AN ADDRESS delivered before the American Dairymen's Association, at Utica, N. Y., on Wednesday, January 10th, 1872, by X. A WILLARD, A. M., of Herkimer County, New York, Lecturer at Cornell University, and at the Maine State Agricultural College.

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BY

X. A. WILLARD, A. M.,

Of Herkimer County, New York,

ECTURER AT CORNELL UNIVERSITY AND AT THE MAINE STATE AGRICULTURAL COLLEGE.

CONDENSED MILK MANUFACTURE.

ORIGIN AND EARLY HISTORY OF MILK CONDENSING IN AMERICA.

The history of experiments for condensing milk in America dates back to 1846. Possibly the idea of reducing milk to a solid may have occurred earlier in Europe, but if experiments were made in that direction they obtained no success, or at least were of no practical importance. For many years preparations under the name of "Dessicated Milk," "Milk Powders," and "Milk Essence," have been put upon the market, but they were too imperfect to meet the conditions required for general introduction. They were articles prepared from milk, and not the actual milk.

It became evident at an early day that if milk could be

eliminated simply of its water, leaving the other constituents unimpaired, unaltered—in other words, if milk could be converted into a solid, so as to be easily kept for long periods, and then by the addition of water could be brought back again to its original consistency and flavor, such form of milk would prove a boon to consumers, and must find a ready sale if put upon the market at reasonable prices. To Mr. Gail Borden, of White Plains, New York, must be awarded the credit of essentially accomplishing these results. It is true his milk is not reduced to a solid or dry state, but three quarters of its bulk in water have been eliminated, while the other conditions are very perfectly met, and in the present form it is better adapted to the manifold uses and wants of consumers than if it were in a dry state. The history of Mr. Borden's labors and ultimate success has been well portrayed by a writer in the MILK JOURNAL, from which I quote, correcting the errors and giving dates as related to me by Mr. Borden.

It is affirmed that "all the brands of good, or even fair quality now sold, are prepared substantially under the system originated by him (Borden.) As long ago as 1849 he began his experiments, simultaneously with others whose aim was the preservation of meat. It may be mentioned here that in the London Exhibition of 1851 the Council Bronze Medal was awarded to Mr. Borden for his meat biscuit. He did not at this time exhibit his condensed milk. It was not until about 1853 that he himself arrived at the conviction that he had obtained the quality he had been seeking. Meanwhile he had expended energy, time, and quite a fortune in his experiments, for he at length saw that to experiment to advantage, a large amount of material, involving much expense, must be used in each instance.

At an early stage of his experiments he decided that milk could not be preserved in a dry form as "dessicated," or "powdered," or "solidified," but must be left in a semi-liquid state. That some preservative agent must be added, and that nothing but water must be eliminated also became apparent.

The result is that condensed milk, as known to the trade and consumers, consists of milk from which only water has been taken, and to which nothing but sugar has been added, the product being of the consistency of honey, and by a dilution in water reconvertible to milk itself, somewhat sweetened. It may be stated in this connection that all the dry preserved milks require to be

dissolved in hot water while the condensed milk, prepared under the Borden system, readily dissolves in cold water.

By 1861 Mr. Borden had quite extensively introduced his article, and four or five factories were in operation, capable of producing in the aggregate, five thousand cans, of one pound each, per day.

During the war of the Rebellion large quantities were required for the Northern armies, the officers and many privates purchasing it of the sutlers, while the hospitals were supplied by the Government and the various Christian and Aid Societies. This gave an impetus to the trade, at the same time that shipping demand steadily increased.

About 1857 Mr. Borden put upon the market for city use, what he calls *Plain Condensed Milk.* This is prepared in the same way as the other, except that no sugar is added, and it is not hermetically sealed. It will remain sound from one to two weeks according to the temperature in which it is kept, and it is so convenient as well as economical that it is stated that now a large quantity of the milk used in New York City is of this kind.

With the end of the war and the dissolution of the armies the demand for sugared condensed milk fell off and the manufacturers who had been stimulated to too great a production turned their attention to this *Plain Condensed Milk.*"

We have no means of estimating the present extent of the manufacture of condensed milk in the United States. For this we must wait for the returns of the census of 1870. However, we know that the capacity of the factories on the Hudson, in Connecticut, Pennsylvania and Illinois, is not less than five hundred cases of four dozen one pound cans per day, equal to eight million, five hundred thousand pounds per annum. It may be stated that one pound of the condensed milk is equivalent to three or four pounds of crude milk.

In 1865 an American gentleman who had noted the advantages of the article in the American army during the four years of the war, became resident in Switzerland in the capacity of U. S. Consul. Remembering the cheapness and richness of Swiss milk, the cheapness of labor and other facilities afforded in that country, he conceived the idea of preparing condensed milk in Switzerland.

He communicated his views to a gentleman late of the U. S. Patent Office, who visited several factories in America, producing

the condensed milk under the Borden patent, where he learned the art of manufacturing the milk under the Borden process, and commenced manufacturing the same in Switzerland. The Swiss condensed milk has always been made under this process, and from what I can learn, the manner of obtaining information relating to the process was not such as Mr. Borden approved.

The ultimate success of this project has abundantly proved the soundness of this Consul's conception. He promoted the *Anglo-Swiss Condensed Milk Co.*, the extent of whose present business is set forth in the following extract from the "Grocer" of Dec. 31, 1870. The facts seem to have been compiled from statistics procured at the Board of Trade, which were doubtless obtained from the Report of the British Legation at Berne:

"In the Canton of Zug there has of late grown up a new mode of preserving milk, which, owing to the good pasturage of that locality, is very excellent in quality. In the Commune of Cham the *Anglo-Swiss Condensed Milk Co.*, with a capital of $60,000, employ about sixty operatives in their factory, the tall chimney of which may be seen by the railway traveler passing over the line from Lucerne to Zurich. The number of cows hired for the year is 1,440, and the average amount of condensed milk prepared daily during three hundred and sixty-five days of the year—as it is necessary to include the Sundays—is one hundred and ten cases of four dozen each of one pound cans; these equal one million nine hundred and twenty-seven thousand two hundred cans, as the product of the year.

The price of crude milk is about two cents (1d) per quart, and the daily cost of the cans made at this establishment amounts to £16 10s or a trifle over 1½c. for each can.

About one-half of the produce is sent direct to London, where one-half of this is consumed, while the remainder goes for ship-stores, is exported to the colonies and sent to the provincial towns of England. The half of the product not sent to London is distributed over Germany, and there is some demand from France and Russia. It should be remembered that this Company was the first in Europe to introduce condensed milk to family use. Until its advent the article was known only for ship-stores and colonial consumption. By extension and systematic advertising, and through the boundless energy which characterizes your business Yankee, this Company has received a large demand for ordinary family consumption, not

only in England, but also in Germany and Russia. In this respect its success may be largely attributed to the fact that Baron Liebeg and other authorities on questions of food, supported it heartily from the first, and allowed the patronage of their names for publication. Its success led naturally enough to the springing up of competition companies.

These have been established at Gruyeres and half a dozen other places in Switzerland, in Bavaria, in Holstein, in Ireland and in England. But failing to produce a standard quality, and wanting in *prestige*, they have nearly all ceased to manufacture.

All now known to the London trade are the "Anglo-Swiss," Mr. Newman's "Irish Condensed Milk," at Mallow, near Cork, and the "English Condensed Milk Co.," whose works are at Aylesbury, Buckinghamshire. The two last put their milk in the market during the year 1870, and it is stated upon good authority that neither the Swiss nor the English Company has lately been able to supply the call for their products."

PRE-REQUISITES.

I have now given some general features in the history of condensed milk manufacture, and before entering upon details of factories and the process of manufacture, the essential requisites for success may be discussed. In Mr. Borden's early experiments, and indeed up to within a few years past, the nature and cause of a peculiarly bad behavior in milk from time to time were imperfectly understood. Under certain circumstances and conditions the milk could be readily handled, and gave no trouble in its manipulation. When in this state comparatively inexperienced operators, men who simply followed a set of rules, with little or no knowledge of principles, were enabled to turn out a good product, whether it was butter or cheese. Sometimes these conditions would continue for days, for weeks, or for months; but there was no reliability of its continuing for any specified time, or indeed in different localities during the same time. The milk might be easily worked one day, and the next would refuse to be controlled under ordinary treatment. The fault was at first supposed to originate in some want of cleanliness either at the factory, or among those who produced and delivered the milk. This was a part but not the whole trouble.

The importance of cleanliness, and what seemed to many to be "an absurd, fastidious neatness," became apparent to Mr. Borden at

an early stage of his investigations. He therefore instituted a set of rules for the government of dairymen in the care and management of milk; and as he bought only such milk as would pass the closest scrutiny of an expert, he was able after a time to enforce an observance of his printed regulations among dairymen. I shall presently refer to these rules and give them in detail, because they strike home to some of the leading principles for obtaining good milk, and they are such as should be a guide to dairymen generally.

He adopted also the practice of cleaning and steaming at the factory his patrons' delivery milk cans, because he feared, and with good reason, too, that this work might not be properly done at the farm. But when farmers had become educated, and all his conditions of cleanliness had been observed and carried out to the letter, milk not unfrequently came to his factories, which, though apparently perfect, or at least so perfect as to pass the rigid scrutiny of his experts, was in a condition that rendered it impossible to be converted into a good product.

The reason for this was not of easy solution, and it has been the cause of heavy losses and the closing up of factories altogether—factories not under Mr. Borden's immediate supervision.

