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PASTEURIZATION AND MILK PRESERVATION, WITH A CHAPTER ON SELLING MILK.

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L. Pasteur in his Laboratory.

LOUIS PASTEUR.

Born Dec. 27th 1822, this son of a tanner early showed his extraordinary talent, and if I was to attempt only to enumerate the results of his life's work, it would take more space than this pamphlet.

Nevertheless I cannot publish a treatise on Pasteurizing without hinting at some of the benefits which the farmers have derived from this great man's work.

He is the first one who studied this world of bacteria, or, as he called it, "*infinite little*," in a systematic manner. Thus he proved how fermentations such as in beer, wine and milk are due to living organisms and that different bodies are acted upon by different ferments.

He also showed how most—if not all—epidemic or infectious diseases are due to these little fellows and that when once properly known the remedy for the disease may be found. Thus, he saved millions of dollars to the silk worm growers in southern Europe and to the sheep-farmers of Australia.

The manufacturers of vinegar learned from him that the true vinegar ferment is a little fungus.

The winegrowers learned that by heating their light wines to 140° and cooling them again, they could preserve them much longer.

The brewers received the hint that it was possible to make a uniform good beer, which would keep well, by the same process of heating and cooling (pasteurization) and the use of a pure culture yeast.

All these hints, even if they have not been developed practically by Pasteur, have saved millions of dollars to the farmers. Though Pasteur never took up the milk studies, he is said to have remarked to an English scientist with a sigh: "Ah! *there* is a rich field indeed for investigations."

Nevertheless the useful investigations of milk and its ferments made by other scientists such as Storch, Grotenfeldt, Weigman, Freudenreich, Kramer, Adamets, Hueppe, Graeff, Duclaux, Conn and others, is all more or less excited by Pasteur's original work.

Hence I am correct in saying that if dairy farmers will only apply the lessons given by these men practically, Pasteur will also have been the means of saving them millions of dollars.

But all this may be said to refer only to dollars and cents, when I think of the human life which this man's work has saved, when I think of the human sufferings which he has alleviated, then I lay down my pen, no words of mine can express the gratitude which we all owe him.

J. MONRAD.

After writing the above, news comes from Paris that Louis Pasteur died Sept. 28th, having suffered a considerable time from paralysis.

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INTRODUCTION.

The following treatise on pasteurization must not be taken as an endorsement of the general introduction of the system, *far* from it:—

While conditions often exist which make pasteurizing highly profitable, it is much better if we can eliminate these conditions, in short, *provention is better than cure*.

However, we must take the conditions as we find them, and it is far better to pasteurize the milk than to use any of the different preservatives if it is desired to keep the milk sweet longer than is possible by simple cleanliness and ice.

Chemical preservatives of whatsoever name and however harmless for preserving other foods, should never be used in milk, as the latter may be given to *infants*, while the other foods are only used by adults.

It seems to me that if strict prohibition laws are not enforced, every milk producer, every milk dealer ought to have enough conscience to prevent them from using a preservative which may make them guilty of *manslaughter*.

Nor is there any excuse for using chemical preservatives, as pasteurization will do all that they can do, and more.

It is well however to understand clearly that pasteurization should not be confused with *sterlization*. The latter, to be *perfect*, involves the heating of the milk to such a high degree (above the boiling point) that it practically destroys it for commercial purposes, and even where a somewhat lower temperature is used, (210° to 215°) there is sufficient boiled flavor to make it more or less unpopular.

Meanwhile I shall show the different purposes for which pasteurization may be utilized, and describe most of the devices proposed and used.

It is my pleasant duty to acknowledge the use of Dr. H. Weigman's excellent little book on this subject "Milch conservirung," the works of Profs. Duclaux, Freudenreich and Leze, as well as Bulletin 44 (Wis. Station) and "Milch Zeitung" a paper which every dairyman who reads German should keep.

J. H. MONRAD.

CHAPTER I.

MILK AND ITS PRESERVATION.

Milk as it comes from a healthy cow fed on pure food is absolutely pure and steril, that is, if we could secure it without admission of air in a sterilized bottle, it would keep—if not forever—for a very long time indeed.

Practically this is of course impossible, and thousands of germs (bacteria) float in the dust laden air, adheres to the udder the flanks of the cow, the hands and the clothing of the milker.

Even supposing that the utmost precaution is taken, that the cows are carded and brushed that the udder, and the hands of the milker are washed, that the barn is thoroughly ventilated just before milking, even then remains the favorable breeding place for bacteria the end of the milk duct in the teats of the cow where they find the best temperature and the best nutrition in the few drops of milk which remain from the previous milking

But it must not be supposed that all these bacteria are undesirable, some of them do no harm, and some of them are useful, not only in the manufacture of cheese and butter, but also in aiding us to digest the milk.

This explains why there is a difference of opinion among physicians as to the desirability of giving infants sterilized milk.

I am therefore of the opinion that wherever we are sure of getting milk from a healthy cow under veterinary inspection and with the above mentioned safeguards, as well as the additional one of using only *sterilized* vessels, or at least those which have been exposed to steam or boiling water for 10 or 15 minutes, we have done all that can be expected even in this "*antiseptic*" age.

But, when we come to the practical task of supplying large cities like Chicago and New York with milk at a reasonable price, we meet the difficulty of an effective control. In these cases I do not hesitate to recommend pasteurization for two reasons. (1) It will, without perceptibly changing the taste and digestibility, kill a great many if not all bacteria. (2) It will enable the milk producer and dealer, to preserve the milk sweet for 36 or 48 hours longer without fear of committing infanticide with *preservatives*.

In order, however, to get the full benefit of pasteurization it should be done as quickly after milking as possible and the before mentioned precautions in the shape of the utmost cleanliness must not be neglected.

CHEMICAL PRESERVATIVES.

The usual precaution taken by honest milk shippers, is to cool the milk before hauling it to the railroad, and where this is done properly and the cans kept clean, the dealers in the city manage by a liberal use of ice to sell most of it before souring.

But the eloquence of the agents for preservatives as well as the inherent laziness of human nature which said agents know how to "work," has lately dulled the sense of responsibility in the shippers and induced them to use these preservatives extensively.

Their use is made illegal in most civilized countries England excepted, where I find not less than 10 different (?) kinds advertised in the dairy papers for 1895 under the following names "Semper Dulcis," "Arcticanus," "Glacialine," "Sal Preservare," "R. J. J. & B. Preservative," "Preservitas," "Crystalline," "Periodate," "Tomlinson's Preservative" and Duncan's Preservative.

Add to this, sundry American fancy names, and it may be imagined to what extent the public is being imposed upon by the milk dealers who on their side are being imposed upon by the manufacturers who charge from two to ten prices for a fancy name!

I shall not enter a discussion on their comparative value, be they composed of Bicarbonate of soda, Borax, Boracic acid, Salicylic acid or the latest by "Effront" Hydrofluoric acid and Fluorites.

No honest man should use either of them in milk.

PRESERVING BY COOLING.

This has, as before said, been used more or less—generally less—by all milk producers and, if properly done, is very effective.

Most of the bacteria do not develop at a low temperature which however does not kill them.

It has been demonstrated by "**CNOPF**" and "**ESCHERICH**" that they multiply in milk at 90° Fah. twenty-three times in 2 hours while at 54° they only multiply four times in the same time and while in four hours at 90° 215 times, they only multiply 8 times at 54°.

To show how enormous the increase is at the favorable temperature (90°) it is enough to say that in *six hours they multiply*

3800 times. Just think of it! for every one of these little germs, hundreds of which may ride on a speck of dust floating in the air, or left in the seam of the milk can, there will be 3800 if the milk is left for six hours at 90° ! If the milk is kept close to the freezing point the increase is hardly perceptible. Ice should thus be the basis for all honest and healthy milk supplies and the idea of freezing the milk into solid blocks lies near.

This has been done in Paris (France) by "G. B. Guerin." The milk was filled in vessels which when frozen by a refrigerator machine, were insulated for transportation. Frozen milk has been used for years on board ocean steamers.

As it takes quite a while to freeze the milk solid, there is a drawback in its creaming during the process, so that the "block" consists of a very poor layer at the bottom with one of cream on top and a very concentrated not frozen milk in the funnel-shaped indention in the middle of the block. Thus a thorough mixing after melting is made rather difficult.

This phenomenon has even been suggested for the condensing of milk instead of heat which will be mentioned later on.

Lately Mr. Casse of Denmark has taken a patent on a process, infreezing milk which has been utilized in shipping large quantities to the London market.

Part of the milk is frozen in solid blocks and these are packed in large pine casks which are provided with certain hooks to hold the ice in place. The cask is then filled completely with milk, that has been cooled to 34° . The

Fig. 1.

Fig. 2.

casks are more or less insulated in the cars and on board the steamers by covering them with sawdust, and the milk arrives in London in a sufficient good condition to alarm the british dairymen.

I understand however that before freezing the milk is pasteurized.

PRESERVING IN VACUUM.

In L'Industrie Latiere May 10th. 1891. M. C. Nourry expresses

his belief in this system and though I do not share this belief, it may be of interest to put it on record here. Figs. 1 and 2 represent the proposed can, A is the body of the can preferably enamelled. C is the piston screw which is turned by the handle D. B is the piston head with valve G opening up and F opening downwards. H is the opening in the cover and J a slide which slides in a groove on the lower side of the cover.

Suppose the pistonhead B is at the top *ab*, the can is full of air. By screwing the pistonhead down to *cd* the air is expelled through the valve G.

The milk is now poured in by the opening H so as to fill the whole can and the opening H as well. This drives all (or nearly all) the air out and the slide J is closed.

Pistonhead is then screwed up to *ab*, letting the milk through by F into the space *c d e f* where it is free from air.

When the milk is needed, a few turns on piston will press some through G and it is poured out by H. The apparatus is cleaned by unscrewing the cover at V and the inside of the can as well as the pistonhead may be made of glass!

Granted that this process will do all that it is claimed, granted it will prevent the cream from rising, granted that the anaerobic microbes cannot develop without their aerobic cousins have prepared the way for them and granted that the latter cannot live without air. Granted all this, my readers will agree with me that the cost of such cans would preclude their use.

PRESERVING BY ELECTRICITY.

This, like butter and cheesemaking by electricity, has been talked about, but while experiments seem to have proved that electricity may to a certain extent paralyze microbes, nothing *practical* has been evolved as yet.

PRESERVING BY HEAT.

It has been shown how the bacteria germs develop best at about blood heat and how their development is reduced all the more, the colder they are kept,—but excessive heat has a similar and even better effect. This has been known for ages and the preservation of milk and cream by boiling is a common precaution among house-keepers.

Yet, unless the milk is cooled down and kept cool, the effect is only to keep it sweet for 12 to 24 hours longer and the boiled taste,

to which so many people object, prevents its general use. This taste is much more pronounced in milk heated in open vessels than in milk sterilized under steam pressure in the modern apparatus and yet there is the same objection of its being less digestible by the coagulation of the albumen. Compare the digestibility of a soft boiled and a hard boiled egg or that of a raw and boiled oyster.

PRESERVING BY CONDENSING.

If this boiled taste were not objectionable, it seems to me that condensed milk as lately made without addition of sugar would be a more rational way of solving the milk supply of large cities, but though this has been attempted in several large places, it can not be said to have become very popular. Condensing milk with addition of sugar has been and, I believe, will be the favorite method of preserving milk for ship's use and in mining camps, where the transportation of 75% water is quite an item.

As condensing requires a large and expensive plant it is no use to more than mention it, unless it be to draw the attention of city milk inspectors to the necessity of having an eye to the frauds in these preparations, as I have tested several samples which showed they were nothing but condensed skim milk. I refer also to the so-called evaporated cream, often simply condensed new milk.

I may in this connection express the opinion that at the present demand for these goods there is at present more than enough factories to supply it, and that farmers should be very cautious about establishing small inefficient plants, they will find it difficult to compete with the two world renowned firms "**BORDEN** and **ANGLO SWIZZ**."

Whatever the new system of condensing milk by freezing may turn out to be, I cannot foresee, but unless such milk is kept frozen or nearly so, it seems that its keeping quality must be very problematic.

