On conditions necessary to obtain a clean milk supply and on methods of testing cows' milk in relation to standards of cleanness : report to the Sub-committee on clean milk / by S. Delépine, June 16th, 1918.

On Conditions necessary to obtain a Clean Milk Supply

and

On Methods of Testing Cows' Milk in relation to Standards of Cleanness.

Report to the Sub-Committee on Clean Milk.

By S. Delépine.

June 16th, 1918.

In this report clear evidence is given of the way in which milk, under the present conditions, is contaminated at its source and how this can be prevented with the result that the souring of milk which at present heavy losses can be delayed by and also that dangerous contamina- considerably reduced or pre- vented.

On Conditions necessary to obtain a Clean Milk Supply

and

On Methods of Testing Cows' Milk in relation to Standards of Cleanness.

Report to the Sub-Committee on Clean Milk.

By S. Delépine.

June 16th, 1918.

CONTENTS.

		PAGE
Section	I.—Methods used in the examination of Cow's Milk	6
,,	II.—State of Manchester Milk Supply	19
,,	III.—Results of the examination of samples of milk collected and handled at the farm under definite conditions	41
,,	IV.—Average state of milk supplies under present conditions. State practically attainable under improved conditions ...	63
,,	V.—Conditions promoting the cleanness and keeping qualities of cow's milk	66
	General Remarks and Conclusions	77
Addenda	1—American milk grading system	80
,,	2—Losses due to premature souring	81
,,	3—The souring test	82
Plate	1—Cells in tuberculous milk	86
,,	2—Dirt in Milk	88
,,	3—Some sources of milk bacteria	90
,,	4—Bacteria in the air at a dairy farm	92
,,	5—The Jersey milk can	94
,,	6—American milk pails	96
,,	7—Old and improved milk pails	98
,,	8—Simple arrangement for sterilising milk pails, cans, and covered milk pails	100
,,	9—Experimental sterilising apparatus	102
,,	10—Milking of a cow into a covered pail	104
,,	11—An inexpensive milk-house	106
,,	12—Contamination of a pail by an ordinary draining board	108

INTRODUCTION.

The following report is the outcome of a request made by the Sub-Committee on Clean Milk appointed in 1916 by the Sanitary Committee of the Manchester City Council. My instructions were to report on :—

(1) The best method of determining the degree of contamination of milk for administrative purposes ;

(2) The actual state of the Manchester milk supply.

These points are dealt with in Sections I. and II. of the report. The state of things evidenced by the results recorded in Section II. is very unsatisfactory, and it is clear that if samples of milk were tested regularly for administrative purposes the Sanitary Committee would be placed in a difficult position, for if no action was taken, this would be equivalent to a tacit acceptance of a deplorable state of things. If, on the other hand, action were taken, a considerable portion of the milk supply would have to be condemned.

I believe that *farmers and dairymen are, generally, unacquainted with the precautions which have to be adopted in order to produce clean, uncontaminated milk*, and that the unsatisfactory state of the milk supply is not, as a rule, due to wilful neglect on their part. Consequently, the mere condemnation of contaminated milk would not necessarily cause a certain or rapid improvement.

It appeared, therefore, desirable that I should give a short account of the ways in which, under existing conditions, cow's milk is contaminated at the time of collection and in the course of distribution. This I have done in Section III., in which the beneficial effects of certain precautions are also indicated. In Section IV. a comparison is made between the existing state of things and the improvements resulting from the adoption of better methods. The last section deals with the methods which, in my opinion, should be adopted in order to obtain a clean milk supply.

Before concluding these preliminary remarks, I may point out that, while it is necessary to obtain a good supply of clean milk in order to protect the community against milk-borne diseases, this is also desirable from an economic point of view, for it is clear that as clean milk retains its freshness for two or three days without any special treatment, it could be utilised to greater advantage than dirty milk, which is very liable to become sour in less than 24 hours. The frequency with which large consignments of milk are spoilt owing to early souring is, under existing conditions, a cause of a very material loss of food and money.

SHERIDAN DELÉPINE,
Professor of Public Health and Bacteriology,
University of Manchester.

ON CONDITIONS NECESSARY TO OBTAIN A CLEAN MILK SUPPLY

AND

ON METHODS OF TESTING COWS' MILK IN RELATION TO STANDARDS OF CLEANNESS.

REPORT TO THE SUB-COMMITTEE ON CLEAN MILK.

BY S. DELÉPINE.

June 16th, 1918.

At the meeting of the sub-committee held on May 18th, 1916, at the Civic Buildings, I was invited to prepare a report upon methods available for determining the state of cows' milk as to cleanness.

I made a brief statement based upon the experience gained in the course of some 25 years at the Public Health Laboratory regarding the relative value of the various kinds of tests in current use.

The sub-committee requested me to prepare a statement based upon my previous work, and to arrange with Dr. Niven for the examination of a new series of samples for the purpose of ascertaining by various methods the present state of the milk supplied to the town at various stages of its distribution.

The part taken by the Laboratory in the testing of the samples in connection with the Farmers' Milk Competition at a meeting of the Royal Agricultural Society, held in Manchester during the months of May and June, made it impossible to begin the clean milk investigation immediately. The work done for the Agricultural Society has, however, supplied data which I am authorised to place at the disposal of the Committee.

The regular examination of the new series of samples collected in Manchester was considerably delayed by the calls made upon the Laboratory by the Military Authorities. The work began in November, and samples continued to be collected with unavoidable interruptions until the 21st May. The results of the last inoculation tests were obtained on the 25th June, 1917.

The selection of places where representative samples of town milk had to be collected was made by Dr. Niven, who also took charge of the arrangements necessary for the collection of samples by the inspectors.

The exceptional difficulties which had to be overcome both at the Health Office and at the Laboratory under existing war conditions made it necessary to spread the work over a much longer period than would otherwise have been required.

In order to complete the evidence already available, I arranged to conduct a new series of experiments with the co-operation of Principal Young at the Cheshire Council Agricultural College at Holmes Chapel.

Councillor Simon, on hearing of this, generously offered to defray the experimental expenses of this work, an offer which I gratefully accepted.

In making arrangements for the immediate examination of the material arriving at the Laboratory I frequently experienced serious difficulties. I have carried out myself all the experimental work, many of the cultural tests have been carried out under my close supervision by Mr. F. Simons. Miss E. C. Iliff has given me valuable assistance in connection with the Holmes Chapel experiments. As it appeared to me desirable in an investigation of this kind to have accurate chemical data regarding each sample, I asked Mr. Heap to take charge of this part of the work. The chemical data were useful for the purpose of eliminating any samples the genuineness of which was doubtful.

SECTION I.

Methods used in the examination of cow's milk.

Of the methods which are in more or less current use I need only mention six groups :—

1.—Chemical methods.

By these methods it is possible to determine whether (*a*) the composition of the milk under investigation is normal, and the amount of its chief constituents is above or below the normal ; (*b*) the milk has been treated by heat or by various chemicals used as preservatives ; (*c*) the milk has been adulterated by the addition of water or other products.

The chemical testing of our samples was conducted according to well-known standard methods, which need not be discussed in this report. The information given by the chemical tests is of little value with regard to the question of cleanness, as to which it is even occasionally misleading, for samples of dirty or highly-infectious milk may on the strength of chemical results appear to be of good quality.