It may be observed here that good condensed milk is more reliably clean and healthy than most milk that goes to city consumers. Dirty milk, milk foul with the drippings of the stable, cannot be condensed into a clean-flavored product. The success of the condensing factory depends entirely upon the ability to put a fine flavored, perfect article upon the market. The milk must be uniformly good. An inferior condensed milk is more readily detected than an inferior article of cheese. At least, imperfections in cheese may be tolerated and the article may find a place in the market, but a factory sending out imperfect or badly flavored milk, must soon cease to be remunerative, and must inevitably close its doors. To attain any success in this business there is an absolute necessity for clean, healthy milk in the first instance, and when a knowledge of this fact becomes familiar among consumers, condensed milk must take the place of the vile fluid under the name of milk, which is now hawked about in all our leading towns and cities.

And it may be well to warn those who propose to enter upon condensed milk manufacture, that more than ordinary difficulties lie before them. In the first place arrangements must be perfected for obtaining good clean healthy milk and this imposes a sort of edu-

cation upon those producing milk of the greatest importance, and and which, at least in the United States, does not generally obtain. This may be properly discussed under the head of the

FUNGI THEORY.

I have said that farmers need to be educated in the production of milk, to be so well grounded in a knowledge of facts and principles that a high moral responsibility shall obtain.

I have no Utopian theories for regenerating the world, and I have no hope but there will always be more or less bad men, even among dairymen, but I have faith to believe that most farmers when they know a thing to be morally wrong—when they are convinced that right pays best, will generally choose the latter. I assume that no fair minded man will go deliberately to work administering poison to his domestic animals to make their meat bad and unwholesome, when there is no reason to hope that such meat will sell in market for any more than sound meat, while there is probability that it must sell for less, or be a total loss, while at the same time there is the fear of detection and of being held in the estimation of his neighbors and community as a knave and a cheat.

Why then should farmers who have the means at hand for making good milk persist in making that which is bad and unwholesome, if it be not from a lack of knowledge in regard to principles? It is not sufficient to be *told* that he is making bad milk, the *reasons* must be given plainly and the conviction firmly established in his mind as to the truth of the principles enunciated. Then with this knowledge and conviction before him by day and by night, his moral sense is brought into action, and permanent improvement may be expected.

The investigations of Hallier and Pasteur with the microscope have explained the nature of causes in operation to change milk from its normal condition, or render it filthy and unwholesome. They show that this state is brought about by living organisms—that these pervade the atmosphere, and the germs absorbed in the milk from this source multiply and increase with wonderful rapidity, and take complete possession of the fluid, changing it into their own nature. The germs from cesspools, from decomposing or putrid animal matter, when introduced in the milk, carry their own peculiar taint, and by their growth and multiplication soon convert the milk into a filthy putrifactive state similar to that of the substance from which they emanated.

"The micrococcus, for instance," says Professor Caldwell, "appear only in substances rich in nitrogen, but when it does appear, no matter from what fungus it may come, it causes putrifaction. The cryptococcus not only causes the particular kind of decomposition called alcoholic fermentation, but appears only in solutions that are fit for that kind of decomposition," and so on.

The wonderful rapidity with which these fungi produce new cells, each one of which can act as a starting point for new and distinct growth, also increases their power of making their influence for good or evil to be felt everywhere.

"The Pencillium Crustaccum can run through its whole course in forty-eight hours at the most, at a temperature of 50° to 60° Fahr., and produce a new crop of several hundred spores for each old one; and in forty-eight hours more, each spore of this crop of several hundred will produce several hundred more, and so on. At such a rate of multiplication it would take but a few days to reach numbers too great for an adequate conception.

And what is more, this is not the only way, nor even the most rapid way, in which the Pencillium can propogate itself. A Pencillium spore will, in the course of an hour, at a moderately elevated temperature, produce from 20 to 100 micrococcus cells; each one of these cells will sub-divide into two in another hour, and so on. At this rate of increase, we should have, at a low estimate of fifty cells from one spore to start with, four hundred million micrococcus cells from this one spore in twenty-four hours."

Again he says, "From the moment the milk leaves the cow, the work of the fungi commences. They begin to increase, and simultaneously the milk begins to change, both operations going on with a rapidity that varies according to the circumstances of the temperature and exposure, and never ceasing entirely till the milk or its products are digested in the stomach, or have putrified and decayed in the air, producing results that vary according to the product, whether butter or cheese, or simply the milk itself, and what is very important and more pertinent to my subject, according to the kind of fungus that gets a foothold in the substance. The elements of fungi that are already in *pure clean milk*, to begin with, or that are added in the rennet, (when cheese is to be made,) appear to do no harm, but on the contrary, by their legitimate growth and action on the substance in the midst of which they find themselves, to

bear at least an important part in the elaboration of the very principles which give the final product i s savor and its value.

"But the case is quite different in the case of such fungi as are introduced from without, and which originate in *putrid matter* of any kind; their whole influence is harmful in a high degree, and so readily can these minute germs make their way anywhere and everywhere, that if the air containing them in unusual quantity *is inhaled by the cows, their milk will be infected before it leaves the bag.*"

We find this consistent with numerous well authenticated facts. Milk from cows inhaling bad odors has been found to be tainted and incapable of being made into good cheese. The fact was first brought to notice by Mr. Foster, of Oneida, whose herd of cows inhaling the emanations from the decaying remains of a dead horse caused their milk to be unfit for making cheese; and not only the milk from the cows inhaling the odor, but that from a large number of other cows, when mingled together in the cheese factory vats. All the circumstances and facts concerning the case were so carefully noticed and investigated that it left no doubt as to the cause of the tainting of the milk.

Repeated observations by members of the American Dairymen's Association establish this principle beyond peradventure.

Again, I have seen numerous cases where the milk was tainted from cows having passed through sloughs of decomposing vegetable matter. Particles of dirt adhere to the udder, or other parts of the animal, and becoming dry some of the dust perchance falls into the milk during the milking, thus introducing germs which make rapid work in decomposing and putrifying good healthy milk. A most notable example of this came under my observation while on a visit to the cheese factory of Mr. L. B. Arnold of Tompkins County, in 1870. When the milk was received at the factory there was no reason to suspect taint from any particular dairy. The delivery from the several patrons went into the vat together, and was set in the usual manner with rennet. But during the process of heating up the curds a most intensely foul and disagreeable odor was emitted. The cheese maker sent for Mr. Arnold and myself and we went down to the factory together. We found the curds then about half scalded and were giving off a stench exceedingly offensive,—a smell like that coming from a nasty mud hole stirred up and exposed to the air in hot weather.

There was no mistaking the peculiar odor, and I suggested at once that some of the patrons were allowing their cows to slake their thirst from stagnant, filthy pools. He afterwards traced the milk to its source, and found the trouble to come from one patron, who allowing the cows to cross a narrow slough, when particles of mud adhering to the udder and becoming dry, the dust entered the milk during milking, had introduced a class of fungi, which by their multiplication had spoiled the milk.

The patron had meant no harm. He had taken every precaution so far as his knowledge extended for the delivery of good milk, and on correcting this fault the trouble ceased.

Another case is in point and which occurred during the past summer, 1871.

Professor Law, of Cornell University, gets his supply of milk from a "milk man." One day, during the hot weather, he observed a peculiar ropy appearance in the cream which had risen on the milk. He examined it under a powerful microscope and found it filled with living organisms of a character quite foreign to good milk. He immediately called upon his milk-man to enquire concerning his management of stock and general treatment of milk, with a view of accounting for the trouble. There was no fault discovered at the dairy-house or in the milking or general treatment of the milk, but on looking through the pastures he found that the cows, for lack of clean running water, were compelled to slake their thirst for the most part from a stagnant pool. This water he examined under the microscope, and discovered the same class of organisms as those in the cream. He then took some of the blood from the cows, and examined it under the glass, when the same organisms made their appearance.

He next obtained a specimen of good milk—milk which on examination was free from animalculæ—and into this he put a drop of water from the stagnant pool. In a short space of time the milk developed an infinite number of these living organisms, and became similar in character to the milk obtained from his milk-man.

He examined the cows and made the usual thermometer tests for determining health and disease in animals. The cows were found to be hot and feverish, thus evidently showing that the organisms, entering the circulation, had affected the health of the animals.

I have called attention to these facts because it has been very

commonly supposed among milk producers that so long as a due degree of cleanliness in respect to dairy utensils has been observed, the responsibility of bad milk can be shifted upon other parties.

I have said that it is important that the milk producer who delivers milk to the condensed milk factory be thoroughly educated in all the leading causes which injure milk,—that he have a moral sense of the dishonesty and wrong he would be doing in delivering milk which he has good reason to believe would spoil the whole product of the factory for the day.

No system of inspecting the milk as it comes to the factory will reach all the causes affecting milk or determine imperfections often contained in it at the time of delivery.

The milk of cows in heat, of cows over-exercised on account of this disturbance, cannot be used with safety. Yet when such milk comes to the factory mingled with the other milk of the herd, it will be very likely to pass the scrutiny of the expert and be accepted.

Under the best management and most careful examination, losses will inevitably occur from time to time on account of imperfect milk, and a certain per centage must be allowed in making up an estimate of expenses to cover this item. But unless there be some reliability for obtaining good, clean, healthy milk it would not be advisable to enter upon condensed milk manufacture. To this end the character of the country where the milk is produced should be studied. The pastures should be upon high undulating or well drained soils. The farms should have an abundance of clear, sweet, running water while extra attention must be given to the care and management of herds, never over-driving in hot weather, milking with regularity and with fastidious neatness, together with absolute cleanliness in dairy utensils and dairy buildings.

I am told that Mr. Borden's success has resulted in a great measure in locating his factories in the most favorable districts for obtaining good milk, and in every instance he selected for milk producers persons whose long experience in furnishing milk for city consumption had taught a higher appreciation in the care of milk than is common among the cheese dairymen.

Upon this element he commenced and inaugurated a set of rules for guidance in the delivery of milk, a faithful performance of which was rigidly exacted.