It is claimed (Mc Intyre) that by freezing the milk in shallow metal pans it is possible to secure a thin layer of pure ice on top and by breaking this up the whole mass of milk is converted into a mixture of ice crystals and condensed milk.

This mixture is put into a large separator like those used in sugar factories and the condensed milk strained from the crystals by centrifugal force.

The remaining crystals are said to analyze 0.2 of solids. This system would have the advantage of a natural flavor, but I fear it will not prove practical.

PRESERVING BY PASTEURIZING.

While the heating of milk to boiling point, or there about, always gives a boiled flavor, it is possible to reduce this so as to make it barely perceptible, by heating only to 150° to 155° Fah.

Experiments have shown that if the milk is kept at this temperature for 20 to 30 minutes most of the bacteria will be killed.

First of all the lactic acid bacteria will succumb and this is the fellow which generally "loppers" the milk.

But other and more dangerous bacteria among those which are most liable to be found, are also killed.

Thus did "**BITTER**" find that 30 minutes at 155° killed the tubercle, the typhoid and the cholera bacillus.

But there are also others which require a temperature of 230° and more to destroy—and it is thus evident that a perfect safeguard is not even obtained by heating to 212° or 215° .

And if this is so, it seems to me absurd to attempt to overcome the popular prejudice against the "boiled flavor" when we can secure a safeguard against the most common dangers by heating only to 155° which does not develop that flavor.

But, while heating to boiling point and even heating to 155° kills most of the bacteria, it does not kill their spores, and hence if the milk is left at a favorable temperature (between 80° and 100°) for any length of time, the genus will develop and the battle commence anew.

The milk must therefore be cooled immediately as low down as possible, at least to 50° , and it is of the highest importance that this is done quickly, especially between the temperature of 120° and 70° . It matters less if the cooling is slow from 155° to 120° .

INTERMITTENT PASTEURIZATION.

In view of the above fact, it has been proposed by Dahl to heat the milk inclosed in vessels to 158° for $\frac{3}{4}$ hour, then cool to 104° for the same time, then heat again and cool, in all four times. At last heat it to 175° or 212° for half an hour and cool to 55° .

This is however neither sterilizing nor pasteurizing and is simply a modification of the intermittent sterilization proposed by Tyndall, and though very effective it is very complicated and expensive. Large quantities of milk has nevertheless been shipped to London from Norway, preserved by this "**DAHL**" method.

Meanwhile I have made a few experiments which lead me to believe that if an increased safety and keeping quality is desired the following process may be practical. It is simply a modification of Dahl's and is to heat to 155° . Keep it there for half an hour then cool to 100° and keep it between 90 and 100 for 2 or 3 hours, then heat to 155° for half an hour and cool to 50° .

While no bacteriological examination controlled these experiments I secured a prolonged keeping quality over and above the single heating and cooling of about 12 hours.

PASTEURIZING FROM THE MILK SHIPPER'S STANDPOINT.

In the above I have chiefly discussed the advantages of pasteurizing from the consumer's stand point in so far as its protecting them against dangerous germs.

But to the milk-shipper, the main question is the increased keeping quality, and to be protected against the losses incurred by sour milk,—often large in hot weather, and always larger when there is a surplus of milk on the market (queer is'nt it?) If we consider these losses I believe that pasteurization will pay the shipper to large cities as a business proposition by its increased keeping quality.

And the more so, as the middlemen should certainly be able to handle this milk, the keeping quality of which is at least 12 to 24 hours better, at a smaller margin.

Nor should the consumer object to paying something extra for the extra protection which the pasteurizing gives him.

STERILIZING.

Though I consider it absurd to object to the insignificant "boiled flavor" which the best sterilizing apparatus leave in the milk, and though I acknowledge that if pasteurizing is good as a protection against infection and as a means of preservation, sterilizing is certainly better. I write for the great army of practical dairymen, and for these sterilizing with its rather expensive apparatus is of less interest and hence I confine myself to pasteurizing.

I just mention the apparatus shown at the Columbian Expo- by Popp & Becker of Berlin, which is advertised in German papers under the name of "**STERILICON**" and for which F. Correll & Co. 132 Nassau Street, New York is agent. Neuhauss Gronwald Oehlmann also showed his apparatus both for bulk and bottle sterilizing and showed it in working order.

Besides this Dr. Weigman describes one made by Paul Ritter von Hamm.

Any one who studies the apparatus described for pasteurizing can easily adapt or modify some of them for sterilizing.

But if care is needed for pasteurizing much more care is required for sterilizing as the object here is not only to kill most of the bad bacteria, but also to preserve the milk not for days or weeks, but for months.

I sampled milk sterilized in the "Sterlicon" which was claimed to be 6 months old and which was perfect.

CHAPTER II.

THE FARM PASTEURIZER.

In giving a review of the different apparatus proposed for pasteurizing I regret to say that it seems to me that none of them are perfect though most of them fulfill their object.

It may also here be in place to make it clear that the process and apparatus needed in pasteurizing milk or cream for commercial purposes is different from what may be used in pasteurizing cream for butter making or milk for cheese making.

In the latter two cases it has been proved sufficient to heat to 155° or 160° and cool immediately to 65° or 70° as the "starter" is then added and the, therein contained, right kind of bacteria have a chance to develop and predominate before any of the bad bacteria get time to recover from the paralyzing effect of the heating.

Otherwise the keeping of the milk or cream at 155° for at least 20 minutes (30 is better) is *essential*, and this has caused bacteriologists like "Bitter" and "Russell" to condemn the continuous pasteurizing apparatus

In this they are right when used as at present, but it will be shown later that the objection is not tenable, as the temperature may easily be maintained for the desired period by introducing an insulated storage tank between any of the continuous heaters and coolers, a plan which was first proposed by me in Hoard's Dairyman.

Yet it is important that the readers understand the necessity of this difference, and when they choose an apparatus to do so with a view of the desired object.

The beauty of this process is that anybody may use it on a small scale without investing any money in special apparatus more than a small thermometer. Take a glass jar, a tin can or bucket holding the desired amount of milk, and place it in a boiler with warm water on the stove.

Stir the milk continuously until it is 155° Fahrenheit, and see to it that when it has reached that temperature the water in the boiler is only a degree or two higher.

If it should be higher, reduce it by adding cold water. Place

the boiler where the temperature will remain stationary for 20 to 30 minutes and cover the milk can.

Meanwhile, have a tub filled with cold water, preferably with ice water, and place the milk can in it. Moving the can round with one hand (so as to stir the water), the milk is stirred with the other hand until 50 degrees cold.

Where there is a tank with flowing cold water, it is enough to stir the milk, but where neither this nor ice are at hand, the quantity of water must be regulated according to its temperature.

If, as for instance, there are 20 lbs. of milk at 155° that we desire to cool to 60° (50 would be better), we have to cool 20 lbs. 95° or 1900 units.

Supposing then we have water at our command at 48° ; then we must theoretically have $158\frac{1}{2}$ lbs. of this water to reduce the milk to 60° , but practically this is not enough and it would be too slow work, hence I consider that 300 lbs. of such water would be nearer the mark.

This question of cooling is the great stumbling block which for years will prevent farmers from pasteurizing the milk. Indeed, I feel inclined to make the broad assertion that unless there is flowing water of not more than 48° or else a good supply of ice, pasteurizing should not be attempted.

But, as I have urged again and again, there is no reason why every farmer should not lay in a stock of ice. In Sweden I had my ice-heap simply covered with saw dust. There is no need of expensive ice-houses, and a stock of ice will prove a blessing to the housekeeper and useful for other purposes.

As to ice, the theoretical amount required to cool 20 lbs. 95° would be about 14 lbs., but practically it will take about pound for pound unless the first cooling is done with water. In that case $\frac{1}{2}$ lb. of ice to 1 lb. of milk may be figured on.

Pasteurizing costs money for fuel to heat and ice to cool, and the latter is the most expensive, but even if we take the highest amount of ice, the cooling will after all only cost 10 cents for 100 lbs. if the ice is \$2.00 per ton.

It is an easy matter for anyone who has a thermometer to make the above experiment on a small scale and convince himself of the effect. Unless more than 200 lbs. are to be pasteurized I see no need

Fig. 3.

of buying any expensive apparatus. Get as many shot-gun cans, 8 inches in diameter and 22 inches high, holding 40 lbs. each, as may be needed. Place them in an oblong boiler (Fig. 3), made to order if necessary. Get a suitable tank for cooling, and a stirrer (see Fig. 3). That is all there required.

I acknowledge, however, that if money and steam is at command, it is less work to use some special apparatus than to keep four or five cans stirred by hand, yet part of this gain is counterbalanced by the increased labor in keeping the apparatus clean, and at present I know of nothing better for small quantities than common shot-gun cans.

CHAPTER III.

THE PASTEURIZING HEATER.

In writing the history of the apparatus which have been and are used practically, I find it impossible to mention them in their proper chronological order.

It must always be remembered that a pasteurizing apparatus must consist of a heater and a cooler unless indeed the same apparatus is used for both as in Prof. Reessell's, John Boyd's and others.

In Denmark the first heater used was the one constructed by the late Prof. Fjord for heating the milk for the separators Fig. 4. This consists of a strong wooden barrel *D* in which a tinned copper vessel *C* is inserted. A stirring apparatus *K* prevents the milk, which enters at *M* through *H*, from scorching on the side. Steam is introduced by *F* if exhaust and *E* if direct steam is used. Condensed water escapes through *G*. The milk outlet not shown in the illustration, is above the the wood. The cooler used is generally of the Lawrence type.

Fig. 4.

In Sweden the first Laval Pasteurizer (see Fig. 14, page 21) represents another principle. The milk is pumped up over a series of disks, the upper ones being heated by steam, the lower ones cooled by water.

Both these were designed originally for pasteurizing the skim milk, a practice to which the economical sense of the Scandinavian farmers insisted on soon after the introduction of the separators.

The Fjord heater has the advantage of holding the milk a little

longer warm than the other, but as far as practical results they are about alike and the features of both, may be traced in most of the German and English heaters.

FJORD HEATERS (CHURN HEATERS).

Thus in England R. A. LISTER & CO of *Dursley* make the one illustrated in Fig 6 and judging from appearance a very substantial and well made heater it is.

In Germany "Bergendorfer Eisenwerk" constructs an apparatus shown in Fig. 7. The main difference is the milk intake which is from an open gutter *M* into the cover which has an open pipe in the centre round the shaft of the stirring apparatus. The steam enters at *s* and condensed water escapes at *n*. The milk outlet is at *k* and the last milk is emptied at *v*.

The well known manufacturer Ed Ahlborn of Hildesheim makes a very neat modification

Fig. 6.

Fig. 7.

Fig. 9.

Fig. 8.

shown in Figs. 8 and 9. The apparatus is swung on pivots. The steam enters through one of them (b), this facilitates the cleaning of the apparatus. The condensed water escapes at d, while the milk enters by a cup a a which is connected with the stirring apparatus and provided with two tubes which lead to the bottom. The milk escapes by c.

A. RÖSSLER of Berlin constructs a similar apparatus and so does "AHRENS" but his apparatus has a larger capacity and thus exposes the milk to the heat for a longer time.

Fig. 10.

Messrs. D. H. BURRELL of Little Falls N. Y. constructed another modification of this apparatus suggested by Mr. J. D. Frederiksen. This is illustrated in Fig. 10. It has the wooden tub A, but the inner vessel B B B B has a cone in the centre B' B' B' B' which leaves a deep annular vat M with a stirrer D D D D.

The milk enters at h and the stirrer is driven by a cord pulley L below the bottom which is connected by a shaft n through the tube k k. Steam enters at s through a perforated coil s s which ends in the centre of the cone. The space o o o o is filled with water and has an overflow pipe not shown. The last milk is emptied at v and the water at w. The top of the cone B' B' B' is kept below the surface of the milk which escapes at p. In order to prevent steam from forcing the air from the cone, an aircock is provided at a.

