THE DEVELOPMENT OF PASTEURIZING MACHINERY.

By E. H. Farrington.

The machinery used for pasteurizing cream for buttermaking in creameries is somewhat similar in purpose to certain kinds of farm machinery. The farm cultivator and the cream pasteurizer are both machines used for "killing weeds" and for preparing the soil in which it is desired to plant selected pure seed. The pasteurizer, however, is capable of doing much more damage to the bacteria in the cream than is the cultivator to the weeds. A pasteurizer purifies its soil by fire which is one of the most effective weapons of destruction known to man, but the cultivator only tears the weeds out by the roots and this does not always insure complete destruction.
The weeds in the corn field and some of the fermentations in the cream are enemies to the crops which we wish to harvest from the farms and from the creameries and when the purpose of the pasteurizer is well understood there ought to be no opposition from the patrons of a creamery to spending the money necessary to buy one.

Nearly every farmer who milks cows has a cultivator on the farm and he understands the necessity of equipping his farm with this machine. As soon as he learns that the pasteurizer at

A Type of Vat Pasteurizer.

the creamery not only aids the buttermaker in making butter of uniform quality but it also destroys the disease germs which may be spread from one farm to another by the raw skim milk, the buttermilk and the whey, the creamery and the cheese factory patrons will doubtless become enthusiastic advocates of the introduction of pasteurizers into all the factories of the state.

The creamery buttermaker usually favors the use of a pasteurizer because it aids him in making butter of a uniform quality from day to day. He knows that the flavor of the butter is influenced to some extent by the souring of the cream, and if he by using the pasteurizer is able to destroy most of the bacteria present in the cream when he receives it, he can then plant in this cream a pure culture starter and develop the kind of bacteria he wants for producing a butter of uniform flavor.

The effect of cream ripening or souring on butter flavor is
easily noticed by comparing the flavor of sweet cream butter with that of sour cream butter and it is still more exaggerated by comparing sweet with rancid butter, which latter shows the effect of excessive souring on the butter flavor.

In sweet cream butter we have a mild flavor which by some is considered rather tasteless and unsatisfactory. In the sour cream butter, especially that which has been ripened with a pure culture starter, we usually have the characteristic butter flavor due to the products formed by the souring process.

This brief explanation may give some buttermakers and some creamery patrons, who have not had any experience in the making of pasteurized cream butter, an idea of the uses of the pasteurizer and what it is supposed to accomplish.

A Cream Ripener and Pasteurizer.

When a pasteurizer was first introduced into creamery buttermaking, nothing but sweet milk or sweet cream was received and the buttermaker could control the richness of the cream because he skimmed the milk himself with his own factory separator. In recent years the situation has become more or less complicated by the skimming of milk on the farm and the holding of cream several days at the farm before delivery to the creamery. This condition of the cream has made it necessary to vary the process of pasteurization to some extent in order to overcome certain difficulties that have arisen from the necessity of handling cream that is more or less sour and that varies in richness from day to day.
A Type of Continuous Pasteurizer.

One of the first things noticed when an attempt was made to pasteurize this farm separated cream at the creameries was the excessive loss of fat in the buttermilk. Repeated observations soon showed that this loss would be reduced somewhat by increasing the richness of the cream, and patrons are now continually urged to skim a richer cream at the farm because it not only gives them more skimmilk but the cream sent to the creamery can be more satisfactorily pasteurized and a better quality of butter made from it than is the case with thin cream.

It has been found that if cream contains thirty per cent fat or more, pasteurization is usually satisfactory even if the cream is sour, but when it tests so low as twenty per cent there is likely to be a large loss in the buttermilk.

Several attempts have been made to explain this loss and ways of overcoming it have been suggested. One of the best explanations offered, up to the present time, is the suggestion that by heating the sour cream, some of the fat globules become
A Type of “Holder” Pasteurizer and Ripener.

enclosed in such a tough covering of curd which is coagulated by the heat when the cream is sour, that these particles of curd enclosing the fat, fail to break and the butter is not churned out of them but passes into the buttermilk.

Expense of the Process.

The making of pasteurized butter is not a difficult piece of work. Nearly every creamery buttermaker can learn how to run the necessary machinery but he must also learn how to make a good starter. These two things, the machine and the starter, will necessarily increase the expenses and the labor connected with the process and in this way pasteurized buttermaking is somewhat different than simply weighing the cream delivered by haulers and after cooling in a vat, running it directly into a churn without the use of a starter or without any attempt to control the ripening process.