These rules are as follows :

I. The milk shall be drawn from the cow in the most cleanly manner and strained through wire-cloth strainers.

II. The milk must be thoroughly cooled, immediately after it is drawn from the cow, by placing the can in which it is contained in a tub or vat of cold water deep enough to come up to the height of the milk in the can, containing at least three times as much water as there is milk to be cooled ; the milk to be occasionally stirred until the animal heat is expelled, as below.

III. In summer or in spring or fall, when the weather is warm, the bath shall be spring water, not over 52° temperature, (a day or night after a heavy rain excepted,) constantly running or pouring in at bottom, necessary to reduce the temperature of the milk within forty-five minutes to below 58° ; and if night's milk, to remain in such bath until the time of bringing it to the factory, to below 55°. The morning's milk not to exceed 60° when brought to the factory.

IV. In winter or in freezing weather, the bath shall be kept at the coolest point (it need not be running spring water) by the addition of ice or snow sufficient to reduce the temperature of the nights' milk speedily below 50°.

V. In spring and fall weather a medium course will be pursued, so that nights' milk shall be cooled within an hour below 50°, and mornings' milk below 55°.

VI. The bath and supply of water shall be so arranged as to let the water flow over the top to carry off the supply of warm water. The can in which the milk is cooled shall be placed in the water immediately after the milking, and shall remain therein until the process of cooling shall be finished.

VII. The nights' and mornings' milk shall be separately cooled before mixing.

VIII. No milk shall be kept over to deliver at a subsequent time.

IX. The milk shall be delivered on the platform at the factory in Elgin every day except Sunday.

X. Suitable cans of proper dimensions to transport the milk from the dairy to the milk works, shall be furnished by the seller, and the cans must be brought full.

XI. The Company shall clean and steam the cans at the factory, free of charge, but customers shall keep the outside clean. The

pails and strainers employed shall be by the seller thoroughly cleaned, scalded in boiling water and dried morning and night.

XII. Immediately before the milk is placed in the cans they shall be thoroughly rinsed with clean cold water, and great care shall be taken to keep the cans and milk free from dirt and impurities of any kind. When the cans are not in use they shall be turned down on a rack with the tops off.

XIII. All the "strippings," as well as the first part of the milk, shall be brought. No milk will be received from a cow which has not calved at least twelve days, unless by consent of Superintendent or Agent, who may determine its fitness sooner by a sample of the milk.

XIV. The cows are not to be fed on turnips or other food which would impart a disagreeable flavor to the milk, nor upon any food which will not produce milk of standard richness.

XV. It is further understood and agreed by the parties hereto, that if the Superintendent or Agent of the Company shall have good reason to suspect, either from evidence furnished or from the state of the milk itself, that water has been added, or that it has not been cooled as provided, or that it has been injured by carelessness, he shall have a right to refuse to receive such milk or any other further quantity of milk from the person so violating these direc-rections and stipulations.

EXPELLING THE WATER BY MEANS OF FANS.

Mr. Borden's plan for condensing milk is to eliminate the water "in vacuo," a description of which will be given further on. This plan involves the employment of machinery somewhat expensive and complicated, and efforts have been made from time to time to accomplish the object by more simple methods and at less cost. Among the most successful methods brought to my notice was that adopted by Provost, of Orange County, New York.

During the year 1865 I visited this factory and made drawings of its ground plan.

The process of evaporation was different from that of Borden, and was claimed to be less expensive, and to be effected with less heat.

In this plan the engine and boiler room is lower than the floor of the evaporating room, and the steam pipes leading to the heating vat and condensing pan are carried along in the basement under the evaporating room. Above the evaporating pan is a chimney-

like ventilator, extending above the building, in which are placed the revolving fans, driven by power supplied by the engine.

THE PROCESS FOR CONDENSING.

The leading features in the treatment of the milk are briefly as follows: The milk, as it comes to the factory, is carefully examined, and if all right it is received and weighed. The cans are then placed upon the car, which runs on rails to the cooling vat. Here the milk is drawn into long tin pails 8 inches in diameter and 18 inches long, holding 20 quarts each. About 18 quarts are put in each pail, when it is placed in the vat containing cold spring water. After the milk has been cooled to 60°, the pails are immediately plunged into the water of the heating vat, which has a temperature of 185° to 190° Fahr. The best refined white sugar is now added at the rate of four pounds for each pail. It is kept in the vat of heated water about 30 minutes, when it is poured into the large condensing pan. This pan has fifty corrugations, and sets over water and upon a furnace in an adjoining room. Directly above the pan are arranged the the two large pans previously alluded to, and which are kept in motion by machinery. The temperature of the milk while evaporation is going on is uniform at 160° Fahr.

The fans carry off the water, forcing it through ventilators out of the building as fast as it is formed into vapor. Under this process it takes about seven hours to condense the milk, seventy-five per cent. of its bulk in water being driven off. The faucets at each end of the pan are then opened, and the condensed fluid passes through fine wire strainers, or seives, into large cans. These cans, when filled, are rolled away to the tables at the back side of the room, where their contents are drawn off into small tin cans holding one pound each, and are then immediately sealed up to exclude the air.

The condensed milk has the consistency of thick syrups; it has a rich, creamy taste, rather sweet, with a flavor of boiled milk, but by no means unpleasant. Dr. Crane informed me that milk thus prepared had been preserved in good order for years, and he opened cans in my presence containing milk a year old, and it was apparently sound and of good flavor.

For shipping, this establishment packed its cans in barrels, with sawdust between the packages, a form which ensured their safe arrival in market. During the war these pound packages were sold at the rate of 40 cents each, and the price paid for crude milk at

the factory during summer was about five cents per quart, but in winter the price ranged from seven to seven and one-half cents per quart.

At this factory, like those under the Borden process, two kinds of condensed milk were manufactured: that which has been described and the plain condensed milk, in which no sugar is added in the manufacture.

This factory is not now in operation. Whether this plan can be made successful in furnishing a uniform product equal to that under the Borden method, is a question upon which I have not sufficient information to give an opinion..

COST OF FITTING UP A FACTORY ON THE BORDEN METHOD.

It is charged as a prominent characteristic of Americans that among the first questions they ask concerning any particular object, is its cost. Perhaps this may not always be in good taste, but among practical men who are investigating a business with the view of investing capital and taking risks, it is always well to look expenses fair in the face.

The building is 16 x 50 feet, with veranda, or shed, 4 feet wide, on two sides. The ground floor is divided into four departments; the first to the right is the can-washing room, 16 x 16 feet, containing the hot water washing tank, with coil of steam pipe; the hot water sink and scalding jacket, the cold water sink and platform for cleaning can. The steam pipe leads from the boiler to this room.

The next is the receiving, condensing, and delivery room, 16 x 16 feet. It contains the receiving and cooling tanks, the heating vat and the vacuum pan. Then comes the engine room, 7 x 16 feet, containing duplex engine and pump, with steam pipes leading to the other rooms. The rooms to the left are the coal shed and boiler room, 9 x 11 feet, where is situated the boiler (60 horse power) and the boiler pump.

Communication is easy from one department to the other by wide doors, and the whole is arranged for convenience in doing the necessary work. The cost of an establishment is put by Prof. Chace of Cornell University, who obtained the estimates for parties proposing to build, as follows:—

Erection of the building, 16x50 feet ready for machinery, &c., &c....	$ 2.500
Vacuum Pan and Condenser, from 4 to 6 feet in diameter.....	1.800
One Duplex 14 inch Pump and Engine.....	1.500

Piping and fitting out	1,500
One boiler, (60 horse power,) and fitting up	3,000
One Pump for Boiler	100
Outside water pipes	not estimated
Water pipes, &c	500
One Cooling tank for receiving and storage	500
One Heating tank and pipes for milk	300
Hot water tank and steam pipes for washing cans, and two rinsing sinks	600
One steam bath for scalding cans and pipes	150
Making a total of	12,450

The daily running expenses of this establishment may be estimated as follows:—

5000 gallons crude milk, say at 12 ½ cents per gallon	$ 625.00
One superintendent per day	5.00
Two men at $2 per day	4.00
One engineer per day	2.00
One-half ton Coal per day	3.00
Wear and tear per day	2.00
Taxes and Insurance per day	.50
Interest on Capital	3.00
Incidental expenses, say	5.00
*Total daily expenses	649.50

To this may be added value of crude milk, say 200 gallons, as an offset against waste, occasional bad milk, &c.

Taking out the 200 gallons crude milk per day as waste, we have remaining 4,800 gallons milk which is condensed at a total cost, (counting the original value of the 5000 gallons,) at the rate of only a fraction above 13½c. per gallon, or say 1c. per gallon more than the original cost of the milk. This would be at the rate of ¼c. per quart for condensing. On 2080 gallons, 80 gallons being allowed as daily waste, the cost of condensing, with the same expenses as before, would be nearly one and three-quarter cents per gallon or less than half a cent per quart. This it must be understood is for *plain* milk. When sugar is added the expense of the sugar must be added, but as sugared milk is sold by the pound, and as the addition of sugar adds to the weight, the increased weight more than pays the cost of the sugar.

In a well conducted factory, and where milk can be purchased at 12 1-2 cents per gallon, (3 1-8c. per quart,) the cost of condensing

*Note.—On submitting the figures for cost of Condensing Milk, &c., to Mr. Gail Borden, he states the estimates above are put altogether too low. To condense 5000 gallons of milk he says would require a larger capacity—of vacuum pans and much more labor than we have estimated. That no one may be misled by low estimates, we may add, say twelve more men at $1.50 per day and daily expenses for coal and larger vacuum pans, $6.00, making $24.00. This sum subtracted from net daily profits, as given, I think must more than cover the case in point.

is from a quarter to a half cent. per quart, and this includes the value of a certain number of gallons of crude milk, daily set apart to cover waste which possibly may not occur.

