U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY—Bulletin No. 58.
D. E. SALMON, D. V. M., Chief of Bureau.

THE FAT TESTING OF CREAM

BY THE

BABCOCK METHOD.

BY

ED. H. WEBSTER, *Inspector and Dairy Expert*,
DAIRY DIVISION, BUREAU OF ANIMAL INDUSTRY,

AND

C. E. GRAY, *Special Agent*,
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., February 4, 1904.

SIR: I have the honor to transmit herewith the manuscript of an article on "The fat testing of cream by the Babcock method," prepared by Ed. H. Webster, inspector and dairy expert, and C. E. Gray, special agent, under the direction of Henry E. Alvord, Chief of the Dairy Division of this Bureau. Mr. Gray, chemist, of Topeka, Kans., was temporarily appointed as special agent to assist in this work.

It is evident from investigations conducted in the field in connection with the gathering of data for this volume that much misapprehension exists in regard to the proper way of making the Babcock test with cream, and that loose and inaccurate methods of doing the work are universally in vogue. This matter becomes of much importance when large operations are involved, consequently the information and directions submitted in the following pages are of value to creamery men and others interested in the subject. I therefore recommend the publication of the work as Bulletin No. 58 of the series of this Bureau.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON, *Secretary.*

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INTRODUCTION.

Investigations made during the summer of 1903 among the large centralizing creamery plants in Iowa, Missouri, Kansas, Nebraska, and Colorado revealed some surprising facts in regard to the general practice of handling the Babcock method in cream testing. It would seem that a subject which has had so much attention given it from experiment stations and practical creamery men everywhere would have been thoroughly familiar to everyone in the creamery business. The investigations showed quite the contrary. Men who used the test daily were found to be at fault in many particulars, and in some instances not the first idea of the principle underlying the method seemed to be in the mind of the operator. Much of this has grown out of carelessness on the part of the user and much is due to improper instruction given for the use of the test as applied to cream. These difficulties and the discrepancies resulting therefrom led to a more thorough examination of the whole subject of cream testing by the method named, and it is the purpose of this bulletin to give the result of these investigations. It will be necessary to go over the entire field and follow each step in detail to insure any completeness in the discussion of this subject. Therefore some things may be repeated which may not seem necessary, but there will be enough new, at any rate to most users of the test, to make the subject as a whole interesting.

It may be stated that a large part of the creamery men are gradually departing from the rules for operating the Babcock test as prescribed by standard works on the subject. There are various reasons for this, but uppermost is the shortage which these creameries are experiencing in the overrun or churn yield. In many cases the test is read lower than the instructions would warrant, and in others the methods of sampling and measuring the cream into the test bottle are modified in one way or another. In practically all cases this is not done with

any thought of "robbing the patron," as the phrase is commonly put, but it is done with a conviction that present methods are somewhere at fault, and the attempt is made to even things up and still give everybody his due.

Instances were found where the creamery, as operated under the hand-separator system, was getting considerably less butter from 100 pounds of butter fat from cream than they had formerly obtained from the same measure under the whole-milk system. This seemed to indicate plainly that the method of testing was at fault, for it was justly argued that 100 pounds of butter fat should make the same amount of butter, whether bought as cream or as whole milk.

With this brief introduction to an old but exceedingly important question, the manipulation of the test will be described in detail, faults will be noted, and better methods suggested. Illustrations as to what the results of some practices are in dollars and cents are included in order to emphasize the importance of very careful work by the man who is doing the testing.

The three vital points in making a test are: (1) A true sample of the cream to be tested; (2) an exact quantity of the sample in the test bottle; (3) reading the test accurately. These three statements seem simple enough at first glance, but they are more complex in actual practice, as many a creamery man has been brought to believe when the month's business was checked up.

A TRUE SAMPLE OF THE CREAM TO BE TESTED.

CUSTOM OF DELIVERING CREAM AT STATIONS.

It is the custom of the patrons of the Western creameries to bring their cream to the factory or to the cream-receiving station in any sort of vessel, from a 1-gallon molasses pail to a 10-gallon milk can. The molasses pail may be filled completely full, and the milk can may have but 8 to 10 pounds in it. In the one case the pail is so full that the cream can not be stirred without spilling, and in the other it is so far down from the top of the can and the cream is spread out so thin over the bottom that it is often difficult to get a proper sample after it is stirred. These cases are not ideal, but they are given as they are found in the field, and it is in the field that the testing is done.

The territory in which these investigations were made has two extremes of weather—hot, sultry, summer days, when the thermometer hovers around 100° F. in the shade and 125° or 130° F. on the creamery or receiving-station platform; and the cold, blizzardy days of winter, when the station or creamery is the coldest place in the country except the back of the buggy in which the patron's can has been tied for its ride to the station. These two extremes of weather present their problems to the man who is going to sample the cream, and they are quite different in character.

The cream is received in all kinds of places; it may be in an ideal creamery or receiving station; it may be in the back end of a store of some sort, without hot water or heat of any kind; or it may be on the route wagon, with the sampling to be done by the route driver. All these methods are in accordance with the facts and have to be considered.

THOROUGH UNIFORMITY OF THE CREAM.

When the can of cream arrives at the weigh platform, there are some things of importance to be noted. If the patron has used water to flush or wash out the last of the cream after separating, in most cases this water would be in a layer on the bottom of the can. It is possible that thorough stirring at the farm would overcome this difficulty, but usually this stirring is not done, and the water is in the bottom of the can. The portion richest in butter fat is on top, and there is a gradation which varies with every inch of depth from this richest cream down to the water. The cream may be thick because of the great amount of butter fat in it, it may be thick because it is sour, or it may be thick from age. The first and most important thing in getting a true sample in any of these cases is to make the cream to be sampled uniform throughout in richness and in physical condition. If this is not done, the first step has gone wrong, and every succeeding step will be wrong just to that extent. The final result will be wrong, and in nearly every case the creamery is the loser and the patron the gainer.

This uniformity of the cream can best be obtained in either of two ways—pouring or stirring. It can never be properly done by shaking. Pouring from one can to another is the best way to do it. At most receiving platforms there is nothing at hand but the ordinary 5, 8, or 10 gallon milk cans. These cans have a narrow neck and cause a waste of time and of cream. They waste time because the cream has to be poured slowly, and yet there is always a tendency to hurry, so that a little cream is often spilled. Two or more cans should be provided for this purpose. They should have straight sides and a top entirely open, a good heavy bail, and a large hand-hold near the bottom for grasping to tip and empty them. If the cream is to be poured directly into cans for shipping, the pouring can should have one side elongated like the "nose" of a pitcher or coffeepot. A can of this sort should hold either 6 or 12 gallons, so as to give plenty of space to empty a 5, an 8, or a 10 gallon can of cream without overflowing.

If the patron's cans are not filled too full, the uniformity of the cream may be insured by using a stirring rod in the patron's can. Stir vigorously for a few moments. This rod should be made of good heavy wire with a disk of tin from $3\frac{1}{2}$ to 4 inches in diameter securely soldered to the lower end. This disk should have a slight cup shape and the rod soldered to the inside center of the cup. A good hand-

hold should be bent on the other end of the wire. Make the rod long enough to work to the bottom of a 10-gallon can. Stirring is not so good as pouring, however, and the safest way is to pour the cream and then use the stirring rod a moment in addition.

