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Kentucky Agricultural Experiment Station
UNIVERSITY OF KENTUCKY

THE BABCOCK TEST FOR BUTTER FAT

The Babcock test affords an easy and correct method for determining the amount of butter fat in milk or its products. It is the method in general use in this country for ascertaining the percentage of butter fat in milk and cream. It depends upon the action of sulfuric acid on the milk or cream, using a special test-bottle and a centrifugal machine for bringing the fat together in such a way that it can be measured. The test is extremely useful for ascertaining the butter fat production of individual cows in a herd and for rapidly determining the percentage of fat in milk or cream brought to a creamery, cheese factory or milk depot.

Average milk is composed of 87.0 per cent water, 4.0 per cent fat, 3.0 per cent casein, 0.5 per cent albumen, 4.8 per cent milk sugar and 0.7 per cent ash. In the Babcock test, sulfuric acid of 1.82 specific gravity (65° B.), or about 90 per cent strength, is mixed with the charge of milk. The acid dissolves all constituents except the fat which is set free and rises to the top of the hot mixture, in a melted condition. Separation of the fat is hastened by the use of a centrifugal machine or "Babcock tester," and by adding hot water to bring the melted fat up into the graduated neck of the test-bottle, where it may be measured.

Observations made during inspection work and in testers' license examinations indicate that cream station operators are often lacking in detailed information concerning the testing of milk and cream. An average of one operator out of every six has failed to pass a satisfactory examination in the operation of the Babcock test for butter fat, and many who do pass barely reach the grade of 75%, which entitles them to a Certificate of Proficiency. Four or five weeks of actual cream-station experience should be sufficient to enable an operator to qualify for a tester's license, and yet many fail with even longer experience. In such

instances it is considered that the operator has not been properly instructed. If field superintendents do not give enough time to the training of new operators it cannot be expected that they will prove to be anything but inefficient. But it is admitted that field superintendents do not, as a rule, have the time to devote to the thoro training of new operators. It then falls on the operator to get himself the training he needs, by study and experience. The purpose of this circular is to supply operators with the details in the testing of milk and cream that they are known to be in need of.

APPARATUS REQUIRED

The following standard apparatus will be required in testing milk and cream.

Babcock Milk Test Bottles. Those legal in Kentucky, Fig. 2, A, are graduated on the cylindrical neck for a total fat-content of 8 per cent, subdivided to one per cent, one-half and one-tenth of one per cent, each whole per cent being numbered. The graduated part must be at least 63.5 millimeters (2½ inches) long and the cylindrical neck must extend at least 9 mil-

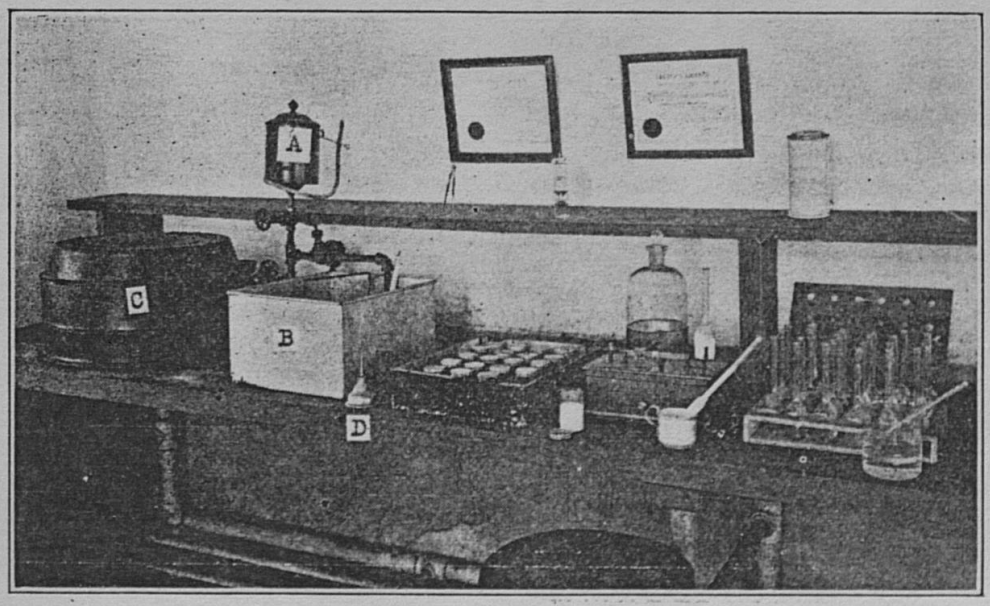

FIG. 1.—Good equipment for testing cream and milk by the Babcock method. Note the compact arrangement. A. Hot Water Tank. B. Water Bath. C. Tester. D. Can for Glymol.

limeters above and below the graduated part. The capacity of the bulb must be not less than 45 cubic centimeters and the total height of the bottle must be between 150 and 165 millimeters (5 7/8 and 6½ inches).

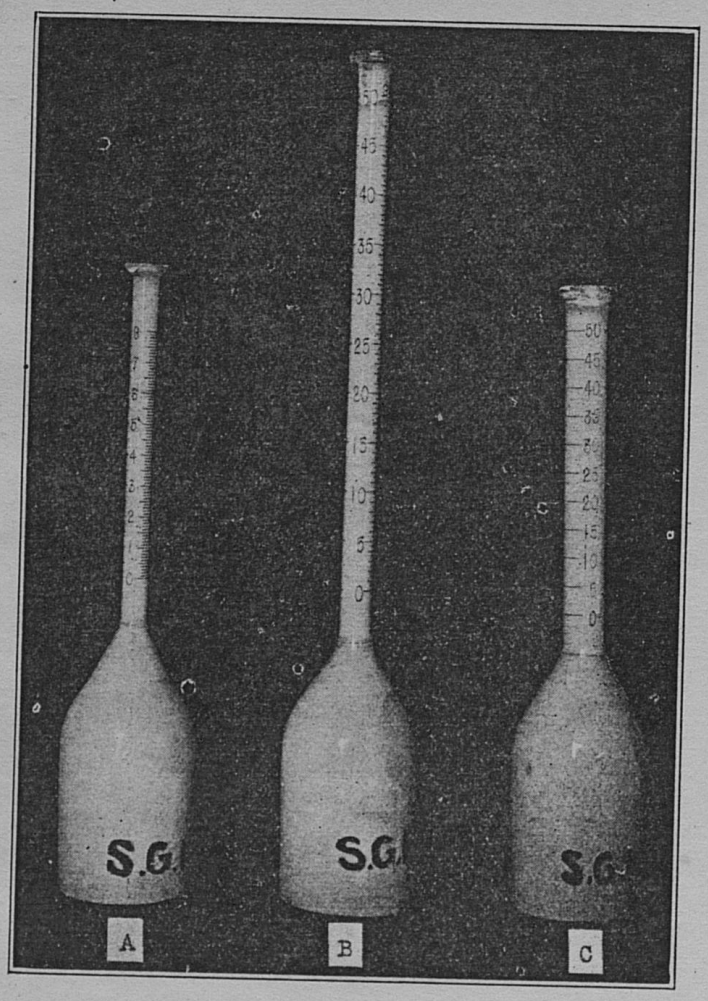

FIG. 2.—Standard milk and cream test-bottles.

Babcock Cream Test-Bottles, of which two types are allowed by the Kentucky law; the short-neck, 50 per cent, 9-gram bottle, Fig. 2, C, and the long-neck, 50 per cent, 9-gram bottle, Fig, 2, B.

(a) The short-neck bottle is of the same general style and dimensions as the standard milk-test bottle, except that the neck

is wider. It is intended for a 9-gram charge of cream, and must be so marked on the neck, above the graduation. It is graduated for a total of 50 per cent, the subdivisions representing 5 per cent, one per cent and 5/10 of one per cent. This is the type commonly used.

FIG. 3. — Standard milk pipette

(b) The long-neck bottle is 210 to 235 millimeters (8¼ to 8⅞ inches) in height and the graduated scale on the neck is not less than 120 millimeters long; in other respects, this bottle conforms to the specifications for the short-neck cream bottle. The long-neck bottle is too tall to be used in the ordinary Babcock centrifugal machines.

17.6 cc. Babcock Milk Pipettes (Fig. 3). These must conform in their dimensions to specifications prescribed in the law.