It was, however, desirable to submit the samples used in this investigation to a certain number of carefully-made chemical tests in order to exclude, if necessary, any samples that might have an exceptional composition, and could not be considered as representing fairly normal milk. The samples examined for the Agricultural Society gave me the means of obtaining standard figures for the districts supplying Manchester.

2.—Separation of extraneous matter and of cellular products by mechanical methods.

Cow's milk always contains some *cells and cellular products* derived from the secreting elements and from the ducts of the udder as well as from the skin of the teat. When the udder is diseased, the number of cells may be considerably increased and their characters altered. The milk may also contain variable amounts of degenerative or inflammatory products such as mucus, cheesy matter, clots, blood, pus, as well as some pathogenic micro-organisms.

In addition to these cellular products, some *extraneous or foreign matter* is almost invariably present in cow's milk as supplied by the farmer.

When milking is carefully conducted and the milk properly handled the extraneous matter is very scanty, and consists chiefly of a few cow hairs, some epithelial scales derived from the epidermis, a few vegetable or mineral particles derived from the dust in the air.

But when the shippons, cows, and milkers are dirty, the milk carelessly handled, the dairy vessels and water supply not clean, the amount of extraneous matter and the variety of its constituents increase considerably.

Among the extraneous products I may mention, wool, cotton, and other fibres derived from the clothing of the milker, from strainers, and from other articles used in the dairy. Animal, vegetable, and mineral matter derived from food, water, litter, dung, soil, and all kinds of dirt adhering to the skin of the cow, the hands and clothing of the milker, etc.

Various animalcules, moulds, algæ, bacteria (derived from the fodder, litter, water, farm animals, and workers) may also find their way into the milk.

Micro-organisms of various kinds, including some capable of producing disease, may infect the milk in several ways.

The object of the mechanical methods of examination is to discover whether milk contains more cellular and extraneous products than has been found to be the *irreducible minimum* under satisfactory circumstances.

The following mechanical methods may be mentioned among others :—

Filtration method.—A definite amount of milk is filtered through a piece of some white fabric such as flannel, flannelette, or other porous material, through which milk filters readily. The dirt causes a discolouration of the part of the filter through which the milk has passed. The degree of discolouration indicates roughly the amount of dirt present. By this method it is difficult to form an accurate idea of the amount of cellular products. More elaborate methods of filtration have been used by some observers.

Slow sedimentation methods.—The simplest of these consists in allowing a fairly large amount of milk to stand for twelve or twenty-four hours in a tall cylindrical glass vessel. The amount and characters of the deposit which forms at the bottom of the vessel are then observed. There are objections to this method, viz. : its slowness and the large amount of milk which some observers require for each test (nearly 1 quart). Some preservative has to be added to the milk to prevent the changes liable to occur during the long period the fluid has to remain under observation.

Quick sedimentation method or *centrifugalisation.*—This is the method which I have used at the Public Health Laboratory during the past twenty-two years. The amount of milk used for a test was up to about twelve years ago 40 cc. (about $1\frac{2}{5}$ ounces). Since then I have preferred to take 50 cc. ($1\frac{3}{4}$ ounces) for this test. The quantity of milk used was in part deter-

mined by the size of the centrifugal machine available. (Before 1906 I had to use a centrifugal machine made in Germany. Since then I have used a better and larger one made in Manchester, in which 16 large samples can be centrifugalised at the same time and at a high constant speed.)

The volume of sediment is estimated in parts of moist sediment per 100,000 parts of milk, so that a difference of 10 cc. does not affect the value of my record, the oldest of which are quite comparable with the most recent.

Centrifugalisation is used not only for the purpose of estimating the amount and general characters of the extraneous and cellular products (*slime* of dairymen), but also to separate these products for purposes of microscopical examination and inoculation.

Until about 12 years ago the sediment was generally obtained and measured at one operation, but, even then, when very accurate measurements were required the operation was conducted in three steps and the sediment was washed before being measured.

Of late years the last method has been used in preference to the simpler one, but this has affected the results only in minor details. The general adoption of the more elaborate method has been made possible by various improvements in the apparatus used.

Simple method.—(Unwashed sediment).

50 cc. (1¾ ounces) of well-shaken milk is poured into a strong glass tube of standard diameter, the bottom of which is hemispherical. The tube is placed in a centrifugal machine (effective diameter 17″) run for 15 minutes at a speed of 2,000 increasing gradually to 3,000 revolutions per minute for 15 minutes. (*i.e.*, the bottom of the sedimentation tubes travel at the rate of a little over 2¼ miles per minute).

After this operation, unless the milk is distinctly abnormal, the cream forms on the surface of the fluid a layer so firm that the tube can be turned upside down without any spilling of milk.

The greater part of the cellular and extraneous products, including bacteria, form at the bottom of the tube a sediment (slime) so dense and compact that, after removal of the cream, the separated milk contained in the tube can be poured out without the sediment being displaced.

The bulk of the slime can be estimated with a fair amount of accuracy by measuring the diameter of the sediment. Tables giving the relation between the diameter and bulk are used for that purpose.

The colour and other characters of the various parts of the sediment can also be observed.

Elaborate method.—(Washed sediment).

The sediment may either be obtained in the kind of tubes described above or in metal tubes, the lower part of which forms a chamber containing a small glass tube in which the sediment is collected. By opening this chamber the small glass tube can be removed.

The sediment is thoroughly mixed with 15 cc. of 0. 75 per cent. saline solution and this mixture is transferred to small tubes, the lower conical part of which is continuous with a well calibrated barometric tube, the length of which is about one-third of the total length. The internal diameter of this narrow part is 1.5 mm. in some of the tubes : there are other tubes 2 mm., 3 mm., and 4 mm. in diameter. The narrower tubes are used when the sediment is very scanty, the larger tubes when the sediment is bulky.

These tubes were originally graduated, but to avoid this expense the measurements are now taken with a pair of fine-pointed calipers and transferred to a standard scale, where the volume of the sediment can be read in relation to its height and to the diameter of the tube.

These sedimentation tubes are open at both ends. Before any fluid is poured into them the lower opening of the barometric tube is closed with a small disc of paper covered with a thin layer of gelatine. The disc is slightly damped, the end of the tube gently warmed and pressed against the disc of paper, which adheres firmly to the glass. By this arrangement it is possible not only to measure the sediment and the various strata of which it is composed, but also after removal of the paper disc to drive the material out of the tube in the form of a small cylinder, the various parts of which can be separated and examined microscopically.

I will give some detailed examples of the results obtained by this method after dealing with the microscopical method.

Without the help of the microscope it is possible on inspection of the sediment to form an opinion as to the nature of its constituents.

The sediment of clean milk from *healthy cows* is scanty, seldom exceeding 15 to 20 parts per 100,000 (7 to 10 parts per 100,000 appears to be an irreducible minimum), it has usually a creamy white or buff colour, and its upper layers are slightly translucent. It is composed almost entirely of cells and cellular products from the udder, with a variable number of bacteria.

