DEPARTMENT OF AGRICULTURE
DAIRY AND COLD STORAGE COMMISSIONER'S BRANCH
OTTAWA, CANADA

Determination of the Specific Gravity of Milk; the Percentage of Acid and Casein in Milk; the Adulteration of Milk by Skimming and Watering; the Percentage of Water and Salt in Butter; the Percentage of Fat and Water in Cheese

BY

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LETTER OF TRANSMITTAL.

OTTAWA, November 27, 1915.

To the Honourable
The Minister of Agriculture.

SIR,—I have the honour to submit the manuscript for a bulletin dealing with certain determinations as to the composition and condition of milk, cheese and butter, which has been prepared by Mr. J. F. Singleton, Chief Inspector of Dairy Products in this branch.

The information herein presented should be of great value to cheesemakers, buttermakers and others who have to deal with milk and its products.

I have the honour to recommend that it be published as Bulletin 46 of the Dairy and Cold Storage series.

I have the honour to be, sir,
Your obedient servant,

J. A. RUDDICK,
Dairy and Cold Storage Commissioner.

THE AVERAGE COMPOSITION OF BUTTER AND CANADIAN CHEDDAR CHEESE.

Per cent—	Butter.*	Cheese.**
Water	13·0	32·06
Fat	83·5	34·43
Casein	1·0	28·00
Salt and ash	2·5	5·51

* Van Slyke. ** Shutt.

DETERMINATION OF THE SPECIFIC GRAVITY OF MILK.

By specific gravity (Sp. Gr.) is meant the weight of a definite volume of any substance as compared with the weight of an equal volume of some other substance chosen as a standard, both being at the same temperature.

In determining the specific gravity of liquids or solids, pure distilled water is taken as a standard and the specific gravity of water is represented by 1.

One gallon of water weighs ten (10) pounds. If one gallon of sulphuric acid is found to weigh eighteen (18) pounds, the specific gravity of the acid is found by the following calculation:—

When a volume of water weighs 10 lbs. an equal volume of sulphuric acid weighs 18 lbs.

When a volume of water weighs 1 lb. an equal volume of sulphuric acid weighs $18 \div 10 = 1{\cdot}8$ lbs.

This means that the acid is 1·8 times as heavy as water or has a specific gravity of 1·8.

The Use of Hydrometers.

The specific gravity of a liquid is not usually obtained by weighing a definite volume of the liquid, but it is obtained by means of an instrument known as an hydrometer. The hydrometer is a glass instrument which floats upright in the liquid, constructed with a small bulb on the lower end, which is loaded with either mercury or fine shot, and a larger hollow bulb above, to the top of which is attached a slender stem with a graduated paper scale inside from which to read the specific gravity. The use of such an instrument for determining the specific gravities of liquids is based on the natural law that "A body floating in a liquid will displace a volume of that liquid equal in weight to the weight of the body floating." The hydrometer sinks in the liquid until it has displaced a volume of the liquid equal in weight to the weight of the hydrometer. In constructing hydrometers for determining the specific gravities of different liquids, the weight of shot or mercury in the lower bulb, and the size of the hollow bulb above, are varied, depending on the specific gravity of the liquid or liquids to be tested. The greater the specific gravity of the liquid or liquids to be tested, the heavier must the hydrometer be loaded in proportion to the size of the hollow bulb. The reading on the graduated stem is taken just at the surface of the liquid. The lighter the liquid, the farther will the hydrometer sink into the liquid, and the heavier the liquid, the higher up will the hydrometer float.

Since liquids expand and become lighter when warmed, and contract and become heavier when cooled, an hydrometer will only give a correct reading when used in a liquid at the temperature for which it is constructed to be used.

The Lactometer.

Such an hydrometer is used to determine the specific gravity of milk and is usually called a lactometer. The lactometer commonly used in determining the specific

gravity of milk is known as the "Quevenne" lactometer. It is usually constructed as a combined thermometer and hydrometer (Fig. 1) and is constructed to give a correct reading when used in milk at a temperature of 60° F.

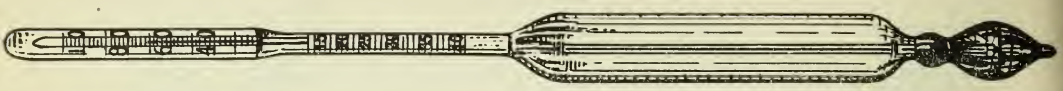

Fig. 1.

The scale on the lactometer is usually graduated from 14 at the top to 42 at the bottom and each of the twenty-eight (28) divisions between 14 and 42 is called a lactometer degree.

Fig. 2.

If the lactometer is constructed as a combined thermometer and hydrometer, the thermometer scale should be *above* the lactometer scale in the stem, so that the temperature may be read when the lactometer is at rest in the milk.

In taking the lactometer reading of milk, a glass or tin cylinder about one and one-half inches in diameter and twelve inches high (Fig. 2) is necessary. To be strictly accurate, the milk should be brought to a temperature of 60° F. and after carefully pouring the milk from one vessel to another a few times to distribute the fat uniformly throughout the milk, the cylinder is filled with milk to within about one and one-half inches of the top. The clean, dry lactometer is now gradually lowered into the milk in the cylinder until it comes to rest and floats steadily in the milk. The point on the scale which shows at the surface of the milk is at once read and recorded and is known as the lactometer reading (L.R.).

The Influence of Different Temperatures.

As pointed out above, as the temperature of the milk is raised above 60° F. (the temperature at which the lactometer is constructed to be used) the milk expands and becomes less dense; consequently, the lactometer must sink farther into the milk to displace its own weight. Since the lactometer scale is graduated from 14 at the top to 42 at the bottom, the lower the lactometer sinks the lower is the reading. On the other hand, as the temperature of the milk is reduced below 60° F. the milk contracts and becomes more dense and the lactometer does not sink as low in the milk to displace its own weight. This means a higher reading on the graduated stem than if the temperature was at 60° F.

In order to avoid the necessity of bringing the temperature of each sample of milk to exactly 60° F., the lactometer reading is usually taken at whatever temperature the milk may be, provided it is between 50° F. and 70° F. It will be found that if a sample of milk has a lactometer reading of say 30 at a temperature of 60° F., the sample will have a lactometer reading of approximately 29 at a temperature of 70° F. and of approximately 31 at a temperature of 50° F. From this, a rule for making corrections to the lactometer reading on account of the temperature being above or below 60° F. is deducted, viz., for each degree that the temperature exceeds 60° F. add $\frac{1}{10}$ or ·1 to the lactometer reading and for each degree that the temperature is less than 60° F. substract $\frac{1}{10}$ or ·1 from the lactometer reading.