When the milk is put up in pound cans, the 5000 gallons of milk condensed, allowing for waste as previously estimated, would require ten thousand and forty tin cans, which at $30 per thousand, the estimated cost, would amount to $300,00, or three cents for every two quarts of crude milk condensed. The whole expense then of condensing and canning the 5000 gallons would be at the rate of one and three-fourth cents per quart of crude milk; for the 2000 gallons it would be two cents per quart. The daily expenses then may be summed up as follows:—

Cost of 5000 gallons milk	$625.00
Daily running expenses of factory as previously estimated	24.50
10,040 Cans	300.00
To this must be added expenses of sealing up and labelling the cans, at say 1c. per can	100.00
Making a total of	1,049.50

The daily product of the factory would be ten thousand and forty pound cans of sugared, condensed milk, which at 29c. per can amounts to $2,911.60, leaving a balance of one thousand, eight hundred and sixty-two dollars and ten cents above expenses, for the day's operations. But the milk must now be marketed, and of this I shall treat in another place.

The delivery of 5000 gallons crude milk per day, would require the product of sixteen hundred and sixty cows, allowing each to yield on an average, three gallons of milk per day. If we estimate for a smaller number of cows as within an easy reach of most factories in the dairy districts, the 2080 gallons would represent say 660 cows. For this quantity the account would stand thus:—

Cost of 2080 gallons of milk at 12½c. per gallon	$ 260.00
Daily running expenses of factory as before estimated	24.50
4,016 tin cans at 3c.	120.00
Filling, sealing and labeling cans, (1c.)	40.00
Making a total of	444.50

The product would stand:—

4,016 cans of sugared, condensed milk at 29c. per can	$1,164.64
Leaving a daily balance above expenses of	720.14

Having presented this general survey of the business, we may now turn our attention to some of the details in regard to machinery and manufacturing, and the first that claims attention is

THE VACUUM PAN.

In order to show how milk is condensed "*in vacuo*," it may be well perhaps to give an illustration of some of the modern improved machinery employed for this purpose.

The drawing represents an improved cast iron vacuum pan. Different liquids, as is well known, boil at different temperatures, and the same liquid may be made to boil at any temperature from the freezing point up, according as the pressure upon its surface is taken off or increased. If by reason of boiling in confined space the pressure upon the surface is increased so that steam cannot readily pass off, the heat accumulates to a greater degree than 212° till the steam acquires sufficient elasticity to overcome this increase of pressure. At the bottom of deep mines the increased pressure of the air has the same effect, and steam is not generated at so low a temperature as at the surface. As the pressure is diminished either mechanically by the use of the air pumps, or by ascending elevations, steam is generated and passes off more freely and at a lower temperature. On high mountains it may be difficult even to produce sufficient heat in open vessels to boil eggs.

Darwin was led to notice this when he ascended with his sailors one of the mountains of Patagonia. They took with them a new pot, in which they attempted in vain to boil potatoes. But for the pressure of the atmosphere the ocean would boil and evaporate with heat equivalent to that of the sun's rays. Several ingenious experiments have been devised to illustrate these facts. The simplest is in making a glass of warm water boil under the receiver of an air pump. The pulse glass, consists of two glass bulbs, connected by a glass tube. The fluid in one is made to boil by holding one of the bulbs in the warm hand. This property of being converted into vapor at different temperatures, is made to serve important purposes.

Liquids intended to be evaporated are sometimes partially freed from the pressure of the air, and are thus boiled "in a vacuum" with economy of fuel. This process is adopted with great success in sugar refining. When the temperature of the usual boiling point would injuriously affect the liquid to be evaporated, as milk for instance, it is advantageously boiled with reduced pressure at a low temperature. Syrups are evaporated as in the refining of sugar in vacuum pans, or vessels in which the atmospheric pressure may be partially

taken off by air pumps. A low degree of heat only, is thus required, producing economy in fuel and avoiding the risk of overheating and burning the syrup.

With these well known principles in mind, dairymen will be able to see the advantages obtained by Mr. Borden in using the vacuum pan in expelling the water from his milk. It will be observed too that from the moment the milk enters the pan it is protected from various harmful influences, such as dust, flies and other insects which are liable to be caught in the liquid when evaporation is carried on by an open exposure, like that under the Provost method.

In Europe and indeed in the United States until quite recently, vacuum pans have been formed of copper, but owing to the high price of that metal, the temptation is to make them as thin as possible, and the collapse of the pan, owing to the external atmospheric pressure, is not an unfrequent occurrence. In America the substitution of cast iron has in a great measure obviated this difficulty. I am told that the cast iron pans for condensing milk are employed with quite as much success as those made of copper, and the illustration is that of an iron pan, showing one of the best forms of construction in this material. The illustration shows three coils of pipe, but for condensing milk but one or two—the lower coils in the pan,—are used and the coils are arranged in a circle around the pan instead of across as represented in the cut.

I am indebted to the *Technologist* which furnishes me with the illustration and description of its parts. The drawing is so well arranged to give a good idea of the manner in which solutions of sugar and other organic substances may be evaporated at comparatively low temperature that I deem it important in this connection to a clear understanding of what I shall have to say in regard to condensed milk manufacture.

The pan A, is ten feet, six inches in diameter, and is cast in four pieces, A1 being the bottom, A2 and A3 shells, and A4 the dome piece, B is the dome connected by the vapor pipe C, to the catcher D,—the latter being a cylindrical vessel, divided part way by a partition or apron D1, against which, in case of boiling over, the liquor would be dashed and would gather in the bottom, where the amount can be seen at the glass gauge d1, and if necessary, emptied into the pan by means of the faucet and pipe d. From the top of the catcher D, the vapors are conducted by pipe E to the condenser E1, which is placed 33 feet above the water level in the basin G, to which the

condenser is connected by the stand pipe F. The water rises in the latter to about 30 feet, more or less according to the amount of vacuum, and is held therein by atmospheric pressure on the surface of the water in basin G, the condensing water added flowing off from G, by overflow g. The water enters the condenser at E2, falls over the seive plates e, e1, e2, and comes in direct contact with the vapors which have to pass also through the openings in the seive plates e1, e2, by which arrangement the greatest condensation is produced with the least amount of water.

At E3, the vacuum pump, in this case a dry one, is connected. To prevent the condensing water from being drawn along with the vapors to the pump, the opening E3 is guarded by an apron. H is the pipe through which the liquor enters the pan. I is the drop valve composed of a rubber disk, i, between two plates on the end of lever i2,—a simple and most effective construction, the pressure of the outside air holding the valve perfectly tight; i1 is a semi-globular casing which prevents the liquor from spreading too much when it is discharged. On the end of the valve stem is fastened a scraper J, intended to break any crust of crystalized sugar that may have formed, as any such crust unless removed would of course obstruct the exit of the liquid.

The regular mountings of the pan consists of a man-hole; a thermometer L, the tube of which is enclosed in a pipe l, and reaches to the centre of the boiling liquor; a vacuum gauge M; a glass gauge K, by which the quantity of liquor in the pan is observed; a butter cup N, butter quieting the liquor if it shows a tendency to boil over; an eye glass O, opposite to which is another similar glass through which a lamp gives light to the interior of the pan. Q is a light glass on the top of the pan, through which the entire surface of the boiling liquor may be illuminated, and R is the tester by which proofs are drawn to see how far the process has advanced.

Heat is applied in the following manner:—The bottom of the pan is double, and steam is admitted thereto by the pipe P; the upper shell which forms the heating surface being generally of copper. The steam also passes through one, two, three or even four coils, according to the size of the pan and the amount of water to be evaporated in a specified time. P is the steam branch. The pipe S leads to the bottom, S1 to the lowest coil, S2 to the middle coil, and S3 to the upper one.

As fast as the steam is condensed, the water is led by the pipes U U from the bottom and coils to a steam trap.

It might at first sight be supposed that cast iron would fail to resist the corroding action of solutions, but the results of practice show that the scale which in every case covers the metal, protects the pan completely; and as the liquor is in all cases, charged to some extent with lime, the pan speedily becomes covered with a fine scale or fur, which effectully prevents all injurious action. This is especially the case if the pan be worked continually, but if long stoppages are made, copper possesses decided advantages over cast iron.

Under ordinary circumstances, however, the cast-iron vacuum pan answers every purpose, and they can be constructed in such a perfect manner that one similar to that described, will retain a vacuum of 29 inches for a space of 12 hours without losing more than one inch.

PROCESS OF CONDENSING.

In some of the recently erected factories an improvement has been made in heating tanks, cooling vats, and in the manner of locating these appliances, whereby the milk can be manipulated with more ease or be turned to other purposes besides condensing. The plans of factories previously given, are arranged for the condensing process alone. The new factories are more elaborate in their arrangements, and combine all the conveniences of the cheese and butter factories, as well as those for condensing milk. I shall presently describe one of these establishments, the best built of its kind in America and designed to be a model in all its internal machinery and appliances; meanwhile the general features of the condensing process may be briefly stated.

The milk is delivered morning and evening in small cans, holding about 40 quarts each. They are filled quite full and have a tight-fitting cover. It is understood, of course, that the treatment of milk at the farm, shall have been in accordance with the rules previously given. Then as the cans are placed upon the factory platform the covers are removed and each subjected to a rigid scrutiny by the factory manager, with a view to discover any imperfections. Imperfect milk can sometimes be detected immediately after removing the can cover, from its odor, but if left for a few moments thus exposed to the atmosphere the odor escapes so that the milk, though imperfect, might pass undetected. The examination of the milk as

it comes to the factory, and the faculty of the manager in detecting its condition, will have much to do in securing an uniform good product and it is important that this matter be well understood. The examination should be rigid, and the manager should have sufficient decision of character to reject every sample of milk which is not found to be in good order. After the milk is received it passes through a strainer to the receiving vat. From this it is conducted off, going through another strainer into the heating cans, each holding about 20 gallons. These cans are set in hot water, and the milk is held here till it reaches a temperature of 135° to 140°. It then goes through another strainer into a large vat at the bottom of which is a coil of copper pipe, through which steam is conducted and here the milk is heated up to the boiling point.

