THE PASTEURIZATION OF MILK, CREAM AND DAIRY BY-PRODUCTS

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THE PASTEURIZATION OF MILK, CREAM AND DAIRY BY-PRODUCTS

INTRODUCTION

Pasteurization as applied to dairying is the process of heating milk, cream or dairy by-products to a temperature at which all the disease germs that may be contained therein will be destroyed and, in the case of milk or cream, of also cooling to a temperature at which the growth of the surviving organisms will be restrained. Efficient pasteurization insures a safe supply of milk and other dairy products, delays the souring of milk and improves the flavour and keeping quality of butter. On the other hand, inefficient methods of pasteurization give the public a false sense of security and form one of the chief criticisms by those opposed to the practice. The purpose of this bulletin, therefore, is primarily to effect a greater efficiency in the pasteurization of milk, cream and dairy by-products in Canada and, incidentally, to present in a concise form information that will answer the numerous questions received by this Branch regarding pasteurizing methods and equipment.

I.—PASTEURIZATION OF THE MARKET MILK SUPPLY

There are three methods of pasteurization in use commercially:—

1. The flash or continuous method of heating, followed by immediate cooling.
2. The final package method in which the milk is bottled and sealed before heating and cooling.
3. The vat or holding method in which the milk is heated, held for thirty minutes, cooled and bottled.

Various combinations of the flash and holding methods are used in the larger milk plants but, in Canada, the last method is of most general commercial importance.

The Flash Method

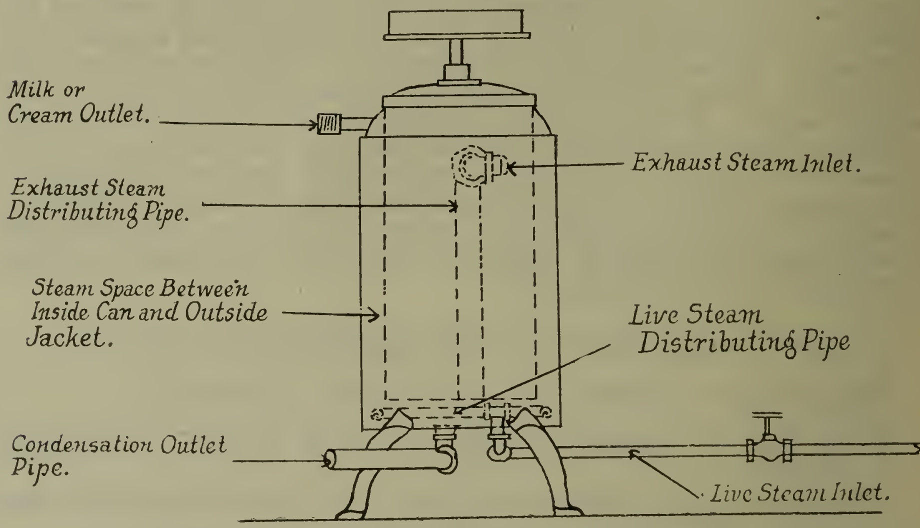
The type of pasteurizer generally used consists of a cylindrical milk chamber with a revolving paddle surrounded by a steam or hot water jacket (figs. 1 and 9). The milk flows from a receiving tank into the milk chamber at the bottom, is thrown by the revolving paddle in a thin layer against the sides of the heated jacket and forced out through the outlet at the top of the machine. The milk is heated in the pateurizer to 160° F. for thirty seconds to one minute, cooled immediately to a temperature of 50° F. or lower, and bottled.

The objections to this method of pasteurization and the probable reasons for its limited use in Canada are:—

1. The uncertainty as to the destruction of pathogenic (disease carrying) bacteria.
2. The difficulty of accurately controlling the temperature.
3. The apparent reduction of the quantity of cream owing to the fact that the fat globules do not rise as readily and as completely as in milk pasteurized by the holding method.

The Final Package Method

While pasteurization of milk in the final package or bottles is not commonly practised, it is the ideal method from a sanitary and bacteriological standpoint. The milk is bottled, sealed, immersed in water which is gradually heated to a temperature of 142° F. to 145° F., held for thirty minutes and then cooled. In some machines, the heating of the milk is effected by spraying hot water on the bottles. Compared with the other methods, the pasteurization of milk in the final package has the advantage of eliminating all danger of recontamination after heating. The disadvantages are increased cost of equipment and greater operating costs.



Fig, 1

The Holding Method

In the holding method of pasteurization, milk is heated to 142° F. to 145° F., held for thirty minutes and then cooled as quickly as possible to 50° F. or less and put in the final containers immediately. The definition of pasteurization as given by the Committee on Pasteurization of Milk and Cream of the International Association of Dairy and Milk Inspectors is as follows:—

"Pasteurization is a process by which every portion of milk so treated is heated to a temperature of approximately 145° F., never lower than 142° F. and held thereat for not less than thirty minutes and cooled to a temperature of 45° F., or lower. The degree and time of heating, holding and cooling should invariably be recorded by a tested automatic device, the records of which should be dated daily and should be checked at regular intervals by the health authorities. Immediately after pasteurization, and at the place thereof, the milk should be filled in the final containers and stored at a temperature lower than 50° F. until delivered to the consumers. Repasteurization is unnecessary, objectionable and should be prohibited. Deviation from the processes stated above should disqualify resulting products, so far as city milk supplies are concerned, from being termed pasteurized."

The above definition covers specifically the conditions in the process that should be followed in pasteurizing market milk supplies.

HEATING THE MILK

Various types of equipment may be used to heat the milk. In small plants, heating, holding and cooling may be done in the ordinary insulated vat with revolving coil, through which the heating and cooling media pass. This vat is operated in the same manner as described under "Pasteurization of Cream for Buttermaking." Another type of vat consists of a jacketed tank or vat in which the milk is agitated by a mechanical contrivance. Heat is supplied by steam or hot water in the outer jacket.

The vat covers should be kept closed to avoid loss from evaporation and to avoid contamination of the milk. The coils are kept revolving during the whole process, but it is important that they revolve at the proper speed. Violent agitation of the milk by fast revolving coils injures the cream line.

In plants handling over 600 gallons of milk a day, some system of continuous heating and cooling is best. With such a system, there is a continuous flow of milk from the receiving tank through the pasteurizer, holders and coolers to the bottling machines. The common continuous heaters used are the flash pasteurizer and the internal tubular heater. When either type of heater is employed, some kind of tank or vat is necessary to hold the milk after the required temperature has been reached.

When the flash pasteurizer is used as a heater, the process is the same as for flash pasteurization, except that the milk is heated to a much lower temperature. The heating surface in this pasteurizer is so small that a high temperature is necessary in the heating medium. For this reason, it is difficult to maintain a uniform temperature for all the milk and some may possibly be heated so high as to give a burnt or cooked taste. If the steam be controlled by a hand valve, it requires the constant attention of one man and even then it is difficult to have all milk heated uniformly. By means of an automatic temperature control, the temperature can be controlled to one degree above or below the required heat.

Good results can be obtained by a combination of this pasteurizer and a series of coil vats. The milk is heated from 125° F. to 135° F. in the flash machine, the remainder of the heating being accomplished in the vats which also act as holders. This will overcome any danger of overheating. This pasteurizer has the advantage of being durable, economical and requiring a limited floor space. The disadvantage is the difficulty of controlling temperatures.

The internal tubular heater consists of a series of pipes outside of which are other pipes. The milk passes through the inner pipes and the heating medium passes around the inner pipes through the outer ones. The milk and hot water flow in opposite directions. The water is heated by a steam jet connected to the water pipe before it enters the heating coil. The heating surface is comparatively large and the hot water is forced through fairly quickly, so that the temperature of the heating medium need not be much higher than that to which the milk is heated. This facilitates maintaining a uniform temperature for all the milk and avoids overheating.