For example, if a sample of milk shows a lactometer reading of 29·5 at 67° F., the correct reading would be 29·5 + ·7 = 30·2; and if a sample shows a lactometer reading of say 31·5 at 52° F., the correct reading would be 31·5 — ·8 = 30·7. This rule gives fairly accurate results when the temperature at which the reading is taken ranges

between 50° F. and 70° F., but if strictly accurate results are desired, it is best to bring the temperature of the milk to exactly 60° F. before taking the lactometer reading so that no correction on account of temperature will be necessary.

In taking a lactometer reading of a sample of milk, the milk should not be allowed to stand after pouring, before taking the reading. If the sample is allowed to stand, the cream rises to the surface and the bulb of the lactometer will be in partially skimmed milk which is heavier than the whole milk; consequently, the lactometer will not sink as deeply into the milk, giving a lactometer reading which will be too high.

The lactometer reading of milk should not be taken until milk is at least two or three hours old, as the lactometer reading of fresh milk will usually be about one degree lower than it will be from two to three hours later.

Obtaining the Specific Gravity from the Lactometer Reading.

In order to obtain the specific gravity of milk from the lactometer reading, 1,000 is added to the lactometer reading and the result is divided by 1,000. That is:

$$\frac{\text{L. R.} + 1000}{1000} = \text{Specific Gravity.}$$

For example, if the correct lactometer reading is 30, the specific gravity will be

$$\frac{30 + 1000}{1000} = \frac{1030}{1000} = 1 \cdot 030$$

In order to obtain the lactometer reading of milk from the specific gravity, the specific gravity is multiplied by 1000 and 1000 is subtracted from the result of the multiplication. That is, the lactometer reading = (Sp. Gr. $\times$ 1000) — 1000.

For example, if the specific gravity of a sample of milk is 1·029, the lactometer reading is $(1 \cdot 029 \times 1000) - 1000 = 1029 - 1000 = 29$.

The specific gravity of normal milk usually ranges between 1·029 and 1·034, and will average about 1·0315.

DETERMINATION OF THE PER CENT OF SOLIDS NOT FAT AND TOTAL SOLIDS IN MILK.

The solids of milk consist of fat, casein, albumen, sugar and ash. These total solids (T.S.) are frequently divided and referred to as "Fat" and "Solids other than Fat," or "Solids not fat" (S.N.F.). The percentage of fat is determined by means of the Babcock test.

Calculating the Percentage of Solids not Fat in Milk.

The percentage of solids not fat in milk is calculated from the percentage of fat and the lactometer reading. Several different formulas have been worked out for calculating the percentage of solids not fat. The one most commonly used is to add the percentage of fat to the lactometer reading at 60° F. and divide the result by 4.

$$\% \text{ S.N.F.} = \frac{\% \text{ Fat} + \text{L.R. at } 60^\circ}{4}$$

For example, if a sample of milk tests 3·5 per cent of fat with a lactometer reading of 31·5 at 60°

$$\% \text{ S.N.F.} = \frac{3{\cdot}5 + 31{\cdot}5}{4} = \frac{35}{4} = 8{\cdot}75.$$

Another formula commonly used is to multiply the per cent of fat by 0·2, divide the lactometer reading by 4 and add the two results:—

$$\% \text{ S.N.F.} = \text{Fat} \times 0{\cdot}2 + \frac{\text{L.R.}}{4}$$

Using this formula with a sample testing 3·5 per cent fat and having a lactometer reading of 31·5, the calculation is as follows:—

$$\% \text{ S.N.F.} = 3{\cdot}5 \times 0{\cdot}2 + \frac{31{\cdot}5}{4}$$

$$= 0{\cdot}7 + 7{\cdot}875$$

$$= 8{\cdot}575.$$

This latter formula is slightly more complicated to use, but is more accurate than the former.

Determination of the Per Cent of Total Solids.

The per cent of total solids may be obtained by adding the per cent of solids not fat to the per cent of fat. For example, if a sample of milk is found to contain 4 per cent fat and 9 per cent solids not fat, the per cent of total solids is 4 + 9 = 13.

THE DETECTION OF ADULTERATION OF MILK BY MEANS OF SKIMMING, WATERING, OR BOTH, AND CALCULATION OF THE EXTENT OF ADULTERATION.

The detection of adulteration by means of skimming, watering, or both, and the calculation of the extent of the adulteration is dependent on the effect of such adulteration on the per cent of fat, on the lactometer reading or specific gravity, and on the per cent of solids not fat of the milk.

The specific gravity of water is 1·0, of fat about 0·9, of whole milk usually from 1·029 to 1·034, with an average of about 1·0315, of skimmed milk from 1·032 to about 1·037.

The Effect of Skimming or Partially Skimming Milk.

It will be readily understood that removing part of the cream from milk will cause the milk to test lower in fat content. Since fat has a specific gravity of 0·9, which is considerably less than the specific gravity of milk, removing part of the fat from milk by means of skimming will cause the partially skimmed milk to have a higher specific gravity or higher lactometer reading than the whole milk had before being partially skimmed. Roughly speaking, for each one per cent of fat removed by skimming, the lactometer reading of the partially skimmed milk will be increased by about one degree.

For example, if a sample of milk tests 4 per cent fat and has a lactometer reading of 32, removing 1 per cent of fat, that is, skimming it down to 3 per cent of fat, will increase the lactometer reading to about 33. Applying the formula

$$\% \text{ S.N.F.} = \frac{\% \text{ F.} + \text{L.R. at } 60°}{4}$$

to both the pure sample and the partially skimmed sample, we find the per cent of solids not fat is 9 in each case. That is, if the lactometer reading increases 1 degree with each 1 per cent of fat removed by skimming, the per cent of solids not fat would not be affected. In actual practice, it is usually found that partially skimming milk slightly increases the per cent of solids not fat.

Skimming milk, therefore, reduces the per cent of fat, increases the lactometer reading, and leaves the per cent of solids not fat normal or slightly high.

The Effect of Adding Water to Milk.

If a sample of milk contains 4 per cent of fat with a lactometer reading of 32 (that is a Sp. Gr. of 1·032) and 9 per cent solids not fat, one gallon of such milk will weigh 10·32 pounds. If one gallon of this milk is mixed with one gallon of water, we will have two gallons of watered milk which will contain 2 per cent of fat (one-half of 4 per cent) and 4·5 per cent solids not fat (one-half of 9 per cent). Since a gallon of water weighs 10 pounds the two gallons of milk and water will weigh 20·32 pounds, and one gallon of such milk and water will weigh 10·16 pounds, or have a Sp. Gr. of 1·016 or a lactometer reading of 16. From this we see that adding water to milk reduces the per cent of fat, the lactometer reading and the per cent of solids not fat, *all three being reduced in equal proportions.*

The Effect of Both Skimming and Watering Milk.