A 9-gram cream weight for weighing 9 grams of cream into the test-bottles.

All the foregiong apparatus must have been inspected and approved by the Kentucky Agricultural Experiment Station before it can be legally used within this State in testing milk and cream for the purpose of buying and selling the same on the basis of butterfat content. Babcock testing glassware and cream weights which have been thus examined and approved are permanently marked with the letters "S. G. K.," meaning "standard glassware, Kentucky."

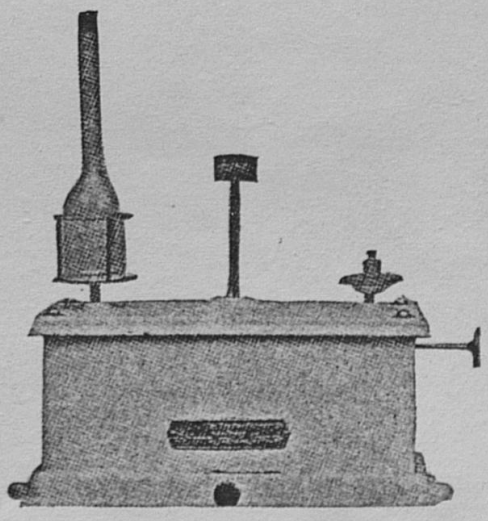

FIG. 4.—Torsoin balance No. 1500.

In addition to the foregoing standard apparatus, the following will be needed:

Cream-Test Balances. Several types of scales for weighing the charge of cream may be used. A good kind is illustrated in Fig. 4. A one-bottle scale is to be preferred, as being the most sensitive and accurate, tho the two-bottle type is quite good. Multiple-bottle scales, that is, those in which several test-bottles are balanced at one time, should not be used.

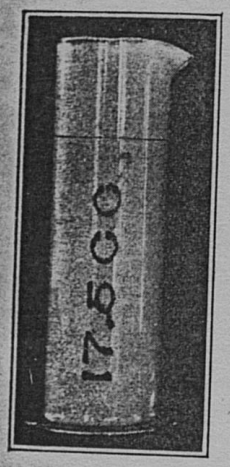

FIG. 5. — Acid measure.

The scales and weights should be kept scrupulously clean and protected from corrosive substances, such as acid, salt and water.

A measure for acid, which may be a glass dipper of proper size, Fig. 16, a small glass cylinder graduated at 17½ cc, Fig. 5, or one of the special contrivances for delivering 17½ c.c. of sulfuric acid, several forms of which are obtainable from dealers.

A water-bath, Fig. 6, and Fig 1, B, in which the test-bottles can be brought to a temperature of 135 to 140° F. before reading the fat.

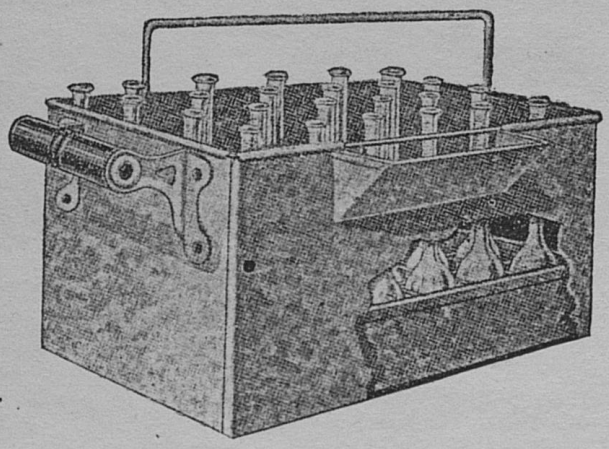

FIG. 6.—Water bath.

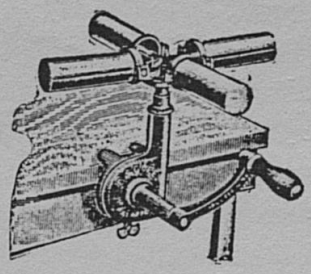

FIG. 7.—A four-bottle hand tester.

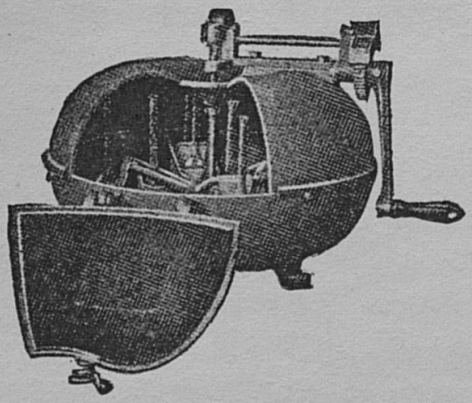

FIG. 8.—An enclosed hand tester.

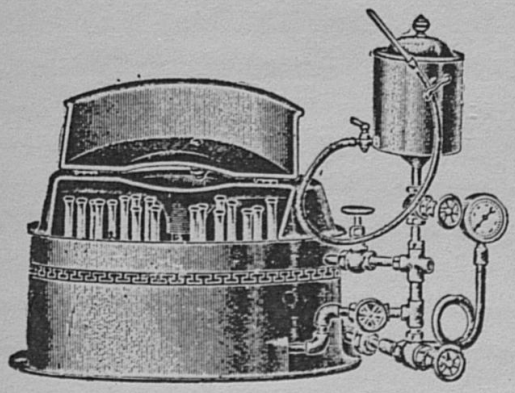

FIG. 9.—A steam turbine tester.

A Babcock tester or centrifugal machine, Figs 7, 8, and 9, of a size appropriate to the amount of testing to be done at one time. The steam-turbine machines, Fig. 9, and Fig. 1, C, are very advantageous, where much testing is done and steam pressure is available. The electrically driven and hand driven machines are very satisfactory. Machines having an odd number of bottle hangers are to be avoided, because it is difficult to balance them, when all the hangers are not in use. The common form of 10-bottle machine having five hangers, each for two bottles, is undesirable on this account. A good tester must be capable of being driven at a high speed. An 18-inch machine should be run at not less than 800 revolutions a minute; a 12-inch machine at not less than 1,000 revolutions and smaller machines faster in proportion.

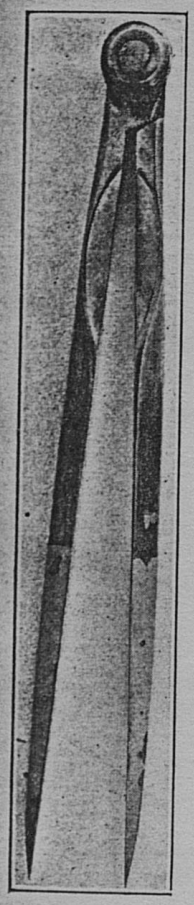

FIG. 10.—Dividers

A pair of dividers, Fig 10, for measuring the fat-column. These are indispensable for rapidly and accurately reading the percentage of butter fat. They should be of substantial construction, with fine points and a joint which permits smoth movement but firm enough to maintain the position of the arms when set at any point.

Suitable bottles for samples, which may be the regular milk-bottle of the dairy, "ideal" jars, wide-mouth, stoppered bottles or the like, Fig. 11.

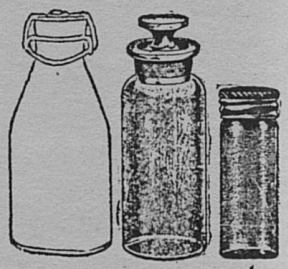

FIG. 11.—Sample bottles for milk and cream.

Other Appliances. Some arrangement for taking samples, such as a combined stirrer and dipper, Fig. 19, No. 1, or one of the several kinds of sampling-tubes sold by supply houses; cream transfer-pipettes for use in transferring cream into test-bottles; small brushes for cleaning the necks of test-bottles; some arrangement for adding hot water to the test-bottles, Fig 1, A and Fig. 9; a small oil can for handling Glymol, Fig. 1, D, and other conveniences which will suggest themselves to the worker. Tables to aid in computing the value of milk or cream from the percentage of butterfat found are obtainable from dealers in creamery supplies and are very useful.

