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PREFACE.

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The contents of the following pages are by no means to be considered an exhaustive treatise on the subject of the examination of milk. The intention of the writer is to put before the reader those methods for testing milk, with regard to its purity and quality, which at the present time are in his opinion the most useful and reliable, as well as the most widely applicable.

When selecting a method for the purpose of carrying out a scientific investigation, the utmost exactitude ought to be the only point aimed at regardless of difficulty, time and cost; but for practical purposes the question of applicability and suitability cannot be left unconsidered.

A careful perusal of this pamphlet will, it is hoped, afford sufficient information to the reader, desirous of examining milk, to enable him to select the method best adapted to his case, and, after he has done so, give him full instructions for carrying out the test in a successful manner.

P. V.

31, St. Petersburgh Place,

Bayswater, London, W.

January, 1887.

ILLUSTRATIONS.

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EASY METHODS

FOR THE

EXAMINATION OF MILK.

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VICE-PRESIDENT, SOCIETY OF PUBLIC ANALYSTS.

Considering the important part which cows' milk plays, not only as an article of diet, especially for the younger portion of the population, but also as the basis of a very widespread and important agricultural industry, it is not surprising to find that increasing attention is being paid to its composition and to the means by which its purity may be readily ascertained. Producer and consumer, vendor and purchaser, are equally interested in the richness and purity of the article, and methods and apparatus, which in their hands will give results with regard to its composition so far accurate as to enable them to judge of its quality, must be of the greatest value to them.

The intelligent farmer, who wishes to try by practical experiments the comparative value of different feeding stuffs, and the effect which they have upon the produce of his milch cows, cannot draw any definite conclusions, unless he obtains some knowledge of the percentage quantities of at least the most valuable component parts of the milk produced.

The cowkeeper, in these days of keen competition and agricultural depression, should not only measure or weigh, but also test the milk of his cows at regular intervals, in order to find out those members of his herd which are profitable and those which do not repay him for their keep, and for the care and trouble bestowed upon them.

The milk seller should make sure that he receives from the producer an article which has not been tampered with, as, should there have been any adulteration, and it is found out, the blame and disgrace will rest with him, although he may be quite innocent of any ill doing; and lastly, the consumer ought to be in a position to know that he gets for his money as much nutritive value as he may fairly expect.

The composition of cows' milk in its natural state is very variable, and depends upon conditions, of which the following are the most prominent:—

Food and shelter of cattle; intervals between milkings; length of time after calving; breed; and individuality; the last being of special importance. Amongst a herd of cattle, of whatever breed they may be, there will be found individual cows giving milk of a most varying composition, and although it is obvious that the variations are very much reduced when the total yield of a number of cows, say at least four or five, is mixed together, they are even then wide enough to render it impossible to give figures which may be taken in every case, and under any circumstances, as representing the average composition of milk.

Nevertheless, with the view of rendering what is hereafter written more intelligible, we give below the following figures:—

Composition of Cows' Milk.

Water	87·5	to	87·0	per cent.
Fat (Butter) ...	3·5	,,	3·8	,,
Proteids (Cheese) ...	3·7	,,	3·8	,,
Milk Sugar	4·6	,,	4·6	,,
Ash (Mineral Matter)	·7	,,	·8	,,
	100·0		100·0	

The specific gravity of milk is less variable than the percentages of solids which it contains, and in the case of the mixed yield of several cows it varies very slightly indeed. The determination of the specific gravity, therefore, is, if made in conjunction with other tests, one of the most valuable means for examining milk, as will be shown in the following pages, and deserves much more attention than has hitherto been paid to it.

Milk has often, and very rightly, been called a natural emulsion, because the butter fat, the most valuable component part of milk, is present in an emulsified state, *i. e.* in the form of minute globules of microscopic size distributed through a watery liquid, the serum, composed of the other constituents. The fat globules, which are surrounded by an envelope of condensed serum, being lighter than the serum, have a tendency to rise to the surface, forming by degrees quite a distinct layer called cream. It is, therefore, of the greatest consequence to make it a rule, upon which too much stress cannot be laid, that milk should be most thoroughly mixed before a sample of it is taken for examination.

SPECIFIC GRAVITY.

The specific gravity of liquids is generally determined by means of instruments, called hydrometers. For particular liquids hydrometers, with a scale of limited extent, suited to the special requirements, are employed and termed accordingly ; thus, for alcohol alcoholometers, for solutions of sugar saccharometers, and for milk lactometers are used. There are instruments manufactured, called percentage-lactometers, which do not show the specific gravity proper, but which are supposed to give exact indications as to whether the milk is pure or watered, and in the latter case the percentage of water which has been added. These instruments are misleading and should not be used.

Lactometers are made of different materials, but those manufactured of glass can only be recommended. It is true that they easily break if not carefully handled, but there are graver objections against other materials which have been used or suggested for the manufacture of lactometers.

Most lactometers bear a scale extending from 15 to 40 degrees, which is equal to a specific gravity of 1·015 to 1·040 (specific gravity of water = 1·000); an extension of the scale, however, from 25 to 40 degrees is quite sufficient (*Fig. 1*).

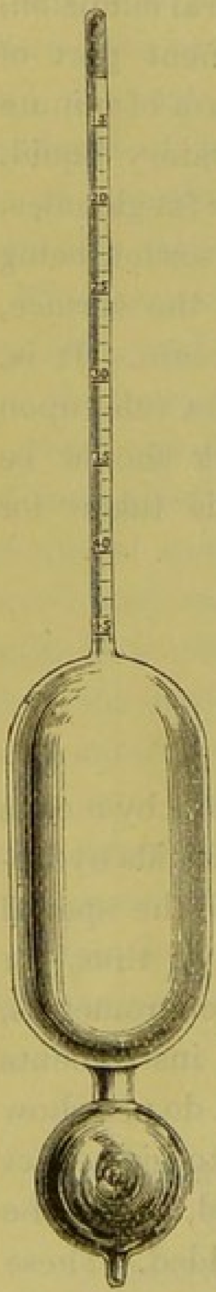

Fig. 1.

In order to determine the specific gravity, the milk is poured into a vessel at least ¼-in. greater in diameter than the widest part of the lactometer, and deep enough to allow the instrument to float. A cylindrical glass jar, with foot, is the most suitable vessel for the purpose. The lactometer is gradually lowered into the milk to the 25th degree, care being taken that the instrument is entirely wetted by the milk and that no air adheres to it. When released, the lactometer will move up and down, and after a little while become stationary. That degree of the scale which coincides with the surface of the milk is then noted. It will be observed that, where the milk touches the vessel and the stem of the lactometer, the surface is not level, but, in consequence of the adhesion of the milk to the glass, forms a curve. There is no difficulty, however, in ascertaining the extension of the curve sufficiently near, and this has to be allowed for in reading off the specific gravity. When using instruments of ordinary size, the curve will be found to extend to about one-half degree.

Lactometers indicate the exact specific gravity at a temperature of 60° Fahr. It is, therefore, necessary, as soon as the position of the lactometer has been noted, to remove the instrument from the milk, immerse a thermometer, and ascertain the temperature.

Combined lactometers and thermometers — lactothermometers — are made (*Fig. 2*), and these instruments are very convenient, as by their use the specific gravity and temperature can be read at the same time.

If the temperature is found to be 60° Fahr., the observed specific gravity is correct, but should the temperature of the milk be higher or lower than 60° Fahr. the specific gravity must be corrected by the aid of the appended Table I. which is used as follows:—Find the temperature of the milk in the uppermost horizontal line, and the observed specific gravity in the first or last vertical column; in the same line with the latter, and under the temperature, is given the corrected specific gravity. For example: Supposing the temperature to be 51° and the specific gravity 34°, the specific gravity corrected to 60° Fahr. is 32·9° = 1·0329; or if the temperature is 66° and the specific gravity 29°, the corrected specific gravity is 29·8° = 1·0298.

The specific gravity of the mixed yield of not less than four cows usually varies between the limits of 1·030 and 1·034, or from 30 to 34 degrees, but in rare instances it may be one degree lower or higher.

As by the addition of water to milk the specific gravity is reduced, while by the abstraction of cream it is increased, it is obvious, that by both these acts its original specific gravity can be restored to milk. Moreover, an unusually large percentage of cream in milk has the effect of so reducing the specific gravity, that it falls below the normal limit. In either case—low specific gravity of unusually rich milk, or normal specific gravity of skimmed and watered milk,—anyone having experience in the testing of milk would be likely from the mere appearance of such a sample to suspect its character and further examine it as to its composition.

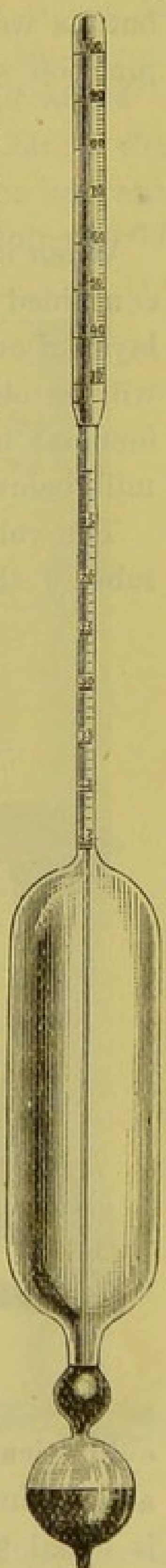

Fig. 2.

Useful, therefore, though the determination of the specific gravity alone certainly is, it cannot be considered a decisive test; but, as we have said before, it is of the greatest value in conjunction with other tests, which we will now describe.

CREAM TEST.

When milk is allowed to remain undisturbed, the fat globules contained in it rise and accumulate on the surface, forming a layer of cream. If the milk is put into a vessel of clear glass it will be observed that this layer, after a time, does not further increase in volume, and that it is separated from the skim milk below by a sharp and distinct line.