Clean milk from *diseased cows* generally yields a much more bulky sediment. This may be greenish yellow when containing pus ; pinkish, red, or brown when blood is present, etc.

When the milk is dirty there is beneath the layer described above a stratum usually much thinner and variously coloured. Soot and coal dust are indicated by a grey or black colour ; a brown or greenish-brown tint suggests debris of dry fodder, litter, or dung ; there is at times enough green fodder to impart a bright green colour to this part of the sediment.

There is sometimes above, or mixed with, the layer of cellular products another more or less bulky and often ill-defined deposit which seems to be composed of minute clots. This is noticeable in samples of stale milk, more particularly after the milk has been heated, or in the milk of cows suffering from certain forms of mammitis.

The study of sediments obtainable from cow's milk yielded very useful and interesting results between the years 1896 and 1906, and gave me the means of estimating some of the improvements which had taken place as a result of the inspection of farms conducted under the direction of the Manchester Sanitary Committee. (See Special Report to the Sanitary Committee, July 29th, 1908.)

About that time farmers were led to adopt improved methods of filtration or straining more generally than they had previously done, and as a result of this the amount of extraneous matter recoverable from the milk sent to town became very rapidly less. I soon found that this improvement was more apparent than real, as it did not correspond with a similar improvement in the keeping qualities of the milk. Straining and filtration of the milk at the farm served very often to cloak serious defects in the methods of collection and handling.

It appears, therefore, that although the detection of an undue amount of dirt in a sample of milk is always an indication of gross and reprehensible carelessness, the absence of obvious dirt is not in itself evidence that the milk has been carefully handled and is clean in a sanitary or bacteriological sense.

The adoption of improved methods of straining or filtration has considerably reduced the value of the sedimentation test. Another objection that may be offered to this method is that it is liable to considerable errors in the hands of persons who have not at their disposal centrifugal machines running at a sufficiently high and constant speed ; the completeness of sedimentation, the bulk of the sediment and its appearance are considerably influenced by the conditions under which centrifugalisation is effected, and unless these conditions are fixed the results recorded by various observers or even by the same observer at various times are not comparable. The cost of centrifugal machines and tubes suitable for accurate work on a large scale is fairly great.

3.—Microscopical methods.

Milk is examined microscopically to obtain information regarding the following points :—

(1) Characters of the normal constituents of milk.

(2) Number and characters of cells and cellular products supposed to indicate disease of the udder.

(3) Nature and amount of extraneous products.

(4) Number of bacteria.

(5) Presence of bacteria capable of producing disease.

The milk may be examined directly under the microscope, or a thin layer of it may be dried upon a glass slide and stained in various ways. Generally, however, the milk is centrifugalised first and parts of the sediment are taken for examination under the microscope, either in the fresh state or after being submitted to various treatments according to the object in view.

The method of sedimentation which I have previously described has allowed me to examine separately the various constituents of slime, and to determine the nature of the cellular products, extraneous matter, and bacteria entering into its composition. A first series of observations made between the years 1896 and 1899 led me to the conclusion that this method did not yield results capable of general application in administrative work. The number of cells, their varieties, the morphological characters of the bacteria, the nature of the extraneous products as revealed by microscopical examination, gave, except in a limited number of cases, insufficient and unreliable bases for a determination of the quality of the milk examined.

The importance attached by some subsequent observers to the cellular contents of milk led me to make a new series of observations some ten years ago, with results which confirmed my original opinion.

The fact that tubercle bacilli may be found by microscopical examination in the milk of some tuberculous cows is from an administrative point of view less important than the failure of detecting by this method this bacillus in the milk of a large proportion of the tuberculous animals.

The presence of pus in the milk of some of the cows affected with infectious mammitis can undoubtedly be revealed by the microscope, but there are many cases of mammitis which would escape detection if this method was the only one available.

The negative results obtained by the microscopical method are therefore unreliable for the purpose of determining the soundness of individual samples of milk.

The results of the microscopical examination of milk sediments are, however, of considerable use, because they supply general information as to the sources of contaminations of cow's milk. This is clearly shown by the results summarised in the following table, which is based partly upon the microscopical examination of 300 samples of milk between the years 1896 and 1899 and of 63 more samples during the year 1908.

PRODUCTS FORMING AN APPRECIABLE PART OF THE SEDIMENTS OBTAINED FROM SAMPLES OF COWS' MILK AND READILY OBSERVED IN FRESH OR STAINED PREPARATIONS UNDER THE MICROSCOPE.

	Rate of occurrence per cent. of total number of samples examined
CELLS AND CELLULAR PRODUCTS—	
Large epithelial cells from *the udder*	73
Coarsely granular cells ,, ,, ...	50
Small round cells ,, ,, ...	95
Leucocytes or pus cells ,, ,, ...	9
Red blood corpuscles ,, ,, ...	3
Squamous epithelial cells from the skin of milkers, cows, or other farm animals	60
Hairs from the skin of milkers, cows, or other farm animals	85
EXTRANEOUS MATTER—	
Animal products :	
Wool (clothing)	63
Protozoa (water)	9
Worms ,, ...	4
Rotifers ,, ... } Acari, insects (litter, air, dust) }	6

EXTRANEOUS MATTER—*continued*—

	Rate of occurence per cent. of total number of samples examined
Vegetable products :	
Bright green vegetable debris (green fodder)	66
Brown vegetable debris (fodder, litter, dung)	95
Cotton and flax fibres (clothing, etc.)	82
Starch granules (food)	77
Moulds and yeasts (food, litter, dust).	58
Green and other algæ (water)	28
Mineral products :	
Carbon, coal dust (air, dust)	95
Colourless and coloured particles (soil, buildings, etc.)	82
Types of Bacteria (present in fairly large numbers in stained films) :	
Staphylococci	75
Diplococci	78
Tetracocci or Sarcinæ	22
Streptococci	46
Short bacilli in clumps	52
Short bacilli in chains	56
Slender long bacilli	14
Thick long bacilli	41
Tubercle bacilli	3*

* Out of 13 cases detected by the inoculation method.

By spreading evenly definite quantities of milk over areas of definite size, drying these films, staining them after suitable treatment, and examining them under a high power of the microscope, it is possible to *count the bacteria* revealed by this method and to make an approximate estimate of their number per 1cc. This method, which requires a fair amount of skill and of familiarity with the use of the microscope, is not always reliable, and the results obtained by different observers are less comparable than those obtained by the cultivation method.

4.—Inoculation method.

This method is of use for certain limited purposes: it is the best available for the *detection of tubercle bacilli* in cow's milk. In the case of *milk from single cows* it is possible by carefully conducted microscopical examination to detect the presence of tubercle bacilli in about 90 per cent. of the cases proved to be tuberculous by inoculation; but in the case of *mixed milk*, such as reaches towns, the microscopical examination fails to reveal the presence of tubercle bacilli in over 60 per cent. of the cases detected by the inoculation method.

Dirty milk sometimes produces lesions in inoculated animals, but this method of examination, though useful for investigation purposes, is unsuitable for administrative work; this is so not only on account of its slowness, but also owing to the fact that milk may be materially dirty without producing any obvious lesion in animals inoculated or fed with it.

5.—Cultivation methods.