MILK TESTING*

Taking the Sample. The value of the result depends as much upon a correct sample as upon any other factor. When milk or cream is allowed to stand, the particles of fat, being rel-

* Applicants for testers' license are examined on milk testing as well as cream testing. The law requires that cream-station operators be proficient in testing milk.

atively lighter than the other constituents, tend to rise, causing the upper part of the milk or cream in the container to become richer than the lower part. Therefore, immediately before taking the sample, the can of milk or cream should be thoroly mixt by being well stirred with a suitable paddle or stirrer, Fig. 19, No. 1, drawn rapidly up and down thru the milk or cream or, better, the contents of the can may be poured back and forth several times from one can to another. After thus making sure that the butter fat is uniformly distributed thruout the whole bulk to be sampled, a portion of about 2 ounces should be dipt out immediately for the sample. This quantity will be sufficient for duplicate tests, and a retest, if necessary. Small glass jars provided with tight-fitting tops, Fig. 11, or with corks, are used to contain the samples. If the sample is to be kept for a day or more before testing, a preservative tablet should be added. Directions for use come with the tablets. The preservatives are poisonous, so the sample bottles should be labeled "poison" and care exercised to prevent the preserved sample from being mistaken for wholesome milk or cream.

Composite Samples. A composite sample is one made up of a number of small samples that have been gathered from various cans of milk. For instance, where a consignment of milk consists of several cans full, it saves time to determine its percentage of fat by testing a composite sample obtained by putting into one vessel a small portion of milk taken from each can. To make the composite sample truly representative, when the milk in the several cans is not all of the same richness, it is necessary that the portion taken from each can shall be the same proportionate part, or aliquot, of the quantity of milk which it represents. Thus, if there are 5-gallon and 10-gallon cans of milk in the lot and 2 ounces are taken from each 10-gallon can, then only 1 ounce should be taken from each 5-gallon can. Again, it may be convenient and desirable to make a composite sample of the milk brought by each consignor, over a period of several days or a week, especially where consignments are not large. In testing the cows of a herd, it is a good plan to take composite samples representing the milk of each indi-

vidual over a period of several milkings. A preservative should be used in composite samples which are not to be tested immediately. It is permissible to use composite samples of milk but not of cream.

Preparing the Samples for Testing. Just before testing, the contents of the sample-jar should be warmed to 55 to 70 degrees F. and thoroly mixt by shaking the test-jar vigorously or, preferably, by pouring the milk back and forth several times from one jar to another. If a sample is sour or curdy, a very little dry caustic soda (concentrated lye) should be added and the jar shaken to dissolve the lumps of curd. Where this has been done, care must be exercised subsequently, when adding acid to the milk so treated, as some of the contents of the test-bottle may be thrown out by the violence of the chemical action.

FIG. 12. — Proper method of running the milk into the test bottle.

Measuring the Milk for a Test. For measuring out the charge of milk, a standard 17.6 cc milk pipette, Fig. 3, is used. Place the small end of the pipette in the milk and draw up the milk by suction, filling the bulb and the stem to about an inch above the zero mark. Place the finger quickly on the upper end of the pipette to close it air-tight and thus control the flow of milk from the pipette. Allow the milk to run slowly out of the pipette by loosening the finger slightly, until the lowest point of the curved surface of the milk is exactly even with the ring or zero mark that is found ground into the glass stem. Lower the pipette into the milk test-bottle until the bulb rests on the top of the neck, then remove the finger and let the pipette drain into the bottle, Fig. 12, blowing into the bottle the last drop that usually clings to the pipette. The finger should be perfectly dry.

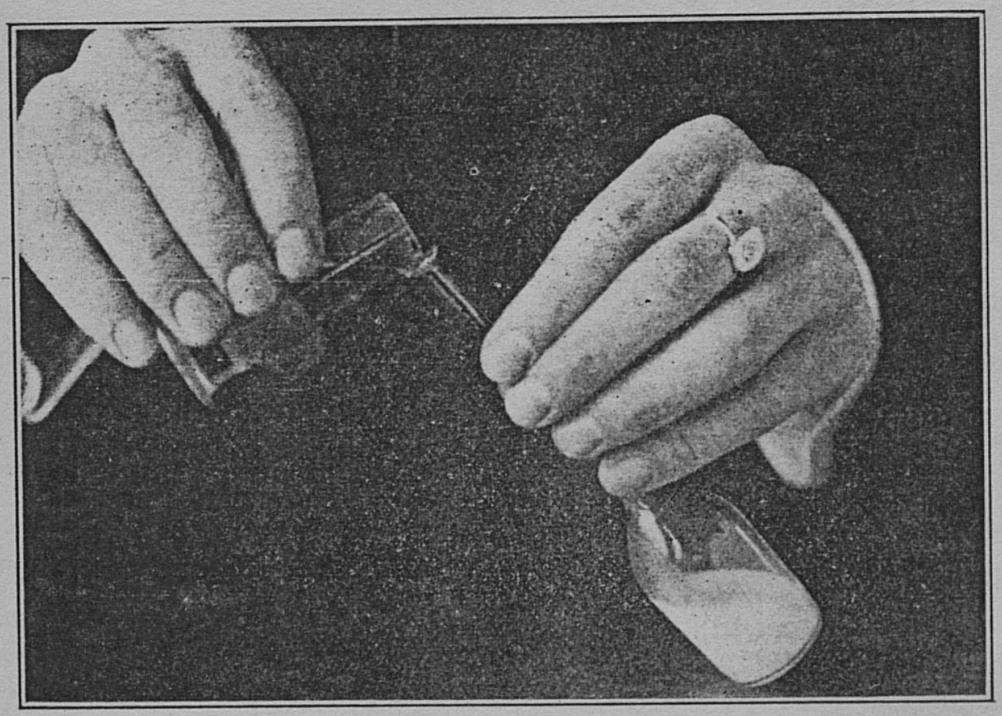

FIG. 13.—Adding acid to milk-test bottle.

Adding the Acid. Add 17.5 cubic centimeters of commercial sulfuric acid to the test-bottle containing the measured portion of milk. The acid should be at 55 to 70 degrees F. and of a specific gravity of 1.82 to 1.83. The bottle should be held in an inclined position and the acid allowed to flow slowly down the inside of the bottle neck, Fig. 13, to the bottom of the bulb, forming a distinct layer separate from the milk on top. It must quickly be mixt with the milk, by giving the bottle a rotary motion, Fig. 14. The mixture gets hot and should produce a liquid, coffee-brown in color, not containing any flakes of undissolved curd or charred particles.

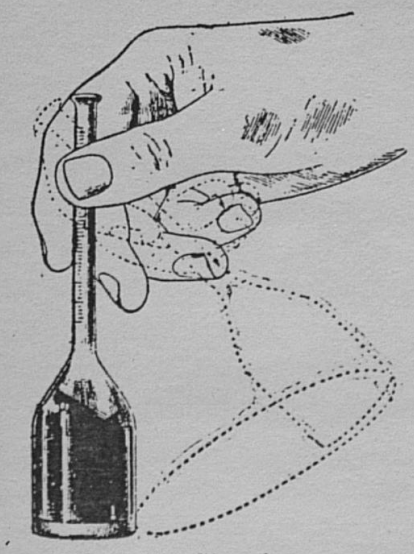

FIG. 14.—Showing proper method of shaking bottle to mix acid and milk.

Whirling the Bottles and Adding Water. The next step is to separate the fat by whirling the bottle in a centrifugal, Figs.

7, 8, and 9, and by adding hot water. First whirl the bottle for five minutes at the proper speed for the particular machine. An 18-inch machine should be operated at 800 revolutions a minute, while a 12-inch tester should revolve 1,000 revolutions a minute. If the machine is not full, it should always be balanced by having the bottles opposite each other. A test-bottle filled with water should be put in opposite an odd test. At the end of five minutes stop the machine and add hot water sufficient to bring the contents up to the neck of the bottle. Next whirl two minutes and then add hot water to bring the fat up into the neck of the bottle, almost to the top of the graduations, dropping the water directly on the fat to wash the fat-column of charred material. For this purpose use clean, soft water. If the water is hard it may sometimes be softened by boiling; it is better to use rain-water or distilled water. Finally, whirl the bottles one minute.

After the whirling is completed, place the bottles in a water bath, Fig. 6, for at least 5 miuutes where they are surrounded by hot water at a temperature of 135 to 140 degrees F. The water in the bath should reach to the top of the fat-column.