If a sample is both skimmed and watered, the watering reduces the per cent of fat, the lactometer reading and the per cent of solids not fat, and all are reduced in the same proportion. The skimming would reduce the fat still further, increase the lactometer reading and either not affect or only slightly increase the per cent of solids not fat. The result will be a low per cent of fat, a lactometer reading normal or low (more frequently low) and a low per cent of solids not fat, *with the fat reduced in greater proportion than either the lactometer reading or per cent of solids not fat.*

To recapitulate:—

Skimming is indicated by (*a*) low per cent of fat,
(*b*) high lactometer reading,
(*c*) normal or slightly high per cent of solids not fat.

Watering is indicated by (*a*) low per cent of fat,
(*b*) low lactometer reading,
(*c*) low per cent of solids not fat, *all three being reduced in equal proportion.*

Watering and skimming is indicated by (*a*) low per cent of fat,
(*b*) lactometer reading may be normal, but is more usually low,
(*c*) low per cent of solids not fat, *the fat being reduced in greater proportion than either the lactometer reading or per cent of solids not fat.*

If a sample of milk appears to be adulterated, a control sample should, if possible, be secured; that is, a sample from the same herd, milked in the presence of the inspector or person making the test. The control sample serves as a basis of comparison and if the original sample shows a marked inferiority to the control sample, it will be fairly conclusive proof of adulteration. There may be, under ordinary

conditions, in the milk of individual cows, variations from day to day, of at least one per cent of fat and one-half per cent of solids not fat. The variations will not be so great in the milk of herds, and the larger the herd, the less will the variation be. In comparing the original sample with the control sample, reasonable allowance, taking into consideration the number of cows, must be made for this natural variation from day to day.

At times there will be a wide variation in the fat content in the night's and morning's milk of herds. Particularly is this the case when the milking is not done at the same hour night and morning. When the periods between milkings are not equal, the richer milk will be obtained after the shorter period, and the variation in fat content between the two milkings will frequently exceed one per cent. The effect of irregular milking on the lactometer reading is, however, not so marked.

Determination of the Extent of Adulteration by Skimming.

In samples which are simply skimmed, the pounds of fat removed from each hundred pounds of the milk is obtained by subtracting the per cent of fat in the skimmed sample from the per cent of fat in the pure sample. For example, if the skimmed sample tests 2·7 per cent fat and the control sample tests 4·0 per cent fat: 4·0 — 2·7 = 1·3 pounds of fat removed from each hundred pounds of the skimmed milk. Therefore, the pounds of fat removed from each 100 pounds of milk = per cent fat in control sample — per cent of fat in the adulterated sample.

Determination of the Extent of Adulteration by Watering.

In calculating the per cent of foreign or extraneous water present in a watered sample, either the fat, the lactometer reading, or the solids not fat might be used as a basis of calculation since all are reduced in the same proportion, but since the solids not fat are less subject to variation from day to day than either the per cent of fat or the lactometer reading, the calculation is based on the solids not fat. To illustrate, if we have a watered sample showing 3·0 per cent fat, a lactometer reading of 24 and 6·75 per cent solids not fat, and a control sample showing 4·0 per cent fat, a lactometer reading of 32 and 9 per cent solids not fat, to determine the per cent of foreign water, the calculation is as follows:—

There are 9 lb. solids not fat in 100 lb. pure milk.
" is 1 " " " $\frac{100}{9}$ " "
" are 6·75 " " " $\frac{100 \times 6{\cdot}75}{9}$ = 75 lb. pure milk.

That is, 6·75 pounds solids not fat are present in 75 pounds pure milk, and since we have 6·75 pounds solids not fat in 100 pounds of adulterated milk, it is evident that 75 pounds of pure milk have been increased to 100 pounds by the addition of water. That is in each 100 pounds of *watered milk* there are 100 − 75 = 25 pounds of foreign water or 25 per cent of foreign or extraneous water. Since the calculation is similar in all cases, we may deduce the following formula:—

The per cent of extraneous water =

$$100 - \frac{\text{per cent solids not fat in adulterated sample} \times 100}{\text{per cent solids not fat in the pure sample.}}$$

That is, to find the per cent of extraneous water, multiply the per cent of solids not fat in the adulterated sample by 100, divide the product of this multiplication by the per cent of solids not fat in the pure sample and subtract the result of this division from 100. The difference will be the per cent of extraneous water present.

DETERMINATION OF EXTENT OF ADULTERATION OF MILK BOTH SKIMMED AND WATERED.

In case a sample is both skimmed and watered, the above formula for determining the per cent of foreign water present, holds good.

To illustrate, if we have an adulterated sample showing 2% fat, a lactometer reading of 22, and 6% solids not fat, and a control sample showing 4% fat, a lactometer reading of 32 and 9% solids not fat, it is plainly evident that the adulterated sample is both skimmed and watered since while the fat is reduced by one-half (from 4% to 2%) the lactometer is only reduced about one-third (from 32 to 22) and the solids not fat are only reduced one-third (from 9% to 6%).

Applying the above formula, we have the per cent of extraneous water =

$$100 - \frac{6 \times 100}{9} = 100 - 66\tfrac{2}{3} = 33\tfrac{1}{3}.$$

The determination of the per cent of fat abstracted by skimming depends on the facts, that skimming does not to any extent affect the per cent of solids not fat, and that watering reduces the fat and the solids not fat in the same proportion. The problem is, therefore, one of proportion.

With 6% of solids not fat we have 2% fat.

" 1% " " " $\frac{2}{6}$

" 9% " " " $\frac{2 \times 9}{6} = 3\%$ fat.

That is, the water which will reduce the per cent of solids not fat from 9% to 6% will reduce the fat from 3% to 2%, or the $33\frac{1}{3}\%$ of water is responsible for reducing the fat from 3% to 2% and the sample was skimmed from 4% to 3%, that is, 1% of fat was skimmed off.

From this we may deduce the following formula:—In a skimmed and watered sample, the per cent of fat abstracted = % fat in the pure sample –

$$\frac{\%\text{ fat in adult. sample} \times \%\text{ solids not fat in pure sample.}}{\%\text{ solids not fat in adulterated sample.}}$$

That is, if a sample is both skimmed and watered, to find the per cent of fat abstracted, multiply the per cent of fat in the adulterated sample by the per cent of solids not fat in the pure sample. Divide the product of this multiplication by the per cent of solids not fat in the adulterated sample and subtract the result of this division from the per cent of fat in the pure sample. The difference will be the per cent of fat abstracted.

If a sample appears to be both skimmed and watered, and one cannot tell by inspection whether the fat and solids not fat are reduced in the same proportion or not, this formula may be applied. If the milk is from a herd, and the calculation shows over ·5% fat abstracted, it is fairly good proof of skimming. If the fat abstracted shows under ·5%, the difference may be due to the natural variation in the per cent of fat from day to day, and one would not be safe in saying definitely that the milk had been skimmed as well as watered.

THE DETERMINATION OF THE PER CENT OF ACIDITY IN MILK.