After heating, the milk must be held for thirty minutes before cooling to insure efficient pasteurization. This process is accomplished in a vat or holder separate from the heater, except where all processes are carried out in the one vat. The milk may be held in a series of coil vats, or in a large tank or vat divided into several compartments, which can be filled and emptied by an automatic device. Holders of this type should be well insulated to maintain the milk at a constant temperature for the full thirty minutes. They are equipped with mechanical agitators, so that the cream will not rise during the holding period.

To obtain efficient pasteurization, it is important that all milk be heated to not less than 142° F. and held for the full thirty minutes. A recording thermometer is a great help in keeping temperatures and holding periods uniform. They should be checked regularly against a hand thermometer known to be correct. In a small plant, under the constant attention of a careful operator, such an instrument is not so necessary, but in large plants, they afford the manager the means of keeping a check on the operator, as well as records for the health officials.

The chief advantages of the holding method of pasteurization are:—

1. Much lower temperatures are required to insure complete destruction of disease-producing organisms that may be present, 142° F. for thirty minutes being sufficient with the holding process, while 160° F. is required in flash pasteurization.

2. A greater percentage of bacteria are destroyed than in the flash process, unless very high temperatures are used. This is due to the fact that some milk may pass through the machine without being heated to the temperature indicated by the thermometer.

3. The low temperatures of the holding process do not injure the cream line or produce a cooked flavour in the milk.

4. The use of low temperatures effects a saving in steam for heating and in refrigeration.

COOLING THE MILK

The milk should be cooled as rapidly as possible to 50° F., or lower, regardless of the method of pasteurization. Where small quantities of milk are handled, cooling can be done in the same vat by first running water through the coil and then ice water or brine. But even in the small plant, it is advisable to have a separate cooler, as it is possible to cool the milk much more quickly.

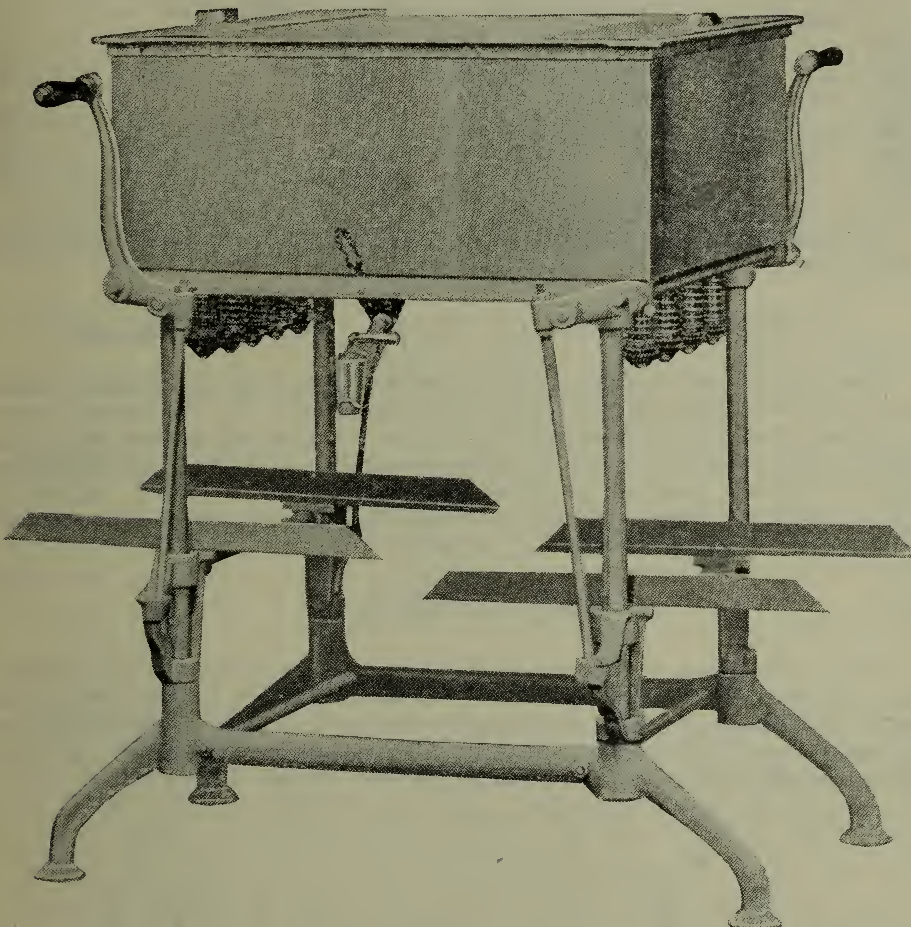
There are two types of coolers that are commonly used, the open surface tubular cooler (fig. 10) and the internal tubular cooler. The milk flows in a thin film over the tubes of the open surface cooler. These coolers are built in two, three or more sections. Water passes through the pipes of the upper sections and ice water or brine through the lower section. As the milk is exposed, the air in the room should be pure and clean and, if possible, the cooler should be placed in a separate room away from draughts. This will avoid recontamination of the milk and loss from evaporation. Some coolers are equipped with covers. The cooler should be of sufficient capacity to handle the milk as fast as it comes from the pasteurizer. If the cooler is small, there is a tendency to allow the milk to flow over the cooler too quickly for proper cooling. The length of the cooler should not be too great in comparison with the height. When the cooler is too long, the milk does not flow over the whole surface and some refrigeration is wasted.

The internal tube cooler is constructed on the same principle as the internal tubular heater. The milk flows through the inner pipes, while the cold water and brine goes through the outer pipes in the opposite direction. It requires about twice the length for the cooling coils as for heating coils. The milk does not come into contact with the air with this type of cooler, so there is no possibility for outside contamination or evaporation. Although there is considerable piping to clean, the cooler is easily sterilized by introducing steam in the coils.

In some forms of regenerative pasteurization, the cold, unpasteurized milk flows through the upper section of the cooler, thence to the pasteurizer. This effects a saving in steam and water, but the pipes are difficult to clean. Another form of regenerative cooler has a thin corrugated section set over the cooling tubes. The top trough is divided in the centre lengthwise by a partition. The cold milk flows over one side of the section to a trough and thence to the pasteurizer. The hot milk flows over the other side, is caught in a trough and distributed over the cooling tubes.

BOTTLING, CAPPING AND STORING

The milk should be bottled and capped immediately after cooling. There are many sizes and kinds of bottling and capping machines on the market. For the small dealer, a good type of bottler consists of a supply tank supported by a metal framework. The smaller machines have four valves for filling quarts at one end and five valves for filling pints at the other end (fig. 2). This bottle filler is operated by hand. The bottles are either capped by hand or with a single bottle capper operated by hand.



Fig, 2

The automatic bottle fillers and cappers are of several types. One type fills and caps whole cases of bottles at a time. Another type extensively used is the rotary filler and capper. The bottles are placed by hand on the machine and then automatically placed and raised under the valves of the supply tank. The capping is done on the other side of the filler. These fillers have eight, twelve or more valves and will fill and cap from twenty-four to seventy-two or more bottles per minute, depending on the size of the machine.

Passing the cases of bottled milk under a cold water spray en route from the bottler and capper to the cold room removes all traces of milk from the exterior of the cap and bottle.

The bottled milk should be stored in a cold, clean room and held below 50° F. until delivered. During pasteurization, all the bacteria are not destroyed and the growth of the remaining living organisms can only be effectively checked by holding at low temperatures.

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The following table furnishes information regarding equipment necessary to pasteurize given quantities of milk per day:—

Pounds of milk per day	Pasteurizer capacity	Cooler capacity	Milk Pump	Motor horsepower	Boiler horsepower
	lbs.	lbs.	inches		
500	500	500	1	¼	2
1,000	1,000	800	1	¼	4
2,000	1,700	1,200	1½	2	6
3,000	2,500	1,600	1½	7½	8
4,000	3.400	2,000	1½	10	10
5,000	2 x 2,500	2,400	1½	15	15
10,000	3 x 1,70C	3,600	1½	16	25
20,000	3 x 2,500	5,500	1½	25	35
50,000	3 x 3,400	8,400	2	35	50

Note.—This table shows minimum equipment. Greater capacity per hour would require greater pasteurizing and cooling capacity.

