TESTING MILK AND ITS PRODUCTS

FARRINGTON AND WOLL

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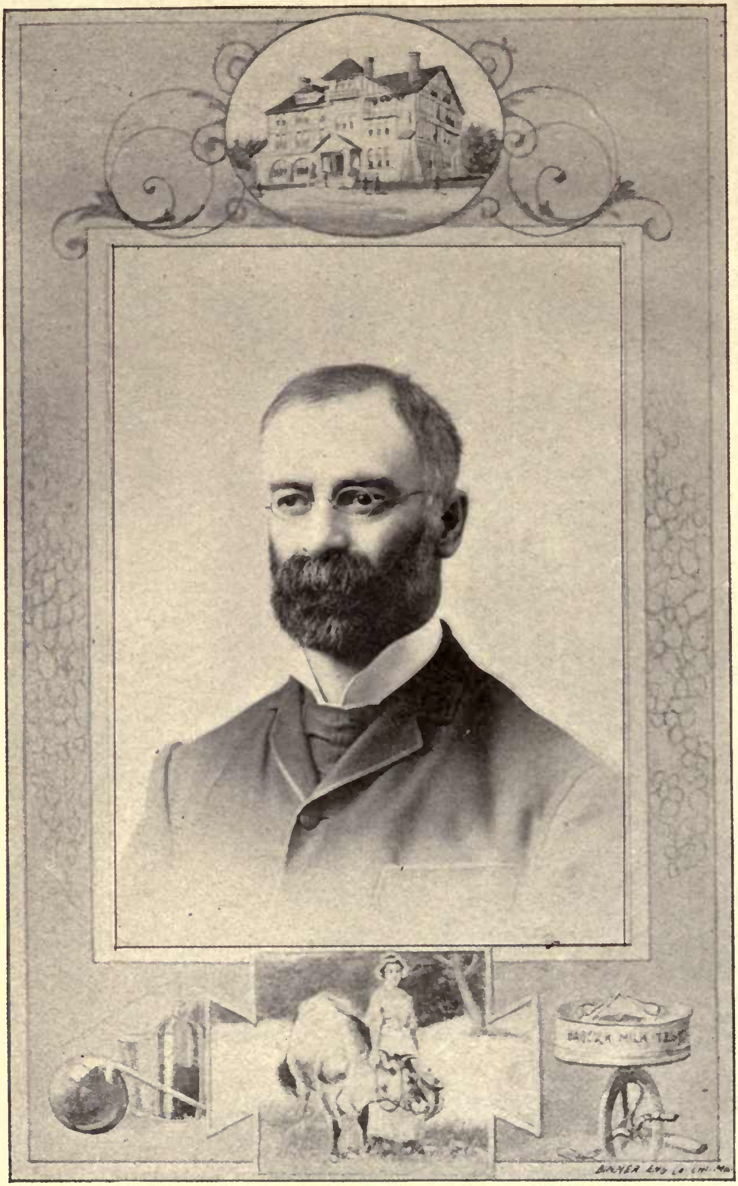

DR. S. M. BABCOCK,

INVENTOR OF THE BABCOCK MILK TEST.

TESTING MILK AND ITS PRODUCTS

A MANUAL FOR DAIRY STUDENTS, CREAMERY- AND CHEESE FACTORY OPERATORS, FOOD CHEMISTS, AND DAIRY FARMERS

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With Illustrations

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PREFACE TO FIRST EDITION.

The present volume is intended for the use of dairy students, factory operators, dairymen, food chemists, and others interested in the testing or analysis of milk and its products. The subject has been largely treated in a popular manner; accuracy and clearness of statement, and systematic arrangement of the subject matter have, however, been constantly kept in mind. The aim has been to make the presentation intelligible to students with no further training than a common-school education, but their work will naturally be greatly lightened by the aid of an able teacher.

Complete directions for making tests of milk and other dairy products are given; difficulties which the beginner may meet with are considered in detail, and suggestions offered for avoiding them. It is expected that a factory operator or practical dairyman, by exercising common sense and ordinary care, can obtain sufficient knowledge of the subject through a study of the various chapters of this book to make tests of milk, cream, etc., even if he has had no previous experience in this line.

For the benefit of advanced dairy students who are somewhat familiar with chemistry and chemical operations, Chapter XIV has been added giving detailed instruction for the complete chemical analysis of milk and other dairy products. The detection of preservatives and of artificial butter or filled cheese has also been treated in this connection.

As the subject of milk testing is intimately connected with the payment for the milk delivered at butter- and cheese factories, and with factory dividends, a chapter has been devoted to a discussion of the various systems of factory book-keeping, and tables greatly facilitating the work of the factory secretary or book-keeper have been prepared and are included in the *Appendix*.

Acknowledgment is due to the following parties for the use of electrotypes, viz: Creamery Pkg. Mfg. Co., Chicago, Ill.; Vermont Farm Machine Co., Bellows Falls, Vt.; Elgin Mfg. Co., Elgin, Ill.; D. H. Burrell & Co., Little Falls, N. Y.; De Laval Separator Co., New York City; Henry Trömner, Philadelphia, Pa.; Springer Torsion Balance Co., New York City; J. H. Monrad, Winnetka, Ill.; Borden & Selleck Co., Chicago, Ill.; Dairymen's Supply Co., Philadelphia, Pa.; Bausch & Lomb Opt. Co., Rochester, N. Y.; John W. Decker, Columbus, Ohio, C. L. Fitch, Fort Atkinson, Wis., and the agricultural experiment stations at New Haven, Conn., and Madison, Wis.

Madison, Wis., October 1, 1897.

PREFACE TO EIGHTH EDITION.

The first three editions of this book were disposed of in about a year and the seventh edition was exhausted three years later. Every year that passes brings some valuable contributions to our knowledge of the subjects treated in the book and a frequent revision of it is therefore desirable.

The present edition contains all the methods and descriptions that have stood the test of actual use during the past few years and the new information which has appeared since the last revision of the book, has been carefully sifted and what was deemed of sufficient importance has been incorporated in such detail as the scope of the book permitted; many changes and additions suggested by the experience of the authors have also been introduced. In brief the book has been subjected to a renewed, critical examination and revision. The general adoption of it as a text book in American Dairy Schools, as well as the favorable reception which it has been accorded by users of Babcock testers and the dairy public in general is naturally a source of gratification to the authors.

Madison, Wis., July 1, 1901.

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Testing Milk and Its Products.

INTRODUCTION.

The need of a rapid, accurate and inexpensive method of determining the amount of butter fat in milk and other dairy products became more and more apparent, in this country and abroad, with the progress of the dairy industry, and especially with the growth of the factory system of butter- and cheese making during the last few decades. So long as each farmer made his own butter and sold it to private customers or at the village grocery, it was not a matter of much importance to others whether the milk produced by his cows was rich or poor. But as creameries and cheese factories multiplied, and farmers in the dairy sections of our country became to a large extent patrons of one or the other of these, a system of equitable payment for the milk or cream delivered became a vital question.

1. The creameries in existence in this country up to within fifteen years were nearly all conducted on the cream-gathering plan: the different patrons creamed their milk by the gravity process, and the cream was hauled to the creamery, usually twice or three times a week, where it was then ripened and churned. The patrons were paid per *inch* of cream furnished; a *creamery inch* is a quantity of cream which fills a can twelve inches in diameter, one inch high, or 113 cubic inches. This quantity of cream was supposed to make a pound of butter, but cream from different sources, or even from the same sources at different times, varies greatly in butter-producing capacity, as will be shown under the subject of cream testing (210[1]). The system of paying for the number of creamery inches delivered could not therefore long give satisfaction.

The proposition to take out a small portion, a pint or half a pint, of the cream furnished by each patron, and determine the amount of butter which these samples would make on being churned in so-called test churns, found but a very limited acceptance, on account of the labor involved and the difficulty of producing a first-class article from all the small batches of butter thus obtained.

2. The introduction of the so-called *oil test churn* in creameries which followed the creamery-inch system, marked a decided step in advance, and it soon came into general use in gathered-cream factories (203). In this test, glass tubes of about $\frac{5}{8}$ inch internal diameter and nine inches long, are filled with cream to a depth of five inches, and the cream churned; the tubes are then placed in hot water, and the column of melted butter formed at the top is read off by means of a scale showing the number of pounds of butter per creamery inch corresponding to different depths of melted butter. While the oil test is capable of showing the difference between good and poor cream, it can not make strictly accurate distinctions between different grades of good and of poor cream[2]. As

1 Refers to paragraph numbers.
2 Wisconsin Experiment Station Bulletin 12.

a result, perfect justice cannot be done to different patrons of creameries where payments for cream delivered are made on the basis of this test.

3. In cheese factories, and since the introduction of the centrifugal cream separator, in separator creameries, the problem of just payment for the milk furnished by different patrons was no less perplexing than in the case of gathered-cream factories. By the pooling system generally adopted, each patron received payment in proportion to the number of pounds of milk delivered, irrespective of its quality. Patrons delivering rich milk naturally will not be satisfied with this system when they find that their milk is richer than that of their neighbor's. The temptation to fraudulently increase the amount of milk delivered, by watering, or to lower its quality by skimming, will furthermore prove too strong for some patrons; the fact that it was difficult to prove any fraud committed, from lack of a reliable and practical method of milk analysis, rendered this pooling system still more objectionable.

4. As another instance in which the need of a simple test for determining the fat content of different kinds of milk was strongly felt, may be mentioned the case of private dairymen and breeders of dairy cattle, who desired to ascertain the butter-producing capacities of the individual cows in their herds. The only manner in which this could be done, was by the cumbersome method of trial churnings: by saving the milk of the cow to be tested, for a day or a week, and churning separately the cream obtained. This requires a large amount of work when a number of cows are to be tested, and can not therefore be done except in comparatively few cases, with cows of great excellence or by farmers having abundant hired help.

5. Introduction of milk tests. The first method which fulfilled all reasonable demands of a practical and reliable milk and cream test was the Babcock test, invented by Dr. S. M. Babcock, chemist to the Wisconsin experiment station. A description of the test was first published in July, 1890, as bulletin No. 24 of Wisconsin experiment station, entitled: *A new method for the estimation of fat in milk, especially adapted to creameries and cheese factories.* This test, which is now known and adopted in all parts of the world where dairying is an important industry, was not, however, the first method proposed for this purpose which could be successfully operated outside of chemical laboratories. It was preceded by a number of different methods, the first one published in this country being Short's method, invented by Mr. F. G. Short and described in bulletin No. 16 of Wisconsin experiment station (July, 1888).

6. Short's test. In this ingenious method, a certain quantity of milk (20 cc.[1]) was boiled with an alkali solution and afterwards with a mixture of sulfuric and acetic acids; a layer of insoluble fatty acids separated on top of the liquid and was brought into the graduated neck of the test bottles by addition of hot water; the reading gave the per cent. of fat in the sample of milk tested.

Short's method did not find very wide application, both because it was rather lengthy and its manipulations somewhat difficult for non-chemists, and because several

[1] See 48, footnote.

other methods were published shortly after it had been given to the public.

7. Other milk tests. Of these may be mentioned, besides the Babcock test already spoken of, the Failyer and Willard method,[1] Parson's method,[2] Cochran's test,[3] the Patrick or Iowa station test,[4] and the Beimling (Leffmann and Beam) test.[5] Of foreign methods published at about the same time, or previously, the Lactocrite,[6] Liebermann's method,[7] the Schmid,[8] Thörner,[9] Nahm,[10] and Röse-Gottlieb[11] methods may be noted.

8. All these tests were similar in principle, the solids not fat of the milk being in all cases dissolved by the action of one or more chemicals, and the fat either measured as such in a narrow graduated tube, or brought into solution with ether, gasoline, etc., and a portion thereof weighed on evaporation of the solvent. While this principle is an old one, having been employed in chemical laboratories for many years past, its adaptation to practical conditions, and the details as to apparatus and chemicals used were of course new and different in each case. The American tests given were adopted to a limited extent within the states in which they were originated

1 Kansas experiment station report, 1888, p. 149.

2 N. H. experiment station report, 1888, p. 69.

3 Journal of Anal. Chem., III (1889), p. 381.

4 Ia. exp. sta., bull. No. 8, February, 1890; Iowa Homestead, June 14, 1889.

5 Vermont exp. sta., bull. No. 21, September, 1890. For description of these and other volumetric methods of milk analysis, see Wiley, Agricultural Analysis, Vol. III, p. 490 et seq; Wing, Milk and its Products, p. 33 et seq, and Snyder, Chemistry of Dairying, pp. 112-113.

6 Analyst, 1887, p. 6.

7 Fresenius' Zeitschr., 22, 383.

8 Ibid., 27, 464.

9 Chem. Centralbl., 1892, 429.

10 Milchzeitung, 1894, No. 35; 1897, No. 50.

11 Landw. Vers. Stat., 40, 1.

and even outside of them, as in case of the Short, Patrick and Beimling methods. The Babcock test soon, however, nearly everywhere replaced the different methods mentioned, and during the past eight or ten years it has been in practically exclusive use in creameries and cheese factories in this country, where payments are made on the basis of the quality of the milk delivered, as well as in the routine work in experiment station laboratories, and among milk inspectors and private dairymen.

9. The Babcock Test. An examination of the causes of the present general adoption of the Babcock test will show the strong points of the test, and the requirements made of a practical milk test. The main causes why this test has replaced all competitors are doubtless to be sought in its simplicity and its cheapness. Its manipulations are few and readily learned, and it is cheap, both in first cost and as regards running expenses.

The test is furthermore speedy, accurate,[1] and easily applicable to practical conditions, and in the opinion of the writers it is the very best milk test at our disposal.

The method is applicable, besides to whole milk, to cream, skim milk, butter milk, whey, condensed milk, and (if a small scale for weighing out the sample is available) to cheese.

With all its advantages, the Babcock milk test is not in every respect an ideal test. The handling of the very corrosive sulfuric acid requires constant care and atten-

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[1] For a summary of comparative analyses made by the Babcock test and gravimetric analysis up to 1892, see Hoard's Dairyman, Oct. 7, 1892, p. 2560; also Schrott-Fiechtl, Milchzeitung, 1896, p. 183 et seq.

tion; the speed of the tester, the strength of the acid, the temperature of the milk to be tested, and other points, always require watching, lest the results obtained be too low or otherwise unsatisfactory. In the hands of careful operators the test can, however, always be relied upon to give most satisfactory results.

10. Foreign methods. In European countries four practical milk and cream tests, besides the Babcock test, are in use at the present time, viz.: *Gerber's acid-butyrometer, the lactocrite, DeLaval's butyrometer,* and *Fjord's centrifugal cream test.*[1]

Of these, the last test given has never, to our knowledge, been introduced into this country, and the first three only on a small scale.

11. The Gerber method[2] (fig. 1) is essentially the old Beimling method (7), worked out independently by the Swiss chemist, Dr. N. Gerber. In this test sulfuric acid of the same strength is used as in the Babcock test, and a small quantity of amyl alcohol is added. The amyl alcohol facilitates the separation of the fat, but introduces

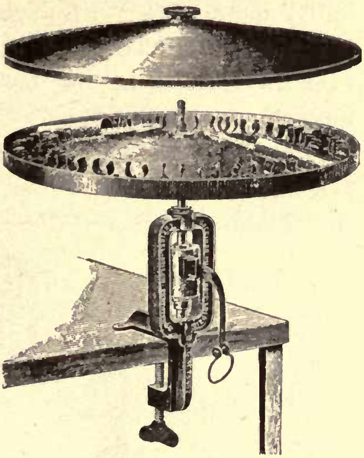

FIG. 1. The Gerber acid-butyrometer.

[1] The *Lister-Babcock* milk test advertised in English papers and known as such in England, is the regular Babcock test, to which the English manufacturers have prefixed their names; the same applies to the *Ahlborn-Babcock* method and the *Krugmann-Babcock* method.

[2] Gerber, Die praktische Milchprüfung 7th edition, 1900.

a source of error which may become serious, and especially so, where the results obtained with a new lot of amyl alcohol can not be compared with gravimetric analysis or with tests made with amyl alcohol known to give correct results. This method is, however, extensively used in several European countries, having there practically replaced the Babcock test or been adopted in preference to it.

12. The **Lactorite** was one of the earliest practical milk tests introduced. It was invented by De Laval in 1886. The acids used in this test are lactic acid (originally, acetic acid) with a mixture of hydrochloric and sulfuric acids. This test is now but rarely met with, even in Europe, having been largely replaced by the following method.

13. In the **De Laval butyrometer** (fig. 2) the same acid is used as in the Babcock test, but the tubes employed and the manipulations of the method differ materially from

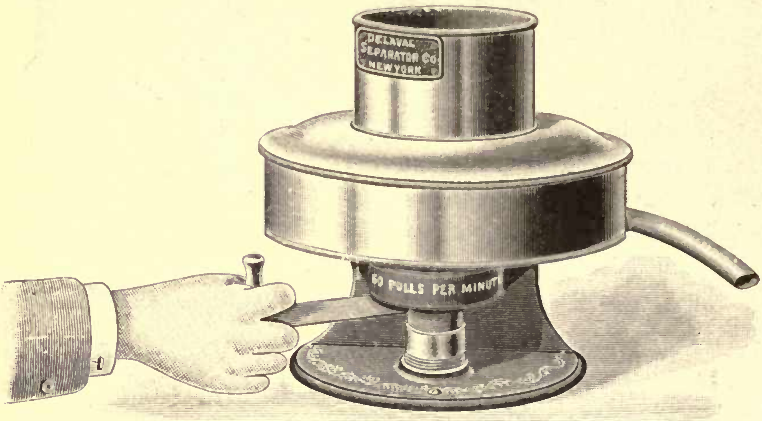

FIG. 2. DeLaval's butyrometer.

this test; a smaller sample of milk is taken (only 2 cc.) and a correspondingly small quantity of acid used. Where a large number of milk samples are tested every day, as is the case, for instance, in European milk control stations, the butyrometer may be preferable to the Babcock test; but it requires more skill of the operator and does not work satisfactorily in case of sour, loppered, or partially churned milk. The machines placed on the market both by Dr. Gerber and the De Laval Company are more expensive than the Babcock testers sold in this country; the DeLaval test requires a high speed, 5-6000 revolutions per minute; and therefore places greater demands for solidity in the machine than does the Babcock test.

14. Fjord's centrifugal cream tester[1] (fig. 3) is extensively used in Denmark and is mentioned in this connection as it furnishes, as a rule, a reliable method for comparing the quality of different lots of milk. The method was published in 1878, by the late N. J. Fjord, director of the state experiment station in Copenhagen, through whose exertions and on whose authority it was introduced into Danish creameries in the middle of the eighties. No chemicals are added in this test, the milk being simply placed in glass tubes, seven inches long and about two-thirds of an inch in diameter, and whirled

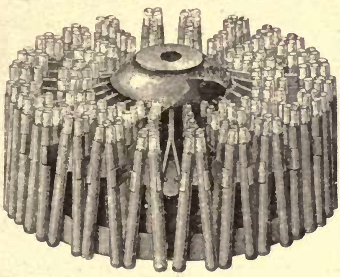

FIG. 3. Fjord's centrifugal cream tester.

[1] State Danish experiment station, Copenhagen, sixth and ninth reports, 1885–7.

for twenty minutes at a rate of 2000 revolutions per minute at 55° C (131° F.). The reading of the cream layer thus obtained gives the per cent. of cream, and not of butter fat, in the sample tested. One hundred and nine-two samples of milk can be tested simultaneously. Within the limits of normal Danish herd milk, the results obtained correspond to the percents of fat present in the samples, one per cent. of cream being equal to about 0.7 per cent. of fat; outside of these limlts the test is, however, unreliable, especially in case of very rich milk and strippers' milk. Only sweet milk can be tested by this method. The recent introduction of milk tests proper into Denmark, like the Gerber, Babcock and De Laval tests may, however, in time force the Fjord cream test out of Danish creameries, for similar reasons that relegated to obscurity the gravity cream tests (*creamometers*).[1]

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[1] Among foreign milk tests in use abroad should also be mentioned the *Wollny Refractometer*, which, in the hands of a trained chemist, is better adapted for use where a very large number of samples are to be tested at a time, than any other milk test available.

CHAPTER I.

COMPOSITION OF MILK AND ITS PRODUCTS.

Before taking up the discussion of the Babcock milk test, a brief description of the chemistry of milk and its products is given, so that the student may understand what are the components of dairy products, and the relation of these to each other. Only such points as have a direct bearing on the subject of milk testing and the use of milk tests in butter and cheese factories or private dairies will be treated in this chapter, and the reader is referred to standard works on dairying for more detailed information in regard to the composition of dairy products.

15. Composition of milk. Milk is composed of the following substances: *water*, *fat*, *casein*, *albumen*, *milk sugar*, and *ash*. A few other substances are present in small quantities, but they are hardly of any practical importance and will not be considered here. The components of the milk less the water are known collectively as *milk solids* or *total solids*, and the total solids less the fat, i. e., casein, albumen, milk sugar, and ash, are often spoken of as *solids not fat* or the *non-fatty milk solids*. The *milk serum* includes all components of the milk less the fat; the *serum solids* are therefore another name for the solids not fat; when given, they are, however, generally calculated to per cent. of milk serum, not of milk. If, e. g., a sample of milk contains nine per cent. of solids not fat, and three per cent. of fat, the milk serum will make up 97 per cent. of the milk, and the serum solids, $\frac{9}{.97}=9.28$ per cent. of the milk serum.

16. Water. The amount of water contained in cows' milk ranges from 82 to 90 per cent. Normal cows' milk will not as a rule contain more than 88 per cent. of water, nor less than 84 per cent. In states where there are laws regulating the sale of milk, as is the case in eighteen states in the Union (see *Appendix*), the maximum limit for water in milk in all instances but one (South Carolina) is 88 per cent.; the state mentioned allows 88.5 per cent. of water in milk offered for sale within her borders. The effect of fraudulently increasing the water content of milk by watering is considered under *Adulteration of Milk* (118).

17. Fat. The fat in milk is not in solution, but suspended as very minute globules, which form an emulsion with the milk serum; the globules are present in immense numbers, viz., on the average about one hundred million in a single drop of milk; a quart of milk will contain about two thousand billions of fat globules, a number written with thirteen figures. The size of the globules in the milk from the same cows varies according to the stage of the period of lactation, the globules being largest at the beginning of the lactation period, and gradually decreasing in size with its progress. Different breeds of cows have fat globules of different average sizes; the Channel Island cows are thus noted for the relatively large fat globules of their milk, while the Lowland breeds, the Ayrshire, and other breeds have uniformly smaller globules. The diameter of average sized fat globules in fresh milkers is about 0.004 millimeter, or one-six-thousandth of an inch; that is, it takes about six thousand such globules placed side by side to cover one inch in length. The globules in any sample of milk vary greatly in size; the largest globules are recovered in the cream when the milk is set or run through a cream separator, and the smallest ones remain in the skim milk; thoroughly skimmed separator skim milk will contain only a small number of very minute fat globules.

Milk fat is composed of so-called glycerides of the fatty acids, i. e., compounds of the latter with glycerin; some of the fatty acids are insoluble in water, viz., palmitic, stearic, and oleic acids, while others are soluble and volatile, the chief ones among the latter being butyric, caprylic, and caproic acids. The glycerides of the insoluble fatty acids make up about 92 per cent. of the pure milk fat; about 8 per cent. of the glycerides of volatile fatty acids are therefore found in natural milk-(and butter-) fat. The distinction between natural and artificial butter lies mainly in this point, since artificial butter (butterine, oleomargerine) as well as other solid animal fats contain only a very small quantity of volatile fatty acids. The glycerides of the volatile fatty acids are unstable compounds, easily decomposed through the action of bacteria or light; the volatile fatty acids thus set free, principally butyric acid, are the cause of the unpleasant odor met with in rancid butter.

Cows' milk generally contains between three and six per cent. of fat; in American milk we find on the average toward four per cent. of fat. The milk from single cows in perfect health will occasionally go below or above the limits given, but the mixed milk from a whole herd rarely falls outside of these limits. The legal standard for fat in milk in most states of the Union is 3 per cent.; Rhode Island allows milk containing 2.5 per cent. of fat to be sold as pure, while Georgia and Minnesota require it to contain 3.5 per cent., and Massachussetts 3.7 per cent. (in the months of May and June; see *Appendix*, *Table II.*)

18. Casein and albumen. These belong to the so-called *nitrogenous* substances, distinguished from the other components of the milk by the fact that they contain the element nitrogen. Another name is albuminoids or protein compounds. Casein is precipitated by rennet in the presence of soluble calcium salts, and by dilute acids and certain chemicals; albumen is not acted upon by these agents, but is coagulated by heat, a temperature of 170° F. being sufficient to effect a perfect coagulation. The casein, with fat and water, form the main components of nearly all kinds of cheese. In the manufacture of cheddar and most other solid cheeses, the casein is coagulated by rennet, and the curd thus formed holds fat and whey mechanically, the latter containing in solution small quantities of non-fatty milk solids. The albumen goes into the whey, and in some countries is also made into cheese by evaporating the whey with constant stirring; whole milk of cows or goats is often added and incorporated into such cheese (*primost*, *gjedost*).

Casein is present in milk partly in solution, in the same way as milk sugar, soluble ash-materials and albumen, and partly in suspension, in an extremely fine colloidal condition, mixed or combined with insoluble calcium phosphates. The casein and calcium phosphates in suspension in milk may be retained on a filter made of porous clay (so-called *Chamberland filters*).

About 80 per cent. of the nitrogenous compounds of normal cows' milk are made up of casein; the rest is largely albumen. If the amount of casein in milk be determined by precipitation with rennet or dilute acids, and the albumen by boiling the filtrate from the casein precipitate, it will be found that the sum of these two compounds does not make up the total quantity of nitrogenous constituents in the milk. The small remaining portion (about five per cent. of the total nitrogenous constituents) has been called by various authors, globulin, albumose, hemi-albumose, nuclein, nucleon, proteose, etc. The nitrogenous constituents of milk are very unstable compounds, and their study presents many and great difficulties; as a result we find that no two scientists who have made a special study of these compounds agree as to their properties, aside from those of casein and albumen, or their relation to the nitrogenous substances found elsewhere in the animal body. For our purpose we may, however, consider the nitrogen compounds of milk as made up of casein and albumen, and the term *casein and albumen*, as used in this book, is meant to include the total nitrogenous constituents of milk, obtained by multiplying the total nitrogen content of the milk by 6.25.[1]

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[1] The factor 6.25 is generally used for obtaining the casein and albumen from the total nitrogen in the milk, although 6.37 would be more correct, since these substances, according to our best authorities, contain on the average 15.7 per cent. of nitrogen $\left(\frac{100}{15.7} = 6.37\right)$

The quantity of casein in normal cows' milk will vary from 2 to 4 per cent., and of albumen, from .5 to .8 per cent. The total content of casein and albumen ranges between 2.5 and 4.6 per cent., the average being about 3.4 per cent. Milk with a low fat content will contain more casein and albumen than fat, while the reverse is generally true in case of milk containing more than 3.5 per cent of fat.

19. Milk sugar or **lactose** belongs to the group of organic compounds known as *carbohydrates.* It is a commercial product manufactured from whey and is obtained in this process as pale white crystals, of less sweet taste and less soluble in water than ordinary sugar (cane sugar, sucrose). About 70 per cent. of the solids in the whey, and 33 per cent. of the milk solids, are composed of milk sugar.

When milk is left standing for some time, viz., from one to several days, according to the temperature of the surrounding medium, it will turn sour and soon become thick and loppered. This change in the composition and the appearance of the milk is brought about through the action of acid-forming bacteria on the milk sugar; these are present in ordinary milk in immense numbers, and under favorable conditions of temperature multiply rapidly, feeding on the milk sugar as they grow, and decomposing it into lactic acid. When this change alone occurs, there is not necessarily a loss in the nutritive value of the milk, since milk sugar breaks up directly into lactic acid; this is shown by the following chemical formula:

$$C_{12}H_{22}O_{11}.\ H_2O\ (\textit{lactose}) = 4\ C_3H_6O_3\ (\textit{lactic acid}).$$[1]

---

[1] One molecule of milk sugar is composed of 12 atoms of carbon (C), 22 atoms of hydrogen (H), 11 atoms of oxygen (O), and one molecule of water (H_2O). In the same way, the lactic-acid molecule consists of 3 atoms of carbon, 6 atoms of hydrogen, and 3 atoms of oxygen.

Ordinarily the souring of milk is, however, more complicated, and other organic bodies, like butyric acid, alcohol, etc., and gases like carbonic acid are formed, resulting in a loss in the feeding value of the milk. While sour milk may therefore contain a somewhat smaller proportion of food elements than sweet milk, the feeding of it to farm animals, especially pigs, will generally produce better results than is obtained in feeding similar milk in a sweet condition. The cause of this may lie in the stimulating effect of the lactic acid of sour milk on the appetites of the animals, or in its aiding digestion by increasing the acidity of the stomach juices.

That the souring of milk is due to the activities of bacteria present therein is shown clearly by the fact that sterile milk, i. e., milk in which all germ life has been killed, will remain sweet for any length of time when kept free from infection.

The amount of milk sugar found in normal cows' milk varies from 3.5 to 6 per cent., the average content being about 5 per cent.; in sour milk this content is decreased to toward 4 per cent.

20. Ash. The ash or mineral substances of milk are largely composed of chlorids and phosphates of sodium, potassium, magnesium and calcium; iron oxid and sulfuric and citric acids are also present in small quantities among the normal mineral milk constituents. The amount of the different bases and acids found in milk ash have been determined by a number of chemists; the average figures obtained are given in the following table, calculated per 100 parts of milk (containing .75 per cent of ash) and per 100 parts of milk ash.

Mineral Components of Milk.

	In per cent. of Milk.	*In per cent. of Ash.*
Potassium oxid (K_2O)...........	.19 per ct.	25.64 per ct.
Sodium oxid (Na_2O)..............	.09	12.45
Lime (CaO)...........................	.18	24.58
Magnesia (MgO)....................	.02	3.09
Iron oxid (Fe_2O_3)..................	.002	.34
Phosphoric anhydrid (P_2O_5).	.16	21.24
Chlorin (Cl)..........................	.12	16.34
	.762 per ct.	103.68 per ct.
Less oxygen, corresponding to chlorin...........................	.012	3.68
	.75 per ct.	100.00 per ct.

The combinations in which the preceding bases and acids are contained in the milk are not known with certainty. According to Söldner, 36 to 56 per cent. of the phosphoric acid found in milk, and from 53 to 72 per cent. of the lime, are present in suspension in the milk as di- and tri-calcium phosphates, and may be filtered out by means of Chamberland filters (18), or by long continued centrifuging (Babcock[1]), The rest of the ash constituents are dissolved in the milk serum.

The ash content of normal cows' milk varies but little, as a rule only between .6 and .9 per cent., with an average of .7 per cent. Milk with a high fat content generally contains about .8 per cent. of ash; strippers' milk always has a high ash content, at times even exceeding one per cent. Ordinarily, the mineral constituents are, however, the components of milk least liable to variation.

21. Other Components. Besides the milk constituents enumerated and described in the preceding pages, nor-

[1] Wis. Experiment Station, twelfth report, p. 93.

mal milk contains a number of substances which are present in but small quantities and have only scientific interest, such as the milk gases (carbonic acid, oxygen, nitrogen), citric acid, lecithin, cholesterin, urea, hypoxanthin, lactochrome, etc.

22. Average Composition. The average percentage composition of cows' milk will be seen from table I in the *Appendix.* The following statement shows the limits within which the components of normal American cows' milk are likely to come:

	Minimum.	*Maximum.*	*Average.*
Water	82.0 per ct.	90.0 per ct.	87.4 per ct.
Fat	2.5	7.8	3.5
Casein and albumen	2.5	4.6	3.4
Milk sugar	3.5	6.0	5.0
Ash	.6	.9	.7

23. Colostrum Milk. The liquid secreted directly after parturition is known as colostrum milk or biestings. It is a thick, yellowish, viscous liquid; its high content of albumen and ash is characteristic, and also its low content of milk sugar. Owing to the large quantity of albumen which colostrum contains, it will coagulate on being heated toward the boiling point. In the course of four to five days the secretion of the udder gradually changes from colostrum to normal milk; the milk is considered fit for direct consumption or for the manufacture of cheese and butter, when it does not coagulate on boiling and is of normal appearance as regards color, taste, and other properties. For composition of colostrum milk, see *Appendix.*

24. Composition of milk products. In addition to its use for direct consumption, milk is the raw material from which cream, butter, cheese, and condensed milk are obtained.

When milk is left standing for some time or subjected to centrifugal force, it will separate into two distinct parts, *cream* and *skim milk.* The proportion of each part which is obtained and their chemical composition will depend on the method by which the separation is effected; in the so-called gravity process where the cream is separated on standing—either in shallow pans in the air, or in deep cans, submerged in cold water — a less complete separation is reached, less skim milk being obtained and this being richer in fat than when the separation takes place through the action of centrifugal force.

In modern creameries the milk is now generally skimmed by means of cream separators. *Separator cream* will contain from 15 to 50 per cent. of fat, according to the adjustment of the separator and of the milk supply; ordinarily it contains about 25 per ct. of fat. Cream of average quality, in addition to the fat content given, consists of about 66 per ct. of water, 3.8 per ct. casein and albumen, 4.3 per ct. milk sugar, and .5 per ct. ash.

The *skim milk* is made up of the milk serum (15) and a small amount of fat, viz., toward .4 per ct. when obtained by the gravity process, and less than .2 per ct. in the case of separator skim milk. Milk set in shallow pans in the air, or in deep cans in water above 60° F., will give skim milk containing one-half to over one per ct. of fat. Skim milk is used as a food for young farm animals or as human food, and in this country in exceptional cases, for the manufacture of cheese.

25. Cream is used for the manufacture of *butter* or for direct consumption. In the former case a certain amount of acidity is generally allowed to develop therein previous to the churning process. This secures a more complete churning and produces peculiar flavors in the butter, without which it would seem insipid to the majority of people in this country. Nearly all American butter is salted before being placed on the market. Salt is a preservative and for a limited length of time prevents butter from spoiling. Unsalted butter made from sweet cream is a common food article in Southern and Middle Europe, but only an insignificant amount is manufactured and consumed in America; salted butter made in Europe also contains considerably less salt than American butter (see *Appendix*). Butter contains all the fat of the cream but a small portion which goes into the butter milk, and a small unavoidable mechanical loss incident to the handling of the products. Butter should contain at least 80 per ct. of fat, and ordinarily contains about 83 per ct.; besides this amount of fat, butter is generally composed of, water about 13 per ct., curd and milk sugar 1 per ct., and salt 3 per ct.

Butter milk is similar to skim milk in composition, but varies much more than this product, according to the acidity, temperature, and thickness of the cream, and other churning factors. It contains about 9 per ct. of solids, viz., milk sugar (and lactic acid) 4 per ct., casein and albumen 4 per ct., fat .3 per ct., and ash .7 per ct.

26. The quantities of butter and by-products obtained in the manufacture of butter are as follows: 1000 lbs. of milk of average quality will give about 850 lbs. of skim milk and 145 lbs. of cream (separator slime and mechanical loss, 5 lbs.); this amount of cream will make about 42 lbs. of butter and 100 lbs. of butter milk (mechanical loss, 3 lbs.).

27. In the manufacture of *American cheddar cheese*, whole milk is heated to about 86° F., and a small amount of rennet extract is added, which coagulates the casein; the albumen of the milk is not precipitated by rennet and remains in solution (18). "Green" cheese, as taken from the press, is made up, roughly speaking, of 37 per ct. of water, 34 per ct. of fat, 24 per ct. of albuminoids (nearly all casein), and about 5 per ct. of milk sugar, lactic acid, and ash. In the curing of cheese there is some drying off, but the main changes occur in the breaking up of the firm curd into soluble and digestible nitrogenous compounds, peptons, amids, etc.

Whey is the by-product obtained in the manufacture of cheese. It consists of water and less than 7 per ct. ot solids; of the latter about 5 per ct. is milk sugar, .8 per ct. albumen, .6 per ct. ash, and .3 per ct. fat. Whey is generally used for feeding farm animals; it is the raw-product from which milk sugar and whey cheese are made.

28. *Condensed milk* is manufactured from whole milk or from partially skimmed milk. In many brands a large quantity of sugar (33 per ct. or more) is added to the condensed milk in the process of manufacture so as to secure perfect keeping quality in the product. Other brands to which no sugar has been added are, however, on the market, and in case of such brands the relation between the various solid constituents of the condensed milk will be essentially the same as that between the constituents of milk solids. Condensed milk should contain at least 10 per ct. of fat, and must be free from preservatives and all other foreign substances (except sugar).

Tables are given in the *Appendix* showing the average composition of the various milk products.

CHAPTER II.

SAMPLING MILK.

29. The butter fat in milk is not in solution, like sugar dissolved in water, but the minute fat globules or drops, in which form it occurs, are held in suspension in the milk serum (17). Being lighter than the serum, the fat globules have a tendency to rise to the surface of the milk. If, therefore, a sample of milk is left standing for even a short time, the upper layer will contain more fat than the lower portion. This fact should always be borne in mind when milk is sampled. The rapidity with which fat rises in milk can be easily demonstrated by leaving a quantity of sweet milk undisturbed in a cylinder or a milk can for a few minutes, and testing separately the top, middle and bottom layer of this milk.

The amount of mixing necessary to evenly distribute the constituents of milk throughout its mass may be ascertained by adding a few drops of cheese color to a quart of milk. The yellow streaks through the milk will be noticed until it has been poured several times from one vessel to another, when the milk will have a uniform pale yellow color. Stiring with a stick or a dipper will not produce an even mixture so quickly or so completely as pouring the milk a few times from one vessel to another; in sampling milk for testing it should always be mixed by pouring, just before the milk is measured into the bottle; if several tests are made of a sample, the milk should be poured before each sampling.

30. Partially churned milk. A second difficulty sometimes met with in sampling whole milk arises from the fact that a part of the butter fat may be separated in the form of small butter granules, by too zealous mixing or by reckless shaking in preparing the sample for testing. This will happen most readily in case of milk from fresh cows or with milk containing exceptionally large fat globules. When some of the butter granules are thus churned out, they quickly rise to the surface of the milk after pouring and cannot again be incorporated in the milk by simple mixing; it is, therefore, impossible to obtain a fair sample of such milk for testing without taking special measures which will be explained in the following. The granules of butter may be so small as to pass into the pipette with the milk and the quantity measured thus contain a fair proportion of them, but they will be found sticking to the inside of the pipette when this is emptied, and thus fail to be carried into the test bottle with the milk.

A similar partial churning of the milk will sometimes take place in the transportation cans. When such milk is received at the factory, the butter granules are caught by the strainer cloth through which the milk is poured, and are thus lost both to the factory and to the farmer. This separated fat cannot be put into the cream or added to the granular butter, without running the risk of making mottled butter, and it will not enter into the sample of milk taken for testing purposes.

When milk samples are sent by mail or express in small bottles, or carried to the place of testing, they often arrive with lumps of butter floating in the milk or sticking to the glass. This churning of the milk can be easily prevented by completely filling the bottle or the can. If there is no space left for the milk in which to splash around, the fat will not be churned out in transit.

31. Approximately accurate results may generally be obtained with a partially churned sample of milk, if a teaspoonful of ether be added to it. After adding the ether, cork the bottle and shake it until the lumps of butter are dissolved. This ether solution of the butter will mix with the milk, and from the mixture a uniform sample may generally be taken without difficulty. The dilution of milk by the ether introduces an error in the testing, and only the smallest quantity of ether necessary to dissolve the lumps of butter should be used. If desired, a definite quantity of ether, say five per cent. of the volume of the sample of milk to be tested, may be added; in such cases the result of the test must be increased by the per cent. of ether added.

EXAMPLE.—To a 4-oz. sample (120 cc.) of partially churned milk, 5 per cent., or 6 cc., of common ether are added: the mixture gives an average test of 4.2 per cent. The test must be increased by $\frac{5}{100} \times 4.2 = .21$, and the original milk therefore contained $4.2 + .21 = 4.41$ per cent. of fat.

Instead of adding ether to partially churned samples, the milk may be heated to about 110° F. for about ten minutes, so as to melt the butter granules; the sample is now shaken vigorously until a uniform mixture of milk and melted butter is obtained, and a pipetteful then quickly drawn from the sample.

32. Sampling sour milk. When milk becomes sour, the casein is coagulated and the mechanical condition of the milk thereby changed so as to render difficult a proper sampling. The butter fat is not, however, changed in the process of souring; this has been shown by one of us, in a series of tests which were measured from one sample of sweet milk into six test bottles.

A test of the milk in one of these test bottles was made every month for six months, and approximately the same amount of fat was obtained in the tests throughout the series, as was found originally in the milk when tested in a sweet condition.[1] If the milk is in condition to be sampled, its souring does not therefore interfere with its being tested by the Babcock test or with the accuracy of the results obtained.

In order to facilitate the sampling of sour or loppered milk, some chemical may be added which will re-dissolve the coagulated casein and produce a uniform mixture that can be readily measured with a pipette. Any alkali (powdered potash or soda, or liquid ammonia) will produce this effect. Only a very small quantity of powdered alkali is necessary for this purpose. The complete action of the alkali on sour milk requires a little time, and the operator should not try to hasten the solution by adding too much alkali. An excess of alkali will often cause such a violent action of the sulfuric acid on the milk to which the acid is added (on account of the heat generated or the presence of carbonates in the alkali) that the mixture will be thrown out of the neck of the test bottle when this is shaken in mixing the milk and the acid (37). When powdered alkali is added to the milk, it should be

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[1] See Hoard's Dairyman, April 8, 1892. The same holds true for cream, as shown by Winton (U. S. Dept. Agr., Div. of Chemistry, bull. 43, p. 112).

allowed to stand for a while, with frequent stirring, until the curd is all dissolved and an even translucent liquid is obtained. Such milk may become dark-colored by the action of the alkali, but this color does not interfere with the accuracy of the test.

Instead of powdered soda or potash, these substances dissolved in water (soda or potash lye), or strong ammonia water, may be used for the purpose of dissolving the coagulated casein in a sample of sour milk. In this case, a definite proportion of alkali solution must, however, be taken, 5 per cent. of the volume of milk being usually sufficient, and the results obtained are increased accordingly. (See example cited on p. 25.)

33. Sampling frozen milk. When milk freezes, it separates into two distinct portions: Milk crystals, largely made up of water, with a small admixture of fat and other solids, and a liquid portion, containing nearly all the solids of the milk. In sampling frozen milk it is therefore essential that *both* the liquid and the frozen part be warmed and mixed thoroughly by pouring gently back and forth from one vessel into another; the sample is then taken and the test proceeded with in the ordinary manner (36).

CHAPTER III.

THE BABCOCK TEST.

34. The Babcock test is founded on the fact that strong sulfuric acid will dissolve all non-fatty solid constituents of milk and other dairy products, and will set free the fat. This will separate on standing, but to effect a speedy and complete separation, the bottles holding the mixture of milk and acid are placed in a centrifugal machine, a so-called *tester*, and whirled for five minutes; hot water is then added so as to bring the liquid fat into the graduated neck of the test bottles, and after a repeated whirling, the length of the column of fat is read off, showing the per cent. of fat contained in the sample tested.

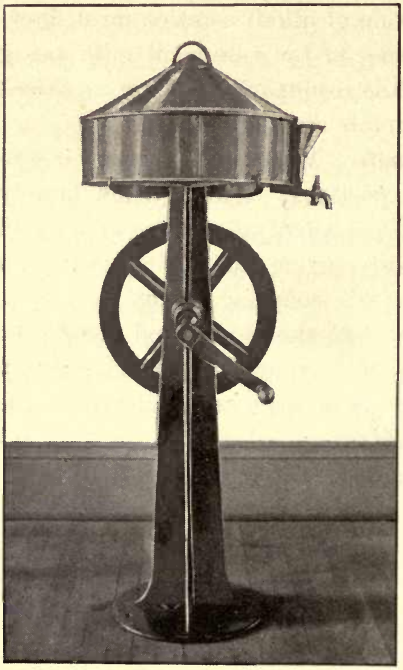

FIG 4 The first Babcock tester made.

Sulfuric acid is preferable to other strong mineral acids for the purpose mentioned, on account of its affinity to water; when mixed with milk, the mixture heats greatly, thus keeping the fat liqnid without the application of artificial heat and rendering possible a distinct reading of the column of fat brought into the neck of the test bottles.

So far as is known, any kind of milk can be tested by the Babcock test. Breed, period of lactation, quality or age of the milk is of no importance in using this method, so long as a fair sample of the milk can be secured. In case of samples of milk or other dairy products rich in solids it requires a little more effort to obtain a thorough mixture with the acid than with dairy products low in solids, like skim milk or whey, which may be readily mixed with the acid.

A—Directions for Making the Test.

35. The various steps in the manipulation of the Babcock test are discussed in the following pages; attention is drawn to the difficulties which the beginner and others may encounter in the use of the test, and the necessary precautions to be observed in order to obtain accurate and satisfactory results are explained in detail. The effort has been to treat the subject exhaustively and from a practical point of view, so that persons as yet unfamiliar with the test may turn to the pages of this book for help in any difficulties which they may meet in their work in this line.

36. Sampling. The sample to be tested is first mixed by pouring the milk from one vessel to another two or three times so that every portion thereof will contain a uniform amount of butter fat (29). The measuring pipette which has a capacity of 17.6 cubic centimeters (see fig. 6), is filled with the milk immediately after the mixing is completed, by sucking the milk into it until this rises a little above the mark around the stem of the pipette; the forefinger is then quickly placed over the end of the pipette before the milk runs down below the mark. By slightly releasing the pressure of the finger on the end of the pipette, the milk is now allowed to run down until it just reaches the mark on the stem; the quantity of milk contained in the pipette will then, if this is correctly made, be exactly 17.6 cc. The finger should be dry in measuring out the milk so that the delivery of milk may be readily checked by gentle pressure on the upper end of the pipette.

The point of the pipette is now placed in the neck of a Babcock test bottle (fig. 5), and the milk is allowed to flow slowly down the inside of the neck. Care must be taken that none of the milk measured out is lost in this transfer. The portion of the milk remaining in the point of the pipette is blown into the test bottle.

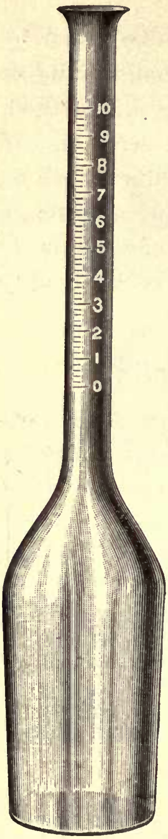

FIG. 5. Babcock milk test bottle.

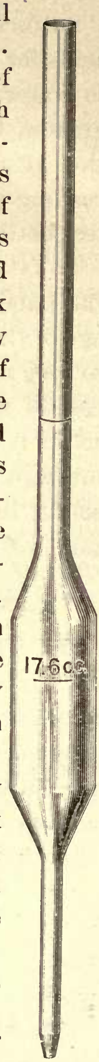

FIG. 6. 17.6 cc. pipette.

The best and safest manner of holding the bottle and the pipette in this transfer is shown in fig. 7. Fig. 8 shows a position which should be avoided, since by holding the bottle in this way, there is a danger that some of the milk may completely fill the neck of the bottle, and as a result, flow over the top of the neck.

Pipettes, the lower part of which slip readily into the necks of the test bottles, may be emptied by lowering the pipette into the neck of the bottle till it rests on its rim, when the milk is allowed to run into the test bottle.

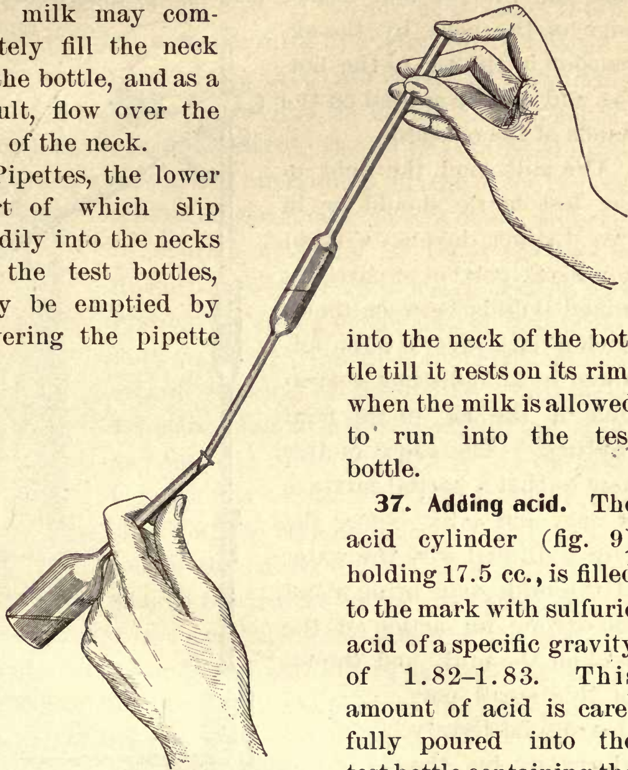

FIG. 7. The right way of emptying pipette into test bottle.

37. Adding acid. The acid cylinder (fig. 9) holding 17.5 cc., is filled to the mark with sulfuric acid of a specific gravity of 1.82–1.83. This amount of acid is carefully poured into the test bottle containing the milk. In adding the acid, the test bottle is conveniently held at an angle (see fig. 7), so that the acid will follow the wall of the bottle and not run in a small stream into the center of the milk, the bottle being slowly turned around and the neck thus cleared of adhering milk. By pouring the acid into the middle of the test bottle, there is also a danger of completely filling this with acid, in which case the plug of acid formed will be pushed over the edge of the neck by the expansion of the air in the bottle, and may be spilled on the hands of the operator.

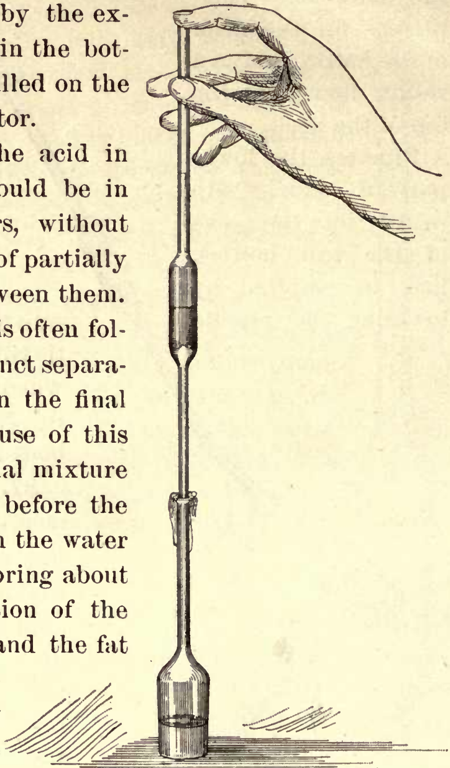

Fig. 8. The wrong way of emptying pipette into test bottle.

