DEPARTMENT OF AGRICULTURE
DAIRY AND COLD STORAGE COMMISSIONER'S BRANCH
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THE TESTING OF

MILK, CREAM AND DAIRY BY-PRODUCTS

BY MEANS OF

THE BABCOCK TEST

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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 on the testing of milk and its products by means of the Babcock milk tester, which has been prepared under my direction by Mr. J. F. Singleton, Chief Inspector of Dairy Products.

The growing interest in the testing of cows and the increasing use of the Babcock tester in this connection calls for authoritative instruction in its manipulation, and the need of a bulletin of this description for distribution by this branch has been felt for some time.

Mr. Singleton is an authority on milk testing, his training, and his experience as instructor in milk testing at the Kingston Dairy School for several years before joining the staff of this branch, having qualified him to deal with the subject in a scientific as well as a practical manner. It is not claimed that anything fundamentally new is presented in these pages, but the best practices in the operation of the test are set forth with such clearness and detail, that the bulletin should make a useful and reliable handbook for those who require instruction or information respecting the testing of milk, cream, skim-milk, etc.

I have the honour to recommend that the manuscript be published as Bulletin 45 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 TESTING OF MILK, CREAM AND DAIRY BY-PRODUCTS

BY MEANS OF THE BABCOCK TEST

INTRODUCTORY

The Babcock test derived its name from the originator, Dr. S. M. Babcock, of the University of Wisconsin. This was the first satisfactory short method for determining the percentage of fat in milk, and since it was made public in 1890 it as been widely adopted, particularly in the United States, Canada, Australia and New Zealand. It has since, with slight modification, been successfully applied in the testing of cream, skim-milk, buttermilk, whey and cheese. This test has been of immense value to the dairy industry, since it has provided a practical means of:—

(a) determining the fat production of individual cows;
(b) making a more equitable division of cheese factory and creamery proceeds;
(c) detecting abnormal losses of fat in such by-products as skim-milk, buttermilk and whey;
(d) detecting adulterations such as watering and skimming.

The test is quite easy to operate as no extensive training on the part of the operator is necessary. The simplicity of the test has probably been overemphasized, producing a corresponding carelessness on the part of some operators, resulting in inaccurate tests and subsequent criticism of the method. While the test is simple to operate, *great care and accuracy must* be *exercised* in all *details of the work,* or the results will be inaccurate and misleading. The necessity of care and accuracy in operating the test cannot be over-emphasized. It has been truly said that "in operating the Babcock test there is more to learn in care than in principle."

THE TESTING OF MILK

The apparatus employed in making a test of a sample of milk consists of four pieces:-

(a) pipette;
(b) test bottle;
(c) acid measure or acid burette;
(d) centrifuge.

THE PIPETTE

The pipette is a glass instrument used to measure the sample of milk required for testing. Two different forms of pipette are in use which are usually designated as the "ordinary pipette" and the "automatic pipette."

The ordinary pipette consists of a glass tube enlarged into a bulb about midway between the two ends (Fig. 1). The lower stem of the pipette should be small enough in diameter to pass readily into the neck of the test bottle. It should also be drawn into a small opening at the point, since if the opening is too large air bubbles will pass up into the bulb when measuring the sample and thus make accurate measurement impossible.

The upper stem of the pipette is marked and the pipette filled to this mark contains seventeen and six-tenths cubic centimetres (17.6 cc). The pipette should be so constructed that the graduation mark is low down on the stem and quite close to the bulb.

The construction of the automatic pipette is shown in Fig. 2. The novice will measure the sample more quickly and possibly more accurately with the automatic pipette than with the ordinary pipette. The automatic pipette is more likely to be broken and is more expensive.

THE MILK TEST BOTTLE

The construction of the milk test bottle is illustrated by Fig. 3. The bulb of the bottle is about one and one-quarter inches in diameter, and should have a capacity of, at least, forty-five cubic centimetres (45 cc). The neck of the bottle is about four inches in length and is graduated to read the percentage of milk fat when the test is completed. The graduation consists of ten main divisions numbered from zero at the bottom to ten at the top. Each division represents one per cent of fat and is subdivided into five equal subdivisions, consequently each subdivision represents one-fifth or two-tenths of one per cent of fat.

THE ACID MEASURE AND ACID BURETTE

The acid measure (Fig. 4) is a small cylinder graduated to contain seventeen and five-tenths cubic centimetres (17.5 cc). Frequently an acid burette (Fig. 5) is used instead of the acid graduate. Each division on the scale of the burette represents 17.5 cc. A stand with a clamp attached is used to hold the burette.

THE CENTRIFUGE

The centrifuge (Fig. 6) is a machine for whirling the bottles in making the test. It is fitted with swinging pockets to receive the test bottles and when the machine is in motion the pockets assume a horizontal position. The machine is usually driven by either hand power, or by a steam jet or turbine. hand-driven testers are usually made to receive either two, four, eight, ten or twelve bottles, while the turbine testers will usually receive either twenty-four or thirty-six bottles. The two-bottle and four-bottle hand testers are not made with a covering frame. The larger capacity hand testers are constructed with a frame (usually cast metal) which closes in the bottles when the machine is running, which aids in keeping the samples warm. Where steam is available and the amount of testing to be done will warrant the additional expense, the turbine tester is preferable as it keeps the samples hot while being revolved.

THE REQUIRED SPEED OF THE CENTRIFUGE

The speed at which the tester should be revolved is usually stated on the machine and varies with the diameter of the circle described by the *bottom of the bottle* in revolving.

The following table of speeds for machines of different diameters is given by Farrington and Woll in "Testing Milk and its Products ":—

Diameter of Circle (inches)	No. of Revolutions of bottle per Min.	Diameter of Circle (inches)	No. of Revolutions of bottle per Min.
10	1,074	18	800
12	980	20	759
14	909	22	724
16	848	24	693

No. 1.

Fig. 2—Up-to-date Pipette.

Fig. 3—Milk Test Bottle.

Fig. 4—Acid Measure.

Fig. 5.

When operating a turbine tester the speed must be ascertained by means of a speed indicator, which is applied to the spindle of the machine. The speed is regulated by varying the steam pressure used, which is indicated by a steam gauge attached to the machine. The operator must determine what steam pressure on the gauge will give the desired speed to the tester.

When operating a hand-driven tester the number of revolutions which the bottle makes, to each revolution of the handle, should be determined by counting. The diameter of the circle described by the bottom of the bottle when in the horizontal running position should be measured. By consulting the above table, the required speed of the bottle is obtained. The number of revolutions per minute required as indicated by the table is divided by the number of revolutions the bottle goes to each revolution of the handle. The result will be the number of revolutions of the hand per minute.