II. PASTEURIZATION OF CREAM FOR BUTTERMAKING

The two methods of pasteurization commonly practised in Canadian creameries are the vat or holding and the flash or continuous. By the former method the cream is heated to at least 170° F., held for short periods of time and cooled, usually in the same vat, to the churning temperature or lower. The continuous method consists of heating the cream to a temperature of 185° F. to 190° F. in the flash pasteurizer and of immediately cooling by means of a separate cooler to the churning temperature or lower.

HOLDING METHOD

The modern type of vat pasteurizers consists of an insulated vat equipped with a horizontal revolving spiral coil through which the heating and cooling media pass (fig. 3). In some machines the heating or cooling medium is pumped through the coil while in others it is self-circulating. The latter system is effected by the admission through an automatic air vent to the coil of a small

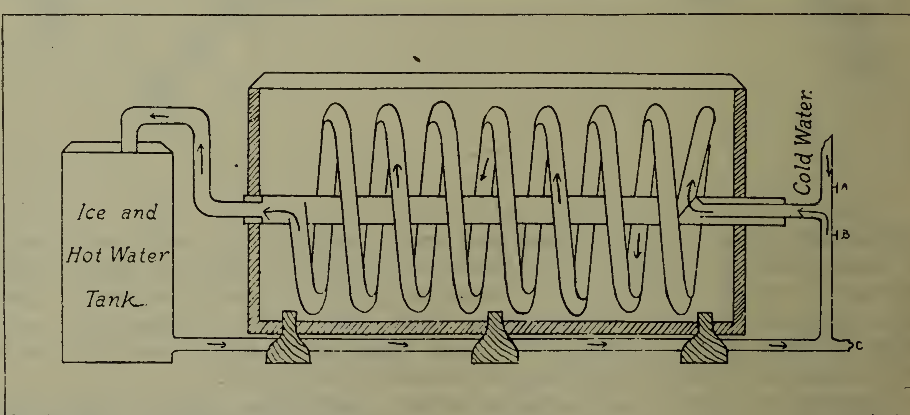


Fig. 3

amount of air with the water. The air rises to the upper part of the coil and forces the water forward with each revolution. More water and air are drawn in by suction and thus the operation is repeated with each revolution of the coil, creating a circulation.

In fig. 3 the circulation of hot or ice water is indicated by the arrows—valve (a) closed.

When cooling with well or city water, valve (b) is closed and valve (a) opened to allow the exhaust water to escape to the drain by removing plug at (c).

To obtain the maximum efficiency from the pasteurizer, the vat should be full of cream and the coils submerged. When the vat is only partially full, the coils will lose heat by being exposed to the air and, similarly, a loss of refrigeration will occur during the cooling period. There will be considerable foaming when the coil is exposed due to the whipping of air into the cream. Foaming is also caused by too high a speed of the coil and is objectionable because of the difficulty of completely emptying the vat without using excessive quantities of water or increased loss of fat.

The following table furnishes information regarding equipment required to pasteurize given quantities of cream per day by the holding method:—

Pounds of Cream per day	Pasteurizer capacity	Water Pump	Cream Pump	Motor or Engine horsepower	Boiler horsepower
	lbs.	inches	inches		
500 to 1,000	1 x 850	1	1	5	6
2,000	1 x 2,500	1	1½	9	15
3,000	1 x 3,400	1½	1½	9	20
4,000	2 x 2,500	1½	1½	9	20
5,000	1 x 1,700 1 x 3,400	2	1½	10	25
10,000	3 x 2,500	2	1½	12	25
20,000	4 x 2,500	2	2	35	40
50,000	12 x 4,300	2	2	50	75

HEATING THE CREAM

During the heating process, hot water only should be permitted to enter the coil. The entrance of live steam causes the cream to be burned on the coil thus decreasing the heating and cooling efficiency of the machine, increasing the labour required in cleaning and being detrimental to the packing in the glands. By heating the water in the ice box at the rear end of the vat instead of introducing steam into the water returning to the head of the coil, this danger is eliminated.

The partial neutralization of sour cream before heating reduces the loss of fat in the buttermilk and avoids curdling troubles that are usually associated with the pasteurization of unneutralized cream. Detailed information regarding methods of neutralizing is given in Pamphlet No. 52, " Neutralization of Cream for Buttermaking," which may be obtained from the Publications Branch, Department of Agriculture, Ottawa. After neutralizing, the cream should be heated to the desired temperature as quickly as the supply of steam and the circulating system will permit. The slow heating of cream tends to induce mealiness in the butter. In order to avoid this condition, there should be a good fire under the boiler, a good head of steam and plenty of water in the boiler before pasteurization is begun.

The coil should be kept revolving during the whole process of pasteurization to eliminate the possibility of the " oiling off " of the hot cream. When the hot cream has been allowed to " oil off," the fat develops a granular texture during the cooling of the cream and the result is a mealy butter which is objectionable.

During the heating operation, it is a good practice to have the vat covers open to allow the escape of those gases and tainted odours that may be driven off by heat.

In Canada, butter must pass the Storch test before it is legally considered " pasteurized ". The differential of about one cent per pound between pasteurized and unpasteurized butter is based on this test. At the conference of dairy experts held in Ottawa in 1918, it was recommended that a minimum temperature of 170° F. for ten minutes be adopted as the standard for the pasteurization of cream for buttermaking. Butter made from cream pasteurized at 170° F. and held at this temperature for ten minutes will successfully pass the Storch test.

By turning off the steam when the temperature of the cream is within a few degrees of the holding temperature and allowing the hot water to circulate through the coil during the holding period, the possibility of over-heating the cream is eliminated. There is sufficient heat in the hot water to raise the temperature of the cream the remaining few degrees.

As soon as the cream has reached the pasteurizing temperature, a pailful should be drawn from the outlet gate and returned to the vat. This will ensure the proper heating of the plug of raw cream that would otherwise stay in the outlet gate and contaminate the pasteurized cream.

During the holding period, the vat covers should be closed to keep the temperature of the cream more constant and to reduce the loss of heat to a minimum.

COOLING THE CREAM

After the cream has been held for the required period of time, it should be cooled immediately and as quickly as possible. The slow cooling of cream is apt to cause a mealy textured butter. During the cooling process, the vat covers should be closed.

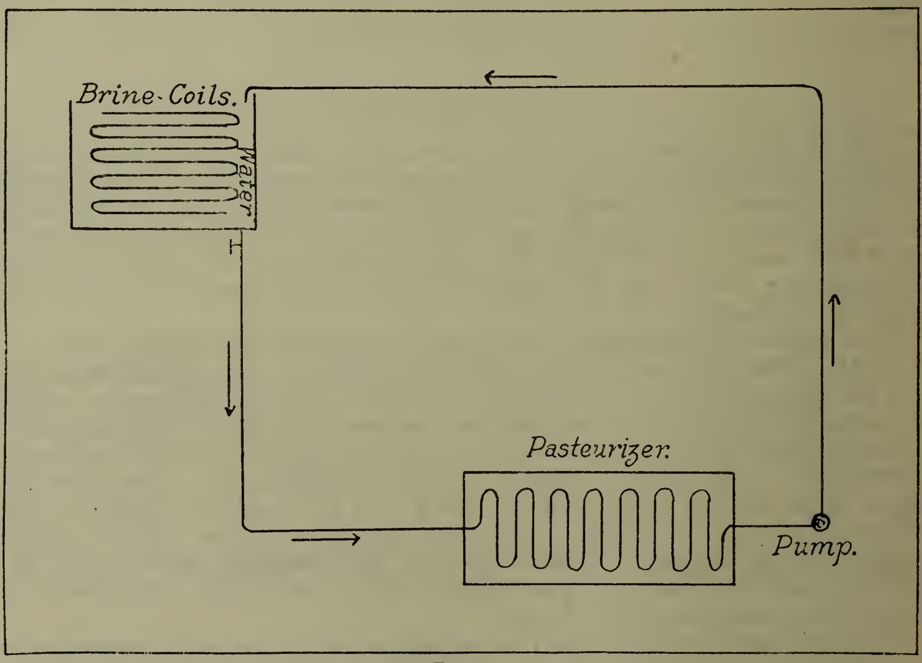


Fig. 4

The cooling of the cream is effected by running cold water through the coil, entering at the head and exhausting through the rear end of the coil to the drain. When the temperature of the cream is within a few degrees of the temperature of the water, the exhaust is closed and the cooling completed by circulating ice-water or brine through the coil. When using brine, all the water remaining in the coil should be drained away by revolving the coil a few times after the water has been shut off in order to avoid weakening the brine. A further precaution is to leave the exhaust of the coil open after the brine has been turned on until the exhaust begins to taste salty. Because of the corroding effect of brine on the coil, some creameries practise cooling the water in a tank containing brine coils. The cooled water is then circulated from the tank through the pasteurizer coil and back to the cooling tank (fig. 4).