The milk and the acid in the test bottle should be in two distinct layers, without any black portion of partially mixed liquids between them. Such a dark layer is often followed by an indistinct separation of the fat in the final reading. The cause of this may be that a partial mixture of acid and milk before the acid is diluted with the water of the milk may bring about too strong an action of the acid on the milk, and the fat in this small portion may be slightly charred by the strong acid. The appearance of black flocculent matter in or below the column of fat which generally results, in either case renders a correct measurement of fat difficult and at times even impossible; if the black specks occur in the fat column itself, the readings are apt to be too high; if below it, the difficulty comes in deciding where the column of fat begins.

38. Mixing milk and acid. After adding the acid, this is carefully mixed with the milk by giving the test bottle a rotary motion. In doing this, care should be taken that none of the liquid spatters into the neck of the test bottle. When once begun, the mixing should be continued until completed; a partial and interrupted mixing of the liquids will often cause more or less black material to separate with the fat when the test is finished. Clots of curd which separate at first by the action of the acid on the milk, must be entirely dissolved by persistent and careful shaking of the bottle. Beginners sometimes fail to mix thoroughly the milk and the acid in the test bottle. As the acid is much heavier than the milk, a thin layer of it is apt to be left unnoticed at the bottom of the bottle, unless this is vigorously shaken toward the end of the operation.

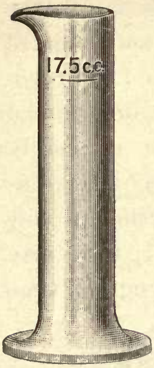

FIG. 9. 17.5 cc acid cylinder.

The mixture becomes hot by the action of the acid on the water in the milk and turns dark colored, owing to the effect of the strong sulfuric acid on the nitrogenous constituents and the sugar of the milk.

Colostrum milk or milk from fresh cows will form a violet colored mixture with the acid, due to the action of the latter on the albumen present in such milk in considerable quantities (23).

When milk samples are preserved by means of potassium bichromate (188), and so much of this material has been added that the milk has a dark yellow or reddish color, the mixture of milk and acid will turn greenish black, and a complete solution is rendered extremely difficult on account of the toughening effect of the bichromate on the precipitated casein. An indistinct separation of the fat is also sometimes obtained in such samples, but this difficulty can generally be overcome by using a little less than the regular quantity of acid.

39. Whirling bottles. After the milk and the acid have been completely mixed, the test bottle is at once placed in the centrifugal machine or tester and whirled for four or five minutes at a speed of 600 to 1200 revolutions per minute, the proper speed being determined by the diameter of the tester (66). It is not absolutely necessary to whirl the test bottles in the centrifuge as soon as the milk and the acid are mixed, although this method of procedure is much to be preferred; they may be left in this condition for any reasonable length of time (24 hours, if necessary) without the test being spoiled. If left until the mixture becomes cold, the bottles should, however, be placed in warm water (of about 160° F.) for about 15 minutes before whirling.

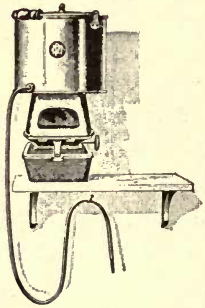

FIG. 10. Oil stove for heating water.

Four minutes at full speed is sufficient for the first whirling of the test bottles in the centrifuge; this will bring the fat to the surface of the liquid in the bottle.

40. Adding water. Hot water is now added by means of a pipette or some special device (Fig. 10), until the bottles are filled to near the scale on the neck (80). The bottles are whirled again at full speed for one minute, and hot water added a second time, until the lower part of the column of fat comes within the scale on the neck of the test bottle, preferably to the 1 or 2 per cent. mark, so as to allow for the sinking of the column of fat, due to the gradual cooling of the contents of the bottle. By dropping the water directly on the fat in the second filling, the column of fat will be washed free from light flocculent matter, which might otherwise be entangled therein and render the reading uncertain or even too high. A final whirling for one minute completes the separation of the fat.

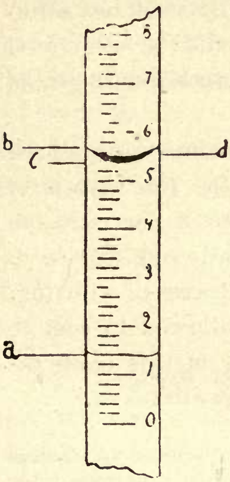

FIG. 11. Measuring the column of fat in a Babcock test bottle.

41. Measuring the fat. The amount of fat in the neck of the bottle is measured by the scale or graduations on the neck. Each division of the scale represents two-tenths of one per cent. of fat, and the space filled by the fat shows the per cent. of butter fat contained in the sample tested.

The fat is measured from the lower line of separation between the fat and the water, to the top of the fat column, at the point *b*, shown in the figure 11, the reading being thus taken from *a* to *b*, and not to *c* or to *d*. Comparative gravimetric analyses have shown that the readings obtained in this manner give correct results. While the lower line of the fat column is nearly straight, the upper one is curved, and errors in the reading are therefore easily made, unless the preceding rule is observed.

The fat obtained should form a clear yellowish liquid distinctly separated from the acid solution beneath it. There should be no black or white sediment in or below the column of fat, and no bubbles or foam on its surface. The bottles must be kept warm until the readings are made, so that the column of fat will have a sharply defined upper and lower meniscus.

The readings should be made when the fat has a temperature of about 140° F., although the results obtained will not be appreciably affected if the temperature falls below 120°. The fat separated in the Babcock test solidifies at about 100° F. No reading should be attempted if the fat is partly solidified, as it is impossible to get an accurate reading in this case.[1]

Readings of tests of milk made in turbine testers with tightly closed covers which prevent the free escape of the exhaust steam (71) will come .2 to .3 per cent. too high if the temperature of the fat is allowed to rise to that of the exhaust steam during the process of whirling. In such cases the test bottles must be allowed to cool to about 140° (by placing them in water of this temperature for a few minutes) before readings are taken.[2]

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[1] The effect of differences in the temperature of the fat on the readings obtained will be seen from the following: If 110 and 150° F. be taken as the extreme temperatures, at which readings are made, this difference of 40° F. (22.3° C.) would make a difference in the volume of the fat column obtained in case of 10 per cent. milk, of .00064 x 2 x 22.3=.028544 cc., or .14 per cent., .00064 being the expansion coefficient of pure butter fat per degree Centigrade between 50 and 100° C. (*Zune*, *Analyse des Beurres*, I, 87), and 2, the volume of the fat in cc. contained in 17.6 cc. of 10 per cent. milk. On 5 per cent. milk this extreme difference would therefore be about .07 per cent., or considerably less than one-tenth of one per cent.

[2] See Wis. Experiment Station Rep. XVII, p. 76.

A pair of dividers (Fig. 12) will be found convenient for measuring the fat, and the liability of error in reading is decreased by their use. The points of the dividers are placed at the upper and lower limits of the fat column (from *a* to *b* in Fig. 11). The dividers are now lowered, one point being placed at the zero mark of the scale, and the mark at which the other point touches the scale will show the per cent. of fat in the sample tested. The dividers must be tight in the joint to be of use for this purpose.

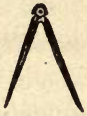

Fig. 12. Dividers.

42. An apparatus called the *Calometer*, for measuring the column of fat in bottles with plain, ungraduated necks, has been placed on the market of late. While the theory of the apparatus is correct, there are practical objections to its use, which are likely to prevent its general adoption.

B—Discussion of the Details of the Babcock Test.

43. Although the manipulations of the Babcock test are few and comparatively simple, various difficulties may be met with in using it, particularly in the hands of beginners.

The main points that have to be observed as to apparatus and testing materials in order to obtain correct and satisfactory results by this test will now be considered, and such suggestions and help offered, as has been found desirable from an extensive experience with a great variety of milk samples, apparatus, and accessories.

1—Glassware.

44. Test bottles. The test bottles should have a capacity of about 50 cc., or less than two ounces; they should be made of well-annealed glass that will stand sudden changes of temperature without breaking, and should be sufficiently heavy to withstand the maximum centrifugal force to which they are likely to be subjected in making tests. This force may on the average not be far from 30.65 lbs. (see 66), which is the pressure exerted in whirling the bottles filled with milk and acid in a centrifugal machine of 18 inches diameter at a speed of 800 revolutions per minute.

Special forms of test bottles used in testing cream and skim milk are described under the heads of cream and skim milk testing (89, 90, 91, 99).

When 17.6 cc., or 18 grams of milk (48), are measured into the Babcock test bottle, the scale on the neck of the bottles shows directly the per cent. of fat found in the milk. The scale is graduated from 0 to 10 per cent. 10 per cent. of 18 grams is 1.8 grams. As the specific gravity of pure butter fat (i. e. its weight compared with that of an equal quantity of pure water) at the temperature at which the readings are made (about 140° F.), is 0.9, then 1.8 grams of fat will occupy a volume of $\frac{1.8}{.9}=2$ cubic centimeters. The space between the 0 and 10 per cent. marks on the necks of the test bottles must therefore hold 2 cc., if correctly made. The scale is divided into 10 equal parts, each part representing one per cent., and each of these is again sub-divided into five equal parts. Each one of the latter divisions therefore represents two-tenths of one per cent. of fat when 17.6 cc. of milk is measured out. The small divisions are sufficiently far apart in most Babcock test bottles to make possible the estimation of one-tenth of one per cent. of fat in the samples tested.

As the necks of Babcock test bottles vary in diameter, each separate bottle must be calibrated by the manufacturers; the length of the scale is not, for the reason given, apt to be the same in different bottles.[1]

If the figures and lines of the measuring scale become indistinct by use, the black color may be restored by rubbing a soft lead pencil over the scale, or by the use of a piece of burnt cork after the scale has been rubbed with a little tallow. On wiping the neck with a cloth or a piece of paper the black color will show in the etchings of the glass, making these plainly visible.

45. Marking test bottles. Test bottles can now be bought with a small band or portion of their neck or body ground, or "frosted," for numbering the bottles with a lead pencil. Bottles without this ground label can be roughened at any convenient spot by using a wet fine file to roughen the smooth surface of the glass. There is this objection to the latter method that unless carefully done, it is apt to weaken the bottles so that they will easily break, and to both methods, that the lead pencil marks made on such ground labels may be effaced during the test if the bottles are not carefully handled.

[1] A flat-bore test bottle and one with a brass collar and screw used for opening and closing a small hole in the neck of the test bottle have lately been placed on the market by the Wagner Glass Works of New York. These have been tried by us, but no particular advantage over the round necks was discovered.

Small strips of tin or copper with a number stamped thereon are sometimes attached as a collar around the necks of the bottles. They are, however, easily lost, especially when the top of the bottle is slightly broken, or at any rate, are soon corroded so that the numbers can only be seen with difficulty.

The best and most permanent label for test bottles is made by scratching a number with a marking diamond into the glass directly above the scale on the neck of the bottles. In ordering an outfit, or test bottles alone, the operator may specify that the bottles are to be marked 1 to 24, or as many as are bought, and the dealer will then put the numbers on with a marking diamond.

A careful record should be kept of the number of the bottle into which each particular sample of milk is measured. Mistakes are often made when the operator trusts to his memory for locating the different bottles tested at the same time.

46. Cleaning test bottles. The fat in the neck of the test bottles must be liquid when these are cleaned. In emptying the acid the bottle should be shaken in order to remove the white residue of sulfate of lime, etc., from the bottom; if the acid is allowed to drain out of the bottle without shaking it, this residue will be found to stick very tenaciously to the bottom of the bottle in the subsequent cleaning with water.

A convenient method of emptying test bottles is shown in the illustration (Fig. 13). After reading the fat column, the bottles are placed neck down, in the half-inch holes of the board cover of a five-gallon stoneware jar.

An occasional shaking while the liquid is running from the bottles will rinse off the precipitate of sulfate of lime. A thorough rinsing with boiling hot water by means of an apparatus, devised by one of us[1] (see Fig. 14), is generally sufficient to remove all grease and dirt, as well as acid solution, from the inside of the bottles. When the bottles have been rinsed, they are placed in an inverted position to drain, on a galvanized iron rack, as shown in Fig. 15, where they are kept until needed. The outside of the bottles should occasionally be wiped clean and dry.

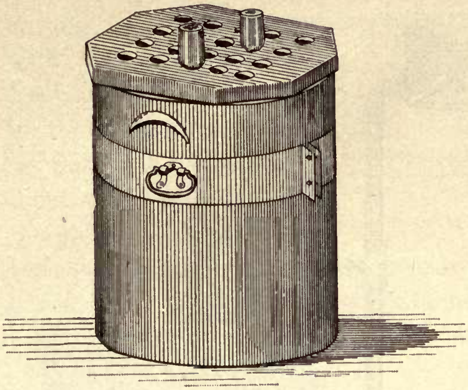

FIG. 13. Waste-Acid Jar.

47. The amount of unseen fat that clings to test bottles used for testing milk or cream, is generally not sufficient to be noticed in the results obtained in testing whole milk, but it plays an important part in testing samples of separator skim milk. It may be readily brought to light by making a blank test with clean water in bottles used for testing ordinary milk, which have been cleaned by simply draining the contents and rinsing once or twice with hot water; at the conclusion of the test the operator will generally find that a few drops of fat—

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[1] Farrington.

sometimes enough to condemn a separator—will collect in the neck of the bottles.

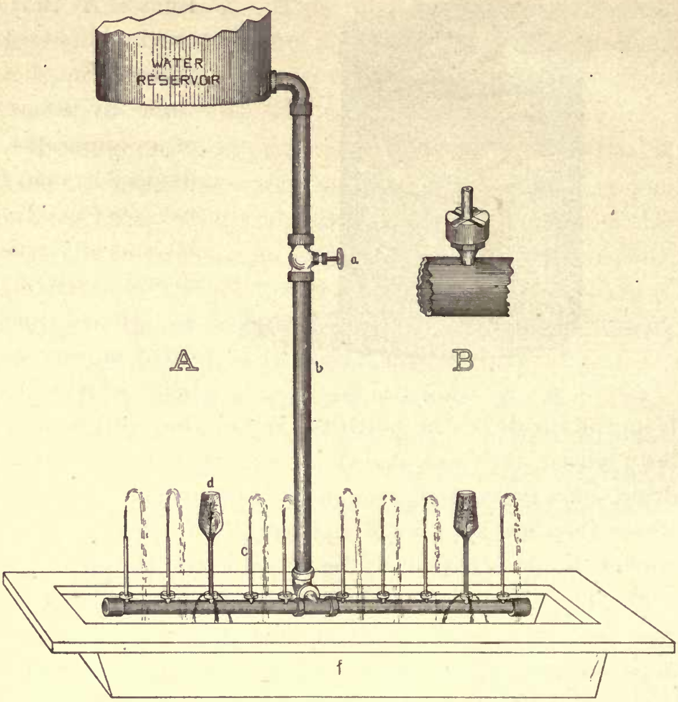

FIG. 14. Apparatus for cleaning test bottles. *A*, apparatus in position; the water flows from the reservoir through the iron pipe *b* into the inverted test bottle *d* through the brass tube *c*, screwed into the iron pipe. *B* shows construction of the rubber support on which the top of the test bottle rests; *f*, draining sink.

Boiling hot water will generally clean the grease from glassware for a time, but all test bottles should, in addition, be given an occasional bath in some weak alkali or other grease-dissolving solution. Persons doing considerable milk testing will find it of advantage to provide themselves with a small copper tank, which can be filled with a weak alkali-solution (Figs. 16 and 17). After having been rinsed with hot water, the test bottles are placed in the hot solution in the tank, where they may be left completely covered with the liquid. If the tank is provided with a small faucet at the bottom, the liquid can be drawn off when the test bottles are wanted.

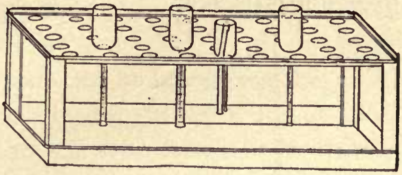

FIG. 15. Draining-rack for test bottles.

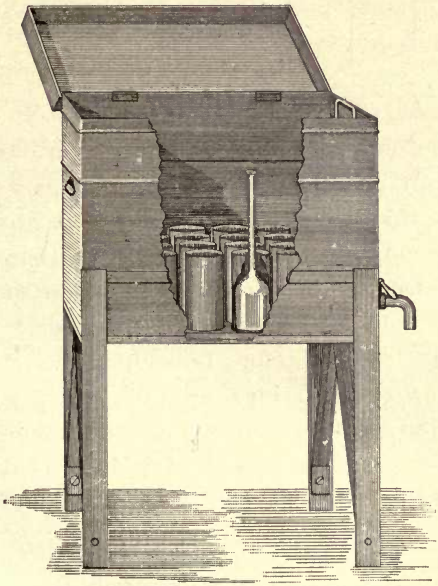

FIG. 16. Tank for cleaning test bottles.

A tablespoonful of *Savogran* to about two gallons of water will make a very satisfactory cleaning solution; *sal soda, Gold Dust, Lewis' lye or Babbitt's potash* are equally efficient. The cleansing properties of solutions of any of these substances are increased by warming the liquid. The test bottles must be rinsed twice with hot water after they are taken from this bath.

The black stains that sometimes stick to the inside of test bottles after prolonged use, can be removed with a little muriatic acid.

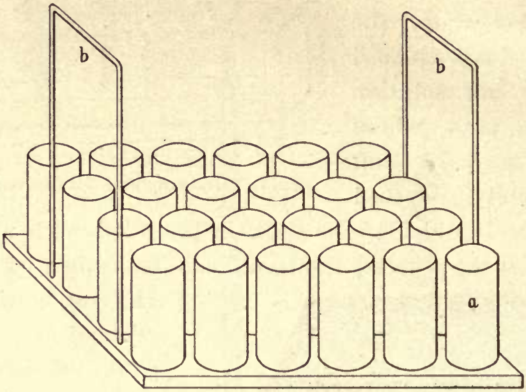

FIG. 17. Rack for holding test bottles in tank shown in Fig. 16.

48. Pipette. The difference in the weights of various samples of normal milk generally falls within comparatively narrow limits; if a given volume of water weighs one pound, the same volume of the usual grades of normal milk will weigh from 1.029 to 1.033 pounds, or on the average 1.03 lbs. 18 grams of water measures 18 cc.[1]; 18 grams of milk will therefore take up a smaller volume than 18 cc., viz: 18 divided by 1.03, which is very nearly 17.5. This is the quantity of milk taken in the Babcock test. A certain amount of milk will adhere to the walls of the pipette when it is emptied, and

---

1 Cubic centimeters (abbreviated: cc.) are the standard used for measuring volume in the metric system, similar to the quart or pint measure in our ordinary system of measures. One quart is equal to a little less than 1,000 cubic centimeters. In the same way, grams represent weight, like pounds and ounces. One cc. of water at 4° Centigrade weighs 1 gram; 1,000 grams (=1 kilogram) are equal to 2.2 lbs. Avoirdupois. (See *Appendix* for *Comparisons of Metric and Customary Weights and Measures.*)

this thin film has been found to weigh about one-tenth of a gram; consequently 17.6 cc. has been adopted as the capacity of the pipette used for delivering 18 grams of milk.

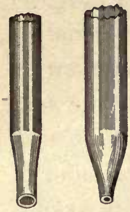

FIG. 18. Pipette points—A, proper construction; B, undesirable construction

For convenience in measuring the milk, the shape of the pipette is of importance. The mark on the stem should be two inches or more from the upper end of the pipette. The lower part should be small enough to fit loosely into the neck of the test bottle, and not contracted to a fine hole at the point; the point should be large enough to allow a quick emptying of the pipette (Fig. 18).

49. Fool Pipettes. Soon after the Babcock test began to be generally used at creameries as a method of paying for the milk, a creamery supply house put on the market a 20 cc. milk-measuring pipette, which was claimed to show the exact *butter* value of milk, instead of its content of butter *fat*, as is the case in using the ordinary 17.6 cc. pipette. A 20 cc. pipette will deliver 2.4 cc. more milk than a 17.6 cc. pipette, (or 13.6 per cent.), and the results obtained by using these pipettes will, therefore, be about 13.6 per cent. too high. In considering the subject of *Overrun* (214) it is noted that the excess of butter yield over the amount of fat contained in a certain quantity of milk will range from about 10 to 16 per cent., or on the average about 12 per cent. 20 cc. pipettes may, therefore, give approximately the yield of butter obtained from a quantity of milk, but as will be seen, this yield is variable, according to the skill of the butter maker and according to conditions beyond his control; it cannot therefore be used as a standard in the same manner as the fat content of the milk. Similar 22 cc. pipettes were also sent out. These pipettes created a great deal of confusion during the short time they were on the market, and were popularly termed "fool pipettes." It is not known that any of these pipettes have been sold of late years.

50. Acid measures. A 17.5 cc. glass cylinder (Fig. 9) for measuring the acid is generally included in the outfit, when a Babcock tester is bought. This cylinder answers every purpose if only occasional tests are made; the acid is poured into the cylinder from the acid bottle as needed, or a quantity of acid sufficient for the number of test bottles to be whirled at a time, is poured into a small glass beaker provided with a lip, or into a small porcelain pitcher; these may be more easily handled than the heavy acid bottle, and the acid measure is then filled from such a vessel.

Where a considerable number of tests are made regularly, the acid can be measured into the test bottles faster and with less danger of spilling, by using some one of the many devices proposed for this purpose. There is some objection to nearly all of these appliances, automatic pipettes, burettes, etc., although they will often give good satisfaction for a time while new. Sulfuric acid is very corrosive, and operators as a rule take but poor care of such apparatus, so that it is a very difficult matter to design a form which will remain in a good working order for any length of time. Automatic pipettes attached to acid bottles or reservoirs, to prove satisfactory, must be made entirely of glass, and strong, of simple construction, tightly closed and quickly operated.

51. The Swedish acid bottle answers these requirements better than any other device known to the writers at the present time. Its use is easily understood (see Fig. 19); it gives good satisfaction if the hole in the glass stop cock through which the acid passes has a diameter of at least one-eighth of an inch, as is generally the case. We have used or inspected some half a dozen other devices, which have been placed on the market by various dealers for delivering the acid, but cannot recommend them for use in factories or outside of chemical laboratories.

FIG. 19. Swedish acid bottle; the side-tube is made to hold 17.5 cc. of acid.

52. Instead of measuring out the acid, Bartlett[1] suggested adding it directly to the milk in the test bottles, till the mixture rises to a mark on the body of the bottle at the point where this will hold 37.5 cc., i. e., the total volume of milk and acid (89). This method of adding the acid is in the line of simplicity, but has not become generally adopted. If the method is used the marks should be put on by the manufacturers, as the operator in attempting to do so will be apt to weaken or break the bottles.

CALIBRATION OF GLASSWARE.

Test bottles. The Babcock milk test bottles are so constructed that the scale or graduation of the neck measures a volume of 2 cubic centimeters, between the zero and the 10 per cent marks (44). The correctness of the graduation may be easily ascertained by one of the following methods:

53. (A.) **Calibration with mercury.** 27.18 grams of metallic mercury are weighed into the perfectly clean

[1] Maine experiment station, Bull. No. 31.

and dry test bottle. Since the specific gravity of mercury is 13.59, double this quantity will occupy a volume of exactly 2 cubic centimeters (48). The neck of the test bottle is then closed with a small, smooth and soft cork, or a wad of absorbent cotton, cut off square at one end, the stopper being pressed down to the first line of the graduation. The bottle is now inverted so that the mercury will run into its neck. If the total space included between the 0 and 10 marks is just filled with the two cubic centimeters of mercury, the graduation is correct. Bottles, the whole length of the scale of which vary more than two-tenths of one per cent., are inaccurate and should not be used.

The mercury may be conveniently transferred from one test bottle to another, by means of a thin rubber tube which is slipped over the end of the necks of both bottles, and one weighing of mercury will thus suffice for a number of calibrations. In transferring the mercury, care must be taken that none of it is lost, and that small drops of mercury are not left sticking to the walls of the bottle emptied. A sharp tap on the bottle with a lead pencil will help to remove minute drops of mercury from the inside of it. Unless the bottles to be calibrated are perfectly clean and dry, it is impossible to transfer all the mercury from one bottle to another.

After several calibrations have been made, the mercury should be weighed again in order to make certain that none has been lost by the various manipulations. The scales, figs. 33 and 34, shown in (94), are sufficiently delicate for making these weighings.

54. Cleaning mercury. Even with the best of care, mercury used for calibration of glassware will gradually become dirty, so that it will not flow freely over a clean surface of glass. It may be cleaned from mechanical impurities, dust, films of grease, water, etc., by filtration through heavy filter paper. This is folded the usual way, placed in an ordinary glass funnel and its point perforated with a couple of pin holes. The mercury will pass through in fine streams, leaving the impurities on the filter paper. Mercury may be freed from foreign metals, zinc, lead, etc., sometimes noticed as a grayish, thin film on its surface, by leaving it in contact with common nitric acid for a number of hours; the mercury is best placed in a shallow porcelain or granite ware dish and the nitric acid poured over it, the dish being covered to keep out dust. The acid solution is then carefully poured off and the mercury washed with water; the latter is in turn poured off, and the last traces of water absorbed by means of clean, heavy filter paper.

The mercury to be used for calibration of glassware should be kept in a strong bottle, closed by an ordinary stopper. In handling mercury, care must be taken not to spill any portion of it; finger-rings should be removed when calibrations with mercury are to be made.

Mercury forms the most satisfactory and accurate material for calibration of test bottles, on account of its heavy weight and the ease with which it may be manipulated. Equally correct results may, however, with proper care be obtained by using water for the calibration.

(B.) **Calibration with water.** This may be done by means of a delicate pipette or burette, or by weighing in a somewhat similar manner, as explained in case of calibration with mercury.

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55. a, **Measuring the water.** Fill the test bottle with water to the zero mark of the scale; remove any surplus water and dry the inside of the neck with a piece of filter paper or clean blotting paper; then measure into the bottle 2 cc. of water from an accurate pipette or burette, divided to $\frac{1}{20}$ of a cubic centimeter. If the graduation is correct, 2 cc. will fill the neck exactly to the 10 per cent. mark of the scale.

56. b, **Weighing the water.** Fill the bottle with water to the zero mark of the scale and remove any surplus water in the neck, as before. Weigh the bottle with the water contained therein. Now fill the neck with water to the 10 per cent. mark, and weigh again. The difference between these weights should be 2 grams.

In all cases when calibrations are to be made, the test bottles, or other glassware to be calibrated, must be thoroughly cleaned with strong sulfuric acid, or soda lye, and washed repeatedly with pure water, and dried. Glassware is not clean unless water will run freely over its surface, without leaving any adhering drops.

57. (C.) **The Trowbridge method of calibration.**[1] An extremely simple and accurate method of calibrating test bottles has been proposed by Mr. O. A. Trowbridge of Columbus, Wis. He conceived the idea of measuring the capacity of the graduated portion of the neck of a milk test bottle with a piece of metal which is carefully filed to such a size that it will displace exactly two cubic centimeters of water. He used a thirty-penny wire nail, cutting off the head of the nail and attaching to it a short piece of fine wire, either looped at one end, as shown in

1 Hoard's Dairyman, Mar. 8, 1901, by De Witt Goodrich.

Fig. 20 (A), or as one straight piece of about three inches long.

The wire serves as a handle for lowering the measure into the neck of the test bottles. If the wire is attached as shown in Fig. 20 (A), a string can be fastened to the loop for holding the measure in the proper place in the test bottle.

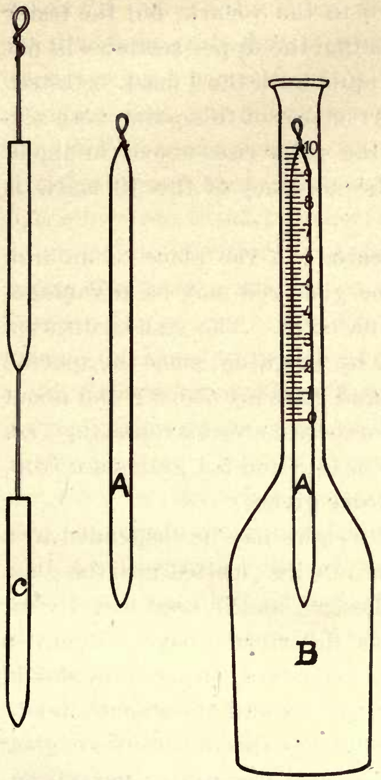

FIG. 20. (A) Trowbridge calibrator as used in test bottle (B). (C) Nafis modification of (A).

When a test bottle is to be calibrated by this standard measure, it is filled with water to the zero mark on the neck of the bottle. The water adhering to the neck is carefully removed with a strip of blotting paper, and the measure (A), is then lowered into the test bottle, as shown in (B), to the point where the wire loop is attached. If the water rises from 0 to 10 on the neck when the point of the measure is also at ten, the scale is correct. If greater variations than .2 of one per cent. occur, the bottle should be rejected.

The diagram (C), shows how one of these testers may be made in two sections, and the accuracy of the 5 as well as the 0 and 10 marks on the scale ascertained. This modification was proposed by Louis F. Nafis & Co., Chicago.

The lower section of this tester will displace 1 cc. of liquid and raise it from 0 to the 5 mark, but the tester must be lowered slowly so that the upper section will not come in contact with the liquid until the 5 mark is tested. After ascertaining the correctness of this point, both sections are lowered so that the water rises above the top of the upper section and the accuracy of the 10 mark is also tested.

58. The standard measure. In the place of an iron nail, a piece of copper or glass rod may be advantageously used as a standard measure. The standardization is most conveniently done by weighing; since the specific gravities of iron, copper and glass are 7.8, 8.9 and about 2.7, respectively. Pieces of these materials replacing 2 cc. of a liquid, will weigh 15.6, 17.8 and 5.4 grams, for iron, copper and glass in the order given.

A measure of the right weight may be suspended by a very fine copper or platinum wire (melted into the glass rod if this material be chosen), and is used directly for calibrating test bottles as described above. Before a measure so made is used as a standard, its accuracy should be determined by weighing the amount of water at a temp. of 17.5° C, which it replaces. The specific gravity of glass especially, varies somewhat according to its composition, so that a standardization of a measure by weight alone cannot be depended upon always to give correct results.

59. In submerging the measure in the test bottle to be calibrated, care must be taken that all air bubbles are removed before the position of the meniscus of the water is noted; if a metal standard measure is used, it must be kept free from rust or tarnish.

60. Intermediate divisions. The space between 0 and 10 on the scale of the Babcock test bottle is divided into 50 divisions, each five of which, as previously shown, representing 1 per cent. (44). Since these intermediate divisions are generally made with a dividing machine, they are as a rule correct, but it may happen that the divisions have been inaccurately placed, although the space between 0 and 10 is correct. The accuracy of the intermediate divisions can be ascertained by sliding along the scale a strip of paper upon which has been marked the space occupied by one per cent., and comparing the space with those of each per cent. on the scale.

61. Calibration of skim milk test bottles. The value of each division on the skim milk bottles is one-twentieth of one per cent. (99) and there are ten of these divisions or .1 cc. in the whole scale which shows .5 per cent. fat. It requires very careful work to calibrate this scale and it is best done by weighing the amount of mercury which will just fill the space between the first and the last divisions (53); the correct weight of this mercury is 1.359 grams.

62. Calibrating cream test bottles. The cream bottles may be calibrated by any of the methods given for milk bottles. A cream test bottle neck that measures thirty per cent. fat will hold 6 cc., and 6 grams of water or 81.54 grams of mercury.

The Trowbridge method of calibrating milk test bottles may also be found convenient for cream bottles and the same standard measure used. The part of the scale from 0 to 10 being calibrated first, then from 10 to 20 and 20 to 30 per cent. in the same way.

63. Pipette and acid cylinder. The pipette and the acid cylinder used in the Babcock test may be calibrated by any of the methods already given. Sufficiently accurate results are obtained by weighing the quantity of water which each of these pieces of apparatus will hold, viz., 17.6 grams and 17.5 grams, respectively. The necessity of previous thorough cleaning of the glassware is evident from what has been said in the preceding. The pipette and the acid measure may be weighed empty and then again when filled to the mark with pure water, or the measureful of water may be emptied into a small weighed vessel, and this weighed a second time. In either case the weight of the water contained in the pipette or acid measure is obtained by difference.[1]

Calibrations of the acid cylinder are generally not called for, except as a laboratory exercise, since small variations in the amount of acid measured out do not affect the accuracy of the test.

2.— Centrifugal Machines.

64. The capacity of the testing machine to be selected should be governed by the number of tests which are likely to be made at one time. For factory purposes a twenty-four to thirty bottle tester is large enough, and to be preferred for a larger tester, even if toward a hun-

[1] 1 cubic centimeter of distilled water weighs 1 gram, when weighed in a vacuum at the temperature of the maximum density of water (4° C); for the purposes of calibration of glassware used in the Babcock test, sufficiently accurate results are, however, obtained by weighing the water in the air and at a low room-temperature (60° F.).

dred samples of milk are to be tested at a time. The operator can use his time more economically in running a machine of this size than one holding fifty or sixty bottles; the work of filling or cleaning the bottles and measuring the fat can be done while the tester is running if a double supply of bottles is at hand. Large testers require more power than smaller ones, and when sixty tests are made at a time, the fat column in many bottles will get cold, before the operator has time to read them, unless special precautions are taken for keeping the bottles warm.

65. The tester should be securely fastened to a solid foundation and set so that the revolving wheel is level. The latter must be carefully balanced in order that the tester may run smoothly at full speed when empty. A machine that trembles and shakes when in motion is neither satisfactory nor safe, and the results obtained are apt to be too low. High-standing machines are more apt to cause trouble in this respect than low machines, and should therefore be subjected to a severe test before they are accepted.

If all the sockets are not filled with bottles when a test is to be made, the bottles must be placed diametrically opposite one another so that the machine will be balanced when run. The bearings should be kept cleaned and oiled with as much care as the bearings of a cream separator.

The cover of the machine should always be kept closed while the bottles are whirled, and should not be removed until the machine stops; the cover should be tight fitting and may be fastened with hooks soldered on the side of the machine; test bottles sometimes break while the machine is running at full speed, and every possible precaution should be taken to protect the operator from any danger from spilled acid or broken glass.

66. Speed required for the complete separation of the fat. There is a definite relation between the diameter of the Babcock testers and the speed required for a perfect separation of the fat. In the preliminary work with the Babcock test the inventor found that with the machine used, the wheel of which had a diameter of eighteen inches, it was necessary to turn the crank, so as to give the test bottles seven or eight hundred revolutions per minute, in order to affect a maximum separation of fat; later work has shown that this speed is ample. Taking therefore this as a standard, the centrifugal force to which the contents of the test bottles are subjected when supported on an eighteen inch wheel and turned 800 revolutions per minute, can be calculated as follows:

The centrifugal force, F, acting on the bottles is expressed by the formula

$$F = \frac{w.\ v^2}{32.2r} \quad . \quad . \quad . \quad . \quad . \quad . \quad (I)$$

in which w = the weight of the bottle with contents, in pounds; v = the velocity, in feet per second, and r = the radius of the wheel, in feet.

When the wheel is turned 800 times a minute, a bottle supported on its rim will travel $2\pi r \times \frac{800}{60} = 2 \times 3.1415 \times \frac{9}{12} \times \frac{800}{60} = 62.83$ feet per second. The weight of a bottle, with milk and acid, is very near 3 ounces, or $\frac{3}{16}$ of a pound. Substituting these values for v and w, gives

$$F = \frac{\frac{3}{16} \times 62.83^2}{32.2 \times \frac{9}{12}} = 30.65 \text{ lbs.}$$

The bottles are therefore, under the conditions given, subjected to a pressure of about 30.65 pounds. In order to calculate the speed required for obtaining this force in case of machines of other diameters, the value of v in formula (I) is found from

$$v = \sqrt{\frac{32.2 \, F \times r}{w}} \quad . \quad . \quad . \quad . \qquad (II)$$

Substituting the values for F and w,

$$v = \sqrt{\frac{32.2 \times 30.65 \, r}{\frac{3}{16}}} = \sqrt{5264 \, r}$$

In this equation the values r = 5, 6, 7, 8, 9, 10, 11, 12 inches are substituted in each case ($\frac{5}{12}$, $\frac{6}{12}$, $\frac{7}{12}$, . . . $\frac{12}{12}$ feet), and the velocity in feet per second then found at which the bottles are whirled when placed in wheels of diameters 10 to 24 inches, and subjected in each case to a centrifugal force of 30.65 lbs. As the number of revolutions per minute $= \frac{60 \, v}{2 \, \pi \, r}$, v being as before the velocity in feet per second, and r the radius of the wheel, the speed at which the wheel must be turned, is found by substituting for v the values obtained in the preceding calculations in case of wheels of different diameters. The results of these calculations are given in the following table:

Diameter of wheel, d.	*Velocity in feet per second, v.*	*Number of revolutions of wheel, per minute.*
10	46.84	1074
12	51.31	980
14	55.43	909
16	59.26	848
18	62.84	800
20	66.24	759
22	69.47	724
24	72.56	693

These figures show that a tester, for instance, 25 inches in diameter, requires less than 700 revolutions per minute for a perfect separation of the fat in Babcock bottles, while a ten-inch tester must have a speed of nearly 1100 revolutions, in order to obtain the same result.

The speed at which testers of different diameters should be run to affect a complete separation has been calculated by Prof. C. L. Beach in the following manner[1]. The same standard as

[1] Private communication.

before is taken, viz., 800 revolutions for an 18 inch tester (radius 9 inches); then if x designate the radius of the tester and y the speed required, we have

$$xy^2 = 9 \times 800^2, \text{ or}$$

$$y = \sqrt{\frac{9 \times 800^2}{x}}$$

The figures obtained by the use of this formula are similar to those given in the preceding table.

67. To find the number of turns of the handle corresponding to the number of revolutions made by the wheel, the handle is given one full turn, and the number of times which a certain point or part of the wheel revolves, is noted. If the wheel has a diameter of 20 inches, and revolves 12 times for one turn of the handle, the latter should be turned $\frac{759}{12} = 63$ (see table), or about once every second, in order to affect a maximum separation of fat. By counting the number of revolutions, watch in hand, and consulting the preceding table, the operator will soon note the speed which must be maintained in case of his particular machine. It is vitally important that the required speed be always kept up; if through carelessness, worn-out or dry bearings, slipping belts, etc., the speed is slackened, the results obtained will be too low; it may be a few tenths, or even more than one per cent. Care as to this point is so much the more essential, as the results obtained by too slow whirling may seem to be all right, a clear separation of fat being often obtained even when the fat is not completely separated.

68. Ascertaining the neccessary speed of testers. In buying a tester the operator should first of all satisfy himself at what speed the machine must be run to give correct results: the preceding table will serve as a guide on this point. He should measure out a dozen tests of the same sample of milk, and whirl half the number at the speed required for machines of the diameter of his tester. Whirl the other half at a somewhat higher speed. If the averages of the two sets of determinations are the same, within the probable error of the test (say, less than one-tenth of one per cent.) the first whirling was sufficient, as it is believed will generally be the case. If the second set of determinations come higher than the first set, the first whirling was too slow, and a new series of tests of the same sample of milk should be made to ascertain that the second whirling was ample.

This method will test not only the speed required with the particular machine at hand, but will also serve to indicate the correctness of the calibration of the bottles. A large number of tests of the same sample of milk made as directed (pouring the milk once or twice previous to taking out a pipetteful for each test) should not vary more than two-tenths of one per cent. at the outside, and in the hands of a skilled operator will generally come within one-tenth of one per cent. If greater discrepancies occur, the test bottles giving too high or too low results should be further examined, and calibrated according to the directions already given (53 *et seq.*).

69. Hand testers. When only a few tests are made at a time, and at irregular intervals, as in case of dairymen who test single cows in their herds, a small hand tester answers every purpose. These may be had in sizes from two to twelve bottles. In selecting a particular make of tester the dairyman has the choice of a large number of different kinds of machines. It is a source of regret that most of the machines placed on the market for this purpose in the past have been so cheaply and poorly constructed as to prove very unsatisfactory after having been in use for a time. The sharp competition between manufacturers of dairy supplies and the clamor of dairymen for something cheap, fully account for this condition of affairs.

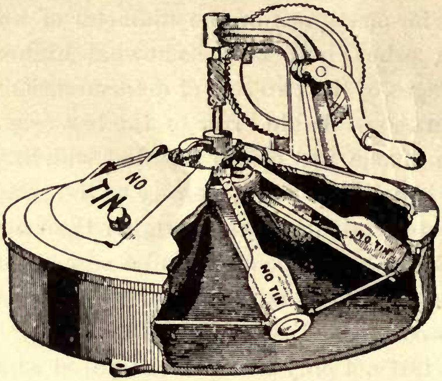

FIG. 21. "No-tin" test.

This applies especially to the many machines made with belts or friction application of power. The main objection to these machines is the uncertainty of the speed obtained, when they have been in use for some time, and the belt or friction appliance begins to slip. Hand testers made with cog gear wheels are more to be depended on for giving the necessary speed than belt or friction machines; the earlier

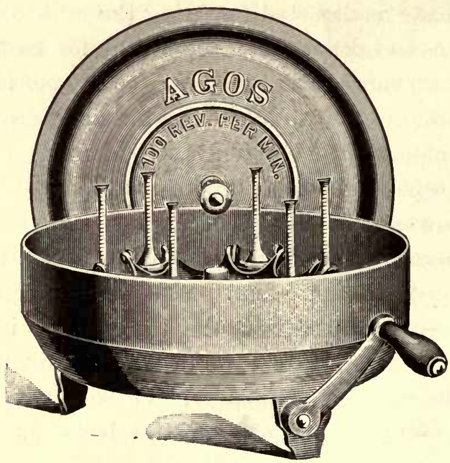

FIG. 22. Type of Babcock hand testers.

machines of this kind were very noisy, but at the present time the best machines on the market are of this type. These are provided with spiral cog gear and ball bearings, are strongly made and will run smoothly and without noise (Figs. 21–22); in cog gear machines the bottles are always whirled at the speed which the number of turns made by the crank would indicate.

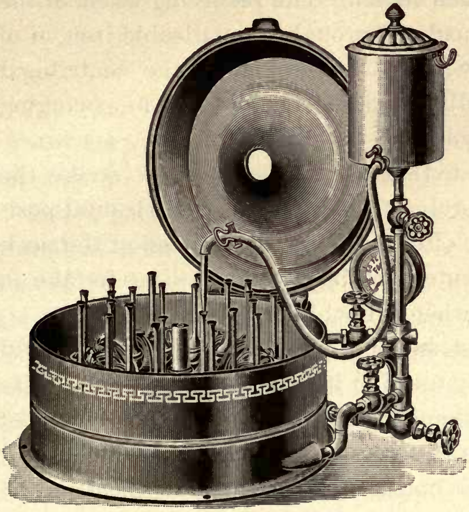

FIG. 23. Type of Babcock steam turbine testers.

70. Power testers. For factory purposes, steam turbine machines (Figs. 23–24) are most satisfactory when well made and well cared for. They should always be provided with a speed indicator and steam gauge, both for the purpose of knowing that sufficient speed is attained, and

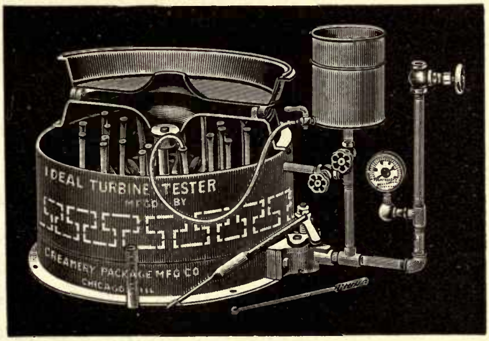

FIG. 24. Type of Babcock steam turbine testers.

also to prevent what may be serious accidents from a general smash up, if the turbine "runs wild" by turning on too much steam. The revolving wheel of the tester should be made of wrought or malleable iron, or of wire, so that it will not be broken by the centrifugal force, thus avoiding serious accidents. The swinging pockets which hold the test bottles in some machines, should be so made that the bottles will not strike the center of the revolving frame when in a horizontal position. Tests have often been lost by the end of the neck catching at the center, the bottles thus failing to take an upright position when the whirling stops.

71. The exhaust steam pipe of turbine testers should not have too many turns in it or be much reduced in size from that of the opening in the tester. A free escape of the exhaust steam is necessary to prevent the steam collecting in the test bottle chamber and overheating the test bottle when whirled (41).

The cover of the tester should have an opening in it which is provided with a sliding damper or some arrangement by which this opening can be closed when desired. If whole milk or cream is being tested, this hole in the cover should be open so that a draft of air may enter the test bottle chamber during whirling, and force the steam out of the bottle chamber into the exhaust pipe. If skim milk is being tested, all openings in the cover should be closed. This shuts off the draft of air, and the exhaust steam heats the test bottles during whirling to 200° F. in some cases. This high temperature aids in separating the last traces of fat in skim milk and gives a most accurate test of samples containing less than one-tenth per cent. fat. Some of the most recent makes of turbine testers are provided with holes in the cover and dampers. A thermometer is also placed in the cover.

3 — Sulphuric Acid.

72. The sulfuric acid to be used in the Babcock test should have a specific gravity of 1.82-1.83.[1] The commercial oil of vitriol which can be bought for about 2 cents a pound in carboy lots, is commonly used. One pound of acid is sufficient for fifteen tests. The acid should be kept in stoppered glass bottles, preferably glass or rubber stoppered ones, since a cork stopper is soon dissolved by the acid and rendered useless. If the bottle is left uncorked the acid will absorb moisture from the air and will after a time become too weak for use in this test. Lead is the only common metal which is not dissolved by strong sulfuric acid; where considerable milk testing is done, it is therefore desirable to provide a table covered with sheet lead on which the acid may be handled.

The acid dissolves iron, tin, wood and cloth, and burns the skin. If acid is accidently spilled, plenty of water should be used at once to wash it off. Ashes, potash, soda, and ammonia neutralize the action of the acid, and a weak solution of any one of these alkalies can be used after the acid has been washed off with water. The red color caused by the action of the acid on clothing can be removed by wetting the spot with weak ammonia water;

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[1] A specific gravity of 1.82 means that a given volume of the acid weighs 1.82 times as much as the same volume of water at the same temperature (see also under *Lactometer*, 106).

the ammonia must, however, be applied while the stain is fresh, and is in its turn washed off with water.

73. Testing the strength of the acid. The strength of the acid can be easily tested by the use of such a balance as shown in Fig. 33 (94). A *dry* test bottle is weighed, and then filled with acid exactly to the zero mark, or to any other particular line of the scale. It is then again weighed accurately; the difference between these two weights will give the weight of the acid in the bottle. Next empty the bottle and rinse it thoroughly with water (until the water has no longer an acid taste); fill the bottle with water to the same line as before and weigh; the difference between this weight and that of the empty bottle gives the weight of the same volume of water as that of the acid weighed. Divide the weight of the acid by the weight of the water; the quotient gives the specific gravity of the acid. If this is between 1.82 and 1.83, the strength of the acid is correct. The outside of the test bottle should always be wiped dry before the liquids are weighed in it. Unless great care is taken in measuring out the acid and the water, and in weighing both these and the test bottle, the results obtained will not be trustworthy.

74. Too strong acid can sometimes be successfully used by taking less than the required amount of each test, e. g. about 15 cc. Operators are warned against reducing the strength of the acid by adding water to it, as accidents are very apt to occur when this is done. A too strong acid can, if desired, be weakened by simply leaving the bottle which holds it, uncorked for a time, or by pouring the acid into a bottle containing a small quantity of water. In the latter case the first portions of acid should be added carefully, a little at a time, shaking the bottle after each addition, so as not to cause it to break from the great heat evolved in mixing the acid and the water. *Never dilute sulfuric acid by pouring water into it.*

75. If the acid is too weak, correct results may sometimes be obtained by using more than the specified quantity, say 20 cc. If a good test is not obtained with this quantity of acid, a new lot must be secured, as its specific gravity in such a case is below 1.82. The observing operator will soon be able to judge of the strength of the acid by its action on milk in mixing the two liquids in the Babcock test bottles; it is indeed remarkable what slight differences in the specific gravity of the acid will make themselves apparent in working the test, as regards the rapidity with which both the curdled milk is dissolved and the mixture of acid and milk turns black.

76. Strength of sulfuric acid. The relation between the strength of sulfuric acid and its specific gravity will be seen from the following table:

Strength of Sulfuric Acid (Lunge and Isler, 1890.)

Sulfuric Acid (H_2SO_4).	*Specific Gravity* (*15° C, water 4° C*).
97 per cent	1.841
96 "	1.840
95 "	1.839
94 "	1.837
93 "	1.834
92 "	1.830
91 "	1.825
90 "	1.820
89 "	1.815
88 "	1.808

It will be noticed that the sulfuric acid to be used in the Babcock test should contain 90 to 92 per cent. of acid (H_2SO_4); slightly weaker or stronger acid than this may, as previously stated, be used by adjusting the quantity of acid taken for each test to the strength of the acid, but successful tests cannot be made with acid weaker than 89 per cent. or stronger than 95 per cent.

77. The Swedish acid tester (Fig. 24) is a small hydrometer, intended to show whether the acid to be used in the Babcock test is of the correct strength. We have examined a number of these testers, and have found them practically useless for the purpose intended. The reason for this is that the instrument is not sufficiently sensitive; while the testers examined were found to sink to the line marked *Correct* on the scale, when lowered into sulfuric acid of a specific gravity of 1.83, they would sink to a point much nearer the same mark, than to the lines marked *Too strong* or *Too weak*, respectively, when lowered into either too strong or too weak acid.

Fig. 24.
Swedish acid tester.

An examination of the proportionate parts of these testers shows that such must be the case: The total weight of the testers varies between 7 and 8 grams; the diameter of the stem is nearly 5 millimeters, and the distance between the two lines marked *Too strong* and *Too weak* is 13.5 millimeters. A good hydrometer, such as used in chemical laboratories for determining the specific gravity of liquids of 1.8 to 2.0, weighs about 75 grams; the diameter of the stem is 6 mm., and the distance between the 1.82 and 1.84 marks on the scale is 15.5 mm.; these limits may be taken to represent too weak and too strong acid, respectively. Comparing such a hydrometer with the Swedish tester, the weight of the former would make it ten times as sensitive as the latter, if the size of the stem was the same in either case; as it is, the tester has the advantage in point of thinness of stem (see 106), as the volumes of the same lengths of stem in the two instruments are as the squares of their diameter, i. e., as 25:36. This means that the Swedish testers are only $\frac{36}{10 \times 25} = \frac{1}{7}$ as sensitive as the hydrometer, or a difference on the scale of the latter amounting to 15.5 mm. (see above), would represent only 2.2 mm., on the scale of the Swedish tester. The line marked *Too strong* must therefore be only 1.1 mm. ($\frac{1}{23}$ of an inch) below the *Correct* line; and that marked *Too weak* the same distance above the line. But this is too small a distance to be differentiated by persons unfamiliar with the use of delicate hydrometers, especially since the meniscus of the liquid formed around the stem of the tester renders an accurate reading somewhat difficult.

The Swedish acid tester can be made more delicate by changes in one or two directions; by making the bulb larger, thus necessitating an increase in weight, or by making the stem thinner. By way of comparison it may be stated that the hydrometers used for determining the specific gravity of the ether-fat solution in Soxhlet's areometric method of milk analysis have a stem only 2 mm. in diameter, and the distance of the scale between .765 and .745 is 70 mm., or $2\frac{3}{4}$ inches.