The object of these methods is to determine :—

(1) The number of bacteria and incidently the degree of contamination or pollution of the milk.

(2) Some of the properties of these bacteria.

(3) The presence or absence of certain disease-producing bacteria.

Enumeration of Bacteria (bacterial counts).

The quantity of milk which has been universally adopted as the unit for this purpose is 1 cc. (about $\frac{1}{28}$ of a fluid ounce or 15 grains).

To find the number of bacteria present in that quantity of milk it is usual to take small fractions of a cubic centimetre of the milk to be tested, each of these fractions is mixed thoroughly with sterile melted jelly in which bacteria grow readily, the jelly is then poured upon glass plates, allowed to set, and incubated at a suitable temperature. The *aerobic bacteria* scattered through the jelly multiply and form colonies which, according to the kind, become visible in 1, 2, 3, or more days ; in some cases over one week is needed to obtain this result. It is not usual to estimate the number of *anaerobic bacteria*.

The rate of growth is more or less delayed when the milk has been heated (short of killing the bacteria), or when preservatives have been added to it. In such cases the emuneration of bacteria may give misleading indications.

Different methods are used by various bacteriologists to measure fractions of a cubic centimetre.

Graduated pipettes are unreliable to measure quantities of milk under $\frac{1}{2}$ cc. I prefer to use only 1 cc. pipettes carefully calibrated ; with one of these pipettes I add one cc. of milk to each of a series of measured quantities of sterile water, say 9, 99, 1,000, 10,000 cc., contained in suitable flasks ; one cc. of each of these mixtures corresponds to a definite fraction of 1 cc. of milk (in practice the higher are prepared by sub-diluting the lower dilution) from which the bacterial contents of 1 cc. can afterwards be calculated easily.

For purposes of investigation it is necessary to use a series of several dilutions in order to obtain some plates containing about 50 to 100 colonies. A larger number of colonies introduces various sources of error, a smaller number is unreliable as a basis for an average.

In routine work, and when standards have been fixed, two or three dilutions may suffice to determine quickly whether a sample of milk is above or below certain predetermined figures.

The care with which the required quantity of milk taken for cultivation is measured influences very much the accuracy of the results.

The sample itself should be well stirred or shaken before any part of it is taken. Each dilution should likewise be thoroughly shaken. No attempt should be made to measure, without previous dilution, small fractions of 1 cc., more particularly when a large amount of work has to be conducted in a limited amount of time.

When the milk is added to the jelly the two should be thoroughly mixed before being poured on to the plate, and the temperature of the melted jelly should not be above blood heat.

In some American laboratories the measured quantity of milk is poured direct into the dish in which the gelatine plate is made. I doubt whether uniformly satisfactory results can be obtained by such a hasty procedure. It is true that minute accuracy is not necessary to obtain results capable of general application in administrative work. On the other hand, any slackness in bacteriological work is liable to degenerate into carelessness, the results of which may lead to gross injustices and other unpleasant consequences.

The results obtained are greatly influenced by the culture media used, the temperature at which they are incubated, and the duration of the incubation.

The methods adopted in various countries and laboratories differ materially, so that the results obtained in various places are not absolutely comparable. This must always be kept in mind in connection with the fixing of standards.

The culture media used in my laboratory are (*a*) peptone-bouillon-gelatine (nutrient gelatine) and (*b*) peptone-bouillon-litmus-lactose-agar (litmus lactose agar). The first of these media has been used in most bacteriological laboratories, including my own, for more than thirty years, and when due attention is paid to its reaction and the quality of the peptone and of the gelatine it may be looked upon as one of the most valuable standard media, owing to the great number of observations for which it has been used by leading bacteriologists all through the world.

Nutrient gelatine is used to cultivate bacteria at a temperature of 20° C., which is that of a warm room. Many of the air, water, and soil bacteria grow well at that temperature, and are capable of producing in two days colonies large enough to be visible to the naked eye; in the case of a fairly large number of bacteria three days are necessary to obtain this result, and there are some slow-growing bacteria which become visible only at the end of several more days. Most of the bacteria capable of growing on nutrient gelatine at 20° produce colonies clearly recognisable in three days. It has, therefore, been customary to enumerate the colonies at the end of 72 hours, the number recognisable at the end of 48 hours does not bear a constant relation to the number of those visible at the end of 72 hours, but some observers are satisfied with the results of the shorter incubation; their figures are very much lower than those of other bacteriologists, and do not represent accurately the bacterial contents of milk. In some laboratories only the bacteria visible to the naked eye are counted; in others, my own included, a microscope magnifying 10 to 15 times is used.

There are many common and pathogenic bacteria which do not grow on gelatine under the conditions described above: several thousand tubercle bacilli might be present in a sample of milk without any sign of their presence being found by the ordinary plate method.

On the other hand, a very large proportion of the bacteria usually present in dirt grow well on this medium, so that the number of colonies bears a general relation to the amount of dirt.

This relation is not, however, so simple as it may appear at first sight, because milk is a very good medium for the growth of many microbes, and the rapidity of bacterial multiplication is much influenced by time and by temperature.

When milk, *handled as it is at present*, is forwarded to town from a great distance *without being refrigerated*, the number of bacteria found on arrival is greater than it was at the beginning of the journey, and in summer this increase is very considerable.

The bacteria which multiply in this way are chiefly the common bacteria of air, water, and soil, but several of the fæcal bacteria are also capable of multiplication at ordinary temperature.

The number of bacteria in milk arriving to town from various parts of the country is, under present conditions, determined both by the care taken by the farmer and by the facilities given by railway companies for the proper keeping of the milk in transit (refrigerated clean vans are seldom available). By taking certain precautions to reduce the amount of dirt in milk to a minimum the farmer would suffer less from the defects of carriage than he does at present. To this point I will refer in the latter part of this report.

It is possible to reduce to a certain extent the error to which I have just alluded by taking less account of the number of bacteria of all sorts and paying more attention to bacteria growing at blood or fever heat. Many of these, which are mostly derived from living animals and men, and are of excretal origin, grow comparatively slowly at the ordinary temperature of the air, and *on an average* do not grow so rapidly in transit as common bacteria. From a Public Health point of view their presence in the milk is of greater moment than that of the ordinary saprophytic bacteria.

Peptone bouillon agar is one of the media most commonly used to cultivate bacteria at blood heat, as it does not melt as gelatine would do at that temperature.

This medium has, like peptone bouillon gelatine, been used for a considerable number of years by bacteriologists, The results yielded at the present time are therefore comparable with results obtained more than thirty years ago. For over 20 years it has been my practice to add to this medium a small amount of milk sugar and enough litmus to give to the jelly a pale blue colour. The additions of these products does not affect to an appreciable extent the number of colonies, and facilitates the discovery of bacteria capable of producing typhoid fever, food-poisoning, and several allied diseases.

Plates made with this *litmus lactose agar* are incubated at a temperature of 37° to 42° C. and the colonies are counted at the end of 24 hours and of 48 hours. The number of colonies is often more than doubled between the 24th and the 48th hour, but the 24-hour results are generally significant and usually bear some relation to the 48-hour figures.

The number of colonies does not usually increase very materially after 48 hours.