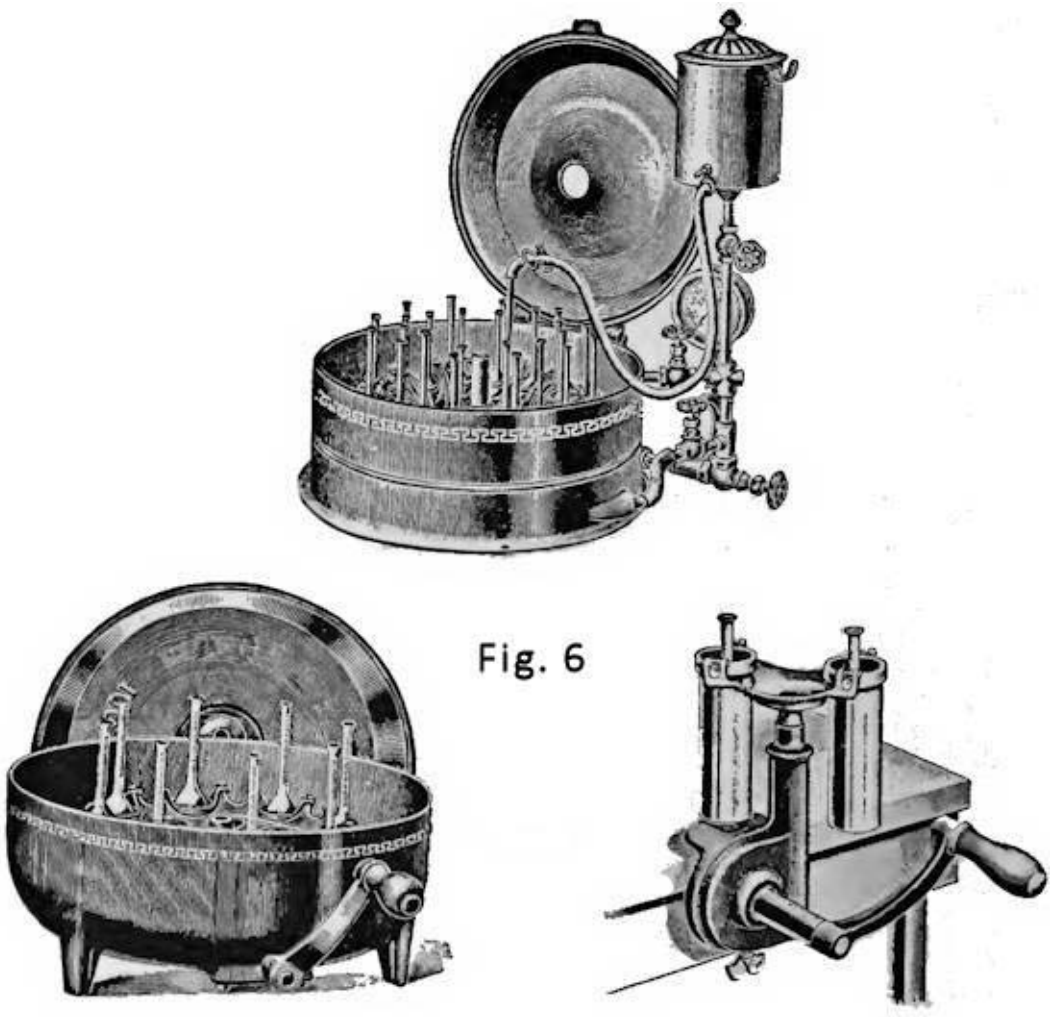

Fig. 6

For example, if the bottle is found to complete twelve revolutions for each revolution of the handle, and the diameter of the circle described by the bottom of the bottle is fourteen inches, we find by consulting the above table that for a fourteen-inch diameter, the bottle must revolve 909 times per minute; 909 divided by 12 is 76 (almost), which is the number of revolutions required of the handle each minute.

The tester should be placed perfectly level on a firm bench and be kept well oiled.

THE MILK-TEST ACT

The Milk-Test Act which came into force January 1, 1911, provides that all test bottles and pipettes used, or sold to be used, for the testing of milk and cream in connection with the Babcock test must be verified by the Standards Branch of the and Revenue Department, Ottawa. Glassware, when verified and found to be correct within a specified limit of error, must "be ineffaceably marked with the outline a crown having within it the initial letter of the reigning sovereign." All milk cream test bottles and pipettes, now in use or offered for sale, must be so marked.

MAKING THE TEST

Before starting to make a test of whole milk see that all glassware to be used is clean and bears the verification mark.

SECURING A REPRESENTATIVE SAMPLE OF MILK

In testing milk it is necessary that the sample taken for testing represents the average quality of the quantity of milk to be tested. If such is not the case, the result of the test will, of course, be inaccurate and misleading. When milk is allowed to stand for even a short time, cream rises to the surface and in order to thoroughly mix the milk before taking a sample for testing, it is best to pour the entire quantity of milk from one vessel to another several times. If the quantity is too great to permit of pouring, it should be well stirred. After being thoroughly mixed a smaller quantity (three to six ounces) should be taken out and put into a separate vessel.

SAMPLING AND ADDING MILK TO THE TEST BOTTLE

The sample should be brought to a temperature of 60°F to 70°F. and then poured from one vessel to another several times. Care must be taken that all the cream mixes back with the milk and that none adheres to the sides of the vessel. In pouring allow the milk to follow down the side of the vessel into which it is being poured. By so doing there is less tendency to partially churn the sample which would render the results less accurate. After the sample is thoroughly mixed, if using the ordinary pipette, insert the lower stem of the pipette into the milk and by suction of the mouth raise the milk above the graduation mark on the pipette. Quickly cover the top of the pipette with the index finger, taking care to keep the top of the pipette and the finger dry. By slightly removing the finger allow the milk to drop slowly from the pipette until it comes exactly to the 17.6 cc graduation mark on the stem of the pipette. The lower stein of the pipette is now inserted into the neck of the test bottle and the sample allowed to run into the bottle. The last few drops should be expelled from the pipette into the test bottle by blowing through the pipette.

If using the "up-to-date" automatic pipette, have the glass petcock of the pipette open and insert the lower stem of the pipette into the milk. By 'suction on the tube leading from the large upper bulb, draw the milk up into the pipette until the lower bulb is filled and the milk is overflowing from the upper stem into the large bulb. While the milk is still overflowing into the large bulb, quickly close the petcock. The lower stem of the pipette is inserted into the neck of

the bottle and the petcock is opened to allow the milk to flow into the test bottle. As with the ordinary pipette the last few drops should be expelled from the pipette into the test bottle by blowing through the pipette.

It is a rather common practice for operators of the test to blow through the pipette into the milk before drawing the sample up into the pipette. This should never be done as air is incorporated in the sample which will affect the result of the test.

While the sample of milk is measured into the test bottle, the test is based on weight. The 17.6 cc pipette will deliver, of average milk, a definite weight- eighteen grams- into the bottle. Since the weight of a given volume of milks of different richness is fairly constant, measuring with the pipette is quite accurate and does not introduce any appreciable error.