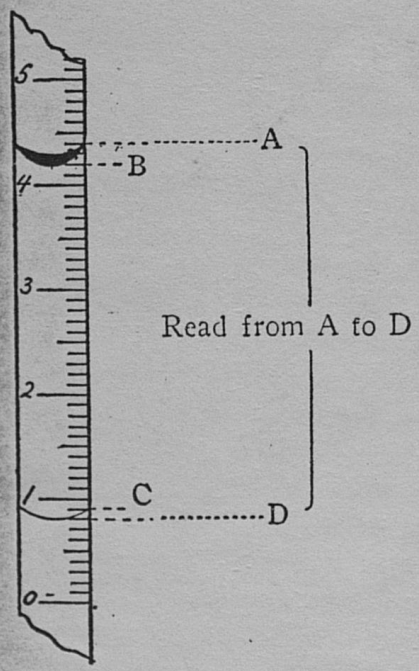

FIG. 15.—Proper method of reading milk test.

Reading the Percentage of Fat. The fat-column will be of a straw color and clear, if the test has been correctly made. A small dip or curve called the meniscus will be found at the top of the fat, and a less pronounced one at bottom. In testing milk, the measurement of the fat-column, Fig. 15, should be taken from the lowest point of the curve at the bottom to the top of the meniscus. Some fat still remains in the bulb, but it is small in quantity, and allowance is made for it by reading to the top of the meniscus.

A pair of dividers, Fig. 10, must be used to read the percentage of fact accurately. Place one point of the dividers opposite the lowest point of the fat-column and the other point opposite the top of the meniscus, to measure the exact length of the fat-column. Without changing the adjustment of the dividers, rest one point on the zero mark, and note where the upper point reaches on the graduated scale, Fig. 17; this reading gives the percentage of fat in the milk.

Dark fat-columns, or those containing charred material, result from using too much acid, too strong acid, or having milk or acid too hot; white or curdy fat-columns result from opposite causes. Great care should be taken to have everything right, to insure correct tests.

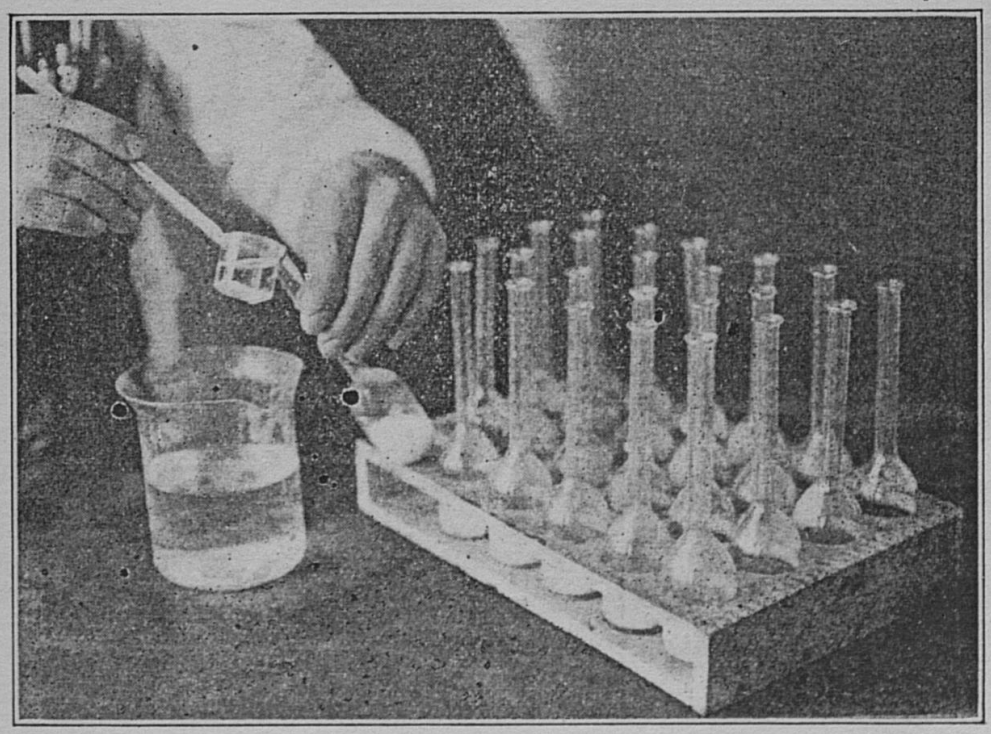

FIG. 16.—Method of adding acid to cream tests.

CREAM TESTING

By P. E. BACON.*

I. SAMPLING CREAM.

The first important step in making an accurate butter fat test is to secure a representative sample. Where cream is smooth and easy flowing a correct sample may be obtained after the cream has been thoroly mixt by stirring or pouring. But, unfortunately, all cream is not smooth and in the best condition for sampling. Cream often is lumpy, clabbery, thick, frozen, or partially churned, and ordinary stirring will not distribute the butter fat uniformly. But stirring, supplemented by other treatment, will usually result in a uniform sample.

Lumpy Cream. Lumps will oftentimes dissolve when the cream is well stirred, unless they are too large or too firm. If vigorous stirring does not break them up the cream may be warmed until the lumps disappear; altho warming is objectionable from the standpoint of quality, since it tends to cause the multiplication of bacteria. A better method is to pass the cream thru a funnel-shaped sieve made of strong galvanized wire (one-eighth inch mesh). Lumps remaining in the sieve should be prest thru with the stirring rod and the cream thoroly mixt before the sample is taken. The sample should not be taken while lumps of cream or curd are present in the mixture.

Curdy or Clabbery Cream. This type of cream is prevalent in warm weather. It should never be heated, as heating toughens the curd, making it more difficult to break up, and therefore more difficult to sample. Use the sieve, as with lumpy cream, stirring thoroly after the curd has been prest thru. It is necessary to take the sample while the cream is being stirred, as curd quickly settles after stirring has ceased. If no sieve is available, break the lumps as fine as possible by stirring.

Thick Cream. When cream sours and cools it becomes thick and viscous. If such cream is very rich in fat it may be-

* Resigned.

come so thick that stirring is well-nigh impossible. Operators have been observed to sample this type of cream by simply dipping a sufficient quantity from the surface without stirring. Incorrect tests are the result. Such cream must first be warmed until it can be easily stirred before sampling is attempted.

Frozen Cream. Care should be taken not to overheat frozen cream in thawing. Warming should be gradual and should not exceed 100° Fahrenheit. Excessive heat liquifies the butter fat, causing it to "oil off," a condition unfavorable to accurate sampling. Allow the cream to thaw at ordinary room temperature when practical.

Buttery Cream. The condition of this cream is due to partial churning. It must be heated in order to melt the particles of butter. Some of the fat will be liberated, or melted, in the process of heating, but this is unavoidable. The cream must then be stirred rapidly and thoroly and the sample taken at once before the liquified fat rises to the surface.

Composite Samples. Because cream is thick, viscous and rich in fat, it is almost impossible to secure a reliable composite sample from a number of cans. *Composite sampling of cream is unlawful in Kentucky.*

Careful Sampling is Worth While. Some operators may feel that these above instructions for sampling can be followed only at the expense of time and labor. This is to some extent true. But when it is remembered that, as often as not, inaccurate tests are due to improperly sampled cream, the conscientious operator will take whatever of time and labor is necessary to insure accuracy.

PREPARING THE SAMPLE FOR TESTING.

Warming and Mixing. If the sample to be tested is cold, thick or lumpy, it should be warmed in a shallow sample bath at a temperature not to exceed 110° Fahrenheit. A higher temperature is in violation of the rules and regulations of the Experiment Station, and may cause the sample to "oil off." A

special pan, three or four inches deep and large enough to accommodate about a dozen sample jars, should be used for warming. Samples will become overheated if placed in the regular hot water bath. After all lumps have dissolved and the cream flows easily, mix the sample thoroly and immediately draw up a portion into the cream pipette for weighing out the nine-gram charge. Some operators mix the sample by stirring with the pipette or by shaking the bottle vigorously, but the method recommended is to pour the cream back and forth several times from sample jar to some other receptacle. Stirring alone, unless very thoroly done, will often result in a poorly mixt sample. If the mixing is accomplished by shaking, care should be taken not to shake too long or too violently, as instances have been observed where this procedure has caused the cream to "churn," resulting in the formation of lumps of butter. When mixing is done by pouring, the receptacle used for that purpose must be rinsed with hot water and allowed to drain before the next sample is mixt.