The volume of this cream is ascertained by means of the test tube or the creamometer. The cream test tube (*Fig. 3*) is a

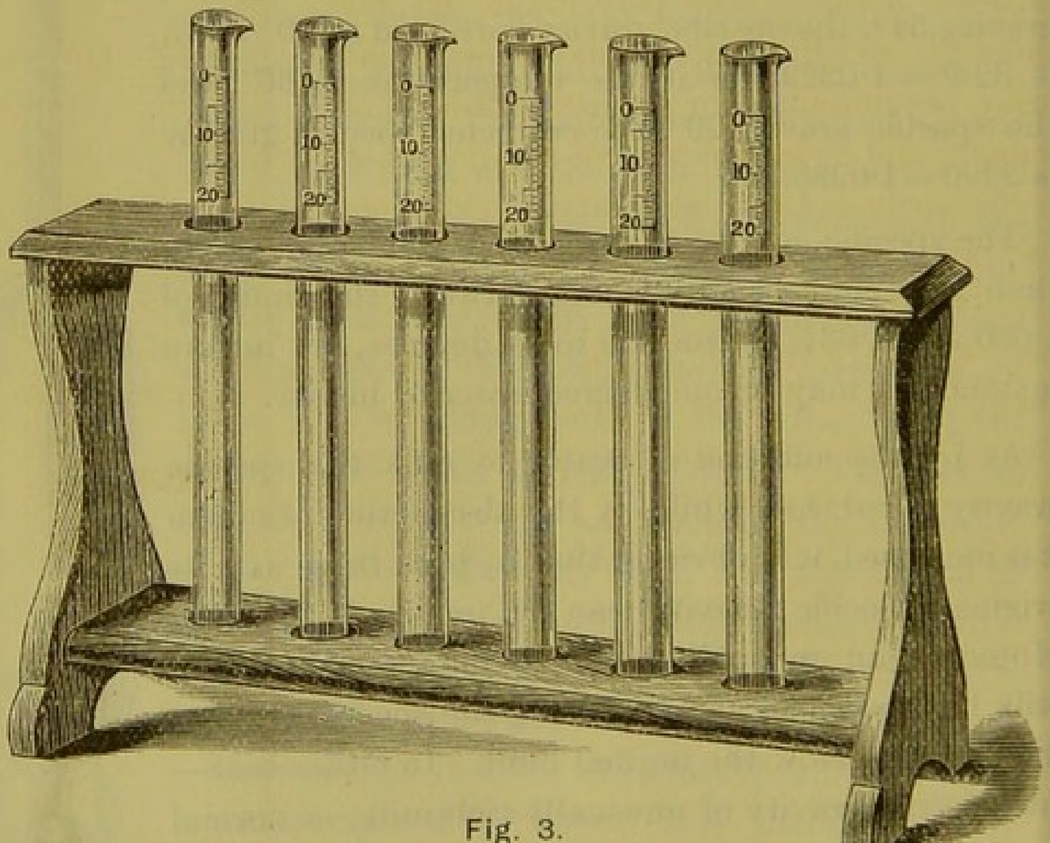

Fig. 3.

cylindrical glass tube open at one end and closed at the other, and having the upper part graduated in divisions, each of which is equal to the one-hundredth part of the capacity of the vessel below the top line marked "0." To ascertain the volume of cream, the milk to be tested is poured in until it reaches the top line, and left standing undisturbed for 12 to 24 hours, when the volume of cream is read off.

It would not be unreasonable to expect that the richer or poorer milk is in fat, the more or less cream it will throw up, and that, consequently, the volume of risen cream will afford a basis upon which conclusions as to the percentage of fat in the milk may be drawn. If there existed a definite relation between the percentage of fat and the volume of cream, nothing could be better or simpler than the cream test; but, unfortunately, this is not the case. There is always some fat left in the skim milk, and the amount differs very considerably according to circumstances. Again, the volume of cream formed is dependent on a great many other conditions besides the percentage of fat present, so that equal quantities of fat may be contained in different volumes of cream, and equal volumes of cream do not necessarily indicate the same percentage of fat. However, the creamometer, if judiciously used, is not without some merit, and gives, in a great number of cases, a fair idea as to the comparative value of different samples of milk, more especially so if the milk is tested immediately after it has been drawn from the cow. On the other hand the result obtained is rarely of much or any value, if the milk tested has been refrigerated, conveyed by road or rail for a long distance, repeatedly mixed, or is stale.

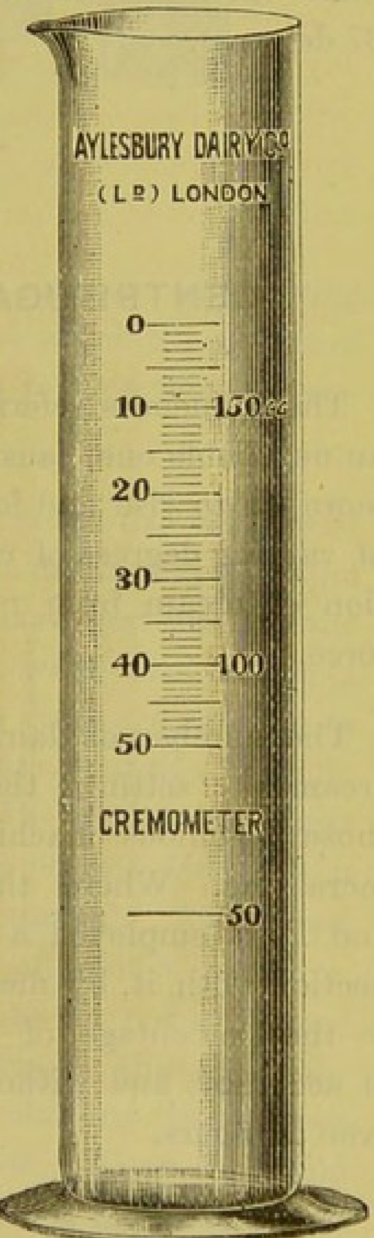

Fig. 4.

A better form of creamometer than the narrow test tubes, illustrated above, are glass cylinders not less than 1½ inches wide, and so graduated that the top line of the divisions is 6 inches from the bottom (*Fig. 4*). These cylinders are also convenient for taking the specific gravity of the whole, and, when deemed necessary, of the skim milk left after the removal of the cream.

We have mentioned above that milk, which has been skimmed and slightly watered, may be of normal specific gravity, but, if tested in a creamometer, such milk will only throw up a very small volume of cream, and the specific gravity of the skim milk will fall below the normal limit of 1·033 to 1·037 (=33 to 37 degrees).

CENTRIFUGAL CONTROL APPARATUS.

The influences referred to above, which render the cream test an unreliable one, causing in some instances less and in others more fat to rise and form a smaller or larger volume of cream of varying degrees of richness, do not operate when the separation of cream from milk is effected by means of centrifugal force.

The number of dairies, in which the old method of raising cream by "setting" the milk has been abandoned in favour of those ingenious machines, called cream separators, are daily increasing. Where the Danish cream separator, size A, A A, and B, is employed a control apparatus may be used in connection with it, by means of which the milk can be tested, as to the percentage of cream it contains, with a high degree of accuracy, and without having to wait for the results 12 or even 24 hours.

The centrifugal control apparatus, in connection with the A and A A separators, consists of a metal disc with a raised centre, and having on the circumference a number of projections or hooks, on which nine metal cases are hung up by means of pivots fixed on the sides and near the top of the cases (*Fig. 5*). Each case is provided with six test tubes, so that 54 samples

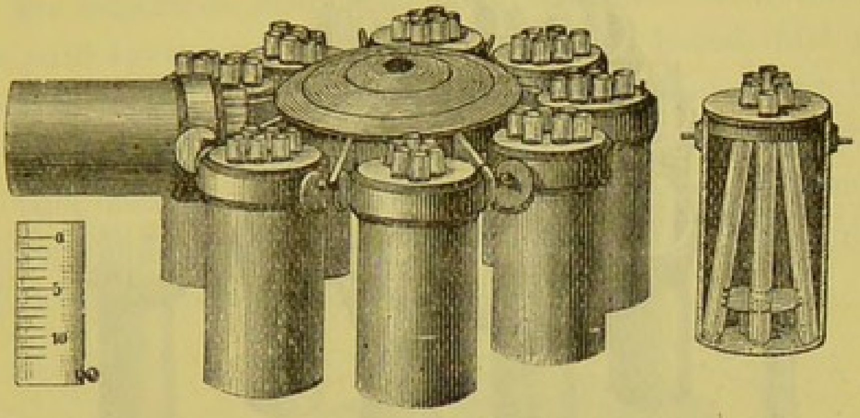

Fig. 5.

can be tested at one and the same time. A measure for drawing the sample, and a scale or rule, by means of which the extent of the cream layer after such has been formed is ascertained, complete the apparatus.

When the apparatus is to be used the metal disc is screwed on the top of the spindle of the separator drum, and the nine cases hung up in their places, care being taken that none of the cases will touch the blades in the drum when they attain a horizontal position. As many test tubes as there are samples to be examined are then filled with a definite quantity of milk, and inserted in the cases. The drum of the separator is next filled with as much water of a temperature of 140° Fahr. as it will hold when revolving, and the separator started. As the test tubes are only able to withstand a certain amount of pressure, the speed of the drum must be so regulated as not to exceed 1,200 revolutions per minute. At this speed the separator is worked until a total of 60,000 revolutions have been accomplished, and then allowed to run down. When the drum has come to a standstill, the test tubes are taken out, and the extent of the cream layer ascertained by means of the rule or scale, which indicates the percentage volume of the cream formed.