If several samples are to be tested, each sample should be given a serial number and a test bottle marked with a corresponding serial number for each sample. A part of the bulb of the test bottle is usually frosted so that such a number may be written on with a lead pencil.

ADDING THE ACID

The next step is the addition to the test bottle of the acid which is used in making the test. Commercial sulphuric acid with a specific gravity (Sp. Gr.) of 1.82 to 1.83 is used and should be at a temperature of 60°F to 70°F. The acid is measured in the cylinder provided for the purpose which is graduated to contain 17.5 cc. After measuring the correct quantity of acid into the graduate it is slowly poured into the test bottle. When pouring the acid into the test bottle the bottle should be held in a slanting position and if any drops of milk are adhering in the neck of the bottle, the bottle should be slowly revolved so that the acid will carry the milk down into the bottle. By holding the bottle in a slanting position the acid flows down the walls of the bottle and lies under the milk. The acid should never be allowed to drop directly on the milk, and after adding the acid to the bottle there should be a distinct line between the milk and the acid. If the bottle is placed on the table after adding the acid, care should be taken not to jar the bottle, which will tend to partially mix the milk and acid.

In case the acid burette is being used it is filled with acid to the top graduation mark. The test bottle is held in a slanting position underneath the burette with the top of the burette inserted' into the neck of the test bottle. By opening the petcock the acid is allowed to flow into the bottle. When the surface of the acid in the burette is lowered to the second graduation mark, the petcock is closed and 17.5 cc of acid will have been delivered into the test bottle.

The sulphuric acid used in making the test is extremely corrosive. It is advisable to have, at all times, a bottle of liquid ammonia at hand, and in case of any acid coming in contact with the clothing, a liberal application of the ammonia will neutralize the acid and prevent the destruction of the cloth. Should the acid come in contact with the face or hands, wash immediately with cold water.

MIXING THE MILK AND ACID

After adding the acid to the test bottle the milk and acid should be thoroughly mixed, shaking the bottle with a rotary motion. The neck of the bottle must not be covered with the finger while mixing the milk and acid and care should be taken to avoid splashing particles of milk or curd into the neck of the bottle. As the milk and acid are mixed the milk is first curdled, then the clots of curd are dissolved and disappear, the mixture turns a dark chocolate colour, and becomes hot, due to the action of the acid on the milk.

PLACING THE BOTTLES IN THE TESTER

The bottle or bottles should, at once, be placed in the tester in such a way that the machine will be balanced. If an odd number of samples are being tested an extra test bottle may be filled with water and placed in the machine to properly balance it. If the machine is not properly balanced it will not run smoothly and the bottles are likely to be broken.

KEEPING THE BOTTLES WARM

If the bottles are allowed to become cool, previous to, or while whirling, an incomplete separation of fat will result and the reading will be too low. There is, of course, no difficulty in keeping the samples sufficiently warm when using a turbine tester. When using a hand machine in a cool room it is advisable to partially fill the frame of the machine with boiling water before commencing the whirling. When using the two, or four-bottle hand tester, which has no covering frame, the pockets should be filled with boiling water surrounding the bottles.

WHIRLING THE BOTTLES

The bottles are whirled for five minutes at the proper speed. As pointed out above, he bottle when in motion assumes a horizontal position. The bottle, rapidly revolving, is subject to a force which tends to throw it away from the centre. This is known as "centrifugal force." This force is exerted most strongly on the heaviest parts of he mixture which work to the outside, thereby forcing the fat, which is lightest, to he centre. When the whirling ceases the bottle assumes a vertical position with the at on the surface. If the machine is not run long enough or sufficiently fast, the separation of fat will not be complete.

ADDING THE HOT WATER TO THE TEST BOTTLES

Hot water is now added to the bottle to float the separated fat up into the neck of he bottle so that the percentage may be read.

The turbine tester usually has a small pail attached for heating and adding the water to the test bottles. The pail is fitted with a small rubber tube leading from the bottom of the pail, into the end of which is fitted a piece of glass tubing drawn to a point similar to the glass of an eye-dropper. There is a spring pinch cock on the rubber tubing to shut off the water. If using a hand tester and only a few samples are being tested at one time, the pipette will answer very well for adding the water to the bottles. If many samples are being tested it is advisable to provide such a pail as described above and attached to the turbine tester as shown in Fig. 6.

Rain water or condensed steam is preferable to hard water as it will give a clearer fat column in the finished test. If hard water must be used, a few drops of sulphuric acid should be added to the water before it is heated. Adding acid to hot water is dangerous as it is liable to be splashed on the face, hands or clothes of the operator.

If a turbine tester is being used a temperature of 140°F to 160° F will be high enough at which to have the water for adding to the bottle. If a hand machine is being used the water should be made much hotter, in fact there will be no disadvantage in using boiling water. As far as possible the work should be done in such a manner as to have the temperature of the samples between 130°F and 140°F when the test is completed, and the temperature of the water used may be varied somewhat with this end in view.

Sufficient water is added to fill the bottle to the bottom of the neck and the bottle whirled for one minute at the proper speed, after which water is again added until the top of the fat column in the neck is raised to about the eight per cent mark on the scale. In adding water the second time it is advisable to allow the water to drop directly on the fat in the neck of the bottle. The water passing through the fat column tends to wash the fat and carry any impurities, which may be in the fat, down into the body of the bottle. The bottles should be again whirled for one minute.

Many operators add all the water at one time but clearer readings will usually be obtained by adding the water twice as outlined above. If the water is all added at once the bottles should be whirled for two minutes after adding the water.

TEMPERATURE OF FAT WHEN READING THE TEST

The Third Dominion Conference of Dairy Experts held at Ottawa, December 6 and 7, 1911, adopted a temperature of 130°F to 140°F as the proper one at which to have the fat when the percentage is read. If the fat is too hot when read, the result will be too high owing to expansion and if the fat is too cold the result will be low owing to contraction.

THE USE OF A WATER BATH

In order to get accurate results and uniformity from time to time, the bottles should be placed in a water bath at a temperature of 130°F to 140°F for, at least, two minutes before the per cent of fat is read. The water surrounding the bottles should extend up on the neck of the bottle as high as the top of the fat column. If man, samples are to be tested, it is well to have a rectangular tin dish (Fig. 7) made to be used as a water bath for the bottles. This dish should be about one-half inch less in depth than the length of the bottles, so that the bottles cannot be overflowed with water. A false bottom in the bath, with round holes in it, or wire rack to receive the bottles, will prevent them from being overturned in the water.