This number is usually smaller than that of colonies growing at 20° in 72 hours on gelatine, but this is not invariably the case. I am of opinion that milk containing a large number of bacteria growing at 42° on agar is more objectionable than milk containing the same number of colonies growing on gelatine at 20° C.

6.—Incubation method (souring or clotting test).

Milk kept at summer's temperature clots more or less rapidly. This is due to the multiplication of microbes, including several fæcal bacteria, which are present in very small numbers in milk obtained direct from the udder, and are more numerous in the milk leaving the farm.

These bacteria have the power to ferment milk sugar, and one of the effects of this fermentation is the production of lactic acid, which gives to the milk a sour taste and an acid reaction: this after a time is followed by clotting. The multiplication of these acid-producing bacteria generally checks more or less completely that of several other bacteria (including several putrefactive organisms) associated with dirt, but the presence of the acid-producing bacteria is also an indication of various contaminations, for they are not present in the milk *as secreted* by the udder of a healthy cow. Contamination generally begins in the duct of the teat. The bacilli of lactic acid fermentation are frequently thought to be beneficial organisms, and in a limited sense they are, but none the less they must be looked upon as evidence of contamination.

The rapidity of the occurrence of souring and clotting is determined by the number of bacteria originally introduced into the milk, the temperature at which it has been kept, and the time which has elapsed since milking.

The time at which souring or clotting are recognisable bears a distinct relation to the number of bacteria capable of producing lactic acid fermentation. The rapidity of clotting may therefore serve as an indication of the degree of contamination and may supply information resembling, though not quite equivalent to, that yielded by the counting of bacteria (see Section I., 5).

As there is a distinct correlation between the number of bacteria of all kinds and the rate of clotting, it is obvious that the latter phenomenon could form the basis of a method more suitable for administrative purposes than the plate method, for the souring and clotting tests can be carried out by any careful observer, and requires no bacteriological training or any elaborate apparatus (*see* Addendum 3).

With the object of obtaining some data on this point I have incubated samples of milk at various temperatures, taken at intervals their reaction, and noted the times at which coagulation began to appear and was completed.

The quantity of milk was 5 cc. (about $\frac{1}{5}$ ounce) in each case, This was contained in a sterilized glass tube provided with a glass or metal cap.

At stated intervals a minute drop of milk was taken by means of a sterilised platinum loop and applied to very sensitive blue litmus paper (almost neutral). The glass tube was then tilted in order to ascertain

whether the milk was quite fluid or had begun to thicken, complete clotting was considered to have taken place when the milk had become quite solid, with or without separation of whey.

This was done in the case of all the samples collected for the clean milk investigation, including those taken at Holmes Chapel. I will use some of the latter to show the relations between contamination of the milk and the rate of souring and clotting, as they make it possible to follow the changes taking place from the time of milking.

On the 2nd June, 1916, I collected four samples of milk at the Holmes Chapel Agricultural College.

Samples A, B, and C were obtained from three different cows. While these cows were milked into the ordinary milk pails some of the milk of each cow was received direct into a corresponding sterilized bottle (sample C consisted entirely of strippings, and was obtained slowly with the help of much manipulation of the udder). The milk collected in the milk pails and corresponding to the milk of the three cows (less the few ounces taken from each in the sterilised bottles) was then strained through the strainer (which had been used for the afternoon milk) into a farm churn. A sample of this milk was taken in a sterilised bottle immediately after straining.

The three samples A, B, and C represented therefore samples of milk collected as it left the cows, and sample ABC the same milk collected fifteen minutes later, after being treated in the usual way and ready to leave the farm. (Fuller details are given in Section III. of this report.)

The reaction was tested at various intervals in the course of 90 hours, and note was taken at the same time of the state of the milk as regards coagulation.

Equal parts of each of the four samples were incubated at 20° C. and at 37° C. respectively.

The degree of acidity as revealed by the colour of the litmus paper is indicated in the table by figures :—

0	meaning	an amphoterous reaction (neither clearly acid nor clearly alkaline).
1	,,	a very slight acid reaction.*
2	,,	a more distinct ,, ,,
3	,,	a well-marked ,, ,,
4	,,	a strong ,, ,,

(0 to 1 correspond to 1·9 per cent. normal NaOH ;
4 to about 7·5 normal NaOH.)

The degree of clotting is indicated in the same way:

0	means	no change.
1	,,	slight doubtful thickening.
2	,,	distinct partial thickening, small curds.
3	,,	general soft clot
4	,,	firm clot with or without separation of whey.

* An alkaline reaction would be indicated by similar signs preceded by −, thus −2 would mean a slight but distinct alkaline reaction, which would probably be the result of putrefactive changes. None of the samples tested became alkaline.

EXPERIMENT LB. 8304.—INCUBATION TEST APPLIED TO MILK BEFORE AND AFTER HANDLING AT THE FARM.

A.	Time after Milking Hours	Acidity (Souring) Test				Clotting Test			
		Unmixed Milk before handling			Mixed Milk after handling	Unmixed Milk before handling			Mixed Milk after handling
		Cow A	Cow B	Cow C	Cows A, B, C	Cow A	Cow B	Cow C	Cows A, B, C
No. of Bacteria growing at 37° C. on Litmus Lactose Agar...	2¾	80	10	6,100	432,000	80	10	6,100	432,000
Incubation at 20° C.	2¾	0	1	0	1	0	0	0	0
	14	0	1	0	2	0	0	0	1
	25	0	1	0	2	0	0	0	3
	46	0	1	0	3	0	0	0	4
	70	1	1	0	4	0	0?	0?	4
	90	1	1	0	4	0	1	0?	4
Incubation at 37° C.	2¾	0	1	0	1	0	0	0	1
	14	0	1	0	3	0	0	0	3
	25	1	1	2	4	0	0?	1	4
	46	2	2	3	4	1	2	3	4
	70	3	3	4	4	3	4	4	4

This experiment shows that there is a relation between souring and clotting on the one hand and the number of bacteria growing at 37° C. on the other hand. This is what could be expected. It will, however, be noticed that in the milk incubated at 20° C. the difference between the milk of cow C and that of cows A and B is not so clearly brought out as in milk incubated at 37° C., or by the difference in the number of bacteria.

The milk of cow C consisted of strippings obtained after manipulation, during which the milk was exposed to more contamination than was the case with regard to the milk of cows A and B.

Similar results were yielded by a number of other experiments, some of which will be dealt with in Section III.

An objection to the incubation method which I have described above is that in order to give it a quantitative character it is necessary to make observations at regular intervals for 48 hours. Most of my observations have been interrupted by night. These difficulties can be overcome by means of a mechanical arrangement for taking the reaction automatically at intervals of 3 or 4 hours for 48 hours or longer. I have actually made use of such an appliance in some of my experiments.

There is a simpler way of carrying out the incubation test. About 1 ounce of each sample is distributed in three sterilised test tubes. These small milk samples are placed in an incubator at 30° C. At theend of eight to twelve hours, one of the three test tubes is transferred to a water bath containing boiling water. After being left there for ten to fifteen minutes the tube is examined. If souring has sufficiently advanced the milk will be found clotted after this treatment (*see* Addendum 3).

Good milk should not clot after being incubated at 30° for over 20 hours.