Even if these testers are changed as suggested, their practicability still remains an open question. The action of sulfuric acid of different strength on milk is very characteristic (75) and in the hands of experienced operators, is as delicate an index to the strength of the acid as can be desired, making rather unnecessary a separate instrument for ascertaining the correctness of the strength of the acid used in milk testing.

78. The color of the fat column an index to the strength of the acid used. The strength of the acid is indicated to a certain extent by the color of the fat which separates in the neck of the test bottle when milk is tested. If the directions given for making the test are carefully followed, the fat separated out will be of a golden yellow color. If the fat is light colored or whitish, it generally indicates that the acid is too weak, and a dark colored fat, with a layer of black material beneath it, shows that the acid is too strong, provided the temperature of both milk and acid is about 70°. [For influence of temperature, see next paragraph.]

The strength of the acid used in the test is not sufficient at ordinary temperatures of testing to appreciably dissolve the fat, but a variation in the strength of the acid or in the temperature of the milk influences the intensity of the action of the acid on the fat, as shown in the color of the fat obtained.

The following experiment shows the relation between the strength of the acid, the temperature of the milk, and the color of the fat:

First: — From a sample of milk, measure the usual quantity for testing into each of three bottles, A, B and C. Place A in *ice* water, and C in *warm* water, having bottle B at the *ordinary* temperature. After the bottles have been left for ten minutes under these conditions, add the normal quantity of acid to each and proceed with the test in the ordinary manner.

Second: — Measure some of the same milk into three other bottles, D, E and F. Into test bottle D pour the usual amount of rather weak acid; add the same amount of acid of normal strength (1.82–1.83) to bottle E, and add 17.5 cc. of a still stronger acid (concentrated sulfuric acid, sp. gr. 1.84), in test bottle F; complete these tests in the usual way.

On the completion of the preceding six tests the operator will notice that the fat in the necks of test bottles A (*cold milk*) and D (*weak acid*) is much lighter colored than that in C (*warm milk*) and F (*strong acid*), and that the color of the fat in B (*normal temperature*) and E (*normal acid*) is somewhere between that of these two series.

79. Influence of temperature on the separation of fat. The intensity of the action of the sulfuric acid on the milk is influenced by the temperature of either liquid; the higher the temperature, the more intense will be the action of the acid on the solids of the milk. It may be noticed that acid from the same carboy will act differently on milk in summer than in winter time, if the acid and the milk are not brought to a temperature of about 70° before testing during both seasons. The temperature of the liquids may be as low as 40° F. in winter and as high as 80° F. in summer. This difference of forty degrees will often have considerable influence on the clearness of the fat separated, showing white curdy substances and a light colored fat in winter, or black flocculent specks, with a dark colored column of fat in summer. Both these defects can be avoided when the acid is of the proper strength, by bringing the temperature of the milk and the acid to about 70° F. before the milk is tested.

The operator should be particularly cautious against over-heating either milk or acid; so intense an action may be caused thereby as to force the hot acid out of the neck of the test bottle when it is added to the milk, thus spoiling the test and possibly causing an accident.

4.—Water to be Used in the Babcock Test.

80. Rain water, condensed steam, or soft water should be used for the purpose of bringing the fat into the neck of the test bottles. The surface of the fat column will then usually be clear and distinct. The foam or bubbles that sometimes obscure the upper line (meniscus) of the fat, making indistinct the point from which to measure it, is generally caused by the action of the acid on the carbonates in hard water. The carbonic acid gas liberated from hard water by the sulfuric acid is more or less held by the viscid fat and produces a layer of foam on its surface. If clean soft water cannot be obtained for this purpose, hard water may be used by adding a few drops of sulfuric acid to the water before it is heated, thus causing the carbonic acid to be driven out of it. By simply boiling, many hard waters will be rendered soft and adapted to use in the Babcock test, as most of the carbonates which cause this foaming are thereby precipitated.

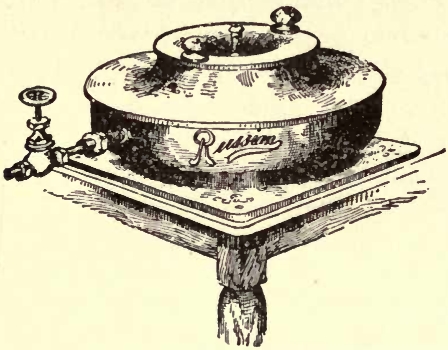

FIG. 25. The Russian test.

If the test has been completed, and a layer of foam appears over the fat, it may be destroyed by adding a drop or two of alcohol. If this is done, the fat column should be read at once after the alcohol is added, as the latter will soon unite with the fat and increase its volume.

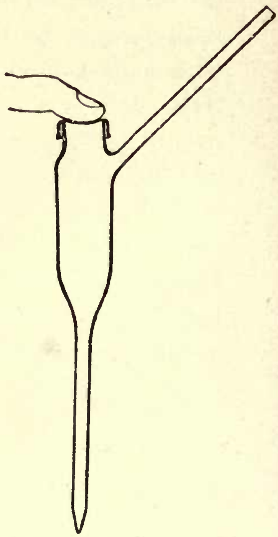

FIG. 26. Pipette used in the Russian test.

81. Reservoir for water. When only a few tests are made at one time, the hot water can be added with the 17.6 cc. pipette. If many tests are made, the water is more conveniently and quickly filled into the test bottles by drawing it from a small copper reservoir or tin pail suspended over the testing machine.[1] The flow of water through a rubber tube connected with the reservoir, is regulated by means of a pinch cock (Fig. 10). The water must be hot when added to the test bottles so as to keep the fat in a melted condition until the readings are taken. Some turbine testers are now made with a very convenient water receiver attached to the tester (Figs. 23–24).

The use of zinc or steel oilers, or perfection oil cans has been suggested, as a handy and rapid method of adding hot water to the test bottles.

5.—Modifications of the Babcock Test.

82. The Russian milk test. The same chemical and mechanical principles applied in the regular Babcock test, are used in the Russian milk test, except that in this case the machine in which the bottles are whirled, and the bottles themselves, are so constructed that the latter can be filled with hot water while the machine is running at full speed, thus saving time and trouble incident to the stopping of the tester and filling the bottles by means of a pipette. The milk-measuring pipette (Fig. 26) and the acid measure used in the Russian test

[1] Ordinary tinware rusts very soon when water is left standing in it, and copper reservoirs are therefore more economical.

are one-half of the ordinary size, and the test bottles are made in two pieces, with a detachable narrow graduated stem (see Fig. 27). The machine is substantially made of cast iron; it is provided with a very satisfactory speed indicator which shows at any time the number of revolutions at which the bottles are being turned. The accompanying illustrations show the apparatus used in the Russian test. When the directions for operating the test are followed closely, the results obtained are accurate and very satisfactory.

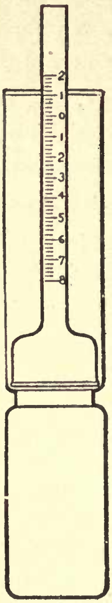

FIG. 27. Test bottle used in the Russian test.

83. Bartlett's modification. Bartlett[1] proposed a modification of the method of procedure in the Babcock test, which aims to simplify the manipulations. 20 cc. of acid are added, instead of 17.5 cc., and the bottles filled with the milk-acid mixture are left standing for not less than five minutes and then filled with hot water to within the scale; the bottles are then whirled for five minutes at the regular rate (52).

In the experience of the authors the modification can not always be depended upon to give satisfactory results. When published it was tried by each of the one hundred students in the Wisconsin Dairy School; while some of these operators obtained a clear separation of fat, and results that compared favorably with those made by the regular Babcock test, others failed to obtain correct results with the method as modified. It is not known that the modifica-

1 Maine experiment station, Bull. No. 31 (S. S.).

tion has proved superior to or taken the place of the regular Babcock test to any extent.[1]

84. Bausch and Lomb centrifuge. Fig. 28 shows a form of hand centrifuge which may be used to advantage by physicians or in pathological laboratories for the determination of fat in milk. The centrifuge is especially designed for examination of urine, sputum, blood, etc., but has been adapted to milk analysis by the Leffmann & Beam test, a special form of bottle (Fig. 29) having been constructed for this purpose. The machine gives satisfactory results by the Babcock test as well, provided the acid used is 1.83–1.84, or if the bottles containing the acid-milk mixture be placed in hot water for five or ten minutes prior to the whirling. As the bottles are calibrated for only 5 cc. of milk and the neck of the bottles, with scale, is correspondingly fine, testing milk with this machine requires some nicety of manipulation not called for in case of testers constructed for the use of farmers and dairymen.

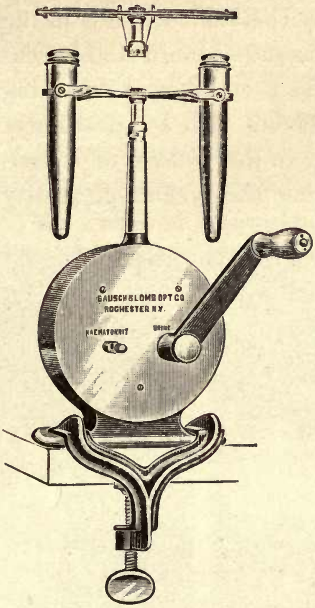

FIG. 28. Physician's centrifuge that may be used for milk testing.

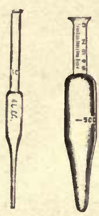

FIG. 29. Pipette and test bottle for physician's centrifuge.

[1] The German dairy chemist Siegfeld in 1899 proposed a modification of the Babcock test (*Molkerei Ztg*, *Hildesheim*, 1899, p. 51), using 2 cc. of amyl alcohol with the sulfuric acid, and filling up with dilute sulfuric acid (1:1, sp. gr. 1.5) in one filling, in place of water, after the whirling. A clear separation of the fat is facilitated by both these changes, but when properly conducted there is no difficulty whatever in obtaining a clear fat column in the Babcock test as described in this book, and the modification will not therefore be likely to be introduced in American factories. It has become quite generally adopted in North German creameries where the Babcock test is used.

CHAPTER IV.

CREAM TESTING.

85. Cream may be tested by the Babcock test in the same manner as milk, and the results obtained are accurate when the necessary care has been taken in sampling the cream and in measuring the fat. The composition of cream varies greatly according to the process of creaming, temperature of milk during the creaming, quality

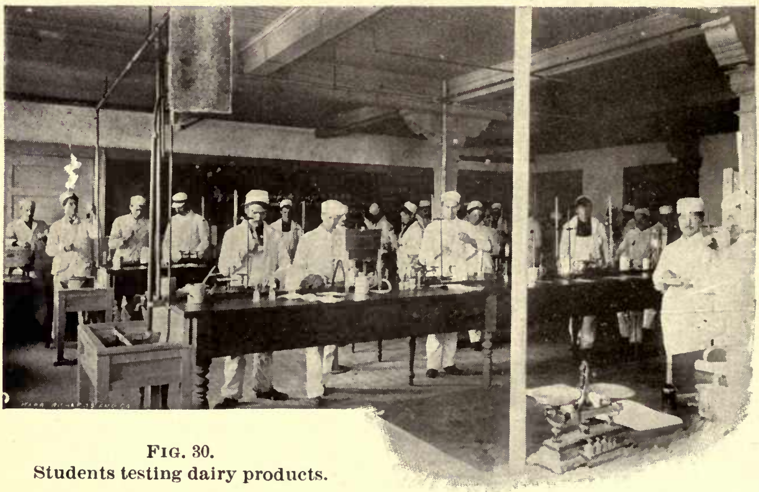

FIG. 30.
Students testing dairy products.

and composition of the milk to be creamed, etc. The cream usually met with in creameries or on the market (outside of large cities) will contain from 15 to 50 per cent., or on the average 35 per cent. of fat.[1] If 18 grams

[1]For average quality of cream furnished at five Connecticut creameries see (202).

of 25 per cent. cream is measured into an ordinary Babcock test bottle, it follows that there will be $18 \times .25 = 4.5$ grams (or $\frac{4.5}{.9} = 5$ cc.) of pure butter fat in the bottle. It is shown, however, (p. 38), that the space from 0 to 10 in the neck of these bottles holds exactly 2 cc. The neck of the milk test bottles will not therefore be large enough to show the per cent. of fat in a sample of cream if 18 grams are taken for testing, so that less cream must be measured out, or special forms of test bottles used (89).

86. Errors of measuring cream. Several factors tend to render inaccurate the measuring of cream for the Babcock test, and in exact work it is recommended to weigh the amount taken for a test. If a 17.6 cc. pipette is used for measuring the cream, it will not deliver 18 grams of cream, as it will of milk, for the following reasons:

1. The specific gravity of cream is lower than that of milk; if a certain quantity of milk weighs 1030 lbs., the same quantity of cream will weigh from 1020 lbs. to below 1000 lbs., the weight being determined by the richness of the cream; the more fat the cream contains, the less a certain quantity of it, e. g., a gallon will weigh.[1]

2. Cream is thicker (more viscous) than milk at the same temperatures, and more of it will adhere to the sides of the measuring pipette than in case of milk. This is of special importance in testing very rich or sour cream.

3. In case of separator cream, more or less air will become incorporated with the cream during the process of separation. In the ripening of cream, the fermentation gases developed are held in the cream in the same way as bread dough holds the gases generated by yeast.

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[1] For specific gravity of cream of different richness, see table on p. 76.

In either case the weight of a certain measure of cream is diminished.

87. As an illustration of the effect of the preceding factors on the amount of cream measured out by a Babcock 17.6 cc. pipette, the following weighings of separator cream are given (columns (a)). The cream was in all cases fresh from the separator; it was weighed as delivered by the pipette into a Winton cream bottle (91), and the test proceeded with at once; the specific gravity of the cream was determined by means of a picnometer. The data given are in all cases averages of several determinations; the samples of cream have been grouped according to their average fat contents.[1]

The figures[2] given in columns (b) and (c) are calculated from the per cent. of fat and total solids in creams containing different per cents. of fat. Column (c) shows approximately the corrections to be added to readings of cream tests when the adhering cream is washed from the walls of a 17.6 cc. pipette, these washings added to the test bottle, and the test completed in the usual way.

Weight of fresh separator cream delivered by a 17.6 cc. pipette.

Per cent. of fat in cream.	*Specific gravity (17.5° C.)* Weighed. (a)	Calculated. (b)	*Weight of cream delivered, grams.* (a)	(b)	*Corrections to be added.* (c) %
10	1.023	1.025	17.9	18.00	0.00
15	1.012	1.020	17.7	17.95	0.04
20	1.008	1.014	17.3	17.84	0.18
25	1.002	1.000	17.2	17.75	0.35
30	.996	1.004	17.0	17.66	0.58
35	.980	.998	16.4	17.56	0.88
40	.966	.993	16.3	17.48	1.19
45	.950	.988	16.2	17.39	1.59
50	.947	.983	15.8	17.30	2.00

[1] For influence of condition of cream on the amount measured out with a 17.6 cc. pipette, see also Bartlett, Maine exp. sta., Bull. 31 (S. S.).

[2] Hoard's Dairyman, 1900, p. 355.

The figures in the table show plainly the variations in the specific gravity of cream of different richness and the error of making tests of cream by measuring it with a 17.6 cc. pipette, especially if the pipette is not rinsed and the washings added to the test bottle; if the cream to be sampled is fresh separator cream testing over 30 per cent., less than 17.0 grams of cream will be delivered into the test bottle, and the results of the reading will be at least one-eighteenth too low, or about 1.4 per cent. on a 25 per cent. cream. If the cream is sour, the error will of course be still greater.

It should be remembered that the specific gravities of the cream given in the table refer to fresh separator cream only. Considerable air is incorporated during the separation, and cream of this kind is therefore lighter than gravity cream of corresponding fat contents.

88. Avoiding errors of measuring cream. The preceding table shows that a 17.6 cc. pipette in case of cream containing less than 25 per cent. of fat and fresh from the separator, will deliver only about 17.2 grams of cream; it is therefore evident that the pipette to deliver cream for the Babcock test must be made larger than the 17.6 cc. pipette used in testing milk. Quite satisfactory results may be obtained in testing such cream by using an 18 cc. measuring pipette; to avoid the expense and trouble of using two different pipettes, one for milk and one for cream, a pipette with two marks on the stem, at 17.6 cc. and 18 cc., has been placed on the market, the former mark being used when milk is tested, and the latter for cream.[1]

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[1] Professor Spillman, in Bull. 32 of Washington experiment station, recommends the use of a 17.6 cc. pipette for testing cream, the results obtained being corrected by a certain per cent., as shown in a table given in the bulletin. The table is based on the figures given on p. 76 of this book, and is therefore only applicable to fresh separator cream.

In testing cream by the Babcock test, one of two methods may be followed:

First, one of the special forms of cream test bottles which have been devised is used; or,

Second, only sufficient cream to be tested in a regular Babcock milk test bottle is taken for a sample.

89. Cream test bottles. Three special forms of bottles have been devised for testing samples of cream by the Babcock test; two of these were suggested by Bartlett of Maine,[1] in 1892; one with a long detachable neck designed for testing very rich cream (up to 35 per cent. fat), and the other with a neck widened into a bulb in the middle so as to allow a large quantity of fat to be measured. The former kind of cream bottle never met with favor among operators; its neck was too long to be used in the ordinary centrifugal machines, and was not attached until the base portion, containing the cream, acid and first filling with water, had been whirled.

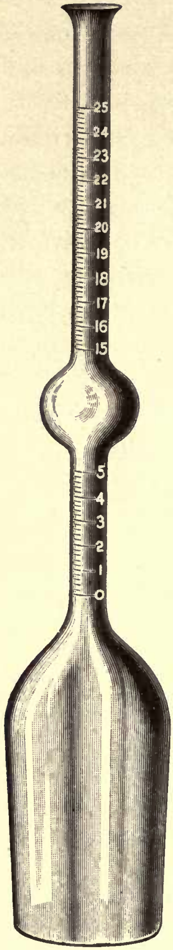

FIG. 31. The bulb-necked cream test bottle.

90. The bulb-necked cream bottles (Fig. 31), allow the testing of cream containing 23 or 25 per cent. of fat, the usual quantity of cream (18 grams) being measured out. The neck is graduated from 0 to 23 per

[1] Maine experiment station, bulletins 3 and 4 (second series).

cent., and in some cases to 25 per cent., the graduation extending both below and above the bulb. This is sometimes an inconvenience, as the water must be added carefully so that the lower end of the column of fat will always come below the bulb, in the graduated part of the neck, and not in the bulb itself. Especially in case of beginners, tests are often lost when this bottle is first used, for the reason given; the operator will, however, soon learn to add the proper amount of hot water to float the fat to some point within the scale. It is recommended to fill these bottles with the first portion of hot water to just above the bulb, so that one can see how much water to add the second time in order to bring the fat within the scale.

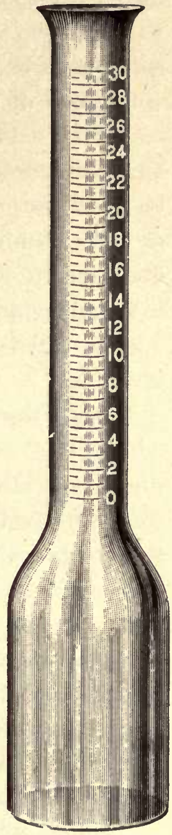

FIG. 32. The Winton cream bottle.

Each division of the scale on these cream bottles represents two-tenths of one per cent. of fat, as in case of the milk test bottles.

91. The Winton cream bottle. The cream test bottle devised by Winton,[1] (Fig. 32), has a neck of the usual length, and sufficiently wide to measure 30 per cent. of fat. The scale of the neck is divided into one-half per cents., but readings of a quarter of a per cent. can easily be estimated. Determinations of fat in cream accurate to a quarter of a

[1] Connecticut experiment station (New Haven), Bull. No. 117; report 1894, p. 224.

per cent. are sufficiently exact for most commercial purposes, e. g., in creameries, and this form of cream bottle will be found very convenient in making tests of composite samples of cream.

92. Use of milk test bottle. Cream may be tested by emptying a 17.6 cc. pipetteful of the sample into two or more milk test bottles, dividing the amount about equally between the bottles and filling the pipette with water once or twice, which is then in turn divided about equally between the test bottles; the per cent. of fat in the cream is found by adding the readings obtained in each of the bottles. Milk and water must be mixed *before* the acid is added.

This method does away with the error incident to the adhesion of cream to the side of the pipette, but not that due to the low specific gravity of the cream, and the results obtained will therefore be too low. The dilution of the cream with water in the test bottles not only makes it possible to bring into the bottle all the cream measured out, but also insures a clear test. If ordinary cream is mixed with the usual quantity of sulfuric acid used in the Babcock test, a dark-colored fat will generally be obtained, while the cream diluted with an equal or twice its volume of water, when mixed with the ordinary amount of acid, will give a light yellow, clear column of fat, which will allow of a very distinct and sharp reading.

The number of bottles to be used for testing a sample of cream by this method must be regulated by the richness of the cream. If the sample probably contains 20 per cent. or more, a pipetteful should be divided nearly equally between three milk test bottles, and two-thirds of a pipetteful of water is added to each bottle. If the cream contains less than 20 per cent. of fat, it will only be necessary to use two milk test bottles, dividing the pipetteful between these, and adding one-half of a pipetteful of water to each bottle.

By using cream test bottles (89), more accurate tests may be obtained in case of cream containing as much as 25 per cent. of fat, by dividing one pipetteful between two bottles, rinsing half a pipette of water into each one, than by adding all the cream to one bottle without rinsing the pipette, for reasons apparent from what has been said in the preceding.

93. Use of a 5 cc. pipette. When the cream is in good condition for sampling, satisfactory results can be obtained by the use of a 5 cc. pipette, provided great care is taken in mixing the cream before sampling; 5 cc. of cream are measured into a milk test bottle, and two pipettefuls of water are added. In this way all the cream in the pipette is easily rinsed into the test bottle. The readings multiplied by $\frac{18}{5}=3.6$ will give the per cent. of fat in the cream. If the specific gravity of the cream tested varies appreciably from 1, corrections should be made accordingly; e. g., if the specific gravity is 1.02; the factor should read $\frac{18}{5 \times 1.02}=3.53$; if .95, $\frac{18}{5 \times .95}=3.79$, etc.

94. Weighing the cream. For the reasons already given it is always to be preferred to weigh the cream in the test bottles when accurate tests are required. When a small, delicate balance is used, this can be done quite rapidly. Either of the scales shown in the accompanying illustration (fig.33), will be found useful and sufficiently accurate for this purpose; a small scale of this kind is also convenient and helpful in testing cheese, butter and condensed milk, in determining the strength of sulfuric acid, and the accuracy of test bottles and pipettes (q. v.). In testing cream by weight, the test bottle is first weighed empty, and again when 5 to 10 cc. of cream have been measured into it; the difference between the two weights gives the weight of cream taken for the test. If the cream contains less than 30 per cent. of fat, the regular milk test bottle can be used for testing the cream, if not much more than 5 grams are weighed out; if more cream is taken, or if this is richer than 30 per cent., it is advisable to use the cream bottle.

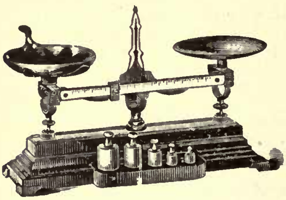

FIG. 33. Scale used for weighing cream, cheese, etc., in the Babcock test.

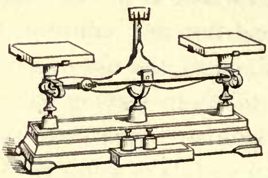

FIG. 34. Beebe and Spillman cream weighing scale.

The operator should be careful in weighing the cream not to spill it on the outside of the test bottle. Sufficient water is added to the bottle to make the total volume about 15 cc. The usual quantity of acid (17.5 cc.) is then added, and the test completed in the ordinary manner. The reading of the amount of fat in the neck of the test bottle in this case does not show the correct per cent. of fat in the cream, because less than 18 grams were weighed out. The per cent. of fat in the cream tested is obtained by multiplying the reading by 18, and dividing the product by the weight of the cream taken.

Example: Weight of cream tested, 5.2 grams; reading of columns of fat 1)4.8, 2)4.7, average 4.75; per cent. of fat in the cream $\frac{4.75 \times 18}{5.2} = 16.44$.

The weighing of cream and the reading of the fat column must be made very carefully; a division of one-tenth on the neck of the test bottle has a value of over three-tenths of one per cent. of fat when 5 grams of cream are tested, and six-tenths of one per cent. if only 3 grams of cream are weighed out. The reading is rendered more accurate and certain if a number of tests of a sample are made, at least two or three, and the results averaged.

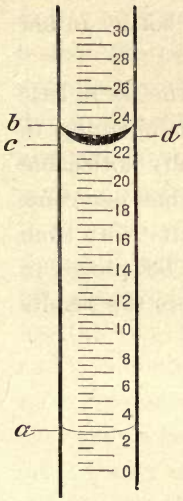

FIG. 35. Measuring the fat column in the neck of a cream bottle. Readings should be made from *a* to *b*, not to *d* or to *c*.

The accompanying illustration (fig. 35), shows the proper method of reading the fat column in cream tests; readings are taken from *a* to *b*, not to *d* or to *c*.[1]

95. No special precautions other than those required in testing milk have been found necessary in testing cream, except that it is sometimes advisable not to whirl the test bottles in the centrifuge at once after mixing, but to let the cream-acid mixture stand for awhile, until it turns dark colored. At first, the mixture of cream and acid is much lighter colored than that of milk and acid, owing to the smaller amount of solids not fat contained in the cream.

[1]The size of the meniscus is magnified in the cut.

The liquid beneath the fat in a completed test of cream is sometimes milky, and the fat appears white and cloudy, making an exact reading difficult. Such defects can usually be overcome by placing the test bottles in hot water for about 10 minutes previous to the whirling, or by allowing the fat to crystallize (which is done by cooling the bottles in cold water after the last whirling) and remelting it by placing the bottles in hot water.

96. The error due to the expansion of the fat in case of excessively hot turbine testers having no openings in the cover as mentioned on p. 36, is especially noticeable in cream testing, where it may amount to one per cent. or more. In order to obtain correct results with such testers, the hot cream test bottles must be placed in water at about 140° F. for ten minutes before the results are read off.

CHAPTER V.

BABCOCK TEST FOR OTHER MILK PRODUCTS.

97. Skim milk. Each division on the scale of the neck of the regular Babcock test bottle represents two-tenths of one per cent. (44). When a sample of skim milk or butter milk containing less than this per cent. of fat is tested, the estimated amount is expressed by different operators as one-tenth, a trace, one-tenth trace, or one- to five-hundredths of one per cent. Gravimetric chemical analyses of skim milk have shown that samples which give only a few small drops of fat floating on the water in the neck of the test bottle, or adhering to the side of the neck, generally contain one-tenth of one per cent. of fat, and often more. Samples of skim milk containing less than one-tenth of one per cent. of fat are very rare, and it is doubtful whether a sample of separator skim milk representing a full run of say 5,000 lbs. of milk, has ever shown less than five-hundredths of one per cent. of fat. Under ordinary factory conditions, few separators will deliver skim milk containing under one-tenth of one per cent. of fat, when the sample is taken from the whole day's run. This must be considered a most satisfactory separation.[1]

98. The reason why the Babcock test fails to show all the fat present in skim milk must be sought in one or two causes: a trace of fat may be dissolved in the sulfuric acid, or owing to the minuteness of the fat globules of

[1] For comparative analyses of separator skim milk by the gravimetric method and by the Babcock test, see Wis. exp. station, bull. 52 and rep. XVII, p. 81.

such milk they may not be brought together in the neck of the bottles at the speed used with the Babcock test. The latter cause is the more likely explanation. If a drop of the dark liquid obtained in a Babcock bottle from a test of whole milk, be placed on a slide under the microscope, it will be seen that a fair number of very minute fat globules are found in the liquid. These globules are not brought into the column of fat in the neck of the bottle by the centrifugal force exerted in the Babcock test, unless the bottles are whirled in a turbine tester in which they are heated to 200° F. or higher, see (71); the loss of the fat contained in these fine globules is compensated for, in the testing of whole milk, by a liberal reading of the column of fat separated out, the reading being taken from the lower meniscus of the fat to the top of the upper one (see p. 35); in some separator skim milk, on the other hand, not enough fat remains to completely fill the neck, and the apparent result of the reading must therefore be increased by from five-hundredths to one-tenth of one per cent. or the sample tested in a double-necked skim milk bottle.

It follows from what has been said that tests of skim milk showing no fat in the neck of the test bottles on completion of the test, generally indicate inefficient work of the centrifugal tester or of the operator, or of both. The test should be repeated in such cases, using more acid and whirling for full four minutes.

In order to bring as much fat as possible into the neck of the bottles in testing skim milk, it is advisable to add somewhat more acid than when whole milk is tested, viz., about 20 cc., and to whirl the bottles at full speed for four to five minutes, keeping the tester as hot as possible the whole time.[1] The readings must be taken as soon as the whirling is completed, as owing to the contraction of the liquid by cooling, the fat otherwise adheres to the inside of the neck of the test bottle as a film of grease which cannot be measured by the scale.

99. The double-necked test bottle, (Fig. 36), suggested by one of us,[2] is made especially for measuring small quantities of fat and gives most satisfactory results in testing skim milk and butter milk. Each division of the scale in these bottles represents five-hundredths of one per cent., and the marks are so far apart that the small fat column can be easily estimated to single hundredths of one per cent. In the first forms, now out of use, the neck was graduated to hundredths of one per cent.

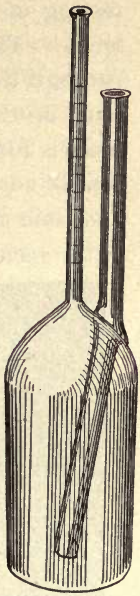

Fig. 36. The double-necked skim milk bottle (sometimes called the Ohlson or B. & W. bottle.)

The value of the divisions of the scale on the double-necked test bottles has been a subject of considerable discussion, and various opinions have been expressed whether they show one-tenth or one-twentieth (.05) of one per cent. of fat. By calibration with mercury the value of the divisions will be found to be .05 or one-twentieth of one per cent., but as shown above, the results obtained in using the bottles for thin separator skim milk often come at least .05 per cent. too low, so that, practically speaking, each division may be taken to

[1] See Wis. exp. station, report XVII, p. 81.

[2] Farrington, and constructed by Mr. J. J. Nussbaumer, of Illinois.

show one-tenth of one per cent., if the fat fills only one division of the scale or less.[1]

The double-necked bottle is very convenient for the testing of separator skim milk, thin butter milk and whey. The milk, acid and water are added to the bottle through the large side-tube; the mixing of milk and acid must be done with great care, so that none of the contents is forced into the fine measuring tube and lost; it is best to add half of the acid first and mix it with the milk, and then add the rest. When the fat is in the lower end of the measuring tube, it can be forced into the scale by pressing with the finger on the top of the side tube.

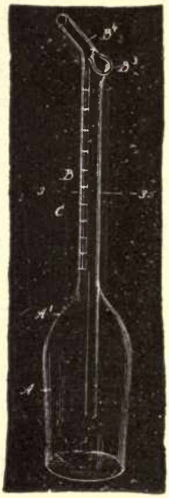

FIG. 37 Wagner skim milk bottle.

In placing the double-necked bottle in the tester they should be put with the filling tube toward the center so as to avoid any of the fat being caught between this tube and the side of the bottle when it resumes a vertical position.

This test bottle is more fragile and expensive than the ordinary Babcock bottles, and must be carefully handled; it has recently been made of heavier glass and this form is to be highly recommended.[2]

100. *The double-sized skim milk bottle* is of no particular value. It is difficult to obtain a thorough mixture of the milk and the acid in

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1 Wis. experiment station, bull. 52; Penna. experiment station, report 1896, p. 221.

2 During the past year a copper double-necked test bottle with a detachable graduated glass neck was designed and tried by one of us (F.), but no special advantages over the glass bottle has so far been found for it.

these bottles, and the tests invariably come too low, more so than with the regular Babcock bottles or the double-necked skim milk bottles, for reasons that are readily seen.

101. Buttermilk and whey. The testing of *buttermilk* or *whey* by the Babcock test offers no special difficulties, and what has been said in regard to tests of separator skim milk is equally true in case of these by-products. Whey contains only a small quantity of solids not fat, viz., less than 7 per cent. (27), and the mixing with acid and the solution of the whey solids therein is therefore readily accomplished; the acid solution is of a light reddish color, turning black but very slowly.

102. Cheese. Cheese can be easily tested by the Babcock test if a small scale (fig. 33) is at hand for weighing the sample; the results obtained will furnish accurate information as to the amount of fat in the cheese, provided good judgment and exactness are used in sampling and weighing the cheese. The following method of sampling cheese is recommended:[1]

"Where the cheese can be cut, a narrow wedge reaching from the edge to the center of the cheese will more nearly represent the average composition of the cheese than any other sample. This may be cut quite fine, with care to avoid evaporation of water, and the portion for analysis taken from the mixed mass. When the sample is taken with a cheese trier, a plug taken perpendicular to the surface, one-third of the distance from the edge to the center of the cheese, will more nearly represent the average composition than any other. The plug should

[1] U. S. Dept. of Agriculture, Chemical Division, bull. No. 46, p. 37.

either reach entirely through or only half way through the cheese.

"For inspection purposes the rind may be rejected, but for investigations, where the absolute quantity of fat in the cheese is required, the rind should be included in the sample. It is well, when admissible, to take two or three plugs on different sides of the cheese and after splitting them lengthwise with a sharp knife, take portions of each for the test."

103. When a satisfactory sample of the cheese has been obtained, about 5 grams are weighed into a milk test bottle, or a larger quantity may be used with a cream test bottle. The test bottle is first weighed empty, and again after the pieces of cheese have been added. About 15 cc. of warm water is added to the cheese in the test bottle, and this is shaken occasionally until the cheese softens and forms a creamy emulsion with the water. A few cc. of acid will aid in this mixing and disintegration. When all lumps of cheese have disappeared in the liquid, the full amount of acid is added, and the test completed in the ordinary manner.

The per cent. of fat in the cheese is obtained by multiplying the reading of the fat column by 18 and dividing the product by the weight of cheese added to the test bottle. The weighing of the cheese and the reading of the fat must be done with great care, since any error introduced is more than trebled in calculating the per cent. of fat in the cheese.

104. Condensed milk. The per cent. of fat in *unsweetened* condensed milk can be obtained by weighing 8 grams into a test bottle and proceeding in exactly the same way as given under testing of cheese. It is not necessary to add ammonia or to warm the condensed milk in the test bottles, since the solution of this in water is readily effected without any outside agency. Enough water should be added to make the total volume of liquid in the bottles 15-18 cc.

If a scale is not available for weighing the sample, fairly accurate results may be obtained by diluting the condensed milk with water (1:3), and completing the test in the ordinary manner. When this is done, the results must be corrected for the dilution which the sample received.

105. Sweetened condensed milk. This presents peculiar difficulties, whether it is to be tested by the Babcock test or by chemical analysis. It may, however, be readily tested by the Babcock test by introducing certain changes in the manipulation of the test as worked out by one of us (F).[1]

A brief description of the manipulations adopted will explain the method that has proved satisfactory.

About sixty grams of condensed milk are weighed into a 200 cc. graduated flask; to this 100 cc. of water are added and the solution of the condensed milk effected. The flask is then filled to the mark with water and after mixing thoroughly, a 17.6 cc. pipette full is measured into a Babcock test bottle. About three cc. of the sulfuric acid commonly used for testing milk are then added and the milk and acid mixed by shaking the bottle vigorously. The milk is curdled by the acid, and the curd and whey separated somewhat.

(1) 17th Annual Report of Wis. Expt. Station, pp. 86-89.

In order to make this separation complete and to compact the curd into a firm lump, the test bottle is whirled for about six minutes at a rather high speed (1,000 rev.) in a steam-heated turbine centrifuge.

The chamber in which the bottles are whirled ought to be heated to about 200° F. This can be done either by the turbine exhaust steam which leaks into the test-bottle chamber of some machines, or by means of a valve and pipe which will allow steam to be turned directly into the test bottle chamber. After this first whirling the test bottles are taken from the centrifuge and by being careful not to break the lump of curd nearly all the whey or sugar solution can be poured out of the neck. Ten cc. of water are then poured into the test bottle and the curd is shaken up with it so as to wash out more of the sugar. Three cc. of acid are now added as before and the test bottle whirled a second time in the centrifuge. The whey is decanted again and this second washing removes so much of the sugar that what remains will not interfere with testing in the usual way. The curd remaining in the test bottle after the second washing is shaken up with ten cc. of water and to this water emulsion of the curd the usual amount, 17.5 cc. of sulfuric acid is added and the test completed in the same way as milk is tested. The amount of fat finally obtained in the neck of the test bottle is calculated to the weight of condensed milk taken.

Five brands of sweetened condensed milk were examined by this process, at least four determinations being made of each sample. The fat separated was clear and the final results satisfactory.

CHAPTER VI.

THE LACTOMETER AND ITS APPLICATION.

106. The Quevenne lactometer. This instrument (see Fig. 38, next page) consists of a hollow glass cylinder weighted by means of mercury or fine shot so that it will float in milk in an upright position, and provided with a narrow stem at its upper end, inside of which is found a graduated paper scale. In the better forms, like the Quevenne lactometer shown in the figure, a thermometer is melted into the cylinder, with its bulb at the lower end of the lactometer and its stem rising above the lactometer scale.

The lactometer is used for the determination of the specific gravity of milk. The term *specific gravity* means the weight of a certain volume of a solid or a liquid substance compared with the weight of the same volume of water at 4° C. (39.2° Fahr.); for gases the standard of comparison is air or hydrogen. If the milk which a can will hold weighs exactly 103.2 lbs., this can will hold a smaller weight of water, say 100 lbs., as milk is heavier than water; the specific gravity of this milk will then be $\frac{103.2}{100}=1.032$.

The specific gravity of normal cows' milk will vary in different samples between 1.029 and 1.035 at 60° F., the average being about 1.032.

107. The lactometer enables us to determine rapidly the relative weight of milk and water. Its application rests on well-known laws of physics: When a body floats in a liquid, the weight of the amount of liquid which it replaces is equal to the weight of the body. It will sink further into a light liquid than into a heavy one, because a larger volume of the former will be required to equal the weignt of the body. A lactometer will therefore sink deeper into milk of a low specific gravity than into milk of a high specific gravity.

FIG. 38. Quevenne lactometer floating in milk in a tin cylinder (112).

The scale of the Quevenne lactometer is marked at 15 and 40, and divided into 25 equal parts, with figures at each five divisions of the scale. The single divisions are called *degrees.* The 15 degree mark is placed at the point to which the lactometer will sink when lowered into a liquid of a specific gravity of 1.015, and the 40 degree mark at the point to which it will sink when placed in a liquid of a specific gravity of 1.040. The specific gravity is changed to lactometer degrees by multiplying by 1000 and subtracting 1000 from the product.

Example: Given, the specific gravity of a sample of milk is 1.0345; corresponding lactometer degree, $1.0345 \times 1000 - 1000 = 34.5$.

Conversely, if the lactometer degree is known, the corresponding specific gravity is found by dividing by 1000 and adding 1 to the quotient ($34.5 \div 1000 = .0345$; $.0345 + 1 = 1.0345$).

108. Influence of temperature. Like most liquids, milk will expand on being warmed, and the same volume will, therefore, weigh less when warmed than before; that is, its specific gravity will be decreased. It follows then that a lactometer is only correct for the temperature at which it is standardized. If a lactometer sinks to the 32-mark in a sample of milk of a temperature of 60° F., it will only sink to, say 33, if the temperature of the milk is 50° F., and will sink farther down, e. g., to 31, if the temperature is 70° F. Lactometers on the market at present are generally standardized at 60° F., and to show the correct specific gravity the milk to be tested should first be warmed (or cooled, as the case may be) to exactly 60° F. As this is a somewhat slow process, tables have been constructed for correcting the results for errors due to differences in temperature (see *Appendix*, Table V).

109. As the fat content of a sample of milk has a marked influence on its specific gravity at different temperatures, the co-efficient of expansion of fat differing greatly from that of the milk serum, the table cannot give absolutely accurate corrections for all kinds of milk, whether rich or poor. But the errors introduced by the use of one table for any kind of whole milk within a comparatively small range of temperature, like ten degrees above or below 60°, are too small to have any importance outside of exact scientific work, and in such, the specific gravity is always determined by means of a picnometer or specific gravity bottle, at the temperature at which this has been calibrated. In taking the specific gravity of a sample of milk by means of a lactometer, the milk is always warmed or cooled so that its temperature does not vary ten degrees either way from 60° F.

110. The temperature correction table for whole milk, given in the *Appendix* shows that if, e. g., the specific gravity of a sample of milk taken at 68° F. was found to be 1.034, its specific gravity would be 1.0352 if the milk was cooled down to 60°. If the specific gravity given was found at a temperature of 51°, the corrected specific gravity of the milk would be 1.0329.

In practical work in factories or at the farm, sufficiently accurate temperature corrections may generally be made by adding .1 to the lactometer reading for each degree above 60° F., and by subtracting .1 for each degree below 60°; e. g., if the reading at 64° is 29.5, it will be about $29.5 + .4 = 29.9$ at 60° F.; and 34.0 at 52° F. will be about $34.0 - .8 = 33.2$ at 60° F. The table in the *Appendix* gives 33.0 as the corrected figure in both cases.

The scale of the thermometer in the lactometer should be placed *above* the lactometer scale so that the temperature may be read without taking the lactometer out of the milk; this will give more correct results, will facilitate the reading and save time.

111. N. Y. Board of Health lactometer. In the East, and among city milk inspectors generally, the so-called New York Board of Health lactometer is often used. This does not give the specific gravity of the milk directly, as is the case with the Quevenne lactometer, but the scale is divided into 120 equal parts, known as *Board of Health degrees,* the mark 100 being placed at the point to which the lactometer sinks when lowered into milk of a specific gravity of 1.029 (at 60° F.); this is considered the lowest limit for the specific gravity of normal cows' milk. The zero mark on the scale shows the point to which the lactometer will sink in water; the distance between these two marks is divided into 100 equal parts, and the scale is continued below the 100 mark to 120. As 100° on the Board of Health lactometer corresponds to 29° on the Quevenne lactometer, the zero mark showing in either case a specific gravity of 1, the degrees on the former lactometer may easily be changed into Quevenne lactometer degrees by multiplying by .29. To further aid in this transposition, table III is given in the *Appendix*, showing the readings of the two scales between 60° and 120° on the Board of Health lactometer.

112. Reading the lactometer. For determining the specific gravity of milk in factories or private dairies, tin cylinders, $1\frac{1}{2}$ inches in diameter and 10 inches high, with a base about four inches in diameter, are recommended (see Fig. 38); another form of specific gravity cylinders, in use in chemical laboratories, is shown in Fig. 39. The cylinder is filled with milk of a temperature ranging between 50° and 70° F., to within an inch of the top, and the lactometer is slowly lowered therein until it floats; it is left in the milk for about half a minute before lactometer and thermometer readings are taken, both to allow the escape of air which has been mixed with the milk in pouring it preparatory to the specific gravity determination, and to allow the thermometer to adjust itself to the temperature of the milk. The lactometer

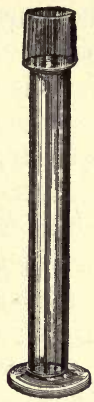

FIG. 39. Specific gravity cylinder.

should not be left in the milk more than a minute before the reading is taken, as cream will very soon begin to rise on the milk, and the reading, if taken later, will be too high, as the bulb of the lactometer will be floating in partially skimmed milk (23). In reading the lactometer degree, the mark on the scale plainly visible through the upper portion of the meniscus of the milk should be noted. Owing to surface tension the milk in immediate contact with the lactometer stem will rise above the level of the surface in the cylinder, and this must be taken into consideration in reading the degrees. There is no need of reading closer than one-half of a lactometer degree in the practical work of a factory or a dairy.

113. Time of taking lactometer readings. The specific gravity of milk should not be determined until at least three hours after the milk has been drawn from the udder, as too low results are otherwise obtained (*Recknagel's phenomenon*).[1] The cause of this phenomenon is not definitely understood; it may come from the escape of gases in the milk, or from changes occurring in the mechanical condition of the nitrogenous components of the milk. The results obtained after three or four hours will as a rule come about one degree higher than when the milk is cooled down directly after milking and its specific gravity then determined.

114. Influence of bi-chromate on the lactometer reading. When potassium bi-chromate is added to milk samples to preserve them from souring (188), the specific gravity

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[1] Milchzeitung 1883, 419; Bulletin No. 43, Chem, Div., U. S. Department of Agriculture, p. 191; Analyst 1894, p. 76.

of the milk is thereby increased; with the quantity usually added ($\frac{1}{2}$ gram to a pint of milk) the increase amounts to about 1 lactometer degree, and this correction of lactometer readings should be made with milk samples preserved in this manner. To avoid this error, Dr. Eichloff[1] recommends using a solution of bi-chromate in water (43 grams to 1 liter), the specific gravity of which is 1.032, or similar to that of average milk; 5 cc. of this solution is required for a pint of milk. No correction is necessary for the dilution with this small amount of liquid preservative.

115. Cleaning of lactometer. The lactometer should be cleaned directly after using, by rinsing with cold water; it is then wiped dry with a clean cloth and placed in the case.

CALCULATION OF MILK SOLIDS.

116. A number of chemists have prepared formulas for the calculation of milk solids when the fat content and the specific gravity (lactometer reading) of the milk are known. By careful work with milk tester and lactometer it is possible by means of these formulas to determine the composition of samples of milk with considerable accuracy outside of, as well as in chemical laboratories. As the complete formulas given by various chemists (Behrend and Morgen, Clausnitzer and Mayer, Fleischmann, Hehner and Richmond, Richmond, Babcock)[2] are very involved, and require rather lengthy calculations, tables facilitating the figuring have been prepared. The formulas in use at the present time, in this country and

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[1] Technik der Milchprüfung, p. 98.

[2] Agricultural Science, vol. III, p. 139.

abroad, are those proposed by Fleischmann, Hehner and Richmond, and Babcock. Babcock's formula is the one generally taught in American dairy schools and is therefore given here; it forms the foundation of table VI for solids not fat in the *Appendix.*

By the use of these tables the percents of solids not fat may be found, corresponding to lactometer readings from 26 to 36, and to fat contents from 0 to 6 per cent. The formula, as amended in 1895,[1] is as follows, *S* being specific gravity and *f* the percent of fat in the milk:

$$\text{Solids not fat} = \left(\frac{100\ S - Sf}{100 - 1.0753\ Sf} - 1 \right) (100 - f)\ 2.5$$

The derivation of this formula is explained in the report referred to.

117. Short formulas. The tables made up from this formula, giving the percentages of solids not fat corresponding to certain per cents. of fat and lactometer readings, are given in the *Appendix.* A careful examination of the same discloses the fact that the per cent. of solids not fat increases uniformly at the rate of .25 per cent. for each lactometer degree, and .02 per cent. for each per cent. of fat. This relation is expressed by the following simple formulas:

$$\text{Solids not fat} = \tfrac{1}{4}\ L + .2\ f$$
$$\text{Total solids} = \tfrac{1}{4}\ L + 1.2\ f,$$

L being the lactometer reading at 60° F. (specific gravity $\times$ 1000 — 1000), and *f* the per cent. of fat in the milk.

Rule: a, *To find the per cent. of solids not fat in milk, add two-tenths of the per cent. of fat to one-fourth of the lactometer reading,* and

b, *To find total per cent. of solids in milk, add one and two-tenths times per cent. of fat to one-fourth of the lactometer reading.*

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[1] Wisconsin experiment station, twelfth report, p. 120.

These formulas and rules are easily remembered and can be quickly applied without the use of tables. The results obtained by using them do not differ more than .04 per cent. from those of the complete formula for milks containing up to 6 per cent. of fat, and may be safely relied upon in practical work.

Adulteration of Milk.

118. Methods of adulteration. The problem of determining whether or not a sample of milk is adulterated becomes an important one in the work of milk inspectors and dairy- and food chemists. Managers of creameries and cheese factories are also sometimes interested in ascertaining possible adulterations in case of some patron's milk, although at present, since the general introduction of the Babcock test in factories and the payment for the milk on the basis of the amount of butter fat delivered, the temptation to water or skim the milk has been largely removed. In the city milk trade, especially in our larger cities, watered or skimmed milk is still frequently met with, in spite of the vigilance of their milk inspectors or officers of the city boards of health.

When the origin of a suspected sample of milk is known, a second sample should always be taken on the premises by or in the presence of the inspector, and the composition of the two samples compared. If the suspected sample is considerably lower in fat content than the second, so-called *control-sample,* and has a normal per cent. of solids not fat, it is skimmed; if the solids not fat are below normal, it is watered; and if both these percentages are abnormally low, the sample is most likely both watered and skimmed (123).

119. Latitude of variation. In order to determine whether or not a sample of milk is skimmed or watered, or both skimmed and watered, the per cents of fat and of solids not fat in the sample must be ascertained, and if a control-sample can be secured, these determinations for both samples compared. The proper latitude to be allowed for the natural variation in the composition of milk differs according to the origin of the milk; in case of milk from single cows, the variations in fat content from day to day may exceed one per cent., although under ordinary conditions the per cent. of fat in most cows' milk will not vary that much. The content of solids not fat is more constant, and rarely varies one-half of one per cent. from day to day with single cows. Cows in heat or sick cows may give milk differing considerably in composition from normal milk.[1]

120. Mixed herd milk is of comparatively uniform composition on consecutive days, and as most milk offered for sale or delivered to factories is of this kind, the task of the milk inspector is made considerably easier and more certain on this account. Daily variations in herd milk beyond one per cent. of fat and one-half per cent. of solids not fat, are suspicious and may be taken as fairly conclusive evidence of adulteration. This is especially true in case the control-sample shows a comparatively low content of fat or solids not fat (155).

121. Legal standards. Where a control-sample cannot be taken, the legal standards of the various states for fat or solids in milk are used as a basis for calculating the

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[1] Blythe, Foods, their Composition and Analysis, London, 1882, p. 246 et seq.

extent of adulteration of a sample of milk. A list of legal standards for milk in this country and abroad is given in the *Appendix.* These standards determine the limits below which the milk offered for sale within the respective states must not fall. Legally it matters not whether a sample of milk offered for sale has been skimmed or watered by the dealer or by the cow; in the latter case, the cows producing the milk are of a breed or a strain that has been bred persistently for quantity of milk, without regard to its quality. In most states the legal standard for the fat content of milk is 3 per cent., and for solids not fat 9 per cent. There are, however, cows which normally produce milk containing only 2.5 to 2.8 per cent. of fat, and less than 8.5 per cent. solids not fat. Such milk cannot therefore be legally sold in most states in the Union, and the farmer offering such milk for sale, even if he does not know the composition of the milk produced by his cow, is as liable to prosecution as if he had directly watered the milk. By mixing the milk of several cows, the chances are that the mixed milk will contain more fat and solids not fat than called for by the legal standard; if such should not be the case, cows producing richer milk must be added to the herd so as to raise the quality of the herd milk up to the legal standard.