Where local conditions of relative positions of ice house and creamery permit, a system of cooling as described in the accompanying diagram (fig. 5) may be used to advantage.

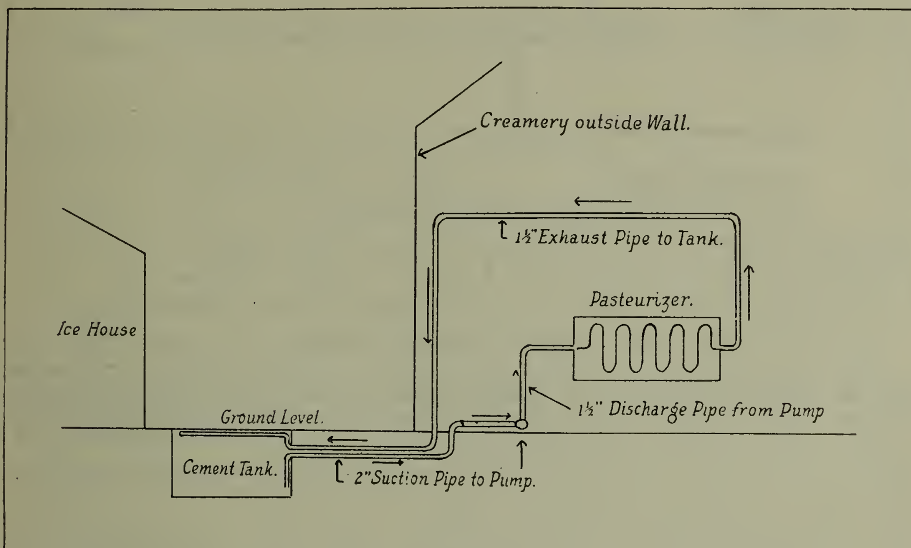


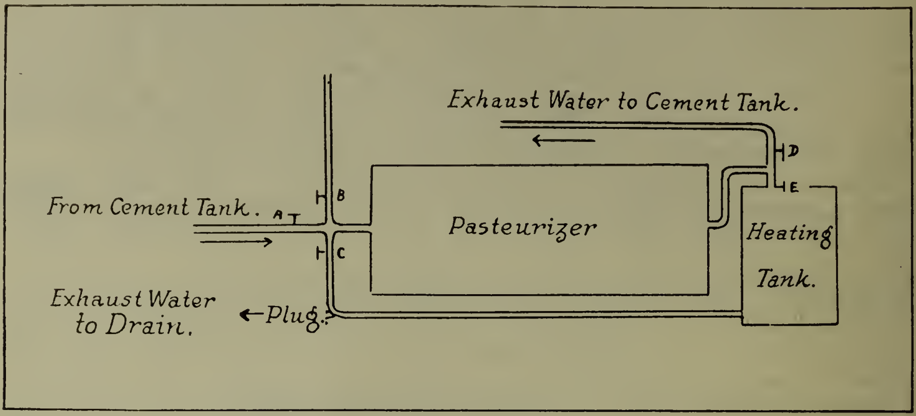
Fig. 5

The cement tank for holding the ice and water is situated close to the ice-house, the top of the tank being on a level with the ground surface. A depth of 5½ feet and a width of about 6 inches greater than the length of the cakes of ice are recommended. The length of the tank for an annual output of 500,000 pounds of butter should allow for four cakes of ice to lie side by side, although this will vary with the amount of cream to be cooled. The walls should be six inches thick. The suction and exhaust pipes of 2-inch and 1½-inch diameter respectively are laid about 2 feet below the ground surface. The suction pipe is carried directly through the cement wall of the tank, provision having been made for this during construction and an elbow and additional pipe are attached to continue it to within 3 inches from the bottom of the tank. After entering the tank, the exhaust pipe is directed up and across the upper part of the tank. Holes of ⅜-inch diameter in the horizontal portion of the pipe assist in spraying the water over the ice. A heavy wooden cover, preferably insulated, saves ice and keeps the water in the tank clean.

The circulation of the cold water through the pasteurizer is effected by means of a pump conveniently situated in the creamery.

Economy in labour and ice is reported from creameries practising this system of cooling.

By a proper arrangement of valves (fig. 6) this system may be installed without interfering with the heating circulation of the pasteurizer.

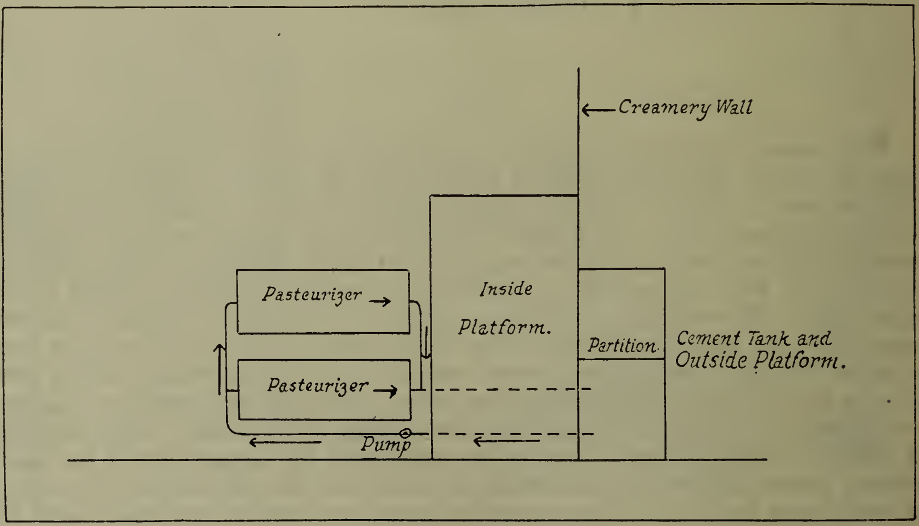


Fig, 6

Arrangement of Valves

I. Heating.—Valves a, b, d and plug closed. Valves c and e open.
II. Cooling with Water.—Valves a, c and d closed. Valves b, e and plug open.
III. Cooling with Ice Water.—Valves b, c and e closed. Valves a and d open.