Oily Samples. Cream that has partially churned will oil off at temperatures around 100° Fahrenheit. A sample of cream in this condition is difficult to handle, since fat will rise to the surface so rapidly after mixing that the securing of a representative sample for the nine-gram charge is difficult. The best way to treat an oily sample is to warm to 110° F., and then emulsify the mixture by hard shaking for a few seconds. As rapidly as possible thereafter, weigh out the charge for test. It is recommended that duplicate tests be made when oily samples are dealt with.

Curdy Samples. Samples containing curd or clabber are very common in summer and are the cause of many incorrect tests. The operator's problem is to break up the lumps as fine as possible. If the curd is tough, pour through a small coarse-mesh coffee strainer and press thru with the fingers the curd remaining in the strainer. Mix the sample well and weigh out nine grams before the curd settles to the bottom of the jar.

CREAM FOR THE TEST.

Cream must be weighed into the test bottles, not measured. It is viscous and does not flow well from a pipette; besides, a given volume of cream varies in weight according to its richness; 17.6 c.c. of cream, for instance, might vary in weight from 17.2 grams to 18.0 grams, depending on its fat content and the amount of air that is mixt with it. The lawful amount of cream to use in testing is 9 grams.

CREAM BALANCES.

The cream balance, or scale used in weighing the cream for testing, is a delicate mechanism and should be properly used and cared for. Any factor affecting the accuracy of scales will likewise affect the correctness of tests. The scale should be conveniently placed in the testing room, and should be on a firm foundation not subject to vibration. Light, unsteady tables are especialy to be avoided, as scales are often thrown out of balance by a hand resting on the table or by a person standing near one of the supports. Operators should be provided with a small pocket level so that the scales may at all times be level when in use. Scales should also be protected from drafts. A convenient means of doing this is to obtain a suitable box to enclose the scale, the top and front being removed.

Sensitiveness. Inspectors are supplied with equipment to check the sensitiveness of scales, but operators should learn to test their own scales frequently. The following method is simple and effective: Balance the scales and allow a *small* drop of cream from the point of a pencil to fall on one of the pans. If the scale "breaks" easily and the pointer swings several spaces or graduations from equilibrium the scale is sufficiently sensitive. Scales in poor condition should be reported at once to the Creamery License Station.

Cleanliness. Scales and weights will accumulate much grease and dirt if not cleaned daily. Weights have been found with enough foreigh matter adhering to top, sides and bottom to

cause several points variation in test. The inspector will not receive a very favorable impression of the operator's ability if station and equipment are unclean.

WEIGHING THE NINE-GRAM CHARGE.

Everything should be in readiness for weighing the nine-gram charge immediately after the sample has been mixt—scales clean, level and protected from drafts; test bottles clean, dry and carefully balanced on the scales; cream pipette clean and well drained; and the nine-gram weight clean and dry. The process of weighing the cream for test should not be interrupted after the sample has been mixt, but should an unavoidable interruption occur (such as a patron requiring attention) the sample should be mixt a second time.

Under no circumstances should cream be transferred from sample jar to test bottle otherwise than by means of a pipette. After each sample is weighed the pipette should be rinsed with hot water, and then allowed to drain. *This is very important.* The hotter the water used in rinsing the pipette the quicker and better it will drain. A small hole bored in the table, in which the pipette can be placed perpendicularly will be found convenient and useful. If, while weighing the charge, any cream is dropt on the pan of the scale or on the outside of the test bottle it should be removed before proceeding with the weighing. Many operators are careless about properly rinsing the pipette.

ADDITION OF ACID.

Many cream tests are ruined by the improper use of acid. A common practis of operators is to add a dipper (or measure) of acid to each test, then shake the mixture and immediately fill the bottle up to the neck with water. The test is thus diluted, often before sufficient chemical action has taken place, and the usual result is a whitish or curdy fat-column. There are several factors governing the action of acid on cream that operators

should understand in order that they may use better judgment in adding acid. These are given as follows:

Strength of Acid. Commercial sulfuric acid is used for the test. Its specific gravity should be 1.82, but acid received at cream stations is often stronger or weaker than this. If left uncovered or exposed to the air acid loses strength from the absorption of moisture. More of it must then be used for the test in order to secure satisfactory results. On the other hand, if acid is too strong, less of it should be used and the operator should exercise greater care in the process of pouring and mixing.

Amount of Acid. This is best determined by first adding two-thirds of a dipper (holding about 9 c.c.) of acid to the cream, mixing thoroly, and then gradually adding small amounts of acid until the proper color is obtained. A dipper full should not be poured in at once. Experience and observation will soon enable the efficient operator to determine when just enough acid has been used.

Temperature of Acid and Cream. Best results will be obtained if acid and cream are both at a temperature of around 70° F. when mixt. Burnt or charred tests are usually caused by the cream or the acid, or both, being too warm. Particular attention should be given to cooling the acid in warm weather, by placing the acid jar in cool water several times during the day. In cold weather acid needs to be warmed to ordinary room temperature, for if cream and acid are both too cold when mixt, curdy tests frequently result. As a general rule slightly more acid should be used in cold weather, and slightly less in hot weather, than under normal temperatures.

Manner of Adding Acid. If poured directly onto the cream, acid sometimes chars the test. Add the acid by allowing it to flow down the side of the test bottle. This washes down the cream adhering to the side of the bottle as well as minimizes the danger of charring. Cream, when too cold or very thick, sometimes adheres so tenaciously to the neck of the bottle that acid will not wash it down. In such case a little hot water poured

around the outside of the bottle neck, before acid is added, will be found helpful.

Richness of Cream. Cream rich in butter fat requires less acid than thinner cream. The color of the resulting mixture is the indication by which to judge. The color is commonly known as "coffee-brown." The operator must remember that he can not add the same amount of acid to all tests and expect satisfactory results.

Mixing. The importance of thoro mixing of acid and cream is sometimes overlooked. Do not allow the acid and cream to stand unmixed, but shake at once by revolving the bottle with a rotary motion until all curd has disappeared. A partially charred test may result if acid and cream remain long in contact unmixt. The practis of adding acid to a half dozen or more tests before any of them are mixt should be abandoned. If the mixing operation is suspended before completion (that is, while much of the curd remains undissolved) a blackened, charred test is the usual result. Shaking should be continued for a short time even after all curd has disappeared.

Diluting with Water. With but few exceptions, operators follow the practis of adding water to the acid-cream mixture right after the mixing. Many operators have no idea why the water is added, and consequently are careless about its use. Inspections have shown that a common cause of sediment in tests is this careless use of water. The reason for its use seems to be two-fold; first, to prevent charring; second, to insure a better colored fat column. It is apparent that if just the right amount of acid be used, and used carefully, no charring will ensue, and the addition of water would therefore be unnecessary as a preventative. Under ordinary cream-station conditions, however, the use of a little (4 or 5 c.c.) water is considered advisable. Operators are cautioned against using *too much* water, *too soon* after shaking. Allow the acid-cream mixture to become a dark brown color before any water is added. The water used should be clean, hot and, preferably, soft. Shake well after adding. Do not use the dirty, greasy water usually found in the hot water bath.

WHIRLING IN THE CENTRIFUGAL.

Speed. Whether hand, electric or steam machines are used, the operator should see that the proper speed is observed in whirling, as indicated on page 6 of this circular. Unless the machine is driven at proper speed, particles of air and water will remain in the fat column, the globules of fat will not be thrown compactly together, and inaccurate tests will result. Too high speed will sometimes cause the bottles to break in the machine.

Number of Whirlings. Some operators are instructed by their field men or companies to make only two whirlings of the centrifugal when running the test. This department recommends three whirlings, of five, two and one minute each. Time should be taken after the machine has reached full speed, and not when it has just started.

Adding Hot Water. Clean, soft water of a temperature not less than 140° Fahrenheit should be used. After the first whirling of five minutes add hot water until the contents reach the neck of the bottle. Then after the second whirling of two minutes add hot water until the fat rises well into the graduated portion of the neck. Drop the water directly on the fat to wash the fat column of charred material. Finally whirl one minute, then remove the bottles from the centrifuge and place them in the hot water bath.

Cold Weather. In cold weather, when a hand machine is used, pour a quantity of boiling water into the centrifugal to keep the tests warm while whirling. If the tests become too cold some of the fat will be found adhering to the side of the bottle below the neck. This may be prevented by keeping the tests warm and whirling at proper speed.