122. The specific gravity of the milk solids. A calculation of the specific gravity of the milk solids is of considerable assistance in interpreting the results of analyses of suspected milk samples. The milk solids vary but slightly in specific gravity, viz., between 1.25 and 1.34, the richer milks having solids of low specific gravities.

The specific gravity of the solids of milk is calculated by means of Fleischmann's formula

$$S=\frac{t}{t-\frac{100\,s-100}{s}}$$

S being the sp. gr. of the milk solids, *s* that of the milk, and *t* the total solids of the milk.

Example: A sample of milk has been found to contain 13 0 per cent. of solids, sp. gr. 1.032; then $\frac{100\times103.2-100}{1.032}=3.101$; 13.0 $-3.101=9.899$; $\frac{13.0}{9.899}=1.31=$ the specific gravity of the milk solids.

The specific gravity of the solids does not change if the milk is watered, while it is increased when the milk is skimmed. If a sample of milk of the composition given in the preceding example had been watered so as to reduce the solids to 11.7 per cent, and the specific gravity to 1.0291 (as would be the case when 10 per cent. of water was added), we would again have, by calculation as above, S=1.31. If, on the other hand, the milk was skimmed so as to reduce the solids to 11.7 per cent., thereby increasing the specific gravity of the milk to, say 1.035, we would have by substituting these values in the preceding formula, S=1.41, showing conclusively that the milk had been skimmed.

Addition of skim milk to whole milk would have the same effect as skimming, as regards the composition of the latter, and the specific gravity of its solids.

The specific gravity of pure butter fat at 60° F. is .93, and of the fat-free milk solids 1.5847 (Fleischmann). The solids of skim milk have a specific gravity of 1.56. Samples of whole milk, the solids of which have a specific gravity above 1.34 are suspicious, and a specific gravity over 1.40 is conclusive evidence of skimming.

To facilitate the calculation of the specific gravity of milk solids, table IV is given in the *Appendix*, showing at a glance the value of $\frac{100\,s-100}{s}$ for specific gravities between 1.019 and 1.0369. An example will readily illustrate the use of the table.

Example: A sample of milk has a specific gravity of 1.0343 and contains 12.25 per cent. solids. In table IV, we find in the horizontal line beginning with 1.034 under the column headed 0.0003, the figure 3.316, which is the value for $\frac{100\,s-100}{s}$ when $s=1.0343$. Introducing this value and that of the total solids in the formula, the calculation is $12.25-3.316=8.934$; $12.25 \div 8.934=1.37$. The specific gravity of the solids in this case therefore is **1.37.**

123. To recapitulate. Adulteration of milk by watering or skimming or both may be established by a comparison of the composition of the suspected sample with that of a control-sample, or if none such can be obtained, with the legal standards. If the components of the two samples vary appreciably, the milk has been adulterated, and the character of the adulteration is shown from the following statement:

If the analysis of the suspected sample shows		*the milk is*
sp. gr. of milk	low.	watered
fat and solids not fat	low.	watered
sp. gr. of solids	normal	watered
sp. gr. of milk and of solids	high	skimmed
solids not fat	high	skimmed
fat and solids	low	skimmed
sp. gr. of milk	normal	watered and skimmed
sp. gr. of solids,	normal or high	watered and skimmed
fat and solids not fat	low	watered and skimmed

The extent of the adulteration is determined as given below.

124. Calculation of extent of adulteration.[1] In the following formulas, per cents. found in the control-samples, if such are at hand, are always substituted for the legal standards.

a. *Skimming.*—1. If a sample of milk has been skimmed, the following formula will give the number of pounds of fat abstracted from 100 lbs. of milk:

Fat abstracted $= (x) =$ legal standard for fat—f, . (I)

f being the per cent. of fat in the suspected sample.

2. The following formula will give the per cent. of fat abstracted, calculated on the total quantity of fat originally found in the milk:

$$x = 100 - \frac{f \times 100}{\text{legal standard for fat}} \quad \ldots\ldots \quad \text{(II)}$$

b. *Watering.*—1. If a sample is watered, the calculations are most conveniently based on the percentage of solids not fat in the milk:

Per cent. of foreign (*extraneous*) water in adulterated

$$\text{milk} = 100 - \frac{S \times 100}{\text{legal standard for solids not fat}} \quad \ldots \quad \text{(III)}$$

S being the per cent. of solids not fat in the suspected sample.

Example: A sample of milk contains 7.5 per cent. solids not fat; if the legal standard for solids not fat is 9 per cent., $100 - \frac{7.5 \times 100}{9} = 16.7$, shows the per cent. of extraneous water in the milk.

2. Watering of milk may also be expressed in per cent. of water *added to the original milk*, by formula IV:

[1] Woll, Handbook for Farmers and Dairymen, New York, 1897, pp. 207-8.

Per cent. water added to original milk

$$=(x)=\frac{100 \times \text{leg. stand. for sol. not fat}}{S} - 100 \quad . \quad (IV)$$

In the example given above, $\frac{100 \times 9}{7.5} - 100 = 20$ per cent. of water was added to the original milk.

c. *Watering and skimming.*—If a sample has been both watered and skimmed, the extent of watering is ascertained by means of formula (III) or (IV), and the fat abstracted found according to the following formula:

Per cent. fat abstracted =

$$(x) = \text{leg. stand. for fat} - \frac{\text{leg. stand. for sol. not fat}}{S} \times f \quad . \quad (V)$$

Example: A sample of milk contains 2.4 per cent. of fat and 8.1 per cent. solids not fat; then

Extraneous water in milk $= 100 - \frac{8.1 \times 100}{9} = 10$ per cent.

Fat abstracted $= 3 - \frac{9 \times 2.4}{8.1} = .33$ per cent.

100 lbs. of the milk contained 10 lbs. of extraneous water and .33 lbs. of fat had been skimmed from it.

For methods of detection of other adulterations and of preservatives in dairy products, see Chapter X, 281 *et seq.*

CHAPTER VII.

TESTING THE ACIDITY OF MILK AND CREAM.

125. Cause of acidity in milk. Even directly after milk is drawn from the udder it will be found to have an acid reaction, when phenolphtalein is used as an indicator.[1] The acidity in fresh milk is not due to the presence of free organic acids in the milk, like lactic or citric acid, but to acid phosphates, and possibly also in part to free carbonic acid gas in the milk or to the acid reaction of casein. Even in case of so called sweet milk, nearly fresh from the cow, a certain amount of acidity, viz., on the average about .07 per cent., is therefore found. When the milk is received at the factory it will rarely test less than .10 per cent. of acid, calculated as lactic acid; some patrons bring milk day after day that does not test over .15 per cent. of acid; that of others tests from .20 to .25 per cent., and some lots, although very rarely, will test as high as .3 of one per cent. of acid. It has been found that milk will not usually smell or taste sour or "turned," until it contains .30 to .35 per cent. of acid.

126. The acidity in excess of that found normally in milk as drawn from the udder, is due to other causes than those described. Bacteriological examinations of milk from different sources and of the same milk at different times have shown that there is a direct relation

[1] Freshly drawn milk shows an *amphoteric* reaction to litmus, i. e., it colors blue litmus paper red, and red litmus paper faintly blue.

between the bacteria found in normal milk, and its acidity; the larger the number of bacteria per unit of milk, the higher the acidity of the milk. The increase in the acidity of milk on standing is caused by the breaking-down of milk sugar into lactic acid through the influence of acid-forming bacteria. Since the bacteria get into the milk through lack of cleanliness during the milking, or careless handling of the milk after the milking, this being kept under conditions that favor the multiplication of the bacteria contained therein, it follows that an acidity test of new milk will give a good clue to the care bestowed in handling the milk. Such a test will show which patrons take good care of their milk and which do not wash their cans clean or their hands and the udders of the cows before milking, and have dirty ways generally in milking and caring for the milk. The acidity test is always higher in summer than in winter, and is generally high in case of milk kept for more than a day (Monday milk), or delivered after a warm, sultry day or night. The bacteria have had a chance to multiply enormously in such milk, even if it be kept cooled down to 40°–50° F., and as a result considerable quantities of lactic acid have been formed. The determination of the acidity of fresh milk is explained in detail below (143).

127. Methods of testing acidity. Methods of measuring the acidity or alkalinity of liquids by means of certain chemicals giving characteristic color reactions in the presence of acid or alkaline solutions (so-called *volumetric* methods of analysis) have been in use for many years in chemical laboratories. They were applied to milk as early as 1872 by Soxhlet,[1] and the method worked out

[1] Jour. f. prakt. Chemie, 1872, p. 6, 19.

by Soxhlet and Henkel has since been in general use by European chemists. They measured out 50 cc. of milk to which was added 2 cc. of a 2 per cent. alcoholic solution of phenolphtalein, and this was titrated with a one-fourth normal soda solution[1] (see below). In this country, Dr. A. G. Manns in 1890 published the results of work done in the line of testing the acidity of milk and cream,[2] and the method of procedure and apparatus proposed by him has become known under the name of *Manns' test*, and has been advertised as such by dealers in dairy supplies.

128. Manns' test. The acid in milk or cream is measured by using an alkali solution of a certain strength, with an indicator which shows by a change of color in the milk when all its acid has been neutralized. Any of the alkalies, soda, potash, ammonia, lime or barium can be used for making the standard solution, but it requires the skill and apparatus of a chemist to prepare it of the proper strength. A one-tenth normal solution[3] of caustic soda is the alkali solution used most frequently in determining the acidity of milk, and is the solution labeled *Neutralizer* of the Manns' test.

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1 Fleischmann, Lehrb. d. Milchwirtschaft, p. 126.

2 Illinois experiment station, bulletin No. 9.

3 *Normal solutions*, as a general rule, are prepared so that one liter shall contain the hydrogen equivalent of the active reagent weighed in grams (Sutton). Caustic soda (Na. OH.) is made up of an atom each of sodium (Na), oxygen (O), and hydrogen (H); its molecular weight is therefore

$$\underset{Na}{23} + \underset{O}{16} + \underset{H}{1} = 40$$

A normal soda solution then is made by dissolving 40 grams of soda in water, making up the volume to 1000 cc.; a one-tenth normal solution will contain one-tenth of this amount of soda, or 4 grams dissolved in one liter. One cubic centimeter of the latter solution will contain .004 grams of soda, and will neutralize .009 grams of lactic acid. The formula for lactic acid is $C_3 H_6 O_3$ (see page 16), and its molecular weight therefore $3\times12+6\times1+3\times16 = 90$. A one-tenth normal solution of lactic acid contains 9 grams per liter, and .009 grams per cubic centimeter.

The indicator used is a solution of *phenolphtalein,* a yellowish light powder; its compounds with alkalies are red, in weak alkaline solutions pink colored, while its acid compounds are colorless. The phenolphtalein solution used is prepared by dissolving 10 grams in 300 cc. of 90 per cent. alcohol (Mohr).

129. In testing the acidity of either milk or cream it is necessary to measure out with exactness the quantity of liquid to be tested; Manns recommended using a 50 cc. pipette. This amount of milk or cream is measured into a clean tin, porcelain or glass cup, a few drops of the phenolphtalein solution are added, and the *Neutralizer* (or alkali solution) is cautiously dropped in from a burette, the point at which the solution stands before any is drawn out being noted. By constant stirring during this operation it will be noticed that the pink color formed by the addition of even a drop of alkali solution will at first entirely disappear, but as more and more of the acid in the sample becomes neutralized, the color will disappear more slowly, until finally a point is reached when the pink color remains permanent for a time. No more alkali should be added after the first appearance of a uniform pink color in the sample. This color will fade and gradually disappear again on standing, owing to the effect of the carbonic acid of the air, to which phenolphtalein is very sensitive. The amount of the alkali solution used for the test is then obtained from the reading on the scale of the burette. The per cent. of acid in the sample is calculated by multiplying the number of cc. of alkali solution used, by .009 and dividing the product by the number of cc. of the sample tested, the quotient being multiplied by 100.

$$\text{Per cent. acidity} = \frac{\text{c. c. alkali} \times .009}{\text{c. c. sample tested}} \times 100$$

If 50 cc. of cream required 32 cc. of alkali solution to produce a permanent pink color, the per cent. of acid in the cream would be $\frac{32 \times .009}{50} \times 100 = .58$ per cent. A part of this calculation may be saved by using a factor for multiplying the number of cc. of alkali added in each test. This factor is obtained by dividing .009 (the number of grams of lactic acid neutralized by one cc. of alkali solution) by the number of cc. of sample tested, and multiplying the quotient by 100. If a 50 cc. pipette is used for measuring the sample to be tested, the factor will be $(.009 \div 50) \times 100 = .018$; if a 25 cc. pipette is used, the factor will be $(.009 \div 25) \times 100 = .036$; and if a 20 cc. pipette is used, $(.009 \div 20) \times 100 = .045$ will be the factor to be applied in calculating the per cent. of acidity, the number of cc. of alkali used being in all cases multiplied by the particular factor corresponding to the volume of the sample tested.

130. If a Babcock milk-test pipette is taken for measuring the milk or cream to be tested for acidity, the factor will be $(.009 \div 17.6) \times 100 = .051$. This is so nearly .05 that sufficiently accurate results may be obtained by simply dividing the number of cc. used by two; the result will be the per cent. of acid in the sample tested, e. g., if 17.6 cc. of cream required 12 cc. of one-tenth normal alkali to give the pink color, then the per cent. of acid is $12 \div 2 = .6$ per cent.

131. Manns' testing outfit. The apparatus (see Fig. 40) and chemicals needed for testing the acidity of milk or cream by the so-called Manns' test include one gallon one-tenth normal alkali solution; four ounces of an alcoholic solution of phenolphtalein, one 50 cc. glass burette with stop-cock, one burette stand, and a pipette for measuring the sample. This outfit will make about 100 tests and is sold for $5.00.[1]

132. The Alkaline tablet test. Solid alkaline tablets were proposed by Farrington in 1894, as a substitute for the liquid used in Manns' test.[2] It is found possible to mix a solid alkali and coloring matter, and compress the mixture into a small tablet, which would contain an exact amount of alkali. The advantage of the tablets lies in the fact that they will keep far better than a standard alkali solution, and they can be easily and safely sent by mail; they also require less apparatus and are considerably cheaper than standard alkali solutions; 1,000 of these tablets, costing $2.00, will make about 400 tests.[3] Similar alkaline tablets were placed on the market in Europe at about the same time, viz., Stokes' *Acidity Pellets* in 1893, and Eichler's *Säurepillen* (acid-pills) in 1895.[4]

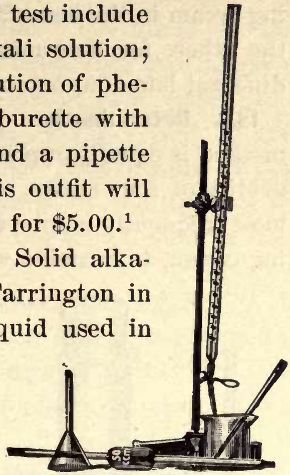

FIG. 40. Apparatus used in Manns' test.

Two methods of using the tablets have been proposed, one, for the titration (determination of acidity) of ripen-

1 *Devarda's acidimeter* (Milchzeitung, 1896, p. 785) is built on the same principle as Manns' test; one-tenth soda solution is added to 100 cc. of milk in a glass-stoppered graduated flask, 2 cc. of a 4 per cent. phenolphtalein solution being used as an indicator. The graduations on the neck of the flask give the "degrees acidity" directly.

2 Illinois experiment station, bulletin No. 32.

3 The tablets are sold by dealers in dairy supplies.

4 Milchzeitung, 1895, pp. 513-16.

ing cream in the manufacture of sour-cream butter; and the other, for determining the approximate acidity of different lots of apparently sweet milk or cream.

133. Determination of acidity in sour cream. The method is equally applicable for the determination of the acidity of sour cream, sour milk and butter-milk, but is most frequently employed in testing the acidity of ripening cream, to examine whether or not the ripening pro-

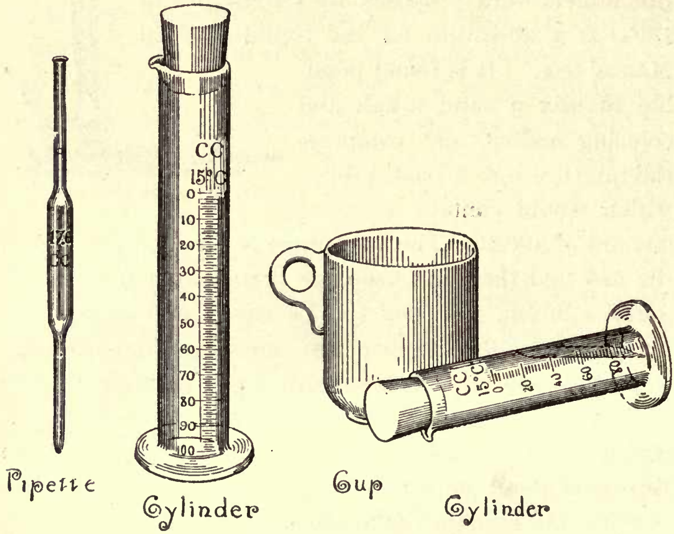

FIG. 41. Apparatus used for determining the acidity of cream or milk.

cess has reached the proper stage for churning the cream. The apparatus used (see Fig. 41) is as follows:

1 Babcock 17.6 cc. pipette.

1 white cup.

100 cc. graduated cylinders; it is well to provide two or three of these, although only one is strictly necessary.

134. Preparation of the solution. The tablet solution formerly used was prepared by dissolving five tablets in 50 cc. of water; with 20 cc. of cream each cubic centimeter of this solution represents .017 per cent. of acid (lactic acid) in the sample tested. The amount of acid in a given sample is then obtained by multiplying the number of cubic centimeters of the tablet solution used by .017.

135. According to a suggestion made by Mr. C. L. Fitch,[1] the strength of the solution has been changed in such a manner that the percentages of acidity are indicated directly by the number of cubic centimeter of tablet solution used in each test. The solution may be made up in two ways, viz., by use of a 20 cc. or a 17.6 cc. pipette.

a. **Use of 20 cc. pipette.** When a 20 cc. pipette is used for measuring the sample to be tested, the tablet solution is prepared by dissolving one tablet for every 17 cc. of water; for five tablets 85 cc. of water are therefore taken. When made in this way, each cubic centimeter of solution represents .01 per cent. of acid in the sample tested, 10 cc. being equal to .10 per cent. acid, 32 cc. to .32 per cent., 65 cc. to .65 per cent., etc.

b. **Use of 17.6 cc. pipette.** The 17.6 cc. Babcock milk test pipette may be used for measuring the sample for acidity testing, and the results read directly from the graduated cylinder, if the tablet solution is prepared by taking one tablet for every 19.5 cc. of water; five tablets are therefore dissolved in 97 cc. of water.

136. As cream during its ripening process under our conditions generally has from .5 to .6 per cent. of acid

[1] Hoard's Dairyman, Sept. 3, 1897.

before it is ready to churn, a 50 cc. cylinderful of tablet solution of this strength will not be sufficient to make a test of cream containing over .5 per cent of acid, although it is enough for testing the cream up to this point during the ripening process. The acid-testing outfit should therefore contain a 100 cc. graduated cylinder, instead of one of 50 cc. capacity, so that cream of any amount of acidity up to 1 per cent. can be tested. A tablet solution of the strength given has not only the advantage over the solution previously recommended (5 tablets to 50 cc. of water)[1] of showing the per cent. of acidity directly, without tables or calculations, but being weaker, the unavoidable errors of determination are decreased by its use.

Equally accurate results may be obtained by using solutions made up according to method *a* or method *b*, explained in the preceding. The latter method (17.6 cc. cream, 5 tablets per 97 cc. of water) has, however, the advantage in point of economy of apparatus, since a 17.6 cc. pipette is found in creameries and dairies with the Babcock test outfit and is therefore most likely already available for use in testing the acidity of cream. This method is therefore considered preferable and referred to as

137. The standard solution. The preparation of this solution is as follows: Five tablets are placed in the 100 cc. cylinder which is filled to the 97 cc. mark with clean soft water[2]. The cylinder is tightly corked, shaken

1 Illinois experiment station. bulletin No. 32; Wisconsin experiment station, bulletin No. 52.

2 Condensed steam or rain water should be used, and not hard water or alkali water, since the impurities in these affect the strength of the tablet solution.

and laid on its side, as the tablets will dissolve more quickly when the cylinder is placed in this position than when left upright with the tablets at the bottom. Several cylinders containing the tablet solution may be prepared at a time; as soon as one is emptied, tablets and water are again added, and the cylinder is corked and placed in a horizontal position. In this way fresh solutions ready for testing are always at hand. The cylinder is kept tightly corked while the tablets are dissolving, so that none of the liquid is lost by the shaking. It is well to put the tablets in the cylinder with water at night; the solution will then be ready for use in the morning. Excepting a flocculent residue of inert matter, "settlings," which will not dissolve, the tablets must all disappear in the solution before this is used. The strength of the tablet solution does not change perceptibly by standing for twenty-four hours; but a change takes place in solutions older than this. The solid tablets will not change if kept dry any more than dry salt changes by age. The only precaution necessary is to use a fresh solution when acidity tests are made.

138. Accuracy of the tablets. The tablets have been repeatedly tested by competent persons and found to be accurate and very uniform in composition. Tests made with the tablets according to the directions here given can be relied on as correct. The alkali solution is very sensitive however and should not be measured in a cylinder which has been previously used for measuring sulfuric acid as the smallest drop or film of acid from a dish or from the operator's fingers will change the standard strength of the tablet solution. The tablets must be completely dissolved before the standard solution is used and the solution must be made with clean water.

139. Making the test. The cream to be tested is thoroughly mixed, and 17.6 cc. is measured into the cup. The pipette is rinsed once with water, and the rinsings added to the cream in the cup. A few cc. of the tablet solution prepared as given above are now poured from the cylinder into the cream and mixed thoroughly with it by giving the cup a gentle rotary motion. The tablet solution is added in small quantities until a permanent pink color appears in the sample. The number of cc. of tablet solution which have been used to color the cream is now read off on the scale of the cylinder.

In comparing the results of one test with another, the same shade of color should always be adopted. The most delicate point is the first change from pure white or light yellow to a uniform pink color which the sample shows when the acid contained therein has just been neutralized. This shade of color is easily recognized with a little practice. The pink color is not permanent unless a large excess of the alkaline solution has been added, on account of the influence of the carbonic acid of the air (129), and the operator should not therefore be led to believe by the reappearance of the white color after a time, that the point of neutralization was not already reached when the first uniform shade of pink was observed.

140. Acidity of cream. 17.6 cc. of sweet cream is generally neutralized by 15–20 cc. of this tablet solution, representing from .15 to .20 per cent. of acid. A mildly sour cream is colored by 35 cc. tablet solution, and a sour cream ready for churning by about 50 60 cc. tablet solution. As the cream ripens, its acidity increases. The rate of ripening depends largely on the temperature at which the cream is kept. Cream containing .5 to .6 per cent. of acid will make such butter as our American market demands at the present time. Cream showing an acid test of .55 per cent. may not be too sour, but .65 per cent. of acid is very near, if not on the danger line, since such cream is likely to make strong flavored, almost rancid butter. Each lot of cream should be tested as soon as it is ready for ripening, and the result of the test will show whether the cream should be warmed or cooled in order to have it ready for churning at the time desired. Later tests will show the rate at which the ripening is progressing, and the time when the cream has reached the proper acidity for churning.

141. The influence of the richness of cream on the acid test has been studied by Professor Spillman,[1] and others.[2] Since the acidity develops in the cream serum, it follows that an acidity of, say .5 per cent. in a 40 per cent.-cream represents a larger acidity than in 20 per cent.-cream, e. g. In the former case we have .5 grams of acid in 60 grams of serum (=.83 per cent. of the serum); in the latter case .5 grams acid is found in 80 grams serum (=.63 per cent. of the serum). Therefore, rich cream need not be ripened to as high a degree of acidity as thin cream. A table is given in the bulletin referred to, showing the relation between the richness and the acidity of cream.

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1 Washington experiment station, bulletin No. 32.

2 Chicago Dairy Produce, April 21, 1900, p. 30, Bull. 52, Iowa Expt. Sta.

142. Spillman's cylinder. The graduated cylinder shown in Fig. 42 was devised by Professor Spillman for use in testing the acidity of milk and cream with Farrington's alkaline tablets. The following directions are given for making tests with this piece of apparatus:[1]

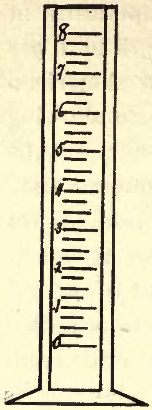

FIG. 42. Spillman's cylinder, used in determining the acidity of cream or milk.

"All that is needed in addition to the acid test graduate shown in the accompanying illustration, is a common prescription bottle of six or eight ounce capacity, and a package of Farrington's alkaline tablets. Fill the bottle with water and add one tablet for each ounce of water in the bottle. Shake the bottle frequently to aid in dissolving the tablets.

"*Making the test.* In making the test, the acid-test graduate is filled to the zero mark with the milk or cream to be tested. The tablet solution is then added, a little at a time, and the graduate shaken after each addition, in order to thoroughly mix the milk and the tablet solution. In shaking the graduate, give it a rotary motion to prevent spilling any of the liquid. Continue adding the tablet solution until a permanent pink color can be detected in the milk. The level of the liquid in the graduate, measured by the scale on the graduate, will then be the per cent. of the acidity of the milk. It is best to stand the graduate on a piece of white paper, so that the first pink coloration of the milk may be easily detected."

143. Rapid estimation of the acidity of apparently sweet milk or cream. a, **Milk.** The alkaline tablet method offers a ready means of estimating the acidity of milk or cream that is still apparently sweet. The selection of the best kinds of milk is especially important in pasteurizing milk or cream. Investigations have shown that milk which gives the highest acid test contains, as a rule, a larger

[1] Washington experiment station, bulletin No. 24.

number of bacteria and spores not destroyed by pasteurization than does milk giving a low acid test (126); the acidity test may therefore be used to advantage for the purpose of selecting milk best adapted for pasteurization, as well as such as is to be retailed or used in the manufacture of high-grade butter and cheese.

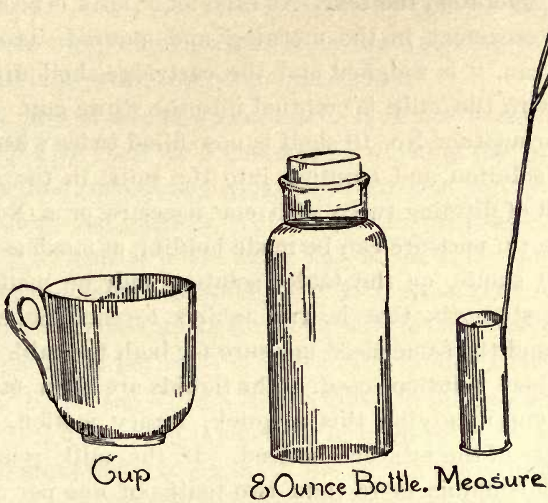

FIG. 43. Apparatus used for rapid estimation of the acidity of apparently sweet milk or cream.

In distinguishing milk fit for pasteurization purposes from that which is doubtful, an arbitrary standard of two-tenths of one per cent. of acid may be taken as the upper limit for milk of the former kind. The apparatus used in making this test is shown in the accompanying illustration (Fig. 43), and consists of a white teacup; a four-, six-, or eight-ounce bottle, and a No. 10 brass cartridge shell, or a similar measure. A solution of the tablets in water is first prepared, one tablet being always added for each ounce of water: four tablets in a four-ounce bottle; six, in a six-ounce bottle, etc., the amount of tablet solution prepared depending on the number of tests to be made at a time. The bottle is filled up to its neck with clean soft water, and the solution prepared in the manner previously given (137).

144. Operating the test. As each lot of milk is brought to the creamery in the morning and poured into the weigh can, it is weighed and the cartridge-shell dipper filled with the milk is emptied into the white cup. The same or another No. 10 shell is now filled twice with the tablet solution and emptied into the milk in the cup. Instead of dipping twice with one measure or a No. 10 shell, a tin measure can be made holding as much as two No. 10 shells, or the tablet solution may be made of double strength, that is, two tablets to each ounce of water and the same sized measure for both the milk and the tablet solution used. The liquids are then mixed in the cup by giving this a quick, rotary motion, and the color of the mixture noticed. If the milk remains white it contains more than two-tenths of one per cent. of acid and should not be used for pasteurization. If it is colored after having been thoroughly mixed with two measures of tablet solution, it contains less than this amount of acid and may, as far as acidity goes, be safely used, for pasteurization or for any other purpose which requires thoroughly sweet milk. The shade of color obtained will vary with different lots of milk; the sweetest milk will be most highly colored, but a milk retaining even a faint pink color with two measures of tablet solution or one measure of the double strength solution to one measure of milk contains less than .2 per cent. of acid.

By proceeding in the manner described, the man receiving and inspecting the milk at the factory weigh-can is able to test the acidity of the milk delivered nearly as quickly as he can weigh it; and according to the results of the test he can send the milk to the general delivery vat or to the pasteurization vat, as the weighing-can may be provided with two conductor spouts.

145. Size of measure necessary. It is not necessary to use a No. 10 shell for a measure in working the preceding method; one of any convenient size that can be filled accurately and quickly, will answer the purpose equally well, if a measure of the same size is used for both the sample and the tablet solution. Each measureful of tablet solution made up as directed, will in this case represent one-tenth per cent. of acid in the sample tested.

146. b, **Cream.** Cream can be tested in the way already described for testing the acidity of fresh milk, by adding to one measureful of cream in the cup as many measures of tablet solution as are necessary to change the color of the cream when the two liquids are thoroughly mixed. If one measure of tablet solution colors one measure of cream, this contains less than .1 per cent. acid; if five measures of tablet solution are required, the cream contains about .5 per cent. acid, etc. By proceeding in the manner described, the operator can estimate the acidity to within .05 per cent. of acid, if half measures of tablet solution are added. The results thus obtained are sufficiently delicate for all practical purposes.

147. Detecting boracic-acid preservatives in milk. The application of the alkaline tablet test for detecting boracic acid in milk was first discussed in bulletin No. 52 of Wisconsin experiment station. The acidity of the milk is increased by the addition of boracic acid, but neither the odor nor the taste of the milk is affected thereby. By adding to sweet milk the amount of boracic acid which will keep it sweet for 36 hours, its acidity may be increased to .35 per cent., in a sample of milk which previously tested perhaps only .15 per cent. acid.

As before stated, unadulterated milk will usually smell or taste sour or "turned," when it contains .30–.35 per cent. acid (118); milk testing as high as this limit, which neither smells nor tastes sour in any way, is therefore in all probability adulterated with some preparation containing boracic acid or a similar compound.

148. "Alkaline tabs." These are not alkaline tablets, but a substitute which was put on the market by a New York firm. The outfit furnished consisted of four packages of paper discs made of filter paper, each of about the size of an old-style copper cent; two packages of square paper; one glass of about 10 cc. capacity, and one small glass bottle. An investigation of the reliability of these "Tabs" soon disclosed the fact that they were entirely inaccurate, and that no dependence could therefore be put on the results obtained by their use.

CHAPTER VIII.

TESTING THE PURITY OF MILK.

149. The Wisconsin curd test. Cheese makers are often troubled with so-called floating or gassy curds which produce cheese defective in flavor and texture. These faults are usually caused by some particular lot of milk containing impurities that cannot be detected by ordinary means of inspection. The Wisconsin curd test is used to detect the source of these defects and thus enable the cheese maker to exclude the milk from the particular farm or cow to which the trouble is traced. This test is similar in principle to tests that have for many years past been in use in cheese-making districts in Europe, notably in Switzerland,[1] but was worked out independently at the Wisconsin Dairy School in 1895 and has become generally known as the "Wisconsin Curd Test" from the description of it in the report of the Wisconsin experiment station for 1895.[2]

The apparatus used for the test was greatly improved in 1898, and a description of the improved test is given in bulletin No. 67 and the annual report of this station for 1898,[3] from which source the accompanying illustrations are taken (see Figs. 45 and 46).

150. Method of making the test. Pint glass jars, thoroughly cleaned and sterilized with live steam, are pro-

1 Herz, Unters. d. Kuhmilch, Berlin, 1889, p. 87; Siats, Unters. landw. wicht. Stoffe, 1897, pp. 129-131.

2 Twelfth report, p. 148.

3 Fifteenth report, pp. 47-53.

vided; they are plainly numbered or tagged, one jar being provided for each lot of milk to be tested. The jars are filled about two-thirds full with the milk from the various sources; it is not necessary to take any exact quantity; they are then placed in a water tank, the water of which is heated until the milk in the jars has a tem-

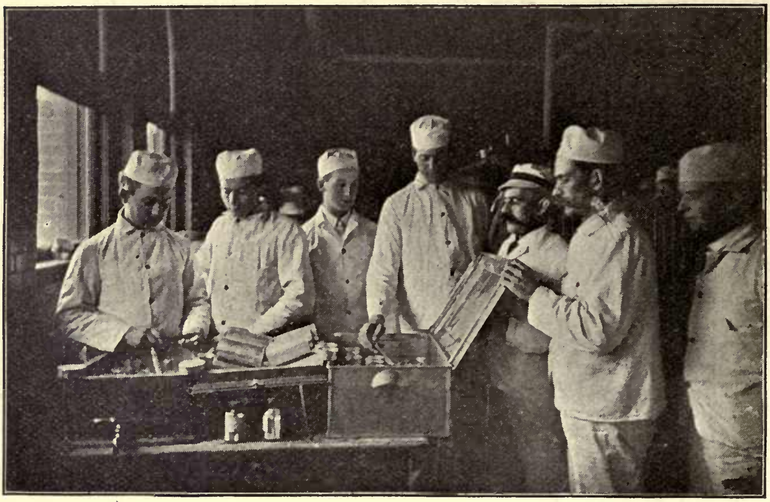

FIG. 44. Students operating the Wisconsin curd test

perature of 98° F. The thermometer used must not be transferred from one sample to another, unless special precautions are taken, for fear of contaminating the pure lots of milk by impure ones.

When the milk has reached a temperature of 98°, add to each sample ten drops of rennet extract, and mix by giving the jar a rotary motion. The milk is thus curdled, and the curd allowed to stand for about twenty minutes until it is firm. It is then cut fine with a case knife, and after settling, the whey is poured off. The best tests are made when the separation of the whey is most complete. By allowing the samples to stand for a

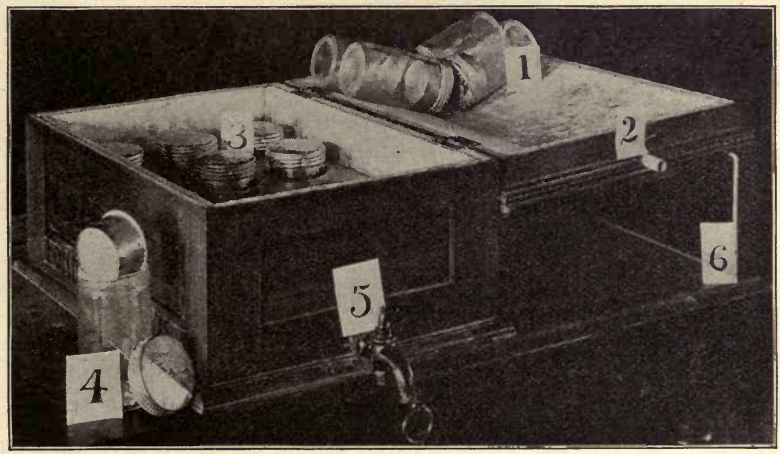

FIG 45. The Wisconsin curd test. 1, Test jars draining; 2, whey outlet; 3, test jars in water tank; 4, test jars in parts; 5, stop cock for water; 6, stand to support cover.

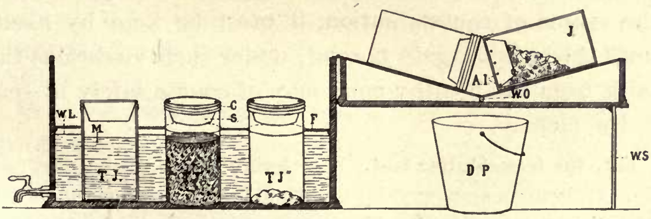

FIG. 46. Cross-section of the Wisconsin curd test. T J-TJ″, testing jars showing different stages of test; WL, water line; M, milk; F, frame; WS, stand to support cover; AI, drain holes; WO, water outlet; DP, drain pail.

short time, more whey can be poured off, and the curd thereby rendered firmer. The water around the jars is kept at a temperature of 98°, the vat is covered, and the curds allowed to ferment in the sample jars for six to twelve hours.

During this time the impurities in any particular sample will cause gases to be developed in the curds so that by examining these, by smelling of them and cutting them with a sharp knife, those having a bad flavor or a spongy or in any way abnormal texture may be easily detected, and the milk from which it was made, thereby picked out.

151. By proceeding in the same way with the milk from the different cows in a herd, the mixed milk of which produced abnormal curds, the source of contamination in the herd may be located. Very often the trouble will be found to come from the cows' drinking foul stagnant water or from fermenting matter in the stable. In the former case the pond or marsh must be fenced off, or the cows kept away from it in other ways; in the latter, a thorough cleaning and disinfection of the premises are required. If the milk of a single cow is the source of contamination, it must be kept by itself, until the milk is again normal; under such conditions the milk from the healthy cows may of course safely be sent to the factory.

152. The fermentation test. The Gerber fermentation test (see fig. 47) furnishes a convenient method for examining the purity of different lots of milk. The test consists of a tin tank which can be heated by means of a small lamp, and into which a rack fits, holding a certain number of cylindrical glass tubes; these are all numbered and provided with a mark and a tin cover. In making the test, the tubes are filled to the mark with milk, the number of each tube being recorded in a note-book, opposite the name of the particular patron whose milk was placed therein. The tubes in the rack are put in the tank, which is two-thirds full of water; the temperature of the water is kept at 104–106° F. for six hours, when the rack is taken out, the tubes gently shaken, and the appearance of the milk, its odor, taste, etc., carefully noted in each case.

The tubes are then again heated in the tank at the same temperature as before, for another six hours, when observations of the appearance of the milk in each tube are once more taken. The tainted milk may then easily be discovered by the abnormal coagulation of the sample. According to Gerber,[1] good and properly handled milk should not coagulate in less than twelve hours, when kept under the conditions described, nor show anything abnormal when coagulated. Milk from sick cows and from cows in heat, or with diseased udders, will always coagulate in less than twelve hours. If the milk does not curdle inside of a day or two, it should be tested for preservatives (290).

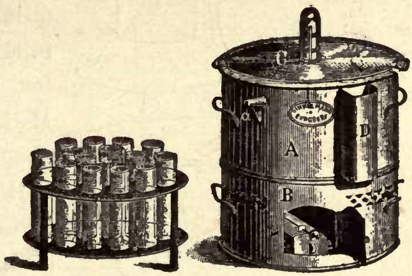

FIG. 47. The Gerber fermentation test.

153. The Monrad Rennet test is used by cheese makers for determining the ripeness of milk. Fig. 48 shows the apparatus used in the test. 5 cc. of rennet extract is measured by means of a pipette into a 50 cc. flask; the

[1] Die praktische Milchprüfung, p. 85.

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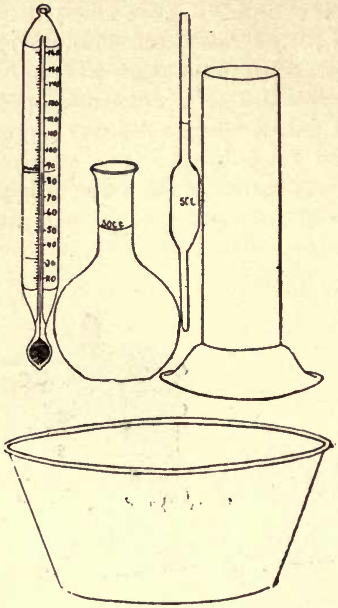

FIG. 48. The Monrad rennet test.

pipette is rinsed with water and the flask filled to the mark with water. 160 cc. of milk is now measured into the tin basin from the cylinder and slowly heated to exactly 86° F. 5 cc. of the diluted rennet solution is then quickly added to the warm milk and the time required for coagulation noted.[1] Milk sufficiently ripe for cheddar cheese making will coagulate in 30–60 seconds, according to the strength of the rennet extract used.

154. The Marshall Rennet test is used for the same purpose as the Monrad test. The time required for coagulating the milk is shown directly by a scale given on the apparatus.

[1] Decker, Cheese Making, 1900, p. 36.

CHAPTER IX.

TESTING MILK ON THE FARM.

155. Variations in milk of single cows. The variations in the tests of milk of single cows from milking to milking or from day to day, are greater than many cow-owners suspect. There seems to be no uniformity in this variation, except that the quality of the milk produced generally improves with the progress of the period of lactation; even this may not be noticeable, however, except when the averages of a number of tests made at different stages during the lactation period are compared with each other. When a cow gives her maximum quantity of milk, shortly after calving, the quality of her milk is generally poorer (by one per cent. of fat, or less) than when she is drying off. Strippers' milk is therefore as a rule richer in fat than the milk of fresh cows.

156. By testing separately every milking of a number of cows through their whole period of lactation, the results obtained have seemed to warrant the following conclusions in regard to the variations in the test of the milk from single cows, and it is believed that these conclusions allow of generalization.[1]

1. Some cows yield milk that tests about the same at every milking, and generally give a uniform quantity of milk from day to day.

2. Other cows give milk that varies in an unexplainable way from one milking to another. Neither the

[1] Illinois experiment station, bulletin No. 24.

morning nor the evening milking is always the richer, and even if the interval between the two milkings is exactly the same, the quality as well as the quantity of milk produced will vary considerably. Such cows are mostly of a nervous, excitable temperament, and are easily affected by changes in feed, drink, or surrounding conditions.

3. The milk of a sick cow, or of a cow in heat, as a rule, tests higher than when the cow is in a normal condition; the milk yield generally decreases under such conditions; marked exceptions to this rule have, however, been observed.

4. Half-starved or underfed cows may give a small yield of milk testing higher than when the cows are properly nourished, probably on account of an accompanying feverish condition of the animal. The milk is, however, more generally of an abnormally low fat content, which may be readily increased to the normal per cent. of fat by liberal feeding.

5. Fat is the most variable constituent of milk, while the solids not fat vary within comparatively narrow limits. The summary of the analyses of more than 2400 American samples of milk calculated by Cooke[1] shows that while the fat content varies from 3.07 to 6.00 per cent., that of casein and albumen varies only from 2.92 to 4.30 per cent., or less than one and one-half per cent., and the milk sugar and ash content increases but little (about .69 per cent.) within the range given.

6. A test of only one milking may give a very erroneous impression of the average quality of a certain

[1] Vermont experiment station, report f. 1890, p. 97.

cow's milk. A composite sample (see 175) taken from four or more successive milkings will more nearly represent the quality of the milk which a cow produces at the time of sampling.

157. The variations that may occur in testing the milk of single cows, are illustrated by the following figures obtained in an experiment made at the Illinois experiment station,[1] in which the milk of each of six cows was weighed and analyzed daily during the whole period of lactation. Among the cows were pure-bred Jerseys, Shorthorns and Holsteins, the cows being from three to eight years of age and varying in weight from 850 to 1350 lbs. During a period of two months of the year, the cows were fed a heavy grain ration consisting of 12 lbs. of corn and cob meal, six lbs. of wheat bran, and six lbs of linseed meal, per day per head. This system of feeding was tried for the purpose of increasing, if possible, the richness of the milk. The influence of this heavy grain feed, as well as that of the first pasture grass feed, on the quality and the quantity of the milk produced is shown in the following table, which gives the complete average data for one of the cows (No. 3). The records of the other cows are given in the publication referred to; they were similar to the one here given in so far as variations in quality are concerned.

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[1] Bulletin No. 24.

Average results obtained in weighing and testing a cow's milk daily during one period of lactation.

MONTH.	Live weight, lbs.	Daily milk yield.			Tests of one day's milk.			Yield of fat per day.		
		Average lbs.	Highest lbs.	Lowest lbs.	Average per ct.	Highest per ct.	Lowest per ct.	Average lbs.	Highest lbs.	Lowest lbs.
December.....	920	12.1	16.0	10.0	3.8	4.9	3.0	.46	.60	.34
January........	927	16.0	17.7	14.0	3.7	4.6	2.7	.59	.76	.44
February......	1035	16.1	17.7	13.5	3.6	5.8	3.2	.58	.84	.51
March	1017	14.3	16.0	12.5	3.8	4.7	3.4	.54	.61	.50
April	1054	13.8	16 5	11.5	4.0	5.8	3.0	.55	.72	.46
May	1079	14.5	17.2	10.0	3.8	4.6	3.4	.55	.70	.44
June..............	1105	12.1	14.0	9.2	3.9	4.6	3.2	.47	.57	.35
July	1180	9.3	12.2	6.0	4.2	6.2	2.8	.39	.60	.27
August..........	1130	6.4	9.3	3.5	4.7	7.9	2.9	.30	.50	.16

158. The average test of this cow's milk for her whole period of lactation was 3.8 per cent. of fat (i. e., the total quantity of fat produced ÷ total milk yield × 100); twice during this time the milk of the cow tested as high as 5.8 per cent., and once as low as 2.7 per cent., while tests of 3.0 and 4.6 per cent. were obtained a number of times. The average weight of milk produced per day by the cow was 14 lbs.; this multiplied by her average test, 3.8, shows that she produced on the average .53 lbs., or about one-half of a pound, of butter fat per day during her lactation period. If, however, her butter-producing capacity had been judged by the test of her milk for one day only, this test might have been made either on the day when her milk tested 5.8 per cent., or when it was as low as 2.7 per cent. Both of these tests were made in mid-winter when the cow gave about 16 lbs. of milk a day. Multiplying this quantity by .058 gives .93 lbs. of fat, and by .027 gives .43 lbs. of fat. Either result might show the butter fat produced by the cow on certain days, but neither gives a correct record of her actual average daily performance for this lactation period.

A sufficient number and variety of tests of the milk of many cows have been made to prove that there is no definite regularity in the daily variations in the richness of the milk of single cows. The only change in the quality of milk common to all cows is, as stated, the natural increase in fat content as the cows are drying off, and even in this case the improvement in the quality of the milk sometimes does not occur until the milk yield has dwindled down very materially.

159. Causes of variations in fat content. The quality of a cow's milk is as a rule decidedly influenced by the following conditions:

Length of interval between milkings.
Change of feed.
Change of milkers.
Rapidity of milking.
Rough treatment.
Exposure to rain or bad weather.
Unusual excitement or sickness.

160. Disturbances like those enumerated frequently increase the richness of the milk for one, and sometimes for several milkings, but a decrease in quality follows during the reaction or the gradual return to normal conditions, and taken as a whole there is a considerable falling off in the total production of milk and butter fat by the cow, on account of the nervous excitement which she has gone through. Aside from changes due to well-definable causes like those given above, the quality of some cows' milk will often change very considerably without any apparent cause. The dairyman who is in the habit of making tests of the milk of his individual cows at regular intervals will have abundant material for study in the results obtained, and he will soon be able to tell from the tests made, if these are continued for several days, whether or not the cows are in a normal healthy condition or have been subjected to excitement or abuse in any way.

161. Number of tests required during a period of lactation in testing cows. The daily records of the six cows referred to on page 133 give data for comparing their total production of milk and butter fat during one period of lactation, as found from the daily weights and tests of their milk, with the total amount calculated from weights and tests made at intervals of 7, 10, 15 or 30 days. The averages of all results obtained with each of the six cows show that weighing and testing the milk of a cow every seventh day gave 98 per cent. of the total milk and butter fat, which according to her daily record was the total product. Tests made once in two weeks gave 97.6 per cent. of the total milk, and 98.5 per cent. of the total butter fat, and tests made once a month, or only ten times during the period of lactation, gave 96.4 per cent. of the total milk, and 97 per cent. of the total production of butter fat.

162. The record of one of the cows will show how these calculations are made: It was found from the daily weights and tests that cow No. 1, in one lactation period of 307 days, gave 5,044 lbs. of milk which contained 254 lbs. of butter fat. Selecting every thirtieth day of her record as testing day, the total production of milk and fat is shown to be as follows:

Production of milk and butter fat per day.

Testing day.	Weight of milk.	Test of milk.	Yield of butter fat.
	lbs.	per cent.	lbs.
Nov. 4	20.5	4.7	.96
Dec. 4	18.7	4.6	.86
Jan. 3	17.7	4.9	.86
Feb. 2	20.0	4.5	.90
Mar. 3	18.2	4.7	.86
April 2	19.5	4.4	.81
May 2	17.7	4.8	.85
June 1	13.1	5.5	.72
July 1	12.2	6.2	.76
July 31	3.2	7.2	.23
Total	160.8 lbs.	....	7.81 lbs.
Average per day.	16.08 lbs.	4.85	.78 lbs.

The average daily production of the cow, according to the figures given in the preceding table, was nearly 16 lbs. of milk, containing .78 lbs. of butter fat. Multiplying these figures by 307, the number of days during which the cow was milked, gives 4,903 lbs. of milk and 240 lbs. of fat. This is 141 lbs. of milk and 14 lbs. of fat less than the total weights of milk and butter fat, as found by the daily weights and tests, or 2.8 and 5.5 per cent. less, for milk- and fat production, respectively. This is, however, calculated from only ten single weights and tests, while it required over 600 weighings and 300 tests of the milk to obtain the exact amount.

Similar calculations from the records of the other cows gave fully as close results, showing that quite satisfactory data as to the total production of milk and butter of a cow may be obtained by making correct weighings and tests of her full day's milk once every thirty days.

163. When to test a cow.[1] The Vermont experiment station for several years made a special study of the question when a cow should be tested in order to give a correct idea of the whole year's performance, when only one or two tests are to be made during the lactation period.[2] The results obtained may be briefly summarized as follows:

a. *As to quality of milk produced.* If two tests of each cow's milk are to be made during the same lactation period, it is recommended to take composite samples at the intervals given below:

	First sample.	*Second sample.*
For spring cows,	6 weeks after calving.	6½–7½ mos. after calving.
For summer "	8 " " "	6 –7 " " "
For fall "	8–10 " " "	5½–7 " " "

If only one test is to be made, approximately correct results may be obtained by testing the milk during the sixth month from calving, in case of spring cows; during the third to fifth month in case of summer-calving cows, and during the fifth to seventh month for fall-calving cows.

In all cases composite samples of the milk for at least four days should be taken (165). "The test of a single sample, drawn from a single milking or day, will not of necessity, or indeed usually, give trustworthy results."

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1 H. B. Gurler in *American Dairying*, p. 18, suggests that three months after calving a cow's milk may be weighed for a week and a composite sample tested. The average weight of butter fat produced per day is calculated and this average figure multiplied by 252 or the number of days in 8.4 months. It is assumed that a cow gives milk more than 8.4 months and the quantity produced beyond this time will bring the production during the last 2.4 months up to the same average per month as in the first six months.

2 Sixth report, 1882, p. 106; Ninth report, 1895, p. 176.

b. *As to quantity of milk produced.* The milk may be weighed for four days in the middle of the month, and the entire month's yield obtained with considerable accuracy (barring sickness and drying off), by multiplying the sum by 7, $7\frac{1}{2}$ or $7\frac{3}{4}$, according to the number of days in the different months. The weighing is most readily done by means of a spring balance, the hand of which is set back so that the empty pail brings it to zero (Fig. 49.) If several pails are to be used, they should first be made to weigh the same by putting a little solder on the lighter pails. Milk scales which weigh and automatically register the yield of milk from twenty cows have been placed on the market, but no perfectly satisfactory devise of this kind has yet been brought out, so far as is known to the authors.