The determination of the per cent of acid in milk is based on the facts that acids and alkalis neutralize each other in definite proportions and that certain chemicals known as indicators may be used to denote by a change of color in the liquid being neutralized, the exact point at which all the acid and all the alkali are neutralized. This is known as the neutral point. The method of determining the per cent of acid in milk consists of neutralizing the acid in a definite volume of the milk by means of an alkaline solution (usually caustic soda) *of known strength* and using a solution of

phenolphthalein which is colorless in acids and pink in alkalis, as an indicator. By measuring the quantity of alkaline solution of known strength used to neutralize the acid in a given volume of milk, and by knowing the proportions in which caustic soda and lactic acid neutralize each other (which is 40 grams of caustic soda to 90 grams of lactic acid) the per cent of acid in the milk may be calculated. In order to avoid the necessity of calculating the per cent of acid in each sample tested, the alkaline solution is made of such a strength that each cubic centimetre of solution used will neutralize $\frac{1}{10}\%$ or $\cdot 1\%$ of lactic acid in a 10 c.c. sample of milk. This strength of solution is known as a one-tenth normal $\left(\frac{n}{9}\right)$ solution, and consists of four and four-ninths (4 4/9) grams of chemically pure caustic soda in 1,000 c.c. of solution.

The standard alkaline and the indicator solutions may be obtained from the dairy schools and agricultural colleges throughout the country.

The test for determining the per cent of acid in milk is termed the acidimeter and the apparatus (Fig. 3) employed in making such a test consists of:

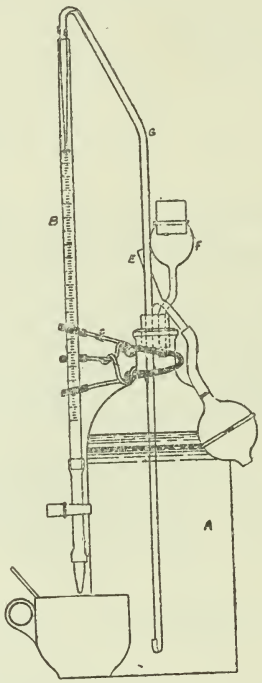

Fig. 3.

1. A 10 c.c. burette, preferably one with a blue line down the back to ensure accuracy of reading, and a glass stop-cock. The burette should be graduated to 0·1 c.c.
2. A clamp for holding the burette.
3. A 10 c.c. pipette known to be correct. Since many of the c.c. pipettes sold are not accurate, the pipette should be tested for accuracy by comparison with the 10 c.c. burette.
4. A delf cup or glass beaker.
5. A glass stirring rod.
6. A dropper bottle for the indicator solution.
7. A bottle for the standard alkaline solution.

Protecting the Alkaline Solution from the Air.

The alkaline solution must be protected from the air since if exposed to air it weakens, due to the neutralization of the alkali by the carbonic acid of the air. The most common form of acidimeter is arranged to syphon solution through glass and rubber tubing from the bottle into the burette. The air admitted to the bottle to replace the solution drawn out, is first passed through the alkaline solution in a small "wash bottle" to neutralize the carbonic acid. This method of protecting the solution from the carbonic acid has not been entirely satisfactory. Prof. W. O. Walker of Queen's University, Kingston, Ont., has recommended covering the surface of the solution in the bottle with kerosene which prevents air from coming in contact with the solution.

Making the Test.

In determining the per cent of acid in a sample of milk, one should first see that all glassware is perfectly clean. The sample is poured to ensure uniformity and by means of the 10 c.c. pipette, 10 c.c. of milk is measured and delivered into the cup or beaker. The pipette should be rinsed with a few cubic centimetres of distilled water or clean rain water, and the rinse water added to the cup. Three to five drops of the indicator solution are now delivered from the dropper bottle into the cup and the burette filled with solution to the 0 mark on the graduation scale, care being taken that no air remains in the tip of the burette. Solution is now carefully dropped from the burette into the milk in the cup, and the milk and solution constantly mixed by stirring with the glass rod. The solution is added until a faint pink colour is obtained uniformly throughout the mixture, which indicates that the neutral point has been reached. If one ceases adding the solution at the correct point, this faint pink colour will disappear in a few seconds due to the action of the carbonic acid on the air. *Sufficient solution should not be added to make the pink colour permanent, as the neutral point will have been passed and the mixture in the cup will be decidedly alkaline.* The number of cubic centimetres of solution drawn from the burette is now noted, and each 1 c.c. used represents ·1 per cent of acid in the milk; therefore, to determine the per cent of acid in the milk, multiply the number of cubic centimetres of solution used by ·1. For example, if 2·1 c.c. of solution have been used, the per cent of acid in the milk equals $2{\cdot}1 \times {\cdot}1 = {\cdot}21$.

Preparation of the Alkaline Solution.

As previously stated, the alkaline solution is a caustic soda solution of strength known as $\frac{n}{9}$, which means that in each 1000 c.c. of the solution there are 4⅑ grams of chemically pure caustic soda. Owing to the difficulty of getting caustic soda absolutely pure and free from moisture, the solution is not prepared by weighing out a definite quantity of caustic soda and dissolving the same in a definite volume of water. A $\frac{n}{9}$ acid (usually hydrochloric) solution is prepared by a trained chemist and the alkaline solution made of such a strength that the $\frac{n}{9}$ acid solution and the alkaline solution neutralize each other in equal volumes; that is, 10 c.c. of the $\frac{n}{9}$ acid solution will exactly neutralize 10 c.c. of the alkaline solution. The alkaline solution will then be $\frac{n}{9}$.

The cheese or butter maker who wishes to prepare the standard alkaline solution for himself should secure a quantity of the standard $\frac{n}{9}$ acid solution from one of the