These methods will answer the purpose in every case except three: (1) The cream may be so thick it will not pour, (2) it may be frozen, or (3) it may be churned. Warm the thick cream until it will pour. If no heat is available for this work, the creamery operator will have to make a guess at the richness of the cream, or test it and probably overestimate the amount of butter fat it contains. When the cream freezes, it is the water which crystallizes out, leaving the richer part of the cream in the center of the can. If a test is made of this central portion the result may be from 1 to 20 per cent too high. It must be thoroughly thawed out and mixed. When the cream is churned, if such cream is received at all, test the buttermilk and estimate the butter.

METHODS OF SAMPLING.

After insuring a uniform mixture of the cream, there are two general methods in use for taking the sample—the dipper and the sampling tube. If thorough work has been done in the first step, a small portion dipped from the cream will be a fair representative of it. A dipper about the size of a No. 10 shotgun shell is the most common in use. If the sample is to be tested at once, enough cream should be taken to make two tests. This insures enough cream for a second test should any accident occur to the first. If a composite sample is kept, a smaller amount should be taken.

If the sampling tube is employed, it should be lowered slowly through the cream, with the top end open, so that it may fill just as fast as it is lowered. When it reaches the bottom, place the thumb tightly over the top of the tube and lift it out. The rich cream from the top of the can will adhere to the outside of the tube. Instances have been noted where the operator rubbed this, or a portion of it, into the sample jar. The effect, of course, is to give too high a test. The tube, in order to work best, should be hot when it is put into the cream. This will help the cream to flow readily into it and will also prevent its sticking to the outside, and the general results will be better. Keep the tube under a small steam jet, and just before using blow it out with steam. This will prevent any cream from the previous test from influencing the one about to be made and will insure the tube being used hot. In the absence of steam pour hot water through the tube. The tube sampler, if properly handled, is the preferable way to secure the sample. It takes a proportional part and is the surest to give a just result when the cream is not thoroughly mixed.

SOME WRONG METHODS.

The amount of cream used in making up composite samples for a large number of patrons runs pretty well up in value when it is computed. If a half-pint sample is taken for each of 1,000 patrons, this is equal to 500 pounds of cream. Each sample will take a little less than 20 c. c. if a full 18-gram charge is used. For 1,000 patrons this will require 20 pounds of cream, leaving 480 pounds to be thrown away because of the corrosive sublimate or other preservative added to it. If the average test be 35 per cent, the amount of butter fat lost will be 168 pounds, which at 20 cents per pound amounts to $33.60 per thousand patrons. Should this occur twice a month, the loss per thousand for a month will be $67.20. If there are 10,000 patrons, as is the case with some creameries in the West, this loss amounts to $672 per month, which is well worth looking after.

Observations in the field were to the effect that in many instances samples were dipped from the top of the can without stirring or pouring; this doubtless checked up with an unpleasant loss for these stations at the end of the month. One instance was observed where the tube sampler was used without stirring or pouring the cream previous to its use; the result would be the same as where the sample was dipped from the top of the can. The tube always lets a little run back into the can before the weight of the cream is balanced by the vacuum created at its upper end; the small amount which thus runs back is nearly all water or very thin cream. This water is weighed as cream and the patron given credit for it; the sample thus taken is, therefore, not a true one and the analysis shows too high a percentage of fat.

If a tester, by careless methods of sampling, makes his average test one-half of 1 per cent too high, the result will be astonishing. This amounts to 5 pounds of butter fat per 1,000, and at a creamery making 5,000 pounds of butter per day the loss would be 25 pounds, or $5 per day, figured at 20 cents per pound; in a creamery making 20,000 pounds per day it amounts to $20 per day. Combine this with the loss previously mentioned and it means a total loss of over $900 per month, if there be 5,000 patrons and a make of 20,000 pounds of butter per day. These losses have actually occurred in many instances at the above ratio per thousand patrons.

AN EXACT QUANTITY OF THE SAMPLE IN TEST BOTTLE.

There are two general methods of procedure in practice after securing the correct sample, namely, by testing each delivery as it is made, or by making a composite sample, which is tested each week or semimonthly, or in some cases only once a month.

TESTING AFTER EACH DELIVERY.

This is for many reasons a better method than taking a composite sample. The cream is in better condition to test. There is no chance for loss by evaporation, and an absolute check can be kept upon the work each day. The chief objections to it are the extra time and greater amount of acid required for doing the work. (Details of measuring the sample are taken up after the discussion of the composite sample, as they apply to both alike.)

THE COMPOSITE SAMPLE.

There are several things leading up to the measuring of the sample into the test bottle which will be considered first, as they have a direct bearing on the final result.

The sample jar.—When a composite sample is kept, the sample jar is of great importance. It must have a perfectly tight cover to prevent evaporation. The amount of evaporation that may take place is shown by the following data taken from the testing room of a large Western creamery:

TABLE I.—*Effects of evaporation under varying conditions of jar covers.*

Condition of jar cover.	Quantity of cream or milk.	Per cent of fat on—		
		Nov. 13.	Nov. 27.	Dec. 4.
Series A.	*c. c.*	*Per cent.*	*Per cent.*	*Per cent.*
Tight cover	35.2	37.2	39.4	40.2
Do	70.4	38.2	38.2	39.0
Do	140.8	38.4	38.8	39.2
Loose cover	35.2	39.4	58.6	(a)
Do	70.4	38.4	40.2	42.4
Do	140.8	38.2	39.6	40.2
No cover	35.2	38.4	(a)	(a)
Do	70.4	37.8	51.6	82.8
Do	140.8	38.6	45.4	50.4
Series B.				
Tight cover	35.2	27.8	28.8	29.6
Do	70.4	28.2	27.8	29.2
Do	140.8	27.8	28.0	27.0
Loose cover	35.2	28.2	31.0	34.0
Do	70.4	27.8	35.4	41.6
Do	140.8	27.4	28.4	33.3
No cover	35.2	28.2	(a)	(a)
Do	70.4	27.8	43.6	80.8
Do	140.8	28.0	30.8	45.3
Series C.				
Tight cover	35.2	3.8	3.8	3.8
Do	70.4	4.0	3.9	3.8
Do	140.8	3.8	3.8	3.8
Loose cover	35.2	3.8	4.4	4.8
Do	70.4	3.8	4.0	4.2
Do	140.8	3.8	4.2	4.2
No cover	35.2	4.0	(a)	(a)
Do	70.4	3.8	4.4	5.4
Do	140.8	4.0	4.0	4.5

(a) Sample dried.

The jars used in the above test were the ordinary half-pint sample jars used for composite samples. The covers were the "Lightning" pattern. The jars classed as "tight cover" were in good repair and the covers as tight as such jars usually are. The "loose-cover" jars had covers that did not fit well and were left somewhat loose. The "no-cover" jars were entirely open. Each jar contained the number of cubic centimeters of cream recorded under the heading "Quantity of cream or milk." On November 13 the cream was tested and put into the bottles. This test is recorded under the date named. On November 27 and December 4 the samples were again tested, and the records of these tests appear under these dates.

These data are worthy of considerable study. The covers that were supposed to be tight evidently were loose enough to let out some moisture. The smaller samples show the greatest loss. Those marked "Sample dried" were so dried out that they could not be tested at all. The sample jars can not be too carefully looked after, and yet it is no uncommon thing to see jars containing samples without covers or with very imperfect ones.

The result of such practices is inevitable. The creamery will lose money and will, in all probability, never know how it occurred.