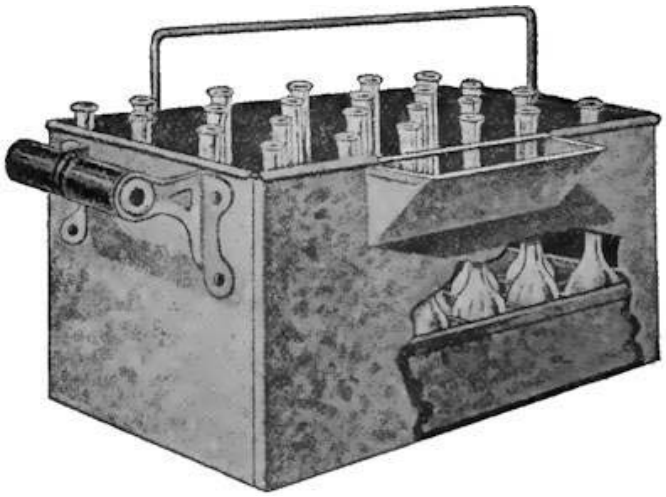

Fig. 7.

READING THE TEST

If the work of making the test has been properly performed, the fat column will be a bright amber colour free from any dark or curdy specks. The top of the fat column will appear slightly hollow or concave and the bottom of the column will appear slightly rounded or convex (Fig. 8). The bottle should be held level with the eye to be read, and the reading taken from the extreme points of the fat column, that is from A to B and not from C to B. By reading from the extreme points, allowance is made for a slight amount of fat which is not raised into the neck of the bottle, and the results will correspond more closely with chemical analyses.

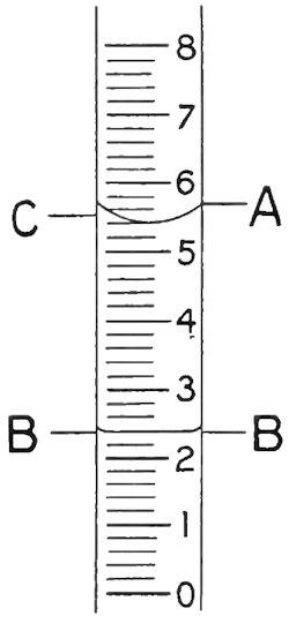

Fig. 8.

The reading of the fat is most conveniently taken by means of a pair of dividers (Fig. 9), with fine, sharp points. The hinge of the dividers must be stiff enough that the dividers will not work too freely. The dividers are spread until the points are farther apart than the fat column is long, then one point is placed at the extreme lower end of the fat column, and the dividers slowly closed until the other point is at the extreme upper end of the fat column. One point of the dividers is now placed at the zero mark on the scale and the other point will indicate on the scale the correct reading. For instance, if the length of the fat column, as shown by the dividers, is three main divisions and four subdivisions, the reading is $3\ ^{4}/_{5}$ per cent. This may also be expressed as $3\ ^{8}/_{10}$ per cent or 3.8 per cent. This would mean that in each one hundred pounds of such milk there are 3.8 pounds of milk fat.

Fig. 9.

CLEANING THE BOTTLES

As soon as the readings of fat are taken the bottles should, while still hot, be emptied and rinsed with warm water. They should next be thoroughly washed with hot water to which has been added a little of some good washing compound, using the brush provided to clean out the neck. The bottles should be again rinsed with hot water to thoroughly remove the washing compound from the bottle. Even with such washing the bottles will in time become coated on the inside. To prevent this an occasional cleaning, using a very strong solution of washing compound, with some shot in the bottle, is advisable. Sulphuric acid, to which has been added as much bichromate of potash as the acid will dissolve, makes an excellent material for cleaning any dirty glassware, and the same solution may be used many times.

DARK-COLOURED OR BURNT READINGS

If, when the test is completed, the fat column contains black specks or is too dark in colour, the test is not satisfactory and a duplicate test should be made.

Dark-coloured or burnt readings may be due to one or more of the following causes:—

(a) the milk, the acid, or both, being at too high a temperature (over 70°);
(b) too much or too strong acid;
(c) allowing the acid to fall directly on the milk;
(d) allowing the bottles to stand too long after adding the acid before mixing.

LIGHT-COLOURED OR CURDY READINGS.

If when the test is completed the fat column is too light in colour or shows curdy, the results of the test may be too high and a second test should be made.

Light-coloured or curdy readings are due to one or more of the following causes:—

(a) the milk, the acid, or both, being at too low a temperature (under 60°);
(b) too little or too weak acid;
(c) not thoroughly mixing the milk and acid before whirling.

Acid supplied for testing is not always of the proper strength. If the test is carefully and properly made, a *dark-coloured or burned reading indicates that the acid is too strong, while a light-coloured or curdy reading indicates that the acid is too weak.* If the acid is only slightly too strong, satisfactory results may be obtained by using somewhat less than 17.5 cc, and if the acid is only slightly weak, using a little more than 17.5 cc will give satisfactory results. Acid that is much too strong or much too weak cannot be used satisfactorily. Acid, if left exposed to the air, becomes weaker by absorbing moisture from the air, consequently acid of the correct strength should be kept stoppered when not in use. Acid, which is too strong, will in time weaken to the correct strength if left uncorked. If a cork stopper is used, the acid will char the cork and the acid becomes dark. A glass-stoppered bottle is preferable.

COMPOSITE SAMPLES OF MILK

A composite sample of milk is a quantity of milk composed of several smaller samples taken from different sources and *should represent the average quality of the different quantities from which the samples are taken.*

Cheese factories, which divide the proceeds on a basis of the test, use the composite sample and the great majority test only monthly.

A tightly stoppered bottle is provided for each patron, and some means provided to identify each patron's bottle. A convenient way is to gum a label bearing the patron's name, or a number to designate the patron, to each bottle. If the label is covered with two coats of shellac, the bottle may be washed without injury to the label.

THE USE OF A PRESERVATIVE

Some chemical is used as a preservative to prevent souring and other fermentations. Since nearly all strong preservatives suitable for this purpose are very poisonous, some colouring matter is mixed with the preservative which gives the sample a distinctive colour and thereby indicates that the sample is unfit for use as a food. Preservative may be purchased in tablet form from the dairy supply houses. These commercial tablets are usually composed largely of corrosive sublimate and are very satisfactory. Powdered corrosive sublimate is also very efficient. If this is used a small proportion of magenta should be mixed with the corrosive sublimate to colour the sample.

In case one is troubled with mould growing on the walls of the bottle a few drops of formaldehyde may be added to the sample. This will prevent the growth of mould.

THE QUANTITY OF PRESERVATIVE TO USE

The preservative is added to the bottle before any sample is put in. No definite quantity of preservative can be said to be the correct quantity. The correct quantity to use is the least that will preserve the sample efficiently, and this depends on:

(a) the quantity of milk that will be in the sample bottle;
(b) the length of time over which a sample extends;
(c) the temperature at which the sample will be kept;
(d) the degree of ripeness of the milk composing the sample.

An excess of corrosive sublimate affects the casein in such a manner that it seems more difficult to dissolve and more shaking is required in mixing the milk and acid in the test bottle.

SAMPLING MILK FOR THE COMPOSITE JAR

The sample of milk added each day to the composite jar should not only represent the average quality of the quantity from which it is taken, but should also be proportionate to the quantity.