The apparatus holds 500 lbs. and thus exposes the milk for 15 minutes to the heat if 2000 lbs. an hour is run through it.

The objection to all these apparatus is that the stirrers keep on mixing the new cold milk with the heated and this objection is the greater the smaller the quantity of milk is which the apparatus holds.

In spite of the stirrers running close to the walls, there will always be some coagulated albumen on the sides and it has been proposed to have the stirrers covered with brushes as has been done in the case of other apparatus which will be shown later.

All the above mentioned apparatus were designed to heat the milk to 150° or 160° Fah. only, but it is in order here also to mention the two latest sterilizing heaters which of course may be used for pasteurizing, as they evidently are an evolution of the afore mentioned heaters.

It is true **KLEEMAN'S** Fig. 11 may be also said to be a simplification of his previous rather complicated but effective sterilizer. The milk enters at the bottom of the vessel at *M* in the centre of the cone, flows upward and then down in the annular ring and up again compelled by a cor-

Fig. 11.

responding annular water tank which is attached to the cover.

The steam or hot water is found in *s*, *s'* and *s''* and the milk passes between these leaving at *O*. The dasher *D D D D* prevents the scorching of the milk.

The milk is forced through the apparatus and elevated from *O* up to the cooler by a force pump.

In Fig. 12. we find a similar idea by Mr. W. Wetterling of Wismar, Germany. Two steam chambers are inserted in a barrel *A* one *G* in the centre and another *E* ringformed, leaving an annular space between them.

The milk enters into this by *L* and rises between the two steam

Fig. 13. Dierk & Mollman's Heater.

Fig. 12.

providing the dasher with brushes see Fig. 13. The milk is forced through it with the milk pump A and passes between two cylinders which are placed in a tank D, and from there it is forced up through the pipe M to the cooler.

The rod B rotates the stirrer S which is provided with brushes. The steam pipe C has a lower opening into D and an upper one in the centre of B shown by the arrows.

The cover of the outer cylinder can be taken off.

“HOCHMUTH” has also left his surface heaters described elsewhere and constructs an apparatus with stirrer which he rotates by the steam used for heating.

SURFACE HEATERS WITH MILK EXPOSED.

We have thus traced the Fjord heater in all its evolutions and turn now to those heaters where the milk is allowed to trickle over the outside of a heating surface by its own gravity.

In Sweden DE LAVAL constructed the well made if rather expensive combined heater and cooler, Fig. 14.

chambers overflowing the outside steam chamber E and then down again between E and a rotating cylinder B and finally up in the barrel and out by M.

The rotating cylinder B has brushes attached and so have the stirrers F which are screwed in the top of the rotating cylinder.

The pulley D revolves the cylinder and the stirrers which brush the steam chambers on both sides continuously and thus prevent the scorching.

DIERKS D. MOLLMAN in Osnabruck also aims to prevent scorching by

Fig. 14.

Fig. 15.

heater placed horizontally Fig. 16. and also one with both heater and cooler in a horizontal position. Fig. 17. In addition to this change, he also adopted a cover

Fig. 16.

Fig. 17.

which protects the milk against the air as well compels it to follow the curvature of the corrugated surface instead of flowing on top.

LAWRENCE also constructed his apparatus with a cover for the heater (see Fig. 18.) in which is used a hot water circulation system (a—b).

There is thus no end to the combinations of heaters. indeed, every cooler devised may be used as heaters and vice versa, but, as a rule, it requires twice the cooling surface to cool that it does to heat 100°.

Running the milk over an exposed surface may be objected to from a strict bacteriological standpoint, but practically with the milk such as we receive it, I

In Germany Hr von **F. HOCHMUTH** adapted the Lawrence cooler to his purpose as shown in Fig. 15. It is divided in three parts. The lower one acts as cooler, the water enters at the bottom and is then, when warmed at the top of the cooler led through a curved pipe into the upper part leaving at a. There the heat absorbed from the milk is utilized for the preliminary heating. Meanwhile the centre part is heated by steam entering at d and the condensed water escaping at c.

We find the same objection to this apparatus as to the Laval, in the great drop, which requires the milk to be pumped. This led Mr. Hochmuth to modify it and construct one with the

believe it is rather an advantage while it is heating and during the first cooling, as it will drive out many taints which have not a bacteriological origin. During the last cooling it is safer to have the surface protected. If the milk is *perfect*, it is better to exclude the air as much as possible.

SURFACE HEATERS WITH MILK PRO- TECTED.

"CARL THIEL"

as early as 1886 adopted a system of heater Fig. 19 where the milk is not exposed to the open air. It consists of a tinlined wooden cylinder a between which and a corrugated cylinder is a perforated steam coil o with steam entering at h thus heating the water to the desired temperature read off on the thermometer b. The overflow water escapes at p and is emptied at n.

The milk flows from the tank x on to the curved cover which is perforated so as to distribute the milk evenly

Fig. 18.

on the upper corrugation from whence it flows to the bottom and out by i and k, the thermometer m showing its temperature.

Dr Fleishman heated 1250 lbs. of milk per hour from 66° to 140° Fah. with the heating water only 158°.

Theil used a similar constructed cooler, but of course any kind of cooler can be used.

In France **MR. F. FOUCHE** constructed what he calls a multi-tubular pasteurizer. Fig. 20.

The milk leaves the tank **M** and enters the bottom of the heater which is heated by steam entering at **s**. After passing through a lot of

Fig. 19.

Fig. 20.

straight tubes the milk leaves the heater and enters the cooler at the top. The tubes in the cooler are cooled by water from tank **w**. This apparatus fills the bill as far as excluding the air during the entire operation, but whether it has obtained any extensive use I do not know. It can be cleaned by loosening the top.

Prof. Leze describes a heater made by **HIGNETTE** devised by **COLLET**. It is a series of tubes arranged zig zag like the Lawrence cooler see A Fig. 39, but, instead of having only one tube there are three concentric tubes which are joined together with specially constructed concentric elbows held in position by bolts.

By loosening these bolts the tubes can easily be taken apart.

The milk circulates between the centre tube and the second and the hot water circulates in the opposite direction in the centre tube and between the second and third one. This is said to be a very effective heater.

As an experiment I designed the apparatus for Mr. A. H. Barber of Chicago, which is illustrated in Fig. 21. This is really an adaptation of a cooler illustrated by Dr. Fleischmann and made by Jellinek

Romanowsky years ago. Or it might be said to be an adaptation of the latest De Laval Heater shown in Fig 5. It consists of 4 sets of tin cans A B C & D placed inside a galvanized or wooden tank E. The

milk enters at N and passes through a two inch tube in the can A A. From there it escapes through the perforated holes K in the rim at the bottom into the can B B and rises up and flows through 4 pipes X into the third can C C. Here it goes down again as in A and escapes through the perforated rim

Fig. 21.

into the last can D which is provided with an overflow M and draw off faucet P.

The water in the cans is either circulated hot or heated by steam through the pipes S which are provided with a steam jet arrangement which sets the water in a strong circular motion. The overflow nipples (O), as well as the steam pipes, are connected by rubber hose with their respective pipes.

I may say here, that of all systems of heating (excepting direct steam), I prefer to have a hot water circulation (by the aid of a rotary pump); it gives a more even temperature.

The above apparatus heated 2,000

Fig. 5.

lbs. of milk per hour from 54° to 155° Fah., with a circulation of water at 180° . Used as a cooler, it cooled only 1,000 lbs. per hour from 155° to 60° with water pumped over and over through a tank with ice.

In Sweden **DE LAVAL** solved the protection problem as shown in Fig. 5, which takes the place of the heater in his combined heater and cooler (Fig. 14).

This apparatus consists of two closed double vessels fitting one into the other in such a way as to form concentric narrow apertures of large surface, through which the milk is forced. The aperture is only about $\frac{1}{8}$ of an inch and the milk, which is kept in constant motion, is rapidly and evenly heated, without allowing any albumen to coagulate.

Each vessel has a pipe (a) which passes down close to the bottom; these two pipes are at the upper end joined at b where the steam enters.

Both vessels are also connected by a pipe (c) by which the condensed steam escapes from the inner vessel into the outer, from which it again flows through the pipe (d). The inlet of the milk is regulated by an ordinary regulator cup (e) with float, same as used on the separators. After the milk has passed down through the inner conical aperture, it rises through the outer one and flows over the rim of the annular receiver placed round the above named regulator cup, and flows off through the pipe (g). At the base of the outer vessel are fitted a faucet (h) (for drawing off the milk remaining in the apparatus after the work is finished) and a screw-plug (1) for emptying out the heating water from the outer vessel. The inner vessel is emptied of its water through the opening n, by means of a siphon.

Fig. 22.

Similar heaters have been used by Mr. Bentley who uses two or more sets consisting of two cans (Fig. 22), an outer one B B B B. and an inner one A A A A. The inner one has a tube H through which the milk flows under

The apparatus is made in three sizes:

No. 3 heats 650 liters (=150 gallons) per hour

No. 4 heats 1,200 liters (=265 gallons) per hour

No. 5 heats 1,800 liters (=400 gallons) per hour

Similar heaters have been used by Mr. Bentley who uses two or more sets consisting of two cans (Fig. 22), an outer one B B B B. and an inner one A A A A. The inner one has a tube H through which the milk flows under

the bottom into the outer can and thence out to the second set of cans through *m*. Both are set in a tank of water which, together with the water *w* in *a*, is heated by a jet of steam.

The Creamery Package Mfg. Co. has changed this plan somewhat, and just finished a large apparatus, with six set of large cans, arranged in a tank one below the other. It is intended for the creamery of Mr. Wood, and supposed to pasteurize the milk fast enough for two or three Alpha separators.

Mr. Lawson, of Grinnel, uses a similar but simpler device, as he lets the milk down through an outside pipe, something like the inlet to Fjord's heater, into a single can from which it runs into the cooler. The can and pipe is placed in a barrel with boiling water (direct steam).

As cooler he uses something like the cream cooler sold by F. B. Fargo, with a tube soldered to the inside of the can which he places in a barrel with crushed ice and salt. It is possible to pasteurize the cream from one separator with one such heater and two coolers.

Though of no practical value I illustrate in Fig. 23 a heater made as early as 1887, by G. Reinsch, of Breslau.

Fig. 23.

It consists of a steam chamber (5), and a milk chamber (6), which has a high rim (7) to prevent foaming over. The milk enters at (3) and leaves at (4). Not being stirred it seems to me that a direct current from 3 to 4 would soon be established. The proportionate heating surface is also too small.

TANK HEATERS.

To all the "continuous" heaters, the bacteriologists object—as before said—because even with a large body of milk in transit there is no assurance that all the milk has been exposed to the high temperature for the time needed.

On this principle Prof. Russell of Madison, Wis., constructed an apparatus illustrated in Figs. 24, 25 and 26, which he calls a "combined pasteurizer and cooler;" this is a misnomer, it is a "*pasteur-*

izer; if it were not designed to cool as well as heat it would simply be a heater. I point this out as there is a tendency to call the simple heating of the milk pasteurizing; this is wrong, pasteurizing is both heating and cooling.

The apparatus consists of a wooden vat *O V* Fig. 24, with one or two narrow tin vats *I V*.

A rod, *R*, Fig. 26, worked backwards and forwards by a crank, carries the milk paddles *I S*, and is connected with the two rods *R*, which carries the water paddles *O S*. One pipe *W P*, introduces both water and steam. *S* on Fig. 25 represents the milk paddles. The whole is covered with a cover. The milk is filled in and the paddles are kept moving during heating, and when at the desired temperature is left for twenty minutes.

Then the hot water is drawn off and cold water is turned on during constant stirring until it is about 70°. When cold enough the milk is drawn by *M O*, by opening a special constructed faucet *S C*, with a straight cylinder. The temperature is observed at *T H R*.

This apparatus is used successfully in the Madison Experiment Creamery (Dairy School), for pasteurizing small amounts of cream sold in the city.

It is made and improved upon by **CORNISH CURTIS & GREENE MFG. CO.**, of Ft. Atkinson, Wis., who has sold several complete outfits with sterilizing ovens, etc., etc.