If the milk in the first test tube does not clot, the second tube is examined the next morning after it has been incubated for 24 hours; if the milk is clean it does not clot after being left for 10 minutes in the boiling water.

The third tube is allowed to remain in the incubator for another 10 hours, and if at the end of that time it does not clot on heating, the milk may be looked upon as very clean.

By incubation at a lower temperature, say 20° C., the intervals between the observations may be lengthened.

Finer differences might be determined by conducting three sets of tests at incubation temperatures of 20°, 30°, and 35° C. respectively.

SECTION II.

State of the Manchester Milk Supply as indicated by the results of several series of sedimentation, incubation, cultivation, inoculation, and chemical tests.

1.—Samples representing some parts of the milk supply during the years 1916-1917.

The specimens collected in connection with the clean milk investigation supply data regarding—

(1) the milk arriving from various farms to several important town dairies, some smaller dairies, and some hospitals.

(2) milk, treated or untreated, supplied by these dairies to hospitals, schools for mothers, and small general shops.

(3) milk after it has been distributed to various hospital wards.

These samples represent therefore the milk at various stages of its distribution, from the time of its arrival to town to that when it is on the point of consumption.

Table I. gives the results of the analyses of 67 samples collected under Dr. Niven's direction at 5 large dairies (A, B, C, D, and E), 12 hospitals, 4 dealers supplying 7 schools for mothers, and 10 general shops.

Particulars as to the specimens themselves and their source are given in the 4th and 5th columns. The result of the sedimentation, incubation, cultivation, chemical, and inoculation tests are given in the columns under corresponding headings.

With regard to the incubation tests, it was found impossible to give the results in detail. The figures indicate the number of hours at the end of which it was found that certain degrees of acidity or coagulation had been reached; and when it happened that during the whole period of observation the milk had remained normal, the number of hours during which the milk had remained sweet is also given. Many of the figures are approximate only, owing to the difficulty of keeping all the samples under continuous observation.

The results of the cultivation tests need no further explanation except as regards a sample of treated milk, which although it clotted in 48 hours appeared to be free from bacteria capable of growing on plates prepared in the usual way. This milk when cultivated by other methods was found to contain a fairly large number of anaerobic bacteria (I.B. 2716). This shows one of the limitations of the ordinary cultivation method.

With regard to the inoculation tests, the number of days during which the animals were under observation and the results of the inoculation, chiefly as regards tuberculosis, are given in the last two columns. The duration of the period of observation was shortened in some cases by the premature death of the animal. Unfortunately there was at the time a fair amount of mortality among the stock animals, so that the premature deaths among the inoculated animals may have been accidental, and not always due to the inoculation.

In some cases, however, there was clear evidence that the milk had caused acute or sub-acute infection. This was indicated by the presence of local abscesses from which some bacteria, such as streptococci were sometimes recovered. In one case the bacillus enteritidis was the cause of distinct lesions.

As regards tuberculosis, negative results recorded in the case of animals that had lived less than 15 days are not conclusive.

Table II. gives the results of the chemical and sedimentation tests applied to 119 samples of milk examined during May and June, 1916, at the request of the Sanitary Committee and of the Royal Agricultural Society in connection with the Agricultural Show held in Manchester.

As these samples represented in all probability the best milk which farmers were in a position to supply to Manchester at that time, the figures yielded by their analysis are of value in that they give the means of obtaining local standards with which the milk collected at various Manchester dairies and shops can be compared.

It appeared to me best to use only the chemical and sedimentation tests for this purpose, because, on account of the considerable differences in the distances of the various farms and the absence of means of refrigeration in transit, the results of cultivation tests would not have yielded figures useful for the purpose of fixing standards.

TABLE I.—TABULATED RESULTS OF FIVE SERIES OF TESTS APPLIED TO SAMPLES OF MILK COLLECTED AT DAIRIES, INSTITUTIONS, AND SMALL SHOPS, IN CONNECTION WITH THE CLEAN MILK INVESTIGATION (NOVEMBER, 1916, TO MAY, 1917).