Preserving the sample.—The average sample in which a preservative tablet has been placed shows the weakness of the methods of preserving that are commonly in vogue. A bright-red spot appears where the tablet lay in the bottle, the rest of the cream being in no way affected by the tablet. Such a method is a waste of tablets, and the cream sample is practically in the same shape it would have been had no attempt been made to preserve it. The cream is usually thick, or quickly thickens in the jar, and the tablet, although dissolved in it, is not mixed throughout the cream. As quickly as the operator has time after putting the first cream in a jar, if it is too thick, he should warm the bottle to about 100° F., thus bringing the cream to a fluid condition and enabling an easy mixture of the preservative and cream. Usually the next addition of cream can be quite readily mixed with the first. The mixing should be done immediately after adding the sample to the jar. All the jars should be looked over at the end of the day, and any that have not mixed properly should be warmed and shaken up until the mixing is complete.

In the summer time composite samples will sometimes show a separation into layers, the lower portion being whey and the upper part fat and casein. Such samples do not look well, but so far as observations go this does not to any appreciable extent influence the test, provided they are thoroughly mixed before the sample is taken. In the winter season it has not been shown that a preservative other than the cold weather is needed. In shaking composite samples to mix preservative and cream always give a rotary motion to the hand, as this causes the cream to flow around the bottle. A violent agitation will often churn the contents, thus destroying to a great extent the usefulness of the sample.

MEASURING OR WEIGHING THE SAMPLES.

The same precaution used in procuring the sample in the first place must be used in getting it ready for measuring into the test bottle. Bring the cream to a uniform condition by warming the samples to 100° F. or a little more, then pour from one cup to another a sufficient number of times to insure a uniform texture of the cream. Be sure that no cream sticks to the side of the sample jar. There will be no dried cream if the jar has been tightly covered. If dried cream is present the test will not be correct, because some moisture has evaporated. If the cream is lumpy, pour it through a fine sieve and press the lumps through with the finger, as described in Bulletin No. 100 of the Vermont Experiment Station. After pouring the cream until it is uniform, measure quickly the desired quantity before any movement of fat begins toward the top. If the sample has in any way become churned, heat it warm enough to melt the butter fat and very quickly mix and measure out the desired amount. The test of such churned cream can only be taken as an approximation of the true result.

There is only one correct way of securing a true sample, and that is to weigh the cream into the test bottle with a delicate pair of scales or balances. Anyone desiring correct results should not use the pipette measure for cream. There are too many conditions entering into the problem to make the pipette measure at all reliable. The cream, in pouring to get a uniform sample, will incorporate more or less air. Very often it is partially sour when received and in this condition contains many gas bubbles. The specific gravity varies with its richness. Thick and viscous cream may contain large air bubbles in its body which do not move readily to the surface.

Tables for correcting the error due to specific gravity have been compiled and are correct for that factor, but they do not and can not take into account the other factors, which are often of greater importance than the specific gravity. The quantity of cream weighed into the test bottle does not matter, so long as the correct reading of the result can be obtained. Usually 9 or 18 grams are taken, but sometimes a less amount is used.

The details of making the test after weighing out the samples are of so common knowledge as to make it needless to discuss them here. It is sufficient to say that the desired end is a perfectly clear fat column, so that the readings can easily and readily be made.

READING THE TEST ACCURATELY.

This seems the simplest step of all, and yet it has been proven the hardest. Mention has been made of the fact that creamery men were reading the cream test lower than standard instructions warranted. They doubtless reasoned that the test must be too high or they would get an overrun equal to that obtained under the whole-milk system.

Only one creamery in all the territory under investigation had made any attempt to discover why the test seemed to be too high. This creamery, through its chemist, whose work along this line is made use of in this bulletin, had worked out the table below showing that errors of a glaring character were being made in their methods of reading the test. There are a number of different types of cream bottles on the market, and the tests made were between different types of bottles in use at the creamery in question. Those used were the 30 per cent 9-inch, 50 per cent 9-inch, and 50 per cent 6-inch bottles. The first is not in general use, but the last two are used quite extensively in Western creamery practice.

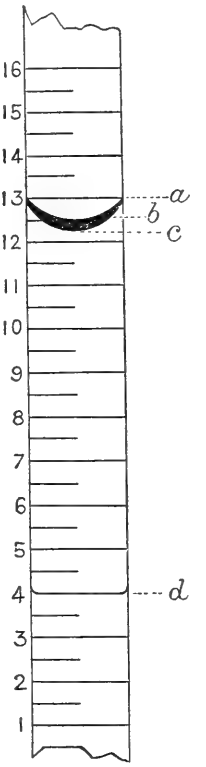


FIG. 1.—The "Meniscus." Section of a test bottle showing readings of fat column from different points of the meniscus.

A COMPARISON OF VARIOUS BABCOCK TESTS WITH THE TEST BY ETHER EXTRACTION.[a]

The tests by the Babcock method were made as follows: All bottles were tested for accuracy of graduation before using. Three types were used: First, a bottle 9 inches in length, graduated to read two-tenths of 1 per cent and up to 30 per cent; this type of bottle will be referred to as the 30 per cent 9-inch bottle. Second, a bottle 9 inches in length, graduated to read five-tenths of 1 per cent and up to 50 per cent; this type of bottle will be referred to as the 50 per cent 9-inch bottle. Third, a bottle 6 inches in length, graduated to read five-tenths of 1 per cent and up to 50 per cent; this type of bottle will be referred to as the 50 per cent 6-inch bottle. All samples were weighed on a Torsion balance, sensitive to 10 milligrams. The weights used were tested for accuracy. All readings were taken at 130° F., this temperature being obtained by placing the bottles in water and heating to this point. Three readings were taken from each test, the method being as follows: Reading A, from *a* to *d;* reading B, from *b* to *d;* reading C, from *c* to *d.* The crescent-shaped surface of the fat in the neck of the bottle, as shown at *a b c*, is called the meniscus.

The determination by the extraction method was made as follows: Samples of about 5½ grams were weighed out into fat-free extraction thimbles, charged with ignited asbestos, then dried to constant weight at 100° C. The samples were then placed in a continuous ether extractor and the extraction carried on with ether that had recently been distilled over sodium. After six to eight hours' extraction the flasks containing the extracts were removed and replaced by other flasks and the extraction again continued for three hours. This extraction gave only a trace of fat. The extracted fat was dried to

[a] Tests made by C. E. Gray.

constant weight at a temperature of 100° C. Duplicate analyses were made of all samples. Only the averages are given in the table below:

TABLE II.—*Readings of Babcock tests compared with similar figures obtained by ether extraction.*

Sample.	Result by ether extraction.	Results by Babcock method.			
		Reading.	30 per cent 9-inch bottle, 9-gram sample.	50 per cent 9-inch bottle, 18-gram sample.	50 per cent 6-inch bottle, 18-gram sample.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*
No. 1	52.32	A	52.90	53.20	53.85
		B	52.50	52.80	53.10
		C	52.00	52.35	52.40
No. 2	43.41	A	44.20	44.10	44.45
		B	43.80	43.70	43.80
		C	43.40	43.30	43.25
No. 3	39.28	A	39.80	39.75	40.00
		B	39.40	39.25	39.40
		C	39.00	38.75	38.75
No. 4	26.23	A	27.00	26.80	27.15
		B	26.60	26.30	26.60
		C	26.20	26.00	26.05
No. 5	23.42	A	23.90	23.90	24.20
		B	23.50	23.45	23.80
		C	23.10	22.95	23.40
No. 6	8.27	A	8.80	8.80	9.55
		B	8.40	8.45	8.90
		C	8.00	8.05	8.25
No. 7	8.30	A	9.00	9.00	9.05
		B	8.60	8.65	8.65
		C	8.20	8.35	8.25

