove impurities. The washed crystals are redissolved in hot water and treated with chemicals. The clear liquid is then heated to about 170° F. and filtered through charcoal to remove coloring matter. It is now condensed to a solid mass in a vacuum pan, which is washed and dried on racks in a drying room in which a temperature of approximately 140° F. is maintained. When dry it is powdered and packed for shipment.

CHAPTER X

THE POWER PLANT

It is not the province of this book to discuss the question whether a steam boiler, a gas engine, or an electric motor is the best equipment for the dairy power plant. There are operating conditions under which a combination of all three of these would prove to be the most economical in the end; and there are other conditions which seem to leave little choice to the dairyman. The relative local cost of coal, gasoline, and electricity would have to be considered very carefully, and the particular milk products to be manufactured, and a dozen other purely individual conditions. We content ourselves, therefore, with referring the dairyman interested in this important question to Bulletin 747 United States Department of Agriculture: "The Economical Use of Fuel in Milk Plants and Creameries," by John T. Bowen. In this bulletin of forty-seven pages every phase of the dairy power-plant problem is discussed in a manner that makes it extremely valuable to the Dairy Industry.

Whatever be the kind of power employed, however, the power plant must certainly not be overlooked when the question of indicating and recording instruments is being considered. Everything gained in the way of productive efficiency and economy in the milk-handling rooms may easily be lost by neglect in the power plant. The cost of fuel alone may run higher than that of any other item of operating expense; and the waste of steam and water, of brine and ammonia, may more than offset the economical administration of other departments. It cannot, therefore, be overemphasized that efficiency and economy in the power plant are fully as important as the control of temperature and pressure in the milk-handling rooms, and that they are just as easily attained.

All this applies not only to large modern plants of complex character, but also to the small plant with its inadequate and, sometimes, antiquated equipment. Indeed, such small plants often offer even greater opportunities for improvement and economy through the installation of the proper instruments. Whether the boilers and refrigerating machines are old or new, large or small, the operators should be provided with high-grade indicating and recording instruments, in order that they may have at all times sufficient information about conditions to maintain a high efficiency and to prevent the loss of costly heat units.

It is assumed here that steam power and some system of artificial refrigeration are used.

Now the choice of indicating and recording instruments for the power plant should be determined by a careful consideration of kind, quantity, and quality. To overload a small plant with instruments that cannot be used to advantage is to gain nothing but expense; yet it is just as shortsighted to attempt to do without those that are really essential to establish a high plant standard. In order to make the installation of instruments an investment rather than an expense, study the performance of the plant itself, note the variable conditions which affect efficiency, and then determine what instruments are needed.

The particular instruments mentioned here are simply suggestive. It may be that some plants will not need them all, but it is very probable that even the engineer of the smallest plant will discover a few suggestions that will help him to reach a higher efficiency and a lower cost in his department.

For the boiler room we recommend Recording Pressure Gauges for steam, Recording and Indicating Thermometers for feed-water, stack, steam, and economizer temperatures; Recording and Indicating Draft Gauges, and a CO Recorder for flue-gas analysis.

In the refrigerating room, thermometers should be provided for the ammonia compressors, freezing tanks, condenser-water, forecooler-water, liquid ammonia, brine lines and brine tanks. A Two-Pen Recording Pressure Gauge for both low and high pressure ammonia attached to the compressor will give a positive check on the efficiency of its operation.

A knowledge of the temperatures of the brine entering and leaving the cooler is of utmost importance to a dairyman. Unless he has accurate and continuous information of these temperatures the efficiency of the plant cannot be maintained. Recording thermometers tell the whole story, and from a study of the charts the temperature of brine flow and refrigerant can be regulated.