Then the best quality of white, granulated sugar, is added in the proportion of one and a quarter pounds of sugar to the gallon of milk, when it is drawn into the vacuum pan having a capacity of condensing three thousand quarts or more at a time. The milk remains in the vacuum pan, subjected to steam for about three hours, during which time about seventy-five per cent. of its bulk in water is eliminated, when it is drawn off into cans holding 40 quarts each. The cans are only partially filled, and are then set in a large vat containing cold water, the water being of a height equal to the milk in the cans. Here it is stirred until the temperature of the condensed fluid is reduced to a little below 70°. It is then turned into large drawing cans with faucets in order to facilitate the filling of the small cans. The drawing cans stand in a room set apart for the purpose, and around the outside of which runs a table or work bench. Here the milk is drawn from the faucets into the small tin cans holding one pound each, when they go to the table, and are immediately soldered to exclude the air. The cans next have the proper labels pasted upon them, and are ready for market. The work of filling the cans, soldering the tops and labelling is usually performed by females. A number of small soldering furnaces are located along the tables where the girls, each with a set of soldering irons, seal the cans as fast as they are brought forward by the fillers.

This is the plan of operations at the Elgin factory, which is somewhat noted for its fine product. In one of the upper apartments of the Elgin factory is the tin room. Here a number of females are employed making the small tin cans. There are machines for cutting out the circular parts of the can at a blow and the putting to-

gether and soldering are very expeditiously effected at the least expense, since all the material is purchased at wholesale, and the employment of females is less expensive than males, while at the same time the work is quite as neatly and substantially made as at the regular shops where males are employed.

THE BORDEN FACTORY AT BREWSTER.

In December, 1871, I visited Mr. Borden at his home in White Plains, spending a couple of days with him and inspecting all the departments of his factory at Brewster. Mr. Borden is three score years and ten, tall, thin, a little stooping from age, and with locks as white as the snow. He has a pleasant, hazel eye, and the whole cast of his face is one of benevolence. He has a hearty, frank, agreeable manner, that is very attractive and puts one at ease from the first. He is a ready talker and has an immense fund of information and anecdote. He gives away large sums of money in charity, and for worthy objects no one appeals in vain. Those who know him best speak of him as the model pattern of a large hearted, kind and christian gentlemen. His integrity is of the sternest kind, and he hates shams and deceptions. He has met with great success in the sale of his condensed milk and deservedly so, because he puts upon the market always a perfect article. The factory at Brewster is an immense establishment and every part of the business is conducted with the regularity of clock-work. The building is located on a small stream where there is a seven foot fall and the water is thus utilized for running the pumps, which is a considerable saving during the year, by way of fuel. The factory has two vacuum pans, but only one was in operation at the time of my visit. It is a six foot pan with two coils of pipe, and 2000 quarts of milk per hour, is the usual rate of condensing. Mr. Borden now believes in doing the work rapidly, and says the sooner you can get the milk from the cow into a condensed form the better. He therefore uses two boilers of 55 horse power each, for supplying steam to the pan. The average pressure of steam in the pipes, at the pan, is 55 to 60 pounds to the square inch. The evaporation goes on best in clear, dry weather. In damp, foggy weather it takes a little longer to get the milk out.

About 10,000 quarts are now being condensed per day. The milk as it is received, goes into square-like boxes or vats; the receiving room being four or five feet higher than the bath and heating room. The bath tubs are circular and have a coil of steam pipe at the

bottom. The bath tubs are filled within six or eight inches of the top, with water. The heating wells are of copper, egg-shaped and stand opposite the bath tubs, a raised platform running between the two. The milk is drawn through a hose from the receiving tanks into copper cans, setting in the bath tubs, each can holding about 40 quarts. Here the milk is heated to from 150° to 175°. It then goes to the heating wells, which have a jacketed bottom for steam, and is heated up to the boiling point. It is then immediately drawn to the vacuum pan, a stream of milk is kept flowing into the pan about as fast as the evaporation goes on, or at the rate of about 2000 quarts per hour. When the sugared milk is to be made, the amount of sugar is calculated for the given quantity of milk, and then turned into a moveable tank or well, and here the hot milk is poured upon it till it is thoroughly dissolved. The hot sugared milk is drawn up last in the pan, and mingles with the milk which has been partially condensed in the pan. The sugared milk must be eliminated of more water than the plain milk, since the addition of sugar partially liquifies the mass—a curious fact.

Three pints of milk makes a pound of sugared milk. The three pints of raw milk will weigh on an average 3 pounds, 3 and $\frac{2}{3}$ ounces. Now by eliminating 75 per cent of water, (38 520-1000 ounces,) we have remaining 12 ounces and 855-1000 of an ounce; add to this the proportion of sugar now used, 6 3 4 ounces, and we have 19 605-1000 ounces, or about 3 and 6-10 ounces more than a pound. So it will be seen this 3 6-10 ounces in water has to be eliminated in addition to the 75 per cent. of water in the first instance.

Mr. Borden told me that the matter of getting the right proportion of sugar was the result of long study and numerous experiments and no other proportion gave such good results in the product. The plain condensed milk is reduced from 4 to 1. It is treated in the pan precisely like the other except near the close of the operation, when the vacuum in the pan is broken and the mass super-heated or raised to a temperature of 190° to 200°. The super-heating process was discovered in 1862, and this is one reason which gives the Borden brands their superiority in the market. The super-heating not only helps its keeping qualities, but prevents granulation. During the super-heating process, the water which passes off has an intensely disagreeable odor. The heat in the vacuum-pan throughout the whole of the Borden process, apart from super-heating, is kept at a temperature of from 135° to 145° Fahr.

At the Brewster factory they have a filling machine by which two women will fill 10,000 pound cans per day, of ten hours. In the old way the two would fill but 3000 cans in ten hours. Two women will put the labels on 10,000 cans in a day, and one woman will seal or solder up 1200 cans per day. The machinery for making cans here is very complete, 14 boys at tops and bodies, and soldering on machines, with one man cutting bodies, will make 11,000 cans per day; the expense being about 2 3-4 cents per can for labor and material all told. This factory sends about 50 forty quart cans of Plain Condensed Milk to New York daily, which is sold at from 40 to 50 cents per quart. The question may occur, why is the milk heated in the bath and then in the wells? and why not heat all in one place? Mr. Borden says milk cannot be heated to the boiling point in one vessel, except at great loss from adhesion to the metal, and besides causing great trouble in cleansing. The heating in two places avoids this. At this factory they have a "can washing machine," which does the work in a moment by machinery.

Mr. Borden in describing his process to me, said, (and I give his exact language,) as follows:—"The milk is brought up to 150° to 175° in the bath, then poured into the heating well where it is brought to a boiling heat and from thence drawn into the pan by atmospheric pressure, by the air pumps. The sugar is dissolved with a portion of the boiling milk taken from the heating well. The making of a good article of milk depends not so much upon the formula in the best specification, *as upon the condition of the milk when brought to the factory*, and the care and attention given to every part of the process, from the washing of the vessels and the thorough cleanliness which should be observed in every department. The success of the milk manufactured at our three factories, known as the 'Gail Borden Eagle Brand,' is due to the attention which we give to the personal inspection of every department of the dairies on the farms, which is assigned to one person at each factory; the constant examination of every man's milk by samples taken and subjected to tests as to cream, sweetness and the time it will keep after being brought from the dairies.

In short there is nothing manufactured requiring so much care and everlasting vigilance and attention as that of milk. From the time it is drawn from the cow, until hermetically sealed in cans, it requires that everything should be done with the utmost integrity.

I am assured from what I see in your writings on the subject of

milk as applied to the making of butter and cheese, that you fully concur in all I have said in relation to this subject. We both realize that it is for want of a full understanding of the delicate character of milk, that so many have failed in producing a good article either of cheese or condensed milk."

After condensing the milk and drawing from the vacuum pan, the pan must be thoroughly cleaned. For this purpose there is a man-hole by which a person can enter the pan and do the work with brushes, sand paper and water. I am told that Mr. Borden for a long time experienced considerable difficulty in having the pans properly cleaned, as the milk during the process of condensing would adhere to the metal, and bake or harden into a crust. After a while it was discovered that by oiling the metal on the inner surface of the pan this difficulty could be obviated.

The discovery was made through merely accidental circumstances and from observing an old housewife grease the pot preparatory to making "minute pudding." On applying the principle to the vacuum pan, it was found to prevent the milk adhering to the metal, and a patent was at once secured upon it. This is one of the secrets of the condensing business. Mr. Borden informs me that by having water in the pan before drawing on the milk the same object is effected as by greasing the pan.

GAUGING THE MILK.

Difficulty is sometimes had in determining when the milk has been reduced to the proper consistency. In regulating this, samples of condensed milk are drawn from the pan, and from its appearance on cooling, the amount of water eliminated is judged. Errors not unfrequently occur in carrying the condensing process too far, especially with persons who have not a correct eye, or who may become a little careless at times.

I am told that a gauge placed in the pan is an important aid in this matter. The quantity of milk when it enters the pan being noted, the gauge indicates the amount and rapidity of the evaporation, and thus renders great assistance in regulating this important point in the process. For it must be observed, if the reduction is carried beyond 75 per cent. there is not only a loss in weight, but the consistency not being uniform will have its influence on sales, besides the quality is liable to be deteriorated.