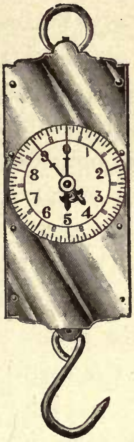

FIG. 49. Milk scale.

164. Sampling milk of single cows. In sampling the milk of single cows, all the milk obtained at the milking must be carefully mixed, by pouring it from one vessel to another a few times, or stirring it thoroughly by means of a dipper moved up and down, as well as horizontally, in the pail or can in which it is held; the sample for testing purposes is then taken at once. A correct sample of a cow's milk cannot be obtained by milking directly into a small bottle from one teat, or by filling the bottle with a little milk from each teat, or by taking some of the first, middle and last milk drawn from the udder. Such samples cannot possibly represent the quality of the milk of one entire milking, since there is as much difference between the first and the last portions of a milking, as between milk and cream.[1] Lack of care in taking a fair sample is the cause of many surprising results obtained in testing milk of single cows.

165. When a cow is to be tested, she should be milked dry the last milking previous to the day when the test is to be made. The entire quantity of milk obtained at each milking is mixed and sampled separately. On account of the variations in the composition of the milk, a number of tests of successive milkings must be made. As this involves considerable labor, the plan of taking composite samples is preferable; the method of composite sampling and testing is explained in detail under the second subdivision of Chapter X (176); suffice it here to say that the method followed in case of single cows' or herd milk is to take about an ounce of the thoroughly mixed milk of each milking; this is placed in a pint or quart fruit jar containing a small quantity of some preservative, preferably about one-half a gram (8 grains) of powdered potassium bi-chromate. If a number of composite samples of the milk of single cows are taken, each jar should be labeled with the number or name of the particular cow. Composite tests are generally taken for four days or for a week. If continued for a week, the jars will contain at the end of this time a mixture of the milk of fourteen milkings. The composite sample is then carefully mixed by pouring it gently a few times from one jar to another, and is tested in the ordinary

[1] Woll, Handbook for Farmers and Dairymen, p. 194; Agricultural Science, 6, pp. 540–42.

manner. The result of this test shows the average quality of the milk produced by the cow during the time the milk was sampled.

166. As the amounts as well as the quality of the milk produced by single cows vary somewhat from day to day and from milking to milking, it is desirable in testing single cows, especially when the test includes only a few days, to take a proportionate part (an aliquot) of each milking for the composite test sample. This is easily done by means of a Scovell sampling tube, the use of which is explained in another place (180), or by a 25 cc. pipette divided into $\frac{1}{10}$ cc.; in using the latter apparatus as many cubic centimeters and tenths of a cubic centimeter of milk are conveniently taken each time for the composite sample as the weight of milk in pounds and tenths of a pound produced by the cow.

The opinion is often expressed that a considerable error is introduced by measuring out milk warm from the cow for the Babcock test, since milk expands on being warmed, and a too small quantity in this manner is obtained. By calculation of the expansion of milk between different temperatures it is found that 1 cc. of milk at 17.5° C. (room temperature) will have a volume of 1.006289 cc. at 37° C. (blood-heat), i. e., an error of less than .03 per cent. is introduced by measuring out milk at the latter temperature. While the temperature has therefore practically no importance, the air incorporated in the milk during the milking process will introduce an appreciable error in the testing, and samples of milk should therefore be left for an hour or more after milking before the test samples are taken. By this time the specific gravity of the samples can also be correctly taken (113).

167. Size of the testing sample. Four ounces is a sufficient quantity for a sample of milk if it is desired to determine its per cent. of fat only; if the milk is to be tested with a lactometer, when adulteration is suspected, as much as a pint is needed for a sample. If this sample of milk is put into a bottle and carried or sent away from the farm to be tested, the bottle should be filled with milk clear up to the cork to prevent a partial churning of butter in the sample during transportation (30).

168. Variations in herd milk. While considerable variations in the quality of milk of single cows are often met with, a mixture of the milk of several cows, or of a whole herd is comparatively uniform from day to day; the individual differences tend to balance each other so that variations, when they do occur, are less marked than in case of milk of single cows. There are, however, at times marked variations also in the test of herd milk on successive days; the following figures from the dairy tests conducted at the World's Columbian Exposition in Chicago in 1893 illustrate the correctness of this statement. The test included twenty-five Jersey and Guernsey cows each and twenty-four Shorthorn cows.

Tests of herd milk on successive days.

DATE.	Jersey.	Guernsey.	Shorthorn.
July 16, 1893..........	4.8 per cent.	4.6 per cent.	3.8 per cent.
July 17, 1893..........	5.0 "	4.5 "	3.8 "
July 18, 1893..........	4.7 "	4.4 "	3.8 "
July 19, 1893..........	4.6 "	4.6 "	3.7 "
July 20, 1893..........	5.0 "	4.5 "	3.8 "

On July 17, 1893, the mixed milk of the Jersey cows tested two-tenths of one per cent. higher than on the preceding day; the Guernsey herd milk tested one-tenth of one per cent. lower, while the Shorthorn milk did not change in composition; comparing the tests on July 19 and 20, we find that the Jersey and Shorthorn milk tested four-tenths and one-tenth of one per cent. higher, respectively, on the latter day than on the former, and the Guernsey milk tested one-tenth of one per cent. lower.

169. Ranges in variations of herd milk. According to Fleischmann,[1] the composition of herd milk may on single days vary from the average values for the year expressed in per cent. of the latter, as follows:

The specific gravity (expressed in degrees) may go above or below the yearly average by more than 10 per cent.

The per cent. of fat may go above or below the yearly average by more than 30 per cent.

The per cent. of total solids may go above or below the yearly average by more than 14 per cent.

The per cent. of solids not fat may go above or below the yearly average by more than 10 per cent.

To illustrate, if the average test of a herd during a whole period of lactation is 4.0 per cent., the test on a single day may exceed $4.0 + \frac{30}{100} \times 4.0 = 5.2$, or may go below 2.8 per cent., (viz., $4.0 - \frac{30}{100} \times 4.0$); if the average specific gravity is 1.031 (lactometer degrees, 31[2]) the specific gravity of the milk on a single day may vary between 1.0279 and 1.0341 ($31 + \frac{10}{100} \times 31 = 34.1$; $31 - \frac{10}{100} \times 31 = 27.9$).

170. Influence of heavy grain-feeding on the quality of milk. If cows are not starved or underfed, an increase in the feeding ration will not materially change the richness of the milk produced, as has been shown by careful

1 Book of the Dairy, p. 32.

2 See page 94.

feeding experiments conducted under a great variety of conditions and in many countries. Cows that are fairly well fed will almost invariably give more milk when their rations are increased, but the milk will remain of about the same quality after the first few days are passed as before this time, provided the cows are in good health and under normal conditions. Any change in the feed of cows will usually bring about an *immediate* change in the fat content of the milk, as a rule increasing it to some extent, but in the course of a few days, when the cows have become accustomed to their new feed, the fat content of the milk will again return to its normal amount.

171. The records of the cows included in the feeding experiment at the Illinois station, to which reference has been made on p. 133, furnish illustrations as to the effect of heavy feeding on the quality of milk. The feed, as well as the milk of the cows, was weighed each day of the experiment. During the month of December each cow was fed a daily ration consisting of 10 lbs. of timothy hay, 20 lbs. of corn silage and 2 lbs. of oil meal; the table on p. 134 shows that cow No. 3 produced on this feed an average of 12.1 lbs. of milk, testing 3.8 per cent. of fat. In January the grain feed was gradually increased until the ration consisted of 12 lbs. of timothy hay, 8 lbs. of corn and cob meal, 4 lbs. of wheat bran and 4 lbs. of oil meal. All the cows gained in milk on this feed; cow No. 3 thus gave an average of 4 lbs. more milk per day in January than in December, but the average test of her milk was 3.7 per cent., or one-tenth of one per cent. lower than during the preceding month. The heavy grain feeding was continued through February and March, when it reached 12 lbs. of timothy hay, 12 lbs. of corn and cob meal, 6 lbs. of wheat bran and 6 lbs. of oil meal per day. The records show that the flow of milk kept up to 16 lbs. per day in February in case of this cow, but fell to 14 lbs. in March and April, the average test of the milk being, in February 3.6, in March 3.8, and in April 4.0 per cent. The milk was, therefore, somewhat richer in April than in December, but not more so than is found normally, owing to the progress of the period of lactation.

172. Influence of pasture on the quality of milk. On May 1, the cows were given luxurient pasture feed and no grain; a slight increase in the average amount of milk produced per day followed, with a reduction in the test, this being 3.8 per cent., the same as in December.

During all these changes of feed, there was, therefore, not much change in the richness of the milk, while the flow of milk was increased by the heavy grain-feeding for several months, as well as by the change from grain feeding in the barn to pasture feed with no grain.[1]

173. The increase which has often been observed in the amount of butter produced by a cow, as a result of a change in feed, doubtless as a rule comes from the fact that more, but not richer milk is produced. The quality of milk which a cow produces is as natural to her as is the color of her hair and is not materially changed by any special system of normal feeding.[2]

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[1] For further data on this point, see Cornell (N. Y.) exp. sta., bulletins 13, 22, 36 and 49; N. D. exp. sta., bull. 16; Kansas exp. sta., report, 1888; Hoard's Dairyman, 1896, pp. 924–5.

[2] On this point numerous discussions have in recent years taken place in the agricultural press of this and foreign countries, and the subject has been under debate at nearly every gathering of farmers where feeding

174. Method of improving the quality of milk. The quality of the milk produced by a herd can generally be improved by selection and breeding, i. e., by disposing of the cows giving poor milk, say below 3 per cent. of fat, and by breeding to pure-bred or high-grade bulls of a strain that is known to produce rich milk. This method cannot work wonders in a day, or even in a year, but it is the only certain way we have to improve the quality of the milk produced by our cows.

It may be well in this connection to call attention to the fact that the quality of the milk which a cow produces is only one side of the question; the quantity is another, and an equally important one. Much less dissatisfaction and grumbling about low tests among patrons of creameries and cheese factories would arise if this fact was more generally kept in mind. A cow giving 3 per cent. milk should not be condemned because her milk does not test 5 per cent.; she may give twice as much milk

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problems have been considered. Many farmers are firm in their belief that butter fat can be "fed into" the milk of a cow, and would take exception to the conclusion drawn in the preceding. The results of careful investigations by our best dairy authorities point conclusively, however, in the direction stated, and the evidence on this point is overwhelmingly against the opinion that the fat content of the milk can be materially and for any length of time increased by changes in the system of feeding. The most conclusive evidence in this line is perhaps the Danish co-operative cow-feeding experiments, conducted during the past ten years with over 2,000 cows in all. The conclusion arrived at by the director of the Copenhagen experiment station, under whose supervision the experiments have been conducted, has been repeatedly stated in the published reports of the station: that the changes of feed made in the different lots of cows included in the experiments have had practically no influence on the chemical composition (the fat content) of the milk produced. In these experiments grain feeds have been fed against roots, against oil cake, and against wheat bran or shorts; grain and oil cake have furthermore been fed against roots, and roots have been given as an additional feed to the standard rations tried,—in all cases with the same negative results so far as changes in the fat contents of the milk produced are concerned.

per day as a 5 per cent.-cow, and will therefore produce considerably more butter fat. The point whether or not a cow is a persistent milker is also of primary importance; a production of 300 lbs. of butter fat during a whole period of lactation is a rather high dairy standard, but one reached by many herds, even as the average for all mature cows in the herd. It should be remembered that a high production of butter fat in the course of the whole period of lactation is of more importance than a very high test.

CHAPTER X.

COMPOSITE SAMPLES OF MILK.

175. Shortly after milk testing had been introduced to some extent in creameries and cheese factories, it was suggested by Patrick, then of the Iowa experiment station,[1] that a great saving in labor without affecting the accuracy of the results could be obtained by mixing the daily samples of milk from one source, and testing this mixture instead of each sample contributing thereto. Such a mixture is called a *composite sample.* The usual methods of taking such samples at creameries and cheese factories during the past few years have been as follows:

FIG. 50. Taking test samples at in-take.

176. Methods of taking composite samples. a. **Use of tin dipper**. Either pint or quart Mason fruit jars, or milk bottles provided with a cover, are used for receiving the daily samples. One of these jars is supplied for each

[1] Bulletin No. 9, May 1890.

patron of the factory and is labeled with his name or number. A small quantity of preservative (bi-chromate of potash, bi-chlorid of mercury, etc., see 188) is added to each jar; these are placed on shelves or somewhere within easy reach of the operator who inspects and weighs the milk as it is received at the factory. When all the milk delivered by a patron is poured into the weighing can and weighed, a small portion thereof, usually about an ounce, is put into the jar labeled with the name or number of the patron. The samples are conveniently taken by means of a small tin dipper holding about an ounce. This sampling is continued for a week, ten days, or sometimes two weeks, a portion of each patron's milk being added to his particular jar every time he delivers milk. A test of these composite samples takes the place of separate daily tests and gives accurate information regarding the average quality of the milk delivered by each patron during the period of sampling. The weight of butter fat which each patron brought to the factory in his milk during this time, is obtained by multiplying the total weight of milk delivered during the sampling period by the test of the composite sample, dividing the product by 100.

177. This method of taking composite samples has been proved to be practically correct. It is absolutely correct only when the same weight of milk is delivered daily by the patron. If this is not the case, the size of the various small samples should bear a definite relation to the milk delivered; one-sixteen hundredth, or one two-thousandth of the amount of milk furnished should, for instance, be taken for the composite sample from each lot of milk.

This can easily be done by means of special sampling devices (see 179 et. seq.). As the quantities of the milk delivered from day to day by each patron vary but little perhaps not exceeding 10 per cent. of the milk delivered, the error introduced by taking a uniform sample, e. g., an ounce of milk, each time is, however, too small to be worth considering in factory work, and the method of composite sampling described is generally adopted in separator creameries and cheese factories, where the payment of the milk is based on its quality.

178. By this method of composite sampling each lot of rich, medium or thin milk receives due credit for the amount of butter fat which it contains, and errors that might arise from testing only one day's milk at irregular intervals are avoided. In order to obtain reliable results by composite sampling it is essential that each lot of milk sampled shall be sweet and in good condition, containing no lumps of curdled milk or butter granules. The milk is of course always evenly mixed before the sample is taken.

179. b. **Drip sample.** Composite samples are sometimes taken at creameries and cheese factories by collecting in a small dish the milk that drips through a fine hole or tube placed in the conductor spout through which the milk runs from the weighing can to the receiving vat or tank. A small portion of the drip collected each day is placed in the composite sample jar, or the quantity of drip is regulated so that all of it may be taken. In the latter case the quantity of milk delivered will enter into the composite sampling as well as its quality, and the sample from, say 200 lbs. of milk will be twice as large as the sample frem 100 lbs. of milk.

Where it is desired to vary the size of the samples according to the quantity of milk delivered from day to day, it is necessary to adopt the method of collecting drip samples, just explained, or to make use of special sampling devices, like the "milk thief" or a Scovell sampling tube. The principle of both these tubes is the same, and it will be sufficient to describe here only one.

180. c. **The Scovell sampling tube.** This convenient device for sampling milk[1] (fig. 51) consists of a drawn copper or brass tube, one-half to one inch in diameter; it is open at both ends, the lower end sliding snugly in a cap provided with three elliptical openings at the side, through which the milk is admitted. The milk to be sampled is poured into a cylindrical pail, or the factory weighing can, and the tube, with the cap set so that the apertures are left open, is lowered into the milk until it touches the bottom of the can. The tube will be filled instantly to the level of the milk in the can and is then pushed down against the bottom of the can, thereby closing the apertures of the cap and confining within the tube a column of milk repsenting exactly the quality of the milk in the can and forming an aliquot part thereof. The milk in the sampling tube is then emptied into the composite sample jar by turning the tube upside down.

FIG. 51. Scovell milk sampling tube.

181. If the diameter of the sampling pail used is 8 inches, and that of the sampling tube $\frac{1}{2}$ inch (these dimensions will be found convenient in sampling milk from single cows), then the quan-

[1] Kentucky experiment station, 8th report, pp. xxvi-xxxii.

tity of milk secured in the tube will always stand in the ratio to that of the milk in the pail, of $(\frac{1}{2})^2$ to 8^2,[1] that is, very nearly 1 to 256; no matter how much or how little milk there is in the pail, the sample will represent $\frac{1}{256}$ part of the milk. For composite sampling of the milk of single cows, this proportion will prove about right; if more milk is wanted for a sub-sample, dip twice, or pour the milk to be sampled into a can of smaller diameter. If the mixed milk from a number of cows is to be sampled, a wider sampling can is used. By adjusting the diameters of the tube and the can, any desired proportion of milk can be obtained in the sample.

For factory sampling, with a weighing can, 26 inches in diameter, a tube three-quarters of an inch in diameter will be found of proper dimensions.

In using any one of these tubes, the size of the sample is regulated by the amount of milk in the sampling can, as the milk always rises to the same height in the tube as in the can. In all cases *cylindrical* sampling cans must be used.

182. The sampling tube will furnish a correct sample of the milk in the can, even if this has been left standing for some time; it is better, however, to take out the sample soon after the milk has been poured into the can, as the possible error of cream adhering to the side of the sampling tube is then avoided.

183. The accuracy of the sampling of milk by means of the Scovell tube was proved beyond dispute in the

[1] The contents of a cylinder are represented by the formula $\pi r^2 h$, r being the radius of the cylinder, and h its height. The relation between two cylinders of the same height, the radii of which are R and r, is therefore as $\pi R^2 h$ to $\pi r^2 h$, or as R^2 to r^2.

breed tests conducted at the World's Columbian Exposition in 1893, in which tests this method was adopted for sampling the milk produced by the single cows and the different herds.[1] The data obiained in these breed tests also furnish abundant proof of the accuracy of the Babcock test.

184. d. **The Equity milk sampler.** This sampling tube, designed by Kolarik and Werder, is attached to the milk weighing can. After lowering it into the milk the tube is opened at the bottom by pressing on the top, fig. 52. The tube then fills to the height of the milk in the can and is raised by sliding it through the collar that holds it in place. The milk in the tube is then discharged into the sample jar, fig. 53.

FIG 52. Lowering tube into milk.

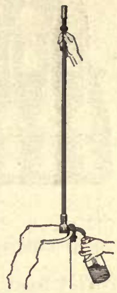

FIG. 53. Discharging sample into jar.

185. e. **Composite sampling with a "one-third sample pipette."** Milk is sometimes sampled directly from the weighing can into the Babcock test bottle by means of a pipette holding 5.87 cc., which is one third the size of the regular pipette. This quantity is measured into the test bottle from three successive lots of milk from the same patron and the test then made in the ordinary manner. In this way one test shows the average composition of the milk delivered during three successive days or deliveries. When this method is adopted, as many test bottles are provided as there are patrons;

[1] Kentucky experiment station, 8th report, pp. xxx-xxxi. Another form of a milk sampling tube in use at the Iowa experiment station was described and illustrated by Mr. Eckles in Breeder's Gazette, May 19, 1897.

there is no need of using any preservatives for the milk in this case. Fig. 54 shows a convenient rack for holding the test bottles used in composite sampling with a "one-third sample pipette."

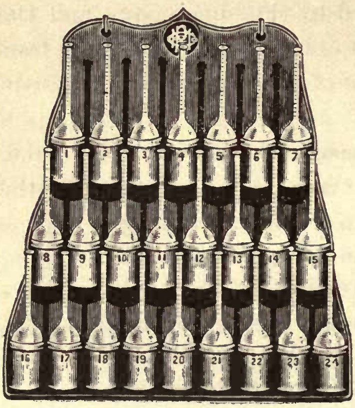

FIG. 54. Test-bottle rack for use in creameries and cheese factories.

Accurate results can be obtained by this method of sampling, if care is taken in measuring out the milk, and if it is not frozen or contains lumps of cream. It is doubtful if the method has any advantage over the usual method of composite sampling. If milk is delivered daily and each lot is sampled with the one-third pipette, twice or three times the number of tests are required as when composite samples are taken in jars and tested once every week or ten days. This method furthermore takes a little more time in the daily sampling than the other, as the quantity of milk must be measured out accurately each time. If the test bottle is accidentally broken or some milk spilled, the opportunity of ascertaining the fat content of the milk delivered during the three days is lost; if a similar accident should occur in testing composite samples collected in jars, another test can readily be made.

186. Accuracy of the described methods of sampling. An experiment made at the Wisconsin Dairy School may here be cited, showing that concordant results will be obtained by the use of the drip sampling method and the Scovell tube. Two composite samples were taken from fifty different lots of milk, amounting to about 6,000 lbs. in the aggregate. One sample was taken of the drip from a hole in the conductor spout through which the milk passed from the weighing can; the other was taken from the weighing can by means of a Scovell sampling tube. The following percentages of fat were found in each of these samples:[1]

	Babcock test.	*Gravimetric analysis.*
Drip composite sample......	4.0 per cent.	4.04 per cent.
Scovell tube composite sample..	4.0 per cent.	4.06 per cent.

Preservatives for Composite Samples.

187. When milk is kept any length of time under ordinary conditions, it will soon turn sour and become loppered, and further decomposition shortly sets in, which renders the sampling of the milk both difficult and unsatisfactory (19). The changes which occur when milk sours are due to the formation of lactic acid by the action of bacteria on milk sugar; the acid coagulates the casein of the milk, but does not destroy or attack the butter fat (32). The period during which milk will remain in an apparently sweet or fresh condition varies with the temperature at which it is kept, and with the cleanliness of the milk. It will not generally remain sweet longer than two days at the outside, at ordinary summer or room temperature.

In order to preserve composite samples of milk in a proper condition for testing, some chemical which will

[1] See also 189 et seq.

check or prevent the fermentation of the milk must be added to it. A number of substances have been proposed for this purpose.

188. Bi-chromate of potash. This preservative is, in the opinion of the authors, to be preferred, on account of its relative harmlessness, its cheapness and efficiency. The bi-chromate method for preserving samples of milk was proposed by Mr. J. A. Alen, city chemist of Gothenburg, Sweden, in 1892,[1] and has been generally adopted in dairy regions in this country and abroad. While not perfectly harmless, the bi-chromate is not a violent poison like other chemicals proposed for this purpose, and no accidents are liable to result from its use; at least none have been known to the writers to occur during the years that it has been used in creameries or dairies as a preserving agent.

189. The quantity of bi-chromate necessary for preserving half a pint to a pint of milk for a period of one or two weeks is about one-half gram (nearly 8 grains). As there are about 900 half-grams in a pound, this quantity will suffice for nine weeks in a creamery having one hundred patrons, if tests are made once a week, or for three months (90 days) if tests are made every ten days.

According to Winton and Ogden,[2] a .22-inch pistol cartridge shell cut to ½ inch long, or a .32-inch calibre shell cut to ¼ inch long, when loosely filled, will hold enough powdered bi-chromate to preserve ½ pint, and a .32-inch calibre shell cut to ½ inch long will hold enough to preserve one pint. These shells may be conveniently

[1] Biedermann's Centralblatt, 1892, p. 549.

[2] Connecticut experiment station, report for 1884, p. 222.

handled by soldering to them a piece of stiff wire which serves as a handle. The amount of bi-chromate placed in each composite sample jar would fill about half the space representing one per cent. in the neck of the Babcock milk test bottle.

190. The first portions of milk added to the composite sample jars containing the specified amount of bi-chromate will be colored almost red, but as more milk is added, day by day, its color will become lighter yellow. The complete sample should have a light straw color; such samples are most easily mixed with acid when tested. If more bi-chromate is used, the solution of the casein in the acid is rendered difficult and requires more persistent shaking. Bi-chromate can be bought at drug stores or from dairy supply dealers at about 30 cents a pound and will cost about 25 cents a pound at wholesale. Powdered bi-chromate of potash should be ordered, and not crystals, as the latter dissolve only slowly in the milk. Farrington's bi-chromate tablets contain the correct quantity of preservative for a quart sample, and will be found convenient.

191. Other preservatives for composite samples. Among other substances recommended for use in butter or cheese factories as milk preservatives for composite samples are formalin, boracic-acid compounds, chloroform, carbon bi-sulfid,[1] copper ammonium sulfate, sodium fluorid, ammonia glycerin (sp. gr., 1.031) and mixtures containing mercuric chlorid (corrosive sublimate) with anilin color (rosanilin).[2] The coloring matter in the latter

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[1] Delaware experiment station, eighth report, 1896, which also see for trials with a large number of different preservatives.

[2] Iowa experiment station, bulletins 9, 11, 32.

compounds is added to give a rose color to the sample preserved, thus showing that the milk is not fit for consumption; the bi-chromate giving naturally a yellow color to the milk, renders unnecessary the addition of any special coloring matter.

None of the substances mentioned are as cheap as bi-chromate or more effective for factory purposes when the milk is to be kept not to exceed two or three weeks. The compounds containing corrosive sublimate are violent poisons and must always be handled with the greatest care, lest they get into the hands of children or persons unfamiliar with their poisonous properties; they will preserve the milk longer than bi-chromate when applied in sufficient quantities, but for factory use the latter is amply effective and has, as already stated, the advantage in several respects.

192. Care of composite samples. The composite sample jars should be kept covered to prevent loss by evaporation, and in a cool, dark place, or at least out of direct sunlight; the chromic acid formed by the reducing influence of light on chromate solutions produces a leathery cream which is very difficultly dissolved in sulfuric acid.

A coating of white shellac has been suggested to protect the labels of the composite sample jars. The shellac is applied after the names of the patrons have been written on the labels, and when these have been put on the jars. Gummed labels, 1x2½ inches, answer this purpose well.

In keeping the milk from day to day, care should be taken that the cream forming on the milk does not stick to the sides of the jars in patches above the level of the milk. Unless the daily handling of the jars and the addition of fresh portions of milk be done with sufficient care, the cream will become lumpy and will dry on the sides of the jars. In some cases it is nearly impossible to evenly distribute this dried cream through the entire sample so as to make the composite sample a true representative of the different lots of milk from which it has been taken.

193. Every time a new portion of milk is added to the jar this should be given a gentle horizontal rotary motion, thereby mixing the cream already formed in the jar with the milk and rinsing off the cream sticking to its side. This manipulation also prevents the surface of the milk from becoming covered with a layer of partially dried leathery cream.

Composite samples having patches of dried cream on the inside of the jar are the result of carelessness or ignorance on the part of the operator. If proper attention is given to the daily handling of the composite samples, the cream formed in the jars can without difficulty again be evenly mixed with the milk.

194. Fallacy of averaging percentages. A composite sample of milk should represent the average quality of the various lots of milk of which it is made up. This will invariably be true if a definite aliquot portion or fraction of the different lots of milk is taken. If the weights of, say ten different lots of milk are added together and the sum divided by ten, the quotient will represent the average *weight* per lot of milk, but an average of the tests of the different lots obtained in this way may not be the correct average *test* of the entire quantity of milk. The accuracy of such an average figure will depend on the uniformity in the composition and weights of the ten lots of milk. When there is no uniformity, the weights of the different lots of milk as well as their tests must be considered. The following example illustrates the difference between the arithmetical average of a number of single tests and the true average test of the various lots.

Methods of calculating average percentages.

I. *Milk varying in weights and tests.*				II. *Milk of uniform weights and tests.*			
LOT.	Weight of milk.	Test of milk.	Weight of fat.	LOT.	Weight of milk.	Test of milk.	Weight of fat.
	lbs.	per ct.	lbs.		lbs.	per ct.	lbs.
I..................	120	3.5	4.2	I..................	250	4.2	10.5
II..................	570	5.0	28.5	II..................	225	4.0	9.0
III..................	360	5.2	18.7	III..................	240	4.3	10.3
IV..................	55	3.0	1.6	IV..................	238	4.1	9.7
V..................	82	4.0	3.2	V..................	234	4.4	10.3
Total...........	1187	....	56.2	Total...........	1187	....	49.8
Average	237	4.14	11.24	Average	237	4.20	10.0
True average test	....	4.73[1]	....	True average test	....	4.22[2]	....

[1] $\frac{56.2 \times 100}{1187} = 4.73.$

[2] $\frac{49.8 \times 100}{1187} = 4.22.$

195. The figures given in the table show that when the different lots of milk vary in test and weight, as in the first case, the correct average test of the 1187 lbs. of milk is not found by dividing the sum of these tests by five, which would give 4.14 per cent.; but the percentage which 56.2 (the total amount of fat in the mixed milk, in lbs.) is of 1187 (the total amount of milk in lbs.) is

4.73, and this is the correct average test of the mixed milk made up of the five different lots.

In the second case, the variations in both the weights of the different lots of milk and their tests, are comparatively small, and both methods of calculation give therefore practically the same average test; but also in this case, the correct average test is found by dividing the total amount of fat by the total quantity of milk, making 4.22 per cent., instead of 4.20 per cent., which is the aritmetical mean of the five tests. The quantities of milk in the various lots do not enter into the calculation of the latter.[1]

196. The second example represents more nearly than the first one the actual conditions met with at creameries and cheese factories. As a rule the mixed milk from a herd of cows does not vary more in total weight or tests, within a short period of time like one to two weeks, than the figures given in this example. On account of this fact, samples taken, for instance, with a small dipper may give perfectly satisfactory results to all parties concerned. If the different lots of milk varied in weight and test from day to day, as shown in the first case, it would be necessary to use a "milk thief" or a Scovell sampling tube for taking the composite samples; the size of each of the samples taken would then represent an exact aliquot portion of the various lots of milk (180).

197. A patron's dilemma. The following incident will further explain the difficulties met in calculating the average tests of different lots of milk.

[1] In the experiment given on p. 137, the arithmetical mean of the tests given is 5.15 per cent., while the true average fat content of the milk is 4.85 per cent.

The weekly composite sample of the milk supplied by a creamery patron from his herd of 21 cows tested 4.0 per cent. fat. One day the farmer brought to the creamery a sample of the morning's milk from each of his cows, and had them tested; after adding the tests together and dividing the sum by 21, he obtained an average figure of 5.1 per cent. of fat. From this he concluded that the average test of the milk from his cows ought to be 5.1, instead of 4.0, and naturally asked for an explanation.

198. The first thing done was to show him that while 5.1 was the correct average of the figures representing the tests of his twenty-one cows, it was not a correct average test of the mixed milk of all his cows, as he had not considered in calculating this average, the quantities of milk yielded by each cow; the following illustration was used:

Cow No. 1, yield	25 lbs. of milk, test	3.6 per cent.=	0.9 lbs. of butter fat.
Cow No. 2, yield	6 lbs. of milk, test	5.0 per cent.=	0.3 lbs. of butter fat.
Total...........	31 lbs.	2)8.6	1.2 lbs.
		4.3 per cent.	

The two cows gave 31 lbs. of milk containing 1.2 lbs. of fat; the test of the mixed milk would therefore not be 4.3 per cent. $\left(\frac{3.6+5.0}{2}\right)$, but $\frac{1.2\times100}{31}=3.87$ per cent. If the fat in the mixed milk was calculated by the average figure 4.3 per cent., 1.33 lbs. of fat would be obtained, i. e., 0.13 lbs. more than the cows produced.

In order to further demonstrate the actual composition of the mixed milk of the twenty-one cows, the milk of each cow was weighed and tested at each of the two milkings of one day. The weights and tests showed that the cows produced the following total number of pounds of milk and of fat:

Morning milking, 113.3 lbs. of milk, containing 5.17 lbs. of fat.
Night milking, 130.9 lbs. of milk, containing 4.98 lbs. of fat.

The morning milk therefore contained $\frac{5.17\times100}{113.3}=4.56$ per cent. of fat, and the night milk $\frac{4.98\times100}{130.9}=3.80$ per cent. of fat.

The sum of the morning and night milkings gave: milk, 244.2 lbs., fat 10.15 lbs. The mixed morning and night milk, therefore, contained $\frac{10.15\times100}{244.2}=4.1$ per cent. of fat. This is the true average test of the morning and night milkings of these twenty-one cows, as found by weighing and testing separately the milk of each cow at both milkings.

199. The total milk was strained into a large can at the farm, both in the morning and in the evening, A sample of the mixed milk was in each case taken with a long-handled dipper as soon as the milkings were finished. When the cans of milk were delivered at the creamery, a sample of each was taken with a Scovell sampling tube. The tests of these four samples are given below, together with the results from the individual tests:

	Morning milk.	*Night milk.*
Sample taken at the farm, with dipper	4.4 per cent.	3.8 per cent.
Sample taken at creamery, with Scovell tube	4.5 per cent.	3.7 per cent.
Calculated from weights and tests of milk from each cow	4.5 per cent.	3.8 per cent.

The figures given show that practically uniform tests were obtained by the different methods of sampling.

The sum of the weights of the milk from the different cows was as follows:

	Morning milk.	*Night milk.*	*Daily milk.*
Total milk produced	113.3 lbs.	130.9 lbs.	244.2 lbs.
Milk in samples	12.3 lbs.	8.9 lbs	21.2 lbs.
Milk for family use	2.5 lbs.	....	2.5 lbs.
Milk taken to creamery	98.5 lbs.	122.0 lbs.	220.5 lbs.

It has already been shown from the weights and tests of each cow's milk that the herd milk contained 4.1 per cent. of fat. Multiplying the total milk delivered at the creamery, 220.5 lbs., by .041 gives 9.04 lbs. of fat. The morning and night milkings, which were weighed and tested separately, contained the following quantities of butter fat:

Morning milk	98.5 lbs. $\times$.045=4.43 lbs. of butter fat.	
Night milk	122.0 lbs. $\times$.038=4.63 lbs. of butter fat.	
Total	220.5 lbs.	9.06 lbs.

By weighing, sampling and testing separately the morning and night milkings of twenty-one cows, deducting the weight of milk in the samples and what was taken out for family use, it was found that 9.04 lbs. of butter fat was sent to the creamery. The weights and tests of this same milk when delivered at the creamery, gave 9.06 lbs. of butter fat.

200. This example furnishes an excellent illustration of the accuracy of the Babcock test and of the closeness of results which may be obtained at creameries when proper care is taken in weighing, sampling and testing the milk. Similar demonstrations may be made by any factory operator, and with equally satisfactory results, provided the work is carefully done.

CHAPTER XI.

CREAM TESTING AT CREAM-GATHERING CREAMERIES.

201. The cream delivered at gathered-cream factories is now in many localities tested by the Babcock test, and this has been adopted as a basis of paying for the cream in the same manner as milk is paid for at separator creameries. It has been found to be more satisfactory to both cream buyer and seller, than either the oil-test churn or the space (or guage) systems which have been used for this purpose in the past.

The details of the application of the Babcock test to the practical work at cream-gathering creameries have been carefully investigated by Winton and Ogden in Connecticut,[1] Bartlett in Maine,[2] and Lindsay in Massachusetts,[3] and we also owe to the labors of these chemists much information concerning the present workings of other systems of paying for the cream delivered at creameries.

202. The space system. Numerous tests have shown that one *space* or *gauge* of cream does not contain a definite, uniform amount of fat. In over 100 comparisons made by Winton it was found that one space of cream[4]

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1 Conn. experiment station (New Haven), bull. No. 108 and 119; report 1894, pp. 214-244.

2 Maine experiment station, bull. 3 and 4 (S. S.).

3 Hatch experiment station, report 1894, pp. 92-103; 1895, pp. 67-70.

4 The *space* is the volume of a cylinder, $8\frac{1}{2}$ inches in diameter and $\frac{19}{64}$ of an inch high. The number of spaces in each can of milk is read off before skimming by means of a scale marked on a strip of glass in the side of the can (Conn. exp. sta., bull. No. 119).

contained from .072 to .170 lbs. of butter fat, or on the average .13 lbs., and the number of spaces required to make one pound of butter varied from 5.01 to 11.72. It is also claimed that in the winter season when the cream is gathered at long intervals, like once a week, it is necessary for the buyer to accept the seller's statement of the record of the number of cream spaces which he

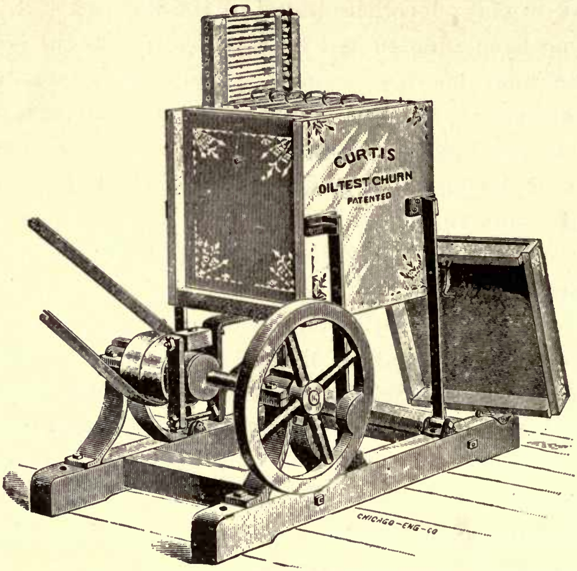

FIG. 55. The oil-test churn.

furnishes, since the cream cannot be left in the creaming cans for so long a time. These objections to the space system apply only to the method of paying for the cream, and not to the manner in which the cream is obtained.

203. The oil-test churn. As stated in the introduction, the *oil-test churn* (fig. 55) has been used quite extensively among gathered-cream factories; this system is based on the number of creamery inches of cream which the various patrons deliver to the factory; one inch of cream contains 113 cubic inches.[1] The driver pours the patron's cream into his 12-inch gathering pail, measures it with his rule and records the depth of the cream in the can, in inches and tenths of an inch. The cream is then stirred thoroughly with a ladle or a stout dipper, and a sample is taken by filling a test tube from the sample case, to the graduation mark by means of a small conical dipper provided with a lip. A driver's case contains either two or three "cards," holding fifteen test tubes each (see fig. 56). The tubes as filled are placed in the case and the corresponding number is in each instance recorded in front of the patron's name together with the number of inches of cream furnished by him.

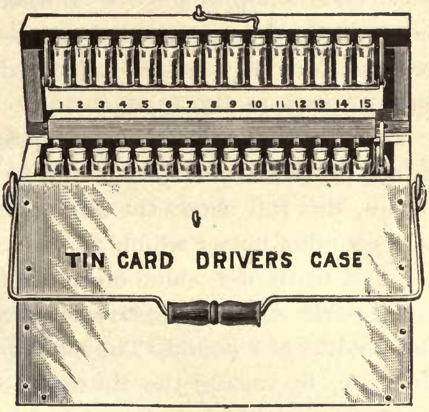

FIG. 56. Cream-gatherer's sample case.

On arrival at the creamery the tin cards holding the tubes are placed in a vessel filled with water of the temperature wanted for churning (say, 60° in summer and 65° to 70° in winter.) When ready for churning they are placed in the oil-test churn, the cover of the churn put on, and the samples of cream churned

[1] I. e., a layer of cream one inch deep in a 12-inch pail; two inches in an 8-inch pail contains 100.531 cubic inches, two inches in an 8⅝-inch pail 110.18 cubic inches, and two inches in an 8½-inch pail 113.49 cubic inches.

to butter. On the completion of the churning, the cards are transferred to water of 175–190° Fahr., where they are left for at least ten minutes to melt the butter and "cook the butter milk into a curd." The oil will now be seen mixed all through the mass. The test tubes are then re-tempered to churning temperature and churned again, by which process the curd is broken into fine particles, which, when the butter is re-melted, will settle to the bottom. The butter is melted after the second churning by placing the tubes in water at 150–175° F., allowing them to remain therein for at least twenty minutes. Some samples must be churned three or four times before a good separation of oil is obtained. A clear separation of oil is often facilitated by adding a little sulfuric acid to the tubes.

The length of the column of liquid butter fat is determined by means of a special rule for measuring the butter oil; this rule shows the number of pounds and tenths of a pound of butter which an inch of cream will make; the first tenth of a pound on the rule is divided into five equal parts, so that measurements may be made to two-hundredths of a pound. The melted fat is measured with the rule, by raising the tin card holding the bottles, to about the height of the eye; the reading is recorded on the driver's tablet under *Test per inch*, opposite the number of the particular patron. The test per inch multiplied by the inches and tenths of an inch of cream supplied will give the butter yield in pounds, with which the patron will be credited on the books of the creamery.

204. The objection to this system of ascertaining the quality of cream delivered by different patrons lies in the fact that it determines the *churnable* fat, and not the *total* fat of the cream; the amount obtained of the former depends on many conditions beyond the control of the patron, viz., the consistency, acidity and temperature of the cream, the size of the churn or churning vessel, etc. The same reasons which caused the churn to be replaced by methods of determining the total fat of the milk, in the testing of cows among dairymen and breeders, have gradually brought about the abandonment of the oil test in creameries and the adoption of the Babcock test in its place.

205. The Babcock test for cream. Both the space system and the oil-test churn used for estimating the quality of cream at creameries have now largely been replaced by the Babcock test in the more progressive creameries in this country, and composite samples of cream are collected and tested in a similar manner as is done with milk at separator creameries and cheese factories.

A very satisfactory method of arrangements for working the Babcock test, in use in many eastern creameries, is described by Winton and Ogden in the Connecticut report previously referred to. The cream gatherer who collects the cream in large cream cans is supplied with a spring balance (1, see Fig. 57), pail for sampling and weighing the cream (2), sampling tube (3), and collecting bottles (5). At each patron's farm he takes from his wagon the sampling pail and tube, the scales, and one small collecting bottle. He should find in the dairy of the patron the cans of perfectly sweet cream, kept at a temperature of 40° to 50° F., and protected from dirt and bad odors. Either sour or frozen cream must be rejected.

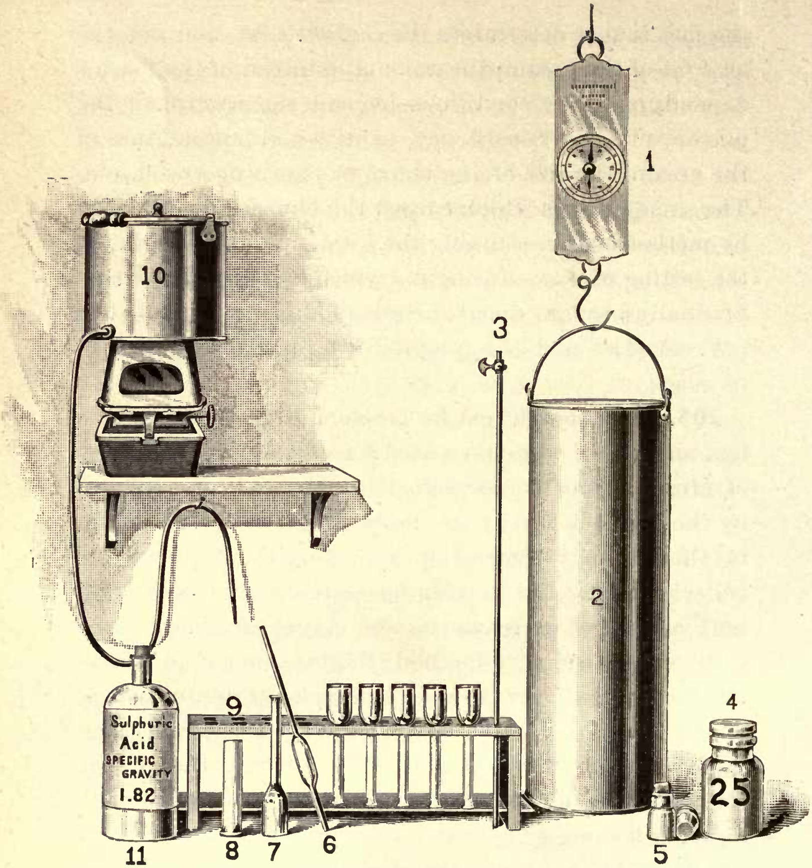

FIG. 57. Outfit for cream testing by the Babcock test at gathered-cream factories.

The patron's number should be painted in some conspicuous place near the cream cans in his dairy house. The gatherer hangs the scale on a hook near the cream to be collected; the scale should be so made that the hand of the dial will stand at zero when the empty pail is hung on it. The cream is then poured at least twice from one can to another in order to mix it thoroughly.[1]

206. When properly mixed, the cream is poured into the weighing pail and is weighed and sampled. The authors give the following description of the cream sampling tube used, and directions for sampling and weighing the cream:

"*Sampling Tube.*—This tube, devised by Mr. Ogden, is of stout brass, about $\frac{1}{32}$ of an inch thick, and a few inches longer than the weighing pail which is used with it. On the upper end, a small brass stop-cock of the same bore is fastened. It should be nickel plated inside and out, to keep the metal smooth and free from corrosion. These tubes may be obtained from less than $\frac{3}{16}$ to over $\frac{1}{4}$ inch bore. The greater the diameter of the weighing pail, the wider should be the bore of the tube. For use with pails 8 inches in diameter, a $\frac{3}{16}$ inch bore sampling tube will serve the purpose, but when the pail has a diameter of 9 or more inches, a tube with a bore of $\frac{1}{4}$ inch or more should be used. It must be borne in mind that doubling the diameter of the pail, or of the sampling tube, increases its capacity fourfold.

"The tube when not in use should be kept in an upright position to permit draining.

"*Sampling and Weighing.*—Lower the sampling tube, cock end up, *with the cock open*, to the bottom of the weighing pail which holds the mixed cream. When it is filled, raise it out of the liquid and allow it to drain for a few seconds. By this means the tube is rinsed with the cream to be sampled and any

[1] The necessity of care in mixing the cream is shown by the following illustration given by the authors referred to:

Per cent. of fat in cream which stood for 24 hours.

	Surface.	Bottom.	Sample drawn with sampling tube.
Not mixed	28.00	5.00	19.25
Poured once	23 75	22.00	22.50
Poured twice	....	....	22.25

traces of cream adhering to the tube from previous use are removed. With the cock still open, slowly lower the sampling tube to the bottom of the cream pail. After allowing a moment for the cream to rise in the tube to the same height as in the pail, close the cock and raise the sampler carefully out of the cream. As long as the cock is closed, the cream in the tube will not flow out, unless the tube is strongly jarred. Allow the cream adhering to the outside of the tube to drain off for a few seconds, then put the lower end into the 1 to 1½ oz. wide-mouth glass collecting bottle which bears the patron's number on its cork, and open the cork. The cream will then flow out of the sampler into the bottle, which is afterwards securely corked and put into the cream gatherer's case. Immediately weigh the cream in the cream pail to the quarter or half pound, as may be judged expedient, and record the weight.

"If the patron has more than one pailful, repeat with each pailful the operation of sampling and weighing, putting all the samples in one and the same bottle. *Weigh all cream collected in one and the same sampling pail and draw a sample from each separate portion weighed.*"

207. After sampling and weighing each patron's cream it is poured into the driver's large can, and the sample bottles are carried in a case to the creamery where the contents of each bottle is poured into the composite sample jar of the particular patron. The samples of cream in the small bottles, besides furnishing the means of testing the richness of the cream, give the creamery owner or manager an opportunity to inspect the flavor of each lot of cream, and the condition in which it has been kept by the various patrons. Potassium bi-chromate is placed in the composite sample jars, and these are cared for and tested in the same manner as composite samples of milk (192).

208. The collecting bottles should be cleaned with cold, and afterwards with hot water, as soon as they are emptied, and before a film of cream dries on them. When washed and dried, these bottles are placed in the cases, ready for the next collecting trip. There can be no confusion of bottles since the corks and not the bottles are marked with the numbers of the respective patrons.

209. When cream is bought by this system of testing composite samples, the patrons are paid for the number of pounds of butter fat contained in their cream, in exactly the same way as milk is paid for at separator creameries. It makes no difference how thick or how thin the cream may be, or how much skim milk is left in the cream when brought to the factory. Eighty pounds of cream containing 15 per cent. of fat is worth no more or less than 48 pounds of cream testing 25 per cent.; in either case 12 pounds of pure butter fat is delivered. This will make the same amount of butter in either case, viz., toward 14 lbs., and both patrons should therefore receive the same amount of money.

There is a small difference in the value of the two lots of cream to the creamery owner or the butter maker, in favor of the richer cream, both because its smaller bulk makes the transportation and handling expenses lighter, and because slightly less butter fat will be lost in the butter milk, a smaller quantity of this being obtained from the richer cream. But it is doubtful if the differences thus occurring are of sufficient importance to be noticed under ordinary creamery conditions; the example selected presents an extreme case of variation in the fat content of cream. A trial of this system at five Connecticut creameries, supplied mostly with Cooley cream, by over 175 patrons, showed that the average composition of the cream from the different patrons varied only from 16.9 to 19.8 per cent. fat. The cream of some patrons on certain days contained only 9.5 per cent. of fat, and other patrons at times had as high a test as 30 per cent., but these great differences largely disappeared when the average quality of the cream delivered during a period of time, like a month or more, was considered.

210. Smaller differences in the composition of cream will, however, always occur, even if the same system of setting the milk, like the cold deep-setting process, is used and the water is kept at the same temperature at all times. This is due to differences in the composition of the milk and its creaming quality; whether largely from fresh cows or from late milkers; whether kept standing for a time before being set or submerged in the creamer immediately after milking and straining; diameter of creaming cans, etc. Bartlett states[1] that the percentage of fat in the cream from the same cows may be increased ten per cent. or more by keeping the water at 70° instead of at 40° F. The higher temperature will give the richer cream, but the separation will not be so complete, since a richer skim milk is obtained from the milk set at this temperature. Separator cream is not materially influenced by the conditions mentioned, as the separator can be regulated to deliver cream of nearly uniform richness from all kinds of sweet milk.

211. At creameries where both milk and cream are delivered, somewhat of an injustice is done to patrons delivering cream, by paying for the amounts of butter fat furnished by the different patrons. By multiplying the

[1] Maine experiment station, bulletin No. 3 (S. S.)

cream fat by 1.03 (or by 1.044[1]), the value of his products to the creamery is taken into proper account, and justice is done to all parties concerned[2] (238).

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[1] See Spillman, Dairy and Creamery, Chicago, April 1, 1899.

[2] This subject is discussed in detail in the 17th Annual Report of Wis. Experiment Station, pp. 90–92.

CHAPTER XII.

CALCULATION OF BUTTER AND CHEESE YIELD.

A.—Calculation of Yield of Butter.

212. Butter-fat test and yield of butter. The Babcock test shows the amount of pure butter fat contained in a sample of milk or other dairy products. The butter obtained by churning cream or milk contains, in addition to pure butter fat, a certain amount of water, salt and curd. While an accurate milk test gives the total quantity of butter fat found in the sample of milk or cream tested, the churn cannot be depended upon either to leave the same amount of butter fat in the butter milk or to include the same amount of water, salt and curd in the butter at each churning.

If a quantity of milk, say 3,000 lbs., be thoroughly mixed in a vat, and then divided into half a dozen equal portions, a Babcock test of the different lots will show the same percentage of butter fat in each portion. If, on the other hand, each of these lots be skimmed, and the cream ripened in different vats and churned separately, the same weight of butter from each lot of 500 lbs. of milk will not be obtained, even by the most expert butter maker, or if all the operations of skimming, cream ripening, churning, salting and butter-working were made as nearly uniform as possible. Careful operators can handle the milk and cream so that very nearly the same proportion of the fat contained in the milk is recovered in the butter in different churnings, but since the water and salt in butter are held mechanically and are not chemically combined with it, the amounts retained by the butter are quite variable in different churnings, especially since the laws governing the retention of water in butter are but imperfectly understood.