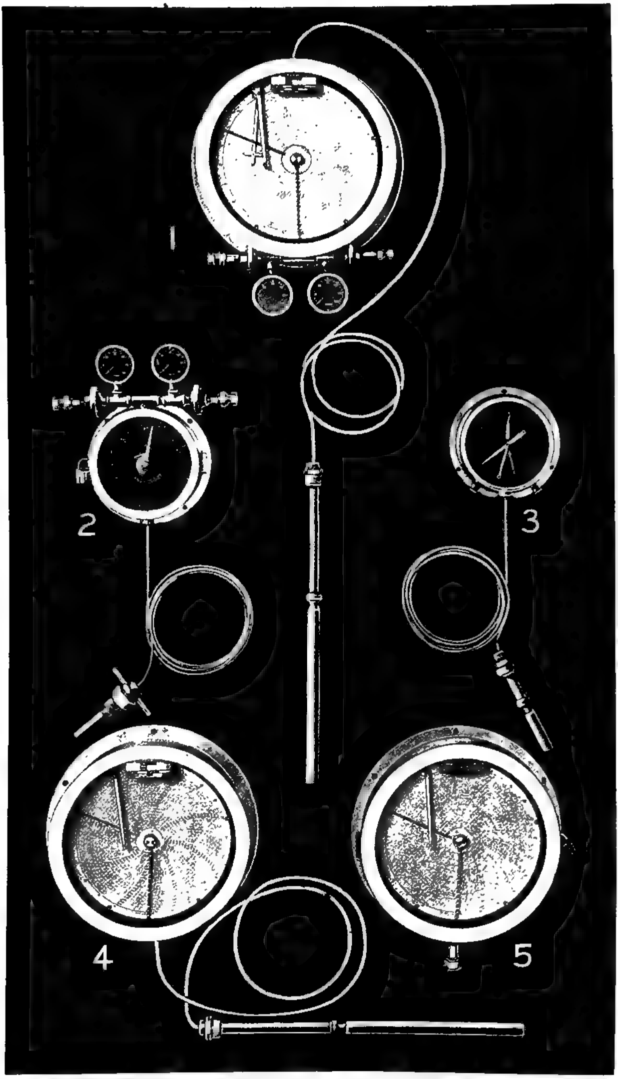
For the condenser-water, recording thermometers make it possible for the operator to estimate the number of gallons required per ton of refrigeration by recording the temperature of the water as it runs on the condenser and as it leaves. They give also a check on operating conditions. If the records show an increase of temperature above normal of the water leaving the condenser, the water pump, or system needs attention. If the temperature of the water running over the condenser shows a decrease, less ammonia has been delivered to the condenser.

On the ammonia compressor, recording thermometers will tell you whether there is enough ammonia in the line, whether it returns superheated, whether the cooling of the compressor — either by water jacket or liquid injection — is correct. By recording both the suction and discharge temperatures of the compressor, the operator has an accurate and continuous picture of what is going on while the plant is in operation.

These are only a few isolated instances of what can be done in the refrigerating room alone by an intelligent use of recorders. Wherever possible in the boiler room and the refrigerating room, recording instruments should be installed. Their slightly additional cost above indicating instruments is far offset by the greater value gained by the continuous records which the operator can compare and study. If properly installed and faithfully used, these instruments will provide the engineer with the most valuable information on all the conditions upon which the productive efficiency and economy of the plant depend.

It is worth emphasizing that, where it is a question of temperature, or pressure, guessing is unscientific, uneconomical, and unsafe. In the power plant, knowledge alone is power; not memory — that is too treacherous; not scraps gathered at irregular intervals by glancing at an indicator — that is the little knowledge which is a dangerous thing. What is needed is complete recorded knowledge of what is happening all the time in and around the boiler and the refrigerating equipment. And this is just what recording instruments give. They are not only perpetual guides to the operators, but they give the engineer an opportunity to compare various records and thus establish an efficient operating standard.