Two methods of taking the sample are in common use:

(a) the small cone-shaped dipper (Fig. 10) ;
(b) the sampling tube (Fig. 11).

Fig. 10.

Fig. 11.

The small cone-shaped or "ounce dipper" as it is commonly called does not take a sample proportionate to the quantity of the milk being sampled. Since milk delivered at a cheese factory is well mixed from the agitation received on the wagon and by pouring into the weighing can the sample taken by the ounce dipper will represent the quality of the milk quite accurately.

The ounce dipper is much more commonly used in cheese factory work than the sampling tube owing to its greater convenience. Since the quantity and quality of milk delivered by a patron to a cheese factory is fairly uniform from day to day, the use of the ounce dipper in taking samples for the composite test will not introduce any serious error.

SAMPLING FROZEN MILK

Milk should not be allowed to freeze, but in severe weather partially frozen milk is occasionally received at cheese factories. In freezing, the fat and other milk solids not in solution are to a great extent forced out of the ice. The ice of frozen milk will frequently contain less than one per cent of fat, the fat being largely in the unfrozen portion. Consequently partially frozen milk should not be sampled until the ice has been melted and the whole quantity thoroughly mixed. It is very difficult to secure a uniform distribution of fat in a quantity of milk which has been allowed to freeze.

MIXING THE COMPOSITE SAMPLES

After adding the sample to the composite jar each day, the sample should be mixed by shaking the bottle in a rotary motion, care being taking not to splash any cream up on the walls of the bottle. If any clots of cream should be splashed on the walls of the bottle, the agitation should be continued until it is completely washed down.

CARE OF COMPOSITE SAMPLES

Composite samples should be kept in a cool place and not exposed to sunlight. Neither should they be exposed to frost as it is extremely difficult to get a correct sample from the jar if the samples have been partially frozen. They should be kept tightly corked at all times since if not tightly stoppered evaporation of water takes place which will result in the test being too high.

PREPARING COMPOSITE SAMPLES FOR TESTING

The composite sample should be prepared for testing by warming to a temperature of 100°F to 110°F. in order to soften any clots of cream and to remove all ream from the walls of the composite jar. The temperature of the sample should not be allowed to become high enough to melt the fat into oil as it is then difficult to get a representative sample from the jar since the oil will quickly rise to the surface. The sample should be carefully poured from one vessel to another several times and the sample *immediately* taken for testing.

TESTING THICK OR CURDLED MILK

Testing thick or curdled milk is not to be recommended as it is more difficult to get a correct sample. However in hot weather a sample may curdle due to insufficient preservative, or to over-ripe milk having been added to the Jar. In such cases a very small quantity of powdered lye may be added to the sample and the sample poured from one vessel to another

several times. The lye neutralizes the acid and when sufficient acid is neutralized the milk again becomes liquid. The lye should be added in small quantities, pouring the sample several times after each addition of lye. In this way the use of an excessive quantity of lye may be avoided. When the lumps of curd disappear and the sample becomes fluid it is sampled in the usual way. Sample treated in this manner require less than a normal sample.

TESTING OF CREAM

DETERMINATION OF THE PER CENT OF FAT IN CREAM

Cream is that portion of milk, rich in fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force.

The Babcock test is used to determine the per cent of fat in cream as well as in milk. In determining the per cent of fat in cream certain modifications of the method already outlined for determining the per cent of fat in milk are necessary.

CREAM TEST BOTTLES

In testing cream specially graduated test bottles are used. Several different style of bottles (fig. 12) are on the market, but those most commonly used are:—

(a) the six and one-half (6½) inch bottle graduated to read fifty (50) per cent of fat, using a nine (9) gramme sample;
(b) the six and one-half (6½) inch bottle graduated to read either forty (40) or fifty (50) per cent of fat, using an eighteen (18) gramme sample;
(c) the nine (9) inch bottle graduated to read fifty (50) per cent of fat, using an eighteen (18) gramme sample.

Each main division on the graduation scale of these bottles, representing one per cent of fat, should be subdivided into two equal subdivisions, each of which represents one-half of one per cent of fat. This is not always done and on many bottles the smallest division of the scale represents one per cent of fat.

Whether the bottle is constructed for a nine (9) gramme or an eighteen (18) gramme sample, the bulb should have a volume, at least, equal to that of the ordinary ten (10) per cent milk bottle.

Both the six and one-half-inch nine-gramme bottle and the nine-inch eighteen-gramme bottle have necks of smaller bore than the six and one-half-inch eighteen-gramme bottle. In this respect either of the former is preferable to the latter, since the smaller the bore of the neck the less error there is likely to be in reading the per cent of fat. In using the nine-gramme bottle, however, any error in weighing the sample produces twice as great an error in the test as the same error in weighing will produce in the eighteen-gramme bottle. This is readily seen from the following calculation

If a nine-gramme sample in a nine-gramme bottle reads 36 per cent fat, each one gramme of the sample reads 36± 9 =4 per cent fat, and each one-half gramme reads 2 per cent fat. If an eighteen gramme sample in an eighteen-gramme bottle reads 36 per cent fat, each one gramme of the sample reads 36/18 = 2 per cent fat, and each one half gramme reads 1 per cent fat.

That is, an error of one-half gramme in weighing the sample produces in one case an error of 2 per cent in the reading and in the other case au error of 1 per cent.

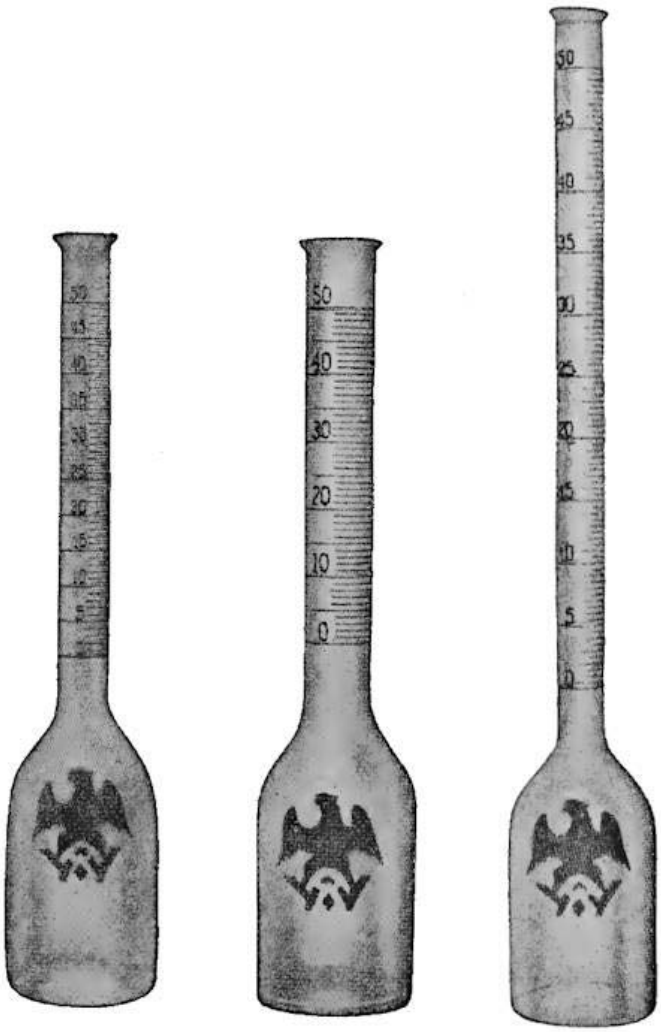

Fig. 12.