The control apparatus, which is worked in connection with the B separator (*Fig. 6*), differs from the one just described, essen-

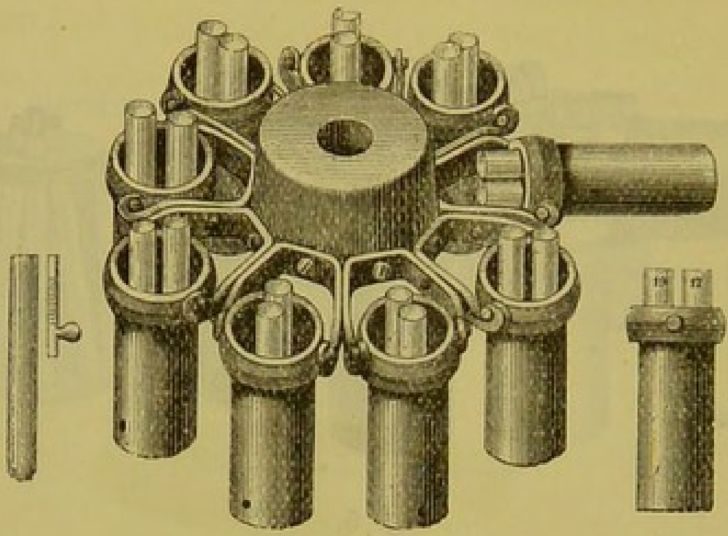

Fig. 6.

tially only in one respect, viz., the number of samples which can be tested at one and the same time, this being 18. The mode of working it is precisely the same as that of the large apparatus.

Although the volume of cream formed is not in every case in absolute concordance with the quantity of fat actually present in the milk under examination, the relation between the two items, viz., volume of cream and percentage of fat, is close enough to stamp the centrifugal control apparatus as being very useful for large dairies, and more especially for dairy factories and similar institutions, where milk is obtained from various sources of supply. Moreover, as the working of it gives only slight trouble, takes up little time, and can be done without any special knowledge or skill, beyond that expected from any dairyman or woman, the apparatus will doubtless ere long be used more generally than it is at present, where separators are worked.

The percentages of fat corresponding to the volume of cream formed are given in Table II.

THE LACTOCRIT.

Another method, in which centrifugal force plays a prominent part, for ascertaining the percentage of fat is that which is based upon the employment of the lactocrit, an apparatus applicable in dairies where De Laval's Swedish cream separator is being worked.

The lactocrit (*Fig. 7*) consists of a steel disc fixed on a spindle, which can be inserted in the frame of De Laval's cream separator after the separator drum has been removed. The disc is provided with twelve cylindrical holes, radially bored, and intended to receive test tubes; these are graduated and fitted in metal cases, the lower ends of which being formed of removable cups. The other instruments and contrivances required for executing the fat determination by means of the lactocrit will be mentioned in the following directions for use.

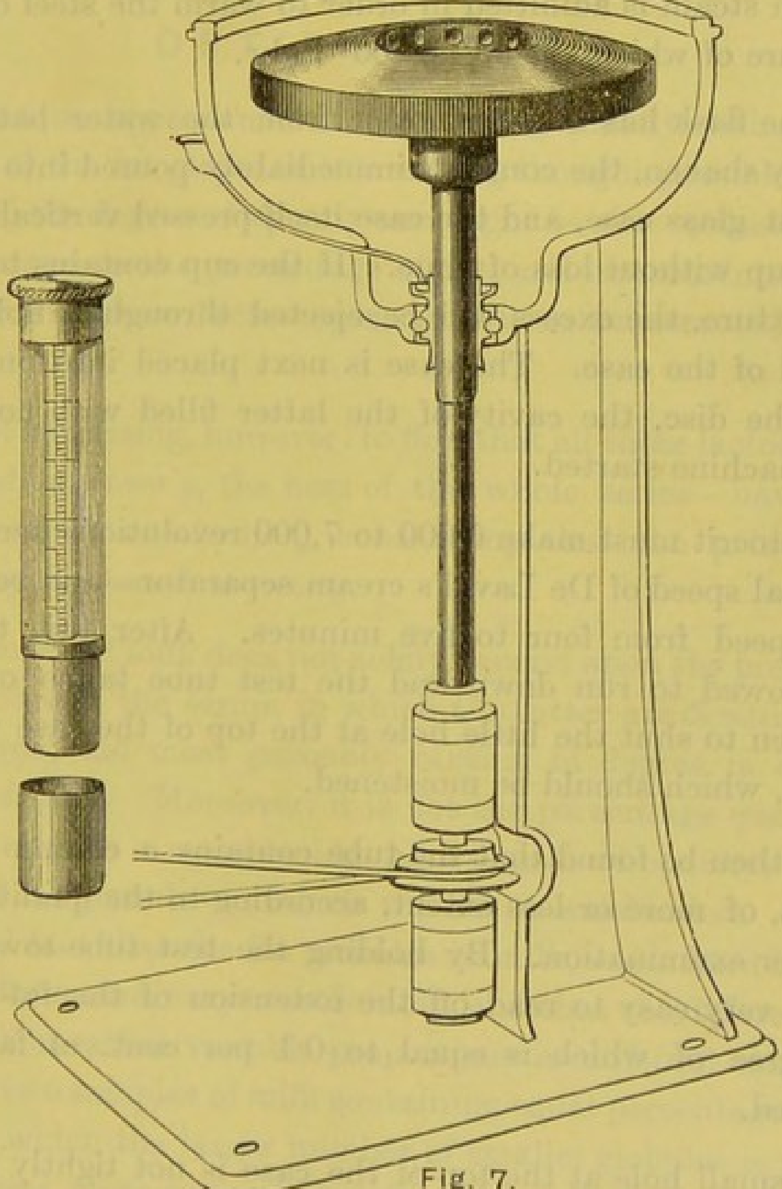

Fig. 7.

10 c.c. of milk are measured by means of a pipette* and run into a flask, which should be quite clean and dry. 10 c.c. of a

* On measuring liquids by means of pipettes, see page 20.

mixture, consisting of 95 parts of concentrated acetic acid and 5 parts of sulphuric acid, are next measured by means of a second pipette and added to the milk. The mixture of the two acids ought to be kept in a moderately warm place, as it congeals at a temperature of 50° Fahr. The flask containing milk and acid is then corked, placed in boiling water and kept therein for seven or eight minutes.

In the meantime the separator frame, in which the lactocrit has been inserted, is covered up with a lid provided with an inlet into which steam is admitted in order to warm the steel disc, the temperature of which should be 100° Fahr.

After the flask has been removed from the water bath, it is thoroughly shaken, the contents immediately poured into the cup of the test glass case, and the case itself pressed vertically down into the cup without loss of time. If the cup contains too much of the mixture, the excess will be ejected through a hole at the upper end of the case. The case is next placed into one of the holes of the disc, the cavity of the latter filled with hot water, and the machine started.

The lactocrit must make 6,000 to 7,000 revolutions per minute —the usual speed of De Laval's cream separator—and be worked at this speed from four to five minutes. After this time the disc is allowed to run down and the test tube taken out, care being taken to shut the little hole at the top of the case with the forefinger, which should be moistened.

It will then be found that the tube contains a column of clear butter fat, of more or less extent, according to the quality of the milk under examination. By holding the test tube towards the light it is very easy to read off the extension of the fat column, each degree of which is equal to 0·1 per cent. of fat in the milk tested.

If the small hole at the top of the case is not tightly shut the fat column will move about, and an exact reading will be found difficult. Should the case be allowed to cool the fat column will sink down, and it will then be necessary to immerse the cup in warm water, thus causing an expansion, which brings the fat up again into the graduated tube. Twelve samples of milk can be tested at a time.

Very extensive series of comparative experiments have proved that the indications of the lactocrit are in perfect agreement with the results of the best gravimetric methods.

OPTICAL TEST.

The opaque appearance of milk being mainly owing to the presence of the fat globules, it was long thought possible that by measuring the degree of opacity one might be able to draw definite conclusions as to the percentage of fat, and instruments, termed optical milk tests or lactoscopes, have been constructed for the purpose.

It is not surprising, however, to find that all these lactoscopes—not excluding Feser's, the best of the whole series—have failed to give general satisfaction, considering that the principle on which they are based is wrong.

The opacity of milk does not solely depend upon the presence of the fat globules, the serum in which the latter are floating being itself opaque, and most probably varying in degree in different samples of milk. Moreover, it is not the percentage quantity of fat which causes a more or less high degree of opacity, but the number of fat globules in which the fat is subdivided. It is an established fact that the fat globules in milk, so far from being all of one uniform size, vary considerably, and that the different sizes are present in rather variable proportions in different samples of milk. Of two samples of milk containing equal percentages of fat, the one in which the larger number of smaller globules is present would appear more opaque, that is, richer, when examined by a lactoscope than the other sample, although the latter contains the same amount of fat, but in a less number of larger sized globules.

Other circumstances, for instance the strength and kind of light in which the examination is made and the eyesight of the observer, also influence the optical tests to a considerable degree, and leave much doubt with regard to the accuracy of the results obtained. The use of lactoscopes cannot, therefore, be well recommended when more than a mere superficial examination is desired.

THE LACTOBUTYROMETER.