Finally, cheap indicating and recording instruments are, like most other cheap things, dear at any price. In the milk-handling rooms and in the power plant accurate knowledge of temperatures and pressures often creates just that distinction between the dairy product that has to be sold at a loss because something is not quite standard about it, and the product that is perfect in purity and flavor because the conditions essential to quality have been carefully watched and controlled. Real quality instruments — high-grade, accurate, and dependable — very soon save many times their initial cost, and should never be considered as an extra expense but as a definite investment. Nowhere is the "Penny-Wise, Pound-Foolish" policy more to be avoided than when equipping the dairy with indicating and recording instruments. Get the best.



SOME FOXBORO DAIRY INSTRUMENTS

FOXBORO DAIRY INSTRUMENTS

TRADE MARK

Foxboro Dairy Instruments are furnished in the standard white-enameled, round-form, dust-proof, moisture-proof case, as illustrated. Full nickel plate or other finishes can be supplied to match existing equipment. Sanitary fittings are supplied to suit any standard make of pasteurizer.

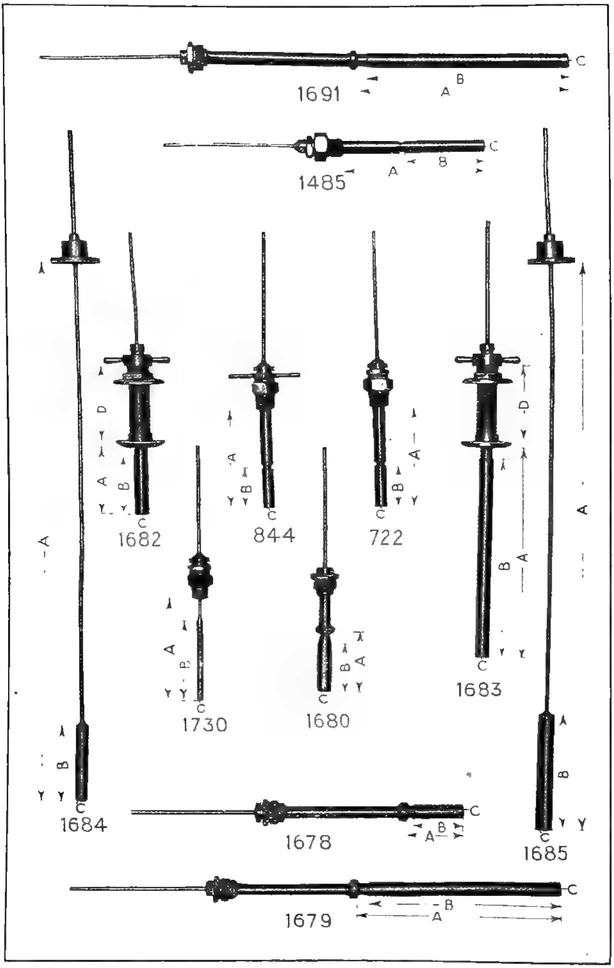
Figure 1 — Foxboro Automatic Temperature Recorder-Controller for the dairy. Combines temperature controller and recording thermometer. Particularly valuable for regulating and recording temperature in pasteurizers, storage rooms, hardening rooms, drying kilns, drying rooms, curing rooms, or wherever it is desired to keep a careful check on holding temperatures and maintain permanent records of these temperatures.

Figure 2 — Foxboro Automatic Temperature Controller for dairy use wherever it is desired to maintain a definite temperature without keeping a record of the temperature.

Figure 3 — Foxboro Long-Distance Dial-Type Dairy Indicating Thermometer used extensively on pre-heaters, cookers, tanks, washers and other equipment if no record is desired. It replaces the ordinary glass thermometer, eliminating breakage and mercury contamination. The instrument shown is provided with double electric alarm attachment for giving a warning signal when the temperature rises to a certain point or falls below a certain point. This device is also provided on recording instruments.

Figure 4 — Foxboro Long-Distance Recording Dairy Thermometer. For every required temperature range in the Dairy Industry. Used in bacteriological laboratories, on pasteurizers, receiving vats, pre-heaters, coolers, holding tanks, storage rooms, ripeners, ageing tanks, freezers, brine tanks, hardening rooms, sterilizers, condensers, drying kilns, drying rooms, cheese vats, curing rooms and in the refrigerating plant.