In using the nine-inch bottle a specially constructed machine is required, which is more expensive than the ordinary tester. The nine-inch bottles are more expensive than the six and one-half-inch bottles, and breakages are more frequent, not only when whirling the bottles but also in handling, since the longer bottle is more easily overturned.

The nine-gramme bottle has an advantage over the eighteen-gramme bottle in that nine cubic centimetres of water are mixed with nine grammes of cream, which tends to give a clearer reading.

Which bottle one shall use is largely a matter of preference on the part of the operator, as any one of the three will give satisfactory results if the work is properly done.

To secure uniform results all bottles used in any plant should be made of uniform construction, all made to test the same weight of sample and with uniform graduation and diameter of bore.

SOURCES OF ERROR IN MEASURING CREAM FOR TESTING

As pointed out previously, the Babcock test is *based on weight* and it is simply for convenience that the sample is measured with the pipette in testing milk. The pipette delivers approximately the same weight of milk from time to time. Several factors, however, tend to render measuring of cream by means of a pipette inaccurate. These are :—

(a) *Variation in richness of cream.—Cream* may test as low as 15 per cent of fat or as high as 50 per cent. As the per cent of fat in cream increases, the weight of a given volume decreases. Therefore a pipette, which will measure a sample of the proper weight from a low testing cream, will measure, from a richer cream, a sample that will be too light.

(b) *Gas and Air in the cream.—More* or less gas due to souring or other fermentations is present in cream. The heavy body of the cream tends to retain these gases in the cream and therefore reduce the *weight* of cream which will be measured by a pipette. This will not have so great an influence if the cream is warmed before the sample is measured with a pipette, as the warming reduces the body of the cream so that the gas will, to a great extent, escape.

This is illustrated by the following table which also illustrates the difference between the results obtained when the scale is used to weigh the sample as compared with measuring with the pipette.

The different samples of sweet cream were tested using both scales and pipette and were then allowed to sour in tightly stoppered bottles, after which they were again tested while cold, using both scales and pipette. The samples were then warmed to 100°F. and tested using the pipette.

TABLE.

	Sweet Cream		Sour Cream		
			Cold Cream		Warm Cream
	Scales	Pipette	Pipette	Scales	Pipette
A.	41.0	39.0	(No test)	41.0	39.0
B.	36.5	34.5	33.5	36.5	34.0
C.	32.0	31.5	31.5	32.0	31.5
D.	34.0	32.5	32.0	34.5	32.5
E.	36.5	35.0	34.0	36.5	35.5
F.	32.0	31.5	31.0	32.0	31.5
G.	35.5	34.5	34.0	36.0	35.0
H.	30.0	30.0	29.5	30.0	29.5

These figures are typical of the results obtained in several more such tests. Practically no difference, beyond a reasonable limit of error, is noticed between the tests of the same cream, sweet or sour, when the sour sample is warmed to 100 degrees before sampling, though in some cases a slightly lower reading is noticed where the sample was taken without warming. It is quite possible that in special cases—with very

gassy cream—this error would show greater than in these figures, as these samples soured quite clean in flavour.

(c) *Cream adhering to the walls of the pipette.—Some* cream adheres to the walls of the pipette and if this is not thoroughly rinsed off and added to the test bottle the result of the test will be inaccurate.

THE USE of SCALES FOR WEIGHING SAMPLES OF CREAM.

In order to avoid these sources of error in measuring cream samples, scales have been devised for weighing the cream samples of either nine (9) grammes or eighteen (18) grammes into the bottles. Cream testing scales are constructed of different capacities. Some scales have a capacity of twelve test bottles (Fig. 13), that is cream samples may be weighed into each of twelve bottles with one balancing of the scales. Other scales have capacities of four bottles, two bottles or one bottle (Fig. 14). The fewer the bottles the scales will carry the more accurate will be the weighing and the longer will the work require since the *scales* must be balanced more frequently. The scales should be kept in a dry place to protect the bearings from rust which would soon render the scales inaccurate. When in use the scale should be placed on a *firm level* shelf or table.

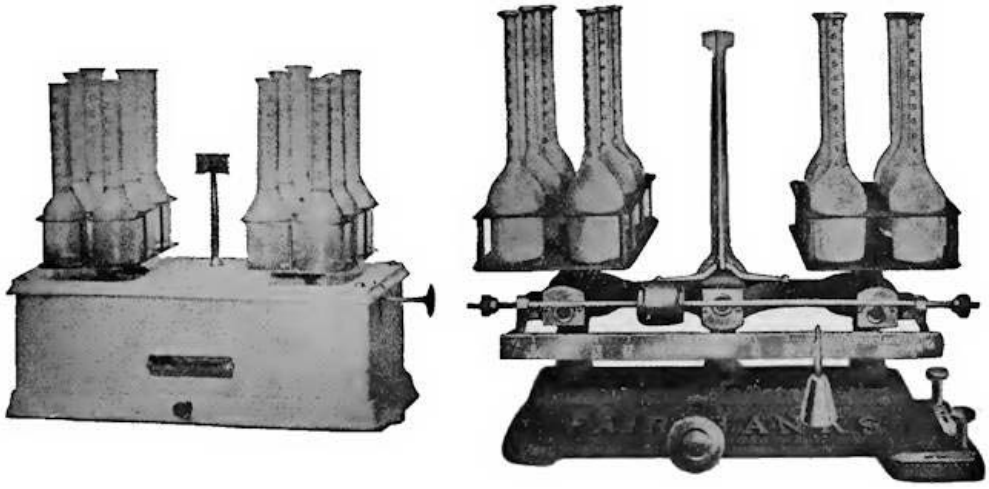

Fig. 13.

In using the twelve-bottle scale the bottles are numbered and placed on the scale. The weight on the weighing beam is placed at the extreme left notch on the beam and the scale is then balanced by moving the ball on the tare beam. The ball or weight on the weighing beam is then moved to the right, to the nine (9) gramme or eighteen (18) gramme mark, depending on the style of bottle being used, and cream is added to bottle No. 1 until the scales again balance. Usually the weight is again moved to the right and the weighing repeated into bottle No. 2. This is repeated until the bottles on the left pan of the scale each contain a sample, when the weight on the beam is moved to the left and samples weighed into the bottles on the right arm of the scale. A better practice is to weigh a sample into a bottle on the left pan, then move the weight back to the left and weigh a sample into a bottle on the right pan, weighing alternately into bottles on the right and left pans until all bottles contain samples. The four-bottle scale is used in the same manner as the twelve-bottle scale, except that nine (9) and

eighteen (18) gramme weights are used on the pans of the scale instead of the weight on the notched beam. With the one-bottle scale (fig. 14) after balancing the scale with the bottle placed on the left pan a nine (9) gramme or eighteen (18) gramme weight is placed on the right pan of the scale and the sample is then weighed into the bottle.