TABLE III.—*Summary of average differences between extraction and Babcock methods.*

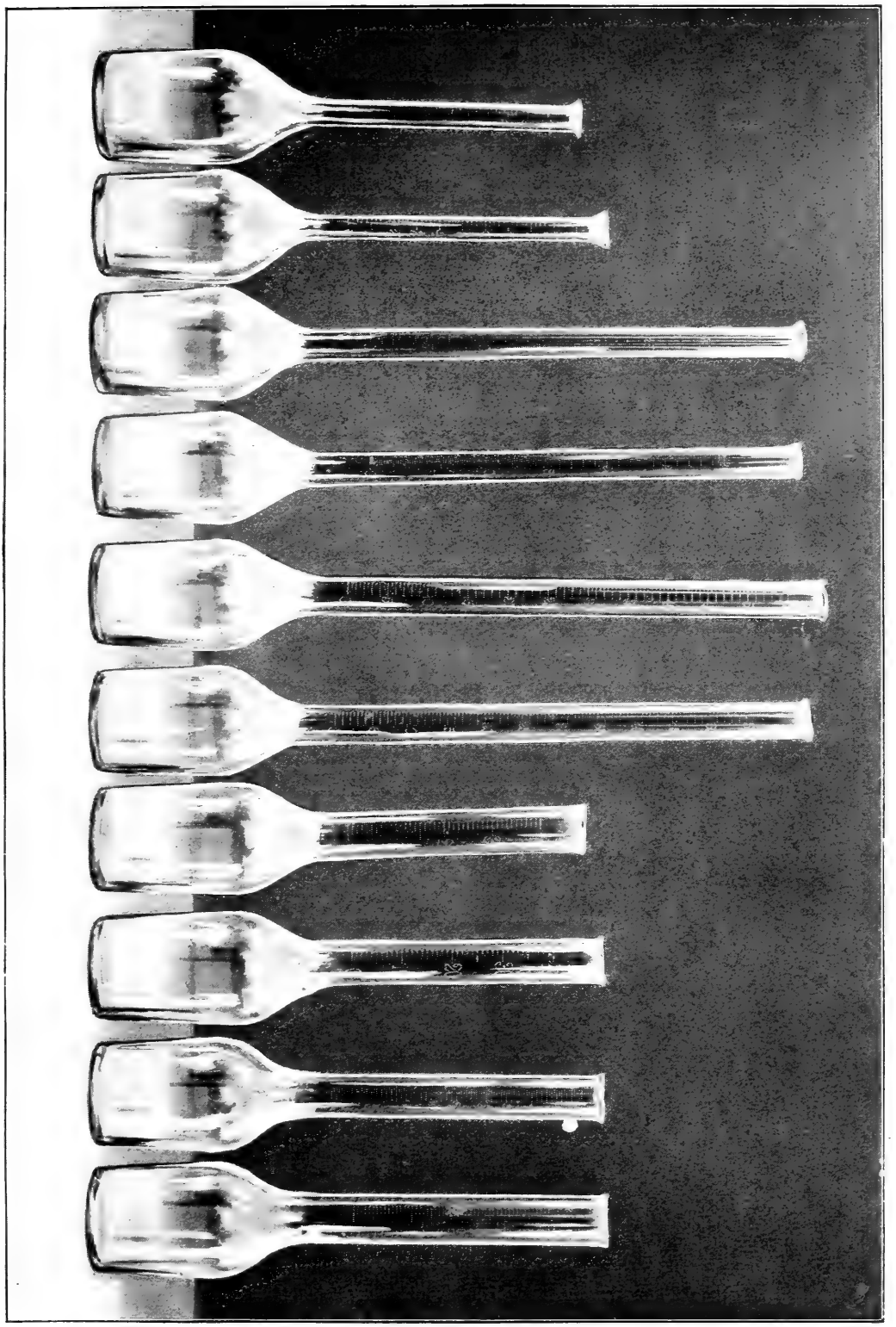
[(+) denotes readings above and (−) readings below those obtained by extraction method.]

Babcock readings.	30 per cent 9-inch.	50 per cent 9-inch.	50 per cent 6-inch.
	Per cent.	*Per cent.*	*Per cent.*
A	+0.62	+0.62	+1.00
B	+ .22	+ .19	+ .43
C	− .19	− .21	− .12

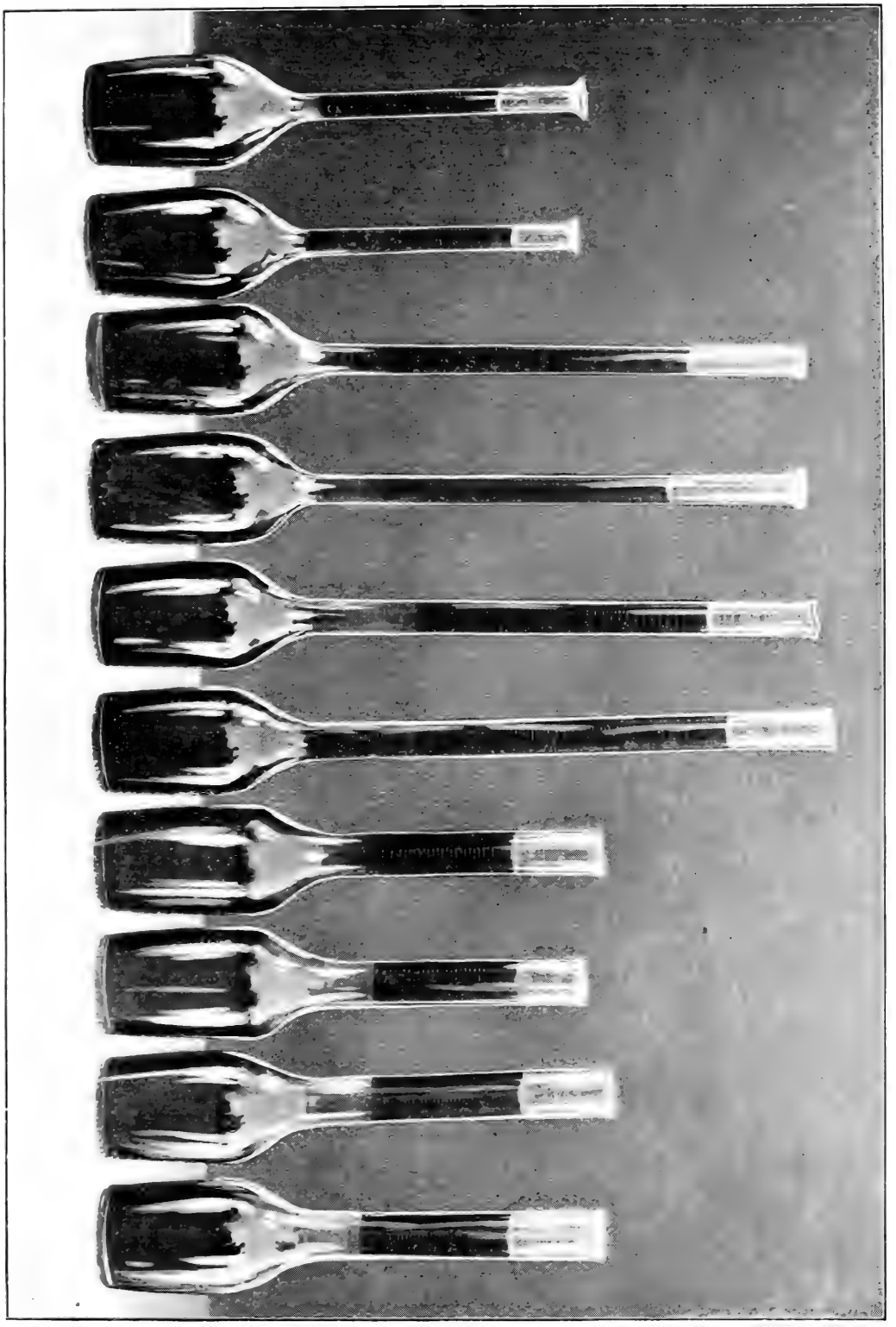
The differences in readings of 9-gram samples were doubled in order that they should appear in such form as to compare with the other columns of the table, which represent 18-gram samples.