HOT WATER BATH.

Required by Law. The use of the hot water bath, winter and summer alike, is required by law. Operators violating this requirement do so at the risk of having the penalties of the law invoked. Whether the operator sees the need of the bath or not, he should use it because correct work requires its use.

Temperature. The water used in the bath must be at a temperature of not less than 135° F. nor more than 140° F. *at the time the tests are read.* Very hot tests coming from a steam machine and placed in 140° water should naturally raise the temperature of the water, whereas cool tests placed in 135° water would bring the temperature down below the minimum allowed, so that operators should observe the temperature of the bath after tests have been placed therein.

Depth of Bath. A water bath preferably nine inches deep should be used. The hot water must be of sufficient depth to surround the entire length of the butter fat column. In warm weather keep the tests in the bath for not less than three minutes and in cool weather for five minutes, before reading. Caution should be observed not to bring the butter fat too high in the neck of the bottle, as it may rise over the top when placed in the hot water. When lifting bottles from the bath be careful that the drip does not fall into the tests remaining in the bath.

READING TESTS.

Take the tests from the bath one at a time for reading. Once removed, tests begin to cool and the fat column to contract. The longer the test remains out of the bath the less accurate becomes the reading. It is quite common for operators to remove all tests from the bath at once. If there are eight or ten tests, and the room is cool, some of the last tests read will certainly be incorrect. Sometimes it will be noted that the base of the fat column is not level or is fringed with little ragged edges of fat. These two things ordinarily occur only if the test is cooling, and as both of them make for inaccurate reading it will be seen that quickness in reading is necessary after the test is once removed from the bath.

Glymol. Glymol or red oil should always be used on the test before it is read. The proper way to add glymol is to allow five or six drops to run slowly down the neck of the test

bottle. Squirting glymol violently from the oil can, or allowing it to drop directly on the fat, causes a mixing of fat and glymol which results in inaccurate readings. Glymol should not be added until after the tests have remained in the bath for the required length of time, and then only to a few tests at a time—not more than three or four. After glymol is added read at once.

Measuring the Fat Column. Hold the test bottle perpendicularly (straight up and down) and have the bottom of the fat column *on a level with the eye.* If the base of the column is at a higher or lowel level than the eye it is difficult to place the point of the dividers correctly. After one leg of the dividers has been placed on the lowest point of the fat column the bottle should be lowered until the top of the column is on a level with the eye; then place the other leg of the dividers on the dividing line between glymol and fat. Without changing the setting of the dividers place one point on the lowest mark of the scale (called the zero mark), and the upper point of the dividers will indicate the percentage of fat. Some operators have been known to measure the fat column on one bottle and then attempt to take the reading on a different bottle, the reason being that they could not see the figures plainly on the first bottle. Always make the reading on the same bottle you have measured the fat column on. If figures or graduations are dim, a little carpenter's chalk rubbed up and down the scale will bring out the markings quite clearly.

Sediment. When sediment of any kind is apparent at the base of the fat column, in appreciable quantities, do not attempt to read but make a retest. If the fat column is too dark and shows evidences of charring, or too light and has a milky appearance, a retest should be made. Only a clear, amber-colored fat column, free from any foreign matter, can be considered perfect.

High Tests. Not infrequently an operator encounters a test so high in fat that it can not be read in the bottle. In such cases weigh out a second test of nine grams and add the same amount of water (a cream pipette full). Mix the contents and then carefully transfer what you think to be approximately one-half of the mixture to another test bottle. Add acid to the two

tests and proceed in the same manner as with other tests. When the whirling is completed measure the fat, then add the two results, which will give you the correct reading of the high-testing cream.

Dividers. Dividers are often found with dull points, or too loose in the hinge, or with a little "play" in the joint, enough to cause a difference of one or two per cent in the reading. Since the reading of the test is so important, and since the divider is the instrument used in reading, it becomes very necessary, therefore, that the dividers be in good working condition.

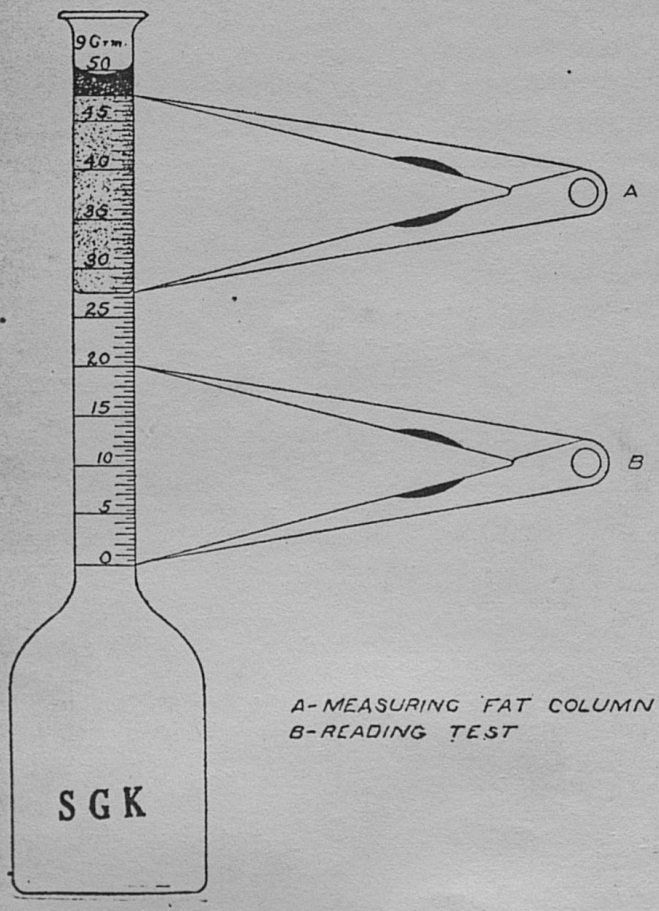

FIG. 17.—Showing correct method of reading cream test, using glymol and dividers.

Alternate Method for Testing Cream. Slight modifications may be made in the method described above. After weighing 9 grams of cream into the test-bottle, an equal quantity of water may be mixt with it, and then 17.5 cubic centimeters of acid added and the test competed as described above for cream.

TESTING SKIM-MILK AND BUTTERMILK.

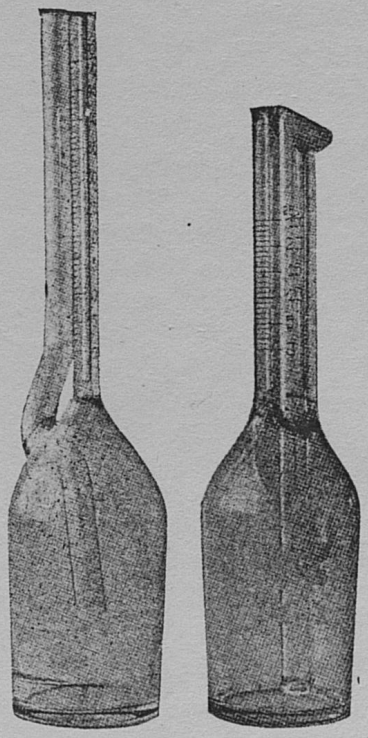

FIG. 18.—Skim-milk test bottles.

Skim-milk is tested in a special bottle that has a small neck and fine graduations, Fig. 18. Skim-milk from a centrifugal separator should contain less than 0.10 per cent fat; in fact, less than 0.05 per cent, if the separator is in good order. 17.6 c.c. of skim-milk are used for a charge, and to this quantity 20 c.c. of acid are added and the bottles whirled twice as long as with whole milk. The small particles of fat in skim-milk are not readily separated out for reading and therefore more acid is used and the bottles are whirled a longer time. The skim-milk bottle has two necks, one for the introduction of milk, acid and water, and the other for collecting and reading the fat. Turn the larger neck toward the center of the centrifugal machine, so the fat will more readily find its way into the small neck, and not collect around the junction of the larger neck with the bulb.

Buttermilk, on the farm, had best be tested in the whole-milk bottle, as it usually contains much fat; the buttermilk of the creamery, however, should be tested in a skim-milk bottle, as it seldom exceeds 0.2 per cent of fat. Buttermilk is tested in the same way as whole milk.