The additional cost of labor, machinery, and fuel needed for pasteurizing, is undoubtedly responsible for the slowness with which the process has been introduced into many creameries, but when one considers the important items of destroying disease germs and of making a uniform quality of butter, the advantages are strongly in favor of pasteurization.
Many estimates of the cost of pasteurizing milk and cream have been published in bulletins, text books, and the dairy press. One of the latest is the following taken from the U. S. Department of Agriculture, Bulletin 85.

**Tests at Four Creameries.**

<table>
<thead>
<tr>
<th>Costs per 100 gallons of cream</th>
<th>Cost per 100 lbs of 39% cream</th>
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<tbody>
<tr>
<td>Interest on investment in equipment, including depreciation, repairs, and labor</td>
<td>31c</td>
</tr>
<tr>
<td>Coal at $5 a ton</td>
<td>4c</td>
</tr>
<tr>
<td>Water and ice for cooling: water at 50c per 1,000 cubic feet, ice at $1 per ton</td>
<td>10c</td>
</tr>
<tr>
<td>Total</td>
<td>45c</td>
</tr>
</tbody>
</table>

When the flash process was used, because of the higher temperature necessary, about seventeen per cent more heat was required for heating the cream than in the holder process and there was a corresponding increase in the quantity of water used for cooling. The cost of pasteurization was therefore somewhat greater.

The proper design and arrangement of the apparatus have much to do with the cost of operations. With poorly arranged apparatus and leaky piping the loss in heat may reach thirty per cent of that required to pasteurize; this of course is an unnecessary waste.

It was found practicable to use exhaust steam from the engine and steam-driven auxiliaries, or water heated by exhaust steam for pasteurizing cream. This lessens the work of the boiler to the extent of about one horse-power for each four hundred pounds of cream pasteurized per hour.

The table given above reveals the fact that in pasteurizing cream the cost of coal and refrigeration is less than one-third the total cost. In a creamery in which the pasteurization is done in the ripener there is no extra investment for machinery, and the depreciation and repairs on the equipment used are but slightly greater than when cream is not pasteurized.
In a creamery equipped with a 300-gallon vat-pasteurizer the total cost of pasteurizing a vat full of cream is about 54 cents, or approximately 0.06 cents per pound of butter. At 45 cents per 100 gallons (the figure given in the table) the cost of pasteurizing 300 gallons of 30 per cent cream would be $1.35, or 0.15 cents per pound of butter manufactured.

The cost of pasteurizing cream, then, varies with local conditions from 0.06 to 0.15 cents for each pound of butter manufactured.

At a creamery whose owners desire to put a first-class product upon the market the cost of pasteurization is negligible.

*Types and Names of Pasteurizers.*

In recent years a number of names have come into more or less common use by those interested in pasteurizing machinery; they indicate the kind of machine or process used for pasteurizing either milk or cream.

These names may be divided into two classes; first, those that apply to machines that heat milk and cream while it flows through the machine and is therefore necessarily exposed to a heating temperature only a very short time. Such machines are the so-called “continuous” and the “flash” pasteurizers. The second class includes the machines in which milk or cream is “held” and heated by means of a revolving coil which keeps the cream in motion during the heating process, distributing the heat uniformly through the entire quantity. This type of pasteurizer has been given such names as the “intermittent,” the “held,” or the “vat” machine or process.

In the machines of the continuous type the cream is heated for a short time at a high temperature and in those of the second type the cream is heated a long time, usually twenty minutes or more, at a lower temperature, the object being in both cases to kill as many bacteria as possible in order that those introduced by the starter may have a chance to grow without being retarded or overcome by the great variety of bacteria which are usually present in unpasteurized milk and cream.
Temperature of Heating.

It has been found that there is a relation between the temperature to which cream should be heated and the number of minutes at which it is held at a certain temperature. Milk commissions and boards of health have recommended certain regulations in regard to this point. One of the most recent of these is, that "pasturization of milk should be between the limits of 140 and 155 degrees Fahrenheit; at 140 degrees Fahrenheit the minimum exposure should be 20 minutes; for each degree above 140 degrees F., the time may be reduced by one minute. In no case should the exposure be less than five minutes.

In order to allow a margin of safety under commercial conditions the commission recommends that the minimum temperature during the period of holding should be made 145 degrees F., and the holding time 30 minutes. This standard may be accepted at the present time as sufficient for destroying all disease germs in milk and cream by the pasteurizing method."

No definite regulations are suggested in regard to the operation of the continuous or flash pasteurizers, but it is generally recommended that when these are used the milk or cream ought to be heated to a temperature of about 185 degrees Fahrenheit.