This instrument (*Fig. 8*) for the determination of fat in milk, consists principally of a glass tube closed at one end and divided by marks into three divisions, each of a capacity of 10 cubic centimetres, and marked "milk," "ether," and "alcohol"

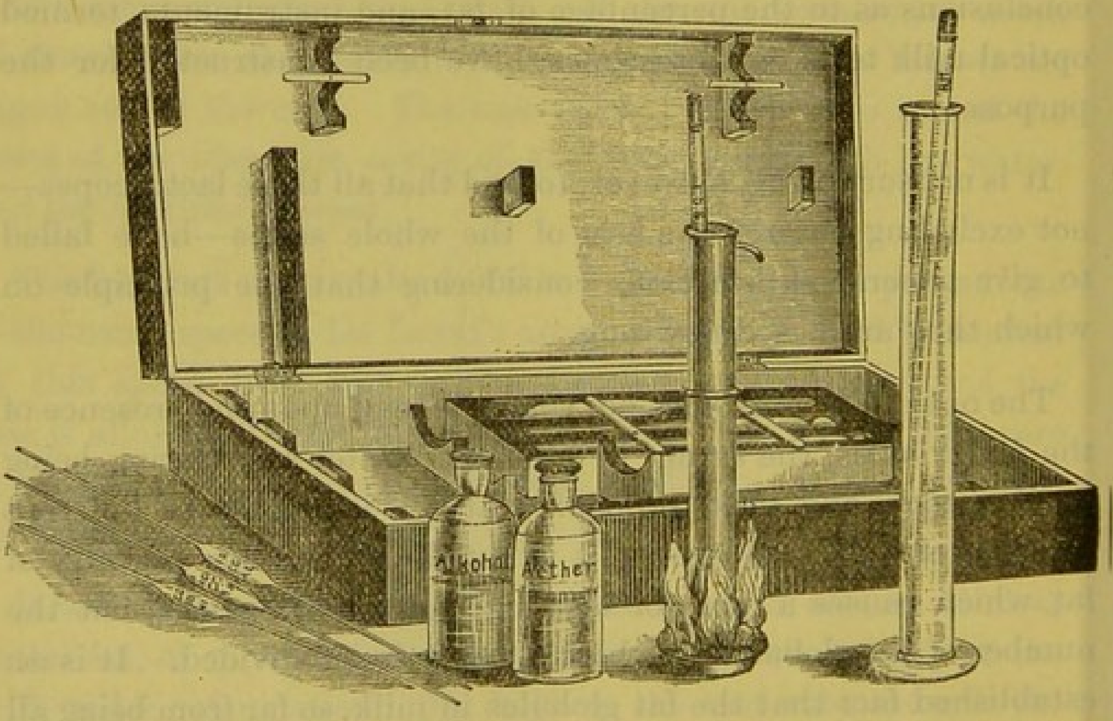

Fig. 8.

respectively, the uppermost division being further sub-divided into $\frac{1}{10}$ c.c. The divisions are meant for measuring the three fluids, the names of which they bear, but it is very much preferable to use 10 c.c. pipettes for the purpose.

Measuring liquids by means of pipettes is done as follows: Hold the pipette near its upper end between the thumb and the third finger of the right hand, insert the lower tapering end into the liquid, and fill it by exhausting the air with the mouth, then remove the lips and quickly close the upper end by means of the second finger. The pipette is then removed from the liquid, and by raising the second finger slightly, so much of the contents allowed to escape, drop by drop, until the lowest point of the curve forming the surface of the liquid coincides with the mark on the upper part of the instrument. The contents are then discharged, the pipette being quite emptied by blowing out the last few drops of the liquid.

The lactobutyrometer is worked in the following manner: 10 c.c. of milk are measured by means of the pipette marked "milk," and discharged into the graduated tube; 10 c.c. of ether* are then added, the tube closed with a well-fitting cork or the thumb, and well shaken until milk and ether are thoroughly intermixed and a homogenous fluid formed; 10 c.c. of alcohol, containing 91 parts by volume of pure spirit in 100 parts, are next added, and the shaking resumed until the precipitated casein is subdivided into very fine flakes; the tube cannot be shaken too much. Whilst the tube is being shaken the cork or thumb, whichever is used, must be several times removed, in order to relieve the pressure formed inside. The tube should then be tightly corked, placed in water at a temperature of from 100° to 105° Fahr. (= 38° to 41° centigrade), and allowed to remain in it until the fat globules, which have been formed and immediately begin to rise to the surface, have all collected in a layer at the top.

If no water of the required temperature is at hand, it may be prepared by filling the brass cylinder, supplied with the apparatus, with cold water, pouring some alcohol into the tray, which forms the foot of the cylinder, and setting it alight. As soon as the thermometer, immersed in the water, indicates the proper temperature the flame is extinguished.

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* Ether being a liquid of highly inflammable nature, the greatest precaution must be taken not to bring it in contact with or even in close proximity to a flame.

When after about ten minutes it is found that fat globules have ceased to rise, the tube may be placed in a glass cylinder, previously filled with water of a temperature of about 68° Fahr. (20° centigrade). The clear liquid below the fat layer will then be seen to become cloudy and after a time clear again, and after about 15 minutes the fatty layer will generally be found to have very slightly increased. The extent of the fatty layer is then read off, the graduation giving the volume in $\frac{1}{10}$th part of cubic centimetre. The corresponding percentage amount of fat is found in Table III.

As the placing of the tube in the second bath makes only a very slight, if any, difference in the results obtained, it may be dispensed with, without any serious disadvantage.

The addition of two or three drops of a 25 per cent. potassium hydrate solution to the mixture of milk and ether, will prevent the precipitation of casein by the subsequent addition of alcohol, and thus facilitate in some degree the process of shaking, which, however, should be continued sufficiently long to form a very intimate mixture of milk, ether, and alcohol. We repeat that the tube cannot be shaken too much. In far the larger number of cases the presence or absence of potash makes no difference to the final result, but it appears that in some instances more correct results are gained if potash is added, while in others the reverse is the case. It is, therefore, always advisable to make two determinations of each sample of milk, the one with and the other without potash, and to take the higher result obtained as the more correct one. If there is reason to suppose that all the fat has not risen to the surface, the tube should be again shaken and once more placed in the warm water bath, the fatty layer soon re-forming.

The strength of the alcohol used for the test is of the greatest importance, and must be checked by means of an alcoholometer, which is supplied with the apparatus. The ether ought to be washed ether, made from pure spirit.

Milk containing less than 1·2 per cent. of fat does not throw up a fatty layer when tested with the lactobutyrometer, but the apparatus may, nevertheless, be used for determining the percentage of fat, even in samples of poor skim milk by proceeding as follows: After the percentage of fat in a sample of normal milk has been determined in the above manner, 5 c.c. of this milk are taken and mixed with an equal quantity of the poor milk in question, and the percentage of fat in the mixture determined. The result of the latter determination is then doubled, and from the figure thus obtained, the result of the former determination—percentage of fat in the normal milk—subtracted. The rest indicates the percentage of fat in the poor milk.

SOXHLET'S AREOMETRIC PROCESS.

A much more correct determination is obtained by using Soxhlet's areometric apparatus; in fact, this gives results as reliable as those arrived at by means of the most exact gravimetric method.

The apparatus (*Fig. 9*) consists of a stand, fitted with brackets for holding three pipettes, and a jacketted tube, in which a hydrometer—areometer—and thermometer combined is placed; a bottle of strong white glass fitted with a cork, and two glass tubes bent at right angles, a blower, and a piece of india-rubber piping, with a pinch-cock, also form part of the apparatus. The chemicals used in the process are pure washed ether and a solution of potassium hydrate of specific gravity 1·26 to 1·27, prepared by dissolving 400 grammes of fused caustic potash in one-half litre of water, the solution after cooling being made up with water to one litre. The milk to be tested, as well as the ether and potash solution used for the examination, should be of a temperature of 61·5° to 65·5° Fahr. (16·5° to 18·5° centigrade).

The examination is carried out as follows: 200 c.c. of milk are measured by means of the largest pipette, and run into the bottle; 10 c.c. of potash solution are added and mixed with the milk; 60 c.c. of ether are next added, the bottle closed with a cork or india-rubber stopper, and *violently* shaken for half-a-minute. The bottle is then placed in a vessel containing water at 63·5° Fahr. (= 17·5° centigrade), and for a quarter of an hour very *gently* shaken every half-minute. After that time it is left to rest standing in an upright, or, better, lying in an oblique position in the water, until a clear layer has collected on the top, consisting of a solution of fat in ether. Up to this time the bottle has been kept tightly corked, but now the stopper is removed and replaced by the cork fitted with the two bent tubes. To the shorter one of these tubes the blowing apparatus is attached, while the longer one, which should reach down to the lower part of the ethereal solution, is connected by means

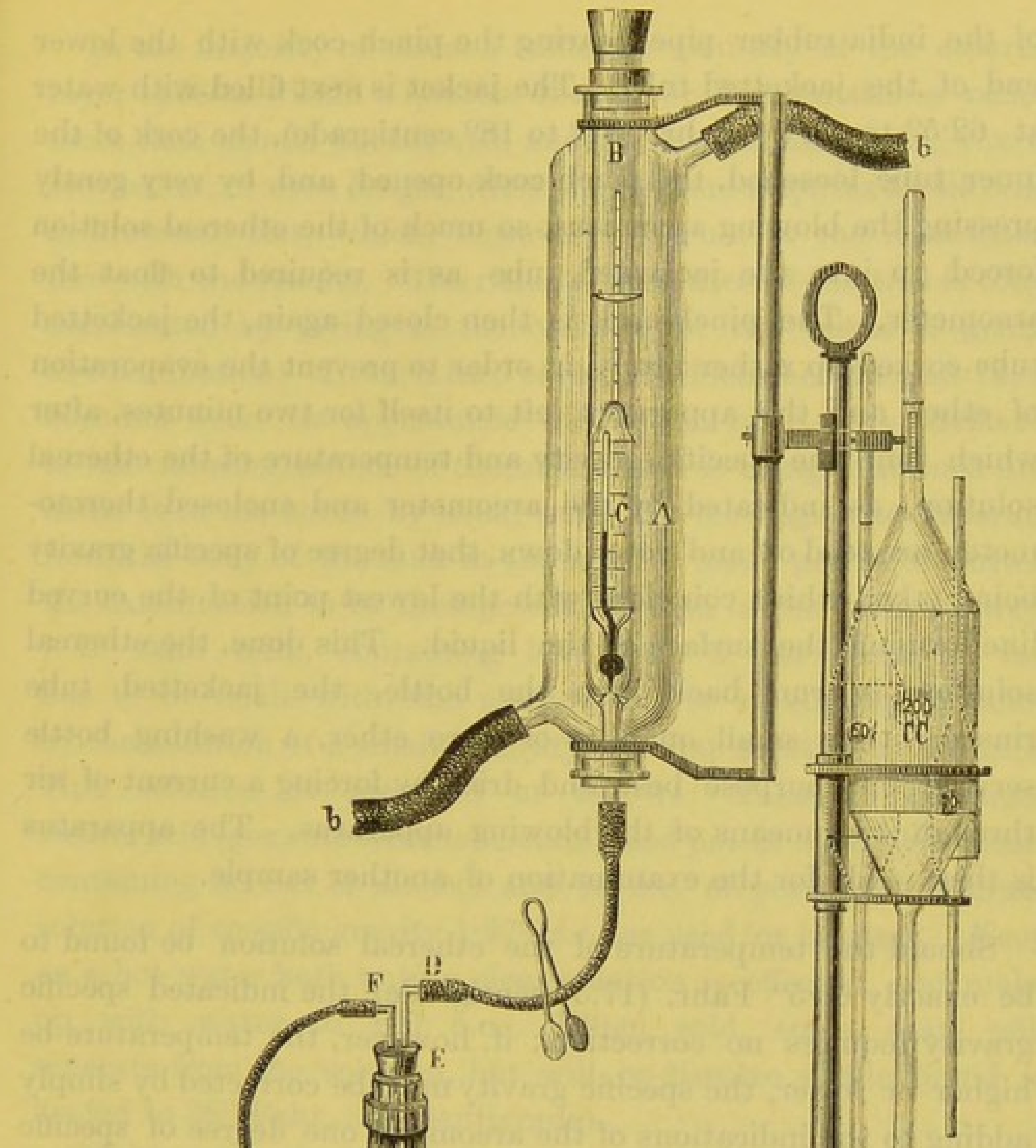

Fig. 9.