dairy schools or agricultural colleges or from a trained chemist. Obtain the best quality of caustic soda and distilled water or clean rain water. If a delicate scale and gram weights are available, 5 grams of caustic soda may be weighed out for each 1,000 c.c of solution it is desired to make. For every 5 grams of caustic soda used, 1,000 c.c. of water is measured out and the soda dissolved in the water. Since a $\frac{n}{9}$ caustic soda solution consists of 4⅑ grams of caustic soda in 1,000 c.c. of the solution, the solution obtained by dissolving 5 grams in 1,000 c.c. of water will be too strong, provided the caustic soda is reasonably pure. In standardizing the alkaline solution, it is best to make it too strong at first and then reduce the strength by adding water, rather than to have it too weak at first and have to increase the strength by adding more caustic soda. Two 10 c.c burettes should be used in standardizing the solution, one to measure the acid solution and one to measure the alkaline solution. If two burettes are not available, the acid solution may be measured with the pipette and the alkaline solution measured with the burette. Have all glassware thoroughly clean and after the caustic soda is thoroughly dissolved and mixed in the water, the burette to measure the acid, or the pipette, if only one burette is available, should be thoroughly rinsed with the acid solution. Ten cubic centimetres of the acid solution are delivered from the acid burette or pipette into the cup or beaker and three to five drops of indicator solution added. The burette for measuring the alkaline solution is rinsed two or three times and filled to the O mark with the alkaline solution already prepared. The alkaline solution is slowly dropped into the acid and constantly stirred until the *neutral* point is reached. The number of cubic centimetres of solution used should be noted and the neutralization performed a second time to verify the accuracy of the result. If the alkaline solution is too strong less than 10 c.c. will be required to neutralize the 10 c.c. of standard acid solution. For example, if 9·2 c.c. of alkaline solution neutralize 10 c.c. of acid solution, the alkaline solution is too strong and ·8 c.c. of water must be added to each 9·2 c.c. of solution. By measuring the volume of solution prepared, the necessary volume of water to add may be calculated. For example, if there are 5,000 c.c. of the solution, the water to be added would be $\frac{5000}{9{\cdot}2} \times {\cdot}8 = 435$ (almost). This volume of water is now added to the solution, which is thoroughly mixed and tested for accuracy. If the work has been carefully done, the solution should be of the correct strength, that is 10 c.c. of the alkaline solution should exactly neutralize 10 c.c. of the acid solution. If the alkaline solution proves to be still too strong, more water must be added, if too weak more caustic soda must be added. In standardizing the alkaline solution, two or more tests should be made each time to ensure accuracy. As soon as the correct strength is obtained, the alkaline solution should be tightly corked in a glass bottle or bottles. Earthen jugs are not suitable as containers for the solution. If the solution is not being prepared in a bottle, but in some other vessel, the bottle or bottles to receive it should be thoroughly clean and rinsed with a little of the solution before being filled.

If a delicate scale and gram weights are not to be had, the caustic soda may be dissolved in a little water, making a strong solution. This strong solution may be gradually added to the water, testing after each addition of the strong solution. If too much of the strong solution is added and the solution being prepared is made too strong, it is reduced by adding water. The solution can soon be brought to the correct strength in this manner.

STRENGTH OF INDICATOR SOLUTION.

The strength of the phenolphthalein solution used as an indicator may be varied considerably without affecting the results of the tests and different strengths of solutions have been recommended by different authorities. Prof. Walker has recommended the use of a 1 per cent solution in connection with the Walker method of determining

the per cent of casein in milk and such a solution is also satisfactory for use in connection with the acidimeter. A 1 per cent solution is prepared by dissolving 1 gram of phenolpthalein in 100 c.c. of 95 per cent alcohol.

TESTING CREAM, SKIMMILK, BUTTERMILK AND WHEY.

The acidmeter is also used to determine the per cent of acid in cream, skimmilk, buttermilk and whey in the same manner as it is used in determining the per cent of acid in milk.

DETERMINATION OF THE PER CENT OF CASEIN IN MILK BY MEANS OF THE WALKER CASEIN TEST.

In determining the per cent of casein in milk by means of the Walker method, the acidimeter as described in this bulletin is used. In addition to the acidimeter, it is necessary to have:

1. A 16·3 c.c. pipette.
2. A 2 c.c. graduate.
3. A bottle of neutral formaldehyde solution (40 per cent).

The neutral formaldehyde solution is prepared by adding a few drops of phenolphthalein indicator to the bottle of commercial formaldehyde and then adding the n caustic soda solution until a faint permanent pink colour is obtained.

Making the Test.

In making the test, first secure a representative portion of the milk to be tested. After thoroughly pouring this portion, take a sample with the 16·3 c.c. pipette and deliver the sample into a white delf cup or beaker. Add about 1 c.c. of indicator (1 per cent solution) and add the alkaline solution as in testing for acidity until a decided permanent pink colour is obtained. Now add 2 c.c. of the neutral formaldehyde solution, which destroys the pink colour in the sample. The burette is again filled to the 0 mark with the alkaline solution, after which the solution is again added to the cup or beaker until a permanent pink colour, of the same shade as in the first operation, is obtained. The number of cubic centimetres of solution used in the second operation is noted and will represent the per cent of casein in the milk. For example, if 2·5 c.c. of solution are used, the percent of casein in the milk is 2·5.

The neutral formaldehyde solution should be kept preferably in a glass-stoppered bottle. In time the faint pink colour of the formaldehyde solution will disappear, owing to the action of the carbonic acid of the air, when a few drops of the alkaline solution should again be added to the formaldehyde to restore the colour.

Using slightly more than 2 c.c. of formaldehyde solution in making the test will not in any way affect the results.

In case a 16·3 c.c. pipette is not obtainable, the 10 c.c. pipette may be used and the test performed as outlined. The number of cubic centimetres of solution required in the second neutralization must be multiplied by the factor 1·63 to give the per cent of casein when the 10 c.c. pipette is used.

To avoid the necessity of this multiplication for each sample tested when using the 10 c.c. pipette, the following table has been prepared by the originator of the test:—

c.c. $\frac{n}{9}$ alkali used.	Per cent casein.	c.c. $\frac{n}{9}$ alkali used.	Per cent casein.
1·00	1·63	1·35	2·20
1·05	1·71	1·40	2·28
1·10	1·79	1·45	2·36
1·15	1·87	1·50	2·44
1·20	1·95	1·55	2·53
1·25	2·04	1·60	2·61
1·30	2·12		

DETERMINATION OF THE PER CENT OF CASEIN IN MILK BY MEANS OF THE HART CASEIN TEST.

The apparatus employed in determining the per cent of casein in milk by means of the Hart casein tester (Fig. 4) consists of:

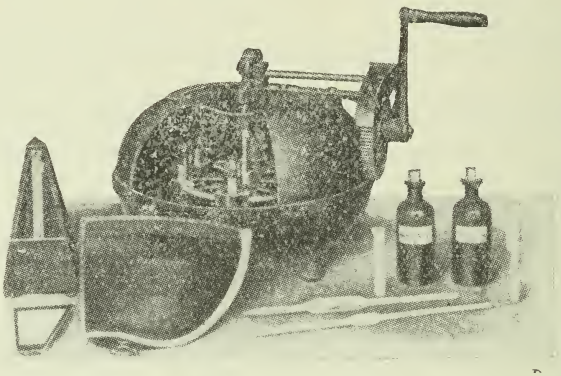

Fig. 4.

1. Centrifuge.
2. Metronome.
3. One pipette, 20 c.c. capacity.
4. One pipette, 5 c.c. capacity.
5. One graduate, 2 c.c. capacity.

The chemicals employed in making a test are chloroform of the best quality and a 0·25 per cent solution of acetic acid.

The centrifuge is constructed to receive either six or twelve bottles, the bottoms of which describe a 15-inch circle when revolving. The bottles are revolved 2,000 times per minute and the machine is so geared that the crank must revolve 55 to 56 times per minute to impart the necessary speed to the bottles.

The metronome is used to enable the operator to turn the crank at a uniform speed of 55 to 56 turns per minute.

The 20 c.c. pipette is used to measure the dilute acetic acid solution, the 5 c.c. pipette is used to measure the milk sample and the 2 c.c. graduate is used to measure the chloroform in making the test.