PLAIN CONDENSED MILK.

The plain condensed milk has the same amount of water eliminated and is treated in the same way as that which has been described, except that no sugar is used in its manufacture. It is not put up in sealed cans, but will keep sound for several days, and is intended for present use. It is sent to market in cans holding 40 quarts each.

Recently a "non conducting can" has been invented for shipping this kind of milk. It is of tin and nearly the same form as the carrying cans, but double, with a space of two inches between the outer and inner surface, which is closely packed with ground felt. In these cans the milk goes to market in sound condition.

THE COMBINED FACTORY.

I have alluded to the modern plan of combining with the manufacture of condensed milk, that of cheese and butter. In other words, the fitting up of a factory in which either one or the other or the whole three products can be made from the daily delivery of the milk. Experience has shown that the combined factory is the safest and in most cases should be adopted. There will be certain seasons of the year when it will be more difficult to make good condensed milk than at others. There are times, too, when the milk received does not prove to be in that prime condition that would be advisable for condensing, but which might suffice for the manufacture of cheese. Again, the breakage of machinery might render it impossible to condense the milk for a day and perhaps for longer periods. Changes in the market also may possibly render it advisable to run a smaller quantity of milk through the condensing process, for a day, a week or a month, than at other times. These, and a variety of other circumstances occuring or liable to occur, demand that ample means be had at the factory for manufacturing the milk into some other form than that of condensed milk. For it must be observed that after a number of persons have been engaged to deliver milk at the factory, it must be received, if in good condition, and unless provision be made for its manufacture, in some form, heavy losses will entail. Where arrangements are perfected for turning the milk into butter or cheese, or condensing it at pleasure, advantage may be taken of any unfavorable circumstance, and the milk is properly disposed of without loss. There are other reasons for the construction of factories on this plan,

which I shall name hereafter under their appropriate headings. The factory plans here referred to are those of the Middletown factory on the Erie Railway, about 60 miles from New York City. This establishment was erected during the year 1870, at a cost of more than $50,000, and is probably the most convenient and best furnished in its internal fittings of any condensing factory in America. The lower story or basement is partly below the surface of the ground. The basement rooms are about nine or ten feet between floors, and the lower floor being about six feet below the level of the ground, built in with heavy walls and thoroughly underdrained, gives a low, even temperature the year round. The floor is covered with stone flagging, nicely laid in cement, so as to make a perfectly tight bottom, and where no accumulation of water or filth can find an entrance. And it may be observed here that all condensing factories should have basements similarly constructed, since by securing a low and uniform temperature, the milk can be kept in better order and a better product be secured. The main building is 40x68 feet, three stories, with wings 22x22 feet on the left, and 22x50 feet on the right and two stories high. The basement is divided into churn and butter room to the left, 22x22 feet, vat room 40x68 feet, containing the cooling vats, cheese vat, elevator, presses, &c., with steam pipes and hose leading to various parts of the building. The room to the right is the pump and wash room 22x22 feet with scalding and cold water vats, vacuum pumps, &c., &c., and containing the lower portion of the vacuum pan, projecting through the ceiling from above. Out of this and along the side of the main building is the boiler and engine room. The boiler is of 60 horse power. On the second floor of the main building is the delivery room 40x68 feet. Here are the heating tanks of galvanized iron or of tin with jacketed bottom of copper, in which steam is admitted to heat the milk. They are each four feet in diameter and about six feet long, rising about eighteen inches above the floor, and extending through the floor and into the room below. They have a capacity of holding about 400 gallons each. Between each two tanks there is a ventilator communicating with the room below and running to the roof. Openings are provided in each room so as to give thorough ventilation. A track for milk-car runs from the delivery window along side of the tanks, and extends to the elevator, so that as fast as the milk is delivered, the cans are placed on the car and thus conveyed to the tanks and dumped, or the milk may be placed on the elevator and

lowered to the room below. This room is double floored,—the floors laid in cement, so as not to allow leakage. On the left is the office 22x22 feet, provided with desks, &c. On the right is the vacuum room 22x22, with vacuum pan in the centre, the lower part of the pan extending through the floor and into the room below, where the condensed milk is drawn from the pan. The communication between the rooms is by stairs Here also is the condenser and pumping machinery. Back of the vacuum room is the canning department where the milk may be drawn from the filling cans into pound packages and then sealed and labeled. The third or upper floor is the cheese curing department, provided with racks or tables for the reception of the cheese.

Near the ceiling of the basement are iron shafts connected with gearing to the engine by which the churns are driven, the elevator raised or lowered at will, and all other work requiring power transmitted. Cold spring water flows in and out of the cooling vats and other water tanks, while steam is conveyed by pipes from the boiler to the heating tanks, and to other parts of the building as desired. The whole structure above the basement walls is of brick and the boiler chimney, 126 feet high, is very substantially laid. Of course, a factory embracing the same ground plan could be erected much cheaper, as everything connected with the building and fixtures has been made upon the most expensive scale.

CONDENSING SKIMMED MILK.

Plain condensed milk is varied in manufacture:

I. By using "whole milk," or milk containing all its own cream.

II. By mixing skimmed with whole milk, and when this is done the skimmed milk is first drawn into the vacuum pan, and after its volume is reduced considerably, the whole milk is added and the mixture then reduced to the required consistency.

III. By condensing the skimmed milk alone.

TREATMENT OF THE MILK.

At the Middletown factory skimmed milk is extensively used for condensing. After the milk is taken from the delivery window and dumped into the heating tanks, steam is admitted to the jacketed bottom and the milk heated to 130°. A small quantity of alum and saltpetre is sometimes added to the milk, for the purpose of more readily clarifying it. During the heating process the impuri-

ties in the milk rise to the surface and are skimmed off, and when this is effected (the time of heating ranging from one and a half to two hours) the milk is ready to be drawn either into the vacuum pan or cooling pails. These pails are eight inches in diameter by twenty-two inches long, with iron bails, and are set in the vats containing cold spring water. The vats are placed in the basement as before described, and the pails of milk are constantly surrounded with flowing spring water. The pails are filled by attaching a rubber hose to the bottom of the heating tank, where there is a faucet with tube going through the jacket to the milk. The operator then carries the hose from one pail to the other and they are thus rapidly filled.

The cooling vats, four in number, are each twenty one feet long by four feet wide, made of three inch pine plank and separated into three divisions. Here the milk sets from eight to twelve hours, according to the character of product which it is desired to make. After the cream is taken off, the milk may be drawn at once into the vacuum pan, simply by running a rubber hose from the milk to the pan, as the pressure on account of the vacuum in the pan is sufficient to draw the milk through the pipes. During the process of condensing, the temperature of the milk in the pan is kept at about 135°, a vacuum of 22 to 25 inches being maintained. The milk having been reduced to its proper consistency is drawn from the vacuum pan into the cooling pails, which are immediately plunged into the vats containing cold spring water. The pails are about half full, and the average temperature of the water is 52° Fahr. When thoroughly cooled it is ready to go into the non-conducting shipping cans to be transported to market. The condensed skimmed milk brings 25 cents per quart. Under this process, in the month of July, when the daily delivery of milk was between five and six thousand quarts, eight quarts of milk yielded one quart of cream, and the whole quantity of cream made 400 pounds of butter per day. When whole milk and skim milk are used together for condensing, the evening's milk having been strained and placed in the small tin cooling pails, they then go to the water pools or tanks and are surrounded with flowing spring water on the same plan as at the butter factories. Here the milk sets until morning, when the pails are taken out, the cream dipped off and the skimmed milk immediately drawn into the vacuum pan. In a vacuum

of about 24 the milk will begin to boil when the mercury indicates 100° Fahr. The heat soon rises to 135° or 140° and is allowed to go no farther. The morning's milk as fast it is delivered goes to the pools in the same way as the night's milk, and after the milk in the vacuum pan has been somewhat reduced in volume, the morning's mess is taken from the pools and is drawn into the pan and the mixture then reduced. By this process a good product of plain condensed milk, it is said, can be made; while for sugared milk some operators think a more uniform product, or the "smoothest milk," is made from milk that has had about half its cream removed before going to the pan. One of the leading difficulties in the condensing process, is to carry the milk along and draw it from the pan, before it is in a condition to granulate in cooking. It should be "smooth" and not gritty under the tongue, the latter state arising from the sugar-of-milk assuming a granulated form. When milk is treated in this way no saltpetre is added, or indeed any other chemical. The use of such substances to clarify the milk is believed to be of doubtful expediency, since it is always better to have the milk in such good order, that these clarifying aids may be dispensed with.

Under this latter plan butter factories have been successfully turned into condensing factories at small cost; since a copper vacuum pan 4 feet in diameter with all the fixtures complete may be had for $1,500, and a single vacuum pump of suitable size for the pan, $800, or a duplex pump, $1,000, making for the pan and pump either $2,300 or $2,500.

RESULTS FROM THE SKIMMED MILK PROCESS.

From the foregoing statistics it appears that 15 quarts of milk were required for one pound of butter, while a pound of butter was made on an average from less than two quarts of cream. The butter in 1871 was marketed at 40 cents per pound, and the buttermilk at 1 cent per quart; 750 quarts of cream taken from the 6,000 quarts of milk would leave 5,250 quarts skimmed milk, and this eliminated of 75 per cent. of water makes 1,312 quarts of plain condensed milk.