of the india-rubber pipe bearing the pinch-cock with the lower end of the jacketted tube. The jacket is next filled with water at 62·5° to 64·5° Fahr. (17° to 18° centigrade), the cork of the inner tube loosened, the pinch-cock opened, and, by very gently pressing the blowing apparatus, so much of the ethereal solution forced up into the jacketted tube as is required to float the areometer. The pinch-cock is then closed again, the jacketted tube corked up rather firmly, in order to prevent the evaporation of ether, and the apparatus left to itself for two minutes, after which time the specific gravity and temperature of the ethereal solution, as indicated by the areometer and enclosed thermometer, are read off and noted down, that degree of specific gravity being taken which coincides with the lowest point of the curved line forming the surface of the liquid. This done, the ethereal solution is run back into the bottle, the jacketted tube rinsed with a small quantity of pure ether, a washing bottle serving this purpose best, and dried by forcing a current of air through it by means of the blowing apparatus. The apparatus is then ready for the examination of another sample.

Should the temperature of the ethereal solution be found to be exactly 63·5° Fahr. (17.5° centigrade), the indicated specific gravity requires no correction; if, however, the temperature be higher or lower, the specific gravity must be corrected by simply adding to the indications of the areometer one degree of specific gravity for each degree of the thermometer above 17.5° centigrade, or subtracting one degree for each degree below 17·5°. If, for instance, the specific gravity is found to be 47·6° at 18·4° centigrade, the corrected specific gravity is 48·5°, or if found to be 58·9° at 16·8° centigrade, the corrected specific gravity is 58·2°. The corrected specific gravity thus ascertained is then looked for in Table IV., which shows the corresponding percentage of fat.

It must here be remarked that the areometer, as well as the table, do not give the complete figures for the specific gravity of the ethereal solution, the first decimal place being omitted. Thus, the figure 43 appears instead of ·7430 specific gravity, and the figure 65·9 instead of ·7659.

In the majority of cases, a sufficient quantity of the ethereal layer collects within a quarter of an hour, but sometimes rather more time should be allowed, and, in exceptional cases, one or two hours, or even longer, when the mixture acquires a yellowish or brownish tint, which, however, does not in the least interfere with the results. The rising of the ethereal solution is often accelerated by giving to the contents of the bottle a gentle circular motion. In such rare cases, in which the ethereal layer does not make its appearance within one hour, it is advisable to take another sample of the milk which is being examined and shake it in the bottle by itself, until the fat begins to separate from the body of the milk in the form of small grains of butter, the examination to be then proceeded with in the ordinary way.

If skim milk, containing less than 2 per cent. of fat, has to be dealt with, the method has to be slightly modified by the addition of a small quantity of a soap solution to the milk. This solution is prepared as follows: Take 15 grammes stearic acid (genuine stearine candle), and put in a suitable vessel containing 25 c.c. of alcohol and 10 c.c. of potassium hydrate solution of specific gravity 1·27°, *i.e.*, as used for the test. Keep on a hot water bath until a clear solution is effected, and make up with water to 100 c.c. When cold, some soap will separate from the solution, but will re-dissolve if the liquid is heated to 86° Fahr. (30° centigrade).

Of this soap solution 0·4 to 0·5 c.c. (= 20 to 25 drops) is mixed with the 200 c.c. of milk taken for examination, and otherwise the process carried out exactly as described above. In such cases, in which the ethereal fat solution takes an exceptionally long time to separate, the process may be repeated, with the extra addition of a small pinch of powdered sulphate of potash to the milk.

A special areometer, furnished with the apparatus, should be used for poor milks, but the readings are to be taken and the corrections to be made exactly in the same way as when richer milks are being tested.

TOTAL SOLIDS.

All the methods for the examination of milk described in the preceding pages, though requiring more or less skill, are of such a character that their execution does not depend either on the chemical laboratory or on the aid of the professional analyst, but may be carried out in almost any room and by anyone who possesses a certain amount of cleverness in manipulation.

Every analytical operation, however simple in itself, necessitating the use of the chemical balance, should be referred to the laboratory of the analyst, and although we are now about to describe the gravimetric determination of the total solids in milk, we do not by any means recommend it for general use. As, however, the gravimetric determination of the solids has been brought before the public on divers occasions, and, we believe, adopted in a number of cases by dairy farmers and milk dealers; as, moreover, existing circumstances may lead others to prefer this to other methods of ascertaining the value of milk; and as, lastly, there is no reason why satisfactory results should not be arrived at outside the laboratory by its use, if the examination is carefully conducted, we give particulars of the process.

The necessary plant consists of a water bath, in which water has to be kept boiling; an air bath, the temperature of which should be very stationary at the boiling point of water (= 212° Fahr.); a chemical balance, constructed to weigh 50 grammes in each pan, and sufficiently sensitive, when so weighted, to detect a variation of one milligramme; a dessicator, charged with exsiccated chloride of calcium, or concentrated sulphuric acid; a number of small porcelain, or, what is better, platinum dishes of 1½ to 2 inches in diameter; a pipette, gauged so as to discharge 5 c.c., or preferably, 5 grammes of milk; and a pair of crucible tongs to handle the dishes when hot.

After having carefully cleansed and well dried a dish, its exact weight is ascertained, and the milk measured and discharged into it by means of the pipette. The dish is then placed on the water bath, and after not less than two hours, when the milk will be found to be dried up, it is removed to the air bath in order to expel the last traces of moisture. After two hours, the dish is taken out, put in the dessicator, and, when cold, weighed. It is then put back into the air bath, kept therein for another hour, and after cooling weighed again. If it be found that there is a loss of more than one milligramme, drying has to be continued until there is a difference of only one milligramme or less between the last and the preceding weighing. The determination is then finished, and the weight of the solids (*i.e.*, weight of solids, *plus* dish, *minus* weight of dish) has only to be multiplied by 20, in order to get the percentage of the total solids present in the milk.

RELATION BETWEEN SPECIFIC GRAVITY, TOTAL SOLIDS, AND FAT.

The solids of milk may be conveniently divided into two classes, viz. : fat and non-fatty solids, the latter class comprising proteids, sugar, and mineral matter. Whilst the non-fatty solids, being heavier than water, raise the specific gravity of milk above that of water (specific gravity of water = 1·000) ; the specifically lighter fat acts in the opposite direction, lowering down the specific gravity of milk to some extent ; thus, while the average specific gravity of milk is 1·032, the specific gravity of poor skim milk is 1·036, and the specific gravity of cream, according to its richness in fat, say 1·020 or lower. The specific gravity of butter fat has always been found to be very uniform, and, consequently, the depression of the specific gravity which the fat effects must directly correspond with its quantity present. With the non-fatty solids the case is somewhat different. Here we have to do, not with one single constituent but with a number of bodies possessing totally different chemical and physical properties, and not always present in the same relative proportions. In spite of all this, however, it has been found, and satisfactorily proved, that the non-fatty solids also influence the specific gravity of milk in every instance directly corresponding to their percentage amount present, or in other words, that, practically speaking, in any sample of milk the non-fatty solids are collectively of the same specific gravity.

If we know, then, the influence exercised by each 1 per cent. of non-fatty solids on the one hand, and fat on the other, it must be possible to find by calculation the specific gravity of a milk, the composition of which is known. But, what is more important, it must be equally possible to calculate from the specific gravity of the milk and the percentage amount of one of the items mentioned, the percentage of the other item. Several investigators have, during the last eight years, taken much pains and trouble to establish and prove these facts, and a number of formulæ for making the necessary calculations have been published. Of all these formulæ, those worked out by Professor Fleischmann are, no doubt, the most useful and correct ones. They are as follows:

$$\text{I.} \quad t = f\ 1{\cdot}2 \quad + 2{\cdot}665\ \frac{100\,s - 100}{s}$$

$$\text{II.} \quad f = t\ \ {\cdot}833 - 2{\cdot}22\ \frac{100\,s - 100}{s}$$

In the formulæ—

t means percentage of total solids,
f ,, ,, fat,
s ,, specific gravity (water = 1).

In order to save the trouble of carrying out the calculation in every individual case, we adjoin Tables V. and VI., which will give at a glance the figure sought for. The tables are used in the same way as the table for correcting the specific gravity, and are so simple that no further word need be said about them.

It will now be apparent why we laid so much stress upon the importance of taking the specific gravity of milk. This simple determination—in conjunction with either the determination of the fat by means of one of the centrifugal apparatus, or of Soxhlet's areometric process, which can be carried out almost anywhere; or of the total solids, which will be found rather less suitable and convenient for general use—is sufficient to give every information with regard to the composition of milk which is required under ordinary circumstances.

TABLE I. For Correcting the Specific Gravity of Milk according to Temperature.