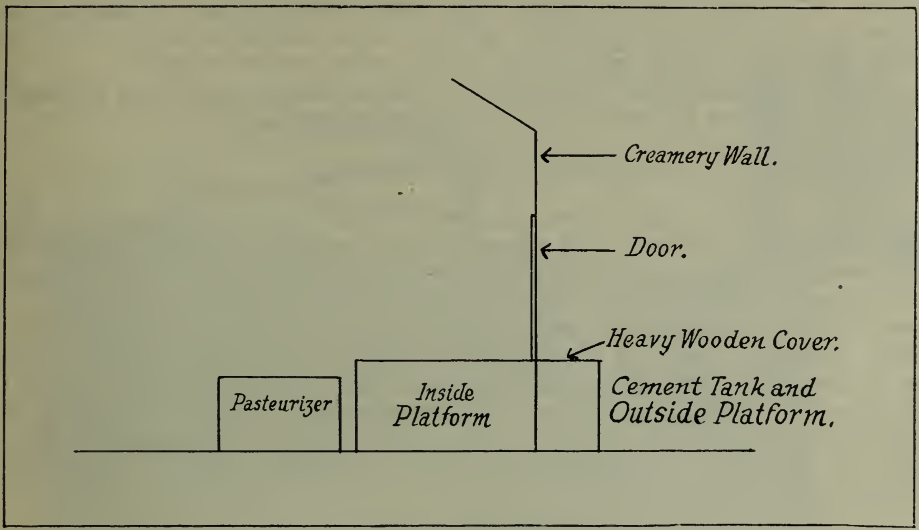
A modification of the foregoing system of cooling is described (figs. 7 and 8). While more labour is required to handle ice, the tank serves as an outside receiving platform and also a storage tank to hold surplus cream in the cans on nights and Sundays. The tank is divided into two compartments by a



PLAN. Fig. 7

cement partition. When circulating ice water through the pasteurizer, only one compartment is used, thus saving ice and speeding up the cooling process. When surplus cream is to be held in the tank, the plug in the partition may be removed and the whole tank utilized.

Where limited floor space is a factor, the cream may be heated and held in one vat pasteurizer and pumped to another elevated vat pasteurizer in which it is cooled by either one of the foregoing methods. In this case, the ice box or heating tank is dispensed with for the elevated vat.



ELEVATION. FIG. 8

The temperature to which the cream should be cooled varies with all the factors affecting the churning temperature, the length of time the cream is held after cooling until churning, and the temperature of the pasteurizing room. While it is not advisable to churn cream until at least two hours after cooling, occasionally force of circumstances compels churning immediately after cooling. In this case, the cream should be cooled to a lower degree than the usual churning temperature. During the summer months, cream that is to be held after cooling on Saturday until Monday morning should be cooled to a lower temperature than cream held over one night. In a general way, it may be stated that cream should be cooled to such a temperature that the body of the resulting butter will not be injured and that will avoid abnormal loss of fat in the buttermilk. Just what that temperature is each buttermaker must decide for himself by intelligent observation from day to day. The length of time churning is an excellent guide in this connection and should be about forty-five minutes.

CARE OF PASTEURIZERS

Too much emphasis cannot be laid on the necessity for care in cleaning the pasteurizer. A dirty pasteurizer not only defeats the very purpose for which pasteurization is practised, viz., to produce a healthy food product and to improve the flavour and keeping quality of the butter, but also shortens the life of the machine and decreases its heating and cooling efficiency.

As soon as the cream is removed, the pasteurizer should be rinsed out and filled half full with hot water to which is added some non-caustic washing powder. The sides, bottom, coil, shaft, gate and covers should be thoroughly scrubbed with a good brush. Under no circumstances should the use of wire cloths or metal bristle brushes be tolerated, as this practice results in the removal of the tinned surface exposing the copper which may cause metallic and other off flavours in the butter. If the method of heating has been done according to the directions previously recommended in this bulletin, i.e., avoiding the entrance of live steam into the coil—there will be no necessity to use anything but a brush for cleaning. After thoroughly cleaning, the pasteurizer should be rinsed out with hot water and steamed, allowing the condensed steam to pass off through the open gate. The covers should then be raised so that all parts of the machine will dry quickly. It is advisable to rinse with hot water and steam before each vat of cream enters the pasteurizer.

Proper attention should be given the stuffiing boxes, glands and packing to prevent the leaking of cream and the heating and cooling media.

RECONTAMINATION OF CREAM

Bacteriological examinations of creamery practices demonstrate that efficiently pasteurized cream is often recontaminated in and on its way to the churn. Mould in pasteurized butter can usually be traced to this source. By thoroughly cleaning and steaming all pumps, conductors and strainers with which the cream comes in contact after pasteurization and by properly treating the churn, butter wrappers, liners and boxes, recontamination of the cream and butter can be avoided. This subject has been thoroughly investigated by Dr. E. G. Hood and A. H. White, whose results and suggestions are given in Bulletin No. 48, "The Cause and Prevention of Mould in Canadian Pasteurized Butter," copies of which may be obtained from the Publications Branch, Department of Agriculture, Ottawa.

The Flash Method

EQUIPMENT

The equipment required to pasteurize cream for buttermaking by the flash method consists of a forewarmer, pasteurizer, cooler and holding vats. The cooling may be and, often is, effected in the holding vats thus eliminating the necessity for a separate cooler—but delaying the cooling process.

The forewarmer is quite similar to the vat pasteurizer previously described, but should be so constructed as to facilitate the dumping of the cream cans. It is equipped with a horizontal revolving coil through which hot water is circulated to pre-heat the cream before flowing to the pasteurizer. The forewarmer and pasteurizer may be so connected that the water in the forewarmer is heated by the exhaust steam from the pasteurizer. The forewarmer should be sufficiently large to hold one full churning of cream, or the neutralization of the cream cannot be done accurately. It is advisable to elevate the forewarmer so that the cream will flow by gravity to the pasteurizer, although it should not be high enough to interfere with the dumping of the cream from the platform.

The type of flash pasteurizer commonly used in Canada has already been described. The exhaust from the engine may be utilized as the heating medium. In some creameries, two pasteurizers are used to ensure thorough heating (fig. 9). The cream is heated to about 135° F. to 140° F. in the first machine from which it flows to the second pasteurizer in which it is heated to 185° F. to 190° F. The exhaust steam from the second machine may be used to heat the cream in the first pasteurizer, thereby effecting economy in operation.

Various types of machines are used to cool the hot cream. The open surface cooler (fig. 10) consists of a series of horizontal tubes constructed of tinned copper. The hot cream is fed from a perforated trough or pipe down on to the cooling tubes over which it spreads out in a thin sheet and flows downwards to a trough at the bottom of the cooler. The cooling medium enters the lower section of the cooler, flows back and forth through the tubes and is discharged at the top. The usual practice is to circulate city water through the upper section of the tubes, well water through the middle section, and brine or ice water through the lower section. In some creameries, the hot exhaust water from the upper section of tubes is returned through the coil of the forewarmer and utilized to heat the cream before pasteurizing.