N. S. Andrews, of Dubuque, Iowa, writes the following description:

"My pastuerizing outfit consists of a heating vat, cooling vat, oven, milk or cream receptacle, and hoisting crane and track. The heating and cooling vats are placed under the track which is suspended from the ceiling, and is of sufficient length to allow the milk receptacle to pass them at one end, and be lowered to receive the milk. When filled it is raised and returned *via* the track to the tank. The milk receptacle has an interior agitating device which may be operated either by steam or hand. The cooling vat is internally arranged so that it may be filled with ice, and not interfere with putting the milk receptacle into it or taking it out.

Among the tank heaters used for pasteurizing must be mentioned Mr. John Boyd's cream vat, Fig. 27.

For pasteurizing he has modified the construction and made the vat with a water space.

PROF. RUSSELL'S PASTEURIZING APPARATUS.

Fig. 24.—Diagrammatic side view of pasteurizer—*i*, *v*.—inside vat for milk; *s*, *c*.—stop-cock in outlet tube; *m*, *o*.—milk outlet; *l*.—lever to control stop-cock; *o*, *v*.—outside vat; *w*, *c*.—water chamber; *w*, *p*.—water pipe (steam or water); *ther*.—thermometer in milk chamber; *r*.—brass rod to which *i*, *s*, (inside stirrers) in milk chamber are attached; *r*.—rod to which *o*, *s*. (outside stirrers) are attached; *c*.—crank; *p*.—pulley.

Fig. 24.

Fig. 25.

Fig. 25.—End view of pasteurizer showing double vat arrangement.—*w*, *c*.—water chamber; *m*, *c*.—milk chamber; *i*, *v*.—inside reservoir for milk; *o*, *v*.—outside reservoir for water; *w*, *p*.—water pipe; *v*.—vent of same; *i*, *s*.—inside stirrer in milk chamber; *o*, *s*.—outside stirrers, (three series); *r*, *p*.—binding piece of wood to which *i*, *v*. is attached. The ends of this rest on outside wooden vat, *o*, *v*.

Fig. 26.—Diagrammatic view of pasteurizer from above.—*m*, *c*.—milk chamber bounded by continuous black line; *w*, *c*.—water reservoir surrounding same; *r*, and *r*.—rods from which stirrers are hung in milk and water chamber.

Left hand of figure shows wooden frame that supports the gearing for stirring; *p*.—pulley on axle for automatic power; *c*.—hand crank. Lower figure *S*.—Face view of one of stirrers in milk chamber. These can be removed from rod (*r*). Lower half of two stirrers is solid so as to mix the milk more thoroughly.

Hot water is circulated through the swinging coil, and from there it enters the water space round the vat through a rubber hose at one end, leaving it at the other.

Fig. 27.

few bacteria floating around, and if there were a few, they will be killed by the heat.

MR. H. CORRELL, of Allegheny, Pa., is making a vat represented in Fig. 28.

Fig. 28.

When cooling, the circulation of the cold water is simply reversed. Mr. Boyd guarantees that 3,000 lbs. of milk may be heated to 155° in sixty minutes, and that—by the aid of ice water—he can cool it even quicker than that.

The objection that the milk is exposed to the air while heating has, in my opinion, but little weight. In a room used for pasteurizing there should be but

There is an agitator (3) which has a swinging motion and a cover (2), which is so arranged as to carry away any condensed vapor from the milk during heating. It has also an opening in the top (1) which is closed with a layer of cotton.

Otherwise it is like an ordinary American cheese vat and may be heated by steam or hot water, and cooled by water. It has, as yet, only been tried with a capacity of 75 gallons, writes the inventor, but he is going to make one for 150 gallons. The time, he says, need not take more than $1\frac{1}{2}$ or 2 hours for both heating and cooling.

I am afraid he will find that it will take too long, if he builds them much larger.

BITTER, who also condemns all continuous apparatus, designed the one shown in Fig. 29.

Fig. 29.

It consists of a tinned copper vessel which is closed with an overlapping cover. Close to the inner wall is a tinned copper coil entering at the top (s), and at the bottom it turns up into a smaller coil in the center of the vessel; this coil returns to the bottom and lets out the condensed water at p and n. Between the two coils rotates a stirrer R. The milk is let out at v.

As the apparatus does not hold more than 100 lbs, I do no injustice by relegating it to experimental purposes only.

In the U. S. Agricultural year book for 1894, just published, Dr. E. A. DeSchweinitz has a treatise on "The Pasteurization and Sterilizing of Milk," from which I gather that the Appleberg Hygienic Milk Co., at Rawling, N. Y., has patented an "apparatus" for pasteurization.

It consists of a wooden box four feet square with a hinged lid. On the bottom is a steam coil. Inside the coils the (rectangular) milk cans, holding forty quarts, are placed and covered with perforated tin lids to permit the insertion of a thermometer. The cans fit closely together inside the coil.

During the process, the milk is kept thoroughly stirred (how?).

The temperature varies from 16° to 180° , and steam is turned on from twenty to thirty minutes.

The milk is filled hot into the glass jars, which are placed in ice water to cool.

At Danby, N. Y., is also a plant for "sterilizing" the milk in bulk, hot water being used instead of dry steam.

Under the heading of tank heaters I must mention the system of heating by leading steam (exhaust or direct) into the milk.

Fig. 30.

called by him a "Genicide." This is indicated in Fig. 31, by two wide tubes in which two steam jets blow in different directions caus-

Fig. 31.

In Fig. 32 I have shown the simple Barber noiseless heater intended for water with which I have made start the current in any desired direction by modifying that, a "heater" for direct steam can be made by anybody at a nominal cost.

This has been used in some German creameries for skim milk on the "Korting" system, illustrated in Fig. 30, which shows how the current is directed diagonally against the sides. The heater consists of a trumpet-shaped end to the steam pipe with openings just behind the point of the steam jet on the same principle as our steam jet pumps and heaters. See fig. 30.

A similar idea has been adopted by **MR. BENTLY**, indicated in Fig. 31, by two wide tubes in which two steam jets blow in different directions causing a current in the milk, as indicated by the arrows. The steam pipes are joined together above (not shown in illustration) with a drip arrangement in the center so as not to introduce any of the steam condensed in the pipes.

Mr. Newton, ex-President of Iowa Dairymen's Association, was the first to suggest the plan of elevating the skim milk into a bucket placed in the tank, and then have an exhaust steam pipe enter into the bucket, thus heating the milk.

Fig. 32.

Fig. 33.

While these methods may do for heating skim milk, I can hardly recommend them for new milk, even if no boiler compounds are used, and even if no oil is carried over from the cylinder in the exhaust steam, the fact remains that as a rule the milk will be diluted with six or seven per cent. of condensed steam, though Mr. Korting claims that there is only a dilution of three to five per cent. with his "heater."

CENTRIFUGAL HEATER.

We now come to the heaters where the milk is forced over the heating surface by centrifugal force. The first one was constructed by the pioneers in the manufacture of separators, Messrs. **LEPELDT & LENTCH**, of Schöeningen Braunschweig, Fig. 33. It consists of a revolving horizontal drum A, in which the milk is cleaned of the dirt the same way as in a cream separator. Then it flows between the outside of the drum and the wall of the steam jacket which receives the steam from the pipe s, and is relieved from the condensed water by k.

Besides the high speed of the drum, the peculiar construction, and a pair of small wings act as a centrifugal pump which forces the milk to any reasonable height through the pipe m. The capacity of this machine is 1,000 lbs. per hour.

Fig. 34.

Finding the apparatus shown in Fig. 21 too cumbersome and having too much surface to clean, I designed the heater shown in Figs. 34 and 35, made by **MR. BARBER**, of Chicago.

It consists of a cast-iron base I, in which a turbine flyer f is inserted and driven by steam from the pipe f s. It has also pipe t for the exhaust, but this is, as a rule, closed by the damper k, when not

While the milk does not get any perceptible "boiled taste," there is, after running 3 000 lbs. through it, quite a layer of coagulated albumen, which takes some labor to clean off. Yet I would far rather clean that one drum instead of five or six cans, even if the albumen deposit is less there. In Fig. 34 the apparatus is shown as connected with three Baer coolers.

Fig. 36.

than that used by me, 450 to 500. it may be arranged to elevate to any height.

After I had run this heater for a month I was amused to hear that K. HANSEN & SCHRODER had made a heater whereby they obtain the same result by other means, and though not strictly a centrifugal heater I class it under these. Fig. 37 represents this heater, consisting of a wooden covered steam jacket A, which is swung on pivots P. Steam enters

I propose to utilize the same idea by having the bottom of the drum T (see Fig. 36) cast with shovels on, and rotate the drum by a steam jet S. By this application, or by driving it with a gearing at the top it is optional whether the milk shall be taken in from the top or through the bottom bearing at L P. The advantage of the latter plan is obvious as the heater will act as an *elevator* at the same time, thus killing two birds with one stone. As the drum is twenty-eight inches deep it will be possible to lift the milk at least two feet from M to the outlet N of the gutter G, and with a higher speed

Fig. 37.

at s, and the condensed water escapes through the waterlock w, both being connected by a union u.

The milk enters the tinned copper vessel B by the funnel-shaped cover c, and the shape of the vessel is made so that the revolving dasher at a certain number revolutions (280, I believe) sends the milk up the sides of B in a thin film with force enough to elevate it through a pipe not shown in the illustration.

These apparatus are sold complete with elevator and cooler for cream from two Alpha separators for \$170, F. O. B. in Denmark; the heater alone for \$55.

Fig. 38.

In Fig. 38 is shown a complete heating outfit, made by P. J. BUAAS, of Aalborg, Denmark.

He seems to have adapted the heavy Lefeldt heater to a lighter apparatus. The milk is received in H, from where it is run into the drum A, which has a steam mantle and a revolving horizontal drum which heats the milk to separating temperature and elevates it into the separator.

From the separator the cream runs into a similar heater C where it is heated to 150 and then elevated to the cooler D from which it runs into the cream tank E.

The skim milk runs into the larger drum B, is heated to boiling point and elevated to cooler not shown.

I regret not to be able to show a sectional illustration of this, the very latest in heaters from Denmark.

CHAPTER IV.

STORAGE TANKS.

In view of the necessity of keeping the milk or cream at the high temperature for 20 or 30 minutes, if it is to be sold and not manufactured, and in view also of the difficulties of heating all the milk in a body when we have to handle large quantities such as must be handled at milk shipping stations if pasteurizing is ever to be introduced generally, I have suggested the following plan.

Use any continuous heater which you find best, but instead of running the milk direct to the cooler, run it into a storage tank which should hold one third of the hourly capacity of your heater and cooler: if you desire to keep the milk for 20 minutes at the high temperature or one half if you want to keep it 30 minutes.

This tank may either be built with water space filled with water at 155° or better still be properly insulated so as to hold the temperature within 5°.

By having one partition in the tank and two attached to the cover the milk is compelled to go to the bottom first then up, then down and at last up and out to the cooler, and I challenge bacteriologists to show any reason why this arrangement does not solve the problem of combining a continuous apparatus with the strictest bacteriological demands!

What is more, I believe that this system of instantaneous (so to say) heating is better than the slower heating of a large body of milk in a tank unless indeed all the milk arrives at once and is left for hours at the dangerous temperature.

Even if it should be found necessary to have several tanks each of a capacity to hold the milk absolutely for the required time, as proposed by Mr. J. D. Frederiksen, this would be better than the slow heating of 3 or 4000 pounds of milk.—

If the milk is 60° or below, it is surely better, the quicker it is heated up. While I express this as my belief at present, I hope to see the experiment stations take the matter up in a *practical* manner free from scientific punctiliousness.

CHAPTER V.

THE PASTEURIZING COOLER.

I have shown how in some pasteurizing apparatus the heating and cooling may be done in one vessel. I have also shown some of those where the same construction is used for both purposes. It remains now to mention a few of the coolers which have been used.

COOLERS WITH EXPOSED SURFACE.