Without taking any account of the buttermilk, the daily receipts may be very nearly estimated as follows:—

400 pounds butter, 40c	$160.00
1,312 quarts condensed skimmed milk, at 25c per quart	328.00
From this we deduct cost of 80 gallons of crude milk allowed for waste, 12½c	10.00
And we have a total of	$478.00

The daily expenses on the basis of former estimates would be as follows :—

6,000 quarts of milk, or 1,500 gallons, at 12½c per gallon.	$187.50	
Daily running expenses of factory	24.50	
Making	$212.00	
Which leaves a daily balance above expenses of		$266.00

Perhaps it may be said that my estimate of factory buildings in the first instance, $2,500, is too low. This is a matter which cannot well be regulated here, but the other expenses, with additional estimates as referred to in the note, $24.00, will give sufficient data for determining the profits to be derived from the business.

Providing one-half of the skimmed milk be made into skimmed cheese, we should have as before :

400 pounds butter, 40c		$160 00
656 quarts condensed milk, 25c per quart		164.00
2,625 quarts milk, or say 525 pounds of skimmed cheese, at 10c.	52.50	
Making a total of		$376.50
Less 80 gallons for waste	10.00	
Leaving		$366.50
The daily expenses as before, 600 quarts milk, 3½c	$187.50	
Running expenses of factory	24.50	
Making total	$212.00	
Leaving a daily balance above expenses when butter and cheese, and plain condensed (skim) milk are made, of..		$154.50

It will be seen that the profits from the business must vary considerably according to the character of product manufactured, and under the combined factory plan here described, great latitude is given to vary the manufacture of the milk into such products, as shall seem most advisable from time to time.

It may be observed in this connection, that when milk is set for cream during 8 to 12 hours only, and is then skimmed, the skimmed milk contains considerable butyraceous matter, and makes a good-tasting and palatable article of condensed milk ; since by varying the quantity of water for the purpose of returning it to its original consistency, or by using less water it can be made to assume the appearance of cream, while it contains more nutrition, bulk for bulk, than the milk in which all the cream is retained. For invalids or those in delicate health the skimmed milk is decidedly preferable, and is so recommended by physicians.

MARKETING.

The question of markets and marketing is perhaps the most serious of any concerning this business. I have given the prices at which the different kinds of condensed milk are sold. But can these prices be maintained, and is there a demand and a market for a large or indeed any considerable increase in these products? These are grave questions and of serious import to those who are proposing to embark upon condensed milk manufacture. So far prices have been maintained, and the Borden factories have met with abundant success. I do not hear of any complaint among consumers that prices are exorbitant, but, on the contrary, many affirm that condensed milk is cheaper than the milk-man's crude milk, inasmuch as the latter is largely adulterated with water, is liable to sour on your hands,—besides from its frequent imperfections losses are entailed upon the consumer which amount to more, during the course of a year, than the difference in price between crude and condensed milk.

City consumers who have become accustomed to the use of condensed milk generally prefer it to the crude milk, as more uniform in quality, more convenient for use, more reliable in flavor, and more healthful as an article of food. But the class using condensed milk in America, as compared with that using crude milk is very small. Indeed, there are thousands of people who have never tasted, or even seen or heard of condensed milk. Doubtless if the public generally could be made acquainted with the cleanliness required, and the freedom from impurities or adulterations in condensed milk, it would soon take the place of crude milk in all our leading towns and cities. Immense sums are now expended in carrying the crude milk to market, 75 per cent. of which would be at once saved if condensed milk could be made to take the place of crude milk. But should the water with which the milk-man dilutes his milk, be also taken into account, the saving on transportation would be much greater. Up to the present time, the condensing business has been in a few hands, and as little has been known generally concerning its manufacture or profits, prices have been controlled and maintained. Is it not to be feared that any large and sudden increase in condensing milk (especially before people have become somewhat educated as to its use and character) would have a tendency to glut the market, and thus prove disastrous to manufacturers?

With an increase of the business, there is little probability that

present prices can be maintained, and here the question occurs whether a considerable reduction in rates could not be made, and yet a fair profit be realized in the business. The price of crude milk in all our large cities will average nearly, if not quite, eight cents per quart. Say that one cent per quart be allowed the factory for manufacturing the plain condensed milk, and four cents per quart as the cost of crude milk at the factory, then there are three cents per quart which remain to be expended in transportation and delivering it to city consumers. Upon this basis, four quarts of crude milk reduced to one quart of condensed milk would be worth twenty cents at the factory. This would give a living profit to manufacturers and to producers.

And now the question occurs, how much is it worth to transport and market the quart of condensed milk? Call it four cents, and we have the quart of condensed milk in the hands of consumers at twenty-four cents, which is equivalent to crude milk at six cents per quart. But as the condensed milk is cleaner, purer, and will remain sweet and sound longer than the crude milk, the consumer realizes the boon long sought for in obtaining a cheap, nutritious and healthful food.

In the higher and more philanthropic aspect of life, the cheapening of food for the masses, and especially the poor, is a consideration not to be overlooked, and cannot be well over-estimated.

Looking at this question of markets in all its relations, we should say that the safest plan to be adopted would be to establish combined factories, where the main business at first would be the manufacture of butter or cheese, or both, entering upon condensed milk gradually, and making no more than could be marketed in the nearest cities and surrounding towns.

I have no doubt that in every country village where crude milk is peddled, plain condensed milk could be readily introduced, and if an uniformly good article were furnished at reasonable rates, I am of the opinion that it would supplant, in a great measure, the crude milk.

I cannot tell how long it may take to introduce this form of milk into general consumption. That must depend upon the activity and energy with which it is placed before the public. People are wedded to old usages, and do not readily change unless urged, or convinced of the advantages resulting from such change. But I am persuaded that condensed milk, like other practical methods for improving the

comforts and healthfulness of mankind, must in the end be triumphant. City consumers have for years endured the bad milk brought to their doors as a necessary nuisance, from which there was no ready way of escape.

The new method opens the remedy for this difficulty, and as people become acquainted with it we may reasonably suppose they will adopt it.

CONCLUSION.

In conclusion we may say that the condensing business requires considerable capital, great labor, unceasing care, and minute attention to details, which paid workmen will neglect if not constantly watched. Mr. Borden thought he could get an extension of his patent if he tried, but he would not try. He preferred to rely on his skill and faithfulness in the manufacture in open competition. The product made at his factories has never been surpassed. In his early experiments scientific men told him that it was useless to think of retaining the (oil) cream, but he said it would not be milk then, only "skim milk," and so he kept on experimenting, and finally succeeded in retaining all the cream. To do this successfully under his process, the milk is brought to a temperature of 212° Fahr. before it goes to the pan, as I have described in the early part of this paper.

Some think that the condensing process must necessarily make slow progress, on account of the difficulty of getting skilled labor and the constant watchfulness required to make an unexceptionable article. Factories have been started from time to time and abandoned on this account. But Mr. Borden has kept steadily on, and he has met with merited success, because he has never allowed a poor article to go upon the markets. And this should be a rule among all those who propose to enter upon its manufacture.

AN ADDRESS

DELIVERED BEFORE THE AMERICAN DAIRYMEN'S ASSOCIATION, ON

THURSDAY, JANUARY 11TH, 1872,

BY

L. B. ARNOLD, Esq.,

Of Ithaca, N. Y.

POISON CHEESE.

With the great expansion of the cheese interest in the United States and Canada, there has been a steady improvement in the quality produced, but there have also sprung up some other results not so desirable; among them is the occasional development of poison cheese, concerning which I have been invited to speak to-day.

The first case of poison cheese that I can recollect, which attracted the attention of the public or the notice of the press, occurred some fifteen or sixteen years ago. It appeared first in Philadelphia, and afterwards in New York City, and, I believe, some other places. The symptoms produced were very distressful, and indicated mineral poison, which it finally proved to be. It was easily distinguished from cheese not poison, by its containing black spots, which were traced to the white lead with which the cheese tubs and milk pails of the dairy were painted. The painting scaled and rubbed off into the milk or whey, and mingled with the curd, and by the agency of the lactic acid, developed in the curing of the

cheese, was converted into lactate of lead. The cause becoming known, it was at once removed by painting dairy utensils with zinc instead of lead. Since that time cases of poison cheese have occasionally made a wave of excitement in the public mind. Lately, since the introduction of the factory system, they have become more frequent. That they should now and then occur is not strange. Cheese, in its best estate, is poisonous to some people. Persons to whom cheese is so distasteful and poisonous that they cannot eat it at all, are often met with. I once knew a case of most distressful vomiting from a child's eating a bowl of bread and milk, in which had been accidentally dropped a piece of cheese about the size of a pea. The cheese was not eaten. The vomiting was produced from the influence of the cheese imparted to the milk, as, upon examination, it was found in the bottom of the bowl. This poisonous action of cheese was not confined to this single instance. It had manifested itself before, and continued the same from childhood to middle age, when the patient was lost trace of.

I have heard of other cases about as striking as the one described. It was not the fault of the cheese, in the case related, that it became so obnoxious. Other members of the household ate of the same cheese with no unusual effect. One of the most singular facts in this case was, that while cheese was so offensive in taste, and poison in effect, milk, and even curd, were eaten with a good relish and with perfect impunity. As long as the curd remained such it was agreeable and harmless; but the moment it became cheese it was distasteful and poisonous. It was therefore nothing in the milk, nor anything in the rennet that converted the milk into curd, that produced the peculiar result. It was evidently due to the cheesy fermentation in connection with a constitutional peculiarity of the individual.

But the cases of poison cheese that are occurring now-a-days are not just like the one described, for they occur with people who have been in the habit of eating cheese without any bad effect. Cases of this kind are not peculiar to the present day: they have occurred at intervals for fifty years or more, both in this country and Europe But they seem to be of more frequent occurrence recently than at any time before. They are peculiar in their nature, and have undoubtedly one common cause. They are all alike in having no connection with any mineral poison. The most rigid analyses by different chemists have invariably failed to find in them any evidence

or trace whatever of any mineral poison, though those analyses have been many times repeated by able professors. The characteristics of the cheese, too, though not such as to attract much attention, are all similar and uniform in all the cases, no matter how widely scattered. It appears riper and richer than usual for its age, has a salvy and fatty appearance, and a strong flavor that is rather acid. Such are the common points of the descriptions so far as received.