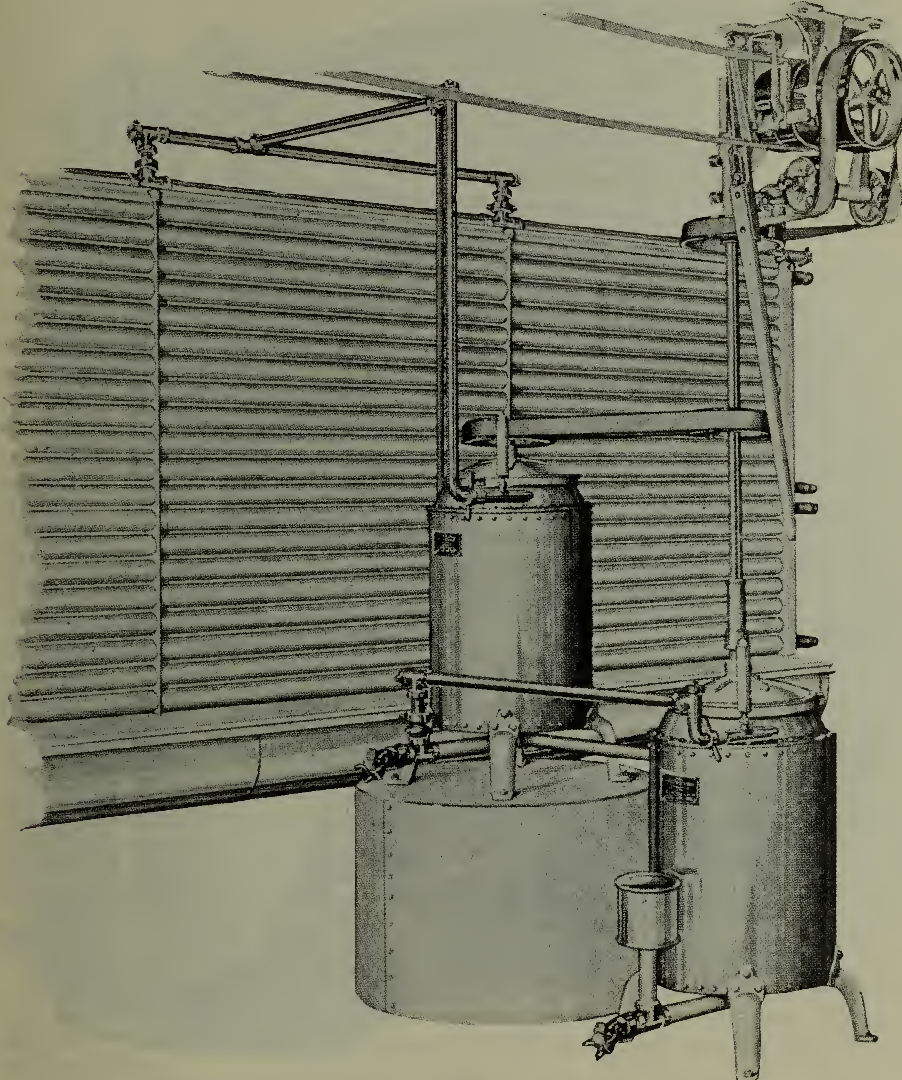


Fig. 9

The advantages of the surface cooler are speed in cooling and the tendency of some objectionable taints to escape from the cream. The disadvantages consist in the possibility of recontamination and of the formation of oxidation products in the cream owing to the exposure of the hot cream to light and air, resulting in such butter defects as metallic, tallowy and fishy flavours.

The internal tubular cooler is so constructed that the cream flows through an inner tube in one direction, while the cooling medium of water or brine flows through an outer enveloping tube of larger diameter in the opposite direction. Both the cooling medium and the cream are enclosed in the tubes.

The vats used for holding the cream after cooling until churning and in which the hot cream is sometimes cooled are exactly the same as the holding pasteurizers previously described.

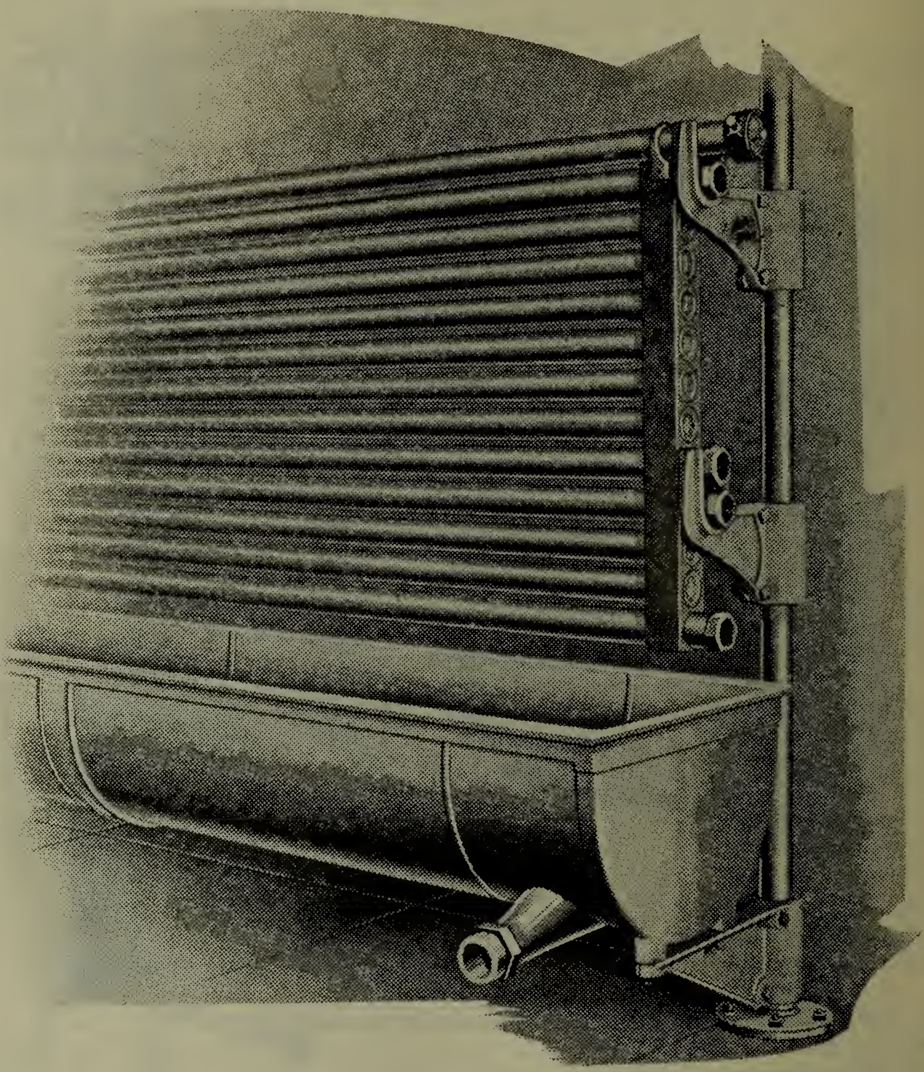


Fig. 10

By elevating the forewarmer and holding vats, and cooling the cream in the vats, the use of pumps is unnecessary. The cream flows by gravity from the forewarmer to the pasteurizer, is raised by the force of the revolving paddle in the pasteurizer to the holding vats and again flows by gravity from the holding vats to the churn. The system of cooling as described on page 11 is particularly applicable to this arrangement, as it eliminates the necessity of an ice tank at the rear of the vat and the increased labour of supplying same with ice at that elevation.

Where a separate cooler is used, the cream must be pumped from the cooler to the holding vats, unless the latter are situated on a lower floor, in which case the cream flows by gravity.

OPERATION

The cream should be thoroughly mixed, if sour neutralized, and heated to 90° F. to 100° F. in the forewarmer before entering the pasteurizer. Methods of neutralizing are given in Pamphlet No. 52, "Neutralization of Cream for Buttermaking," copies of which may be obtained from the Publications Branch, Department of Agriculture, Ottawa.

The operator of a flash pasteurizer must exercise the utmost care if he is to obtain efficient control of the pasteurizing temperature. Without his constant attention throughout the whole operation, optimum results cannot be expected. The two factors affecting the temperature are rate of inflow of cream to the pasteurizer and the steam pressure applied to the heating jacket of the pasteurizer. With the steam pressure constant, the greater the rate of inflow of cream, the lower the temperature. With a constant inflow of cream, the greater the steam pressure, the higher the temperature. The intelligent regulation of these two factors determines the efficiency of temperature control. An automatic heat controller which regulates the steam pressure and an automatic valve regulating the inflow of cream simplify the duties of the operator in controlling the pasteurizing temperature. The majority of Canadian creameries are not equipped with these automatic devices and the responsibility falls to the lot of the man operating the pasteurizer. When the exhaust steam from the engine is used as the heating medium, the practice is usually followed of fully opening the steam valve and regulating the temperature of the cream by the cream valve situated between the forewarmer and the pasteurizer. As the height of cream in the forewarmer lowers, the cream valve is opened further until at last it is turned on full when the temperature must be controlled by gradually closing the steam valve. With experience and constant attention, the operator can so regulate the pasteurizing temperature that all the churnings of butter will successfully pass the Storch test. Carlessness results in the butter being graded "Unpasteurized" and the needless loss of one cent per pound to the manufacturer.

The temperature recommended for flash pasteurization is 185° F. to 190° F.

The first portion of cream to pass through the pasteurizer will not be heated to the required temperature and should be automatically returned to the pasteurizer through a by-pass situated between the pasteurizer and the cooler until the required temperature has been reached and maintained. This precaution is not so essential when the cream is cooled in the holding vats since the temperature of the cream that first passes through the pasteurizer will be raised by mixing with the incoming cream.