213. Variations in the composition of butter. As an illustration of the variability of butter in its composition, the analyses made in the breed tests at the World's Fair in 1893 may here be cited; the butter was in all cases made by as nearly identical methods and under as uniform conditions as could possibly be obtained by the skilled operators having this work in charge; the average composition of 350 samples of this butter, with upper and lower limits, was as shown in the following table:

Composition of samples of butter, World's Fair, 1893.

	Water.	Fat.	Curd.	Salt and ash.	Sum of water, curd, salt and ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Average of 350 analyses	11.57	84.70	.95	2.78	15.30
Lower and upper limits.................	8.63-15.00	76.53-88.26	.50-2.14	1.01-8.58	....

Analyses of fifty samples of creamery butter taken in 1896, from the tubs ready for market at as many Wisconsin creameries, showed that no two of them were exactly alike in composition, but varied within the limits given below:[1]

[1] Wisconsin experiment station, bull. 56.

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Summary of analyses of Wisconsin creamery butter.

	Water.	Fat.	Curd.	Salt and ash.	Sum of water, curd, salt and ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Highest	17.03	87.50	2.45	4.73	22.95
Lowest	9.18	77.07	.36	1.30	12 50
Average	12.77	83.08	1.28	2.87	16 92

The preceding analyses show the composition of butter made at one place where every possible effort was taken to produce a uniform product, and of butter made at fifty different creameries, where there was more or less variation in the different operations of manufacture and in the appliances and machinery used. The majority of the samples of butter analyzed, in either case, were very near the average composition given, but since there are such wide variations in the composition of the butter made by the uniform methods adopted in the World's Fair breed tests, butter of a more uniform composition cannot be expected from the thousands of different creameries and private dairies which supply the general market with butter.

The analyses of the fifty samples of creamery butter, given above, show that the content of the butter fat varied from 77 to over 87.5 per cent., and according to the average of the analyses, 83 pounds of butter fat was contained in, or made, 100 lbs. of butter. There was, therefore, in this case produced 20.5 per cent. more butter than there was butter fat, since

$$83 : 100 :: 100 : x; \text{ therefore}$$

$$x = \frac{100 \times 100}{83} = 120.5.$$

214. "Overrun" of churn over test. The yield of butter is not, however, as a rule compared with the amount of butter fat contained in the butter, but with the total butter fat of the whole milk from which it was made. This "increase of the churn over the test" is what is generally called *overrun* in creameries.

The overrun obtained in different creameries, or even in the same creameries at different times, will be found to vary considerably. When the milk is accurately tested and the butter well worked, this overrun will vary from 10 to 16 per cent.; that is if a quantity of milk contains exactly 100 lbs. of butter fat, as found by the Babcock test or any other accurate method of milk testing, from 110 to 116 lbs. of butter ready for market may be made from it.

215. Factors influencing the overrun. Even under the very best of care and attention to details, variations will occur in the speed of the separator, in the conduct of the ripening and churning processes, and in the condition of the butter when the churn is stopped; hence absolutely uniform losses of fat in skim milk and butter milk, or the same water- and salt contents of the butter, cannot be expected.

The overrun is influenced by two factors: the losses of butter fat sustained in separating the milk and churning the cream, and the gain due to the admixture of water, salt, etc., in the manufacture of butter. Considering first the losses of fat in skim milk and butter milk, the separator will usually, when run at normal speed and capacity, leave the same per cent. of fat in skim milk, whether rich or poor milk is skimmed. An exception to this may be found in separating rich milk having large fat globules or milk from fresh milkers, in either of which cases the large size of the fat globules occasions a more complete separation of fat by the centrifugal force. But generally speaking, the statement holds good that the total loss of fat in separator skim milk is a factor of the quantity of milk run through the separator, rather than of its quality. It follows from this, however, that the *relative* losses of fat in skim milk will vary to some extent according to the quality of the milk separated. Selecting two extremes in the quality of milk, 2.5 and 6.0 per cent. of fat, there will be found, say .2 per cent. of fat in the skim milk from either lot, provided the separator is not unduly crowded, and the separation is conducted under normal conditions in each case. But .2 per cent. fat makes 8 per cent. of the total fat in the poor milk$\left(\frac{.2\times 100}{2.5}=8\right)$, and only 3 per cent. of that in the rich milk. It takes 4000 lbs. of the 2.5 per cent. milk to furnish 100 lbs. of fat, and only 1666 lbs. of the 6 per cent. milk; in skimming the poor milk, a loss of .2 per cent. of fat is sustained in the skim milk from 4000 lbs. of milk, while in the rich milk a similar loss is sustained in the skim milk from only 1666 lbs. of milk.

The example gives an extreme case, and one not likely to be met with in practice. The range in the richness of the milk delivered by different patrons at the factory is usually within one-half or one per cent. of fat. In such cases the proportion of fat lost in skimming does not vary much, e. g., in case of milk containing 3.5 and 4.0 per cent. of fat, and variations in the overrun occurring when the proper care in skimming, ripening and churning is taken, are due, therefore, primarily to differences in the water- and salt contents of the butter made (205).

216. The losses from very poor, very rich and average milk, as received at creameries and cheese factories, can be traced from the following statement; this gives the quantities of fat lost in handling milk of four grades, viz: 2.5, 3.5, 4.0 and 6.0 per cent., in case of each grade calculated to a standard of 100 lbs. of fat in the milk.

To supply 100 lbs. of fat would require the following amounts of the different grades of milk:

4000 lbs.	of milk	testing	2.5	per cent.	will	contain	100	lbs.	of fat.
2857	"	"	"	3.5	"	"	"	100	"	"
2500	"	"	"	4.0	"	"	"	100	"	"
1666	"	"	"	6.0	"	"	"	100	"	"

Assuming that the skim milk contains .2 per cent. of fat and makes up 85 per cent. of the whole milk, that the butter milk tests .3 per cent., and forms 10 per cent. of the whole milk, the butter-fat record of the quantities of different grades of milk containing 100 lbs. of fat will appear as follows:

Fat available for butter in different grades of milk.

Grade of milk.	Whole milk.	Skim milk.	Butter milk.	Total loss.	Fat available for butter.
2.5 per cent............	4000 lb. 2.5 per ct.	3400 lb. .2 per ct.	400 lb. .3 per ct.	lbs.	Per cent.
Fat...............	**100 lb.**	**6.8 lb.**	**1.2 lb.**	**8.0**	**92.0**
3.5 per cent............	2857 lb. 3.5 per ct.	2429 lb. .2 per ct.	286 lb. .3 per ct.		
Fat...............	**100 lb.**	**4.9 lb.**	**0.9 lb.**	**5.8**	**94.2**
4.0 per cent............	2500 lb. 4 per ct.	2125 lb. .2 per ct.	250 lb. .3 per ct.		
Fat..............	**100 lb.**	**4.3 lb.**	**0.7 lb.**	**5.0**	**95.0**
6.0 per cent............	1666⅔ lb. 6 per ct.	1417 lb. .2 per ct.	167 lb. .3 per ct.		
Fat...............	**100 lb.**	**2.8 lb.**	**0.5 lb.**	**3.3**	**96.7**

The table shows that with 2.5 per cent.-milk, there is a loss of 6.8 lbs. of fat in the skim milk and 1.2 lbs. of fat in the butter milk for every 100 lbs. of fat in the whole milk, or a total loss of 8.0 lbs. from these sources. In case of 6 per cent.-milk these losses are 2.8 lbs. and .5 lbs. for skim milk and butter milk, respectively; a total loss of 3.3 lbs., or 4.7 lbs. less than the losses with the very poor milk. This difference in the losses shrinks to only .8 pound of fat in case of 3.5 and 4.0 per ct.-milk, when a quantity containing 100 lbs. of fat is handled in both cases.

The overrun from each of the four grades of milk can be calculated for butter containing a certain per cent. of fat. Assuming the fat content of butter to be 83 per cent. on the average (213), the quantity of butter obtained from the 100 lbs. of fat, or rather from the portion thereof which is available for butter, in each case will be as follows:

	Available fat.	*Butter cont. 83 pr. ct. fat.*
100 lbs. of fat from 4000 lbs. of 2.5 pr. ct. milk,	92.0 lbs.	=110.8 lbs.
100 " " " 2857 " 3.5 " "	94.2 "	=113.5 "
100 " " " 2500 " 4.0 " "	95.0 "	=114.5 "
100 " " " 1666 " 6.0 " "	96.7 "	=116.5 "

The overrun in each case will be:

For 2.5 per cent. milk	=110.8−100=10.8	per cent.
" 3.5 " "	=113.5−100=13.5	"
" 4.0 " "	=114.5−100=14.5	"
" 6.0 " "	=116.5−100=16.5	"

All butter makers should obtain more butter from a certain quantity of milk than the Babcock test shows it to contain butter fat, but it is impossible to know exactly, except by chemical analyses, how much butter fat is lost in the skim milk and the butter milk, and how much water, salt and curd the butter will contain.

217. Calculation of overrun. The overrun is calculated by subtracting the amount of butter fat contained in a certain quantity of milk, from the amount of butter made from it, and finding the per cent. which this difference is of the amount of butter fat in the milk.

Example: 8000 lbs, of milk is received at the creamery on a certain day; the average test of the milk is 3.8 per cent.; 340 lbs. of butter was made from this milk, as shown by the weights of the packed tubs. By a simple multiplication we find that the milk contained $8000 \times .038 = 304$ lbs. of butter fat. The difference between the weight of butter and butter fat is, therefore, 36 lbs.; 36 is $\frac{36 \times 100}{304} = 11.8$ per cent. of the quantity of butter fat in the milk; that is, the overrun for the day considered was 11.8 per cent.

The formula for the *overrun* is as follows:

$$X = \frac{(b-f)\ 100}{f}$$

b and *f* designating the quantities of butter and butter fat, respectively, made from or contained in a certain quantity of milk. In the preceding example, the calculation would be as follows: $\frac{(340-304)\ 100}{304} = 11.8$ per cent.

In gathered-cream factories the overrun will naturally come higher than in separator creameries, since no loss of butter fat in the skim milk occurs in the former. The overrun based on the amount of fat in the cream will not under average creamery conditions be likely to vary much from 18 per cent.

218. Conversion factor for butter fat. A committee of the Association of American Agricultural Colleges and Experiment Stations at the ninth annual convention of the Association reported that "in the ninety-day Columbian Dairy Test, 96.67 per cent. of the fat in the whole milk was recovered in the butter. This butter on the average contained 82.37 per cent. butter fat; in other words, 117.3 pounds of butter were made from each 100 pounds of butter fat in the whole milk.[1] The exact conversion factor would be 1.173. As this is an awkward number to use, and as $1\frac{1}{6}$ is so nearly the same . . . it has seemed best to recommend that the latter be used as the conversion factor."

A resolution was adopted by this association recommending that the approximate equivalent of butter be computed by multiplying the amount of butter fat by $1\frac{1}{6}$.

These figures are the result of more than ordinary care in skimming, churning and testing, and probably represent the minimum losses of fat in the manufacturing processes. The increase of churn over test represented by one-sixth, or 16 per cent., may therefore be taken as a maximum "overrun" under ordinary factory conditions. Butter makers who report overruns of 16–20 per cent. do not show their expertness in butter making by such high figures, but their lack of accuracy in testing, or carelessness in working the butter; a large overrun may be obtained both by reading the test too low, and by leaving an excess of water in the butter, through insufficient working or other causes.

219. Butter yield from milk of different richness. a. **Use of butter chart.** The approximate yield of butter from milk of different richness is shown in table XI in the

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[1] When 82.37 lbs. of butter fat will make 100 lbs. of butter, how much butter will 96.67 lbs. of butter fat make? 82.37 : 96.67 : : 100 : x, x=117.3.

Appendix. This table is founded on ordinary creamery experience and will be found to come near to actual every-day conditions of creameries where modern methods are followed in the handling of the milk and its products. The table has been prepared in the following manner:

It is assumed that the average loss of fat in the skim milk is .20 per cent., and that 85 lbs. of skim milk is obtained from each 100 lbs. of whole milk; to this loss of fat is added that from the butter milk; about 10 lbs. of butter milk is obtained per 100 lbs. of whole milk, testing on the average .30 per cent.

If f designate the fat in 100 lbs. of milk, then the fat recovered in the butter from 100 lbs. of milk will be

$$f-\left(\frac{85}{100}\times.20+\frac{10}{100}\times.30\right)=f-.20$$

There is, on the other hand, an increase in weight in the butter made, owing to the admixture of non-fatty components therein, principally water and salt. Butter packed and ready for the market will contain in the neighborhood of 84 per cent. of fat (213), so that the fat recovered in the butter must be increased by $\frac{100}{84}=1.19$. If B therefore designate the yield of butter from 100 lbs. of milk, the following formula will express the relation between yield and fat content, provided there are no other factors entering into the problem, viz.:

$$B=(f-.20)\ 1.19$$

Certain mechanical losses are, however, unavoidable in the creamery, as in all other factory operations, viz., milk and cream remaining in vats and separators, butter sticking to the walls of the churn, etc. These losses have been found to average about 3 per cent. of the total fat in the milk handled, under normal conditions and under good management (218); we therefore deduct this amount from the preceding value for B, and have:

$$B=(f-.20)\ 1.16$$

220. Table XI in the *Appendix,* founded on this formula, may be used to determine the number of pounds of butter which milk containing 3 to 5.3 per cent. fat will be likely to make. It presupposes good and careful work at the separator, churn and butter worker, and under such conditions will generally show yields of butter varying but little from those actually obtained. It may be conveniently used by the butter maker or the manager to check the work in the creamery; the average test of the milk received during a certain period is found by dividing the total butter fat received, by the total milk, and multiplying the quotient by 100; the amount of butter which the total milk of this average fat content will make, according to the table, is then compared with the actual churn yield.

Example: A creamery receives 200,000 lbs. of milk during a month; the milk of each patron is tested and the fat contained therein calculated. The sum of these amounts of fat may be 7583 lbs.; the average test of the milk is then 3.79 per cent. According to table XI, 10,000 lbs. of milk, testing 3.8, will make 418 lbs. of butter, and 200,000 lbs., therefore, 8360 lbs. of butter. The total quantity of butter made during the month will not vary appreciably from this figure if the work in the creamery has been properly done.

221. b. **Use of overrun table.** The table referred to above gives a definite calculated butter yield for each grade of milk, according to average creamery conditions. As it may be found that this table will give uniformly either too low or too high results, table XII in *Appendix* is included, by means of which the butter yield corresponding to overruns from 10–20 per cent. may be ascertained in a similar way as above described.

The total yield of butter is divided by the total number of pounds of fat delivered; the quotient will give the amount of butter made from one pound of fat, and this figure multiplied by the fat delivered by each patron shows the pounds of butter to be credited to each patron. To use the table, find in the upper horizontal line the number corresponding most nearly to the number of pounds of butter from one pound of fat. The vertical column in which this falls gives the pounds of butter from 100 lbs. of milk containing the per cents. of fat given in the outside columns (Babcock[1]).

B.—Calculation of Yield of Cheese.

222. a. **From fat.** The approximate yield of green cheddar cheese from 100 lbs. of milk may be found by multiplying the per cent. of fat in the milk by 2.7; if f designate the per cent. of fat in the milk, the formula will, therefore, be:

$$\text{Yield of cheese} = 2.7 \text{ f.} \qquad \text{(I)}$$

The factor 2.7 will only hold good as the average of a large number of cases. In extensive investigations during three consecutive years, Van Slyke[2] found that the number of pounds of green cheese obtained for each pound of fat in the milk varied from 2.51 to 3.06, the average figures for the three years 1892–'94, incl., being 2.73, 2.71, and 2.72 lbs. respectively. The richer kinds of milk will produce cheese richer in fat, and will yield a relatively larger quantity of cheese, pound for pound, than poor milk, for the reason that an increase in the fat content of milk is accompanied by an

[1] Woll, Handbook for Farmers and Dairymen, p. 307.

[2] N. Y. experiment station (Geneva), bulletins No. 65 and 82.

increase in the other cheese-producing solids of the milk.[1] The preceding formula would not, therefore, be correct for small lots of either rich or poor milk, but only for milk of average composition, and for large quantities of normal factory milk. For cured cheese the factor will be somewhat lower, viz., about 2.6, on the average.

223. b. **From solids not fat and fat.** If the percentages of solids not fat and of fat in the milk are known, the following formula by Babcock will give close results:

$$\text{Yield of green cheese} = 1.58\left(\frac{s}{3} + .91\,f\right) \quad . \quad . \quad \text{(II)}$$

s being the per cent. of solids not fat in the milk, and *f* the per cent. of fat.[2]

The solids not fat can be readily ascertained from the lactometer reading and the per cent. of fat, as shown on p. 100, by means of table VI in the *Appendix*.

Table XIII in the *Appendix* gives the yield of cheese from 100 lbs. of milk containing from 2.5 to 6.0 per cent. fat, the lactometer readings of which range between 26 and 36. By means of this table cheese makers can calculate very closely the yields of cheese which certain quantities of milk will make; as it takes into consideration the non-fatty solids as well as the fat of the milk, the results obtained by the use of this formula will be more correct than those found by means of formula (I). The uncertain element in the formula lies in the factor

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[1] Investigations as to the relation between the quality of the milk and the yield of cheese have been conducted by a number of experiment stations; the following references give the main contributions published on this point: N. Y. (Geneva) exp. sta., reports 10-13, incl.; Wis. exp. sta., reports 11 and 12; Ont. Agr. College, reports 1894-'96, incl.; Minn. exp. sta. reports 1892-'94, incl.; Iowa exp. sta , bull. 21.

[2] For derivation of this formula, see Wisconsin experiment station, twelfth report, p. 105.

1.58, which, as shown above, is based on an average water content of 37 per cent. in the green cheese. This may, however, be changed to suit any particular case, e. g., 35 per cent ($\frac{100}{65}=1.54$), 40 per cent. ($\frac{100}{60}=1.67$), etc. The average percentages of water in green cheese found by Van Slyke in his investigations referred to above, were for the years 1892-'94, respectively, 36.41, 37.05 and 36.70 per cent.

224. c. From casein and fat. If the percentages of casein and fat in the milk are known, the yield of cheese may be calculated by the following formula, also prepared by Dr. Babcock:

$$\text{Yield of cheese} = 1.1\ f + 2.5\ \text{casein} \quad . \quad . \quad . \quad \text{(III)}.$$

This formula will give fairly correct results, but no more so than formula (II); it is wholly empirical.

CHAPTER XIII.

CALCULATING DIVIDENDS.

A.—CALCULATING DIVIDENDS AT CREAMERIES.

225. The simplest method of calculating dividends at creameries is to find the number of pounds of butter fat delivered to the creamery by each patron for a certain length of time, and then multiply this number by the price per pound of fat. Farmers are usually paid once a month for their milk at the factory. Each lot of milk is weighed when delivered at the creamery, and a small quantity thereof is saved for the composite sample, as previously explained under Composite tests (176). Some creameries test these samples at the end of each week, and others after collecting them for ten days or two weeks. If the four weekly composite samples of a patron's milk tested 3.8, 4.0, 3.9, 4.1 per cent., these four tests are added together, and the sum divided by 4; the result, 3.95 per cent., is used as the average test of this milk. By multiplying the total number of pounds of milk delivered by this patron, by his average test, the total weight in pounds of butter fat delivered to the factory during the month is obtained. This weight of fat is then multiplied by the price to be paid by the creamery per pound of butter fat; the product shows the amount of money due this patron for the milk delivered during the time samples were taken.

226. Price per pound of butter fat. The method of obtaining the price to be paid for one pound of butter fat varies somewhat in different creameries, on account of the different ways of paying for the cost of manufacturing the butter. The method to be followed is generally determined by agreement between the manufacturer and the milk producers, in case of proprietary creameries, or between the shareholders, in co-operative creameries. The following methods of paying for the cost of manufacture are at the present time met with in American creameries.

227. I. **Proprietary creameries.** *First.*—When the creamery is owned by some one person or company, the owner or owners agree to make the butter for 3 or 4 cents a pound; the difference between the total receipts of the factory and the amount due the owner is then divided between the different parties, according to the amount of butter fat contained in the milk which they delivered.

In the majority of cases, the price charged for making butter is now 4 cents a pound; $3\frac{3}{4}$ and $3\frac{1}{2}$ cents are sometimes charged. The larger the amount of milk received at a factory, the lower will naturally be the cost of manufacturing the butter.[1]

Second.—The proprietor of the creamery sometimes agrees to pay a certain price for 100 lbs. of milk delivered, according to its fat content, the price of milk containing 4 per cent. of butter fat being the standard. This price may change during the different seasons of the year by mutual agreement.

Third.—A creamery owner may offer to pay 1 to 2 cents, usually $1\frac{1}{2}$ cents, below the average market price of butter, for each pound of butter fat received in the milk.

228. II. **Co-operative creameries.** In this case, where the creamery is owned by the patrons, one of the stock-

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[1] Wisconsin experiment station, bull. 56, p. 26.

holders who is elected secretary attends to the details of running the factory and selling the product. His accounts show the amount of money received each month for the butter and other products sold, and the expenses of running the factory during this time. The expenses are substracted from the receipts, and the balance is divided among the patrons, each one receiving his proportionate share according to the amounts of butter fat delivered in each case (as shown by the total weight and the average test of milk delivered during this time).

In nearly all cases, the farmers receive about eighty pounds of skim milk for each hundred pounds of whole milk they deliver to the factory, in addition to the amount received for the milk, calculated according to one or the other of the preceding methods.

229. Illustrations of calculations of dividends. In order to illustrate the details of calculating dividends, or the amount to be paid each patron for the milk supplied each month, when payments are made by each of the four systems given, it will be assumed that a creamery receives 5000 pounds of milk daily for thirty days, and makes 6650 lbs. of butter from the 150,000 lbs. of milk received during this time. The average test of this milk may be found by multiplying the total weight of milk delivered by each patron by his average test, and dividing the sum of these products by the total weight of milk received at the creamery (in the example given, by 150,000), the quotient being multiplied by 100. Such calculations may show that, e. g., 5700 lbs. of butter fat have been received in all in the milk delivered by the different patrons; this multiplied by 100 and divided by

150,000 gives 3.8 as the average test, or the average amount of butter fat in each 100 lbs. of milk received during the month.

So far, the method of calculation is common for all different systems of payment given above; the manner of procedure now differs according to the agreement made between owner and patrons, or between the shareholders, in case of co-operative creameries.

230. I. *First.*—If the net returns for the 6650 lbs. of butter sold during the month were $1197, and the creamery is to receive 4 cents per pound of butter as the cost of manufacture, etc., the amount due the creamery is 6650×.04=$266, and the patrons would receive $1197—$266=$931. This sum, $931, is to be paid to the patrons for the 5700 lbs. of butter fat, which, as shown above, was the weight of fat contained in the 150,000 lbs. of milk delivered during the month. The price of one pound of butter fat is then easily found: $931÷5700= 16⅓ cents. This price is paid to all patrons for each pound of butter fat delivered in their milk during the month. The monthly milk record of three patrons may, e. g., be as given in the following table:

Patrons	First week.		Second week		Third week		Fourth week		Total Milk lbs.	Average Test, per cent.
	Milk lbs.	Test pr.ct.	Milk lbs.	Test per ct.	Milk lbs.	Test pr.ct.	Milk lbs.	Test per ct.		
No. 1.....	3500	3.6	3000	3.5	3600	3.65	3450	3.45	13,550	**3.55**
" 2.....	700	3.8	665	3.8	720	3.6	750	3.7	2,825	**3.73**
" 3.....	2480	4.2	2000	3.8	1850	4.0	1500	3.6	7,830	**3.90**

Multiplying each patron's total milk by his average test gives the number of pounds of butter fat in his milk, and this figure multiplied by .16⅓ shows the money due for his milk, as given below:

Patron.	Total milk lbs.	Average test per cent.	Butter fat, lbs.	Price of fat per lb., cents.	Amounts due.
No. 1............	13,550	3.55	481.0	16⅓	$78.56
No. 2............	2,825	3.7	104.5	16⅓	17.06
No. 3............	7,830	3.9	305.4	16⅓	48.96

231. *Second.*—When the proprietor of a creamery agrees to pay a certain price for 100 lbs. of 4 per cent.-milk, the receipts for butter sold and the price per pound of butter do not enter into the calculation of the amount due each patron for his milk; but the weight and the test of each patron's milk are just as important as before. If it is agreed to pay 66 cents per 100 lbs. of 4 per cent.-milk (i. e., milk containing 4 per cent. of butter fat), the price of one pound of butter fat will be $66 \div 4 = 16\frac{1}{2}$ cents, and the amount due each patron is found by multiplying the total weight of butter fat in his milk by this price. To facilitate this calculation, so-called *Relative-Value Tables* have been constructed, the use of which is explained below (237).

232. *Third.*—If a creamery agrees to pay for butter fat, say 1½ cents per pound below the average market price of butter each month, the price of one pound of butter fat is found by averaging the market quotations and subtracting 1½ cents therefrom. If the four weekly market prices were 17½, 17, 16½ and 19 cents, the average of these would be 17½ cents, and this less 1½ gives 16 cents as the price per pound of fat to be paid to the patrons; this price is then used in calculating the dividends as in case of first method (230).

Patron.	Total milk lbs.	Average test per cent.	Butter fat, lbs.	Price of fat per lb., cents.	Amounts due.
No. 1.............	13,550	3.55	481.0	16	$76.96
No. 2.............	2,825	3.7	104.5	16	16.72
No. 3.............	7,830	3.9	305.4	16	48.86

233. II. If the creamery is owned by the farmers, the running expenses for a month are subtracted from the gross returns received for the butter, and the price to be paid per pound of butter fat is found by dividing the amount left, by the total number of pounds of butter fat delivered during the month. This price is used for paying each patron for his milk according to the amount of fat contained therein, as already explained under *Proprietary Creameries* (230).

The monthly running expenses of a co-operative creamery generally include such items as the wages of the butter maker (and manager or secretary, if these officers are salaried), labor (hauling, helper, etc.), cost of butter packages, coal or wood, salt and other supplies, freight and commission on the butter sold, repairs and insurance on buildings, etc. A certain amount is also paid into a *sinking fund* (say 5 cents per 100 lbs. of milk), which represents the depreciation of the property, wear and tear of building and machinery, bad debts, etc. These items are added together, and their sum subtracted from the gross receipts for the butter sold during the month.

234. Assuming the receipts for the butter during the month to be $1197, and the running expenses of the factory $285, the amount to be divided among the patrons is $912; the quantity of butter fat received was 5700 lbs., and the price per pound of butter fat will therefore be 16 cents. The account will then stand as given in (232).

235. Other systems of payment. Besides these four systems of payment, there are various other agreements made between manufacturer and producer, but with them all the one important computation is the price to be paid per pound of butter fat; this forms the basis of calculating the factory dividends, when milk is paid for by the Babcock test.

236. Paying for butter delivered. In some instances patrons desire to receive pay for the quantity of butter which the milk delivered by them will make. This can be ascertained quite accurately from the total receipts and the total weights of both butter fat and butter. The total money to be paid for butter (the net receipts) are divided by the number of pounds of butter sold, to get the price to be paid per pound of butter; the total yield of butter divided by the total amount of butter fat delivered in the milk, gives the amount of butter corresponding to one pound of butter fat, and the pounds of fat delivered by each patron is then multiplied by this figure. This method requires more figuring than those given in the preceding, and the dividends are no more accurate, in fact less so, than when calculations are based on the price per pound of fat.

237. Relative-value tables. These tables give many of the multiplications used in computing the amount due for various weights of milk testing from 3 to 6 per cent. of fat. They can be easily constructed by any one as soon as the price of one pound of fat is determined in each case. If the price to be paid per pound of fat is, say 15 cents, the value of each 100 lbs. of milk of different quality is found by multiplying its test by 15. If the average tests of the different patrons' milk vary from 3 to 5 per cent., the relative-value table would be as follows:

3.0×15=45c.	per 100 lbs.	3.6×15=54c.	per 100 lbs.
3.1×15=46.5c.	"	3.7×15=55.5c.	"
3.2×15=48c.	"	3.8×15=57c.	"
3.3×15=49.5c.	"	3.9×15=58.5c.	"
3.4×15=51c.	"	4.0×15=60c.	"
3.5×15=52.5c.	"	etc.	

By continuing this multiplication, or adding the multiplier each time for each tenth of a per cent. up to 5 per cent. of fat, a table is made that can be used for calculating the amount due per 100 lbs. of milk, at this price per pound, and the weight of milk delivered by each patron is multiplied by the price per 100 lbs. of milk shown in the table opposite the figure representing his test.

Example: A patron supplies 2470 lbs. of milk, testing 3.2 per cent. of fat; price per pound of fat, 15 cents; he should then receive 24.70×.48=$11.85 (see above table). Another patron delivering 3850 lbs. of milk testing 3.8 per cent. will receive, at the same price per pound of fat, 38.50×.57=$21.94.

The relative value tables in the *Appendix* give the price per 100 lbs. of milk testing between 3 and 6 per cent. fat, when the price of three per cent. milk varies from 30 to 90c. per 100 lbs. In using the tables, first find the figure showing the price which it has been determined to pay for 100 lbs. of milk of a certain quality, say 3 or 4 per cent.-milk; the figures in the same vertical column then give the price to be paid per 100 lbs. of milk testing between 3 and 6 per cent.

Example 1: It has been decided to pay 90 cents per 100 lbs. of 4 per cent.-milk. The figure 90 is then sought in the table in the same line as 4.0 per cent., and the vertical column in which it is found gives the price per 100 lbs. of 3 to 6 per cent.-milk. 3.8 per cent.-milk is thus worth 85 cents per 100 lbs. and 4.2 per cent.-milk, $1.01, under the conditions given. The prices of milk of other qualities are found in the same way.

Example 2: In the example referred to under Illustrations of calculating creamery dividends (I b, 231), the figures for the patrons No. 1, 2 and 3, would be as follows:

Patron.	Milk delivered, lbs.	Average test.	Price per 100 lbs. of milk, cents.	Amounts due.
No. 1	13550	3 55	58 5	$79 26
" 2	2825	3 7	61.0	17 23
" 3................	7830	3 9	64.0	50.11

238. Milk and cream dividends. When cream from farm hand separators or other sources is brought to a factory receiving and skimming whole milk, the cream patron's dividend should be calculated a little differently than that of the milk patron.

In one case the dividend is based on the weight and the test of cream and in the other on the weight and the test of milk; the difference between the two being represented by the fat left in the factory skim milk. This skim milk fat is included in the milk patron's dividend and consequently ought also to be allowed for in calculating the amount due the cream patron. Such an allowance can be very fairly made by multiplying the cream fat by 1.03. This is assuming that the one-tenth or more of fat returned to the milk patron in his skim milk is about three per cent. of the total fat in his whole milk.

Both milk and cream patron suffer the same manufacturing loss in the factory butter milk so that an equalization of the skimming losses is all that is necessary to put both on a uniform basis for calculating dividends.

239. The following illustration may help to make these calculations clearer. Milk patron No. 1 may deliver to the creamery during the month 5320 lbs. of milk testing 3.8 per cent. fat, which therefore contains $\left(\frac{5320\times3.8}{100}\right)$ 202 lbs. butter fat. If the price paid the patrons is 20c then the 202 lbs.$\times$20c amounts to $40.40 the money due this patron for his milk. If however another patron sent 485 lbs. of cream testing 22.0 per cent. fat to the same factory during the month the weight of fat in the cream is first found in the same way as in the milk. $\left(\frac{485\times22}{100}\right)$ =106.7 lbs. butter fat. Now instead of multiplying this butter fat by 20c as was done for the milk patron it must first be multiplied by 1.03 which makes the necessary allowance for the skim milk fat that the milk patron was paid for. $106.7\times1.03=109.9$ lbs. butter fat which is now multiplied by 20c per pound giving $21.98. This is the amount due the cream patron when both milk and cream are received at the same factory and the cream from both patrons is churned together.[1]

B.—Calculating Dividends at Cheese Factories.

240. The amount of cheese made from a certain quantity of milk depends, as before shown, in a large measure on the richness of the milk in butter fat (222). Rich milk will give more cheese per hundredweight than poor milk, and the increased yields will be nearly, but not entirely, proportional to the fat contents of the dif-

[1] 17th Report Wis. expt station, p. 90.

ferent kinds of milk. Since the quality of the cheese produced from rich milk is better than that of cheese made from thin milk and will demand a higher price, it follows that no injustice is done by rating the value of milk for cheese production by its fat content. This subject has been discussed frequently during late years in experiment station publications and in the dairy press (222). Among others, Babcock has shown that the price of cheese stands in a direct relation to its fat content.[1] Prof. Robertson, the Dairy Commissioner of Canada, is authority for the statement that the quality of the cheese made from milk containing 3.0 to 4.0 per cent. of fat was increased in value by one-eighth of a cent for every two-tenths of a per cent. of fat in the milk,[2] a figure which is fully corroborated by Dr. Babcock's results. The injustice of the "pooling system," by which all kinds of milk receive the same price, is evident from the preceding; if the milk of a certain patron is richer than that of others, it will make a higher grade of cheese, and more of it per hundredweight; hence a higher price should be paid for it.

Payment on the basis of the fat content of milk is, therefore, the most equitable method of valuing milk for cheese making, and in case of patrons of cheese factories as with creamery patrons, dividends should be calculated on the basis of the results obtained by testing the milk delivered. The testing may be conveniently arranged by the method of composite sampling, in the way already described for creameries (176).

[1] Wisconsin exp. station, 11th report, p. 134.

[2] Hoard's Dairyman, March 29, 1895.

241. Calculation of dividends. As with creameries, the first thing to be ascertained is the price to be paid per pound of butter fat. The factory records should show the number of pounds of cheese made from the total milk delivered to the factory during a certain time, generally one month, and the money received for this cheese. The cost of making the cheese and all other expenses that should be paid for out of the money received for the cheese, are deducted from the total receipts, and the difference is divided among the patrons in proportion to the amounts of butter fat delivered in the milk.

The weights of the milk delivered and the tests of the composite samples furnish data for calculating the quantities of butter fat to be credited to each patron. The money to be paid to the patrons is then divided by the total weight of butter fat delivered to the factory and the price of one pound of fat thus obtained. The money due each patron is now found by multiplying the total number of pounds of butter fat in his milk by this price per pound.

The illustrations already given for calculating patrons' dividends at creameries according to the various methods will serve equally well to show the manner in which dividends are calculated at a cheese factory. For the sake of clearness an example is given that applies directly to cheese factories.

242. Illustration of calculation of dividends. It may be assumed that 15,000 lbs. of green cheese is made from 150,000 lbs. of milk delivered to a factory in a month. According to the weighings and the tests made, the milk contained 5700 lbs. of butter fat. If the cheese sold at an average price of 7½ cents a pound, the gross receipts would be $1,125.00. The amount to be deducted from the gross receipts will depend on the agreement made between the factory operator and the patrons, in case of proprietary cheese factories, or between the shareholders and the maker, when the factory is run on the co-operative plan. As before we shall consider these systems separately.

243. I. **Proprietary cheese factories.** The owner of the factory generally agrees to make the cheese for a certain price per pound and to pay the patrons what is left after deducting this amount. If the price agreed on is 1½ cents per pound of green cheese, this would amount to $225 in the example given. Subtracting this sum from the gross receipts, $1,125, leaves $900, which is to be paid the patrons. The total amount of butter fat delivered by the patrons was 5700 lbs.; hence the price of one pound of butter fat will be 900÷5700=.1577, or 15.8 cents. Taking the figures for the three patrons already mentioned under Creamery Dividends, we then have:

Patron	Total milk, lbs.	Average test, per cent.	Butter fat, lbs.	Price per lb. of fat, cents.	Amounts due.
No. 1.........	13,550	3.55	481.0	15.8	$76.00
No. 2.........	2,825	3.7	104.5	15.8	16.51
No. 3.........	7,830	3.9	305.4	15.8	48.25

244. Co-operative cheese factories. The method of payment at co-operative cheese factories is nearly the same as that already given, except that a certain sum representing the expenses is subtracted from the gross receipts for the cheese, and the balance is divided among the patrons according to the amounts of butter fat furnished by each, in the same manner as in the above case, after the price of a pound of fat has been obtained.

The price per 100 lbs. of milk can be calculated in the same way as at creameries, by multiplying the test of each lot by the price per pound of fat.[1]

[1] Suggestions regarding the organization of co-operative creameries and cheese factories will be found in the *Appendix*, following Table XV. Draft of constitution and by-laws for co-operative factory associations are also given in the *Appendix*. It is hoped that these will prove helpful to farmers who are about to form such associations.

CHAPTER XIV.

CHEMICAL ANALYSIS OF MILK AND ITS PRODUCTS

245. An outline of the methods followed in determining quantitatively the main components of milk and its products is given in the following for the guidance of more advanced dairy students. This work cannot be done outside of a fairly well-equipped chemical laboratory, or by persons who have not been accustomed to handling delicate chemical apparatus and glassware, analytical balances, etc., and who have not a knowledge of at least the elements of chemistry and chemical reactions.

A.—MILK.

246. In a complete milk analysis, the specific gravity of the milk is determined, and the following milk components: water, fat, casein and albumen, milk sugar, and ash. The methods of analysis described in the following are those used in the chemical laboratory of the Wisconsin experiment station, which in the main are the same as those adopted by the Association of Official Agricultural Chemists, and with but slight modifications, in general use in the chemical laboratories of all American experiment stations and agricultural colleges.[1]

247. a. **Specific gravity** is determined by means of a picnometer or specific-gravity bottle, since more accurate

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[1] The methods of analysis adopted by the Association of Official Agricultural Chemists are published annually by the Chemical Division of the U. S. Department of Agriculture; see Bull, No. 46, revised edition, p 54.

results will thus be reached than by using an ordinary Quevenne lactometer. A thermometer is ground into the neck of the specific-gravity bottle so as to form a stopper, and the bottle is provided with a glass stoppered side-tube, to furnish an exit for liquids on expanding. A specific-gravity bottle holding 100 grams of water is preferably used. The empty and scrupulously cleaned bottle is first weighed on a chemical balance. The bottle is then filled with recently-boiled distilled water of a temperature below 60° F. (15.5° C.); the thermometer is inserted, and the bottle is warmed slightly by immersing it for a moment in tepid water and left standing until the thermometer shows 60° F.; the opening of the side tube is then wiped off and closed with the stopper, and the water on the outside of the bottle and in the groove between its neck and the thermometer is wiped off with filter paper or a clean handkerchief, when the bottle is again weighed. The weight being recorded, the bottle is emptied and dried in a water oven, or if sufficient milk is at hand, the bottle is repeatedly rinsed with the milk, the specific gravity of which is to be determined. It is then filled with milk in a similar manner as in case of water; the temperature of the milk should be slightly below 60° F. and is slowly brought up to this degree after the bottle has been filled, proceeding in the same way as before with water; the weight of the bottle and milk is then taken.

The weights of water and of milk contained in the specific-gravity bottle are found by subtracting the weight of the empty bottle from the second and the third weights, respectively, and the specific gravity of the milk then found by dividing the weight of the milk by that of the water.

Example: Weight of sp. gr. bottle+water...146.9113 grams.
Weight of sp. gr. bottle empty..... 46.9423 "

Weight of water............. 99.9690 grams.
Weight of sp. gr. bottle+milk.....149.8708 grams.
Weight of sp. gr. bottle empty..... 46.9423 "

Weight of milk..............102.9285 grams.

$$\text{Sp. gr. of milk} = \frac{102.9285}{99.969} = 1.0296$$

248. If a plain picnometer without a thermometer attached, is available, the method of procedure is similar to that described, with the difference that the temperature of the water and of the milk must be brought to 60° F. before the picnometer is filled, or the picnometer filled with either liquid is placed in water in a small beaker, which is very slowly warmed to 60° F. and kept at this temperature for some time so as to allow the liquid in the picnometer to reach the temerature desired; the temperature of the water in the beaker is ascertained by means of an accurate chemical thermometer. The perforated stopper is then wiped off, the picnometer is taken out of the water, wiped and weighed. It is necessary to weigh very quickly if the room temperature is much above 60° F., as in such cases the expanding liquid will flow on to the balance pan, with a resultant loss in weight from evaporation.

The weights of specific-gravity bottle or picnometer, empty and filled with water, need only be determined a couple of times, and the averages of these weighings are used in subsequent determinations.

249. Westphal balance. Where only a small amount of milk is available, or in rapid work, the specific gravity may be taken with considerable accuracy by means of a Westphal balance. The arrangement and use of this convenient little apparatus is readily explained verbally.

For the determination of the specific gravity of *loppered milk*, see 260.

250. b. **Water.** The milk is weighed into a perforated copper tube filled with prepared dry asbestos. The tubes are made from perforated sheet copper, with holes about .7 mm. in diameter and about .7 mm. apart; they are 60 mm. long, 20 mm. in diameter and closed at the bottom. The asbestos is prepared from clean fibrous asbestos, which is ignited at low heat in a muffle oven, treated with a little dilute HCl (1 : 3) and then with distilled water till all acid is washed out; it is then torn in loose layers and dried at a low temperature in an air bath; when dry it can be easily shredded in fine strings and is placed in a wide-mouth, glass-stoppered bottle.

About two grams of asbestos are placed in each tube, packing it rather loosely; the tube is then weighed, a small narrow beaker being inverted over it on the scale pan. 5 cc. of milk are now dropped on to the asbestos from a 5 cc. fixed pipette, the beaker again placed over the tube, and the weight of the 5 cc. of milk delivered +copper tube taken. The weight of the milk is obtained by difference. The tubes are then placed in a steam oven and heated at 100° C. until they no longer decrease in weight, which ordinarily will take about three hours. Place in desiccator until cold, and weigh; the difference between the weight of the tube+milk and this last weight gives the water contained in the milk, which is then calculated in per cent. of the quantity of milk weighed out.

Example: Weight of tube+beaker+milk........29.3004 grams.
Weight of tube+beaker..................24.1772 "

Milk weighed out.................... 5.1232 grams.
Weight of tube+beaker+milk........29.3004 grams.
Weight of tube+beaker+milk, dry 24.9257 "

Weight of water.................... 4.3747 grams.

Per cent of water in milk $=\frac{4.3747\times100}{5.1232}=85.39$ per cent.

Note. The per cent. of *total solids* in milk is often given, instead of that of water; this may be readily obtained by subtracting the weight of the empty tube from that of the tube filled with milk solids, and finding the per cent. of the milk weighed out which this difference makes. In the above example, the weight of milk solids thus is $24.9257-24.1772=.7485$ grams, and the per cent. of total solids in the milk $=14.61$ per cent.

251. Alternate method. Five cc. of milk are measured out on a weighed flat porcelain dish (50–60 mm. in diameter; porcelain crucible covers will answer the purpose better than any other vessel on the market, provided the handle be broken off or ground off level on an emery wheel); this is weighed rapidly; two or three drops of 30 per cent.-acetic acid are added, and the dish is dried in a steam oven at 100° C. until no further loss in weight is obtained. After cooling in desiccator, the weight of the milk solids is obtained, and by calculation as before, the per cent. of water or total solids in the milk.

252. c. Fat. The dried tubes from the water determination are placed in Caldwell extractors and connected with weighed, numbered glass flasks (capacity, 2–3 oz.); the extractors are attached to upright Liebig condensers and the tubes extracted with pure ether, free from water, alcohol or acid, until all fat is dissolved; 4–5 hours' extraction is sufficient; in case of samples of skim milk it is well to continue the extraction for at least 6 hours. The ether is then distilled off and recovered, and the flasks dried in a copper oven until constant weight; after cooling they are weighed, and the amount of fat contained in the quantity of milk originally weighed into the tubes is thus ascertained, and the per cent. present in the milk calculated.

Example:	Weight of flask + fat....................	15.8039 grams.
	Weight of flask..........................	15.5171 "
	Weight of fat..................	.2868 grams.
Milk weighed out..		5.1232 grams.

Per cent. of fat in milk $= \frac{.2868 \times 100}{5.1232} = 5.60$ per cent.

253. d. **Casein and albumen.** The sum of these components is generally determined by the Kjeldahl method.[1] 5 cc. of milk are measured carefully into a flat-bottom 800 cc. Jena flask, 20 cc. of concentrated sulfuric acid (C. P.; sp. gr., 1.84) are added, and .7 gram of mercuric oxid (or its equivalent in metallic mercury); the mixture is then heated over direct flame until it is straw-colored or perfectly white; a few crystals of potassium permanganate are now added till the color of the liquid remains green. All the nitrogen in the milk has then been converted into the form of ammonium sulfate. After cooling, 200 cc. of ammonia-free distilled water are added, 20 cc. of a solution of potassium sulfid (containing 40 grams sulfid per liter), and a fraction of a gram of powdered zink. A quantity of semi-normal HCl-solution, more than sufficient to neutralize the ammonia obtained in the oxidation of the milk, is now carefully measured out from a delicate burette (divided to $\frac{1}{20}$ cc.) into an

1 Fresenius' Zeitschrift, **22,** p. 366; U. S. Dept. Agr., Chem. Div., bull. 43.

Erlenmeyer flask, and the flask connected with a distillation apparatus. At the other end, the Jena flask containing the watery solution of the ammonium sulfate is connected, after adding 50 cc. of a concentrated soda solution (1 pound "pure potash" dissolved in 500 cc. of distilled water and allowed to settle); the contents of the Jena flasks are now heated to boiling, and the distillation is continued for forty minutes to an hour, until all ammonia has been distilled over.

The excess of acid in the Erlenmeyer receiving-flask is then accurately titrated back by means of a tenth-normal standard ammonia-solution, using a cochineal-solution[1] as an indicator. From the amount of acid used, the per cent. of nitrogen is obtained; and from it, the per cent. of casein and albumen in the milk by multiplying by 6.25.[2] The amount of nitrogen contained in the chemicals used is determined by blank experiments and deducted from the nitrogen obtained as described.

Example: The weight of 5 cc. of milk (as obtained in determining the water in the milk) was 5.1465 grams. 5 cc. of standard HCl are added to the receiver, and 1.55 cc. of $\frac{N}{10}$ alkali-solution are used in titrating back the excess of acid. 1.55 cc. of $\frac{N}{10}$ alkali $= \frac{1.55}{5} = .51$ cc. $\frac{N}{2}$ acid-solution; the ammonia distilled over therefore neutralized $5.00 - .51 = 4.49$ cc. acid. By blank trials it was found that the reagents used furnish an equivalent of .02 cc. acid in the distillate; this quantity subtracted from the acid-equivalent of the nitrogen of the milk leaves 4.47 cc. 1 cc. semi-normal HCl-solution corresponds to 7 milligrams or .007 grams of nitrogen; 4.47 cc. $\frac{N}{2}$ HCl therefore

1 Sutton, Volumetric Analysis, 4th edition, p. 31.

2 The factor 6.30 or 6.37 is more correct for the albuminoids of milk, but has not yet been generally adopted, (p. 15, foot note).

represents .03129 grams of nitrogen. This quantity of nitrogen was obtained from the 5.1465 grams of milk measured out; the milk therefore contains $\frac{.03129 \times 100}{5.1465} = .608$ per cent. of nitrogen, and $.608 \times 6.25 = 3.80$ per cent. of casein and albumen.

254. *Casein and albumen* may be determined separately by Van Slyke's method:[1] 10 grams of milk are weighed out and diluted with about 90 cc. of water at 40°–42° C. 1.5 cc. of a 10 per cent. acetic-acid solution are then added; the mixture is well stirred with a glass rod and the precipitate allowed to settle for 3–5 minutes. The whey is decanted through a filter and the precipitate washed two or three times with cold water. The nitrogen is determined in the filter paper and its contents by the Kjeldahl method; blank determinations with the regular quantities of chemicals and the filter paper used are made, and the nitrogen found therein deducted. The per cent. of nitrogen obtained multiplied by 6.25 gives the per cent. of casein in the milk.

255. *Albumen* is determined in the filtrate from the casein-precipitate; the filtrate is placed on a water bath and heated to boiling temperature of water for ten to fifteen minutes. The washed precipitate is then treated by the Kjeldahl method for the determination of nitrogen; the amount of nitrogen multiplied by 6.25 gives the amount of albumen in the milk. The difference between the total nitrogenous components found by the Kjeldahl method, and the sum of the casein and the albumen, as given above, is due to the presence in milk of a third class of nitrogen compounds. (18).

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[1] Bulletin No, 43, p. 189, Chemical Division, U. S. Dept. of Agriculture.

256. e. **Milk sugar** is generally determined by difference, the sum of fat, casein and albumen, (total $N \times 6.25$), and ash, being subtracted from the total solids. It may be determined directly by means of a polariscope, or gravimetrically by Fehling's solution; only the former method, as worked out by Wiley,[1] will be given here.

The specific gravity of the milk is accurately determined, and the following quantities of milk are measured out by means of a 100 cc. pipette graduated to .2 cc. (or a 64 cc. pipette made especially for this purpose, with marks on the stem between 63.7 and 64.3 cc.), according to the specific gravities given: 1.026, 64.3 cc.; 1.028, 64.15 cc.; 1.030, 64.0 cc.; 1.032, 63.9 cc.; 1.034, 63.8 cc.; 1.036, 63.7 cc. These quantities refer to the Schmidt-Haensch half-shadow polariscopes, standardized for a normal weight of 26.048 grams of sugar. The milk is measured into a small flask graduated at 100 cc. and 102.6 cc.; 30 cc. of mercuric-iodid solution (prepared from 33.2 grams potassium iodid, 13.5 grams mercuric chlorid, 20 cc. glacial acetic acid and 640 cc. water) are added; the flask is filled to 102.6 cc. mark with distilled water, the contents mixed, filtered through a dry filter, and when the filtrate is perfectly clear, the solution is polarized in a 200 millimeter tube. The reading of the scale divided by 2, shows the per cent. of lactose (milk sugar) in the milk. Take five readings of two different portions of the filtrate, and average the results.

257. f. **Ash.** About 20 cc. of milk are measured into a flat-bottom porcelain dish and weighed; about one-half of a cc. of 30 per cent.-acetic acid is added, and the milk

1 Agricultural Analysis, iii, p. 275; Am. Chem. Jour., 6, p. 289 et. seq.

first dried on water bath and then ignited in a muffle oven at a low red heat. Direct heat should not be applied in determining the ash of milk, since alkali chlorids are likely to be lost at the temperature to which milk solids have to be heated to ignite all organic carbon.

Example: Weight of porcelain dish+milk.....49.0907 grams.
Weight of porcelain dish...............28.3538 grams.

Weight of milk..............20.7369 grams.
Weight of dish+milk, after ignition 28.5037 grams.
Weight of dish..............................28.3538 grams.

Weight of milk ash........ .1499

$$\text{Per cent. of ash} = \frac{.1499 \times 100}{20.7369} = .72 \text{ per cent.}$$

The residue from the determination of solids (251) may also be used for the ash determination.