Date of Collection	Laboratory Nos. L.R. & I.B.	Office Nos.	Nature of Specimen	Dealers. No. of Farms	Sediment per 100,000		Effects of Incubation at 21° C. to 22° C. upon Acidity and Coagulation after a stated number of hours					Number of Bacteria per 1 c.c.			Chemical Examination (parts per 100)							Result of inoculation with the sediment of 20 c.c. of milk	
					Total	Extraneous Protein	Acidity 3	Acidity 4	Coagulation 3	Coagulation 4	No marked Acidity or Coagulation (milk good for about)	Growing at 20° C. on Gelatine in 72 hours	Growing at 37° C. on Agar in 24 hours	Growing at 37° C. on Agar in 48 hours	Reaction +	Specific Gravity	Fat %	Solids not fat %	Lactose %	Protein	Ash %	Evidence of partial or complete heating (H = heating)	Number of days after inoculation	Tuberculosis + and other Infection
	LB 8,706		DAIRY A—																				
27/11/16 ...	IB 2,710	1 A	Untreated, mixed milk tank. (Temperature 54° F.)	92 farms in Cheshire, Lancashire, Derbyshire, Yorkshire, Staffordshire, Shropshire, Cumberland, Montgomery, Scotland, and Wales	24	2½	8	12	12	17	—	1,670,000	22,766	42,600	2·0	1032·1	4·01	8·61	4·36	3·60	0·65	0	20	+
,, ...	IB 2,711	B	After heating to 183° F. for 5 to 6 minutes and cooling. (Temperature 52° F.)	,, ,, ,,	41	3	17	21	17	21	—	300	230	280	2·0	1032·2	3·95	8·80	4·66	3·51	0·63	H	20	0
,, ...	IB 2,712	C	After treating as above, ready for delivery. (Temperature 52° F.)	,, ,, ,,	30	2	17	21	17	21	—	23,450	490	800	2·0	1031·6	3·95	8·94	4·59	3·82	0·62	H	20	0
	LB 8,719		DAIRY B—																				
30/11/16 ...	IB 2,713	2 A	Untreated, farm cans. (Temperature 58° F.)	23 farms in Cheshire, Lancashire, Shropshire, and Cumberland	20	1½	17?	21	—	21	—	82,600	11,700	16,550	2·0	1030·6	3·74	8·83	4·59	3·60	0·73	0	33	++
,, ...	IB 2,714	B	Treated in bottle, heated to 212° F. for 45 minutes. Bottle as supplied. (Temperature 212° F.)	,, ,, ,,	26	2	—	—	—	—	72 hours	20	0	0	2·0	1033·2	3·64	9·27	4·82	3·77	0·68	H	33	0
	LB 8,723		DAIRY C—																				
4/12/16 ...	IB 2,715	3 A	Untreated, mixed milk tank. (Temperature 52° F.)	Information withheld ...	20	1½	18?	24	—	24	—	33,900	8,300	9,800	2·0	1031·4	4·07	8·67	4·66	3·41	0·60	0	29	0?
,, ...	IB 2,716	B	Treated in bottle, heated to 212° F. for 30 minutes. Bottle as supplied	,, ,,	35	8	—	48	—	48	—	0	0	0	1·9	1033·3	3·39	9·36	4·59	4·27	0·59	H	29	0
Special Experiment	LB 8,723		*DAIRY C—																				
	IB 2,715		Untreated, milk incubated for 6 hours at 20° C. at the Laboratory	——	—	—	—	—	—	—	Aerobic ...	34,340,000	2,330,000	8,320,000									
	IB 2,716		Treated, milk incubated as above...	——	—	—	—	—	—	—	Aerobic ...	0	0	0									
	,,		,, ,, ,, ...								Anaerobic		Fairly	abundant									
	LB 8,727		DAIRY D—																				
7/12/16 ...	IB 2,717	4 A	Untreated, mixed milk tank. (Temperature 53° F.)	25 farms in Cheshire and Derbyshire	20	3	18?	24	—	24	—	277,000	17,450	31,300	1·9	1032·0	3·91	8·55	4·66	3·22	0·67	0	16	+
,, ...	IB 2,718	B	After filtration. (Temperature 50° F.)	,, ,, ,,	18	1½	18?	24	24	—	—	524,000	42,300	73,100	1·9	1031·7	3·94	8·49	4·49	3·38	0·62	0	34	+
,, ...	IB 2,719	C	After filtration and cooling. (Temperature 36° F.)	,, ,, ,,	19	1½	18?	24	24	—	—	129,800	28,150	50,250	1·9	1031·9	3·92	8·72	4·49	3·61	0·62	0	18	+
,, ...	IB 2,720	D	Treated in bottle, heated to 210° for 1 hour. Bottle as supplied (Temperature 210° F.)	,, ,, ,,	26	Indistinct	—	—	—	—	48 hours	0	10	10	1·9	1031·9	3·98	8·98	4·49	3·87	0·62	H	13	0
	LB 8,735		DAIRY E—																				
11/12/16 ...	IB 2,721	5 A	Untreated, mixed milk tank. (Temperature 42° F.)	27 farms in Cheshire, Derbyshire, Staffordshire, Shropshire, and Lancashire	31	5	17	19	24	—	—	70,650	39,100	62,800	1·8	1032·4	4·00	9·08	4·49	3·92	0·67	0	29	0
,, ...	IB 2,722	B	After filtration, heating to 160° F. for 1 minute and cooling. (Temperature 34° F.)	,, ,, ,,	15	1½	17	19	—	19	—	5,350	200	600	1·9	1032·1	3·94	9·25	4·49	4·09	0·67	H	10	0
	LB 8,769		HOSPITAL 1—																				
3/1/17 ...	IB 2,723	6 A	As received at dairy...	Dairy A	270 (partly heatedet)	7	6	9	9	18	—	38,000,000	82,500	130,000	2·0	1032·3	3·45	8·65	4·80	3·29	0·56	H	35	0
,, ...	IB 2,724	B	S. 3. Male ward kitchen	,, ...	230	5	6	9	9	18	—	31,600,000	140,000	170,000	2·0	1032·2	3·52	8·52	4·88	3·06	0·58	H	35	0
,, ...	IB 2,725	C	S. 4. Female ward kitchen	,, ...	290	8	6	9	9	18	—	40,600,000	380,000	485,000	2·0	1032·3	3·38	8·63	4·64	3·45	0·54	H	21	0
	LB 8,785		HOSPITAL 2—																				
8/1/17 ...	IB 2,726	7 A	Bulk in dairy	Dairy A	24	5	15	19	—	19	—	3,180,000	377,500	868,000	1·7	1030·9	3·29	8·35	4·49	3·36	0·50	H	31	0
,, ...	IB 2,727	B	Ward kitchen, Whitworth ward ...	,, ...	38	5	15	19	—	19	—	6,000,000	930,000	1,771,000	1·8	1030·9	3·19	8·31	4·49	3·45	0·37	0	31	0
,, ...	IB 2,728	C	Rothwell ward kitchen	,, ...	210	6	15	19	—	19	—	11,800,000	750,000	1,216,000	1·8	1033·0	3·36	9·01	4·49	4·02	0·50	H	31	0
	LB 8,795		HOSPITAL 3—																				
10/1/17 ...	IB 2,729	8 A	Bulk in dairy	Dairy A	40	3	12	24	24	—	—	4,970,000	1,250,000	1,312,000	2·0	1032·5	3·81	8·68	4·22	3·80	0·66	0	11	0
,, ...	IB 2,730	B	Ward kitchen No. 2	,, ...	40	4	12	24	24	—	—	8,530,000	1,855,000	2,270,000	2·0	1032·7	3·70	8·65	4·49	3·69	0·47	0	11	0a
,, ...	IB 2,731	C	Ward kitchen No. 3	,, ...	42	4	12	24	24	—	—	5,450,000	1,420,000	1,546,000	2·1	1032·4	3·73	8·91	4·22	4·16	0·53	0	11	0b
	LB 8,801		HOSPITAL 4—																				
15/1/17 ...	IB 2,732	9 A	Arrival churn in dairy	Dairy A	40	22	10	17	—	17	—	2,700,000	341,170	647,330	2·4	1032·7	3·02	8·67	4·72	3·45	0·50	0	2	0c
,, ...	IB 2,733	B	Ward kitchen D	,, ...	36	15	10	17	10	17	—	6,300,000	1,720,000	2,025,000	2·4	1031·6	4·21	8·47	4·29	3·65	0·53	0	36	+
,, ...	IB 2,734	C	Ward kitchen safe, corridor C... ...	,, ...	32	14	10	17	10	17	—	1,670,000	982,000	1,224,000	2·4	1032·5	2·94	8·79	4·29	3·99	0·51	0	23	+

a Local Abscesses. b Abscess. c Anaerobic Infection.