A COMPARISON OF MILK AND CREAM READINGS.

The lowness of the milk test as compared with cream readings is exemplified by the following table, which gives the summary of differences as compared with the test made in the 10 per cent milk bottle.



Types of Cream and Milk Test Bottles Used in Experiments.



Types of Cream and Milk Test Bottles, Showing Fat Columns, Menisccuses, etc.

The readings were made and the differences found in the same manner as in the comparison with the ether extraction figures, shown in Table III.

TABLE IV.—*Excess of average cream readings A, B, and C over milk reading A.*

Cream reading.	30 per cent 9-inch.	50 per cent 9-inch.	50 per cent 6-inch.
A	+0.51	+0.65	+1.50
B	+ .27	+ .32	+ .75
C	+ .07	+ .05	+ .20

Credit is due to Mr. Gray for suggesting this line of investigation. A careful study of the foregoing tables will indicate that something wrong is pretty sure to occur when the Babcock test is applied to cream by a careless or inexperienced operator. The readings were made at *a*, *b*, and *c* in the above work because these points were quite distinct and could be read without much chance of error. The results show that the probable cause of the differences in the readings of the different types of bottles lies in the meniscus. (See fig. 1, p. 15.) Following out this suggestion, a series of experiments were undertaken at the Kansas Experiment Station.

EXPERIMENTS AT THE KANSAS EXPERIMENT STATION.

Through the courtesy of Prof. J. T. Willard, director and chemist of the Kansas station, Manhattan, Kans., the author secured the use of the station chemical laboratory and the cooperation of the assistant chemist, Mr. R. H. Shaw, in carrying on further the work already outlined. Prof. J. O. Hamilton, assistant professor of physics in the Kansas State Agricultural College, gave material assistance in the mathematical and physical problems involved. Experiments were repeated with the same results as obtained in the work already quoted and shown in Tables II, III, and IV.

ERRORS CAUSED BY INCORRECT READING OF THE MENISCUS.

The most interesting feature of the work was a study of the effect of the meniscus in bottles of different diameters on the reading of the test. A series of thirteen bottles were selected ranging in diameter of neck from 0.2338 inch to 0.5862 inch. The bottles were filled with water to some point in the lower part of the neck, and then 1 gram of pure butter fat weighed into the neck. The specific gravity of the fat was 0.9, and each gram should represent just 5.55 plus per cent butter fat. The bottles were whirled in a hand tester and read at 120° F. Readings from extreme top to bottom of fat column were carefully made and the depth of meniscus measured and recorded in per cent of the scale on which the reading was made. The following

table gives the style of bottle, diameter of neck, the per cent of fat, the depth of meniscus in same terms as fat, and the difference from the true amount:

TABLE V.—*Effect of meniscus in bottles of different diameter.*

Style of bottle.	No. of bottle.	Diameter of neck.	Per cent of fat.	Per cent meniscus.	Difference over true amount (5.55+).
10 per cent milk	13	0.2338	5.70	0.20	0.15
	12	.2682	5.80	.30	.25
30 per cent 9-inch cream	3	.2858	5.90	.40	.35
	42	.3056	5.90	.50	.35
	5	.3204	6.00	.50	.45
	7	.3356	6.10	.60	.55
50 per cent 9-inch cream	34	.3916	6.25	.80	.70
	32	.4100	6.25	.90	.70
40 per cent 6-inch cream	45	.5016	6.75	1.50	1.20
	44	.5232	7.00	1.80	1.45
50 per cent 6-inch cream	25	.5498	7.00	2.00	1.45
	20	.5664	7.25	2.25	1.70
	19	.5862	7.40	2.25	1.85

It will be seen in the above table that the 10 per cent milk bottles give a reading of 5.70 and 5.80, respectively, and that the 50 per cent 6-inch cream bottles give a reading of 7.00, 7.25, and 7.40, and that the meniscus of the 10 per cent bottles is 0.20 and 0.30, while for the 50 per cent 6-inch bottles it is 2.00, 2.25, and 2.25, and, further, that the 10 per cent bottles read 0.15 and 0.25 above the true amount and the 50 per cent 6-inch bottles read 1.45, 1.70, and 1.85 above the true amount. This is especially interesting from the fact that all of these bottles have been supposed to read alike. It will also be seen that the 10 per cent bottles read more than the true amount, whereas in general practice the reading of these bottles is supposed to indicate the amount exactly. In ordinary milk testing it is estimated that about two-tenths of 1 per cent adheres to the inside of the bottle below the neck, and in reading the per cent of fat the total length of the fat column will just give the desired reading. In the above table the fat was weighed into the neck of the bottle and was therefore known to be all in the neck, and the effect of the meniscus is thus as apparent in the 10 per cent bottles as with the others.

If we calculate that about the same amount of fat is held back in the bulb of all bottles, regardless of size of the neck, it will be seen that the differences—as shown in the last column of the above table—regularly increase as the necks of the bottles increase in diameter. Taking No. 13, the first bottle in the table, as a standard, the differences from the true amount, here taken as 5.70, are seen to range from 0.10 in bottle No. 12 to 1.70 in bottle No. 19.

This shows the actual errors that would constantly be made in regularly testing with these bottles.

Table V shows that the depth of meniscus increases with the diameter of the neck, and that the true reading comes somewhere between the reading of the top and the reading at the bottom of the meniscus. A careful inspection of Table V will show that if from the depth of the meniscus there is deducted four-fifths of itself, the result will be very near the true difference in reading between that which the bottle actually gives and the true amount. Therefore the shortest rule that can be given to correct the error due to the meniscus is as follows: Read the test from the extreme top to bottom of fat column; deduct from this reading four-fifths of the depth of the meniscus, and add 0.2 per cent to the result. The 0.2 per cent is the amount supposed to adhere to the test bottle and is not shown in the fat column in the neck. In none of the cases in the table will this rule give exactly the right figure, but the differences are all, with one exception, less than one-tenth of 1 per cent.