The bottle is constructed with the graduated stem on the lower end and the bulb on the upper end. The graduation of the scale is similar to that of the 10 per cent Babcock milk test bottle.

Preparation of Acetic Acid Solution.

The dilute acetic acid solution is prepared by adding 90 c.c. of distilled water to 10 c.c. of chemically pure glacial acetic acid. To 25 c.c. of this 10 per cent solution are added 975 c.c. of distilled water, making 1,000 c.c. of a ·25 per cent solution.

Making the Test.

In making the test, the temperature of the milk, the chemicals, and room in which the work is being performed should be between 65° F. and 75° F.—preferably at 70° F.

By means of the small graduate 2 c.c. of chloroform are measured and transferred to the test bottle, and by means of the 20 c.c. pipette, 20 c.c. of the dilute acetic acid are also added to the test bottle. The sample of milk to be tested is carefully poured to ensure uniformity, and by means of the 5 c.c. pipette, a 5 c.c. sample is taken and added to the chloroform and acid in the test bottle. The mouth of the bottle is tightly covered with the thumb and the bottle inverted and carefully shaken for 15 to 20 seconds, which is timed by means of a watch.

Tests should be made in duplicate and should be whirled as soon as possible after being shaken. If more than one sample is being tested, the chloroform and acid are added to all bottles and then the sample of milk added to each bottle, after which all are shaken.

The bottles are placed in the machine in such a manner that the machine is properly balanced. The metronome is now set to beat 55 to 56 beats per minute and the crank is turned 55 to 56 revolutions per minute for seven and one-half to eight minutes.

The bottles are now taken from the machine and placed in a perpendicular position in a rack made for the purpose.

In the lower part of the graduated tube, there is now a liquid which is composed of the chloroform and fat. Above this is the casein, which should appear as solid white column free from ragged edges, and above the casein is the acetic acid mixed with the remaining portion of the milk.

After the bottles have been allowed to stand ten minutes, the per cent of casein is read from the graduated scale.

The test is very sensitive to changes in conditions under which it is operated. Increasing the temperature of the milk, the chemicals, or the room in which the work is performed, will give lower readings, while decreasing the temperature of the milk, the chemicals, or the room, will give higher readings. Decreasing the speed of the centrifuge will give higher readings, while increasing the speed will give lower readings.

THE TESTING OF BUTTER.

Determination of the Per Cent of Water in Butter.

As the principles which determine the percentage of water incorporated in butter have become better understood by buttermakers, a gradual increase in the water content has been apparent. Since it is unlawful to manufacture or to sell butter in Canada containing more than sixteen per cent of water, a simple, rapid and reasonably accurate means of determining the percentage of water in butter has become a necessity for the guidance of the buttermaker as well as for inspection purposes.

Method of Determining the Per Cent of Water in Butter.

Some of the moisture tests which have been put on the market have been complicated and lacked durability. The method most commonly used in Canada at the present time, consists of the evaporation of the water from a definite weight of butter and the determination of the percenatge of water from the loss in weight.

To avoid the necessity of computing the per cent of water from the loss in weight, scales have been constructed to give, when a definite weight of butter is used as a sample, the per cent of water directly from the beam used to balance the scale after the evaporation of the water from the sample. Different makes of scales are on the market which differ greatly in construction, but the principle of the moisture determination is the same.

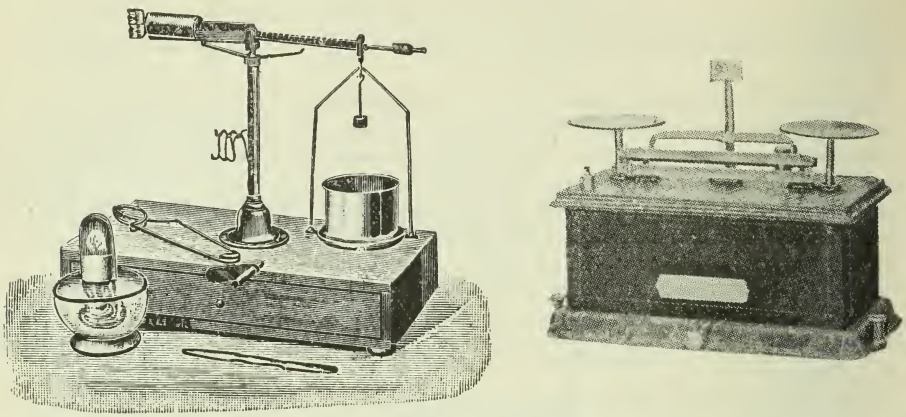

Fig. 5.

The apparatus (Fig. 5) used in making a moisture determination, consists of:

(*a*) The scales;
(*b*) A cup usually made of aluminum in which to heat the sample;
(*c*) Some device to hold the sample cup while heating;
(*d*) An alcohol lamp with which to heat the sample.

Sampling Butter for Testing.

In testing butter for moisture as in testing milk or cream for fat, a sample must be secured which represents as closely as possible the average quality of the quantity to be tested. In taking a sample from the churn, the surface of the mass should be cut away with a spade and a small piece of butter taken from the interior of the mass. Repeat this several times, taking samples from different parts of the churn. Sampling solid boxes, tubs or crocks is best done by means of a trier; taking three or more plugs from different parts of the package. In sampling pound blocks or prints, a good method is to cut out a quarter section of the print, cutting lengthwise of the print. The quarter section may be cut into two pieces, one of which is taken as a sample.

Preparing the Sample for Testing.

When the sample is secured, it should be placed in a clean dry glass jar and the jar surrounded with warm water to soften the butter. The butter should be stirred with a spoon until it is reduced to a creamy consistency and all lumps disappear. The butter should not be reduced to an oil, as the water and salt will settle to the bottom and it is then very difficult to get a representative sample from the jar for testing. If the sample becomes oily, it is difficult to get duplicate tests to agree.

Making the Test.

In making a test, the cup in which the sample is heated should be perfectly clean and wiped dry. It is then heated over the alcohol lamp to dry it thoroughly and placed on the pan of the scale. After the cup is cool, the scale is balanced by adjust-

ing the weight on the tare beam. Ten grams of butter are weighed into the cup from the sample in the jar. The cup is now heated slowly over the lamp to evaporate the water from the sample. The heating should proceed slowly so as not to char the fat, and while being heated the butter should be agitated by shaking the cup with a rotary motion. Care must be taken that no fat is splashed out of the cup. The evaporation will be accompanied with more or less noise from the sample. As soon as the noise ceases and just as the butter commences to take on a more amber colour, the heating should be discontinued, as all the water will have been evaporated. Should the heating be continued beyond this point, the residue will be charred and the result of the test will be too high. As soon as the heating is concluded, the cup is placed on the scale pan and allowed to cool. The scale does not balance now since the sample is lighter, owing to the evaporation of the water. The weights on the beam are now adjusted so that the scale balances exactly and the percentage of water is read from the beam.