258. Acidity of milk. The acidity of milk is conveniently determined by means of Farrington's alkaline tablets (see p. 120), or by one-tenth normal soda solution. In the latter case, 20 cc. of milk are measured into a porcelain casserole; a few drops of an alcoholic phenolphtalein solution are added, and soda solution is dropped in slowly from a burette until the color of the milk remains uniformly pinkish on agitation. 1 cc. of $\frac{N}{10}$ alkali corresponds to .009 grams lactic acid, or to .045 per cent., when 20 cc. of milk are taken (see p. 112).

B.—Cream, Skim milk, Butter milk, Whey, Condensed milk.

259. The analysis of these products is conducted in the same manner as in case of whole milk, and the same constituents are determined, when a complete analysis is wanted. Skim milk, butter milk, and whey generally contain only small quantities of solids, and especially of fat, and it is, therefore, well to weigh out a larger quantity than in case of whole milk; if possible, toward 10 grams. The acidity of sour milk and butter milk must be neutralized with sodium carbonate previous to the drying and extraction, as lactic acid is soluble in ether and would thus tend to increase the ether-extract (fat), if not combined with an alkali previous to the extraction.

260. Specific gravity of butter milk. The specific gravity of butter milk (as well as of sour or loppered milk) is determined by Weibull's method; a known volume of the milk is mixed with a certain amount (say 10 per cent.) of ammonia of a definite specific gravity, and the specific gravity of the liquid determined after thorough mixing and subsequent standing for an hour. If *A* designate the volume of butter milk taken, *B* that of ammonia, and *C* that of the mixture; and if furthermore s designate the specific gravity of the butter milk, s_1 that of the ammonia, and s_2 that of the mixture, we have

$$S = \frac{Cs_2 - Bs_1}{A}$$

Klein[1] has modified this method by weighing the liquids, thus securing greater accuracy; 22 to 24 per cent.-ammonia is used, one-tenth as much being taken as the amount of milk weighed out. The results come uniformly .0005 too high, and this correction should always be made. The following formula will give the specific gravity of the milk, which in case of careful work will be accurate to one-half lactometer degree; if the letters given above designate weights (instead of volume as before) and specific gravities of the liquids, respectively, we have

$$S = \frac{A}{\frac{C}{s_2} - \frac{B}{s_1}}$$

1 Milchzeitung, 1896, p. 656.

261. Condensed milk. The same methods are, in general, followed in the analysis of condensed milk as with whole milk. Condensed milk is preferably diluted with three times its weight of water prior to the analysis, both because such a solution can be more easily handled than the undiluted thick condensed milk, and the errors of analysis are thereby reduced, and because the fat is not readily extracted except when the milk has been diluted. The same constituents are determined as in case of whole milk, viz., solids, fat, casein and albumen, ash, milk sugar, and cane sugar (if any has been added to the milk). The milk sugar is determined by difference; if the student has a knowledge of the manipulation of the polariscope and has had experience in gravimetric sugar analysis, the milk sugar is determined gravimetrically, and the cane sugar by the difference between the polariscope reading after inversion and the milk sugar present.

The *specific gravity of condensed milk* may be determined by a method similar to that of McGill.[1] 50 gr. of the thoroughly mixed sample are weighed into a tared beaker and washed with warm water into a 250 cc. flask, cooled to 60°, filled to the mark and carefully mixed. The specific gravity of this solution (a) is then taken and the original density is calculated by means of the following formula:

$$\text{Sp. gr. of condensed milk} = \frac{1}{6-5a}$$

Concentration. The extent of concentration of condensed milk may be determined approximately by the formula devised by McGill (loc. cit.):

[1] Bulletin 54, Laboratory, Inland Rev. Dept., Ottawa, Canada.

$$\text{Concentration (c)} = \frac{a\,s}{a_1 s_1}$$

where a and s designate the solids not fat and specific gravity, respectively of the condensed milk, and a_1 and s_1 the corresponding data for the milk used. If $s_1 = 1.030$ and $a_1 = 9$ per cent., then $c = \frac{a\,s}{9.27}$ gives the concentration.

C.—BUTTER.

262. Sampling. A four- to eight-ounce sample of butter is melted in a tightly-closed pint fruit jar, shaken vigorously and cooled until the butter is hardened, the jar being shaken vigorously at short intervals during the cooling so as to keep the water of the butter evenly distributed in the mass.

263. a. **Determination of water.** Small pieces of butter (about 2 grams in all) are taken from the sample by means of a steel spatula and placed in glass tubes, seven-eighths of an inch in diameter and two and a half inches long, closed at the bottom by a layer of stringy asbestos, and filled two-thirds full of asbestos prepared as for milk analysis (250). The tubes are dried at 100° C. in a water oven, until no further loss in weight takes place, and are then cooled and weighed. The loss in weight shows the per cent. of water present.

264. b. **Fat.** The tubes are placed in Caldwell's extractors and extracted for four hours with anhydrous ether; the ether is then distilled off, and the flasks dried in the steam bath and weighed, the increase in weight giving the fat in the samples of butter weighed out.

265. c. **Casein.** 10 grams of butter are weighed into a small beaker provided with a lip, and treated twice with about 50 cc. of gasoline each time; the solution is filtered off, and the residue transferred to a filter and dried; its nitrogen content is then determined by the Kjeldahl method (253). The nitrogen in the filter and the chemicals used is determined by blank trials and deducted. The nitrogen multiplied by 6.25 gives the casein in the butter.

266. d. **Ash.** 1. 10 grams of butter are weighed into a porcelain dish and treated twice with gasoline, as in the preceding determination; the solution is filtered through an ash-free (quantitative) filter, and the filter when dry is transferred to the dish. The dish is heated in an air-bath for half an hour and then placed in a muffle oven, where the contents are burnt to a light greyish ash; the dish is now cooled in a desiccator and weighed. The difference between this weight and that of the empty dish gives the amount of ash in the butter weighed out.

267. 2. About two grams of butter are weighed into a small porcelain dish, half filled with stringy asbestos; the dish is dried for an hour in the water oven, and the fat then set fire to with a match, the asbestos fiber serving as a wick. When the flame has gone out, the dish is placed in a muffle oven, and the residue burnt to a greyish ash. After cooling, the dish is weighed, and the per cent. of ash in the butter calculated as under method 1.

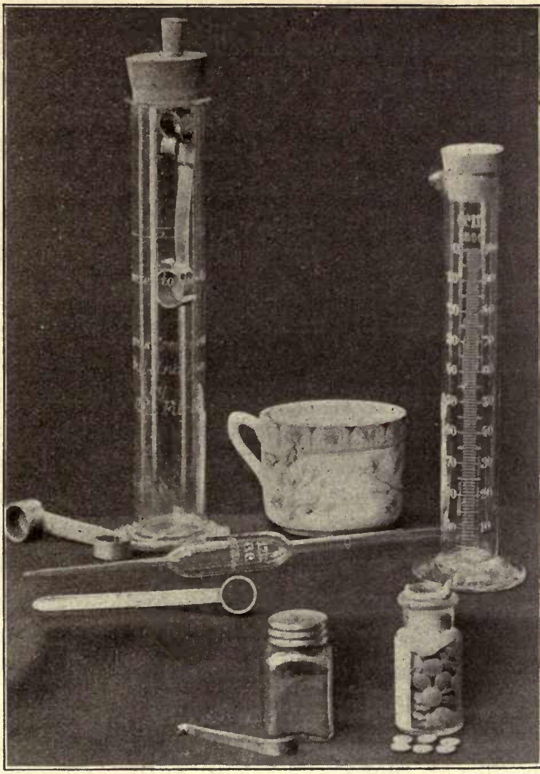
268. Complete analysis of butter in the same sample. About 2 grams of the butter are weighed into a platinum gooch half filled with stringy asbestos, and dried in a water oven at 100° C. to constant weight, cooled and weighed. The difference gives *water* in the sample. The gooch is then treated repeatedly with small portions of gasoline, suction being applied, and again dried in the water oven, cooled, and weighed; the *fat* in the sample is obtained from the difference between this and the preceding weight. The gooch is then carefully heated over direct flame until a light greyish ash is obtained; this operation is preferably done in a muffle oven to avoid possible loss of alkali chlorids. The loss in weight gives the *casein* in the sample weighed out, and the increase in the weight of the gooch over that of the empty gooch with asbestos, gives the *ash* (mainly salt) of the butter. The *salt* in the ash may be dissolved out by hot water, and the chlorin content of the solution determined by means of a standard silver-nitrate solution, using potassium chromate as an indicator.

269. A practical method of estimating the salt content of butter. A method of estimating the salt content of butter, which is applicable also outside of chemical laboratories, has been worked out jointly by Messrs. Alfred Vivian and C. L. Fitch.[1] The salt of the butter is dissolved in hot water, and a certain portion of the solution when cool is pipetted off and titrated with a silver-nitrate solution prepared by dissolving one silver-nitrate tablet in 50 cc. water, potassium chromate being used as an indicator. The silver nitrate tablets are sold for 60 cents per 100, which number is sufficient to make 100–150 tests. The method is advertised in the dairy press under the name of "Fitch's Salt Analysis." Directions for making tests by this method are furnished with the apparatus when this is bought. The price of a complete outfit is $4.50.

[1] Wis. Experiment Station, XVII Report, pp. 98-101; Hoard's Dairyman, February 15, 1901, article: "Uniform Salting of Butter."

DETECTION OF ARTIFICIAL BUTTER.

270. Determination of the specific gravity of the filtered butter fat serves as a good preliminary test. A



Apparatus used in "Fitch's Salt Analysis."

number of practical methods for the detection of artificial butter have been proposed, but they are either worthless, in case of samples containing a considerable proportion of natural butter, or give satisfactory results only in the hands of experts. The Reichert-Wollny method given in detail below is the standard method the world over, and the results obtained by it are accepted in the courts.

271. Filtering the butter fat. The butter to be examined is placed in a small narrow beaker and kept at 60° C. for about two hours. The clear supernatant fat is then filtered through absorbent cotton into a 200 cc. Erlenmeyer flask, taking care that none of the milky lower portion of the contents of the beaker be poured on the filter. In sampling the butter fat, it is poured back and forth repeatedly from a small warm beaker into the flask, and the quantity wanted is then drawn off with a warm pipette.

272. Specific gravity. This is generally determined at 100° C. The method of procedure is similar to that described under milk (248). The picnometer (capacity about 25 cc.) is filled with dry filtered butter fat, free from air bubbles; the fat is heated for 30 minutes in a beaker, the water in which is kept boiling. On cooling, the weight of picnometer and fat is obtained, and by calculation as usual, the specific gravity of the fat.

The specific gravity of pure natural butter fat at 100° C. ranges between .8650 and .8685, while artificial butter fat (i. e., fat from other sources than cows' milk) has a specific gravity at 100° C. of below .8610, and generally about .85.

273. Reichert-Wollny method (*Volatile Acids*). 5.75 cc. of fat are measured into a strong 250 cc. weighed saponification flask, by means of a pipette marked to deliver this amount, and the flask when cool is weighed again. 10 cc. of 95 per cent.-alcohol and 2 cc. of a concentrated soda solution (1 : 1) are then added to the flask which is securely stoppered with a cork stopper tied down with a piece of twine. The flask is heated for an hour on the water bath, being gently rotated from time to time in order to facilitate the saponification. The flask is then uncorked, the alcohol evaporated slowly and the heating continued until the last traces of alcohol are gone.

100 cc. of recently boiled distilled water are now added, and the flask heated on the water bath until the soap formed is completely dissolved. When cooled to about 70° C., 40 cc. of dilute sulfuric acid (25 cc. conc. H_2SO_4 per liter) are added to the soap solution to decompose the soap into free fatty acids and glycerol. The flask is restoppered and heated until the insoluble fatty acids separated out form a clear oily layer on the surface of the acid solution in the flask. After cooling to room temperature, a few pieces of pumice stone (prepared by throwing the pieces at a white heat into distilled water and keeping them under water until used) are added, the flask connected with a glass condenser, heated slowly till boiling begins, and the contents then distilled at such a rate as will bring 110 cc. of the distillate over in as nearly thirty minutes as possible.

The distillate is mixed thoroughly and filtered through a dry filter; 100 cc. of the filtrate are poured into a 250 cc. beaker and titrated with a deci-normal barium-hydrate solution, half a cubic centimeter of phenolphtalein solution being used as an indicator. A blank test is made in the same manner as described, and the amount of alkali solution used deducted from the results obtained with the samples analyzed. The number of cubic centimeters of barium-hydrate solution used is increased by one-tenth, and the so-called *Reichert number* thus obtained.

The Reichert number for pure butter fat will ordinarily come above 24 cc.; butter fat from stripper cows will have a low Reichert number. Pure olemargarine will have a Reichert number of 1–2 cc.; and mixtures of artificial and natural butters will give intermediate numbers.

274. Renovated or process butter. For detection and examination of renovated or "process" butter, see Cochran *Journ. Frankl. Inst.*, 1899, p. 94; *Analyst*, 1899, p. 88.

D.—Cheese.

For method of sampling, see p. 89.

275. a. **Water.** Five grams of cheese cut into very thin slices are weighed into a small porcelain dish filled about one-third full with freshly-ignited stringy asbestos; the dish is placed in a water oven and heated for ten hours. The loss in weight is taken to represent water.

276. b. **Fat.** About 5 grams of cheese are ground finely in a small porcelain mortar with about twice its weight of anhydrous copper sulfate, until the mixture is of a uniform light blue color and the cheese evenly distributed throughout the mass. The mixture is transferred to a glass tube of the kind used in butter analysis (263), only a larger size; a little copper sulfate is placed at the bottom of the tube, then the mixture containing the cheese, and on top of it a little extracted absorbent cotton or ignited, stringy asbestos; the tube is placed in an extraction apparatus and extracted with anhydrous ether for fifteen hours. The ether is then distilled off, the flasks dried in a water oven at 100° C. to constant weight, cooled and weighed. The method is apt to give too low results and, therefore, not to be preferred to the Babcock test for cheese (102).

277. c. **Casein** (total nitrogen × 6.25). About 2 grams of cheese are weighed out on a watch glass and transferred to a Jena nitrogen flask, and the nitrogen in the sample determined according to the Kjeldahl method (253); the percentage of nitrogen multiplied by 6.25 gives the total nitrogenous components of the cheese.

278. d. **Ash.** The residue from the water determination is taken for the ash; it is preferably set fire to, in the same manner as explained under determination of ash in butter (267), before it is placed in the muffle oven and incinerated. The increase in the weight above that of the empty dish + asbestos, gives the amount of ash in the sample weighed out.

279. e. **Other constituents.** The sum of the percentages of water, fat, casein and ash, subtracted from 100, will give the per cent. of other constituents, organic acids, milk sugar, etc., in the cheese.

Detection of Oleomargarine Cheese ("Filled" Cheese).

280. About 25 grams of finely-divided cheese are extracted with ether in a Caldwell extractor or a paper extraction cartridge; the ether is distilled off, and the fat dried in the water oven until there is no further loss in weight. 5.75 cc. of the clear fat are then measured into a 250 cc. saponification flask and treated according to the Reichert-Wollny method, as already explained under *Detection of Artificial Butter* (270).[1]

Tests for Adulteration of Milk and Cream.

281. The **nitric acid** test may prove useful as corroborative evidence that a sample of milk has been watered (123). Normal fresh milk does not contain nitrates, while common well-water, particularly on farms where precautions to guard against contamination of the water supply have not been taken, in general contains appreciable amounts of nitrates, nitrites and ammonia compounds, and watered milk will, therefore, in such cases also contain nitrates.[2] The method for detection of small amounts of nitrates in milk, as given by Richmond[3] is as follows: Place a small quantity of diphenylamin at the bottom of a porcelain dish, and add to it about 1 cc. of pure H_2SO_4 (conc.); allow a few drops of the milk serum (obtained by adding a little acetic acid to the milk and warming) to flow down the sides of the dish and over the surface of the acid. If a blue color developes in the course of ten minutes, though it may be faint, it shows the presence of nitrates, after ten minutes a reddish-brown color is always developed from the action of the acid on the serum. There should be no difficulty in detecting an addition of 10 per ct. of water to the milk by this test, if the water added contained 5 parts of nitric acid, or more, per 100,000.

Besides by the methods given in the preceeding (pp. 101–107), watering or skimming of milk may be detected

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1 See Arb. Kais. Ges.-Amt., 14, 506–598.
2 Uffelmann, Deutsche Vierteljahresschr. f. öff. Ges.-pfl. 15, p. 663.
3 The Analyst, 1893, p. 272.

by determing the specific gravity of *a*, the skim milk, *b*, the milk serum, and *c*, the whey.

282. a. **Specific gravity of skim milk.** The milk is set in a flat porcelain or glass dish for 12–24 hours in a cold room; the layer of cream formed is then skimmed off, and the sp. gr. of the skim milk determined at 60° F. Skim milk has a sp. gr. of .002 to .0035 (2 to 3.5 lactometer degrees) above that of the corresponding whole milk; a smaller difference than this indicates that the milk was skimmed. If both skimming and watering had been practiced, the difference given above might be obtained, but the analysis of the milk would in such case easily disclose the adulteration.

283. b. **Specific gravity of the milk serum.** To 100 cc. milk 2 cc. of 20 per ct.-acetic acid are added, and the mixture heated in a covered beaker or closed flask for 5–10 min. on a water-bath at 55–65° C. After cooling, the milk serum is filtered off and its sp. gr. determined at 60° F. In case of pure milks, the sp. gr. of the milk serum (at 60°) will come above 1.0270. Serum from normal milks contain 6.3 to 7.5 per ct. solids and .22 to .28 per ct. fat; by the addition of 10 per ct. of water, the solids in the serum are lowered .3 to .5 per ct., and the sp. gr., .0005.[1]

c. **Specific gravity of whey.** 500 cc. of milk are warmed in water of 40–50° C. until its temperature is 35° C.; one-half cc. of rennet extract (12–15 drops) is added, and the milk stirred thoroughly. After allowing the curd to solidify for 10 minutes, it is cut and the whey filtered off through several layers of cheese cloth. The

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[1] König, Menschl. Nahrungsmittel II, p. 276.

whey must be clear; it is cooled to 15° C. and its sp. gr. determined. The sp. gr. of whey from normal milk obtained in the manner given will range between 1.027 and 1.031. A sp. gr. of 1.026 or below indicates watering. An addition of 4 per ct. of water lowers the sp. gr. of the whey about 1 lactometer degree.[1]

284. Detection of coloring matter. Milk which has been watered or skimmed, or both, is sometimes further adulterated by unscrupulous milk peddlers through the addition of a small quantity of cheese color; this will mix thoroughly with the milk, and, if added judiciously, will impart a rich cream color to it. The presence of foreign coloring matter in milk is easily shown by shaking 10 cc. of the milk with an equal quantity of ether; on standing, a clear ether solution will rise to the surface; if artificial coloring matter has been added to the milk, the solution will be yellow colored, the intensity of the color indicating the quantity added; natural fresh milk will give a colorless ether solution.

A method given by Wallace[2] is claimed to detect one part of coloring matter in 100,000 of milk.

Inorganic coloring matter like chromates and bichromates have, although fortunately rarely, been used to impart a rich color to adulterated milk or poor cream. Chromates may be detected by the reddish yellow color produced when a little 2 per cent.-silver nitrate solution is added to a few cubic centimeters of the milk.

285. Detection of pasteurized milk or cream. Prof. Storch, of Copenhagen, Denmark,[3] in 1898 published a

[1] Siats, Unters. landw. wicht. Stoffe, p. 88.
[2] N. J. Dairy Commissioner, report, 1896, p. 36.
[3] 40th report, Copenhagen experiment station.

simple method for ascertaining whether milk, cream, butter or other dairy products have been heated to at least 176° F. (80° C.). The test is made as follows: A teaspoonful of the milk is poured into a test tube, and 1 drop of a weak solution of peroxid of hydrogen (2 per cent.) and 2 drops of a paraphenylenediamin-solution (2 per cent.) are added. The mixture is then shaken; if a dark violet color appears at once, the milk has not been heated, or at any rate not beyond 176° F. If a sample of butter is to be examined, 25 grams are placed in a small beaker and melted by being placed in water of 60° C. The clear butter fat is poured off, and the remaining liquid is diluted with an equal volume of water. The mixture thus obtained is examined as in case of milk.

286. Boiled milk. The preceding test will serve to distinguish between raw and boiled milk, and also to ascertain if milk has been adulterated with diluted condensed milk. To what extent such an adulteration can be practiced without being detected by this or similar tests, has not been determined, but if a control test be made at the same time with a sample of milk of known purity, a small admixture of boiled (or diluted condensed) milk can doubtless be detected.[1]

287. Gelatine in cream. This method of adulteration is sometimes practiced in the city cream trade, to impart stiffness and an appearance of richness to the cream. To detect the gelatine, a quantity of the suspected cream is mixed with warm water, and acetic acid is added to precipitate the casein and fat (1.5 cc. of 10 per cent.-

[1] See also Siats, Unters. landw. wicht. Stoffe, p. 60, and Molkerei-Ztg. (Hildesheim), 1899, p. 677.

acetic acid per 10 cc. of cream is sufficient). The precipitate is filtered off, and a few drops of a strong *tannin* solution are added to the clear filtrate. Pure cream will give a slight precipitate, while in the presence of gelatine a copious precipitate will come down.

The picric-acid method has also been proposed for the detection of small quantities of gelatine in cream.[1]

288. Starch in Cream. Starch is mentioned in the dairy literature as an adulterant of milk and cream. It is doubtful, however, if it is ever used for this purpose at the present time. In the case of ice-cream, on the other hand, a small quantity of corn starch is often added to thicken the milk used. It may in such a case be readily detected by means of the iodin reaction. A solution of iodin will produce a deep blue color in the presence of starch; a small amount of iodin is taken up by the cream before the blue coloration appears.

289. Microscopic impurities (particles of hay, litter, woolen or cotton fibres, dung, etc.). These impurities may be separated by repeated dilution of the milk with pure distilled water, leaving the mixture undisturbed for a couple of hours each time before the liquid is syphoned off. When the milk has been entirely removed in this manner, the residue is filtered off, dried and weighed. A quart of milk or cream should not give any visible sediment on standing for several hours.

Detection of Preservatives in Dairy Products.

290. a. **Boracic acid** (*borax, borates, preservaline, etc.*). 100 cc. of milk are made alkaline with a soda or potash solution, and then evaporated to dryness and incinerated.

[1] The Analyst, 1897, p. 320.

The ash is dissolved in water to which a little hydrochloric acid has been added, and the solution filtered. A strip of tumeric paper moistened with the filtrate will be colored reddish brown when dried at 100° C. on a watch glass, if boracic acid is present.

If a little alcohol is poured over the ash to which concentrated sulfuric acid has been added, and fire is set to the alcohol after a little while, it will burn with a yellowish green tint, especially noticeable if the ash is stirred with a glass rod and when the flame is about to go out.

291. The following modification of the first test given is said to show the presence of only a thousandth of a gram of borax in a drop of milk (about .15 per cent.):[1]

Place in a porcelain dish one drop of milk with two drops of strong hydrochloric acid and two drops of saturated tumeric tincture; dry this on the water bath, cool and add a drop of ammonia by means of a glass rod. A slaty blue color changing to green is produced if borax is present.[2]

292. b. **Bi-Carbonate of soda.** 100 cc. of milk to which a few drops of alcohol are added, are evaporated and carefully incinerated; the proportion of carbonic acid in the ash as compared with that of milk of known purity is determined. If an apparatus for the determination of carbonic acid is available, like the Scheibler apparatus, etc., the per cent. of carbonic acid per gram of ash (and quart of milk) can be easily ascertained. Normal milk ash contains only a small amount of carbonic acid (less than 2 per cent.), presumably formed from the citric acid of the milk in the process of incineration.

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[1] N. J. Dairy Commissioner, report 1896, p. 37.

[2] See also 139, 144.

The following qualitative test is easily made: To 10 cc. of milk add 10 cc. of alcohol and a little of a one-per cent. rosolic-acid solution. Pure milk will give a brownish yellow color; milk to which soda has been added, a rose red color. A control experiment with milk of known purity should be made.

293. c. **Fluroids.** 100 cc. of milk are evaporated in a platinum or lead crucible, and incinerated; the ash is made strongly acid with concentrated sulfuric acid. If fluorids are present, hydrofluoric acid will be generated on gentle heating and will be apparent from its etching a watch glass placed over the crucible.[1]

294. d. **Salicylic acid** (*salicylates, etc.*). 20 cc. of milk are acidulated with sulfuric acid and shaken with ether; the ether solution is evaporated, and the residue treated with alcohol and a little iron-chlorid solution; a deep violet color will be obtained in the presence of salicylic acid.

295. e. **Formalin.** (a forty-per cent. solution of *formaldehyde* in water). A solution of diphenylamin is made with water and just enough sulfuric acid to dissolve it. The milk to be tested, or better, the distillate therefrom, is added to this solution and boiled. If formalin be present, a white flocculent precipitate is formed; if the acid used contained nitrates, a green precipitate will be formed.

The following method by Hehner is stated to show the presence of 1 part of formaldehyde in 200,000 parts of milk: the milk is diluted with an equal volume of water,

[1] *Chromates* in dairy products may be readily determined by the use of a silver-nitrate solution, see Molkerei Ztg. (Berlin) 1899, p. 603.

and strong H_2SO_4 (sp. gr. 1.82–1.84) is added. A violet ring is formed at the junction of the two liquids if formaldehyde is present; if not, a slight greenish tinge will be seen. The violet color is not obtained with milks containing over .05 per cent. formaldehyde.[1]

[1] Chem. News, 1896, No. 71; Milchzeitung, 1896, 491; 1897, 40, 667; The Analyst, 1895, 152, 154, 157; 1896, 285.

APPENDIX.

Table I. Composition of milk and its products.

	No. of analyses.	Water.	Fat.	Casein and alb'men	Milk sugar.	Ash.	Authority.
		pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	
Cows' milk	793	87.17	3.69	3.55	4.88	.71	König.[5]
" "	....	87.75	3.40	3.50	4.60	.75	Fleischmann.
" "	900	87.40	3.75	3.10	5.10	.65	Van Slyke.
" "	2173	86.48	4.20	3.51[1]	....	[2].71	Holland.[6]
" "	120,540	87.1	4.1	....	....	....	Vieth.
Colostrum milk	42	74.57	3.59	17.64[3]	2.67	1.56	König.[5]
Cream	43	68.82	22.66	3.76	4.23	.53	"
Cream, Cooley	203	73.90	17.60	....	....	.62	Holland.[6]
Skim milk (gravity)	56	90.43	.87	3.26	4.74	.70	König.[5]
" " "	354	90.52	.32	....	....	....	Holland.[6]
Skim milk (centrifugal)	7	90.60	.31	3.06	5.29	.74	König.[5]
Butter milk	57	90.12	1.09	4.03	4.04	.72	"
" "	31	91.67	.27	....	....	....	Holland.[6]
Whey	46	93.38	.32	.86	4.79	.65	König.[5]
"	....	93.12	.27	.81	5.80		Van Slyke.
Condensed milk, (no sugar added)	36	58.99	12.42	11.92	14.49	2.18	König.[5]
Condensed milk, (sugar added)	64	25.61	10.35	11.79	50.06	2.19	"
Butter	302	13.59	84.39	.74	[4].62	.66	"
" sweet cream	10	12.93	84.53	.61	.68	1.25	"
" sour cream	11	13.08	84.26	.81	.66	1.19	"
" unsalted	78	13.73	84.82	1.33		.09	....
" World's Fair	350	11.57	84.70	.93		2.78	Farrington.
" American premium	9	10.23	85.74	.98		3.05	Morrow.
Cheese, cream	127	36.33	40.71	18.84	1.02	3.10	König.[5]
" full cream	143	38.00	30.25	25.35	1.43	4.97	"
" cheddar, green	....	36.84	33.83	23.72	5.61		Van Slyke.
" cheddar, cured	27	34.38	32.71	26.38	2.95	3.58	Drew.
" World's Fair mammoth	1	32.06	34.43	28.00	5.51		Shutt.
" half-skim	21	39.79	23.92	29.67	1.79	4.73	König.[5]
" skim	41	46.00	11.65	34.06	3.42	4.87	"
" centrifugal skim	....	50.5	1.2	43.1	....	5.2	Storch.

1 Forty-two analyses.
2 Eight analyses.
3 13.60 per cent. albumen.
4 .12 per cent. lactic acid.
5 Mostly European samples.
6 Massachusetts' samples.

Table II. State and city standards for dairy products.[1]

	Milk.			Skim-milk.	Cream.	Butter.	Cheese.
	Total solids.	Solids not fat.	Fat.	Total solids.	Fat.	Fat.	Fat.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
California	....	....	....	....	....	....	Full cream, 30 pr. ct. fat. Half skim, 15 pr. ct. fat. Skim, from skim milk.
Colorado	....	....	....	....	....	....	35 p. c. total sol. to be fat.
District of Columbia	[12.5]	9	3.5	9.3	20	83	
						Not over 12 per ct. water or 5 p. c. salt.	
Georgia	[12.0]	8.5	3.5				
Iowa	12.5	[9.5]	3	....	15		
Maine	12	[9.0]	3				
Massachusetts	13	9.3	3.7	9.3			
April–August	12	9	3				
Michigan	12.5	[9.5]	3				
	Sp. gr. 1.029–33	....	....	Sp. gr. 1.032–37			
Minnesota	13	[9.5]	3.5	....	20	....	45 p. c. total sol. to be fat.
Missouri	....	....	....	....		....	From milk testing at least 3 per ct. fat.
New Hampshire	13						
New Jersey	12						
New York[2]	12	[9]	3				
Ohio[2]	12	[9]	3	....	....	80	20 per ct. fat.
May and June	11.5						

Oregon	12	[9]	3 12 p. c. cream by vol.	Sp gr. 1.035	....	Not over 14 per ct. water.	
Pennsylvania (Cities 2d and 3d class.)	12.5 Sp. gr. 1.029–33	....	3	2.5 p. c. fat. 6 per ct. cream by vol. Sp. gr. 1.032–37	....	....	Full cream, 32 per ct. fat Three-fourths cream, 24 per ct. fat. One-half cream, 16 per ct. fat. One-fourth cream, 8 per ct. fat. Skim'd, below 8 p. c. fat.
Rhode Island	12	[9.5]	2.5				
South Carolina	[11.5]	8.5	3				
Vermont	12.5	9.25					
May and June	12						
Washington	[11]	8.0	3	....	....	....	Full cream, 30 p. c. fat. Half skim'd, 15 p. c. fat. Skim'd, from skim milk
Wisconsin	....	....	3				
City of Baltimore	12.0	....	....				
" Boston	13.0	....	....				
" Chicago	12.0	[9.0]	3.0				
" Denver	12.0						
" Omaha	12.0	....	....	....	16.0		
" Philadelphia	12.0	[8.5]	3.5	....	....		
" St. Louis	12.0	[9.2]	2.8	....	12.0 Solids 22 p. c.		
England (Soc. Pub. Analysts)	[11.5]	8.5	3 0				
France (Paris)	13.0	9.0	4.0				
Germany (Hambu'g)	Sp. gr. 1.029	....	2.7				
Switzerland (Berne)	12.5	9 0	3.5				

[1] State standards from Circ. 25, Bur. Animal Industry, U.S. Dept. of Agriculture.

[2] In New York and Ohio the milk solids of condensed milk shall be in quantity the equivalent of 12 per cent. of milk solids in crude milk, of which solids 25 per cent. shall be fat.

States not named have no laws prescribing standards for dairy products.

Table III. Quevenne lactometer degrees corresponding to N. Y. Board of Health degrees. (See p. 97.)

Bd. of Health degrees.	Quevenne scale.	Bd. of Health degrees.	Quevenne scale.	Bd. of Health degrees.	Quevenne scale.
60	17.4	81	23.5	101	29.3
61	17.7	82	23.8	102	29.6
62	18.0	83	24.1	103	29.9
63	18.3	84	24.4	104	30.2
64	18.6	85	24.6	105	30.5
65	18.8	86	24.9	106	30.7
66	19.1	87	25.2	107	31.0
67	19.4	88	25.5	108	31.3
68	19.7	89	25.8	109	31.6
69	20.0	90	26.1	110	31.9
70	20.3	91	26.4	111	32.2
71	20.6	92	26.7	112	32.5
72	20.9	93	27.0	113	32.8
73	21.2	94	27.3	114	33.1
74	21.5	95	27.6	115	33.4
75	21.7	96	27.8	116	33.6
76	22.0	97	28.1	117	33.9
77	22.3	98	28.4	118	34.2
78	22.6	99	28.7	119	34.5
79	22.9	100	29.0	120	34.8
80	23.2				

Table IV. Value of $\frac{100S-100}{S}$ for sp. gr. from 1.019 to 1.0369.

Sp. gr. (s)=	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
1.019	1.864	1.874	1.884	1.894	1.903	1.913	1.922	1.932	1.941	1.951
1.020	1.961	1.970	1.980	1.990	1.999	2.009	2.018	2.028	2.038	2.047
1.021	2.057	2.066	2.076	2.086	2.095	2.105	2.114	2.124	2.133	2.143
1.022	2.153	2.162	2.172	2.181	2.191	2.200	2.210	2.220	2.229	2.239
1.023	2.249	2.258	2.267	2.277	2.286	2.296	2.306	2.315	2.325	2.334
1.024	2.344	2.353	2.363	2.372	2.382	2.391	2.401	2.410	2.420	2.430
1.025	2.439	2.449	2.458	2.468	2.477	2.487	2.496	2.506	2.515	2.525
1.026	2.534	2.544	2.553	2.563	2.573	2.582	2.591	2.601	2.610	2.620
1.027	2.629	2.638	2.648	2.657	2.667	2.676	2.686	2.695	2.705	2.714
1.028	2.724	2.733	2.743	2.752	2.762	2.771	2.781	2.790	2.799	2.809
1.029	2.818	2.828	2.837	2.847	2.856	2.865	2.875	2.884	2.893	2.903
1.030	2.913	2.922	2.931	2.941	2.951	2.960	2.969	2.979	2.988	2.997
1.031	3.007	3.016	3.026	3.035	3.044	3.054	3.063	3.072	3.082	3.091
1.032	3.101	3.110	3.120	3.129	3.138	3.148	3.157	3.166	3.176	3.185
1.033	3.195	3.204	3.213	3.223	3.232	3.241	3.251	3.260	3.269	3.279
1.034	3.288	3.298	3.307	3.316	3.326	3.335	3.344	3.354	3.363	3.372
1.035	3.382	3.391	3.400	3.410	3.419	3.428	3.438	3.447	3.456	3.466
1.036	3.475	3.484	3.494	3.503	3.512	3.521	3.531	3.540	3.549	3.559

(See directions for use, p. 105).

Table V. Correction-table for specific gravity of milk.

Lactometer reading.	Temperature of milk (in degrees Fahrenheit).									
	51	52	53	54	55	56	57	58	59	60
20	19.3	19.4	19.4	19.5	19.6	19.7	19.8	19.9	19.9	20.0
21	20.3	20.3	20.4	20.5	20.6	20.7	20.8	20.9	20.9	21.0
22	21.3	21.3	21.4	21.5	21.6	21.7	21.8	21.9	21.9	22.0
23	22.3	22.3	22.4	22.5	22.6	22.7	22.8	22.8	22.9	23.0
24	23.3	23.3	23.4	23.5	23.6	23.6	23.7	23.8	23.9	24.0
25	24.2	24.3	24.4	24.5	24.6	24.6	24.7	24.8	24.9	25.0
26	25.2	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0
27	26.2	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9	27.0
28	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.0
29	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9	29.0
30	29.1	29.1	29.2	29.3	29.4	29.6	29.7	29.8	29.9	30.0
31	30.0	30.1	30.2	30.3	30.4	30.5	30.6	20.8	30.9	31.0
32	31.0	31.1	31.2	31.3	31.4	31.5	31.6	31.7	31.9	32.0
33	31.9	32.0	32.1	32.3	32.4	32.5	32.6	32.7	32.9	33.0
34	32.9	33.0	33.1	33.2	33.3	33.5	33.6	33.7	33.9	34.0
35	33.8	33.9	34.0	34.2	34.3	34.5	34.6	34.7	34.9	35.0
	61	62	63	64	65	66	67	68	69	70
20	20.1	20.2	20.2	20.3	20.4	20.5	20.6	20.7	20.9	21.0
21	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	22.0	22.1
22	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	23.0	23.1
23	23.1	23.2	23.3	23.4	23.5	23.6	23.7	23.8	24.0	24.1
24	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.9	25.0	25.1
25	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.9	26.0	26.1
26	26.1	26.2	26.3	26.5	26.6	26.7	26.8	27.0	27.1	27.2
27	27.1	27.3	27.4	27.5	27.6	27.7	27.8	28.0	28.1	28.2
28	28.1	28.3	28.4	28.5	28.6	28.7	28.8	29.0	29.1	29.2
29	29.1	29.3	29.4	29.5	29.6	29.7	29.9	30.1	30.2	30.3
30	30.1	30.3	30.4	30.5	30.7	30.8	30.9	31.1	31.2	31.3
31	31.2	31.3	31.4	31.5	31.7	31.8	31.9	32.1	32.2	32.4
32	32.2	32.3	32.5	32.6	32.7	32.9	33.0	33.2	33.3	33.4
33	33.2	33.3	33.5	33.6	33.8	33.9	34.0	34.2	34.3	34.5
34	34.2	34.3	34.5	34.6	34.8	34.9	35.0	35.2	35.3	35.5
35	35.2	35.3	35.5	35.6	35.8	35.9	36.1	36.2	36.4	36.5

DIRECTIONS.—Bring the temperature of the milk to within 10° of 60° F. Take the reading of the lactometer and that of the temperature of the milk; find the former in the first vertical column of the table and the latter in the first horizontal row of figures; the figure where the horizontal and vertical columns meet is the corrected lactometer reading; e.g., observed, 31.0 at 67° F.; corrected reading, 31.9.

Table VI. Per cent. of solids not fat, corresponding to 0 to 6 per cent. of fat, and lactometer readings of 26 to 36. (See directions for use, p. 100.)

Per cent. of fat.	Lactometer readings at 60° F.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
0	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	0
0.1	6.52	6.77	7.02	7.27	7.52	7.77	8.02	8.27	8.52	8.77	9.02	0.1
0.2	6.54	6.79	7.04	7.29	7.54	7.79	8.04	8.29	8.54	8.79	9.04	0.2
0.3	6.56	6.81	7.06	7.31	7.56	7.81	8.06	8.31	8.56	8.81	9.06	0.3
0.4	6.58	6.83	7.08	7.33	7.58	7.83	8.08	8.33	8.58	8.83	9.08	0.4
0.5	6.60	6.85	7.10	7.35	7.60	7.85	8.10	8.35	8.60	8.85	9.10	0.5
0.6	6.62	6.87	7.12	7.37	7.62	7.87	8.12	8.37	8.62	8.87	9.12	0.6
0.7	6.64	6.89	7.14	7.39	7.64	7.89	8.14	8.39	8.64	8.89	9.14	0.7
0.8	6.66	6.91	7.16	7.41	7.66	7.91	8.16	8.41	8.66	8.91	9.16	0.8
0.9	6.68	6.93	7.18	7.43	7.68	7.93	8.18	8.43	8.68	8.93	9.18	0.9
1.0	6.70	6.95	7.20	7.45	7.70	7.95	8.20	8.45	8.70	8.95	9.20	1.0
1.1	6.72	6.97	7.22	7.47	7.72	7.97	8.22	8.47	8.72	8.97	9.22	1.1
1.2	6.74	6.99	7.24	7.49	7.74	7.99	8.24	8.49	8.74	8.99	9.24	1.2
1.3	6.76	7.01	7.26	7.51	7.76	8.01	8.26	8.51	8.76	9.01	9.26	1.3
1.4	6.78	7.03	7.28	7.53	7.78	8.03	8.28	8.53	8.78	9.03	9.28	1.4
1.5	6.80	7.05	7.30	7.55	7.80	8.05	8.30	8.55	8.80	9.05	9.30	1.5
1.6	6.82	7.07	7.32	7.57	7.82	8.07	8.32	8.57	8.82	9.07	9.32	1.6
1.7	6.84	7.09	7.34	7.59	7.84	8.09	8.34	8.59	8.84	9.09	9.34	1.7
1.8	6.86	7.11	7.36	7.61	7.86	8.11	8.36	8.61	8.86	9.11	9.37	1.8
1.9	6.88	7.13	7.38	7.63	7.88	8.13	8.38	8.63	8.88	9.13	9.39	1.9
2.0	6.90	7.15	7.40	7.65	7.90	8.15	8.40	8.66	8.91	9.16	9.41	2.0
2.1	6.92	7.17	7.42	7.67	7.92	8.17	8.42	8.68	8.93	9.18	9.43	2.1
2.2	6.94	7.19	7.44	7.69	7.94	8.19	8.44	8.70	8.95	9.20	9.45	2.2
2.3	6.96	7.21	7.46	7.71	7.96	8.21	8.46	8.72	8.97	9.22	9.47	2.3
2.4	6.98	7.23	7.48	7.73	7.98	8.23	8.48	8.74	8.99	9.24	9.49	2.4
2.5	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.76	9.01	9.26	9.51	2.5
2.6	7.02	7.27	7.52	7.77	8.02	8.27	8.52	8.78	9.03	9.28	9.53	2.6
2.7	7.04	7.29	7.54	7.79	8.04	8.29	8.54	8.80	9.05	9.30	9.55	2.7
2.8	7.06	7.31	7.56	7.81	8.06	8.31	8.57	8.82	9.07	9.32	9.57	2.8
2.9	7.08	7.33	7.58	7.83	8.08	8.33	8.59	8.84	9.09	9.34	9.59	2.9

Table VI. Per cent. of solids not fat (*Continued*).

Per cent. of fat.	Lactometer Readings at 60° F.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
3.0	7.10	7.35	7.60	7.85	8.10	8.36	8.61	8.86	9.11	9.36	9.61	3.0
3.1	7.12	7.37	7.62	7.87	8.13	8.38	8.63	8.88	9.13	9.38	9.64	3.1
3.2	7.14	7.39	7.64	7.89	8.15	8.40	8.65	8.90	9.15	9.41	9.66	3.2
3.3	7.16	7.41	7.66	7.92	8.17	8.42	8.67	8.92	9.18	9.43	9.68	3.3
3.4	7.18	7.43	7.69	7.94	8.19	8.44	8.69	8.94	9.20	9.45	9.70	3.4
3.5	7.20	7.45	7.71	7.96	8.21	8.46	8.71	8.96	9.22	9.47	9.72	3.5
3.6	7.22	7.48	7.73	7.98	8.23	8.48	8.73	8.98	9.24	9.49	9.74	3.6
3.7	7.24	7.50	7.75	8.00	8.25	8.50	8.75	9.00	9.26	9.51	9.76	3.7
3.8	7.26	7.52	7.77	8.02	8.27	8.52	8.77	9.02	9.28	9.53	9.78	3.8
3.9	7.28	7.54	7.79	8.04	8.29	8.54	8.79	9.04	9.30	9.55	9.80	3.9
4.0	7.30	7.56	7.81	8.06	8.31	8.56	8.81	9.06	9.32	9.57	9.83	4.0
4.1	7.32	7.58	7.83	8.08	8.33	8.58	8.83	9.08	9.34	9.59	9.85	4.1
4.2	7.34	7.60	7.85	8.10	8.35	8.60	8.85	9.11	9.36	9.62	9.87	4.2
4.3	7.36	7.62	7.87	8.12	8.37	8.62	8.88	9.13	9.38	9.64	9.89	4.3
4.4	7.38	7.64	7.89	8.14	8.39	8.64	8.90	9.15	9.40	9.66	9.91	4.4
4.5	7.40	7.66	7.91	8.16	8.41	8.66	8.92	9.17	9.42	9.68	9.93	4.5
4.6	7.43	7.68	7.93	8.18	8.43	8.68	8.94	9.19	9.44	9.70	9.95	4.6
4.7	7.45	7.70	7.95	8.20	8.45	8.70	8.96	9.21	9.46	9.72	9.97	4.7
4.8	7.47	7.72	7.97	8.22	8.47	8.72	8.98	9.23	9.48	9.74	9.99	4.8
4.9	7.49	7.74	7.99	8.24	8.49	8.74	9.00	9.25	9.50	9.76	10.01	4.9
5.0	7.51	7.76	8.01	8.26	8.51	8.76	9.02	9.27	9.52	9.78	10.03	5.0
5.1	7.53	7.78	8.03	8.28	8.53	8.79	9.04	9.29	9.54	9.80	10.05	5.1
5.2	7.55	7.80	8.05	8.30	8.55	8.81	9.06	9.31	9.56	9.82	10.07	5.2
5.3	7.57	7.82	8.07	8.32	8.57	8.83	9.08	9.33	9.58	9.84	10.09	5.3
5.4	7.59	7.84	8.09	8.34	8.60	8.85	9.10	9.36	9.61	9.86	10.11	5.4
5.5	7.61	7.86	8.11	8.36	8.62	8.87	9.12	9.38	9.63	9.88	10.13	5.5
5.6	7.63	7.88	3.13	8.39	8.64	8.89	9.15	9.40	9.65	9.90	10.15	5.6
5.7	7.65	7.90	8.15	8.41	8.66	8.91	9.17	9.42	9.67	9.92	10.17	5.7
5.8	7.67	7.92	8.17	8.43	8.68	8.94	9.19	9.44	9.69	9.94	10.19	5.8
5.9	7.69	7.94	8.20	8.45	8.70	8.96	9.21	9.46	9.71	9.96	10.22	5.9
6.0	7.71	7.96	8.22	8.47	8.72	8.98	9.23	9.48	9.73	9.98	10.24	6.0

Directions for Use of Tables VII, VIII, IX, and XI.

TABLES VII, and VIII. Find the test of the milk in table VII or of cream in table VIII; the first or last horizontal row of figures, the amounts of fat in ten thousand, thousands, hundreds, tens, and units of pounds of milk are then given in this vertical column. By adding the corresponding figures for any given quantity of milk or of cream, the total quantity of butter fat contained therein is obtained.

Example: How many pounds of fat is contained in 8925 lbs. of milk testing 3.65 per cent.? On p. 242, second column the test **3.65** is found, and by going downward in this column we have:

8000 lbs........................	292. lbs.
900 lbs........................	32.9 lbs.
20 lbs........................	.7 lbs.
5 lbs........................	.2 lbs.
8925 lbs. of milk.	325.8 lbs. of fat.

8925 lbs. of milk testing 3.65 per cent., therefore, contains 325.8 lbs. of butter fat.

TABLE IX. The price per pound is given in the outside vertical columns, and the weight of butter fat in the upper and lower horizontal row of figures. The corresponding tens of pounds are found by moving the decimal point one place to the left, the units, by moving it two, and the tenths of a pound, by moving it three places to the left. The use of the table is, otherwise, as explained above.

Example: How much money is due for 325.8 lbs. of butter fat at 15½ cents per pound? In the horizontal row of figures beginning with 15½ on p. 247, we find:

800 lbs........................	$46.50
20 lbs........................	3.10
5 lbs........................	.77
.8 lbs........................	.12
325.8 lbs.	$50.49

825.8 lbs. of butter fat at 15½ cents per pound, therefore, is worth $50.49.

TABLE XI. Find the test of milk in the upper or lower horizontal row of figures. The amounts of butter likely to be made from ten thousand, thousands, hundreds, tens, and units of pounds of milk are then given in this vertical column. The use of the table is, otherwise, as explained above in case of table VII.

Example: How much butter will 5845 lbs. of milk testing 3.8 per cent. be apt to make under good creamery conditions? In the column headed **3.8**, we find:

5000 lbs........................	209.0 lbs.
800 lbs........................	33.4 lbs.
40 lbs........................	1.7 lbs.
5 lbs........................	.2 lbs.
5845 lbs.	244.3 lbs.

5845 lbs. of milk testing 3.8 per cent. of fat will make about 244.3 lbs. of butter, under conditions similar to those explained on pp. 184–188.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk, testing 3.0 to 5.35 per cent. (See directions for use, p. 240.)