The symptoms are equally uniform. Pain in the stomach and nausea, and vomiting in moderate cases; extreme distress and cramping in severe ones, followed with diarrhœa; death rarely, and only in extraordinary cases. The symptoms generally appear within three hours, and are in most cases very intense. As a little five year old boy who was poisoned last summer in Batavia expressed it, they are "awful sick." It is a very singular fact, in most of the cases that have come to my knowledge, that though the poison is so very virulent in some stomachs, others can eat of the same cheese that is so poisonous to some, without any deleterious effects, especially after it has stood a few days with the cut surface exposed to the air.

Cases of cheese-poisoning are becoming quite common, much more so than is generally supposed. Interested parties have preferred to hush them up rather than publish them, for fear of the effect upon the consumption and price of cheese. But this is hardly a fair way of treating the matter. Better face the difficulty squarely; better take the beast by the horns, and master it if we can.

The poison in cheese appears to be very variable in its efficacy. Besides affecting persons differently, cases may be observed of every conceivable shade of strength, from slightly nauseating to those that produce the extremest symptoms. It may be interesting to refer to some of the severer cases that have lately occurred. In St. Lawrence County, New York, a case occurred in October, 1869, that was noticed at the time by Mr. Willard in the *Rural New Yorker*. From the account there published it appears that the poisoned people traced the cheese, through the dealer who purchased it, back to the dairy, where nothing in the making, or about the dairy, was different from usual. All appeared cleanly, and everything done in the usual manner.

"No deaths," he says, "came from eating the cheese, but the persons who ate of it were taken suddenly ill with pains and cramps,

and excessive vomiting, showing evident indications that they had been poisoned." Samples of this cheese were sent to Professor Jackson, of Boston, who, after a rigid examination, reported, as usual, no poison found in any of the samples, but appended the following to his report: "But there is a small proportion of offensive putrifying animal matter, which has been separated here, that does not belong to good cheese." Other facts appeared in the account of this cheese which would be interesting to those who care to investigate this matter. A case appeared in Fairfield, Michigan, last May, the effects of which were more wide-spread and severe. I have no authentic account that any deaths occurred, but a large number of persons were made deathly sick. It was a very serious occurrence, and the most extensive of any that has come to my knowledge. All the cheese made in one of the three vats in a certain factory for three days, not always consecutive, proved to be poisonous. The cheese, when cured, was scattered about the State and out of the State, and spread the poison over a wide extent. Persons partaking of it were made sick in the same way as before described. The effects produced, as the proprietors of the factory related, were nausea, excessive and protracted vomiting, most excruciating pains in the stomach and bowels, followed generally by diarrhœa. And yet, they say, though so many people were made so terribly sick from using this cheese, others partook of it with no unusual effect. A sample of this cheese was sent to Cornell University for Professor Caldwell to analyze. By his kindness a piece of it was presented to me for inspection. It presented no very unusual appearance. It was salvy and rich, and apparently more thoroughly cured than usual for a cheese of its age, being about two months old when I saw it. Though it had ripened rapidly, there was no appearance of huffing, being pretty compact, and exhibiting a few gas holes which were pretty large. It had the same strong, sourish smell that has been said to belong to other poison cheese, but it did not appear to be stronger, I thought, than I had seen in cheese not poison. After inspecting, I ate a piece the size of a hickory nut. It was followed with a little pain in the stomach and feeling of heaviness, as is common in cases of indigestion, which soon passed away, followed by no other effect than offensive breath. The next day I ate more, with less effect; and in a few days, the cheese being exposed to the air all the time, I could partake of it as well as any other cheese, except the unpleasant breath that followed every trial of using. It

was not used long enough to determine whether this peculiarity would also have died away or not.

Professor Caldwell ate of the same, sparingly at first, with no noticeable effect; but increasing the quantity gradually for a few days, vomiting followed, which at the time was thought to result from nothing but an ordinary case of indigestion, but inasmuch as this was one of the customary symptoms of that peculiar poison, I suspect it was due to the cheese.

Last winter a pretty bad case broke out in the city of New York, the particulars of which I have not learned, except that a careful analysis by different chemists in the city failed to find any indication of poison.

Another serious case of the kind is said to have occurred at Anamosa, Iowa, by which a considerable number of persons suffered terribly with the same symptoms that followed the Michigan and other poison cheese.

Five members of a family were, not long since, poisoned in Batavia, N. Y., some very severely, others slightly. Symptoms as usual, distressful vomiting that lasted three hours. The appearance of the cheese was nothing different from usual except the strong odor before mentioned, and also quite ripe and rich. It was highly colored, and said to be a Hamburg cheese.

These instances are sufficient to show the general character of the cheese and its effects. They are some of the strongest cases that to my knowledge have transpired. The milder cases that are occurring more frequently about the country seldom attract attention, or are even suspected of having a poisonous character. But I find them quite often, especially in low situations, and I conclude that cheese buyers do also, for I notice that in trying cheese they seldom *taste*, because they soon find that tasting, to use a mild expression, does not agree with them; and I have tasted enough to understand why. Similar cases have also occurred in Europe. Dr. Voelker reports having analyzed several samples with no more satisfactory results than have been obtained in this country. The description he gives of the cheese is the same as is given of poison cheese here. It is rich and fatty, and strong and acid, and its use is followed by the same results. The cause is evidently the same there as here, and chemical analyses there, as well as here, have settled one point pretty conclusively, viz: That it proceeds from no mineral or other poison that the chemist can reach. It is of some other character; some-

thing that dissolves in his crucibles and eludes his search. What, then, can the cause be? is a query that will very likely be raised in the mind of every hearer. But to that query I can only reply as Agassiz did, when he was asked if the human race had a plurality of origin: "I wish I knew."

I propose now, for a short time, to call your attention to some of the circumstances that might be supposed to vary fermentation in cheese, that you may judge for yourselves whether there is any probability that the poison originates in that quarter.

The subject of fermentation in connection with the dairy interest, is both interesting and important. Everything in cheese-making goes on by fermentation. By fermentation we curdle the milk and extract the whey; fermentation ripens the curd in the vat; and the conversion of that curd into cheese in the curing-room, whether it be palatable or unpalatable, wholesome or unwholesome, is the work of fermentation only. This subject was very clearly and ably presented to this Association two years ago, and by those who heard it is doubtless well remembered now.

Every one present, it may be presumed, has a general idea of the nature of fermentation; but I may remark in passing, that the changes it occasions are always accompanied with the growth and development of myriads of living microscopic fungus plants, and that their growth and multiplication are regarded as the *cause* of the changes produced, and that these microscopic plants, or rather the germs or spores from which they originate, take the general name of *ferment;* so that when the terms ferment and fermentation are used, you will refer them back in your mind's eye to the germs as the moving cause.

I may further remark in regard to these fungus plants, that they are susceptible of great variation from changes in temperature, or from the composition of the substance in which they may grow. It is the same species of fungus, growing under different circumstances, that raises our bread, makes alcohol, beer, vinegar, wine, and cheese. This fact has some significance in looking for the cause of poison cheese. If changes occur from a change of conditions, if the same germs by a change of circumstances can be made to produce wholesome cheese in one case, and alcohol in another, it will require no very great stretch of the imagination to suppose that they *might* be so varied as to produce some *other* poison; and it is possible, at least, that the poison in cheese may be thus origi-

nated. The variations in cheese from temperature alone are very great. If two green cheeses from the same vat are placed to cure, one in a temperature of 70° and the other 50°, the one may become a fine, palatable cheese, the other bitter, offensive and unwholesome. But I must not stop to trace the changes further. I must turn to the examination of milk as the more probable cause of contamination, and from the crucibles of the chemist I appeal to the microscope to aid in the investigation.

I have prepared here some illustrations to show how milk appears, both in its natural and diseased condition, when viewed with the microscope, and also to show some of its natural, as well as unnatural, ferments, and how the latter get into it.

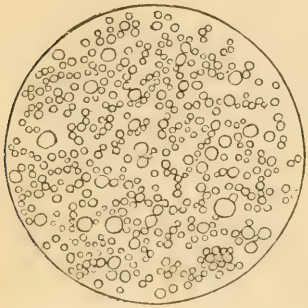

Figure 1 is a greatly enlarged view of the cream globules as they appear in healthy milk. It was taken from the milk of a large number of cows mixed. I wish you to take notice of the great inequality in the size of the globules, as it is an evidence of its healthy condition. This inequality may be a little greater than is common, the sample being taken from the milk of a large number of cows mixed together. The globules in some cases are much larger than in others, but I have seen a difference even greater than this in the milk of a single cow. You will notice also how evenly they are distributed over the view. This is another evidence of healthfulness. In healthy milk the globules are not only evenly distributed through the milk, but they are separate from each other, and move about in the watery mass in which they are suspended with as much freedom and mobility as the particles of the liquid in which they float.

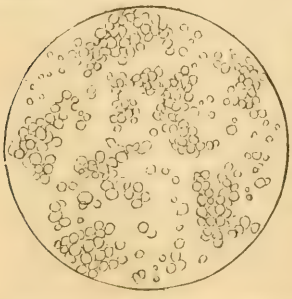

Figure 2 shows a sample of tainted milk, with the globules nearly all in clusters. This was caused by a little fever in the cow. When cows become feverish from any cause, as improper food or water, or exposure to too much hot sun, or by worrying with dogs or flies, their milk under the microscope takes on this appearance. The cream globules change at once when fever occurs, and, probably from incipient decay, their surfaces become viscid and adhesive, and they stick together in