When the hot cup is placed on the scale pan, an upward current of air is set up, due to the cup heating the surrounding air. This upward current of air tends to raise the scale pan. Consequently, if the reading is taken while the cup is still hot. it will be too high, since the weights must be moved farther over on the beam to counteract the effect of the air current.

The high pressure oven described under the "Determination of the Per Cent of Water in Cheese" furnishes a most satisfactory method of evaporating the water from the sample of butter.

A method of heating the sample by using a paraffine bath has also been advocated and widely used. The cup containing the butter to be heated is placed in a second cup which is surrounded by paraffine. A small copper kettle contains the paraffine which is heated to a temperature of 175° C. (347° F.) which temperature is maintained during a period of five to seven minutes. This method avoids danger of over-heating the sample, but lengthens the time required to make the test. Experience has shown that heating directly over the lamp, when carefully done, is quite accurate as compared with chemical analysis.

As with cream testing scales, the scales used for the testing of butter should be kept in a dry place.

DETERMINATION OF THE PER CENT OF SALT IN BUTTER.

The method of determining the per cent of salt in butter is somewhat similar to determining the per cent of acidity in milk and cream.

The method of determining the salt content of butter is based on the fact that salt and silver nitrate neutralize each other in definite proportions. The salt contained in a definite quantity of butter is washed out and dissolved in a definite quantity of water. A definite volume of the salt solution thus obtained is measured out by means of a pipette and the salt in it neutralized by titrating with a silver nitrate solution of known strength, using a potassium chromate solution as an indicator, to determine when the neutral point is reached.

Pipettes of different volumes have been recommended for measuring the salt solution and correspondingly different strengths of silver nitrate solutions. Of the different modifications of the method which have been suggested, that outlined in Circular No. 14 of the University of Wisconsin by J. L. Sammis, seems to be the most adapted to our conditions. In this method, a silver nitrate solution, prepared by dissolving five and one-tenth (5·1) grams of chemically pure silver nitrate in two hundred and fifty cubic centimetres of distilled water, and a potassium chromate solution, prepared by dissolving seven and one-quarter (7·25) grams of potassium chromate in twenty-five (25) cubic centimetres of distilled water are used.

Preparation of the Silver Nitrate Solution.

Solutions of the above strength may be procured from the dairy schools, or may be prepared by the buttermakers. The silver nitrate and potassium chromate may be procured from any good drug house. The moisture scales in use read to one-tenth of one per cent of moisture, using a ten-gram sample, which means that the scales are sensitive to one one-hundredth of one gram. Such scales are sufficiently sensitive for weighing the silver nitrate and potassium chromate in making the solutions used in the salt test. It will be best to provide a set of gram weights for use in connection with the moisture scale. If a set of gram weights are not available, ten and two-tenths (10·2) grams of silver nitrate may be weighed and dissolved in five hundred (500) cubic centimetres of water. To weigh ten and two-tenths grams using the Torsion moisture scale, place a small piece of parchment paper on the right pan of the scale and have the sliding weight on the ten per cent beam placed at the ten per cent mark. Next balance the scale by adjusting the sliding weight on the tare beam. After balancing the scale, place the ten-gram weight on the left pan and move the sliding weight on the ten per cent beam back to the eight per cent mark. Ten and two-tenths (10·2) grams of silver nitrate will be required to balance the scale and it is weighed on to the paper. When using a Funke moisture scale, hang the ten-gram weight on the scale as in balancing to weigh a sample of butter, and place one of the heavier weights used in reading the per cent of moisture on the two per cent notch of the beam. Now place the small piece of parchment paper on the pan and add shot or other heavy substance to the pan of the scale underneath the paper until the scale is almost balanced. Complete the balance by means of the poise on the end of the beam. Remove both weights and add silver nitrate to the paper until the scale balances exactly. The ten and two-tenths (10·2) grams of silver nitrate are transferred to a clean, brown glass bottle, fitted with a ground glass stopper. Five hundred (500) cubic centimetres of distilled water or clear rain water are now added to the bottle and as soon as the crystals are thoroughly dissolved and the bottle shaken, the solution is ready to use.

Protecting Silver Nitrate Solution from Sunlight.

The silver nitrate solution, if exposed to sunlight gradually weakens, and the object of using a brown glass bottle as a container is to protect the solution from the sunlight. In addition to this the bottle should, when not in use, be wrapped in brown paper and kept in a dark cupboard. The same precautions should be taken to protect the silver nitrate crystals from light. Owing to the effect of light on the solution, it is advisable for the creamery man to provide a set of gram weights so that five and one-tenth (5·1) grams may be weighed, which will make two hundred and fifty (250) cubic centimetres of solution. The solution will then be made more frequently and there will be less liability of it becoming weak.

Preparation of Potassium Chromate Solution.

The potassium chromate solution as pointed out above, is prepared by dissolving seven and one-quarter (7·25) grams of potassium chromate in twenty-five (25) cubic centimetres of water. If the gram weights are not to be had, ten (10) grams of the potassium chromate may be weighed on the moisture scale and dissolved in thirty-five (35) cubic centimetres of water. Since the 17·6 c.c. pipette *delivers* about 17·5 c.c. two measures of the pipette will give the required volume of water.

The appliances required for making a salt test are:—

(*a*) a scale for weighing a ten (10) gram sample of butter. The moisture scale is used for this purpose;
(*b*) a cylindrical measuring glass about one and one-half (1½) inches in diameter and twelve (12) inches high, graduated to hold two hundred and fifty (250) cubic centimetres;
(*c*) a 17·6 c.c. pipette;
(*d*) a small glass breaker;
(*e*) a ten (10) cubic centimetre burette with glass stop-cock graduated to one-tenth (1/10) of one (1) cubic centimetres and clamp for holding the burette;
(*f*) a dropper bottle for the potassium chromate indicator;
(*g*) a one-pint wide mouth glass bottle.

Making the Test.

A sample of butter is secured and prepared for testing in the same manner as for a moisture test. The scale is balanced with a small piece of parchment paper on the pan and ten (10) grams of the prepared sample weighed out on the paper. The paper and butter are transferred to the pint bottle and two hundred and fifty (250) cubic centimetres of water (preferably soft) at a temperature of 110° F. to 120° F. measured in the graduate and added to the bottle containing the butter. The bottle is thoroughly shaken to melt the butter and wash out the salt. After allowing the bottle to stand a few minutes, it is again shaken to ensure an even distribution of the salt throughout the water. The bottle is then allowed to stand until the fat comes to the surface. The 17·6 c.c. pipette is inserted into the solution of salt, blowing through the pipette until the end of the pipette is below the surface of the water to prevent the liquid fat rising into the pipette. The pipette is filled to the graduation mark with the salt solution and this quantity is transferred to the beaker. To the salt solution in the beaker is added one drop of the potassium chromate solution from the dropper bottle. The burette is filled to the top of the scale with the silver nitrate solution, care being taken that no air bubbles remain in the tip of the burette. The silver nitrate solution is now slowly dropped from the burette into the beaker, which is shaken constantly to mix the silver nitrate solution with the salt solution. As soon as a permanent faint reddish-brown colour is obtained, the addition of the silver nitrate solution should cease as the salt is all neutralized. The number of cubic centimetres of silver nitrate solution required to neutralize the salt is read from the burette. Each cubic centimetre of solution used represents one per cent of salt in the butter. Thus if two and nine-tenths (2·9) cubic centimetres of solution are used, the butter contains two and nine-tenths (2·9) per cent of salt.