When cooling in the holding vats, the circulation of the cold water should be started as soon as the hot cream reaches the coil. The cooling process is completed in exactly the same manner as described under the holding method of pasteurization.

The cooled cream from the tubular coolers is piped to the holding vats in which it is cooled the remaining few degrees to the temperature at which it is to be held before churning.

CARE OF EQUIPMENT

The necessity for efficient cleaning and care of equipment is perhaps of still greater importance with the flash than with the holding method of pasteurization. The danger of recontamination is greater owing to the extra equipment—coolers, pumps, pipes and holding vats—with which the cream comes in contact after heating. The general instructions, previously given, regarding the care of holding pasteurization equipment are applicable. The rinsing of the flash pasteurizer is accomplished by pumping through water immediately after the heating of the cream is completed. All removable parts should be taken to the wash tank and given a thorough scrubbing with brush and hot water containing washing powder.

Because of the higher pasteurizing temperatures, a coating, which is very difficult to remove, is deposited on the heating surface of the flash pasteurizer. Soaking the pasteurizer over-night with alkali solution will help somewhat, although a quicker method is to charge the heating jacket with steam after rinsing the pasteurizer with water. The coating will then peel off.

III. PASTEURIZATION OF DAIRY BY-PRODUCTS

The benefits to be derived from the pasteurization of dairy by-products are of a threefold nature—prevention of the dissemination of disease amongst live stock, improvement of the feeding value of skim-milk and whey, and the destruction of undesirable organisms which would otherwise cause objectionable flavours in dairy products. The destruction of pathogenic organisms in skim-milk and whey prevents the spread of disease amongst the calves and pigs to which these by-products are fed. The pasteurization of skim-milk and whey prolongs the period of time during which these by-products will retain their original palatability and feeding value. The pasteurization of whey retards the rising of the fat to the surface and thus ensures that each patron receives a proportional share of this valuable food constituent. In unpasteurized whey the fat rises to the surface readily and as the whey is drawn from the bottom, a large proportion of the fat remains in the tank. The possibility of the patrons' cans becoming seeded and recontaminating the milk with organisms that cause objectionable flavours in dairy products is eliminated by the pasteurization of skim-milk and whey. The pasteurization of dairy by-products therefore,—

1. Protects the farmer against financial loss caused by the ravages of such communicable ailments as tuberculosis among his live stock.
2. Effects a more equitable distribution of whey to the patrons of a factory.
3. Improves the feeding value of skim-milk and whey.
4. Improves the quality of dairy products.

Pasteurization of Whey

The following suggestions and illustration (fig. 11), prepared by the Dairy Branch, Ontario Department of Agriculture, Toronto, describe a satisfactory method of pasteurizing whey at the average cheese factory.

"It is an advantage to have either the upper or lower tanks, preferably both, large enough to hold all the whey of one day.

"Heating the whey should begin as soon as possible after the first whey from the vats reaches the whey tank to prevent the development of acidity and to take advantage of the temperature of 98 degrees before it begins to cool. A pasteurizing temperature of 155 degrees F. for at least thirty minutes is recommended. Care must be taken that the temperature does not rise above 160 degrees or the albumin will be precipitated and cause the whey to be flocculent and slimy.

"Whey should not be left over in the tank as this will become sour and increase the acidity of the fresh whey. All the whey should be removed each morning. If any whey is left over in the tank it should be immediately heated to 180 degrees F. to prevent further development of acidity before the fresh whey enters the tank.

"Pressure as high as practicable should be carried on the boiler during the time of heating the whey and the steam not given too much vent into the tank, or the boiler will rapidly be emptied of water. Heat under steam pressure by keeping the live steam, as it is generated by the fuel, going gradually into the whey. Begin with good steam pressure and maintain this pressure during the time required for heating.

"Cement whey tanks in the majority of cases do not give good satisfaction. Steel whey tanks are best.

"A tight valve is required between the boiler and tank or the whey may siphon back to the boiler after the steam goes down. A small hole drilled in pipe will prevent suction."

Fig. 11—(AA) Lower and upper tank; (BE) live steam in upper tank; (C) exhaust steam; (D) pump or ejector; (F) lever to close valve inside of tank to prevent leaking; (G) stopcock.

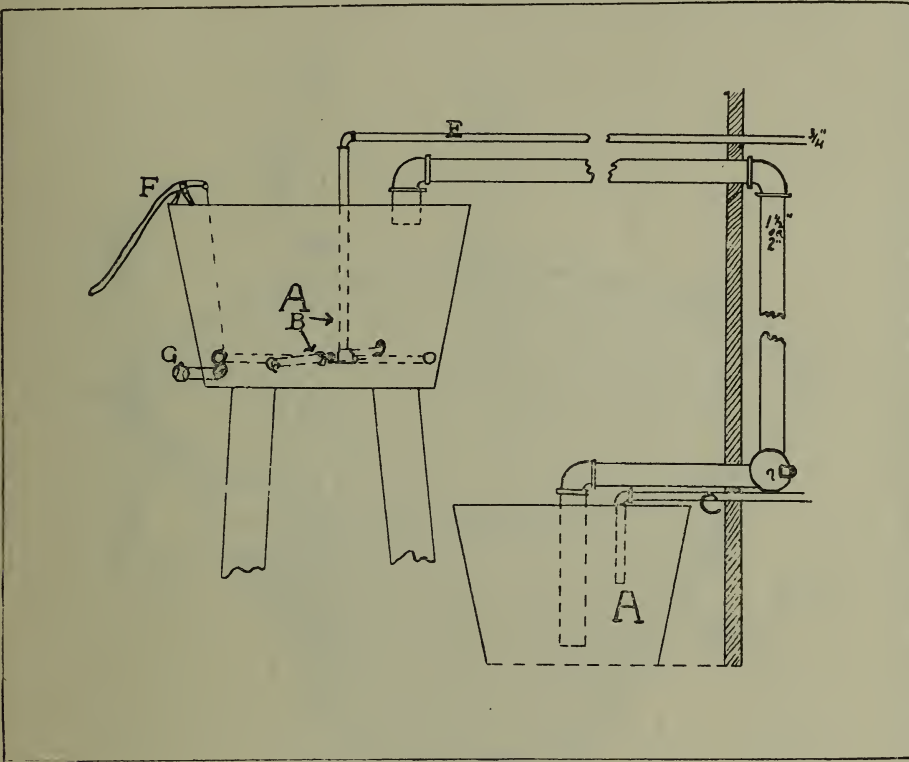


Fig. 11

By using a large size ejector and throttling down the suction of the whey by means of a gate valve attached to the suction pipe, the whey can be heated to the desired temperature as it passes through the ejector from the lower to the upper tank. The steam pipes in the upper tank are necessary to hold the whey at 155° F. for at least thirty minutes.

Pasteurization of Skim-Milk

Skim-milk may be pasteurized by either one of the following four methods:—

1. Heating the whole milk to 176° F. before separating, thus pasteurizing both the skim-milk and the cream in one operation. The objections to this practice are increased fuel costs and the tendency of the separator bowl to clog when separating at this high temperature.

2. Heating the skim-milk in storage tanks to 170° F. with live steam, holding at that temperature for ten minutes and cooling to about 50° F. This method necessitates returning the milk to the patrons the following day and has the further disadvantages of increased cost for cooling and tank equipment.

3. Heating the skim-milk in a flash pasteurizer to 176° F. While this method protects the skim-milk from dilution with condensed steam, the cost of equipment is a serious disadvantage.

4. Introducing steam directly into the skim-milk pipe between the separator and the storage tank, preferably near the separator. The accompanying diagram (fig. 12) illustrates an arrangement* by which the skim-milk is heated to 176° F.