Degrees of Lactometer.	DEGREES OF THERMOMETER *(Fahrenheit)*.																														Degrees of Lactometer.
	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
20	19·0	19·0	19·1	19·1	19·2	19·2	19·3	19·4	19·4	19·5	19·6	19·7	19·8	19·9	19·9	20·0	20·1	20·2	20·2	20·3	20·4	20·5	20·6	20·7	20·9	21·0	21·1	21·2	21·3	21·5	21·6	20
21	19·9	20·0	20·0	20·1	20·2	20·2	20·3	20·3	20·4	20·5	20·6	20·7	20·8	20·9	20·9	21·0	21·1	21·2	21·3	21·4	21·5	21·6	21·7	21·8	22·0	22·1	22·2	22·3	22·4	22·5	22·6	21
22	20·9	21·0	21·0	21·1	21·2	21·2	21·3	21·3	21·4	21·5	21·6	21·7	21·8	21·9	21·9	22·0	22·1	22·2	22·3	22·4	22·5	22·6	22·7	22·8	23·0	23·1	23·2	23·3	23·4	23·5	23·7	22
23	21·9	22·0	22·0	22·1	22·2	22·2	22·3	22·3	22·4	22·5	22·6	22·7	22·8	22·8	22·9	23·0	23·1	23·2	23·3	23·4	23·5	23·6	23·7	23·8	24·0	24·1	24·2	24·3	24·4	24·6	24·7	23
24	22·9	22·9	23·0	23·1	23·2	23·2	23·3	23·3	23·4	23·5	23·6	23·6	23·7	23·8	23·9	24·0	24·1	24·2	24·3	24·4	24·5	24·6	24·7	24·9	25·0	25·1	25·2	25·3	25·5	25·6	25·7	24
25	23·8	23·9	24·0	24·0	24·1	24·1	24·2	24·3	24·4	24·5	24·6	24·6	24·7	24·8	24·9	25·0	25·1	25·2	25·3	25·4	25·5	25·6	25·7	25·9	26·0	26·1	26·2	26·4	26·5	26·6	26·8	25
26	24·8	24·9	24·9	25·0	25·1	25·1	25·2	25·2	25·3	25·4	25·5	25·6	25·7	25·8	25·9	26·0	26·1	26·2	26·3	26·5	26·6	26·7	26·8	27·0	27·1	27·2	27·3	27·4	27·5	27·7	27·8	26
27	25·8	25·9	25·9	26·0	26·1	26·1	26·2	26·2	26·3	26·4	26·5	26·6	26·7	26·8	26·9	27·0	27·1	27·3	27·4	27·5	27·6	27·7	27·8	28·0	28·1	28·2	28·3	28·4	28·6	28·7	28·9	27
28	26·7	26·8	26·8	26·9	27·0	27·0	27·1	27·2	27·3	27·4	27·5	27·6	27·7	27·8	27·9	28·0	28·1	28·3	28·4	28·5	28·6	28·7	28·8	29·0	29·1	29·2	29·4	29·5	29·7	29·8	29·9	28
29	27·7	27·8	27·8	27·9	28·0	28·0	28·1	28·2	28·3	28·4	28·5	28·6	28·7	28·8	28·9	29·0	29·1	29·3	29·4	29·5	29·6	29·8	29·9	30·1	30·2	30·3	30·4	30·5	30·7	30·9	31·0	29
30	28·6	28·7	28·7	28·8	28·9	29·0	29·1	29·1	29·2	29·3	29·4	29·6	29·7	29·8	29·9	30·0	30·1	30·3	30·4	30·5	30·7	30·8	30·9	31·1	31·2	31·3	31·5	31·6	31·8	31·9	32·1	30
31	29·5	29·6	29·6	29·7	29·8	29·9	30·0	30·1	30·2	30·3	30·4	30·5	30·6	30·8	30·9	31·0	31·2	31·3	31·4	31·5	31·7	31·8	32·0	32·2	32·2	32·4	32·5	32·6	32·8	33·0	33·1	31
32	30·4	30·5	30·5	30·6	30·7	30·9	31·0	31·1	31·2	31·3	31·4	31·5	31·6	31·7	31·9	32·0	32·2	32·3	32·5	32·6	32·7	32·9	33·0	33·2	33·3	33·4	33·6	33·7	33·9	34·0	34·2	32
33	31·3	31·4	31·4	31·5	31·6	31·8	31·9	32·0	32·1	32·3	32·4	32·5	32·6	32·7	32·9	33·0	33·2	33·3	33·5	33·6	33·8	33·9	34·0	34·2	34·3	34·5	34·6	34·7	34·9	35·1	35·2	33
34	32·2	32·3	32·3	32·4	32·5	32·7	32·9	33·0	33·1	33·2	33·3	33·5	33·6	33·7	33·9	34·0	34·2	34·3	34·5	34·6	34·8	34·9	35·0	35·2	35·3	35·5	35·6	35·8	36·0	36·1	36·3	34
35	33·0	33·1	33·2	33·4	33·5	33·6	33·8	33·9	34·0	34·2	34·3	34·5	34·6	34·7	34·9	35·0	35·2	35·3	35·5	35·6	35·8	35·9	36·1	36·2	36·4	36·5	36·7	36·8	37·0	37·2	37·3	35

TABLE II.

Centrifugal Control Apparatus,

In connection with the Danish Cream Separator.

Volume of Cream. %	Represents Fat. %	Volume of Cream. %	Represents Fat. %
9·0	5·0	5·4	3·45
8·8	4·9	5·2	3·4
8·6	4·8	5·0	3·3
8·4	4·7	4·8	3·2
8·2	4·65	4·6	3·1
8·0	4·6	4·4	3·0
7·8	4·5	4·2	2·9
7·6	4·4	4·0	2·85
7·4	4·3	3·8	2·8
7·2	4·2	3·6	2·7
7·0	4·1	3·4	2·6
6·8	4·05	3·2	2·5
6·6	4·0	3·0	2·4
6·4	3·9	2·8	2·3
6·2	3·8	2·6	2·25
6·0	3·7	2·4	2·2
5·8	3·6	2·2	2·1
5·6	3·5	2·0	2·0

TABLE III.

The Lactobutyrometer.

Fatty Layer. 1/10 c.c.	Represents Fat. %	Fatty Layer. 1/10 c.c.	Represents Fat. %
1	1·3	10	3·2
2	1·5	11	3·4
3	1·8	12	3·6
4	2·0	13	3·8
5	2·2	14	4·0
6	2·4	15	4·2
7	2·6	16	4·4
8	2·8	17	4·7
9	3·0	18	5·0

TABLE IV.

SOXHLET'S AREOMETRIC METHOD. Specific Gravity of Ethereal Solution of Fat and corresponding Percentage of Fat at 17·5° c.

Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %	Spec. Grav.	Fat %
		24·0	0·28	**27·0**	0·55	**30·0**	0·83	**33·0**	1·10	**36·0**	1·37	**39·0**	1·67	**42·0**	1·97	**45·0**	2·30	**48·0**	2·64	**51·0**	3·00	**54·0**	3·37	**57·0**	3·75	**60·0**	4·18	**63·0**	4·63
21·1	0·00	24·1	0·29	27·1	0·56	30·1	0·84	33·1	1·11	36·1	1·38	39·1	1·68	42·1	1·98	45·1	2·31	48·1	2·66	51·1	3·01	54·1	3·38	57·1	3·76	60·1	4·19	63·1	4·64
21·2	0·01	24·2	0·30	27·2	0·57	30·2	0·85	33·2	1·12	36·2	1·39	39·2	1·69	42·2	1·99	45·2	2·32	48·2	2·67	51·2	3·03	54·2	3·39	57·2	3·78	60·2	4·20	63·2	4·66
21·3	0·02	24·3	0·30	27·3	0·58	30·3	0·86	33·3	1·13	36·3	1·40	39·3	1·70	42·3	2·00	45·3	2·33	48·3	2·68	51·3	3·04	54·3	3·40	57·3	3·80	60·3	4·21	63·3	4·67
21·4	0·03	24·4	0·31	27·4	0·59	30·4	0·87	33·4	1·14	36·4	1·41	39·4	1·71	42·4	2·01	45·4	2·34	48·4	2·70	51·4	3·05	54·4	3·41	57·4	3·81	60·4	4·23	63·4	4·69
21·5	0·04	24·5	0·32	27·5	0·60	30·5	0·88	33·5	1·15	36·5	1·42	39·5	1·72	42·5	2·02	45·5	2·35	48·5	2·71	51·5	3·06	54·5	3·43	57·5	3·82	60·5	4·24	63·5	4·70
21·6	0·05	24·6	0·33	27·6	0·60	30·6	0·88	33·6	1·15	36·6	1·43	39·6	1·73	42·6	2·03	45·6	2·36	48·6	2·72	51·6	3·08	54·6	3·45	57·6	3·84	60·6	4·26	63·6	4·71
21·7	0·06	24·7	0·34	27·7	0·61	30·7	0·89	33·7	1·16	36·7	1·44	39·7	1·74	42·7	2·04	45·7	2·37	48·7	2·73	51·7	3·09	54·7	3·46	57·7	3·85	60·7	4·27	63·7	4·73
21·8	0·07	24·8	0·35	27·8	0·62	30·8	0·90	33·8	1·17	36·8	1·45	39·8	1·75	42·8	2·05	45·8	2·38	48·8	2·74	51·8	3·10	54·8	3·47	57·8	3·87	60·8	4·29	63·8	4·75
21·9	0·08	24·9	0·36	27·9	0·63	30·9	0·91	33·9	1·18	36·9	1·46	39·9	1·76	42·9	2·06	45·9	2·39	48·9	2·75	51·9	3·11	54·9	3·48	57·9	3·88	60·9	4·30	63·9	4·77
22·0	0·09	**25·0**	0·37	**28·0**	0·64	**31·0**	0·92	**34·0**	1·19	**37·0**	1·47	**40·0**	1·77	**43·0**	2·07	**46·0**	2·40	**49·0**	2·76	**52·0**	3·12	**55·0**	3·49	**58·0**	3·90	**61·0**	4·32	**64·0**	4·79
22·1	0·10	25·1	0·38	28·1	0·65	31·1	0·93	34·1	1·20	37·1	1·48	40·1	1·78	43·1	2·08	46·1	2·42	49·1	2·77	52·1	3·14	55·1	3·51	58·1	3·91	61·1	4·33	64·1	4·80
22·2	0·11	25·2	0·39	28·2	0·66	31·2	0·94	34·2	1·21	37·2	1·49	40·2	1·79	43·2	2·09	46·2	2·43	49·2	2·78	52·2	3·15	55·2	3·52	58·2	3·92	61·2	4·35	64·2	4·82
22·3	0·12	25·3	0·40	28·3	0·67	31·3	0·95	34·3	1·22	37·3	1·50	40·3	1·80	43·3	2·10	46·3	2·44	49·3	2·79	52·3	3·16	55·3	3·53	58·3	3·93	61·3	4·36	64·3	4·84
22·4	0·13	25·4	0·40	28·4	0·68	31·4	0·95	34·4	1·23	37·4	1·51	40·4	1·81	43·4	2·11	46·4	2·45	49·4	2·80	52·4	3·17	55·4	3·55	58·4	3·95	61·4	4·37	64·4	4·85
22·5	0·14	25·5	0·41	28·5	0·69	31·5	0·96	34·5	1·24	37·5	1·52	40·5	1·82	43·5	2·12	46·5	2·46	49·5	2·81	52·5	3·18	55·5	3·56	58·5	3·96	61·5	4·39	64·5	4·87
22·6	0·15	25·6	0·42	28·6	0·70	31·6	0·97	34·6	1·24	37·6	1·53	40·6	1·83	43·6	2·13	46·6	2·47	49·6	2·83	52·6	3·20	55·6	3·57	58·6	3·98	61·6	4·40	64·6	4·88
22·7	0·16	25·7	0·43	28·7	0·71	31·7	0·98	34·7	1·25	37·7	1·54	40·7	1·84	43·7	2·14	46·7	2·49	49·7	2·84	52·7	3·21	55·7	3·59	58·7	3·99	61·7	4·42	64·7	4·90
22·8	0·17	25·8	0·44	28·8	0·72	31·8	0·99	34·8	1·26	37·8	1·55	40·8	1·85	43·8	2·16	46·8	2·50	49·8	2·86	52·8	3·22	55·8	3·60	58·8	4·01	61·8	4·44	64·8	4·92
22·9	0·18	25·9	0·45	28·9	0·73	31·9	1·00	34·9	1·27	37·9	1·56	40·9	1·86	43·9	2·17	46·9	2·51	49·9	2·87	52·9	3·23	55·9	3·61	58·9	4·02	61·9	4·46	64·9	4·93
23·0	0·19	**26·0**	0·46	**29·0**	0·74	**32·0**	1·01	**35·0**	1·28	**38·0**	1·57	**41·0**	1·87	**44·0**	2·18	**47·0**	2·52	**50·0**	2·88	**53·0**	3·25	**56·0**	3·63	**59·0**	4·03	**62·0**	4·47	**65·0**	4·95
23·1	0·20	26·1	0·47	29·1	0·75	32·1	1·02	35·1	1·29	38·1	1·58	41·1	1·88	44·1	2·19	47·1	2·54	50·1	2·90	53·1	3·26	56·1	3·64	59·1	4·04	62·1	4·48	65·1	4·97
23·2	0·21	26·2	0·48	29·2	0·76	32·2	1·03	35·2	1·30	38·2	1·59	41·2	1·89	44·2	2·20	47·2	2·55	50·2	2·91	53·2	3·27	56·2	3·65	59·2	4·06	62·2	4·50	65·2	4·98
23·3	0·22	26·3	0·49	29·3	0·77	32·3	1·04	35·3	1·31	38·3	1·60	41·3	1·90	44·3	2·22	47·3	2·56	50·3	2·92	53·3	3·28	56·3	3·67	59·3	4·07	62·3	4·52	65·3	5·00
23·4	0·23	26·4	0·50	29·4	0·78	32·4	1·05	35·4	1·32	38·4	1·61	41·4	1·91	44·4	2·23	47·4	2·57	50·4	2·93	53·4	3·29	56·4	3·68	59·4	4·09	62·4	4·53	65·4	5·02
23·5	0·24	26·5	0·50	29·5	0·79	32·5	1·05	35·5	1·33	38·5	1·62	41·5	1·92	44·5	2·24	47·5	2·58	50·5	2·94	53·5	3·30	56·5	3·69	59·5	4·11	62·5	4·55	65·5	5·04
23·6	0·25	26·6	0·51	29·6	0·80	32·6	1·06	35·6	1·33	38·6	1·63	41·6	1·93	44·6	2·25	47·6	2·60	50·6	2·96	53·6	3·31	56·6	3·71	59·6	4·12	62·6	4·56	65·6	5·05
23·7	0·25	26·7	0·52	29·7	0·80	32·7	1·07	35·7	1·34	38·7	1·04	41·7	1·94	44·7	2·26	47·7	2·61	50·7	2·97	53·7	3·33	56·7	3·72	59·7	4·14	62·7	4·58	65·7	5·07
23·8	0·26	26·8	0·53	29·8	0·81	32·8	1·08	35·8	1·35	38·8	1·65	41·8	1·95	44·8	2·27	47·8	2·62	50·8	2·98	53·8	3·34	56·8	3·73	59·8	4·15	62·8	4·59	65·8	5·09
23·9	0·27	26·9	0·54	29·9	0·82	32·9	1·09	35·9	1·36	38·9	1·66	41·9	1·96	44·9	2·28	47·9	2·63	50·9	2·99	53·9	3·35	56·9	3·74	59·9	4·16	62·9	4·61	65·9	5·11
																												66·0	5·12

TABLE V.

TOTAL SOLIDS—calculated from Specific Gravity and Fat.

Specific Gravity.	Fat 1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0
	Total Solids.									
1·0280	8·6	8·7	8·8	8·9	9·1	9·2	9·3	9·4	9·5	9·7
1·0285	8·7	8·8	8·9	9·1	9·2	9·3	9·4	9·5	9·7	9·8
1·0290	8·8	9·0	9·1	9·2	9·3	9·4	9·6	9·7	9·8	9·9
1·0295	9·0	9·1	9·2	9·3	9·4	9·6	9·7	9·8	9·9	10·0
1·0300	9·1	9·2	9·3	9·4	9·6	9·7	9·8	9·9	10·0	10·2
1·0305	9·2	9·3	9·4	9·6	9·7	9·8	9·9	10·0	10·2	10·3
1·0310	9·3	9·5	9·6	9·7	9·8	9·9	10·1	10·2	10·3	10·4
1·0315	9·5	9·6	9·7	9·8	9·9	10·1	10·2	10·3	10·4	10·5
1·0320	9·6	9·7	9·8	9·9	10·1	10·2	10·3	10·4	10·5	10·7
1·0325	9·7	9·8	9·9	10·1	10·2	10·3	10·4	10·5	10·7	10·8
1·0330	9·8	10·0	10·1	10·2	10·3	10·4	10·6	10·7	10·8	10·9
1·0335	10·0	10·1	10·2	10·3	10·4	10·6	10·7	10·8	10·9	11·0
1·0340	10·1	10·2	10·3	10·4	10·6	10·7	10·8	10·9	11·0	11·2
1·0345	10·2	10·3	10·4	10·6	10·7	10·8	10·9	11·0	11·2	11·3
1·0350	10·3	10·5	10·6	10·7	10·8	10·9	11·1	11·2	11·3	11·4

Specific Gravity.	Fat 2·1	2·2	2·3	2·4	2·5	2·6	2·7	2·8	2·9	3·0
1·0280	9·8	9·9	10·0	10·1	10·3	10·4	10·5	10·6	10·7	10·9
1·0285	9·9	10·0	10·1	10·3	10·4	10·5	10·6	10·7	10·9	11·0
1·0290	10·0	10·2	10·3	10·4	10·5	10·6	10·8	10·9	11·0	11·1
1·0295	10·2	10·3	10·4	10·5	10·6	10·8	10·9	11·0	11·1	11·2
1·0300	10·3	10·4	10·5	10·6	10·8	10·9	11·0	11·1	11·2	11·4
1·0305	10·4	10·5	10·6	10·8	10·9	11·0	11·1	11·2	11·4	11·5
1·0310	10·5	10·7	10·8	10·9	11·0	11·1	11·3	11·4	11·5	11·6
1·0315	10·7	10·8	10·9	11·0	11·1	11·3	11·4	11·5	11·6	11·7
1·0320	10·8	10·9	11·0	11·1	11·3	11·4	11·5	11·6	11·7	11·9
1·0325	10·9	11·0	11·1	11·3	11·4	11·5	11·6	11·7	11·9	12·0
1·0330	11·0	11·2	11·3	11·4	11·5	11·6	11·8	11·9	12·0	12·1
1·0335	11·2	11·3	11·4	11·5	11·6	11·8	11·9	12·0	12·1	12·2
1·0340	11·3	11·4	11·5	11·6	11·8	11·9	12·0	12·1	12·2	12·4
1·0345	11·4	11·5	11·6	11·8	11·9	12·0	12·1	12·3	12·4	12·5
1·0350	11·5	11·7	11·8	11·9	12·0	12·1	12·3	12·4	12·5	12·6