Among those made on this plan the most effective are undoubtedly the Lawrence and the Laval. The former has indeed been so thoroughly copied both in Europe and America by most of the manufacturers, who thus have paid the inventor a high compliment. The latter is illustrated in the lower part of Fig. 18, and the former in the

Fig. 39.

To this should be added the cheap tin cooler made in America under the name of Danish Weston cooler, Fig. 40, and the cooler made by A. H. Barber, of galvanized iron pipes, with close elbows and a partition of tin soldered between them.

The Lawrence style of coolers are made in America by the Star Cooler Manufacturing Co., Haddonfield, N. Y.,

Fig. 40.

Vermont Farm Machine Co., Bellow Falls, Vt., A. H. Reid, Philadelphia, Pa., Dairymen's Supply Co., Philadelphia, Pa., and others, and is, when well made, undoubtedly the most economical as far as utilizing the water.

It requires always a considerable fall, and this has prevented its use in many creameries.

Of the three constructions I believe *c* is the one which utilizes the water most thoroughly when made, as the "Star" people make it, with a very narrow water space, but this is less important where the supply of water is large enough.

Modifications of this cooler, made to do away with the objection of its drop height, have been made. I illustrate a German one in Fig. 41.

This style has been in all angles down to nearly horizontal, as in Hochmuth's, but the great objection to this style has been the tendency of the cold milk to flow straight down on top of that which was in the curves, thus diminishing the effect considerably. Mr. Hochmuth tried to overcome this in Fig. 17, when the cover is corrugated similar to those of the cooler.

Fig. 41.

Fig. 42.

In Fig. 42 we have another cooler. B is a circular corrugated surface with a smooth cylinder inside, between which the water circulates. The milk flows from the distributor A over B into the gutter and out at D. While it in one way is more compact than the Lawrence style, it uses only one side of the cooling water and has the same objection of high drop, though not in the same degree.

Several years ago **MR. U. S. BAER**, the expert separator man working for Laval, tried to overcome the objection of the creamery men to coolers with considerable fall and constructed a shallow 1 foot wide gutter with a double bottom, in which the water was made to go zig zag by half partitions.

The only difficulty was the same as with all surface heaters that when not perfectly level the milk would run on one side only.

MR. A. H. BARBER, who made this cooler, improved on this by making it as illustrated in Fig. 43. The cross section shows the cor-

Cross Section NM.
Fig. 43.

rugated surface which compels the milk to run in the little gutters and increases the cooling surface. Also in P the partitions which turn the current of the water which flows as the arrows show on the exposed part of the sketch. The milk flows, of course, in the opposite direction and on a length of 8 feet, 2 inches drop is fully enough; indeed, they may be placed nearly level.

Where they are not desired to be used as conductors as well as coolers they may be arranged zigzag as shown in Fig. 34.

In a trial I made, 22 feet of this cooler reduced 900 lbs. per hour from 156° to 102° with the cooling water 74° , and the next 20 feet reduced it to 55° with water circulating over an ammonia coil (about 90 feet, 1 inch) which kept the water at 50° .

Mr. Barber makes these double width to order for pasteurizing purposes.

Numerous other surface coolers have been devised, but these are the principal ones.

COOLERS WITH PROTECTED SURFACE.

While I feel inclined from a practical standpoint to overlook the demand of bacteriologists for a heater with covered surface, I am more inclined to acknowledge the value of protection against the air during cooling, especially the last cooling.

Prof. Russell suggests the one shown in Fig. 44. It consists of two tin cylinders with only $\frac{1}{8}$ -inch space between each other, and here the milk flows through (MC). The cylinders can be taken apart at one end and inlet and outlet pipes can easily be removed by "a ground joint like an ordinary sink plug". They are submerged in a tank which is filled with water, which also passes through the inner cylinder as indicated in the illustration.

With this cooler and cold water the milk can be reduced from 25° to 40° , says the professor.

I have shown how Hochmuth and Lawrence protected the milk against the air by a mantel, and now illustrate how the exacting Prof. Bitter protected the cooler shown in Fig. 42 by a cover B (see Fig. 45),

Fig. 44.

Fig. 44. A—Sectional view of water cooler. *m. c.*—milk chamber between the two cylinders; *w. c.*—inside water chamber, water introduced on lower side, outlet on top; *a*—an inner core with partition (see B.) to force the water to flow the whole length of cylinder; *o. w. c.*—outer water chamber made by submerging the cooler in water; *w. p.*—inlet for water; *m. p.*—milk inlet and outlet. The arrows indicate the direction of flow of milk and water. Both the milk inlet and outlet are made with a ground joint connection like a sink plug, so that they can be easily detached and cleaned. The cylinders can be taken apart and thoroughly cleaned without any difficulty. Fig. 44 B.—Apparatus in cross section, showing relation of milk chamber to contiguous cold water spaces.

which is made by von Schmidt in Bretten.

Another late German adoption of cover is show in Fig. 46. and indeed there is hardly a cooler made where the air may not be kept out sufficiently for all practical purposes.

The French heater by Hignet, mentioned on page 24, is of course equally well adapted for cooling.

CENTRIFUGAL COOLERS.

THE BERGDORFER Machine works make a cream cooler illustrated in Fig. 47. It consists of an inverted cone of cast iron in which revolves a similar

Fig. 45.

shaped drum driven by P. The cream enters the lower bearing of the drum and escapes through the perforated upper part of the drum into the gutter and leaves at CR.

The water enters at w and leaves through the siphon o.

The cream is here, as in the centrifugal heaters, spread in a thin film over the drum. The speed given is 600 revolutions per minute.

If the friction of the water be not a too great objection to this system in larger apparatus, it seems to me there are great possibilities in developing this idea. I have thus suggested that the drum be rotated by aid of the cooling water. It may also be used for elevator, as indeed it is in Fig. 47.

ICE COOLERS.

Where water is scarce and ice plenty the cream cooler originally designed by Prof. Fjord, Fig. 48.

Fig. 46.

Fig. 47.

land, N. Y., and another by H. W. Gar-
glay, Cortland, N. Y.,
under the name of the
MODEL COOLER.

PROF. RUSSELL
suggests the ice cooler
shown in Fig. 51.
Finding that it was
difficult, if not im-
possible, to cool the
milk sufficient with
water, he proposes to
have three rectangular
reservoirs made as

has been used. A tin can is
placed inside another, leaving
a space to be filled with ice. On
a bracket there is a funnel with
four curved outlets. This is
revolved by the action of the
milk, which thus sprinkles itself
against the ice cold walls of the
can, flowing to the bottom and out.

Another ice-cooler first de-
signed by the Canadian cheese-
king, McPherson, is shown in
Fig. 49. B is a conical vessel
surrounded by a gutter bb.
When B is filled with ice, A is
placed on top and the milk
poured in the latter, whence it
escapes through the wholes d
and flows over the surface of B.

Modifications of this have
been put in the market under
the name of the **CHAMPION**
milk cooler, Fig. 50, by the
"Champion" Milk Cooler, Cort-

Fig. 48.

Fig. 49.

shown in the cross-section. When the milk leaves the water cooler it flows down the side of the inner ice box, which is corrugated, and close to one side of the milk box *M*, which should be large enough to hold all

Fig. 50.

the milk from one heater.

The bottling arrangement by siphon explains itself.

It stands to reason that any and all of these ice coolers may be used with water, but they will then be found less effective, and it may

be laid down as a rule that ice or a refrigerator machine is a necessity if pasteurizing is to be successful.

THE REFRIGERATOR MACHINE.

I fear that if the "boys" in our creameries have to take out and break the necessary ice for pasteurizing large quantities, the process will be very obnoxious to them.

With a good refrigerator machine it is easy to secure enough cold

Fig. 51.—Sectional view of Ice Cooler.—*w.*—cold water chamber outside; *m.*—milk reservoir; *r.*—receiver from the pasteurizer, milk flows down corrugated side of the chamber and is collected in (*m.*); *s.*—siphon arrangement for drawing off milk. Arrows in water and milk chamber show direction of current.

water by having sufficient ammonia coils in a tank and then circulating the water over them with a pump.

Or, if intense cooling is desired, have the coolers made of tinned copper and circulate cold brine in them. The latter, of course, is impractical to use in tin coolers.

I give fair warning that a good refrigerating plant cannot be bought for a song, and that a poor one is nothing but vanity and vexation.

If sufficient power is present (and it requires it just at a time when other machinery is running), then a good enough plant can be put in a milk depot for from \$1,000 to \$1,500, and in a creamery where cream only is pasteurized for \$800 to \$1,000.

In making inquiries from some manufacturers I have been amused at their refusal to give a description of their apparatus. Thus the *Star Cooler Mfg. Co.* announces in mysterious terms a new device but refuses to describe it, and I understand that Messrs. D. H. Burrell contemplate putting on the market, not only pasteurizers of "*approved style and effect.*" but also a new special apparatus for the practice of Mr. J. D. Frederiksen's process for treating tainted milk. Mr. F. has been working on a method for eradicating bad flavors, especially the garlic flavor so common in Eastern Pennsylvania, Maryland and adjoining territory, for the last few years, and has succeeded in devising a plan which on account of simplicity and efficiency is likely to be generally introduced wherever milk is tainted with the flavor of garlic, ragweed or the like. As soon as the apparatus is perfected it will be offered to the dairymen, and it seems that relief is at last in store for the sections of the country where these pests have heretofore prevented successful dairying though otherwise they are eminently well adapted to this industry."

CHAPTER VI.

SELLING MILK.

DIRECT SALES.

I have said before that when a farmer peddles his own milk, all there is needed is *cleanliness* and *cooling*. I shall shortly outline what I mean by cleanliness, a word which is subject to nearly as many definitions as there are dairy farms.

We will presuppose a herd of healthy cows and a stock of sound and clean fodder. Musty hay and half decayed ensilage is not clean fodder.

The stable must have plenty of light, and should be thoroughly cleaned and whitewashed, if not twice, at least once a year (in the fall). Land plaster should be used to absorb the urine, thus preventing smell. The cost is nothing, as there is full value in it as a manure.

The daily cleaning of the stable and all handling of fodder as well as the carding of the cows should not be done within at least half an hour (one hour is better) of milking time. This precaution is taken to let the dust get a chance to settle and not float in the air, carrying thousands of bacteria with it as it settles on the surface of the milk or is washed down by it as it goes foaming into the bucket.

Before starting milking, just dampen the side of the cow and the udder with a wet cloth, this will make any dust, left in the hairs, adhere and not drop in the bucket during the milking.

The pails and cans used should have been cleaned carefully. Rinse them first with cold or lukewarm water; never use boiling or even scalding hot water until all the milk has been rinsed off. Then use soda or Fairbank's "gold dust" (not soap) and hot water brushing the corners carefully. Then rinse again, and finally—if you have a large open boiler—immerge it in *boiling* water for five or ten minutes. Should you have no open boiler large enough, rinse the pails with *boiling* water, not water 160° or 180° or 200°. but water 212° Fahr.

If you have selected your tinware with proper care and seen that the soldering is smooth and fills all the seams, you will have done all that can be asked in practice.

Neatness and cleanliness in the clothing and hands of the milker is a matter of course. I rely on the women in the house—if they do not milk—not to grudge a clean towel in the barn for the special use of the milkers, and facilities for washing the hands right in the barn should be provided.

In the ideal cow-stable special milking overalls, or at least aprons should also be provided.

Fig. 52.

In a room or a shed next to the stable, free from obnoxious odors, the cooler, be it one like *the Star*, Fig. 52, or any of those illustrated elsewhere, for water, or one like Fig. 43 for ice, should be found, and as soon as the milker is through with one cow, he should strain the milk (through a wire strainer with a piece of *flannel* below) into the tank above the cooler.

If the milk is thus cooled to 60° it will be found good enough to deliver, even though 40° or 45° were better. The night's milk should be placed in a tank with cold water over night (ice water is better), and the morning's milk never be mixed with it until after it has been cooled to 60° .

"*Aeration*" alone without cooling by the aid of water or ice, is certainly better than doing nothing, and will also cool the milk just in proportion to the temperature of the air and the length of time spent in the operation.