CLEANING GLASSWARE

When the test is completed the bottles should be emptied while they are still warm, and rinsed with hot water, to remove the acid and fat. Empty them into an earthenware jar or crock, as the acid corrodes metal. Shake the bottles while emptying them, as that serves to remove the ash material that often clings tenaciously to the bottom of the bottle. If hot water alone does not clean the bottles sufficiently, wash them in hot water to which caustic soda or washing powder has been added. Run a small brush up and down the bottle neck to remove adhering fat. The glassware can be kept bright and clean like new, if carefully washed.

THE BABCOCK TESTERS' LICENSE.

The creamery and testers' license law (Acts of the Kentucky Legislature, 1918, chapter 74) requires that "every creamery, shipping station or other factory, or person, or agent, receiving, buying and paying for milk or cream on the basis of the amount of butter-fat contained therein shall have in its employ a licensed tester who shall supervise and be responsible for the operation of the Babcock test for milk and cream." Under this law, testers' licenses are obtainable only by those who hold certificates of proficiency from the examining board. To determine the qualifications of testers, examinations are held from time to time and to those found competent a certificate of proficiency is given, upon presentation of which to the Director of the Experiment Station and payment of the required fee a tester's license will be issued. The examinations consist of laboratory work in actually testing samples of milk and cream, and in written questions regarding the operation of the test. To comply with the law, testers who have not already been granted licenses should immediately make application to the Experiment Station for a permit to serve in lieu of a license until the next examination.

INSPECTION OF CREAMERIES

From time to time a representative of the Experiment Station will visit the cream stations to see that the testers are making the Babcock tests properly and to inspect the glassware, weights and scales. A tester found derelict in his duty may have his license revoked.

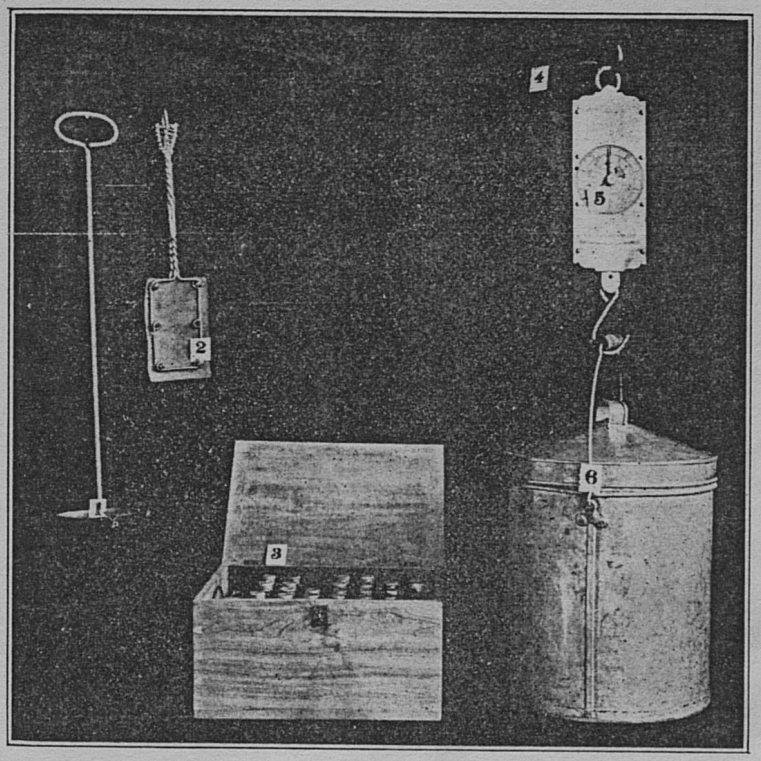

FIG. 19.—Hauler's equipment. 1, Stirrer and sampler. 2, Cream scraper. 3, Box with sample bottles. 4, Bracket to support scales. 5, Scales for weighing milk or cream. 6, Can for weighing milk or cream.

Full information regarding the law may be procured by writing to the Director of the Experiment Station, Lexington, Ky.

ACKNOWLEDGMENT.

We desire here to express our obligation to the Indiana Station for the photographs from which the cuts in this circular were made; except figures 2 and 3, which are original.

QUESTIONS AND ANSWERS

The following questions will serve to acquaint prospective candidates for a certificate of proficiency with the kind of information they will be required to have when examined. It is advisable that each tester should provide himself with an authoritative text book on the subject of milk and cream testing. Two very good texts are, "Testing Milk and its Products," by Farrington and Woll, published by the Mendota Book Co., Madison, Wis., at $1.50, postpaid; and "Modern Methods of Testing Milk and its Products," by Van Slyke, published by Orange Judd Co., New York City, $1.50, postpaid.

Questions such as the following may be asked an applicant for certificate of proficiency in testing milk and cream.

1. What is the composition of average normal milk?

   Answer: Water, 87 per cent; fat, 4 per cent; casein, 3 per cent; albumen, .5 per cent; milk sugar, 4.8 per cent; ash, .7 per cent.

2. How should the sample of milk for analysis be preserved, if it is to be kept several days?

   Answer: Dissolve in it a preservative tablet of corrosive sublimate, potassium bichromate or other preservative. Stop the jar containing the sample tightly so there will be no evaporation and put it away in a cool, safe place.

3. What should be done immediately before drawing out a portion for test, from the sample jar?

   Answer: Rotate the sample jar or pour the milk back and forth from one jar to another at least three times, to mix the fat thoroly in the milk.

4. When the sample contains lumps of cream, how should it be treated before drawing out the test portion?

   Answer: Warm it by placing the jar in a vessel of warm water not to exceed 110 degrees F. until the lumps are softened and shake until they are dissolved.

5. If the milk is sour and contains lumps of curd, how may it be treated before sampling?

   Answer: Add a knife-point of lye, shake the bottle and let stand until curd is dissolved.

6. What is the acid used in the Babcock test?

   Answer: Sulfuric acid of specific gravity 1.82 or 65 degrees Beaume.

7. How much milk and how much acid are used in making a Babcock test?

   Answer: 17.6 cubic centimeters of milk and about 17.5 cubic centimeters of acid.

8. If the acid is too weak, what should be done?

   Answer: Use slightly more of it; but if it is so weak as to result in bad tests, then return it to dealer.

9. What should be done if the acid is too strong?

   Answer: Use less of it. Do not add water to the acid During wet weather the acid will absorb water fast and become weaker, if the container is left unstopt.

10. What should be the temperature of the milk and acid before they are mixt together.

    Answer: 60 to 70 degrees F.

11. How many minutes should the bottles be whirled in the centrifugal?

    Answer: Whirl first time, five minutes; second time, two minutes; and one minute third time.

12. How fast should the test bottles be whirled?

    Answer: At the full speed for which the machine is designed. For a 12-inch tester the speed should be not less than 1,000 revolutions a minute, and for an 18-inch wheel not less than 800 revolutions.

13. What should be the temperature of the test bottle and fat-column when it is read?

    Answer: At 135 to 140 degrees F. The bottles should stand in the hot-water bath at this temperature for 5 minutes before reading the fat.

14. Are the tesst at proper temperature for reading as they come from a steam-turbine tester and from a hand tester?

    Answer: As the tests come from a steam tester they are usually too hot, and too cold as they come from a hand machine. Use of the hot-water bath, containing water at a temperature of 140 degrees F. is essential in making correct tests.

15. How should the fat test be read?

    Answer: With a pair of dividers, measure the exact length of the fat column in the neck of the test-bottle; then place one leg of the dividers at zero on the graduated scale and read the per cent at the point on the scale which the other leg reaches.

16. From what points of the fat column should the measurements be made?

    Answer: Milk tests should be measured from the extreme bottom of the fat column to the extreme top of the meniscus, but in cream tests only one-third of the meniscus is read. In the latter it is best to flatten the meniscus with glymol and read to the dividing line where the glymol and the fat column join.

17. What is the "meniscus?"

    Answer: It is the curve in top of the fat column.

18. What is glymol?

    Answer: A red-colored oil sold by creamery supply houses for use in reading cream tests.

19. Why is glymol used in cream tests?

Answer: Several drops put on top of the fat column flatten the meniscus so that the test can be read more accurately.

20. How should the cream test be read when glymol is not available?

Answer: Include one-third of the meniscus in the reading.

21. How can glymol be handled best?

Answer: From a small oil-can kept for this use, which is much better than using a pipette.