Figure 5 — Foxboro Recording Pressure and Vacuum Gauge used on homogenizers, viscolizers, sterilizers, evaporators, vacuum pans, condensers, drying cylinders and steam lines.



SOME FOXBORO CONTROLLER AND THERMOMETER BULBS

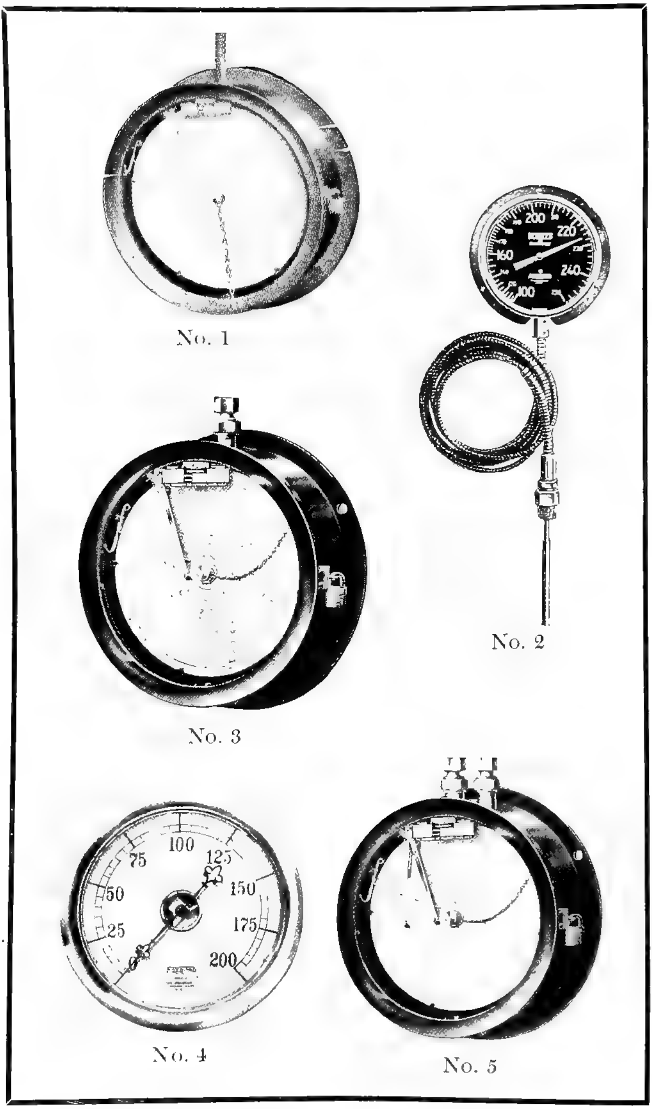
Some FOXBORO Controller and Thermometer Bulbs

Class	Bulb No.	Pasteurizer	Application	Chart Ranges Degrees Fahrenheit	S. P. Thread	Dimensions A	Dimensions B	Dimensions C	Dimensions D
II	1678	Elyria	Heating, Holding, Cooling	30–160, 30–190, 50–220	*	3½″	3¼″	¾″	
III	1679	"	" " "	30–220	*	10½″	10″	¾″	
II	1682	Wizard	Heating, Holding, Cooling	30–160, 30–190, 50–220	*	3½″	3¼″	¾″	†
III	1682	"	" " "	30–220	*	3½″	3¼″	¾″	†
III	1683		" "	30–220	*	10½″	10″	¾″	†
II	1680	Cherry	Heating, Holding, Cooling	30–160, 30–190, 50–220	*	3½″	3¼″	¾″	
III	1680	"	" " "	30–220	*	3½″	3¼″	¾″	
III	1691	Pfaudler	Heating, Holding, Cooling	30–220, 0–250	*	10½″	10″	¾″	
II	1684	Open Vats	Heating, Holding, Cooling	30–160, 30–190, 50–220		28″	4″	⅝″	
III	1685	" "	" " "	30–220		28″	6″	⅞″	
II	1730	Davis, Economy, Simplex	Heating	30–160, 30–190	½″	7″	6″	⅜″	
*a*II	1769			30–160, 30–190	¾″	7″	6″	⅜″	
*b*II	724			50–220	½″	5″	4″	⅜″	
*c*II	1167			50–220	¾″	5″	4″	⅜″	
II	722		Heating, Holding	50–170, 50–200, 50 220	¾″	2½″	2″	⅝″	
II	844		" "	50–170, 50–200, 50–220	¾″	2½″	2″	⅝″	
II	1485		Heating, Holding, Cooling	30–160, 30–190, 50–220	¾″	5″	4″	⅝″	