TABLE VI.—*Showing corrected readings after deducting portion of meniscus, as per rule.*

Style of bottle.	Number of bottle.	Reading.	Depth of meniscus.	Four-fifths of meniscus.	Reading less four-fifths of meniscus.	Reading less four-fifths of meniscus +0.2 per cent.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
10 per cent milk	13	5.7	0.20	0.16	5.54	5.74
	12	5.8	.30	.24	5.56	5.76
30 per cent 9-inch cream	3	5.9	.40	.32	5.58	5.78
	42	5.9	.50	.40	5.50	5.70
	5	6.0	.50	.40	5.60	5.80
	7	6.1	.60	.48	5.62	5.82
50 per cent 9-inch cream	34	6.25	.80	.64	5.61	5.81
	32	6.25	.90	.72	5.53	5.73
40 per cent 6-inch cream	45	6.75	1.50	1.20	5.55	5.75
	44	7.00	1.80	1.44	5.56	5.76
50 per cent 6-inch cream	25	7.00	2.00	1.60	5.40	5.60
	20	7.25	2.25	1.80	5.45	5.65
	19	7.40	2.25	1.80	5.60	5.80
Average		6.40	1.07	.86	5.54	5.74

If the 10 per cent bottles are taken as correct and as standards in this case, the final average is only 0.01 per cent less than the average reading of the 10 per cent bottles, the latter being 5.75 per cent.

If a 9-gram sample is used and the result must be doubled, the 0.2 per cent must not be added until the four-fifths meniscus is deducted and this result multiplied by 2.

The differences shown in Table VI occur because it is a practical impossibility to read the exact amount in any test. In the 10 per cent bottles and the 30 per cent 9-inch bottles tenths have to be estimated; in the 50 per cent 9-inch bottles anything less than 0.5

per cent has to be estimated; in the 40 per cent 6-inch bottles used in this test anything less than 1 per cent has to be estimated; and in the 50 per cent 6-inch bottles used anything less than 0.5 per cent has to be estimated. All of this estimation makes not only possible but altogether probable errors in reading which range from less than 0.1 per cent to as much as 0.5 per cent. The space occupied by 1 per cent in the large-diameter bottles is so shallow that a slight tipping of the bottle away from the perpendicular may easily make a difference of from 0.25 per cent to 1 per cent in the reading.

Applying the rule for reading the meniscus to the readings in Table II, the following is the result:

TABLE VII.—*Results of applying rule for reading meniscus to readings found in Table II.*

Number of sample.	Style of bottle.	Reading.[a]	Meniscus.	Four-fifths of meniscus.	Reading less four-fifths of meniscus.	Double reading.	+0.2 per cent.	True reading (by extraction).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	30 per cent 9-inch	26.45	0.45	0.36	26.09	52.18	52.38	52 32
	50 per cent 9-inch	53.20	.85	.68	52.50	----------	52.70	
	50 per cent 6-inch	53.85	1.45	1.16	52.69	----------	52.89	
2	30 per cent 9-inch	22 10	.50	.40	21.70	43.40	43.60	43.41
	50 per cent 9-inch	44.10	.80	.64	43.46	----------	43.66	
	50 per cent 6-inch	44.45	1.20	.96	43.49	----------	43.69	
3	30 per cent 9-inch	19.90	.40	.32	19.58	39.16	39.36	39.28
	50 per cent 9-inch	39.75	1.00	.80	38.95	----------	39.15	
	50 per cent 6-inch	40.00	1.25	1.00	39.00	----------	39.20	
4	30 per cent 9-inch	13.50	.40	.32	13.18	26.36	26.56	26.23
	50 per cent 9-inch	26.80	.80	.64	26.16	----------	26.36	
	50 per cent 6-inch	27.15	1.10	.88	26.27	----------	26.47	
5	30 per cent 9-inch	11.95	.40	.32	11.63	23.26	23.46	23.42
	50 per cent 9-inch	23.90	.80	.64	23.26	----------	23.46	
	50 per cent 6-inch	24.20	.95	.76	23.44	----------	23.64	
6	30 per cent 9 inch	4.40	.40	.32	4.08	8.16	8.36	8.27
	50 per cent 9-inch	8.80	.75	.60	8.20	----------	8.40	
	50 per cent 6-inch	9.55	1.30	1.04	8.51	----------	8.71	
7	30 per cent 9-inch	4.50	.40	.32	4.18	8.36	8.56	8.30
	50 per cent 9-inch	9.00	.65	.52	8.48	----------	8.68	
	50 per cent 6-inch	9.05	.80	.64	8.41	----------	8.61	

[a] This column gives the highest reading (A) in each case.

In the above table the column headed "Reading" is the extreme reading, and the column headed "Meniscus" is the difference between "*a*" and "*c*," as shown in fig. 1 (on p. 15). For the 30 per cent 9-inch bottles only one-half the amounts given in Table II are used, as one-half is equal to the 9-gram reading that was taken in this case. This is corrected to the proper amount in the column headed "Double reading." The column "+0.2 per cent" gives the corrected reading, and the column "True reading" gives the amount determined by the extraction method.

A rearrangement of the final results in the above table makes the following showing. The sum of the seven samples is taken and the average differences determined:

TABLE VIII.—*Showing average excess of Babcock readings over extraction readings.*

Style of bottle.	Average reading less four-fifths of meniscus.	0.2 per cent addition.	Corrected reading.	Average true amount.	Average difference.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
30 per cent 9-inch	28.69	0.20	28.89	28.74	+0.15
50 per cent 9-inch	28.71	.20	28.91	28.74	+ .17
50 per cent 6-inch	28.83	.20	29.03	28.74	+ .29

The column "Average reading less four-fifths of meniscus" is the average of double the 30 per cent 9-inch readings, and the 50 per cent 9-inch and 50 per cent 6-inch readings. To these is added the 0.2 per cent for the corrected reading. From the corrected reading is taken the average true amount, which gives the difference found in column "Average differences." This is the average above the true amount for each reading "A" in the three classes of bottles represented in Table II. It is doubtful in making these readings in Table II whether the meniscuses were read deep enough, as they were not read with a thought of this comparison in view.

Another possibility enters into the proposition that will have to be left an open question for the time being; that is, whether 0.2 per cent is not too much to allow for the fat which does not rise into the neck when testing cream in the wide-necked bottles. In Table VI it must be remembered that the fat was weighed into the neck of the bottle, and that the amount was positively known to be in the neck. The table was arranged from Table V, with the supposition that 0.2 per cent would remain below the fat column in all the bottles, and that being the case, the assumption that in the 10 per cent bottles the reading would actually be the same as if the test had been made in the regular way and read 5.7 per cent for No. 13, etc. While this is true for the 10 per cent bottles, it may not be true for the cream bottles, as Table VIII would seem to indicate. In view of the fact that nearly every error in sampling and making tests tends toward a larger reading than the correct one, the addition of the 0.2 per cent might safely be omitted and no injustice done to either party of the transaction.

It is a common practice to use a 9-gram charge and double the reading. This multiplies the error made in reading by 2. An examination of the diameter of the bottles given in Table V will show the wide variations to be found in bottles of the same class. The 13 bottles used in this experiment were selected from 50 bottles taken at random from a large stock, and they show almost every grade of variation.

It would not be a safe rule to deduct a certain amount from bottles of the same per cent reading, the differences between bottles of the same class being as great as between classes.

THE LOWER MENISCUS.