22. What else can be used instead of glymol?

Answer: Good separator oil, colored red by putting alkalet or Sudan red III into it, serves the same purpose and is cheaper. The glymol of the drug stores is colorless, but may be colored in the same way. It is more costly than that sold by creamery supply houses.

23. What do the subdivisions in the 8 per cent test bottle represent?

Answer: Each division is one-tenth of one per cent.

24. How should a sample of cream be taken?

Answer: First stir the cream that is to be sampled, or pour it from one can to another three times. Then take out at least two ounces for the sample so as to have some for a retest, if necessary.

25. Should composite samples of cream be taken?

Answer: No; composite sampling of cream leads to inaccuracy. A separate sample should be taken from each can and tested separately. It takes more time, but is decidedly more accurate.

26. Why should cream be weighed into the test-bottle instead of being measured with a pipette as with milk?

Answer: The density of cream varies according to its fat content. A given measure of poor cream is heavier than the same measure of rich cream. The weight of 17.6 cubic centimeters of cream may vary from 17.2 to 18.0 grams. Again, cream does not flow well from a pipette, so it is impossible to accurately measure 9 grams in this way. The 9 grams should be weighed carefully on an accurate, one-bottle scale that is protected from drafts of air.

27. Are multiple-bottle scales desirable?

Answer: No. A one-bottle scale should be used to insure the greatest accuracy.

28. How much sulfuric acid should be used with 9 grams of cream?

Answer: From 8 to 12 cubic centimeters, but the exact amount will vary with different lots of cream and strengths of acid. The right amount is determined from the color of the mixture of acid and cream, which should be a coffee-brown.

29. At what temperature must cream tests be read?

Answer: At 135 to 140 degrees Fahrenheit, obtained by placing the bottles in a hot-water bath heated to this temperature, for a period of five minutes, before reading them.

30. What causes air bubbles in the fat-column?

Answer: Hard water. Only soft water, such as rain water, should be used.

31. What causes a whitish or milky fat-column?

Answer: Too little or too weak acid, or cold acid and milk.

32. What causes a charred fat-column?

Answer: Too much acid, or too strong acid, or allowing the acid and milk to stand too long before mixing, when starting the test.

33. Under what conditions should a retest be made?

Answer: Whenever the test varies 3 per cent, or more, from a previous shipment from the same farm.

34. What is Standard Glassware?

Answer: It is a Babcock testing-glassware that has been examined by the Kentucky Agricultural Experiment Station, found to conform with the specifications of the Kentucky Creamery and Testers' License Law and sealed with the letters "S. G. K."

35. What do the letters "S. G. K." mean when etched on test-bottles and pipette?

Answer: They stand for the words "Standard Glassware, Kentucky," and mean that the articles bearing these letters have been examined by the Kentucky Agricultural Experiment Station and found correct. The use of apparatus which has not been so examined and marked is prohibited by law.

36. What testing apparatus is required by law to be tested and marked by the Experiment Station.

Answer: Babcock milk-test bottles, cream test-bottles, 17.6 c.c. milk pipettes and 9-gram cream weights.

37. How are standard milk-test bottles graduated?

Answer: They are graduated to 8 per cent, with subdivisions of one-tenth of one per ecnt.

38. How are standard cream test-bottles graduated?

Answer: They are graduated to 50 per cent, with subdivisions of 5/10 per cent.

39. What kinds of cream test-bottles are legal in Kentucky?

Answer: There are two types of standard cream test-bottles; the 50-per cent, 9-gram, 6-inch bottle and the 50-per cent, 9-gram, 9-inch bottle. The subdivisions of each type represent 5/10 per cent.

40. How may Standard Glassware be procured?

Answer: By ordering it from a dealer and stipulating that it shall fulfill the requirements of the Kentucky Creamery and Testers' License Law. Such glassware may be shipped, prepaid, directly from the dealer to the Experiment Station for testing, provided the fee of 3 cents for each piece of glassware to be inspected, is remitted to the Station.

41. Is it of benefit to creameries, etc., that the glassware should be inspected in this way?

Answer: Yes. A great deal of glassware that has been used in the State has been found inaccurately graduated.

42. How may a tester's license be procured?

Answer: By applying to the Experiment Station for a permit to serve in lieu of a license until notified to appear for examination. After passing a satisfactory examination and paying the fee of $2.00, a license will be issued.

43. May a tester's license be revoked?

Answer: Yes; whenever the licensee fails to comply with the provisions of the law and the rules and regulations of the Kentucky Agricultural Experiment Station.

44. How may a creamery milk depot procure a license to do business?
Answer: By applying to the Director of the Experiment Station, and sending license fee of $6.00. This is separate from the tester's license fee of $2.00.

45. In case of doubt, what should be done?

Answer: Write to the Experiment Station and ask for information.

BRIEF DIRECTIONS FOR TESTING MILK FOR FAT

1. Secure a representative and well-mixt sample of the milk.
2. With a standard pipette measure 17.6 c.c. (18 grams) into standard Babcock milk test-bottle.
3. Add 17.5 c.c. sulfuric acid and mix milk and acid very thoroly.
4. Put the test-bottles into Babcock tester and whirl for five minutes at proper speed.
5. Add hot water until fat-column reaches neck of bottle.
6. Whirl in tester for two minutes.
7. Add hot water until fat-column is within the graduated scale on neck of test-bottle.
8. Whirl in tester for one minute.
9. Put test bottles into hot water bath at 135-140 degrees F. for five to ten minutes.
10. Read and record the test in per cent and tenths.
11. Clean all utensils.

BRIEF DIRECTIONS FOR TESTING CREAM

1. After the can is thoroly mixt, take a sample of about 2 ounces.
2. Warm this sample to not exceeding 110 degrees F. and mix thoroly.
3. Balance test-bottles accurately.
4. Transfer into test-bottle, using a cream pipette, exactly 9 grams of cream.
5. Add about 2/3 of the measure of acid, mix well; then add gradulaly, shaking after each addition of acid until "coffee-brown" color is obtained.
6. After contents of bottle turn **dark brown** add 4 or 5 c.c. (about 1 teaspoonful of hot water); shake.
7. Place in centrifugal and whirl at proper speed for 5 minutes.
8. Stop machine, add water of temperature of 140 degrees F. or above until contents reach neck of bottle.
9. Whirl 2 minutes; stop, add water of same temeprature as in 8 until all fat is in graduated portion of neck.
10. Whirl 1 minute; remove from centrifugal and place test-bottles in water bath at temperature of 135 degrees to 140 degrees.

11. Allow to remain 5 minutes, then take out, one at a time, add several drops of glymol and read immediately by placing legs of dividers so as to indicate entire fat column; then place lower leg of dividers on zero of same bottle and read where upper leg points.

COMMON CAUSES FOR POOR TESTS

1. Insufficient mixing of milk and acid, which may cause either a burned test or leave some of the curd undissolved.
2. Too much or too little acid, the former giving a dark fat-column containing charred matter and the latter a very light one with some undissolved curd at the bottom of the fat-column.
3. Too strong or too weak acid, the former leaving a dark fat-column while the latter will give a very light-colored fat and some undissolved curd.
4. Too high temperature of either acid or milk or both. The result will always be a dark fat-column containing charred matter and unclean test. Try to have acid and milk between 60 degrees F. and 70 degrees F.
5. Running tester at too low speed.
6. Hard water, which is apt to give a white foam on top of fat-column.
7. Inaccuracy in reading of fat-column.

COMMON REASONS FOR VARIATION IN TEST OF CREAM

1. Change in the position of the cream screw of the separator. If it is turned toward the center the cream will be richer and if turned away from the center it will be thinner.
2. Change in speed of the separator. Low speed means thinner and high speed richer cream; therefore, admitting milk to separator before speed is up means thin cream.
3. Vibrating bowl, caused either by the separator not being level or not standing on a solid foundation. This always means thin cream and rich skim-milk.
4. Dirty separator. This generally means a poor quality of thin cream.
5. Too much rinse water, which always gives a thinner cream.
6. Incorrect rate of inflow. If too much milk is admitted to the separator the cream will be thin; if not enough, the cream will be richer than is desirable.
7. Temperature of milk. Warmer milk produces thinner cream. It is profitable, however, to skim the milk while warm, as the separator will then do cleaner skimming.
8. Richer milk produces a richer cream.