* **Special Sanitary Fittings.** † **To be specified:** 3¾″ for any thickness of wall from ⅞″ to 3″; 6¼″ for any thickness of wall from 3″ to 5½′.
a Not illustrated, same as 1730 except dimension of S. P. Thread. *b* Not illustrated, same as 1730 except dimensions A and B.
c Not illustrated, same as 724 except dimension of S. P. Thread.

All Foxboro bulbs shown are Tinned and the exterior parts Nickel Plated.
With plain copper tubing no special right-angle fitting is needed, as the tube can be bent at any desired angle close to the bulb.
Quick detachable feature can be furnished for any bulb with union connection.

Special Foxboro bulbs can be supplied to cover any specifications.



SOME FOXBORO POWER PLANT INSTRUMENTS

FOXBORO

TRADE MARK

POWER PLANT INSTRUMENTS

Figures 1 & 2 — Foxboro Recording and Indicating Thermometers for power plants. Used on feed-water heaters, stacks, economizers, steam lines, ammonia compressors, freezing tanks, condensers, forecoolers, brine lines, brine tanks.

Figures 3 & 4 — Foxboro Recording and Indicating Pressure Gauges for power plants. For use on boilers, steam lines, liquid lines and compressors.

Figure 5 — Foxboro Two-Pen Recording Pressure Gauges for recording compressor suction and discharge pressures. Low pressure two-pen recorders are used for recording draft at any two parts of the boiler system.

For dairies whose power requirements necessitate plants of large capacity Foxboro-Heath CO_2 Recorders produce permanent records of the CO_2 content in the flue gases. Their use greatly increases the efficiency and economy of plant operation. For large plants we also recommend the use of Foxboro Triplex Draft Gauges for indicating pit pressure, draft in the last pass and in the furnace above the fire. Although this instrument was only recently placed on the market its accuracy, compactness and easy reading quality have made it exceedingly popular with engineer and fireman.

Write us for further information concerning these instruments.