These regulations are just as applicable to cream as to milk and may be used by our creameries in buttermaking. In actual creamery practice several modifications of both the continuous and the holder process have been introduced. These modifications are caused principally by the sourness of the cream pasteurized in some cases and in others by the coldness of the cream which is received in the winter season.

"Forewarming" and "Aeration."

Among the expressions now used at creameries where pasteurization is practiced, the following may be heard. "Forewarming" the cream before pasteurizing by the continuous process and "aeration" of the cream when pasteurized by the holder process.
The "forewarming" of cream has been introduced principally in the winter season when cream is near the freezing temperature. It has been found that if an attempt is made to run this cream immediately through a continuous machine with the expectation of heating it to the required temperature of 185 degrees Fahrenheit, the result would not be satisfactory, and in order to use the continuous process in cold weather, the cream is first heated in a vat or "forewarmed" before it is run through the continuous machine.

Another modification, is to "forewarm" the cream with the continuous machine from which it passes into the vat or holder process and by this means less time is required to get the cream up to the required temperature than if either the continuous or holder process alone is used.

The "aeration" of the cream during or after pasteurization has been recommended as a desirable practice and anyone having an opportunity to get the odor that comes from hot cream during pasteurization and especially when air is blown through it at the same time, will become convinced that aeration drives out odors that the consumer would prefer not to have in his butter.

*Pasteurization at the University Creamery.*

Pasteurizing machines have been in use by the Dairy De-
partment of the University of Wisconsin for twenty years. One of the first pieces of work carried on by the writer at the University was summarized and published in 1898 in Bulletin 69 of the Wisconsin Agricultural Experiment Station. The title of this bulletin is "Pasteurization as Applied to Buttermaking."

The bulletin gives a comparison of the results obtained when butter was made from pasteurized cream and from raw cream. The two kinds of butter were sent to commercial judges for an opinion as to the difference in quality. These indicated at that time that the butter made from pasteurized milk or cream had a more uniform, mild, sweet flavor from day to day than the butter made from raw cream. It was also noticed that the pasteurized cream butter had a little better keeping quality than the raw cream butter, and further that there was some difference in the texture of the two lots of butter. The pasteurized was a little closer grained and more inclined to be sticky than that made from raw cream.

The Second Pasteurizer Used in Wisconsin.

Many other observations were made at the time this work was done and were reported in this bulletin. On page eight a picture is given showing the general arrangement of the machinery for pasteurizing at the creamery. At that time milk was received instead of cream and this milk was heated in a continuous pasteurizer to a temperature of 155 degrees Fahrenheit,
this pasteurized both the cream and the skim milk. After separating, the cream was run over a cooler and then conveyed to a vat where it was ripened with a carefully prepared starter.

At the same time these experiments were being carried on we had in the Dairy School creamery another pasteurizing machine used at that time in our city milk and cream trade. This particular machine was one of the intermittent type, now called "holder" process, and I think it was one of the first machines of this kind ever built in this country. It was developed by Dr. Russell and so arranged that the cream could be heated to any desired temperature and held for a given length of time. The temperature used then was 155 degrees Fahrenheit, at which temperature it was held for 20 minutes and then cooled in the same vat.

The following figures are given in that bulletin to show the extent to which the bacteria are destroyed by pasteurizing milk or cream by the "continuous" and by the "holder" methods of heating.

*Bacteria killed by continuous and by holder methods of heating.*

<table>
<thead>
<tr>
<th></th>
<th>March 17</th>
<th>March 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk before heating</td>
<td>34,603,000</td>
<td>9,781,000</td>
</tr>
<tr>
<td>After heating in continuous machine</td>
<td>2,732,000</td>
<td>661,000</td>
</tr>
<tr>
<td>After heating by the holder process</td>
<td>5,400</td>
<td>6,000</td>
</tr>
</tbody>
</table>

These figures show what is common knowledge now that the holder process kills more bacteria than the continuous heaters when both are operated at the same temperature, but it has since been found that by raising the temperature of heating by the continuous machines to about 185 degrees, it is possible to destroy 99.9 per cent of the bacteria in the milk or cream, or about the same number as are killed by the "holder" process.

*Comparison of Pasteurized and Raw Cream Butter.*

Another series of experiments on the pasteurization of cream for buttermaking was carried out in 1902 and the results obtained were published in the nineteenth annual report of the
One of the Early Types of Vat Pasteurizers and Ripeners.