Dipping the milk with a gallon dipper, holding it high in the air and allowing it to run slowly back in the can, has been and is yet the standby of our American cheese factories.

But while I do not deny that it is better than doing nothing, I do claim that it is but seldom done as it ought to be done in order to be efficient.

Hundreds of devices for aerating the milk have been invented, most of

Fig. 53.

Fig. 54.

Fig. 56.

Fig. 55.

Fig. 57.

the combined aerators and coolers are much to prefer.

There are many milk bottles in the market, with

Fig. 58.

them depending upon perforated tin dividing the milk in fine streams as it is poured into the shipping cans, as Fig. 53, the so-called Vermont strainer and aerator, or by pouring in a bucket (with fine holes in the bottom) fixed two or three feet above the can. Others depend on blowing the air into the milk as invented by MR. E. L. HILL, of West Upton, Mass. Fig. 54 shows the box with the blower which is turned by a crank and the hose connected with the nozzle which is placed in the milk can.

Provided hose and nozzle are kept clean and absolutely pure air is available, this system does good work. Yet, I consider

all kinds of patent tin covers and closing devices. Among those most used are those like Fig. 55. In Fig. 56 I illustrate some bottles used in France.

Lately, however, the "Common Sense" milk bottle, Fig. 57, is absolutely gaining the ground.

and wherever they can be transported "right side" up, they are, undoubtedly, the simplest and easiest to keep clean. The paper cap is renewed each time, and there is no wire or tin to be in the way of

cleaning. The cap is made of paraffined paper, and as a rule fits so well as to allow the bottle to be held upside down without spilling a drop, and there is no trouble at all if they are handled in cases like Fig. 58. These bottles are sold by **THATCHER MFG. CO.**, Potsdam, N. Y., and **JOHN BOYD**, 199 Randolph St., Chicago.

Wire baskets, Fig. 59, or, better still, ice boxes like Fig. 60, are handy for their delivery.

Fig. 60.

Fig. 59.

John Boyd makes an insulated box in which galvanized iron crates fit tightly and in such a manner that the handle of one projects into the next crate, and then three crates make a solid column. Mr. B.

claims that these columns may safely be submerged in the ice water tanks, and the bottles there kept cold until ready to pack in the box which is on the wagon.

In very hot weather a little ice may be placed in the boxes, which are lined with galvanized iron.

The bottle with a ground glass stopper is, of course, in one way the very best, but they are expensive, and it is quite a bother to keep track of the stoppers, so I would advise their use only in exceptional cases where an extra price is received. *They are not practical for general use.*

Selling milk in any kind of bottles should always be rewarded with an extra price of $\frac{1}{2}$ or 1 cent per quart, as there is quite a loss by customers retaining them, besides the breakage and the extra labor. It is considered impractical to demand a deposit on them, a precaution which to me would seem fair and reasonable.

CLEANING AND FILLING THE BOTTLES.

Even in a small dairy, it will pay to get a bottle cleaner, and of those I have seen the one illustrated in Fig. 61 seems to me the simplest.

Fig. 61.

The operator stands on the opposite side of the tank and revolves the crank with his foot. Tank holding about seventy quart bottles and cleaner complete cost only \$10. After cleaning the bottles the same way as the cans, the latter *must* be placed in a boiler large enough so that they are all submerged in the water. The water should only be lukewarm when the bottles are put in and then be brought to a brisk boiling and kept there for ten minutes. When the water is cooled down to 160° take out the bottles and place them bottom up in the racks.

If the bottles are taken immediately out of the boiling water and the air is rather cold, there will be more breakage.

While it may be possible to keep bottles clean with water, there is hardly any reason why every farmer with ten or more cows should not have a so-called feed cooker so as to produce steam, even at a low pressure, and thus have the means of properly cleaning his cans and dairy utensils. They are sold cheap enough, varying from \$35 to \$75, and are as a rule, built

Fig. 62.

in America, like a vertical boiler, Fig. 62

I said a very low pressure would do, yet if *perfect* sterilization is to be obtained, there should be a pressure of not less than twenty lbs., though eight or ten lbs. of steam is practically enough and so much simpler to use than boiling water.

If only cans are to be steamed the usual creamery mode of applying may do, provided time is taken to allow the steam to act. This consists of having a steam pipe some three or four inches through a table and having placed the inverted can over it, opening the valve.

Fig. 63.

It is far better to have a box or room on the plan shown in Fig. 63, taken from Wis. bulletin. There is a square box made of galvanized iron with a door and a vent for the escape of steam *v*. The steam enters at *ST. P* through a pipe provided with a dropcock *c*, and with four openings *ST. P V* with pipes *P* inserted, and one *SV* opening into the upper part of the box. There are two shelves *ws* of wire netting, and the lower space is used for cans placed directly over the steam pipes *P*, while the upper shelf is used for bottles, covers, etc. This and similar boxes are made by Cornish, Curtis & Greene Mfg. Co., Ft. Atkinson, Wis. and may be made in any size or styles to suit.

I have seen some *ovens* (made by Simonds, Tyrrell & Co., of Chicago), with double walls, which seem to me an improvement, though I presume more expensive. These are made to heat directly with a fireplace in the oven and any desired *dry* temperature may be obtained. They can also be made for heating with direct steam.

Mr. H. B. Gurler has built a small room lined with wood for this purpose, and claims it to be superior to those made of galvanized iron, a claim which I shall be willing to allow, when I see the room two or three years hence.

If I were to use wood I should have it built like a round tank.

If absolute sterilization is desired this apparatus should be made of a shape and material strong enough to stand considerable pressure.

Fig. 64.

Much labor is also saved by the use of a bottle filler, and in selecting one it is well to look carefully after the construction. The simplest and the one which is easiest to keep clean is the best. I illustrate one in Fig. 64; it is the cheapest I have seen for small dairies.

On a very small scale, however, I feel inclined to believe that the labor saved is counterbalanced by the extra work of keeping the apparatus clean.

By referring to Fig. 51, Prof. Russel's idea of filling by syphon may be seen. Not having

any practical experience with either I cannot express any opinion.

Selling milk in bottles is getting to be quite common, but unless the utmost care is taken, the advantage of this system is but a delusion and a snare.

Fig. 65.

We are apt to be over tender with bottles and the washing, as it is often done, is a mere farce.

When milk is sold from large cans, and especially when the cans are standing still, it is not advisable to draw it off from the bottom with a faucet, and even when the cans are in constant motion it is claimed that there will be some difference. In order to counteract this a device illustrated in Fig. 65 is inserted in the faucet opening inside the can.

The milk is then drawn from the whole length of the can through the perforated tube.

When a man delivers his own milk all there is needed is a dipper and honesty in the purpose of giving all his customers the same milk. The above mentioned device was constructed for the large cans used in Germany where the faucet projects from the side of the wagon, and the driver cannot get at the inside and manipulate the milk!

SHIPPING MILK BY RAIL.

There is a general idea that the middle-men in the cities get the lion's share of the profit in the milk trade.

There is some truth in it, but I doubt that the farmers have any conception of the enormous expenses in distributing the milk.

'Tis true that these expenses could be reduced materially if the delivery was in the hands of an honest monopoly, and those who have watched from six to ten different milk wagons deliver milk in the same street, will agree with me that the saving in time, horse-flesh and wear and tear of wagon, is enough to enable a monopoly to sell better milk at a lower price with just as much profit to themselves and the producers.

Not that I believe that such is likely to be realized, and least of all by a co-operation among the farmers. It would take too much capital and be too great a strain on the mutual faith in the honesty of their fellow farmers.

Not having been engaged in the milk business practically I shall not dilate on this subject but only give a hint or two.

Co-operation among farmers such as was attempted some years ago without a system of retailing is simply the establishing another "middle-man" and is useless.

The first step is the establishing of "creameries," as they are mis-

named in the East, close to the railroad station. If the farmers can secure the right man to manage such a milk depot (as I should prefer to call it) so much the better, if not let them encourage private individuals to take hold of the matter.

These depots should be built like the German creamery (see page 74) and be provided with machinery for butter-making and for pasteurizing the milk. If the farmers would treat the milk in the same careful manner as suggested when they peddle it themselves, it will be an easy matter to eliminate all losses by sour milk and yet use no chemical preservatives.

I believe it would pay well to run it all through a separator (through the cream tube only) in order to clean it. This is even better than filtering as it is done by the large European milk dealers. For this purpose the old Danish Weston machine is specially adapted unless indeed the centrifugal heater can be run sufficiently high speed to do the work thoroughly.

Surplus milk or cream can be made into butter or cheese, and pasteurized skim-milk sold under its own name at a reasonable price, would be a blessing to the city people and a profit to the farmers.

Such depots having large quantities of milk under their control can always command a better price.

If milk enough to secure a carload at one place can be secured, I believe bottled milk can be shipped for the same price as that in cans.

Possibly the German plan of heating the milk at the shipping point and ship it in large tanks where the temperature could be maintained, and then cooling it in sterilized bottles on arrival at the city, may be found practical though I have my doubts as to the cold season.

Whatever plan is adopted I consider this idea that the farmers themselves see to it that the milk has a better keeping quality as the first step in true co-operation, and when this is first obtained in a system of milk depots along the railroad lines leading to the great cities, then and not till then, can there be any hope of further co-operation in the retail business.

Finally let me urge upon the farmers to remember that such depots should not be considered as temporary make-shifts, but be built

Fig. 65.

in a substantial and perfect manner, somewhat on the plan illustrated on page 74, which shows a German creamery of 1894

There is a building which can be kept clean, clean in a bacteriological sense, and that will be a permanent ornament to the community, increasing the value of the land in the contributing district.

CHAPTER VII.

PASTEURIZATION IN CREAMERIES.

SKIM-MILK.

Reminding the reader again of the reservation with which I recommend every creamery to secure a pasteurizing apparatus for cream, it now only remains for me to suggest the different manner in which it may be utilized. As to skim-milk, there is, if it is to be returned to the farm for stockfeeding, no need of being afraid of any "boiled flavor," nor is the dilution by direct steam heating so very objectionable, and hence a steamjet scalding, be it the fancy Bentley "Germicide" or a common steamjet, is the simplest and cheapest.

But better still is the utilizing of the exhaust steam as suggested in Mr. Floyd's letter or in any other manner. But to heat the milk without cooling is not right and the time is coming when the American farmers, like their European brethren, will insist on having the skim-milk properly pasteurized.

It is a simple thing to arrange for those who have studied the matter and those building creameries will find that it pays to take advice, even if it should cost them a hundred dollars or two.

THE CREAM.

Until the farmers appreciate pasteurization of the skim-milk, there is no reason why the creamery should do so, and by a careful study of the chapter on heaters and coolers, each one must make his own choice.

The apparatus should be of a capacity corresponding to the maximum run of cream and placed in a position so that it may be used or not, as the occasion demands, without being too much in the way.

As cooling to 60° or 65° is, in most cases, possible with water, there is no need of ice or refrigerating machine at this stage if butter is to be made. Cool down to 60° or 65°, and in winter, if the room is cold, only to 70° or 75°, then add the starter, remembering that it will take fully twice as much as for unpasteurized cream.

When nearly ripe, the cream must be chilled down to 45° and

kept there for not less than 2 hours before churning and if the ripening allows it 6 hours is no harm.

This chilling is essential to secure a good body, and must be done either after ripening or before, but I prefer after, as I can raise the cream quicker to churning temperature after chilling than I can cool it.

SOUR CREAM is now pasteurized and to Mr. Bentley, of Circleville, Ohio, is due that this apparently impossible feat has been proved practical.

Not having tried it, I cannot express any opinion, and regret very much that the experiment stations have not at once taken the matter up.

I lack information about the degree of acidity, but if it is sour enough to have wheyed off, leaving a very rich cream, I can understand it. In that case, I presume, the curd, hardened by the heat, will settle to the bottom and not be incorporated in the butter and cause white specks.

Mr. G. B. Lawson, of Grinnell, Iowa, writes me that he has been converted from his doubts by practical tests, and hence I presume that even if it will not do under any and all circumstances, there is enough in it for every gathered creameryman to investigate.