Test.	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	Test.
Milk lbs.													Milk lbs.
10,000	300	305	310	315	320	325	330	335	340	345	350	355	10,000
9,000	270	275	279	284	289	293	297	302	306	311	315	320	9,000
8,000	240	244	248	252	256	260	264	268	272	276	280	284	8,000
7,000	210	214	217	221	224	228	231	235	238	242	245	249	7,000
6,000	180	183	186	189	192	195	198	201	204	207	210	213	6,000
5,000	150	153	155	158	160	163	165	168	170	173	175	178	5,000
4,000	120	122	124	126	128	130	132	134	136	138	140	142	4,000
3,000	90.0	91.5	93.0	94.5	96.0	97.5	99.0	101	102	104	105	107	3,000
2,000	60.0	61.0	62.0	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0	71.0	2,000
1,000	30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5	1,000
900	27.0	27.5	27.9	28.4	28.8	29.3	29.7	30.2	30.6	31.1	31.5	32.0	900
800	24.0	24.4	24.8	25.2	25.7	26.0	26.4	26.8	27.2	27.6	28.0	28.4	800
700	21.0	21.4	21.7	22.1	22.4	22.8	23.1	23.5	23.8	24.2	24.5	24.9	700
600	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	600
500	15.0	15.3	15.5	15.8	16.0	16.3	16.5	16.8	17.0	17.3	17.5	17.8	500
400	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	400
300	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	10.2	10.4	10.5	10.7	300
200	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	200
100	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	100
90	2.7	2.8	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.2	90
80	2.4	2.4	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	80
70	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	2.5	70
60	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	2.1	60
50	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	50
40	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	40
30	.9	.9	.9	.9	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	30
20	.6	.6	.6	.6	.6	.7	.7	.7	.7	.7	.7	.7	20
10	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	10
9	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	9
8	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	8
7	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	1	.1	.1	.1	.1	.1	.1	2
1	......	......	......	......	......	......	......	......	......	......	......	......	1
Test.	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test. / Milk lbs.	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	Test. / Milk lbs.
10,000	360	365	370	375	380	385	390	395	400	405	410	415	10,000
9,000	324	329	333	338	342	347	351	356	360	365	369	374	9,000
8,000	288	292	296	300	304	308	312	316	320	324	328	332	8,000
7.000	252	256	259	263	266	270	273	277	280	284	287	291	7,000
6,000	216	219	222	225	228	231	234	237	240	243	246	249	6,000
5,000	180	183	185	188	190	193	195	198	200	203	205	208	5,000
4,000	144	146	148	150	152	154	156	158	160	162	164	166	4,000
3,000	108	110	111	113	114	116	117	119	120	122	123	125	3,000
2,000	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0	80.0	81.0	82.0	83.0	2,000
1,000	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0	40.5	41.0	41.5	1,000
900	32.4	32.9	33.3	33.8	34.2	34.7	35.1	35.6	36.0	36.5	36.9	37.4	900
800	28.8	29.2	29.6	30.0	30.4	30.8	31.2	31.6	32.0	32.4	32.8	33.2	800
700	25.2	25.6	25.9	26.3	26.6	27.0	27.3	27.7	28.0	28.4	28.7	29.1	700
600	21.6	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	600
500	18.0	18.3	18.5	18.8	19.0	19.3	19.5	19.8	20.0	20.3	20.5	20.8	500
400	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	400
300	10.8	11.0	11.1	11.3	11.4	11.6	11.7	11.9	12.0	12.2	12.3	12.5	300
200	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	200
100	3.6	3.7	3.7	3.8	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	100
90	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3,7	3.7	90
80	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	80
70	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	2.9	70
60	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.5	2.5	60
50	1.8	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	50
40	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	40
30	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1 2	1.2	1.2	1.2	30
20	.7	.7	.7	.8	.8	.8	.8	.8	.8	.8	.8	.8	20
10	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	10
9	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	8
7	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.2	.2	2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Test.	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test.	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	Test.
Milk lbs.													Milk lbs.
10,000	420	425	430	435	440	445	450	455	460	465	470	475	10,000
9,000	378	383	387	392	396	401	405	410	414	419	423	428	9,000
8,000	336	340	344	348	352	356	360	364	368	372	376	380	8,000
7,000	294	298	301	305	308	312	315	319	322	326	329	333	7,000
6,000	252	255	258	261	264	267	270	273	276	279	282	285	6,000
5,000	210	213	215	218	220	223	225	228	230	233	235	238	5,000
4,000	168	170	172	174	176	178	180	182	184	186	188	190	4,000
3,000	126	128	129	131	132	134	135	137	138	140	141	143	3,000
2,000	84.0	85.0	86.0	87.0	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	2,000
1,000	42.0	42.5	43.0	43.5	44.0	44.5	45.0	45.5	46.0	46.5	47.0	47.5	1,000
900	37.8	38.3	38.7	39.2	39.6	40.1	40.5	41.0	41.4	41.9	42.3	42.8	900
800	33.6	34.0	34.4	34.8	35.2	35.6	36.0	36.4	36.8	37.2	37.6	38.0	800
700	29.4	29.8	30.1	30.5	30.8	31.2	31.5	31.9	32.2	32.6	32.9	33.3	700
600	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	600
500	21.0	21.3	21.5	21.8	22.0	22.3	22.5	22.8	23.0	23.3	23.5	23.8	500
400	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	400
300	12.6	12.8	12.9	13.1	13.2	13.4	13.5	13.7	13.8	14.0	14.1	14.3	300
200	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	200
100	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	100
90	3.8	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	90
80	3.4	3.4	3.4	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.8	3.8	80
70	2.9	3.0	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	70
60	2.5	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	60
50	2.1	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.4	2.4	50
40	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	40
30	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	30
20	.8	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	1.0	20
10	.4	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	10
9	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	8
7	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	......	......	......	......	......	......	......	......	......	......	......	......	1
Test.	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test. / Milk lbs.	4.80	4.85	4.90	4.95	5.00	5.05	5.10	5.15	5.20	5.25	5.30	5.35	Test. / Milk lbs.
10,000	480	485	490	495	500	505	510	515	520	525	530	535	10,000
9,000	432	437	441	446	450	455	459	464	468	473	477	482	9,000
8,000	384	388	392	396	400	404	408	412	416	420	424	428	8,000
7,000	336	340	343	347	350	354	357	361	364	368	371	375	7,000
6,000	288	291	294	297	300	303	306	309	312	315	318	321	6,000
5,000	240	243	245	248	250	253	255	258	260	263	265	268	5,000
4,000	192	194	196	198	200	202	204	206	208	210	212	214	4,000
3,000	144	146	147	149	150	152	153	155	156	158	159	161	3,000
2,000	96.0	97.0	98.0	99.0	100	101	102	103	104	105	106	107	2,000
1,000	48.0	48.5	49.0	49.5	50.0	50.5	51.0	51.5	52.0	52.5	53.0	53.5	1,000
900	43.2	43.7	44.1	44.6	45.0	45.5	45.7	46.4	46.8	47.3	47.7	48.2	900
800	38.4	38.8	39.2	39.6	40.0	40.4	40.8	41.2	41.6	42.0	42.4	42.8	800
700	33.6	34.0	34.3	34.7	35.0	35.4	35.7	36.1	36.4	36.8	37.1	37.5	700
600	28.8	29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	600
500	24.0	24.3	24.5	24.8	25.0	25.3	25.5	25.8	26.0	26.3	26.5	26.8	500
400	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.6	20.8	21.0	21.2	21.4	400
300	14.4	14.6	14.7	14.9	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	300
200	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	200
100	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.4	100
90	4.3	4.4	4.4	4.5	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	90
80	3.8	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	80
70	3.4	3.4	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.7	70
60	2.9	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.1	3.2	3.2	3.2	60
50	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.7	2.7	50
40	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	40
30	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	30
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	20
10	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	10
9	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	9
8	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	8
7	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	......	......	......	......	.1	.1	.1	.1	.1	.1	.1	.1	1
Test.	4.80	4.85	4.90	4.95	5.00	5.05	5.10	5.15	5.20	5.25	5.30	5.35	Test.

Table VIII. Pounds of fat in 1 to 1000 lbs. of cream testing 12.0 to 50.0 per cent. fat.

(See directions for use, p. 240.)

Cream lbs. \ Test.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1000	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
900	108	117	126	135	144	153	162	171	180	189	198	207	216	225	234	243	252	261	270
800	96	104	112	120	128	136	144	152	160	168	176	184	192	200	208	216	224	232	240
700	84	91	98	105	112	119	126	133	140	147	154	161	168	175	182	189	196	203	210
600	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180
500	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
400	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120
300	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90
200	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
100	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
90	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0	18.9	19.8	20.7	21.6	22.5	23.4	24.3	25.2	26.1	27.0
80	9.6	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.0	16.8	17.6	18.4	19.2	20.0	20.8	21.6	22.4	23.2	24.0
70	8.4	9.1	9.8	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0
60	7.2	7.8	8.4	9.0	9.6	10.2	10.8	11.4	12.0	12.6	13.2	13.8	14.4	15.0	15.6	16.2	16.8	17.4	18.0
50	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	4.5	15.0
40	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.8	11.2	11.6	12.0
30	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0
20	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0
10	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
9	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.89	1.98	2.07	2.16	2.25	2.34	1.43	2.52	2.61	2.70
8	.96	1.04	1.12	1.20	1.28	1.36	1.44	1.52	1.60	1.68	1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.32	2.40
7	.84	.91	.98	1.05	1.12	1.19	1.26	1.33	1.40	1.47	1.54	1.61	1.68	1.75	1.82	1.89	1.96	2.03	2.10
6	.72	.78	.84	.90	.96	1.02	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80
5	.60	.65	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
4	.48	.52	.56	.60	.64	.68	.72	.76	.80	.84	.88	.92	.96	1.00	1.04	1.08	1.12	1.16	1.20
3	.36	.39	.42	.45	.48	.51	.54	.57	.60	.63	.66	.69	.72	.75	.78	.81	.84	.87	.90
2	.24	.26	.28	.30	.32	.34	.36	.38	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60
1	.12	.13	.14	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30

Table VIII. Pounds of fat in 1 to 1000 lbs. of cream (*continued*).

Test. / Cream lbs.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1000	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
900	279	288	297	306	315	324	333	342	351	360	369	378	387	396	405	414	423	432	441	450
800	248	256	264	272	280	288	296	304	312	320	328	336	344	352	360	368	376	384	392	400
700	217	224	231	238	245	252	259	266	273	280	287	294	301	308	315	322	329	336	343	350
600	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300
500	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250
400	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200
300	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150
200	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
100	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
90	27.9	28.8	29.7	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.9	37.8	38.7	39.6	40.5	41.4	42.3	43.2	44.1	45.0
80	24.8	25.6	26.4	27.2	28.0	28.8	29.6	30.4	21.2	32.0	32.8	33.6	34.4	35.2	36.0	36.8	37.6	38.4	39.2	40.0
70	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5	32.2	32.9	33.6	34.3	35.0
60	18.6	19.2	19.8	20.4	21.0	21.6	22.2	22.8	23.4	24.0	24.6	25.2	25.8	26.4	27.0	27.6	28.2	28.8	29.4	30.0
50	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0
40	12.4	12.8	13.2	13.6	14.0	14.4	14.8	15.2	15.6	16.0	16.4	16.8	17.2	17.6	18.0	18.4	18.8	19.2	19.6	20.0
30	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0
20	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0
10	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
9	2.79	2.88	2.97	3.06	3.15	3.24	3.33	3.42	3.51	3.60	3.69	3.78	3.87	3.96	4.95	4.14	4.23	4.32	4.41	4.50
8	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60	3.68	3.76	3.84	3.92	4.00
7	2.17	2.24	2.31	2.38	2.45	2.52	2.59	2.66	2.73	2.80	2.87	2.94	3.01	3.08	3.15	3.22	3.29	3.36	3.43	3.50
6	1.86	1.92	1.98	2.04	2.10	2.16	2.22	2.28	2.34	2.40	2.46	2.52	2.58	2,64	2.70	2.76	2.82	2.88	2.94	3.00
5	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50
4	1.24	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.56	1.60	1.64	1.68	1.72	1.76	1.80	1.84	1.88	1.92	1.96	2.00
3	.93	.96	.99	1.02	1.05	1.08	1.11	1.14	1.17	1.20	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50
2	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82	.84	.86	.88	.90	.92	.94	.96	.98	1.00
1	.31	.32	.33	.34	.35	.36	.37	.38	.39	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50

Table IX. Amount due for butter fat, in dollars and cents, at 12 to 25 cents per pound.

(See directions for use, page 240.)

Price per pound, cents.	Pounds of butter fat. 1,000	900	800	700	600	500	400	300	200	100	Price per pound, cents.
	$	$	$	$	$	$	$	$	$	$	
12	120.00	108.00	96.00	84.00	72.00	60.00	48.00	36.00	24.00	12.00	12
12¼	122.50	110.25	98.00	85.75	73.50	61.25	49.00	36.75	24.50	12.25	12¼
12½	125.00	112.50	100.00	87.50	75.00	62.50	50.00	37.50	25.00	12.50	12½
12¾	127.50	114.75	102.00	89.25	76.50	63.75	51.00	38.25	25.50	12.75	12¾
13	130.00	117.00	104.00	91.00	78.00	65.00	52.00	39.00	26.00	13.00	13
13¼	132.50	119.25	106.00	92.75	79.50	66.25	53.00	39.75	26.50	13.25	13¼
13½	135.00	121.50	108.00	94.50	81.00	67.50	54.00	40.50	27.00	13.50	13½
13¾	137.50	123.75	110.00	96.25	82.50	68.75	55.00	41.25	27.50	13.75	13¾
14	140.00	126.00	112.00	98.00	84.00	70.00	56.00	42.00	28.00	14.00	14
14¼	142.50	128.25	114.00	99.75	85.50	71.25	57.00	42.75	28.50	14.25	14¼
14½	145.00	130.50	116.00	101.50	87.00	72.50	58.00	43.50	29.00	14.50	14½
14¾	147.50	132.75	118.00	103.25	88.50	73.75	59.00	44.25	29.50	14.75	14¾
15	150.00	135.00	120.00	105.00	90.00	75.00	60.00	45.00	30.00	15.00	15
15¼	152.50	137.25	122.00	106.75	91.50	76.25	61.00	45.75	30.50	15.25	15¼
15½	155.00	139.50	124.00	108.50	93.00	77.50	62.00	46.50	31.00	15.50	15½
15¾	157.50	141.75	126.00	110.25	94.50	78.75	63.00	47.25	31.50	15.75	15¾
16	160.00	144.00	128.00	112.00	96.00	80.00	64.00	48.00	32.00	16.00	16
16¼	162.50	146.25	130.00	113.75	97.50	81.25	65.00	48.75	32.50	16.25	16¼
16½	165.00	148.50	132.00	115.50	99.00	82.50	66.00	49.50	33.00	16.50	16½
16¾	167.50	150.75	134.00	117.25	100.50	83.75	67.00	50.25	33.50	16.75	16¾
17	170.00	153.00	136.00	119.00	102.00	85.00	68.00	51.00	34.00	17.00	17
17¼	172.50	155.25	138.00	120.75	103.50	86.25	69.00	51.75	34.50	17.25	17¼
17½	175.00	157.50	140.00	122.50	105.00	87.50	70.00	52.50	35.00	17.50	17½
17¾	177.50	159.75	142.00	124.25	106.50	87.75	71.00	53.25	35.50	17.75	17¾
18	180.00	162.00	144.00	126.00	108.00	90.00	72.00	54.00	36.00	18.00	18
18¼	182.50	164.25	146.00	127.75	109.50	91.25	73.00	54.75	36.50	18.25	18¼
18½	185.00	166.50	148.00	129.50	111.00	92.50	74.00	55.50	37.00	18.50	18½
18¾	187.50	168.75	150.00	131.25	112.50	93.75	75.00	56.25	37.50	18.75	18¾
	1,000	900	800	700	600	500	400	300	200	100	

Table IX. Amount due for butter fat (*Continued*).

Price per pound, cents.	Pounds of butter fat.										Price per pound, cents.
	1,000	900	800	700	600	500	400	300	200	100	
	$	$	$	$	$	$	$	$	$	$	
19	190.00	171.00	152.00	133.00	114.00	95.00	76.00	57.00	38.00	19.00	19
19¼	192.50	173.25	154.00	134.75	115.50	96.25	77.00	57.75	38.50	19.25	19¼
19½	195.00	175.50	156.00	136.50	117.00	97.50	78.00	58.50	39.00	19.50	19½
19¾	197.50	177.75	158.00	138.25	118.50	98.75	79.00	59.25	39.50	19.75	19¾
20	200.00	180.00	160.00	140.00	120.00	100.00	80.00	60.00	40.00	20.00	20
20¼	202.50	182.25	162.00	141.75	121.50	101.25	81.00	60.75	40.50	20.25	20¼
20½	205.00	184.50	164.00	143.50	123.00	102.50	82.00	61.50	41.00	20.50	20½
20¾	207.50	186.75	166.00	145.25	124.50	103.75	83.00	62.25	41.50	20.75	20¾
21	210.00	189.00	168.00	147.00	126.00	105.00	84.00	63.00	42.00	21.00	21
21¼	212.50	191.25	170.00	148.75	127.50	106.25	85.00	63.75	42.50	21.25	21¼
21½	215.00	193.50	172.00	150.50	129.00	107.50	86.00	64.50	43.00	21.50	21½
21¾	217.50	195.75	174.00	152.25	130.50	108.75	87.00	65.25	43.50	21.75	21¾
22	220.00	198.00	176.00	154.00	132.00	110.00	88.00	66.00	44.00	22.00	22
22¼	222.50	200.25	178.00	155.75	133.50	111.25	89.00	66.75	44.50	22.25	22¼
22½	225.00	202.50	180.00	157.50	135.00	112.50	90.00	67.50	45.00	22.50	22½
22¾	227.50	204.75	182.00	159.25	136.50	113.75	91.00	68.25	45.50	22.75	22¾
23	230.00	207.00	184.00	161.00	138.00	115.00	92.00	69.00	46.00	23.00	23
23¼	232.50	209.25	186.00	162.75	139.50	116.25	93.00	69.75	46.50	23.25	23¼
23½	235.00	211.50	188.00	164.50	141.00	117.50	94.00	70.50	47.00	23.50	23½
23¾	237.50	213.75	190.00	166.25	142.50	118.75	95.00	71.25	47.50	23.75	23¾
24	240.00	216.00	192.00	168.00	144.00	120.00	96.00	72.00	48.00	24.00	24
24¼	242.50	218.25	194.00	169.75	145.50	121.25	97.00	72.75	48.50	24.25	24¼
24½	245.00	220.50	196.00	171.50	147.00	122.50	98.00	73.50	49.00	24.50	24½
24¾	247.50	222.75	198.00	173.25	148.50	123.75	99.00	74.25	49.50	24.75	24¾
25	250.00	225.00	200.00	175.00	150.00	125.00	100.00	75.00	50.00	25.00	25
	1,000	900	800	700	600	500	400	300	200	100	

Table X. Relative-value tables.

(See directions for use, pp. 196–198.

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.										
3.0	.30	.31	.33	.34	.36	.37	.39	.40	.42	.43	.45
3.1	.31	.33	.34	.36	.37	.39	.40	.42	.43	.45	.46
3.2	.32	.34	.35	.37	.38	.40	.42	.43	.45	.46	.48
3.3	.33	.35	.36	.38	.40	.41	.43	.45	.46	.48	.49
3.4	.34	.36	.37	.39	.41	.42	.44	.46	.48	.49	.51
3.5	.35	.37	.38	.40	.42	.44	.45	.47	.49	.51	.52
3.6	.36	.38	.40	.41	.43	.45	.47	.49	.50	.52	.54
3.7	.37	.39	.41	.43	.44	.46	.48	.50	.52	.54	.55
3.8	.38	.40	.42	.44	.46	.47	.49	.51	.53	.55	.57
3.9	.39	.41	.43	.45	.47	.49	.51	.53	.55	.57	.58
4.0	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60
4.1	.41	.43	.45	.47	.49	.51	.53	.55	.57	.59	.61
4.2	.42	.44	.46	.48	.50	.52	.55	.57	.59	.61	.63
4.3	.43	.45	.47	.49	.52	.54	.56	.58	.60	.62	.64
4.4	.44	.46	.48	.51	.53	.55	.57	.59	.62	.64	.66
4.5	.45	.47	.49	.52	.54	.56	.58	.61	.63	.65	.67
4.6	.46	.48	.51	.53	.55	.57	.60	.62	.64	.67	.69
4.7	.47	.49	.52	.54	.56	.59	.61	.63	.66	.68	.70
4.8	.48	.50	.53	.55	58	.60	.62	.65	.67	.70	.72
4.9	.49	.51	.54	.56	.59	.61	.64	.66	.69	.71	.73
5.0	.50	.52	.55	.57	.60	.62	.65	.67	.70	.72	.75
5.1	.51	.54	.56	.59	.61	.64	.66	.69	.71	.74	.76
5.2	.52	.55	.57	.60	.62	.65	.68	.70	.73	.75	.78
5.3	.53	.56	.58	.61	.64	.66	.69	.72	.74	.77	.79
5.4	.54	.57	.59	.62	.65	.67	.70	.73	.76	.78	.81
5.5	.55	.58	.60	.63	.66	.69	.71	.74	.77	.80	.82
5.6	.56	.59	.62	.64	.67	.70	.73	.76	.78	.81	.84
5.7	.57	.60	.63	.66	.68	.71	.74	.77	.80	.83	.85
5.8	.58	.61	.64	.67	.70	.72	.75	.78	.81	.84	.87
5.9	.59	.62	.65	.68	.71	.74	.77	.80	.83	.86	.88
6.0	.60	.63	.66	.69	.72	.75	.78	.81	.84	.87	.90

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.46	.48	.49	.51	.52	.54	.55	.57	.58	.60
3.1	.48	.50	.51	.53	.54	.56	.57	.59	.60	.62
3.2	.50	.51	.53	.54	.56	.58	.59	.61	.62	.64
3.3	.51	.53	.54	.56	.58	.59	.61	.63	.64	.66
3.4	.53	.54	.56	.58	.59	.61	.63	.65	.66	.68
3.5	.54	.56	.58	.59	.61	.63	.65	.66	.68	.70
3.6	.56	.58	.59	.61	.63	.65	.67	.68	.70	.72
3.7	.57	.59	.61	.63	.65	.67	.68	.70	.72	.74
3.8	.59	.61	.63	.65	.66	.68	.70	.72	.74	.76
3.9	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78
4.0	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80
4.1	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82
4.2	.65	.67	.69	.71	.73	.76	.78	.80	.82	.84
4.3	.67	.69	.71	.73	.75	.77	.80	.82	.84	.86
4.4	.68	.70	.73	.75	.77	.79	.81	.84	.86	.88
4.5	.70	.72	.74	.76	.79	.81	.83	.85	.88	.90
4.6	.71	.74	.76	.78	.80	.83	.85	.87	.90	.92
4.7	.73	.75	.78	.80	.82	.85	.87	.89	.92	.94
4.8	.74	.77	.79	.82	.84	.86	.89	.91	.94	.96
4.9	.76	.78	.81	.83	.86	.88	.91	.93	.96	.98
5.0	.77	.80	.82	.85	.87	.90	.92	.95	.97	1.00
5.1	.79	.82	.84	.87	.89	.92	.94	.97	.99	1.02
5.2	.81	.83	.86	.88	.91	.94	.96	.99	1.01	1.04
5.3	.83	.85	.87	.90	.93	.95	.98	1.01	1.03	1.06
5.4	.84	.86	.89	.92	.94	.97	1.00	1.03	1.05	1.08
5.5	.85	.88	.91	.93	.96	.99	1.02	1.04	1.07	1.10
5.6	.87	.90	.92	.95	.98	1.01	1.04	1.06	1.09	1.12
5.7	.88	.91	.94	.97	1.00	1.03	1.05	1.08	1.11	1.14
5.8	.90	.93	.96	.99	1.01	1.04	1.07	1.10	1.13	1.16
5.9	.91	.94	.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18
6.0	.93	.96	.99	1.02	1.05	1.08	1.11	1.14	1.17	1.20

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.61	.63	.64	.66	.67	.69	.70	.72	.73	.75
3.1	.64	.65	.67	.68	.70	.71	.73	.74	.76	.78
3.2	.66	.67	.69	.70	.72	.74	.75	.77	.78	.80
3.3	.68	.69	.71	.73	.74	.76	.78	.79	.81	.83
3.4	.70	.71	.73	.75	.76	.78	.80	.82	.83	.85
3.5	.72	.73	.75	.77	.79	.80	.82	.84	.86	.88
3.6	.74	.76	.77	.79	.81	.83	.85	.86	.88	.90
3.7	.76	.78	.80	.81	.83	.85	.87	.89	.91	.93
3.8	.78	.80	.82	.84	.85	.87	.89	.91	.93	.95
3.9	.80	.82	.84	.86	.88	.90	.92	.94	.96	.98
4.0	.82	.84	.86	.88	.90	.92	.94	.96	.98	1.00
4.1	.84	.86	.88	.90	.92	.94	.96	.98	1.00	1.03
4.2	.86	.88	.90	.92	.94	.97	.99	1.01	1.03	1.05
4.3	.88	.90	.92	.95	.97	.99	1.01	1.03	1.05	1.08
4.4	.90	.92	.95	.97	.99	1.01	1.03	1.06	1.08	1.10
4.5	.92	.94	.97	.99	1.01	1.03	1.06	1.08	1.10	1.13
4.6	.94	.97	.99	1.01	1.03	1.06	1.08	1.10	1.13	1.15
4.7	.96	.99	1.01	1.03	1.06	1.08	1.10	1.13	1.15	1.18
4.8	.98	1.01	1.03	1.06	1.08	1.10	1.13	1.15	1.18	1.20
4.9	1.00	1.03	1.05	1.08	1.10	1.13	1.15	1.18	1.20	1.23
5.0	1.02	1.05	1.07	1.10	1.12	1.15	1.18	1.20	1.23	1.25
5.1	1.05	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.25	1.27
5.2	1.07	1.09	1.12	1.14	1.17	1.20	1.22	1.25	1.27	1.30
5.3	1.09	1.11	1.14	1.17	1.19	1.22	1.25	1.27	1.30	1.32
5.4	1.11	1.13	1.16	1.19	1.21	1.24	1.27	1.30	1.32	1.35
5.5	1.13	1.15	1.18	1.21	1.24	1.26	1.29	1.32	1.35	1.38
5.6	1.15	1.18	1.20	1.23	1.26	1.29	1.32	1.34	1.37	1.40
5.7	1.17	1.20	1.23	1.25	1.28	1.31	1.34	1.37	1.39	1.43
5.8	1.19	1.22	1.25	1.28	1.30	1.33	1.36	1.39	1.42	1.45
5.9	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.42	1.45	1.48
6.0	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.76	.78	.79	.81	.82	.84	.85	.87	.88	.90
3.1	.79	.81	.82	.84	.85	.87	.88	.90	.91	.93
3.2	.82	.83	.85	.86	.88	.90	.91	.93	.94	.96
3.3	.84	.86	.87	.89	.91	.92	.94	.96	.97	.99
3.4	.87	.88	.90	.92	.93	.95	.97	.99	1.00	1.02
3.5	.89	.91	.93	.94	.96	.98	1.00	1.01	1.03	1.05
3.6	.92	.94	.95	.97	.99	1.00	1.03	1.04	1.06	1.08
3.7	.94	.96	.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11
3.8	.97	.99	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.14
3.9	.99	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17
4.0	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
4.1	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23
4.2	1.07	1.09	1.11	1.13	1.15	1.18	1.20	1.22	1.24	1.26
4.3	1.10	1.12	1.14	1.16	1.18	1.20	1.23	1.25	1.27	1.29
4.4	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.28	1.30	1.32
4.5	1.15	1.17	1.19	1.21	1.24	1.26	1.28	1.30	1.33	1.35
4.6	1.17	1.20	1.22	1.24	1.26	1.29	1.31	1.33	1.36	1.38
4.7	1.20	1.22	1.25	1.27	1.29	1.32	1.34	1.36	1.39	1.41
4.8	1.22	1.25	1.27	1.30	1.32	1.34	1.37	1.39	1.42	1.44
4.9	1.25	1.27	1.30	1.32	1.35	1.37	1.40	1.42	1.45	1.47
5.0	1.27	1.30	1.32	1.35	1.37	1.40	1.42	1.45	1.47	1.50
5.1	1.30	1.33	1.35	1.38	1.40	1.43	1.45	1.48	1.50	1.53
5.2	1.33	1.35	1.37	1.40	1.43	1.46	1.48	1.51	1.53	1.56
5.3	1.35	1.38	1.40	1.43	1.46	1.48	1.51	1.54	1.56	1.59
5.4	1.38	1.40	1.43	1.46	1.48	1.51	1.54	1.57	1.59	1.62
5.5	1.40	1.43	1.46	1.48	1.51	1.54	1.57	1.60	1.62	1.65
5.6	1.43	1.46	1.48	1.51	1.54	1.57	1.60	1.62	1.65	1.68
5.7	1.45	1.48	1.51	1.54	1.57	1.60	1.62	1.65	1.68	1.71
5.8	1.48	1.51	1.54	1.57	1.59	1.62	1.65	1.68	1.71	1.74
5.9	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74	1.77
6.0	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74	1.77	1.80

Table XI. Butter chart, showing calculated yield of butter (in lbs.) from 1 to 10,000 lbs. of milk, testing 3.0 to 5.3 per cent. (See directions for use, p. 240.)

Test.	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00	4.10	Test.
Milk, lbs.													Milk, lbs.
10,000	325	336	348	360	371	383	394	406	418	429	441	452	10,000
9,000	293	302	313	324	334	345	355	365	376	386	397	407	9,000
8,000	260	269	278	288	297	306	315	325	334	343	353	362	8,000
7,000	228	235	244	252	260	268	276	284	293	300	309	316	7,000
6,000	195	202	209	216	223	230	236	244	251	257	265	271	6,000
5,000	163	168	174	180	186	192	197	203	209	215	221	226	5,000
4,000	130	134	139	144	148	153	158	162	167	172	176	181	4,000
3,000	97.5	101	104	108	111	115	118	122	125	129	132	136	3,000
2,000	65.0	67.2	69.6	72.0	74.2	76.6	78.8	81.2	83.6	85.8	88.2	90.4	2,000
1,000	32.5	33.6	34.8	36.0	37.1	38.3	39.4	40.6	41.8	43.9	44.1	45.2	1,000
900	29.3	30.2	31.3	32.4	33.4	34.5	35.5	36.5	37.6	38.6	39.7	40.7	900
800	26.0	26.9	27.8	28.8	29.7	30.6	31.5	32.5	33.4	34.3	35.3	36.2	800
700	22.8	23.5	24.4	25.2	26.0	26.8	27.6	28.4	29.3	30.0	30.9	31.6	700
600	19.5	20.2	20.9	21.6	22.3	23.0	23.6	24.4	25.1	25.7	26.5	27.1	600
500	16.3	16.8	17.4	18.0	18.6	19.2	19.7	20.3	20.9	21.5	22.1	22.6	500
400	13.0	13.4	13.9	14.4	14.8	15.3	15.8	16.2	16.7	17.2	17.6	18.1	400
300	9.7	10.1	10.4	10.8	11.1	11.5	11.8	12.2	12.5	12.9	13.2	13.6	300
200	6.5	6.7	6.9	7.2	7.4	7.6	7.9	8.1	8.3	8.6	8.8	9.0	200
100	3.2	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.5	100
90	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.1	90
80	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.5	3.6	80
70	2.3	2.3	2.4	2.5	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.2	70
60	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.7	60
50	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	50
40	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	40
30	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	30
20	.6	.7	.7	.7	.7	.8	.8	.8	.8	.9	.9	.9	20
10	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.5	10
9	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	8
7	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	......	......	......	......	......	......	......	......	......	......	......	......	1
Test.	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00	4.10	Test.

Table XI. Butter chart (*Continued*).

Test.	4.20	4.30	4.40	4.50	4.60	4.70	4.80	4.90	5.00	5.10	5.20	5.30	Test.
Milk lbs.													Milk lbs.
10,000	464	476	487	499	510	522	534	545	557	568	580	592	10,000
9,000	418	428	438	449	459	470	481	491	501	511	522	533	9,000
8,000	371	381	390	399	408	418	427	436	446	454	464	474	8,000
7,000	325	333	341	349	357	365	374	382	390	398	406	414	7,000
6,000	278	286	292	299	306	313	320	327	334	341	348	355	6,000
5,000	232	238	244	250	255	261	267	273	279	284	290	296	5,000
4,000	186	190	195	200	204	209	214	218	223	227	232	237	4,000
3,000	139	143	146	150	153	157	160	164	167	170	174	178	3,000
2,000	92.8	95.2	97.4	99.8	102	104	107	109	111	114	116	118	2,000
1,000	46.4	47.6	48.7	49.9	51.0	52.2	53.4	54.5	55.7	56.8	58.0	59.2	1,000
900	41.8	42.8	43.8	44.9	45.9	47.0	48.1	49.1	50.1	51.1	52.2	53.3	900
800	37.1	38.1	39.0	39.9	40.8	41.8	42.7	43.6	44.6	45.4	46.4	47.4	800
700	32.5	33.3	34.1	34.9	35.7	36.5	37.4	38.2	39.0	39.8	40.6	41.4	700
600	27.8	28.6	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8	35.5	600
500	23.2	23.8	24.4	25.0	25.5	26.1	26.7	27.3	27.9	28.4	29.0	29.6	500
400	18.6	19.0	19.5	20.0	20.4	20.9	21.4	21.8	22.3	22.7	23.2	23.7	400
300	13.9	14.3	14.6	15.0	15.3	15.7	16.0	16.4	16.7	17.0	17.4	17.8	300
200	9.3	9.5	9.7	10.0	10.2	10.4	10.7	10.9	11.1	11.4	11.6	11.8	200
100	4.6	4.8	4.9	5.0	5.1	5.2	5.3	5.5	5.6	5.7	5.8	5.9	100
90	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	90
80	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.5	4.6	4.7	80
70	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.1	4.1	70
60	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.6	60
50	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	3.0	50
40	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	40
30	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	30
20	.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1 1	1.1	1.2	1.2	20
10	.5	.5	.5	.5	.5	.5	.5	.6	.6	.6	.6	.6	10
9	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	9
8	.4	.4	.4	.4	.4	.4	.4	.4	.5	.5	.5	.5	8
7	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	6
5	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	1
Test.	4.20	4.30	4.40	4.50	4.60	4.70	4.80	4.90	5.00	5.10	5.20	5.30	Test.

Table XII. Overrun table, showing pounds of butter from one hundred lbs. of milk. (See directions for use, p. 186.)

Per cent. fat.	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	Per cent. fat.
3.0	3.30	3.33	3.36	3.39	3.42	3.45	3.48	3.51	3.54	3.57	3.60	3.0
3.1	3.41	3.44	3.47	3.50	3.53	3.57	3.60	3.63	3.66	3.68	3.72	3.1
3.2	3.52	3.55	3.58	3.62	3.65	3.68	3.71	3.74	3.78	3.81	3.84	3.2
3.3	3.63	3.66	3.70	3.73	3.76	3.80	3.83	3.86	3.89	3.93	3.96	3.3
3.4	3.74	3.77	3.81	3.84	3.88	3.91	3.94	3.98	4.01	4.05	4.08	3.4
3.5	3.85	3.89	3.92	3.96	3.99	4.03	4.06	4.10	4.13	4.17	4.20	3.5
3.6	3.96	4.00	4.03	4.07	4.10	4.14	4.18	4.21	4.25	4.28	4.32	3.6
3.7	4.07	4.11	4.14	4.18	4.22	4.26	4.29	4.33	4.37	4.40	4.44	3.7
3.8	4.18	4.22	4.26	4.29	4.33	4.37	4.41	4.45	4.48	4.52	4.56	3.8
3.9	4.29	4.33	4.37	4.41	4.45	4.49	4.52	4.56	4.60	4.64	4.68	3.9
4.0	4.40	4.44	4.48	4.52	4.56	4.60	4.64	4.68	4.72	4.76	4.80	4.0
4.1	4.51	4.55	4.59	4.63	4.67	4.72	4.76	4.80	4.84	4.88	4.92	4.1
4.2	4.62	4.66	4.70	4.75	4.79	4.83	4.87	4.91	4.96	5.00	5.04	4.2
4.3	4.73	4.77	4.82	4.86	4.90	4.95	4.99	5.03	5.07	5.12	5.16	4.3
4.4	4.84	4.88	4.93	4.97	5.02	5.06	5.10	5.15	5.19	5.24	5.28	4.4
4.5	4.95	5.00	5.04	5.09	5.13	5.18	5.22	5.27	5.31	5.36	5.40	4.5
4.6	5.06	5.11	5.15	5.20	5.24	5.29	5.34	5.38	5.43	5.47	5.52	4.6
4.7	5.17	5.22	5.26	5.31	5.36	5.41	5.45	5.49	5.55	5.59	5.64	4.7
4.8	5.28	5.33	5.38	5.42	5.47	5.52	5.57	5.62	5.66	5.71	5.76	4.8
4.9	5.39	5.44	5.49	5.54	5.59	5.64	5.68	5.73	5.78	5.83	5.88	4.9
5.0	5.50	5.55	5.60	5.65	5.70	5.75	5.80	5.85	5.90	5.95	6.00	5.0
5.1	5.61	5.66	5.71	5.76	5.81	5.87	5.92	5.97	6.02	6.07	6.12	5.1
5.2	5.72	5.77	5.82	5.88	5.93	5.98	6.03	6.08	6.14	6.19	6.24	5.2
5.3	5.83	5.88	5.94	5.99	6.04	6.10	6.15	6.20	6.25	6.31	6.36	5.3
5.4	5.94	5.99	6.05	6.10	6.16	6.21	6.26	6.32	6.37	6.43	6.48	5.4
5.5	6.05	6.11	6.16	6.22	6.27	6.33	6.38	6.44	6.49	6.55	6.60	5.5
5.6	6.16	6.22	6.27	6.33	6.38	6.44	6.50	6.55	6.61	6.66	6.72	5.6
5.7	6.27	6.33	6.38	6.44	6.50	6.56	6.61	6.67	6.73	6.78	6.84	5.7
5.8	6.38	6.44	6.50	6.55	6.61	6.67	6.73	6.79	6.84	6.90	6.96	5.8
5.9	6.49	6.55	6.61	6.67	6.73	6.79	6.84	6.90	6.96	7.02	7.08	5.9
6.0	6.60	6.66	6.72	6.78	6.84	6.90	6.96	7.02	7.08	7.14	7.20	6.0

Table XIII. Yield of cheese, corresponding to 2.5 to 6 per cent. of fat, with lactometer readings from 26 to 36. (See p. 188.)

Per cent. of fat.	Lactometer degrees.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
2.5	7.28	7.41	7.54	7.67	7.81	7.94	8.07	8.20	8.33	8.47	8.60	2.5
2.6	7.44	7.57	7.70	7.83	7.96	8.09	8.22	8.35	8.49	8.62	8.76	2.6
2.7	7.59	7.72	7.85	7.99	8.12	8.25	8.38	8.51	8.64	8.77	8.91	2.7
2.8	7.74	7.87	8.00	8.14	8.27	8.40	8.53	8.67	8.80	8.94	9.07	2.8
2.9	7.90	8.03	8.16	8.30	8.44	8.56	8.69	8.82	8.95	9.09	9.22	2.9
3.0	8.05	8.18	8.31	8.45	8.58	8.71	8.84	8.97	9.11	9.24	9.37	3.0
3.1	8.21	8.34	8.47	8.60	8.74	8.87	9.00	9.13	9.26	9.39	9.53	3.1
3.2	8.36	8.49	8.62	8.75	8.89	9.02	9.15	9.28	9.42	9.55	9.68	3.2
3.3	8.52	8.65	8.78	8.91	9.05	9.18	9.31	9.44	9.57	9.70	9.84	3.3
3.4	8.67	8.80	8.93	9.06	9.20	9.33	9.46	9.59	9.73	9.86	9.99	3.4
3.5	8.82	8.96	9.09	9.22	9.35	9.48	9.62	9.75	9.88	10.01	10.15	3.5
3.6	8.98	9.11	9.24	9.37	9.50	9.63	9.77	9.90	10.03	10.17	10.30	3.6
3.7	9.13	9.26	9.39	9.52	9.65	9.78	9.92	10.05	10.19	10.32	10.46	3.7
3.8	9.29	9.42	9.55	9.68	9.81	9.94	10.08	10.21	10.34	10.48	10.61	3.8
3.9	9.44	9.57	9.70	9.84	9.97	10.10	10.23	10.36	10.50	10.64	10.77	3.9
4.0	9.60	9.73	9.86	10.00	10.13	10.26	10.39	10.53	10.66	10.79	10.93	4.0
4.1	9.75	9.88	10.02	10.15	10.28	10.39	10.54	10.68	10.81	10.94	11.08	4.1
4.2	9.90	10.03	10.17	10.30	10.43	10.57	10.70	10.84	10.97	11.10	11.24	4.2
4.3	10.06	10.19	10.32	10.45	10.58	10.72	10.85	10.99	11.12	11.25	11.39	4.3
4.4	10.21	10.34	10.48	10.61	10.74	10.87	11.00	11.14	11.27	11.41	11.55	4.4
4.5	10.36	10.49	10.63	10.76	10.89	11.03	11.16	11.29	11.42	11.56	11.70	4.5
4.6	10.52	10.65	10.78	10.92	11.05	11.18	11.31	11.45	11.58	11.71	11.85	4.6
4.7	10.67	10.81	10.94	11.07	11.20	11.34	11.47	11.60	11.73	11.87	12.01	4.7
4.8	10.83	10.96	11.09	11.22	11.36	11.49	11.62	11.76	11.89	12.02	12.16	4.8
4.9	10.98	11.11	11.25	11.38	11.51	11.65	11.78	11.91	12.04	12.18	12.32	4.9
5.0	11.14	11.27	11.40	11.54	11.67	11.80	11.93	12.07	12.20	12.34	12.48	5.0
5.1	11.29	11.42	11.55	11.69	11.82	11.96	12.09	12.23	12.36	12.49	12.63	5.1
5.2	11.45	11.58	11.71	11.85	11.98	12.11	12.24	12.38	12.52	12.66	12.80	5.2
5.3	11.60	11.73	11.86	11.99	12.13	12.27	12.40	12.53	12.67	12.71	12.85	5.3
5.4	11.76	11.89	12.02	12.16	12.29	12.42	12.55	12.69	12.83	12.97	13.01	5.4
5.5	11.91	12.04	12.17	12.31	12.44	12.58	12.71	12.85	12.99	13.12	13.25	5.5
5.6	12.07	12.20	12.33	12.47	12.60	12.73	12.87	13.00	13.14	13.28	13.41	5.6
5.7	12.22	12.35	12.48	12.62	12.75	12.89	13.02	13.16	13.30	13.44	13.57	5.7
5.8	12.38	12.51	12.64	12.77	12.91	13.05	13.18	13.31	13.45	13.59	13.72	5.8
5.9	12.53	12.66	12.79	12.93	13.06	13.19	13.33	13.47	13.60	13.74	13.87	5.9
6.0	12.69	12.82	12.95	13.09	13.22	13.35	13.49	13.62	13.75	13.89	14.02	6.0

Table XIV. Comparisons of Fahrenheit and Centigrade (Celsius) thermometer scales.

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
+212	+100	+176	+80	+140	+60
211	99.44	175	79.44	139	59.44
210	98.89	174	78.89	138	58.89
209	98.33	173	78.33	137	58.33
208	97.78	172	77.78	136	57.78
207	97.22	171	77.22	135	57.22
206	96.67	170	76.67	134	56.67
205	96.11	169	76.11	133	56.11
204	95.55	168	75.55	132	55.55
203	95	167	75	131	55
202	94.44	166	74.44	130	54.44
201	93.89	165	73.89	129	53.89
200	93.33	164	72.33	128	53.33
199	92.78	163	72.78	127	52.78
198	92.22	162	71.22	126	52.22
197	91.67	161	71.67	125	51.67
196	91.11	160	71.11	124	51.11
195	90.55	159	70.55	123	50.55
194	90	158	70	122	50
193	89.44	157	69.44	121	49.44
192	88.89	156	68.89	120	48.89
191	88.33	155	68.33	119	48.33
190	87.78	154	67.78	118	47.78
189	87.22	153	67.22	117	47.22
188	86.67	152	66.67	116	46.67
187	86.11	151	66.11	115	46.11
186	85.55	150	65.55	114	45.55
185	85	149	65	113	45
184	84.44	148	64.44	112	44.44
183	83.89	147	63.89	111	43.89
182	83.33	146	63.33	110	43.33
181	82.78	145	62.78	109	42.78
180	82.22	144	62.22	108	42.22
179	81.67	143	61.67	107	41.67
178	81.11	142	61.11	106	41.11
177	80.55	141	60.55	105	40.55

Table XIV. Comparisons of thermometer scales (*Continued.*)

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
+104	+40	+68	+20	+32	+0
103	39.44	67	19.44	31	—0.55
102	38.89	66	18.89	30	1.11
101	38.33	65	18.33	29	1.67
100	37.78	64	17.78	28	2.22
99	37.22	63	17.22	27	2.78
98	36.67	62	16.67	26	3.33
97	36.11	61	16.11	25	3.89
96	35.55	60	15.55	24	4.44
95	35	59	15	23	5
94	34.44	58	14.44	22	5.55
93	33.89	57	13.89	21	6.11
92	33.33	56	13.33	20	6.67
91	32.78	55	12.78	19	7.22
90	32 22	54	12.22	18	7.78
89	31.67	53	11.67	17	8.33
88	31.11	52	11.11	16	8.89
87	30.55	51	10.55	15	9.44
86	30	50	10	14	10
85	29.44	49	9.44	13	10.55
84	28.89	48	8.89	12	11.11
83	28.33	47	8.33	11	11.67
82	27.78	46	7.78	10	12.22
81	27.22	45	7.22	9	12.78
80	26.67	44	6.67	8	13.33
79	26.11	43	6.11	7	13.89
78	25.55	42	5.55	6	14.44
77	25	41	5	5	15.00
76	24.44	40	4.44	4	15.55
75	23.89	39	3.89	3	16.11
74	23.33	38	3.33	2	16.67
73	22.78	37	2.78	1	17.22
72	22.22	36	2.22	0	17.78
71	21.67	35	1.67	—1	18.33
70	21.11	34	1.11	2	18.89
69	20.55	33	0.55	3	19.44

To convert deg. Fahrenheit to corresponding deg. Centigrade:
Subtract 32, multiply difference by 5, and divide by 9.

Example: Which degree Centigrade corresponds to 110° F.? $110 - 32 = 78$; $78 \times 5 = 390$; $390 \div 9 = 43.33$.

To convert deg. Centigrade to corresponding deg. Fahrenheit:
Multiply by 9, divide product by 5, and add 32 to quotient.

Example: Which degree Fahrenheit corresponds to 95.5° C.? $95.5 \times 9 = 859.5$; $859.5 \div 5 = 171.9$; $171.9 + 32 = 203.6$.

Table XV. Comparison of metric and customary weights and measures.

Customary weights and measures.	Equivalents in metric system.	Metric weights and measures.	Equivalents in customary system.
1 inch............	2.54 centimeters.	1 meter............	39.37 inches.
1 foot	.3048 meter.	1 meter............	1.0936 yards.
1 mile............	1.6094 kilometers.	1 kilometer.......	.6214 mile.
1 square inch..	6.452 sq. centimeters.	1 sq. centimeter	.155 sq. inch.
1 square foot ..	9.29 sq. decimeters.	1 square meter..	10.764 sq. feet.
1 square yard.	.836 sq. meter.	1 square meter..	1.196 sq. yards.
1 acre............	.4047 hectare.	1 hectare	2.471 acres.
1 cubic inch...	16.387 cc.	1 cc..................	.061 cubic inch.
1 cubic foot....	.0283 cub. meter.	1 cub.decimeter	61.023 cubic inches.
1 cubic yard...	.765 cub. meter.	1 cub. meter......	35.314 cub. feet.
1 bushel..........	.3552 hectoliter.	1 hectoliter	2.8377 bushels.
1 fluid ounce..	29.57 cc.	1 cc..................	.0338 fluid ounce.
1 quart...........	.9464 liter.	1 liter...............	1.0567 quarts.
1 gallon	3.7854 liters.	1 decaliter........	2.6417 quarts.
1 grain...........	64.8 milligrams.	1 gram.............	15.43 grains.
1 ounce (av.)..	28.35 grams.	1 gram.............	.035274 ounce.
1 pound (av.)	.4536 kilogram.	1 kilogram.......	2.2046 pounds (av.)

SUGGESTIONS regarding the organization of co-operative creameries and cheese factories.

When the farmers of a neighborhood are considering the establishment of a creamery or cheese factory, they should first of all make an accurate canvas of the locality to ascertain the number of cows that can be depended on to supply the factory with milk. The area which may be drawn from will vary according to the kind of factory which it is desired to operate. A successful separator creamery will need at least 400 cows within a radius of four to five miles from the proposed factory.[1] Small cheese factories can be operated with less milk, and gathered-cream and butter factories generally cover a much larger territory than that mentioned. In all cases, however, the question of the number of cows contributing to the enterprise must be fully settled before further steps are taken, since this is a point upon which success will largely depend.

Methods of organization. The farmers should form their own organization, and not accept articles of agreement proposed by traveling agents. An agreement to supply milk from a stated number of cows should be signed by all expecting to join the association. When a sufficient number of cows has been pledged to insure the successful operation of a factory, the farmers agreeing to supply milk should meet and form an organization. This may be done according to either of the following plans which have been known to give good satisfaction.

Raising money for building and equipment.

First.—Each member will sign an agreement to pay on or before a given date for a certain number of shares in the company at.........dollars per share; or,

Second.—An elected board of directors may be authorized to borrow a sum of money not exceeding.........thousand dollars on their individual responsibility, and the sum of.........cents, (usually five cents) per hundred pounds of milk received at the factory shall be reserved for the payment of this borrowed money.

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[1] Bull. 56, Wisconsin experiment station.

Constitution and by-laws of a co-operative association are drawn up and signed by the prospective members of the association when it has been determined to form such an association. It is impossible to include in an illustration all the articles and rules that may be found useful in each particular instance; the following suggestions in regard to some of the points to be included in the documents are given as a guide only. It may be found advisable to modify them in various ways to meet the needs of the organization to be formed.

After the constitution and by-laws have been drawn up and made plain to all the members of the association, they should be printed and copies distributed to all parties interested.

CONSTITUTION

OR

ARTICLES OF AGREEMENT OF THE...............ASSOCIATION.[1]

1. The undersigned, residents within the Counties of........., State of..........., hereby agree to become members of the........... Co-operative Association, which is formed for the purpose of manufacturing butter or cheese from whole milk.

2. The regular meetings of the association shall be held annually on the...........day of the month of.................. Special meetings may be called by the president, or on written request of one-third of the members of the association, provided three day's notice of such meeting is sent to all members.

Meetings of the board of directors may be called in the same way, either by the president or by any two members of the board of directors.

3. Ten members of the association, or three of the board of directors, shall constitute a quorum for the transaction of business.

4. The officers of the association shall include president, secretary, treasurer, one of whom is also elected manager, and these officers together with three other members of the associa-

[1] The following publications have been freely used in preparing this constitution and by-laws: Woll, Handbook f. Farmers and Dairymen; Minn. experiment station, bull. No. 35; Ontario Agriculture College, special bulletin, May 1897.

tion shall constitute the board of directors. Each of these six officers shall be elected at the annual meeting and hold office for one year, or until their successors have been elected and qualified. Any vacancies in the board of directors may be filled by the directors until the next annual meeting of the association.

5. The duties of the president shall be to preside at all meetings of the association, and perform the usual duties of such presiding officers. He shall sign all drafts and documents of any kind relating to the business of the association, and pay all money which comes into his possession by virtue of his office, to the treasurer, taking his receipt therefor. He shall call special meetings of the association when deemed necessary.

In the absence of the president, one of the board of directors shall temporarily fill the position.

6. The secretary shall attend all business meetings of the association and of the board of directors and shall keep a careful record of the minutes of the meetings. He shall also give notices of all meetings and all appointments on committees, etc. He shall sign all papers issued, conduct the correspondence and general business of the association, and keep a correct financial account between the association and its members. He shall have charge of all property of the association not otherwise disposed of, give bonds for the faithful performance of his duties, and receive such compensation for his services as the board of directors may determine.

7. The treasurer shall receive and give receipt for all money belonging to the association, and pay out the same upon orders signed by the president and the secretary. He shall give such bonds as the board of directors may require.

8. The board of directors shall audit the accounts of the association, invest its funds, appoint agents, and determine all compensations. They shall prescribe and enforce the rules and regulations of the factory. They shall cause to be kept a record of the weights and tests of the milk or cream received from each patron, the products sold, the running expenses, etc., and shall divide among the patrons the money due them each month. They shall also make some provision for the with-

drawal of any member from the association, and make a report in detail to the association at the annual meeting. Such report shall include the gross amount of milk handled during the year, the receipts from products sold, and all other receipts, the amounts paid for milk and for running expenses, and a complete statement of all other matters pertaining to the business of the association.

9. Among the rules and regulations to be enforced by the board of directors may be included some or all of the following:

a. Patrons shall furnish all the milk from all the cows promised at organization of the association.

b. Only sweet and pure milk will be accepted at the factory, and any tainted or sour milk shall be refused.

c. The milk of each patron shall be tested at least three times a month.

d. Any patron proved to be guilty of watering, skimming or otherwise adulterating the milk sent to the factory, or by taking more than 80 pounds of skim milk or whey for every 100 pounds of whole milk delivered to the factory, shall be fined as agreed by the association.

e. A partron's premises may be inspected at any time by the board of directors, or their authorized agent, for the purpose of suggesting improvements in the methods of caring for the milk or the cows, in drainage and general cleanliness; or to secure samples of the milk of his cows for examination when it is deemed necessary.

10. Any changes or amendments to the by-laws or constitution of the association must be made in writing by the parties proposing the same, and posted prominently in a conspicuous place at the creamery, at least two weeks previous to their being acted upon. Such changes to be in force must be adopted by a two-thirds vote of the stockholders.

11. In voting at any annual or special meeting of the association, the members shall be entitled to one vote for each cow supplying milk to the factory, or for each share of the stock owned by them, as agreed upon.

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