Wisconsin Experiment Station. In these experiments, the cream as it came from the separator was passed through a continuous pasteurizer (Farrington Duplex) in which the cream was heated to a temperature of 160 to 180 degrees Fahrenheit. A number of comparisons were made between cream treated in this continuous pasteurizer with cream which was not pasteurized. In most of these experiments about 1,500 pounds of cream was mixed in a large vat as it came from the separator; this was then divided into three lots of about 500 pounds each. One of these lots of cream was churned sweet, another was soured by means of a pure culture starter, and the third was passed through a continuous pasteurizer and then ripened with the same starter that was used in the raw cream. Packages of each lot of butter were sent to market judges for scoring and after they were scored fresh the butter was placed in the butter cellars for several weeks and scored a second time. The comments made on these three kinds of butter will illustrate the general character of the butter made in these different ways.

Comments on the Sweet-Cream Butter.

When one day old it had almost no aroma but a fresh, sweet-cream taste. Its texture was more like the pasteurized than the raw-cream butter; very little moisture showed on the surface and it had a close, solid body. After three days, this
butter had a suggestion of age in its aroma but the taste was still sweet. The butter remained in this condition for three weeks, gradually getting a little more defective in aroma but still sweet to the taste. At that time the flavor was decidedly strong, like that of old butter. The flavor did not improve after the first day, but gradually showed its advancing age by becoming a trifle rancid rather than by developing a clean, sour taste.

The sweet-cream butter was at its best when made. It did not improve with age, but rapidly deteriorated, becoming decidedly off-flavor in three weeks' time.

*Comments on Pasteurized Cream Butter.*

When this butter was one day old it had a clean taste, but not much aroma; it was rather flat but resembled the raw sour-cream butter more than that made from sweet cream.

![A Type of Continuous Pasteurizer.](image)

After three days, more aroma developed and this continued to increase until the butter was three weeks old when the aroma changed somewhat, becoming a trifle sour. No other indications of age were shown until the butter was five weeks old when its age began to be slightly noticed. The texture of this butter was close but not smeary, and fully equal to that of raw ripened cream. The butter surface, however, showed almost no brine
but looked dry and smooth, quite different from that of the raw-cream butter. The pasteurized-cream butter was much better than the sweet-cream butter and its flavor improved or became more pronounced until it was five weeks old. After about three weeks the flavor was fully as good as the raw-cream butter and during this time very little if any objection could be made to it.

The body of this butter was not defective at any time. This is contrary to the general impression in this country about pasteurized-cream butter. In the opinion of the writer the method of cooling the cream directly after the heating as practiced in our experiments was responsible for the perfect body which this butter showed.

Comments on the Raw-Cream Butter.

The day after churning the flavor of the raw-cream butter was the highest of the three. The butter aroma increased a trifle each day for about two weeks when the butter began to show age, and in three weeks it was decidedly strong, almost rancid. The texture of this butter was coarser and more open than either that from the sweet or the pasteurized cream, and considerable brine showed in drops on the surface, making the appearance as well as the flavor of this butter decidedly different from that of the others. The raw-cream butter was at its best when first churned. It showed an age flavor when two weeks old.

The results of this work show that at the present time a much more uniform butter can be made by pasteurizing the cream than is the case when butter is made without pasteurizing. The advantages claimed for pasteurizing, briefly stated, are the following:

First. By using the modern pasteurizer for heating and cooling the cream, the former objections to the body of pasteurized-cream butter are overcome.

Second. The flavor of the pasteurized-cream butter may be made much more uniform from day to day than is the case when butter is made without pasteurizing the cream.
Third. The American market will accept butter of a sweet, mild flavor at the present time and it is more sought for than the high, quick flavors which may disappear quickly and deteriorate in quality as in the case of the butter made from the raw cream.

Fourth. Pasteurized butter will keep longer and hold its good qualities better than that made from raw cream. Most of the advantages in flavor may be obtained in pasteurized butter by the skillful use of starters, and the buttermaker is much more sure of obtaining satisfactory results with starters when they are used in pasteurized cream than in raw cream.

*Pasteurizing Skim Milk, Buttermilk, and Whey.*

It has been repeatedly proved that one easy means of spreading tuberculosis is the feeding of raw skim milk, buttermilk, and whey brought from the creamery and cheese factory to the calves and pigs on the farm.

This is a serious matter and our creameries and cheese factories ought to be eager to provide the necessary pasteurization of these products at the factory.

Several ways of doing this have been suggested:

First. By using exhaust steam from the factory engine.

Second. By forcing high pressure steam directly from the boiler into the skim milk or whey.

Third. By passing these by-products over a heated metal surface such as the ordinary milk heater.

Fourth. By pasteurizing the milk before it is skimmed or before it is made into cheese.