Among other things observed in making this test was the lower meniscus or line between the fat and the liquid below. When the bottles were whirled for five minutes in a tester in which the temperature remained constant, the line between the fat and water was a straight line. Immediately on cooling this line began to have a curved shape, the center being lower than the sides. If the bottles were placed in a hot bath and the temperature raised above that at which they had been whirled, the line curved upward, the center becoming higher than the sides. These changes in the shape of the bottom line, or plane of division, were nearly equal in effect to the upper meniscus. If the line curved either way, the effect was to increase the reading. The curve downward, due to cooling, did not affect the reading as much as the curve upward, due to heating. As the fat is drawn down and the bottom reading made lower, the fat column is shortened at the top, and this in a measure equalizes the error. When the center is moved upward as the result of expansion, the top is pushed up and the bottom line remains the same; the line that touches the glass is then the one from which the reading will be taken. This effect has been observed where a hand tester had a steam connection for heating the bottles. The operator would turn in the steam for the last whirling of one minute and then read the test. This sudden heating caused an expansion, and the movement of the fat and liquid on the surface of the glass being slower than that in the center, the bottom line of the fat column was curved upward, and consequently the reading was too high.

ERRORS DUE TO EXPANSION BY HEAT.

In testing cream the matter of expansion of the fat is of considerable importance. An experiment made by Mr. Gray is here recorded which shows the effect of expansion in heating the fats to temperatures ranging from 110° to 140° F.

Plan of test.—A sample of pure butter fat was separated from pure, fresh butter. A determination of the specific gravity of this fat showed it to be normal (0.9004 at 100° C.) compared with water at the same temperature. Samples of the fat were weighed into the various types of test bottles and skim milk enough added to each to make 18 grams. The fat and skim milk were mixed as thoroughly as possible and the test made as with cream. From this mixture a test was obtained that in appearance was very similar to the regular cream test. Three readings were taken from each test [as described in fig. 1 (p. 15)], at temperatures of 140°, 130°, 120°, and 110° F. Six tests were made with each type of bottle, and the results averaged as in the following table. The correct amount is very near 39.8 per cent. (That is, this would be the accurate reading or test for the fat actually present in this mixture or unnatural cream.)

TABLE IX.—*Average readings of six bottles at different temperatures, showing expansion.*

Style of bottle.	Reading.	Temperatures.			
		140° F.	130° F.	120° F.	110° F.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
30 per cent 9-inch, 9-gram	A	20.1	20.0	19.9	19.85
	B	19.9	19.8	19.75	19.75
	C	19.7	19.65	19.65	19.65
30 per cent 9-inch, reading doubled	A	40.2	40.0	39.8	39.7
	B	39.8	39.6	39.5	39.5
	C	39.4	39.3	39.3	39.3
50 per cent 9-inch, 18-gram	A	39.9	39.7	39.5	39.5
	B	39.4	39.3	39.2	39.1
	C	38.9	38.9	38.8	38.7
50 per cent 6-inch, 18-gram	A	40.5	40.3	40.1	39.9
	B	39.9	39.8	39.6	39.5
	C	39.0	38.9	38.7	38.6

TABLE X.—*Average changes in readings at stated temperatures due to heat expansion.*

Style of bottle.	Temperatures.			
	140° to 130° F.	130° to 120° F.	120° to 110° F.	140° to 110° F.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
30 per cent 9-inch, 9-gram	0.1	0.1	0.05	0.25
Same, doubled	.2	.2	.1	.5
50 per cent 9-inch, 18-gram	.2	.2	.0	.4
50 per cent 6-inch, 18-gram	.2	.2	.2	.6
Average full reading	.2	.2	.1	.5
Theoretical difference	.142	.142	.142	.427
Same, 9-gram	.071	.071	.071	.213

The average increase in reading when the temperature is raised from 110° to 140° is 0.5 per cent, as taken from the readings in Table IX. The theoretical increase is 0.427 per cent. The difference between the practical reading and the theoretical calculation is but 0.073 per cent, which is less than can be read in either of the styles of bottles in the test. The coefficient of expansion of fat is given as 0.00064 for melted butter fat within the range of temperatures as found in common testers in use. For each change of 10° F. 1 c. c. of fat, or 5 per cent, will change 0.0178 per cent. In the above illustration there was 39.8 per cent, or nearly 8 c. c. of fat, and the change would be eight times 0.0178 per cent, or 0.142 per cent, as shown in Table X. Fifty per cent cream would be ten times 0.0178 per cent, or 0.178 per cent. Thirty per cent cream would be six times this factor, etc.

The correct temperature for reading is given as 120° F., and in Table IX the readings, taken at 120° and corrected by the rule for

calculating the correct reading, give results nearest to the true amount, 39.8 per cent.

It will be seen that the differences of reading, when 9 grams of cream are used, are just one-half of those from a full charge, or 18 grams, so far as temperature is concerned. It will also be seen that when the readings of the 9-gram charge are multiplied by 2 to obtain the correct reading, the difference is also multiplied by 2, and the final result is the same as though 18 grams had been used. There has been an objection raised against the long-necked cream bottle to the effect that so long a column of fat necessarily shows more expansion and greater care must be exercised to have the temperatures just right. A careful consideration of the expansion table above will not bear out this assertion. Butter fat expands volumetrically. Cream-test bottles are graduated volumetrically and will take care of any expansion, no matter what the shape of the neck. With the long scale and the narrow neck the expansion is measured in just the same proportion as in a short scale and wide neck.

The hand tester will, as a rule, give nearer the right results than the steam-turbine tester, because the fat from the hand tester is usually read nearer 120°. The steam machine may heat the bottles to 160° or 180° F., and if read at this temperature a little calculation will show the nature of the results. If the steam machine is run with the lid raised an inch or two, better results will be obtained. This will allow an air current to be drawn through the machine, and the temperature will thus be kept down. If bottles are placed in a water bath to bring them to the right temperature for reading, they should remain in the bath for twelve to fifteen minutes before being read to insure an even temperature of fat and liquid below the fat and to insure a straight line between the two.

FINANCIAL RESULTS OF INCORRECT READING OF TESTS.

It has been stated before that a difference in test of one-half of 1 per cent would amount to $1 for every 1,000 pounds of butter made if valued at 20 cents per pound. In the preceding discussion it is shown that in the matter of reading the test alone a difference of 1.7 per cent can be made. Figured on the same basis as the above, this would equal $3.40 per 1,000 pounds, or $68 per day on an output of 20,000 pounds.

The methods of operating and the basis of paying for butter fat in the centralizing plants give the farmer all there is in it. In other words, the farmer in most cases gets a price for a pound of fat or the cream containing it which, together with the transportation charges on this cream, will equal the selling price of a pound of butter. The creamery must make its profits and pay its running expenses out of the overrun it is able to obtain. If this overrun is cut down through

mismanagement of any kind, profits are gone. Instances are now on record where concerns have become bankrupt through bad management along these very lines. The test question is but one item in the way of successful operation, and the things pointed out in this bulletin are not all the corners that must be watched in getting a proper overrun; but so far as the testing goes, this bulletin points out the dangers which are of vital importance to the creamery manager.

The following are examples of shortages occurring on several systems in Kansas and Nebraska largely due to improper methods of testing:

TABLE XI.—*Showing losses occurring at cream-receiving stations in Kansas and Nebraska, 1902–03.*

Month.	Stations.	Butter fat received at factory.	Butter fat paid for.	Loss.	
				Pounds.	Per cent.
1902.	*Number.*	*Pounds.*	*Pounds.*		
June	174	572,936	581,424	8,488	1.45
August	179	481,216	483,612	2,396	.49
September	178	399,276	396,575	[a]2,701	[a].67
October	175	239,847	244,816	4,969	2.03
November	175	191,038	197,672	6,634	3.35
December	164	173,692	181,598	7,906	4.35
1903.					
May	109	377,576	392,891	15,315	3.89
June	177	812,871	817,903	5,032	.61
July	181	655,691	657,806	2,115	.32
September	192	439,073	439,886	813	.18
Do	21	64,326	69,550	5,224	7.49
July	259	794,670	812,303	17,633	2.17
August	257	761,055	777,486	16,431	2.10

[a] Gain.