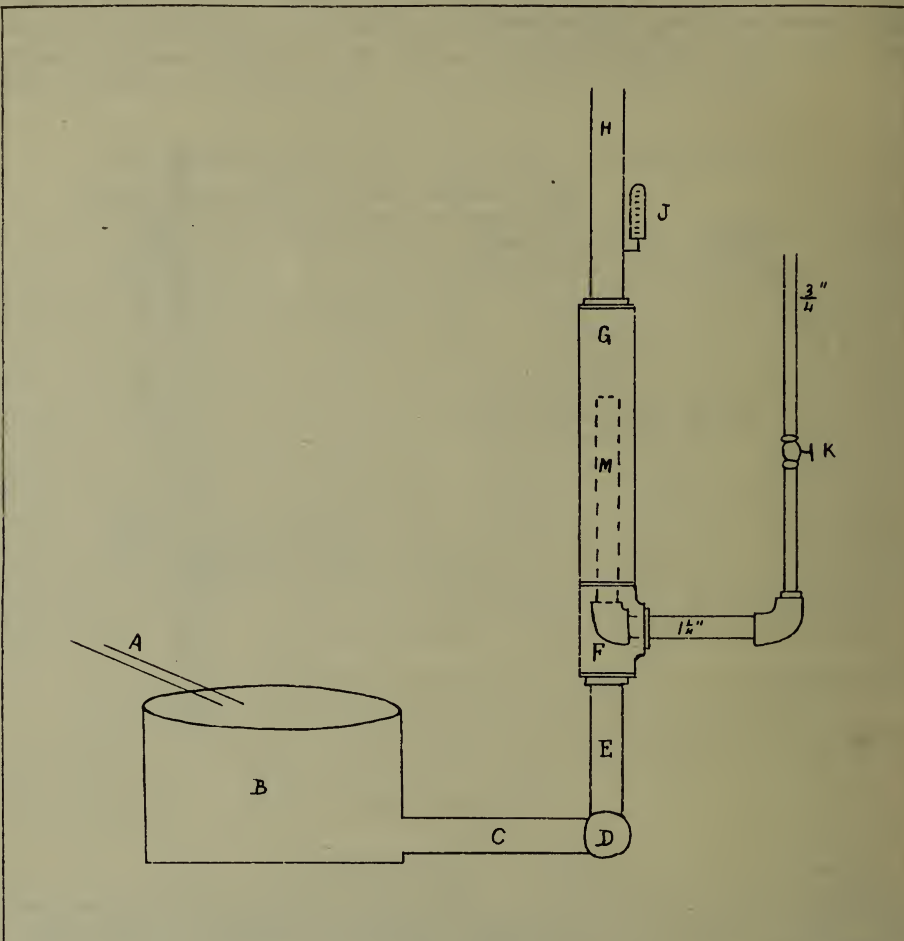


FIG. 12

The skim-milk flows from the separator spout (A) to tank (B) from which it is pumped by a sanitary milk pump (D) through the heater (G) to the storage tank. The diameter of pipes C. E and H and the size of pump (D) will be governed by the number of pounds of milk separated per hour. The heater consists of 3 feet of 3-inch pipe (G) connected to a 3-inch T (F) through which the live steam pipe enters the heating chamber. The pasteurizing temperature of the skim-milk as shown by the angle thermometer (J) is controlled by the pressure of steam allowed to enter the heater by opening or closing the steam valve (K). The heater should be taken apart when necessary to clean the 1¼-inch perforated pipe (M).

*The Pasteurization and the Inspection of Creamery and Cheese Factory By-products, by E. H. Farrington and E. H. Hastings, Madison, Wis.

Difficulty is usually experienced with the foaming of hot skim-milk over the sides of the storage tank. While spraying with cold water destroys the foam, it has the disadvantage of diluting the skim-milk. Spraying the skim-milk into the tank considerably reduces the foam. This may be effected by connecting a perforated inverted tin cone (fig. 13) to the skim-milk discharge, or by directing the discharge pipe lengthwise over the tank and drilling holes of $\frac{3}{8}$-inch diameter in the horizontal portion of the pipe and plugging the end.

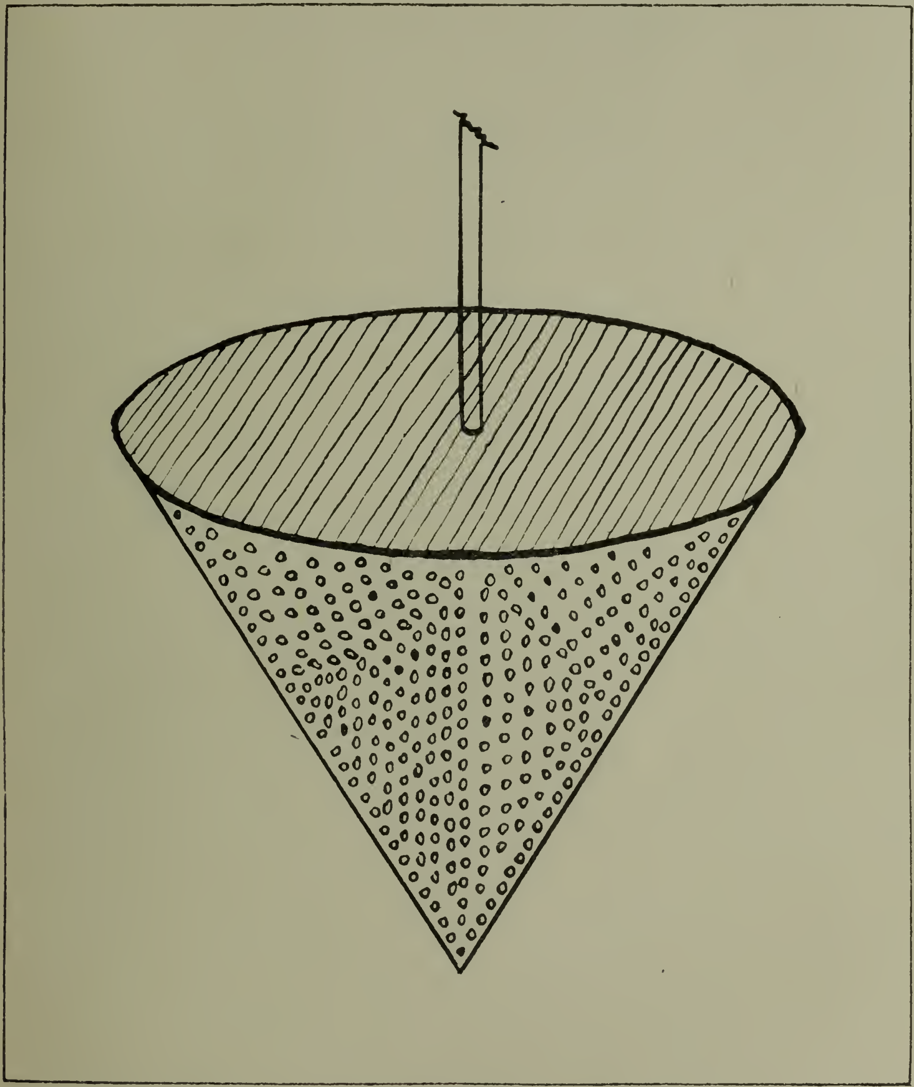


Fig. 13

In some plants, a tightly fitting cover is put on the skim-milk tank, while in others, the foam is prevented from flowing over by means of a float which rises and falls on the surface of the skim-milk.

When skim-milk is cooled at the factory and poured into the patrons' unsterilized cans, it will sour more quickly than when delivered while hot to the patrons. Prompt cooling after return to the farm extends the period of time during which the skim-milk will remain sweet.

Pasteurization of Buttermilk

No satisfactory method of pasteurizing buttermilk has yet been devised. When buttermilk is heated to pasteurizing temperatures, the curd and whey separate into two distinct layers, the former sinking to the bottom of the tank. However, the pasteurization of cream for buttermilk eliminates the need of pasteurizing the buttermilk since all disease-producing germs are destroyed by the former process.

PUBLICATIONS ON DAIRYING

The following publications of the Department of Agriculture relating to Dairying are available on application to the Publications Branch, Department of Agriculture, Ottawa.—

OLD SERIES

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