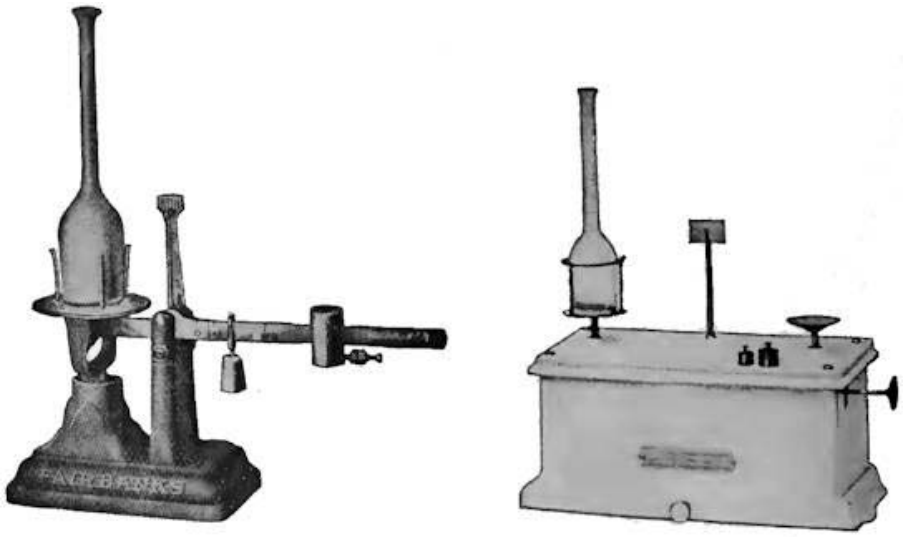

Fig. 14.

SAMPLING CREAM FOR TESTING

In sampling cream for testing special precautions must be taken to secure a sample which represents the average quality to be tested. It is more difficult to get a representative sample of a quantity of cream than it is to get a representative sample of an equal quantity of milk, since the cream does not mix as readily. If circumstances permit it is best to pour the quantity of cream from one vessel to another several times. If pouring is not practicable, the cream should be thoroughly stirred by means of a stirring rod (Fig.15) constructed for the purpose.

Fig. 15.

If the quantity of cream is thoroughly mixed a small dipper (Fig. 10) will be quite satisfactory for taking the sample. Owing to the difficulty of thoroughly mixing a can of cream, several special devices have been recommended for taking the sample. Of these the "McKay Sampler" (Fig. 11) is probably the most satisfactory. This is constructed with two slotted tubes, one inside the other. The tubes are turned to close the slot and the sampler inserted in the cream to the bottom of the can. The slot is then opened to admit the cream to the tube, after which the slot is closed and the tube withdrawn. The sample thus taken is a small column of cream extending from the bottom of the can to the surface of the cream, and is representative both of the *quality* and *quantity* of the cream sampled.

PREPARING AND WEIGHING THE SAMPLE FOR TESTING

The sample of cream to be tested should be warmed to remove any lumps from the cream. Should lumps be present, which will not disappear upon warming, the sample should be poured through a fine wire strainer and the lumps broken up and forced through the strainer. The sample is then carefully poured from one vessel to another several times and, by means of a pipette, cream is transferred to the bottle on the scale until the scale balances exactly.

If using a nine (9) gramme sample in a nine (9) gramme bottle, nine cubic centimetres of water should be added to the sample in the bottle from a nine cubic centimetre pipette. The full quantity of acid (17.5 cc) will be required with a nine-gramme sample, if nine cubic centimetres of water have been added to the bottle. The addition of water in the bottle usually gives a clearer fat column. For the same reason it is advisable to add a few cubic centimetres of water to the eighteen-gramme sample. The addition of water, however, necessitates the use of more than the usual quantity of acid, and care must be taken not to add too much water to the eighteen-gramme sample, as the bulb of the bottle will not be large enough to hold the extra acid required in addition to the water.

MEASURING CREAM SAMPLES WITH TILE PIPETTE

When strict accuracy is not essential fairly correct results may be obtained by using a pipette and measuring the cream into the test bottle. Since cream is lighter than milk, the pipette used for measuring the sample into the eighteen-gramme bottle should be larger than that used for testing milk. A pipette with a volume of eighteen cubic centimetres is used in connection with the eighteen-gramme bottle, and after the sample has been measured into the bottle a few cubic centimetres of warm water should be used to rinse the pipette, which rinse water is added to the bottle. For measuring the sample into the nine-gramme bottle a nine-cubic centimetre pipette is used and nine cubic centimetres of warm water is used to rinse the pipette and is added to the sample in the bottle.

As previously stated, the presence, in a cream sample, of gases due to souring or other fermentations, or of air incorporated by pouring, while introducing no appreciable error when the scales are used, will produce an appreciable error if the pipette is used. The presence of air and gas in the cream lessens the weight delivered by the pipette. Warming the sample reduces the body or thickness of the cream, facilitating the escape of the gas or air from the sample and to a great extent prevents error from this source. For this reason especial attention should be given to the warming of the sample when the pipette is to be used.

READING CREAM TESTS

Especial care should be taken to have the fat at a temperature of 130°F to 140°F for reading. Owing to the volume of fat present in the neck of the cream bottle, considerable error may be introduced by having the samples too hot when read. Cream samples also require longer than milk samples to become adjusted to the temperature of the water bath.

Unlike reading the tests of milk, the reading of cream tests is not taken from the extreme points of the fat column but from the bottom of the fat column to the *bottom* of the meniscus on the surface of the fat column (Fig. 17). The reading should be taken from A to B, not from C to B.

THE USE OF OIL IN READING CREAM TESTS

Owing to the difficulty of determining where the bottom of the meniscus is, a few drops of a light-coloured oil is frequently added to the top of the fat column. This oil must be lighter than the fat, so that it will not mix with, but float on top of the fat. The oil is conveniently added to the bottle by means of a pipette, allowing it to flow down the wall of the neck of the bottle. The meniscus is raised up on the surface of the oil leaving a sharp distinct line between the fat column and the oil. The reading should be taken from this line to the bottom of the fat column.

This oil may be secured from any of the leading dairy supply houses, or may be prepared by any one requiring it. A mineral oil sufficiently light that it will not mix with the fat must first be secured. An oil sold, by one of the leading companies, under the trade name "Albolite" is very satisfactory. Alkanet root, which may be obtained from any good drug house, is used to colour the oil. One ounce of alkanet root will colour one gallon of oil. The alkanet root should be rolled in double ply cheese cloth and soaked for twenty-four hours in the oil. The alkanet root is then removed and the oil will be of a light reddish colour and ready for use.