Of the four methods suggested, the utilization of exhaust steam of the creamery engine is undoubtedly the most economical. The skim milk is somewhat diluted by the steam and a small amount of cylinder oil from the engine also passes into it; but these additions are of little importance compared with the economy of heating in this way, as neither the small quantities of steam nor the trace of cylinder oil will affect the feeding value of the skim milk to an appreciable extent. It is im-
important, however, in using the exhaust steam for the pasteurization of the skim milk to make sure that sufficient steam is obtained to heat all the milk to the desired temperature of 176 degrees Fahrenheit.

A Skim Milk Pasteurizer at the Separator.

Forcing the high-pressure steam into skim milk is the easiest and surest method of getting all the milk heated to the required temperature. It is a more expensive way of heating than using exhaust steam, but this is about the only objection that can be made to it.

The use of milk and cream pasteurizers which heat the skim milk as it passes over a metal surface, which is heated either by steam or hot water, protects the skim milk from dilution with
steam, but the machines designed for pasteurizing in this way are somewhat expensive and they require more attention while in operation than the first two methods of heating.

Skimming the whole milk at a temperature of 176 degrees Fahrenheit is also expensive in the use of fuel, and further objection is made to it because of the difficulties of separating milk at this high temperature. More sediment or bowl slime accumulates in the separator when hot milk is skimmed than in the case of milk having a temperature of 80 degrees Fahrenheit. The clogging of the bowl makes it necessary, therefore, to stop the machine and clean the bowl more frequently than when colder milk is skimmed; the separator, for other reasons, requires more attention on the part of the operator when hot milk is skimmed than when skimming is done at the usual temperature.

The regenerative pasteurizers now on the market are both economical and efficient for this purpose and will undoubtedly give excellent satisfaction as milk heaters which pasteurize both the skim milk and cream by pasteurizing the whole milk before skimming it.

Storage Tank for the Hot Skim Milk.

When exhaust steam is used for heating skim milk, the heating arrangement is usually placed over the skim milk storage tank. When direct steam is used, the heater is placed near the separator. In any case the hot skim milk foams badly and often overflows the storage tank, causing considerable trouble on this account.

Several ways of removing the foam have been suggested but none of them are entirely satisfactory.

1. A tightly fitting cover may be put on the skim milk tank, thus making it impossible for the foam to run over.

2. The air may be blown out of the foam by means of a revolving dasher in a half cylinder placed over an opening in the cover of the storage tank. This fan or dasher throws the foam against the walls of the half cylinder in which the fan
revolves, thus enabling the air to escape through an opening in the top of the fan chamber.

3. A float that rises and falls on the surface of the skim milk may be placed in the tank.

4. The pipe delivering the hot skim milk may empty near the bottom of the storage tank.

5. The foam may be sprayed with cold water. This is an efficient means of destroying the foam, but the method has the objection that it dilutes the skim milk with water.

Delivery of Hot Skim Milk.

Pasteurized milk, when cooled to near 50 degrees Fahrenheit, immediately after heating will keep sweet for a longer time than when allowed to cool gradually. Experiments have shown that pasteurized skim milk when cooled at the creamery and delivered cold to the patrons will not keep sweet so long as when delivered hot. This is because the cans have not been sterilized after the milk is delivered at the factory; the milk left in the empty cans is sufficient to start fermentation in the cooled pasteurized skim milk, no matter how thoroughly this has been pasteurized.

If the skim milk is delivered to the patrons while hot, the rinsings of milk left in the cans are pasteurized by this hot skim milk and if it is then cooled to near 50 degrees Fahrenheit soon after heating it will keep sweet a much longer time than raw skim milk. Cooling the cans of hot skim milk without delay at the farm is an important factor in keeping the milk sweet. It is not sufficient to set the cans of hot skim milk in a small tub of cold water at the farm as this small quantity of water is warmed by the hot milk and unless the water is changed often enough to complete the cooling, the results are unsatisfactory.

The Whole Milk Must be Sweet.

In order to successfully pasteurize skim milk, the whole milk from which it is skimmed must be perfectly sweet; slightly
sour milk is curdled by heat and will clog the pipes through which it passes.

When skim milk is pasteurized, the transportation cans are easily cleaned and freed from the sour milk odor which is so difficult to remove when raw skim milk is allowed to sour in them as is often the case.

A few observations made at the Wisconsin Dairy School Creamery showed that skim milk is diluted with about ten per cent of water when pasteurized by forcing steam into it. The exhaust steam from an engine contains more water than high-pressure steam and skim milk would be diluted even more than this when exhaust steam is used for this purpose.

No satisfactory way of pasteurizing buttermilk without separating the curd from the whey is known, but when sweet cream is pasteurized before ripening and churning there is no need of pasteurizing the buttermilk.