The fact remains that if there is any curd at all in the cream it will be hardened by the heating and, if not eliminated, cause more or less white specks and a very crumbly "body."

That gathered cream which often has a bad taint will be improved in flavor by pasteurizing is sure enough. but, if possible, I would rather see a system where the farmers learned to pasteurize it themselves or to deliver sweet cream.

THE WHOLE MILK.

If it is desired to pasteurize the skim-milk as well as the cream, it is evidently safer to pasteurize the whole milk before separating, as it will be more effective the sooner it is done, as there will be fewer bacteria to kill.

I read years ago about a creamery in Sweden where they heated the milk to 150° and ran it through the separator at that temperature. I lack practical experience and am a little shy of that method, though it is used successfully in several Danish creameries. Nevertheless, I can recommend the following plan. When the milk is weighed and sampled dump it in a small receiving vat (with no waterspace). From this run it through the heater to a regular storage vat with

cover, where the waterspace is kept filled with water of 160°. If any of the centrifugal heaters are used, the milk can be elevated to the second tank while heating; an evident advantage.

From the storage vat the milk is cooled to 85° or 90° by running it over water coolers to the separator.

A second cooler cools the cream and skim-milk to the desired temperature, as they leave the separator, and here must be used ice or iced water.

As objections may be made to the extra work of having three coolers instead of one, I am reminded of the fact that it takes a certain amount of cooling surface to cool a certain quantity of milk a certain number of degrees (100 or more) with water of a certain degree, and hence it is immaterial how that surface is divided. And it is surely better than the plan proposed by Mr. Buass, (Fig. 38, page 37) where he uses three heaters and two coolers, as my plan only requires one heater and three coolers, besides holding the milk longer at the high temperature.

By this system it will be practical to satisfy the bacteriological demand for a longer exposure to the heat in the storage tank.

But, and a very large *but*, if you please, it must be remembered that pasteurization means money, money for coal to make steam for heating, money for ice and labor of handling it or else for coal to pump water or to run a refrigerator machine, and, last, but not least, money to pay for the extra help which is necessary to keep the apparatus and everything else connected therewith clean, bacteriologically clean, if you please.

If there is not sufficient water, if there is no ice or refrigerator machine, if the buttermaker is expected to run the pasteurizer as he is sometimes expected to run the churn while he receives the milk and does the separating, then pasteurization will prove a delusion and a snare, and far better not fool away any money on the machinery.

A man, and a good man at that, should be hired and made responsible for the pasteurization and the proper ripening of the cream. If he does this and keeps everything pertaining thereto clean, he may have some time to spare, but not so very much. It is certainly a fair $\frac{3}{4}$ day's work in a creamery running between 10 and 12,000 lbs of milk.

Nevertheless, it is possible to save part of these expenses if the creamery is arranged so as to utilize all the heat otherwise wasted in

the exhaust steam. Indeed, Mr. Floyd claims it cost him next to nothing, and it will interest the readers to read the following letters in reply to my inquiries.

LETTERS FROM MEN WHO PASTEURIZED,

9th Nov., 1895. SIOUX FALLS, S. D.

MR. J. H. MONRAD,

Dear Sir:

Yours received. We are delivering pasteurized milk to the city trade. The cream will not rise upon the milk which is a drawback and I am afraid will hurt the business. The cream is of course first class. For butter making our experience was that the grain of the butter was injured by the heat. Rapid cooling did not offset it, nor low churning in temperature. Pasteurizing can be done at a very slight expense by using the exhaust steam from the engine and at the same time have on hand all the hot water necessary to use in a creamery. Creameries near large cities can pasteurize cream and milk and work up quite a business, but in small cities the milk supply is good and the cream is wanted. The cream and milk will keep much longer, of course, and for ice cream making pasteurized cream is superior. The time is coming when all cream and milk in large cities will be pasteurized. It is not expensive as we do it hardly taking any more fuel. The truth is that creameries waste in fuel quite a good deal by not using their exhaust steam. It is heat and heat is money if you can use it. We condense it all and return it to the boiler.

Yours truly,

F. H. FLOYD.

16th Sept., 1895. SIOUX FALLS, S. D.

J. H. MONRAD,

Dear Sir:

Your favor received. I have a hot water tank and cold water tank. In the hot water tank I have heavy, but large galvanized iron coils three inches in diameter sufficiently large to heat water very rapidly. The more coils I put in the quicker I heat the water and the quicker I condense the steam, though I find that I do not begin to use up, or rather condense, all of the steam in the coils that are in the hot water tank, consequently I have additional coils that are outside of the building, in the summer time, and inside in the winter. By having large coils the steam condenses rapidly, which in my opinion, makes a vacuum, and, of course, you do not have back pressure. You understand that none of this steam escapes from the coils but simply passes through them until I have at the other end water or condensed steam. There is a large amount of that radiated by these coils, the use of which I make in heating water and heating the building in the winter time. Over my boiler I have two tanks with a partition in one of them and at the bottoms two holes in the partition, with an outlet just below the top of the partition into the other can. This is what I call a filter. When filled with water the oil will stay on top which can be skim-

med off regularly. This is cylinder oil, which should be used very sparingly. This condensed steam is forced back into the boiler by a small steam pump, with a valve, to cut off the supply to the boiler. We give full vent of steam to the pump. It will not be forced into the boiler any faster than it can go through this valve. One portion of the exhaust is tapped and a small piece of pipe is run in to the water before it goes to the boiler. I, therefore, have hot water and no lime going into the boiler. The hot water, from the hot water tank, passes through the pasteurizing coils (if you use them) and overflows into another tank over which is a rotary pump. I use, however, something like the Lackey heater, which is connected up with steam, the hot water and the cold water. To regulate the temperature I have a thermometer in one end of the outlet. I pump hot water back again into the hot water tank just as regularly as it goes through the coils, which it usually does pretty hot, of course not over 160 deg. This practically takes no fuel as my hot water is usually too hot. In pasteurizing I got up a vat, a round one, with the coils inside working on a pivot. The cover acts as a bearing to hold the coils in place. I agitate these coils by a lever handle, but do not make the complete circle. We connected the hot water pipe to the coils by steam hose. This vat, which is a round cylinder, has a wooden jacket with at least six inches of space to pack ice around. Of course, the coil which, by the way, has a good many square inches of radiating surface, cools as well as heats the cream by the use of cold or hot water, and on the outside of the can ice should be packed to cool the milk or cream. This, I believe, is the most successful pasteurizing tank because it does the work very quickly, much quicker than the square tank. My hot water tank and cold water tank are connected by valves. To cool the cream shut off the hot water and reverse by using the cold water and pump that back, if you want to, into the cold water tank or pump direct from the well after using up the cold water as long as possible. Nothing but ice will do to finish the operation. I can pasteurize

Fig. 66.

any amount of sweet cream or milk with the ordinary heat from a 10-horse power engine, during the process of separating or churning. No live steam escapes into anything. I use only exhaust steam to heat all of the milk. before it goes to the separator, and this condensed steam, as we have it, drained back to the boiler tank. I increased the size of my tin heater over the ordinary size (Fig. 66) and it works way ahead of live steam. Twenty-eight cents a day, with coal at three dollars (\$3.00) per ton, will enable me, with a 9 horse power engine 15 horse power, boiler to separate the cream for 5,000 lbs. of milk, heat up 300 gals. of scalding hot water, heat all my milk before it goes to the separator, during the summer months, and lastly, sterilize skimmilk, that is always left over for the farmers to begin on the next day.

Yours truly,

C. L. FLOYD.

P. S.—We have one boiler that we have run for four months the water used for which would be very limey if it was not used over and over again as it is. Our

boiler is just as clean as when it came from the paint shop, but it is not well to use too much cylinder oil. Three or four drops a minute is sufficient and the cost of the fuel bill tells the rest. An injector saves nothing, but put water into a boiler at 190 deg. and the fuel money will be saved very quickly.

GRINNELL, IOWA, Sept. 10th, 1895.

FRIEND MONRAD.

Dear Sir:

Received yours of 7th inst. In reply would say that this is the third season that I have been pasteurizing cream for the city trade. The first year we only pasteurized the cream from about 1500 lbs. of milk a day, which was mostly shipped to Des Moines for making ice cream. That first year all I pasteurized was done in 15 gallon milk cans set in a tub of boiling water. The second year I got up a heater with a continuous flow, which pasteurized the cream as fast as it ran out of the separator, which was a success if it was not done on scientific principles. That year we pasteurized the cream from about 2,500 lbs. of milk daily during the ice cream season and was shipped to Des Moines and Oskaloosa. This past summer I have been pasteurizing new milk, cream and skimmilk for the Crescent Creamery of St. Paul, Minn., doing the heating in a large 300 gallon vat made for the purpose, and cooling by drawing off the milk into 5 gallon cans and setting them in a pool of cold water. This season I have pasteurized 250 gallons of new milk, 150 gallons of cream and 200 gallons of skimmilk a day, which was used in the city of St. Paul. Most of the cream was used for making ice cream, some of the milk was shipped about 60 miles on the railroad and was not received at the creamery until ten o'clock, and before the car could be unloaded and the milk and cream taken care of it was noon, and the pasteurizing could not be done until after noon, and by that time some of the milk had begun to sour, which made pasteurizing a very particular job, as one can of sour milk would spoil the whole vat full, and the greatest care had to be exercised in tasting and smelling every can of milk before it was emptied into the pasteurizing vat. Pasteurized skimmilk will keep sweet longer than the whole milk, or cream, and the richer the cream is the longer it will keep sweet. I have pasteurized cream that was shipped 50 miles on Monday morning after it was separated, and that same cream was made into ice cream the following Friday, and it was in good condition. In the past three years I have made about 300 lbs. of butter from pasteurized sweet cream with good results. Today I have commenced to pasteurize sour cream for buttermaking and shall report results later. Yes, I do find in all vessels, large or small, more or less of a thin film on the sides caused by coagulated albumen, but it is easily washed off if not allowed to become dry before washing, by using gold dust and boiling water and a good scrub-brush. My heater holds 6 gallons, it sets in a barrel of water, which is kept at the boiling point by a steam pipe direct from the boiler. The cooler sits in a barrel of fine ice and salt, the funnel of the heater sets under the cream spout of the separator and it will heat the cream as fast as it comes out of the separator up to 150 deg. if wanted.

Yours truly,

G. B. LAWSON.

FILTERED WATER AND LONG KEEPING BUTTER.

I have again and again emphasized, that the pasteurizing of the cream for buttermakers is only to be recommended. (1) At creameries where, in spite of all precautions, the milk delivered is "off" has weedy or other bad flavors. (2) At creameries where it is known that the butter is to be exported or even held for long cold storage. While there may be exceptions to the last, I am sure that all butter for export should be made from pasteurized cream.

Then, and then only, can we hope to work up a reputation for clean, pure flavor combined with uniformity, which is all-important on the world's market.

It is not my province here to treat buttermaking, but must emphasize the futility of pasteurizing the cream, if the butter afterwards is washed with any kind of water, a custom which I regret to say obtains generally.

If the water supply comes from a deep drive well it may be safely used, but in all cases it would be money well spent for any creamery to have it analyzed chemically and bacteriologically.

Where the water comes from shallow, open wells, or is pumped from creeks or rivers, it should always be boiled or filtered, at least all that is used for rinsing the cream vat, the churn and the butter worker, as well as for washing the butter.

Fig. 67.

Fig. 68.

If our experiment stations had taken this matter up in a practical manner, I am sure they would long ago have demonstrated that much of the faulty butter on the market is due to the water.

From Mr. Boggild's excellent book "Danish Dairying," I take the illustrations Fig. 67-68, which represents a galvanized iron filter. The cross section, Fig. 68, shows first a loose perforated wooden bottom, then a layer of pebbles, then gravel, then sand, then another perforated bottom. On this there is a layer of charcoal and then a layer of scrap iron. The upper bottom has only one hole in the centre, and is covered with pebbles. The height is 3 ft., 6 in., and the filter is filled with the above mentioned materials at least two-thirds. Fig. 67 represents the manner in which the filter (a) is fixed on the wall, with the supply pipe (e) and its cock (f) provided with a rod (g).