Specific Gravity.	Fat 3·1	3·2	3·3	3·4	3·5	3·6	3·7	3·8	3·9	4·0
1·0280	11·0	11·1	11·2	11·3	11·5	11·6	11·7	11·8	11·9	12·1
1·0285	11·1	11·2	11·3	11·5	11·6	11·7	11·8	11·9	12·1	12·2
1·0290	11·2	11·4	11·5	11·6	11·7	11·8	12·0	12·1	12·2	12·3
1·0295	11·4	11·5	11·6	11·7	11·8	12·0	12·1	12·2	12·3	12·4
1·0300	11·5	11·6	11·7	11·8	12·0	12·1	12·2	12·3	12·4	12·6
1·0305	11·6	11·7	11·8	12·0	12·1	12·2	12·3	12·4	12·6	12·7
1·0310	11·7	11·9	12·0	12·1	12·2	12·3	12·5	12·6	12·7	12·8
1·0315	11·9	12·0	12·1	12·2	12·3	12·5	12·6	12·7	12·8	12·9
1·0320	12·0	12·1	12·2	12·3	12·5	12·6	12·7	12·8	12·9	13·1
1·0325	12·1	12·2	12·3	12·5	12·6	12·7	12·8	12·9	13·1	13·2
1·0330	12·2	12·4	12·5	12·6	12·7	12·8	13·0	13·1	13·2	13·3
1·0335	12·4	12·5	12·6	12·7	12·8	13·0	13·1	13·2	13·3	13·4
1·0340	12·5	12·6	12·7	12·8	13·0	13·1	13·2	13·3	13·4	13·6
1·0345	12·6	12·7	12·8	13·0	13·1	13·2	13·3	13·4	13·6	13·7
1·0350	12·7	12·9	13·0	13·1	13·2	13·3	13·5	13·6	13·7	13·8

Specific Gravity.	Fat 4·1	4·2	4·3	4·4	4·5	4·6	4·7	4·8	4·9	5·0
1·0280	12·2	12·3	12·4	12·5	12·7	12·8	12·9	13·0	13·1	13·2
1·0285	12·3	12·4	12·5	12·7	12·8	12·9	13·0	13·1	13·3	13·4
1·0290	12·4	12·6	12·7	12·8	12·9	13·0	13·2	13·3	13·4	13·5
1·0295	12·6	12·7	12·8	12·9	13·0	13·2	13·3	13·4	13·5	13·6
1·0300	12·7	12·8	12·9	13·0	13·2	13·3	13·4	13·5	13·6	13·8
1·0305	12·8	12·9	13·0	13·2	13·3	13·4	13·5	13·6	13·8	13·9
1·0310	12·9	13·1	13·2	13·3	13·4	13·5	13·7	13·8	13·9	14·0
1·0315	13·1	13·2	13·3	13·4	13·5	13·7	13·8	13·9	14·0	14·1
1·0320	13·2	13·3	13·4	13·5	13·7	13·8	13·9	14·0	14·1	14·3
1·0325	13·3	13·4	13·6	13·7	13·8	13·9	14·0	14·1	14·3	14·4
1·0330	13·4	13·6	13·7	13·8	13·9	14·0	14·2	14·3	14·4	14·5
1·0335	13·6	13·7	13·8	13·9	14·0	14·2	14·3	14·4	14·5	14·6
1·0340	13·7	13·8	13·9	14·0	14·2	14·3	14·4	14·5	14·6	14·8
1·0345	13·8	13·9	14·0	14·2	14·3	14·4	14·5	14·6	14·8	14·9
1·0350	13·9	14·1	14·2	14·3	14·4	14·5	14·7	14·8	14·9	15·0

TABLE VI.

FAT—calculated from Specific Gravity and Total Solids.

Specific Gravity.	11·1	11.2	11·3	11·4	11·5	11·6	11·7	11·8	11·9	12·0	12·1	12·2	12·3	12·4	12·5	12·6	12·7	12·8	12·9	13·0	13·1	13·2	13·3	13·4	13·5	13·6	13·7	13·8	13·9	14 0	14·1	14·2	14·3	14·4	14·5	14·6	14·7	14·8	14·9	15·0	Specific Gravity.
	TOTAL SOLIDS. FAT.																																								
1·0280	3·2	3·3	3·4	3·5	3·5	3·6	3·7	3·8	3·9	4·0	4·0	4·1	4·2	4·3	4·4	4·5	4·5	4·6	4·7	4·8	4·9	5·0	5·0	5·1	5·2	5·3	5·4	5·5	5·5	5·6	5·7	5·8	5·9	6·0	6·0	6·1	6·2	6·3	6·4	6·5	1·0280
1·0285	3·1	3·2	3·3	3·4	3·4	3·5	3·6	3·7	3·8	3·9	3·9	4·0	4·1	4·2	4·3	4·4	4·4	4·5	4·6	4·7	4·8	4·9	4·9	5·0	5·1	5·2	5·3	5·4	5·4	5·5	5·6	5·7	5·8	5·9	5·9	6·0	6·1	6·2	6·3	6·4	1·0285
1·0290	3·0	3·1	3·2	3·2	3·3	3·4	3·5	3·6	3·7	3·7	3·8	3·9	4·0	4·1	4·2	4·2	4·3	4·4	4·5	4·6	4·7	4·7	4·8	4·9	5·0	5·1	5·2	5·2	5·3	5·4	5·5	5·6	5·7	5·7	5·8	5·9	6·0	6·1	6·2	6·2	1·0290
1·0295	2·9	3·0	3·1	3·1	3·2	3·3	3·4	3·5	3·6	3·6	3·7	3·8	3·9	4·0	4·1	4·1	4·2	4·3	4·4	4·5	4·6	4·6	4·7	4·8	4·9	5·0	5·1	5·1	5·2	5·3	5·4	5·5	5·6	5·6	5·7	5·8	5·9	6·0	6·1	6·1	1·0295
1·0300	2·8	2·9	3·0	3·0	3·1	3·2	3·3	3·4	3·5	3·5	3·6	3·7	3·8	3·9	4·0	4·0	4·1	4·2	4·3	4·4	4·5	4·5	4·6	4·7	4·8	4·9	5·0	5·0	5·1	5·2	5·3	5·4	5·5	5·5	5·6	5·7	5·8	5·9	6·0	6·0	1·0300
1·0305	2·7	2·8	2·8	2·9	3·0	3·1	3·2	3·3	3·3	3·4	3·5	3·6	3·7	3·8	3·8	3·9	4·0	4·1	4·2	4·3	4·3	4·4	4·5	4·6	4·7	4·8	4·8	4·9	5·0	5·1	5·2	5·3	5·3	5·4	5·5	5·6	5·7	5·8	5·8	5·9	1·0305
1·0310	2·6	2·7	2·7	2·8	2·9	3·0	3·1	3·2	3·2	3·3	3·4	3·5	3·6	3·7	3·7	3·8	3·9	4·0	4·1	4·2	4·2	4·3	4·4	4·5	4·6	4·7	4·7	4·8	4·9	5·0	5·1	5·2	5·2	5·3	5·4	5·5	5·6	5·7	5·7	5·8	1·0310
1·0315	2·5	2·5	2·6	2·7	2·8	2·9	3·0	3·0	3·1	3·2	3·3	3·4	3·5	3·6	3·6	3·7	3·8	3·9	4·0	4·0	4·1	4·2	4·3	4·4	4·5	4·5	4·6	4·7	4·8	4·9	5·0	5·0	5·1	5·2	5·3	5·4	5·5	5·6	5·6	5·7	1·0315
1·0320	2·4	2·4	2·5	2·6	2·7	2·8	2·9	2·9	3·0	3·1	3·2	3·3	3·4	3·5	3·5	3·6	3·7	3·8	3·9	3·9	4·0	4·1	4·2	4·3	4·4	4·4	4·5	4·6	4·7	4·8	4·9	4·9	5·0	5·1	5·2	5·3	5·4	5·4	5·5	5·6	1·0320
1·0325	2·3	2·3	2·4	2·5	2·6	2·7	2·8	2·8	2·9	3·0	3·1	3·2	3·3	3·3	3·4	3·5	3·6	3·7	3·8	3·8	3·9	4·0	4·1	4·2	4·3	4·3	4·4	4·5	4·6	4·7	4·8	4·8	4·9	5·0	5·1	5·2	5·3	5·3	5·4	5·5	1·0325
1·0330	2·2	2·2	2·3	2·4	2·5	2·6	2·7	2·7	2·8	2·9	3·0	3·1	3·2	3·2	3·3	3·4	3·5	3·6	3·7	3·7	3·8	3·9	4·0	4·1	4·2	4·2	4·3	4·4	4·5	4·6	4·7	4·7	4·8	4·9	5·0	5·1	5·2	5·2	5·3	5·4	1·0330
1·0335	2·1	2·1	2·2	2·3	2·4	2·5	2·6	2·6	2·7	2·8	2·9	3·0	3·1	3·1	3·2	3·3	3·4	3·5	3·6	3·6	3·7	3·8	3·9	4·0	4·1	4·1	4·2	4·3	4·4	4·5	4·6	4·6	4·7	4·8	4·9	5·0	5·1	5·1	5·2	5·3	1·0335
1·0340	2·0	2·0	2·1	2·2	2·3	2·4	2·5	2·5	2·6	2·7	2·8	2·9	3·0	3·0	3·1	3·2	3·3	3·4	3·5	3·5	3·6	3·7	3·8	3·9	4·0	4·0	4·1	4·2	4·3	4·4	4·5	4·5	4·6	4·7	4·8	4·9	5·0	5·0	5·1	5·2	1·0340
1·0345	1·9	1·9	2·0	2·1	2·2	2·3	2·4	2·4	2·5	2·6	2·7	2·8	2·9	2·9	3·0	3·1	3·2	3·3	3·4	3·4	3·5	3·6	3·7	3·8	3·9	3·0	4·0	4·1	4·2	4·3	4·4	4·4	4·5	4·6	4·7	4·8	4·9	4·9	5·0	5·1	1·0345
1·0350	1·7	1·8	1·9	2·0	2·1	2·2	2·2	2·3	2·4	2·5	2·6	2·7	2·7	2·8	2·9	3·0	3·1	3·2	3·2	3·3	3·4	3·5	3·6	3·7	3·7	3·8	3·9	4·0	4·1	4·2	4·2	4·3	4·4	4·5	4·6	4·7	4·7	4·8	4·9	5·0	1·0350