LEGAL STANDARDS FOR DAIRY PRODUCTS

STATES	MILK			SKIM MILK	CREAM	BUTTER		CONDENSED MILK				ICE CREAM % fat		CHEESE % fat	
								SWEETENED		UNSWEETENED					
	% Total Solids	% Solids not Fat	% Fat	% Total Solids	% Fat	% Fat	% Moisture	% Fat	% Total Milk Solids	% Fat	% Total Solids	Plain	Fruit or Nut	Whole Milk	Skim Milk
Alabama †															
Arizona		8.5	3.25	9.25	18	80.	16	7.7	28.	7.7	28.	10	8	50	
Arkansas †															
California	11.5	8.5	3.	8.8	18	80.		*	*	*	*	10.	8	50	
Colorado			3.			80.	16	7.7	28.	7.7	24.	10.	10	50	
Connecticut	11.75	8.5	3.25									8.	6		
Delaware		8.5	3.25		18										
Dist. of Col.	12.5	9.	3.5	9.3	20	83.	12								
Florida *															
Georgia	11.75	8.5	3.25	9.25	18	82.5						8	8	50	
Idaho	11.2	8.	3.2	9.3	18	82.5		7.7	28.	7.8	34.3	14.	12	50	
Illinois		8.5	3.	9.25	18	82.5		8.	28.	7.8	25.5	8.	8	50	
Indiana		8.5	3.25	9.25	18	82.5	16	*	*	7.8	25.5	8	8	50	
Iowa	11.5		3.		16	*		*	*	*	*	12.	10	*	*
Kansas		8.5	3.25	9.25	18	80.	16	8.	28.	7.8	25.5	14.	12	50	
Kentucky	12.	8.5	3.25	*	18	*	16	*	*	*	*	14.	12	*	*
Louisiana	12.	8.5	3.5	8.	18	82.5	16	8.	28.	7.8	25.5	10.	8		
Maine	11.75	8.5	3.25		18							14.	12		
Maryland		8.5	3.25	9.25	18	82.5		8.	28.	7.8	25.5	4.	4,6	50	
Massachusetts	12.		3.35	9.3	15	*		*	*	*	*	7.	7	*	*
Michigan	11.5	8.5	3.		18	80.		*	*	*	*	10.	8	30	under 30
Minnesota	13.		3.25		20		16	8.	28.	7.8	33.3	12.	12		
Mississippi	*	*	*	*	18	82.5		8.	28.	7.8	25.5	12.5	10	50	
Missouri	12.	8.75	3.25	9.25	18	82.5	16	8.	28.	8.	28.	8.	8	50	
Montana	11.75	8.5	3.25			82.5	16					10.	9	50	25
Nebraska			3.	9.25	18							14.	12		
Nevada	*	*	*	*	22			*	*	*	*	*	*	*	
New Hampshire	11.85		3.35	8.50	18	80.	16	*	*	*	*	14.	14	*	*
New Jersey	11.5	8.5	3.		16	82.5									
New Mexico †															
New York	11.15		3.		18			8.	28.	7.8	25.5				13,18
North Carolina	11.75	8.5	3.25	9.25	18	82.5	16	8.	28.			10.	8	50	
North Dakota					18		15	*	*	*	*	10.	10	*	*
Ohio	12.	9.	3.							25% of T. S.				30	under 20
Oklahoma	12.	8.5	3.5		18	82.5	16					10.	8		
Oregon	11.7	8.5	3.2		18	80.	16			7.8	25.5	8.	6	50	
Pennsylvania	12.		3.25											32	
Rhode Island	12.		2.5		18 & 40	84.	16	*	*	*	*				
South Carolina	11.5	8.25	3.25									8.			
South Dakota	11.75	8.5	3.25	9.25	18	80.		7.6	28.	7.6	28.	14.	12	50	
Tennessee		8.5	3.25									8.	8		
Texas *															
Utah	12.	8.8	3.2	9.	18, 24, 30	80.	16	7.8		7.8	25.5	14.	12	*	*
Vermont	11.75	8.5	3.25	9.25	18	82.5		*	*	*	*	14.	12	*	*
Virginia	11.75	8.5	3.25		18	*	16	*	*	*	*	8.	8	50	
Washington		8.5	3.25	8.8	18	80		7.8	25.5	7.8	25.5	8.	8	50	
West Virginia	12.		3.		16							8.	8		
Wisconsin		8.5	3.	9.	18	82.5		8.	28.	8.	28.	14.	12	50	
Wyoming		8.5	3.25	9.25	18	82.5	16	7.8	34.3	7.8	25.5	14.	12	50	
U. S. Dept. of Agriculture					18	82.5	12	8.	28.	7.8	25.5	14.	12	50	

* U. S. Department of Agriculture Standards.
† No State Standards.

NOTE: — U. S. Department of Agriculture Standards for milk: **Milk** is the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and five days after calving, or such longer period as may be necessary to render the milk practically colostrum free.

Pasteurized Milk is milk that has been subjected to a temperature not lower than 145 degrees Fahrenheit for not less than thirty minutes. Unless it is bottled hot, it is promptly cooled to 50 degrees Fahrenheit or lower.

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