Nearly all well waters contain more or less salt and for this reason are not suitable for use in making the silver nitrate solution. Condensed steam from a boiler also contains impurities which render it unfit for use for this purpose. Clean rain water will give more satisfactory results than either well water or condensed steam from a boiler.

If well water is used to remove the salt from the butter in making the test, it should be tested for salt in the same manner as the salt solution from the butter is tested. Whatever percentage of salt is present in the well water should be deducted from the result of the test of the butter. For example, if the well water shows 0·5 per cent of salt and the butter shows 3·5 per cent of salt, the correct test of the butter is 3·5 — 0·5 per cent = 3·0 per cent since 0·5 per cent of salt has been added with the water. Condensed steam from a boiler should not be used at all in making the test. Well water to be mixed with the sample of butter should not even be heated by turning live steam into it. The well water may be conveniently heated by surrounding a small pail or jar of the well water with the hot water.

THE TESTING OF CHEESE.

Determination of the Per Cent of Fat in Cheese.

The per cent of fat in cheese is most easily determined by means of the Babcock test.

Sampling Cheese for Testing.

Sampling cheese for testing is conviently done by means of a trier sufficiently long to bore half way through the cheese. Secure two plugs from each end of the cheese taking the plugs from points distant from the edge of the cheese by about one-third of its diameter. These plugs may be cut lengthwise in strips and a small portion of each plug taken. The small portions of the different plugs are thoroughly spread out and mixed by means of a knife and plate, or mortar and pestle.

Making the Test.

By means of a cream-testing scale, four and one-half grams of the prepared sample may be weighed into a 10 per cent milk-test bottle, or nine grams into a cream bottle. Sufficient hot water is added to bring the quantity in the bottle up to about 18 grams. The bottle is shaken until the cheese and water are thoroughly mixed and all lumps of cheese disappear. The sample is now cooled to 70° F. and 17·5 c.c of acid added and the test completed in the usual manner. If a 9-gram sample has been used in a 9-gram cream bottle, the reading on the neck of the bottle will be the per cent of fat. If a 9-gram sample has been used in an 18-gram bottle, the reading must be multiplied by 2 to get the per cent of fat, and if a 4·5 gram sample has been used in a 10 per cent milk bottle, the reading must be multiplied by 4; that is, the per cent of fat is obtained by multiplying the reading by the number of grams for which the bottle is constructed and dividing the result by the number of grams used in making the test.

Determination of the Per Cent of Water in Cheese.

The per cent of water in cheese is determined by evaporating the water from a definite weight of cheese and calculating the per cent from the loss in weight.

If steam under pressure is available, the most satisfactory method of determining the per cent of moisture in cheese is by means of the high pressure oven (Fig. 6)

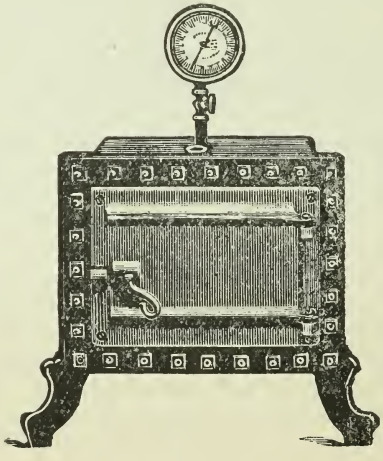

Fig. 6.

which is constructed of cast-iron or boiler plate, and is double-jacketed on four or five sides. It is fitted with a steam inlet to admit live steam to the space in the jacketed

walls and an outlet to drain off the condensed water. The chamber is fitted with a perforated rack on which to place the samples and which permits free circulation of the warm air around the samples. The oven is fitted with a close-fitting door and a thermometer extending into the chamber. The temperature maintained in the oven may be regulated by the steam pressure applied in the hollow walls. In addition to the oven, a fine balance is necessary or a good moisture scale and a set of gram weights. In using the Funke moisture scale with a 10-gram sample, a reading of 39·8 per cent of moisture may be taken, but with a Torsion scale only 30 per cent may be read without the extra gram weights.

Making the Test.

The sample of cheese to be tested is secured in the same manner as for fat determination. The sample is thoroughly spread out by means of a knife and plate, or a mortar and pestle, and 10 grams are weighed into an aluminium or tin dish, which has been thoroughly dried by heating and then balanced on the scale after cooling. The cheese is spread as *thinly* and as *evenly* as possible over the dish. The work of sampling, pulverizing and weighing the cheese into the dish should be done as quickly as possible, to avoid loss of water by evaporation. The dish containing the sample is now placed in the oven, the door closed, and 45 to 50 pounds steam pressure applied to the oven. This should give a temperature of 225° F. to 250° F., which will be sufficiently high. The sample is heated until all the water has been evaporated, which point is determined by successive weighings followed by further heating in the oven, of course allowing the sample to cool before weighing each time. When the sample ceases to lose weight, the water is all evaporated and the per cent of moisture is determined from the loss in weight. The grams of moisture evaporated multiplied by 10 will give the per cent of moisture. For example, if the 10 grams of cheese lose 3·5 grams of water from evaporation, 100 grams would lose 100 divided by 10 and multiplied by 3·5, which equals 35 grams, or 35 per cent.

If steam under pressure is not available, an oven constructed of tin or copper, double-jacketed on five sides, fitted with a perforated rack and close-fitting door will answer. The oven is filled with water between the walls, which water is kept boiling by means of a gas jet or alcohol lamp. Since a lower temperature (boiling) is employed with this oven than with the high-pressure oven, longer time is required to dry to constant weight.

In Conclusion.

To one who has carefully read the foregoing pages it will, no doubt, seem that the manipulation of the tests described is quite simple. While such is the case, extreme care and accuracy must be exercised in all details of the tests in order to secure accurate results. Many of the details in connection with the making of these tests seem unnecessary to the careless operator, but the neglect of a few minor details in making the tests means the difference between accuracy and inaccuracy. It is not uncommon for instructors of milk testing to find students without previous experience in testing doing more accurate work during the first few days of their training than they do some weeks later. "Freedom breeds contempt," and as some operators become more familiar with the tests, the work is less carefully and less accurately performed. To slightly change an old axiom: "Eternal care is the price of accuracy."