COMPOSITE SAMPLES OF CREAM

While many creameries, and the number is increasing test each delivery of cream received from each patron, many still use the composite samples and test either one or twice each month.

What has been said regarding composite samples of milk will also apply to composite samples of cream.

The ounce dipper is not as satisfactory for sampling cream as for sampling milk. Since it is more difficult to thoroughly mix cream than milk and since the deliveries of cream show greater variation both in quality and quantity than deliveries of milk some such device as the McKay sampler already described should be used.

EVAPORATION OF WATER FROM COMPOSITE SAMPLES OF CREAM

Especial care should be taken to see that the sample jars are tightly corked to prevent evaporation of water from the jar, which would cause the samples to test too high.

To illustrate this point, some years ago the writer after testing a number of composite cream samples at the end of a month left the samples uncorked in a cold room for seventeen day and again tested the samples. The tests were as follows:—

	At end of month	Seventeen days later
A.	40	43
B.	25	28
C.	40	42
D.	30	31
E.	21	24
F.	30	32.5
G.	29.5	34

These figures illustrate plainly the necessity of keeping the composite jars tightly corked. The

extreme variation in sample A, is accounted for by the fact that there was very little cream in the jar and the evaporation was higher proportionally than in the other jars.

TESTING OF BY-PRODUCTS

DETERMINATION OF THE PER CENT OF FAT IN SKIM-MILK AND BUTTERMILK

Under the most favourable conditions of separation and churning of cream there is some fat lost in the skim-milk and the buttermilk. The Babcock test may be used to determine the extent of these losses.

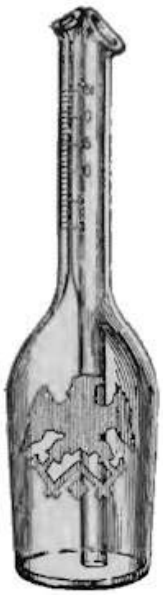

Fig. 16.

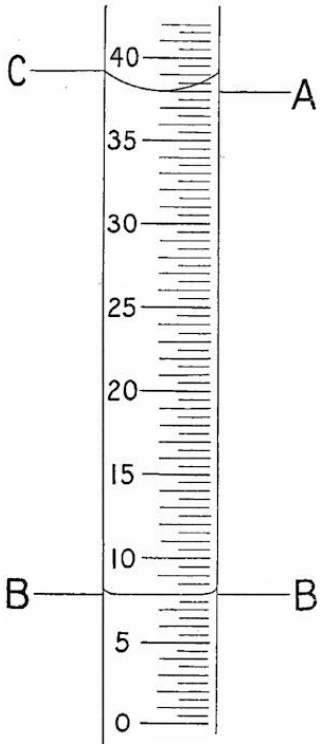

Fig. 17.

THE DOUBLE-NECK BOTTLE

A specially constructed double-neck bottle (Fig. 16) is used. The larger neck is to admit the skim-milk or buttermilk and acid to the bottle and should be conducted down close to the bottom of the bottle. The smaller neck is graduated to read the percentage of fat. The older style of double-neck bottle was usually graduated so that the entire scale consisting of ten divisions represented one-half of one per cent of fat. Each division would, therefore, represent five one-hundredths of one per cent of fat.

Most double-neck bottles now on the market have either five or ten main divisions, each of which represents five one-hundredths of one per cent of fat and is subdivided into five equal divisions. Each small division, therefore, represents one one-hundredth of one per cent of fat.

In testing skim-milk or buttermilk especial care must be taken to have all glassware perfectly clean, as a slight amount of fat in the pipette or bottle would seriously affect the results.

A 17.6 cc pipette is used to measure the sample and 17.3 cc of acid is ordinarily used. It is probable that a slightly more perfect separation of the fat will be obtained if the milk and acid are cooled below 60°F. and about 20cc of acid used.

Care must be taken in mixing the milk and acid to avoid closing the graduated neck of the bottle with small pieces of curd. If this occurs the mixture of milk and acid will be forced out of the other neck and the work must then be repeated. It is a good practice to add half the acid, and mix, then add the remaining half of the acid and mix again. The water must be added slowly to avoid forcing the fat out of the neck. If necessary when reading the test, the fat can be raised by pressing the finger over the opening of the larger neck.

In testing skim-milk or buttermilk the fat is not all recovered in the neck of the bottle. Some fat remains in the mixture of milk and acid. It has been recommended that five one-hundredths of one per cent be added to the reading shown on the bottle to allow for this error and thus make the test correspond more closely with chemical analysis. However, since the fat remaining in the mixture in the bottle cannot be recovered by mechanical means and is, therefore, not available for the manufacture of cheese or butter, and since the testing of these by-products is largely to determine the *comparative* loss from time to time, such addition to the reading would seem to be unnecessary.

DETERMINATION OF THE PER CENT OF FAT IN WHEY

The double-neck bottle and 17.6 cc pipette are used in testing whey. Care should be taken to have the temperature of the whey well down to 60°F. Owing to the fact that part of the milk solids have been removed in the process of cheesemaking less acid is required, and usually slightly over half a measure of acid will be sufficient.

THE AVERAGE COMPOSITION OF MILK, SKIM-MILK, BUTTERMILK AND WHEY.

	Milk.*	Skim-milk †	Buttermilk †	Whey †
	- - - - - - - - - - - Per cent - - - - - - - - -			
Water	87.5	90.30	90.6	93.40
Fat	3.6	0.10	0.1	0.35
Casein	2.5	2.75	2.8	0.10
Albumen	0.7	0.80	0.8	0.75
Sugar	5.0	5.25	4.4	4.80
Ash	0.7	0.80	0.7	0.60
Lactic Acid	-	-	0.6	

* Dean † Van Slyke.

PUBLICATIONS ON DAIRYING

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

BULLETINS

No. 45 The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test.
45-46 The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test.
Determination of the Specific Gravity of Milk.
The Percentage of Acid and Casein in Milk.
Adulteration of Milk by Skimming and Watering.
The Percentage of Water and Salt in Butter.
The Percentage of Fat and Water in Cheese.
53 Butter making on the Farm.
56 Report on the Dominion Educational Butter Scoring Contest, 1919.
58 The Progress of Cow Testing.

PAMPHLETS

No. 2 Simple Methods for Storage of Ice.
3 Outlook for Dairying and Marketing of Dairy Produce.
7 Why and How to Use Cheese.
13 Keeping Dairy Herd Records.
How and Why to Use Milk.

CIRCULARS

No. 5 Why and How to Use Skim Milk.
6 Why and How to Use Cream.
7 Why and How to Use Cottage Cheese.
8 Why and How to Use Buttermilk.
9 The Branding or Marking of Cheese and Butter Boxes.