One-half of 1 per cent is allowed for mechanical loss by some of the larger creameries. Out of the 13 cases represented above, there are four within this limit—one showing a gain of 0.67 per cent and one very close to the limit.

The butter fat paid for and the butter fat received are found by testing at the station and at the factory. When this was checked against a low churn yield, this and the difference between the test called for an investigation. Not all of it can be laid to any one thing, but with careless sampling, loss of cream by spilling, etc., reading the test at too high a temperature, and reading the full meniscus, the losses may be found. The differences between the station and the factory tests are in the main due to poor work in sampling and testing at the station. It is a noteworthy fact that the tests at the factory are made more carefully than those at the stations. The station tests as a rule are made by pipette rather than scales. In most cases a cor-

rection table is used to correct the errors made by pipette measure. Although this method gives lower results than with the scales, the faulty methods of sampling, combined with too high reading, still give the station a higher test than shown at the factory, where the samples are usually weighed and more carefully read.

During the past year the creamery companies that have kept any records of their work have been cutting down this difference between tests and helping to correct the low churn results. It is hoped that the ideas given in this bulletin will be of some benefit to them; also to others who have not realized the possible loss along this line and the great probability that they have sustained it, although ignorant of the fact.

SUMMARY.

CONDENSED DIRECTIONS FOR MAKING FAT TESTS OF CREAM.

SAMPLING:

(1) Uniform composition and texture of cream is necessary.
(2) This is obtained by pouring from one pail or can to another.
(3) Frozen cream must be thawed before it can be sampled.
(4) Churned cream can not be successfully sampled.
(5) The tube sampler gives surest results.
(6) The dipper sampler does well if the cream is thoroughly mixed.
(7) Cream adhering to outside of tube should not get into sample jar.
(8) The tube should be blown out with steam or rinsed with hot water before using each time.
(9) Keep the top of the tube open while it goes down, so it may fill as fast as lowered.

KEEPING THE SAMPLES:

(1) Sample jars must have tight-fitting covers and be kept tight.
(2) If cream is dried in bottles it is evidence that covers are not tight enough to prevent escape of moisture.
(3) Preservatives must be thoroughly mixed with cream; if too thick, heat the jars.
(4) Do not shake the bottle to mix the cream; give it a rotary motion.
(5) It is best to have samples protected from extreme heat or cold.
(6) Churned cream gives only approximate results; dried cream gives too high results.
(7) Extreme hot weather and lack of attention may cause separation of whey.
(8) Do not take too large samples; it is a waste of cream.
(9) Look after samples every day and see that they are in proper shape.

PREPARING SAMPLE FOR MEASURING INTO TEST BOTTLE:

(1) Sample must be absolutely uniform throughout.
(2) Heat sample to about 100° F., or until it is quite fluid.
(3) If sample is weighed, a much higher temperature may be used.
(4) Pour from one cup to another until uniform.
(5) The hotter the sample the more fluid it will be and the easier to make uniform.
(6) Take care that no cream remains in sample jar adhering to the sides.
(7) If sample is lumpy, press lumps through a fine wire sieve (such as is used for a teapot strainer).
(8) Melt any churned samples, mix, and sample quickly.
(9) Make things convenient for this work and see that it is thoroughly done.

MEASURING INTO TEST BOTTLE:

(1) Weighing the sample is the only method that will give correct results.
(2) Use delicate balances and keep them in perfect order.
(3) Test weights and scales for accuracy before using.
(4) Torsion balances are very accurate; weigh one test at a time.
(5) Less than 9 grams may be used, but 9 or 18 grams are more convenient.
(6) Air and gas bubbles in cream cause pipette tests to be inaccurate.
(7) Specific gravity of cream causes pipette tests of cream to be too low.
(8) Tables for correcting specific gravity are in use, but they do not correct for error caused by air and gas.
(9) Weighing corrects all difficulties due to specific gravity and air or gas in cream.
(10) Use great care to get the weights exactly right.

MAKING THE TEST:

(1) If 18 grams of cream are used, add an equal weight of acid of 1.82 to 1.83 specific gravity.
(2) If 9 grams of cream are used, add an equal amount of water, then add acid as for 18 grams.
(3) Use enough acid to make a clear fat column; determine by trial.
(4) Use condensed steam or rain water for filling bottles.
(5) After adding acid, fill bottles at once to bottom of neck with water at about 120° F., and then whirl five minutes.
(6) Then add water of same temperature to bring fat within scale, and whirl two minutes.
(7) Keep the temperature down to 120° F. while whirling.

MAKING THE TEST—Continued.

(8) Have a hole drilled in top of tester to insert thermometer.
(9) Run the tester at as high speed as bottles will stand.
(10) For hand tester put in boiling water when beginning the test till it nearly reaches the bottles.
(11) For steam tester raise the lid slightly while making the test.
(12) When through whirling keep tester closed, so as to maintain heat even as possible.

READING THE TEST:

(1) See that line between fat and water is straight, and read from bottom to extreme top of fat column.
(2) Read the depth of meniscus and deduct four-fifths of it from previous reading. A careful operator can estimate this.
(3) Add 0.2 per cent to the result.
(4) For 9-gram sample, double reading before adding 0.2 per cent.
(5) Read at a temperature close to 120° F.
(6) If bottles are placed in bath to regulate temperature, allow them to stand for fifteen minutes before reading.

THE TEST BOTTLES:

(1) Use as narrow-necked bottles as possible, to get wide divisions of scale.
(2) The 30 per cent 9-inch bottles graduated to 0.2 per cent are most accurate.
(3) Use 9-gram charge with these, doubling the reading.
(4) The 50 per cent 9-inch bottles are next in accuracy, graduated to 0.5 per cent.
(5) The 30 per cent, 40 per cent, and 50 per cent 6-inch bottles are too inaccurate in results.
(6) In wide necks the scale divisions are too close together and errors are more probable.
(7) All bottles should be tested for correctness of calibration.
(8) With cheap bottles nearly half are not correct.
(9) Bottles guaranteed correct can not all be depended upon.

CONCLUDING NOTES.

Little more need be said except that there is still much work to be done to make a perfect cream test, free from the objections noted in this bulletin. The subject of preservatives for composite samples of cream is one that needs the attention of the chemists. A test bottle that will overcome the objectionable features noted is a study for some genius to work upon. A bottle of uniform diameter would greatly simplify matters as they stand, so that a uniform correction could be made for all tests. The great importance of careful work in all details should be urged upon every user of the test. The amount of butter fat that may adhere to the bottle and remain below

the neck should be studied and a large number of experiments made to determine the facts in the case. The common defects observed in field work were improper sampling, poor sample jars, the pipette method used in measuring samples, the test read too high and at too high temperature, and carelessness all along the line.

The question of overrun, while in very close touch with and influenced by the test, is not all dependent upon it. Losses occur due to careless weighing of cream, guessing at the weight of cans, leaving cream in cans while emptying, losses by spilling, and losses in shipping. The greatest factor of all influencing the overrun may be found in the churning and working of the butter. The question under discussion must not be lost sight of, however. Table X is food for reflection along this line. The just distribution of money to patrons and the financial results of the creamery industry in the West call for more careful consideration of this question of the cream test.

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