In order always to have filtered water in stock a storage tank (b) is provided. The latter ought, however, to have a cover not shown in the illustration.

I am of the opinion that the water before filtering or after, ought to be boiled and then cooled, unless indeed the Utopian age were here when every creamery has a

PASTEUR FILTER.

CROSS-SECTION PASTEUR FILTER.

This filter which—I regret to say requires a pressure of at least 20 lbs. to the square inch to do practical work, and which is rather expensive, is not only a filter, but a complete sterilizing apparatus, as no microbe, no germs of microbes even, can pass through those wonderful hollow "candles" made of a composition of unglazed porcelain, prepared by Pasteur's associate, Prof. Chamberland.

The idea of sterilizing milk this way lay near and would obviate the dreaded boiled flavor, but alas and alack, this filter is so powerful that only a very clear

"whey" would be the result.

I have had some correspondence with the company in Dayton, Ohio, and they tell me that a filter like the one illustrated with 18 tubes should filter 250 gallons a day. This, I presume, would be enough for the average creamery, if used only for the washing of the butter. The cost is somewhere about \$100, and this should not prevent their use if they prove otherwise practical. I refer to the trouble of cleaning the "candles" every day. The water is forced into the upper part of the filter and through the "candles" and out at A.

I hope to see this filter given a fair trial.

A PLEA FOR BETTER BUILDINGS.

It is not only with a view to amuse the reader that I have reproduced a picture of the old Swiss cheesefactory and its contrast, the Modern German creamery, on page 74.

Though the first mentioned picture is from an engraving about 200 years old, I regret to say that I have seen cheesefactories within 10 years that were but a small step advanced from this!

Nor can it be said that very many creameries are built so as to make it possible to keep them clean—bacteriologically clean—or, if you please—dairyologically clean.

I know I shall incur the criticism of those men, who, at their own risk, build creameries, so to say, on the suffrage of the farmers. These may at any time see the farmers build one in opposition.

Nor do I deny the justice of such criticism, calling my demand for creameries similar to the modern one shown as an unpractical unbusinesslike proposal, when looked at from *their* standpoint.

Yet I shall raise my voice and use my pen as long as I live for better creamery and cheese factory buildings, and challenge any criticism if made from the standpoint of the permanent interest of the milk producers.

There is a great cry against expensive creameries, but that has been because these buildings were not better than the cheap ones. yet the objection always remains against the increased interest on money invested.

Let us investigate this question a little. In this country the interest is higher than in Europe and hence I shall not challenge the claim that we can afford to put up a cheap wooden building for, let us say \$3,000, for a 5,000 lb. creamery and rebuild it when rotten for

the difference in the interest on a solid brick building costing double the money.

I shall not challenge this, I say, though there may be localities where the difference would not be great enough to do it, and though certainly fire insurance ought to be lower in the latter case.

But I am not only asking for a brick building, I want it finished somewhat in the style of the illustration. *I want a \$10,000 building where there is now a \$3,000 one.*

The interest account will thus be charged with say 6% on \$7,000 extra or \$420. But this will hardly be $\frac{1}{4}$ cent per lb. of butter.

Leaving out the saving labor in keeping such a creamery clean. I claim that the simple moral effect on the men working in such a creamery will easily increase the value of the butter $\frac{1}{2}$ cent per pound. Nor is the claim "theory" but it is based on 20 years close observation of the *practical* creamery work in many countries.

I said that my proposition would be impractical for "individual" creameries, as they are often called, but there is no reason on earth why the farmer should not build such creameries, or the banks lend money in them.

Take any community which has been blessed with the revelation of dairy truth, take any bank that has seen mortgages removed and good accounts opened by the aid of the cow and co-operation, and build such a creamery. Then tell me if it is not sure to make land more valuable in the neighborhood, just as does a good school, or a good county building, or a good road.

Surely there is no use arguing this point with practical men in this year of 1895. Let us have better buildings by all means.

THE MILK AND CREAM VATS.

Dairy Councillor Boggild (Denmark) has demonstrated that rusty milk cans may affect the milk left over in them during the night and give it a nasty, tallowy taste.

A Swedish buttermaker also proved that a peculiar "fishy" taste in the butter may be traced to the ripening of the cream in rusty tin vats. These are facts which are well worth remembering.

There need not be any trouble if the cans are made of the very best tin and condemned when too rusty.

But I have seen some tin plates, said to have been made in America, which I should be ashamed to use for either purpose.

Wood is difficult to keep sweet, glass is too brittle and expensive, and glazed earthenware too cumbersome.

Prepared paper, as used for buckets, I have never tried, but I do believe that enameled steel will prove the very best and most substantial material.

This will not do for milk transportation, they would be too expensive and our milk train men can give "pointers" to the champion baggage smasher in disfiguring a can.

But for cream ripening cans in dairies and "starter" cans in creameries and cheese factories, I see no reason why a good enameled can should not be the very best.

I have been in correspondence with a firm making enameled goods trying to get them to make a sample can holding 180 lbs., but lack of enterprise foiled my plans.

A 20 lb. enameled can may be bought anywhere for the first development and a can holding 180 lbs. would do nicely for the second and one such can would be enough for most creameries as it holds starter for 1800 to 3600 lbs. of cream.

These cans will—I believe—cost from \$14 to \$15 retail, but it would pay to use them.

A CORRECTION.

The pasteurizing heater illustrated in Fig. 38, page 37, which I copied from an advertisement where no explanation was given, is, according to "*Milch Zeitung*," not a centrifugal machine on the Lefeldt plan, but has a horizontal revolving dasher which acts in the same manner as the vertical one in Fig. 37.

CHAPTER VIII.

HOME PASTEURIZING.

Fig. 69.

In families where it is found difficult to get pasteurized milk or where a single cow is kept for own use, it is safer always to boil the milk; if it is properly chilled afterwards, it is quite possible to get over the objection to the boiled flavor.

But where there are children it is the duty of every mother to see that the milk is pasteurized, and it is economy at the same time to pasteurize the cream so as to make it keep better.

In Fig. 69 is shown a tin boiler in which a quart and a pint bottle is placed on a perforated loose bottom. This boiler is placed on the stove and the temperature raised to boiling point; when it is left alone for about 30 minutes, as a rule the temperature will not have fallen below 150° and the bottles are then taken out and cooled.

Another way is to use the tin can of an ice cream freezer and when the cooling is to be done place it in the freezer and turn as you would when making ice cream. There is no need of using salt with the ice and if the dasher is boiled before using this will be found a very efficient and quick way of cooling.

However common sense will tell each one how to put the principle explained into practice under the different circumstances.

I shall only recommend, in case of preparing milk for babies, to use quite small bottles of only 4 or 6 ounces, and mention the precaution taken in the Straus plant (New York.)

They have a copper cylinder a little larger in diameter than the bottles.

The bottles with milk are placed in these cylinders which are filled with water so as to form a cushion and prevent scorching when heating, and bursting when cooling.

After they are heated for half an hour the bottles are corked and the cylinders placed in ice water to cool.

They gave two formulæ for infant's milk.

I.

Sugar of milk.....12 ounces
Lime water..... $\frac{1}{2}$ pint
Filtered water with the above
to make.....1 gallon
Milk.....1 gallon

II.

Milk.....1 gallon
Barley water.....1 gallon
White sugar.....10 ounces
Table salt..... $\frac{1}{4}$ ounce

These are mixed, filled in the bottles and pasteurized. I give them only as an example, but advise in each case to consult the doctor in the matter.

In Boston there are also laboratories where milk for infants is made up according to doctor's prescription.

If large quantities of milk are to be pasteurized in the bottles, I believe Mr. Straus's precaution a happy one, unless indeed some of the large sterilizing apparatus like Pop and Becher was modified so as to use it for pasteurizing.

I must also mention the Soxhlet sterilizing bottles and stoppers. On the rather wide neck fits a loose metal cylinder which holds a circular piece of rubber in place while heating the milk in the bottle; this allows the steam to escape and as soon as the milk is cooled, the vacuum created thereby sucks the rubber firmly into the neck of the bottle. The metal ring is then removed to be used on the next batch.

City people who do not know whence their milk comes may not even find pasteurizing sufficient and Dr. A. Stutzer in his pamphlet on children's milk recommends the following additional precaution.

It consists simply of a strong test tube of same diameter as the neck of the bottle and a short piece of rubber which fits tightly on both.

When the milk is filled in the bottle, the rubber and tube is adjusted and the bottle turned upside down as shown in Fig. 70.

A few hours rest will allow any possible dust or sediment to settle in the test tube, the pinch cock is closed, the bottle raised and the test tube removed.

Fig. 70.

CHAPTER IX.

GENERAL POINTERS.

1. *Sterilization* in the scientific sense means the absolute killing of all germs and requires a temperature of 230° and one which spoils milk for commercial and manufacturing purposes.

When used about milk, it means its heating to from 210 to 218° Fahr. under pressure and holding it for not less than 30 minutes and then cooling to 50° or thereabout.

2. *Intermittent Sterilization* means the above process repeated having the milk warm sufficient time to develop the germs between the operations.

3. *Pasteurizing* means heating to between 150 and 160° Fahr. and keeping it there for 20 or 30 minutes then cooling it to 50° or thereabout.

4. *Heating alone is not pasteurizing*, but the term is also used when the milk or cream is simply heated and cooled immediately which is sufficient for cream which is to be ripened.

5. The keeping of the high temperature for 20 or 30 minutes is absolutely essential if the milk or cream is intended for commercial purposes.

6. *Intermittent Pasteurizing* will prolong the keeping quality of the milk considerably.

7. The effectiveness of pasteurization (and sterilization) is in proportion to the height of the temperature and the length at which the material is exposed to it. Thus heating at a lower temperature for a longer time may be as effective as a higher temperature for a shorter time.

A lower temperature than 150° Fahr. is considered useless.

8. Pasteurizing is but of little avail unless all cans, bottles and utensils are sterilized.

9. Pasteurizing is of the more value the nearer to the milking time it is brought; there will be fewer bacteria to kill.

10. The quickest heating effect and the least "scorching" of the milk is obtained when the milk is kept in constant motion by flowing over the heating surface (not too slow) or by a stirrer as in the Fjord or the Russell or the Boyd apparatus.

11. Same rule holds good when cooling.

12. The best effect of the heating or cooling water is obtained when it is in constant motion, as by circulating with a pump or a continuous flow of water. This rule applies to apparatus using water.

Where steam is used it will take care of itself.

13. When selecting an apparatus, ponder over a. the labor it will take to keep clean, *bacteriologically clean*; b. Its effectiveness; c. Its durability; d. Its uniformity in working; e. Its compactness and last of all, its cost price.

14. Protection against air while heating is desirable where perfect milk is operated on, but it is not only not necessary but not *desirable* where tainted milk is handled. The same holds good while cooling the first 20 or 30 degrees.

This may not be scientific exactness, but it is good practice.

15. If you are not prepared to get help enough to do the work right and fix everything so that they can do it right without useless labor don't attempt to pasteurize.

16. If you are in the milk business try first on a small scale (see Farm Pasteurizing) and see how your customers like it.

17. If you run a creamery have the apparatus ready and when you have tried everything else and yet cannot get your butter perfect. pasteurize the cream.

19. Remember pasteurizing is not a cure-all for tainted and dirty milk.

20. Pasteurizing, while it will give you a mild, clean-flavored butter, will never give that quick, high aromatic flavor which may be obtained from perfect milk.

21. Pasteurizing does *not* spoil the body of the butter if the cream is properly chilled.

22. Cream will not rise as well on pasteurized milk and this may cause some trouble to the milk-sellers until the customers have been educated.

23. If you are not prepared to spend the time on cleaning the heater where always some albumen will coagulate, if you will not arrange it so as to make it easy to keep everything clean, if you will not provide ice or refrigerator machine—don't pasteurize.

24. If you intend to ripen your cream in a rusty vat, do not pasteurize.

25. If you are not thoroughly posted, call in some one else who is for consultation. You will save hundreds of dollars for every ten you pay for such help.

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