TABLE I.—*continued.*

Date of Collection	Laboratory Nos. L.B. & I.B.	Office Nos.	Nature of Specimen	Dealers. No. of Farms	Sediment per 100,000		Effects of Incubation at 29° C. and 37° C. upon Acidity and Coagulation after a stated number of hours					Number of Bacteria per 1 c.c.			Chemical Examination (parts per 100)							Result of inoculation with the sediment of 50 c.c. of milk	
					Total	Extraneous Products	Acidity 3	Acidity 4	Coagulation 3	Coagulation 4	No marked Acidity or Coagulation (milk good for about)	Growing at 29° C. on Gelatine in 72 hours	Growing at 37° C. on Agar in 24 hours	Growing at 37° C. on Agar in 48 hours	Reaction +	Specific Gravity	Fat %	Solids not fat %	Lactose %	Protein %	Ash %	Evidence of partial or complete heating (H—heating)	Number of days after inoculation	Tuberculosis + and other Infection
	LB 8,806		HOSPITAL 5—																				
17/1/17 ...	IB 2,735	10 A	Bulk in dairy	6 farms in Derbyshire ...	25	11	12	18	18	24	—	1,460,000	200,000	235,000	1·9	1030·7	4·86	8·87	4·43	3·95	0·49	0	33	0
,, ...	IB 2,736	B	Supply from separate Farm	,, ,, ...	10	2	18	24	18	24	—	890,000	147,000	170,000	1·9	1033·0	2·74	8·88	4·66	3·71	0·51	0	33	0
,, ...	IB 2,737	C	Pavilion 6, ward kitchen A	,, ,, ...	20	5	18	24	—	24	—	590,000	145,000	185,000	1·9	1033·7	2·63	8·87	4·66	3·69	0·52	0	6	0a
,, ...	IB 2,738	D	Block G, ward kitchen 1	,, ,, ...	21	5	12	18	18	24	—	980,000	115,000	131,000	1·9	1033·3	3·03	8·93	4·92	3·46	0·55	0	33	0
,, ...	IB 2,739	E	No 1, Infirmary block	,, ,, ...	20	15	10	18	18	24	—	4,600,000	670,000	830,000	2·0	1033·5	2·70	8·76	4·74	3·74	0·28	0	33	+
	LB8, 815		HOSPITAL 6—																				
22/1/17 ...	IB 2,745	11 A	Bulk in dairy	1 farm in Lancashire ...	40	10	127	19	—	19	—	52,000	71,500	92,500	1·9	1032·0	4·15	8·83	4·80	3·49	0·54	0	31	0
,, ...	IB 2,746	B	Heywood ward, corridor	,, ...	25	7	19	—	—	—	—	215,000	25,000	30,000	1·6	1023·2	2·35	6·13	3·21	2·55	0·37	0	31	0
,, ...	IB 2,747	C	Borchardt ward, corridor	,, ...	25	6	127	19	—	26	—	453,500	151,000	182,000	2·0	1033·2	3·40	8·93	4·66	3·75	0·52	0	31	0
,, ...	IB 2,748	D	Wrigley ward, corridor	,, ...	30	6	127	19	—	26	—	117,500	69,500	85,000	1·9	1033·0	2·93	8·81	4·80	3·56	0·45	0	31	0
	LB 8,819		HOSPITAL 7—																				
24/1/17 ...	IB 2,749	12 A	Bulk in larder	Dairy A	36	6	15	22	22	24	—	1,150,000	182,500	217,500	1·9	1032·9	2·57	8·51	4·66	3·25	0·60	0	56	+
,, ...	IB 2,750	B	No. 3 ward, kitchen (males)	,, ...	46	6	15	22	22	24	—	3,440,000	600,000	767,500	1·9	1032·0	3·45	8·48	4·49	3·45	0·51	0	56	+
,, ...	IB 2,751	C	No. 2 ward, kitchen (females) ...	,, ...	40	8	15	22	22	24	—	2,860,000	360,500	515,000	1·9	1032·2	3·11	8·57	4·49	3·58	0·50	0	10	0b
	LB 8,847		HOSPITAL 8—																				
6/2/17 ...	IB 2,752	13 A	Bulk in dairy	Dairy A	53	8	13	19	—	19	—	Innumerable	765,000	821,000	1·9	1032·1	3·76	8·52	4·49	3·26	0·77	0	29	0
,, ...	IB 2,753	B	Pavilion 1, refrigerator in ward pantry	,, ...	70	8	19	28	—	19	—	Innumerable	175,000	180,000	2·0	1032·3	3·46	8·58	4·58	3·32	0·68	0	43	+
,, ...	IB 2,754	C	Pavilion 7, refrigerator in ward pantry	,, ...	43	8	13	19	—	19	—	Innumerable	139,000	151,000	2·0	1034·0	3·60	9·13	4·49	4·01	0·63	0	25	+
	LB 8,850		HOSPITAL 9—																				
8/2/17 ...	IB 2,760	14 A	Dairy	Dairy A, from 1 farm in Derbyshire	72	6	127	19	—	19	—	83,000	68,000	81,500	2·0	1031·6	3·06	8·75	4·80	3·43	0·52	0	14	0c
,, ...	IB 2,761	B	Centre ward, pantry, first floor ...	,, ,,	32	10	107	12	—	19	—	Innumerable	5,700,000	5,630,000	2·0	1033·8	2·79	8·91	4·88	3·52	0·51	0	41	0
,, ...	IB 2,762	C	Nurses' scrvery, ground floor ...	,, ,, ...	75	13	12	19	—	19	—	474,000	296,000	333,000	2·0	1033·3	3·25	8·93	4·66	3·73	0·54	0	41	+
	LB 8,858		HOSPITAL 10—																				
13/2/17 ...	IB 2,763	15 A	Dairy, hospital side	14 farms (9 at Bakewell, 2 at Matlock, 2 at Buxton, 1 at Crumpsall)	37	—	13	24	—	24	—	121,000	47,500	73,500	2·1	1032·8	3·35	8·78	4·72	3·46	0·60	0	36	+
,, ...	IB 2,764	B	Dairy, workhouse side		59	19	24	28	—	—	—	103,000	52,000	76,500	1·9	1032·2	2·87	8·71	4·66	3·44	0·61	0	15	0a
,, ...	IB 2,765	C	Ward D1, store room	,, ,, ...	20	6	24	28	24	28	—	13,000	9,900	15,900	1·7	1030·9	3·00	8·36	4·49	3·36	0·51	0	15	0a
,, ...	IB 2,766	D	Male epileptic ward, cupboard ...	,, ,, ...	55	35	10	13	24	28	—	1,780,000	3,600,000	3,900,000	1·5	1028·9	2·92	7·94	4·20	3·29	0·45	0	18	0?a
	LB 8,861		HOSPITAL 11—																				
15/2/17 ...	IB 2,767	16 A	Bulk, foot of cellar steps...	Dairy A	40	5	11	12	—	17	—	3,110,000	755,000	1,590,000	1·9	1032·8	3·21	8·74	4·43	3·73	0·58	0	34	+
,, ...	IB 2,768	B	Kitchen wards, 1 and 2 female ...	,, ...	72	18	8	11	12	17	—	11,200,000	4,500,000	7,600,000	2·0	1032·2	3·75	8·87	4·43	3·90	0·54	0	34	+
,, ...	IB 2,769	C	Kitchen, Rothwell and Jardine wards. Male	,, ...	62	5	8	11	12	17	—	2,870,000	825,000	930,000	1·8	1032·5	3·60	8·72	4·58	3·60	0·54	0	34	+
	LB 8,868		HOSPITAL 12—																				
19/2/17 ...	IB 2,770	17 A	Bulk in larder	Dealer F	93	3	10	12	10	12	—	67,650	25,600	32,200	2·0	1032·5	3·84	8·86	4·43	3·74	0·69	0	31	0
,, ...	IB 2,771	B	Sterilized milk, from sterilizing room	,, ...	75	45	12	22	—	22	—	109,000	165	270	1·9	1028·8	3·72	8·43	4·66	3·14	0·63	H	30	0
	LB 8,949		SCHOOL FOR MOTHERS 1—																				
26/3/17 ...	IB 2,785	19	Bulk at Dealer G	Dealer G, 12 farms... ...	18	10	—	—	—	—	—	1,475,000	23,300	37,300	2·5	1032·3	3·40	8·62	4·36	3·66	0·60	0	31	0
	LB 8,949		SCHOOL FOR MOTHERS 2—																				
26/3/17 ...	IB 2,786	20	Bulk at Dealer H	Dealer H, 2 farms	44	8	—	—	—	—	—	215,000	15,000	20,000	2·1	1030·0	5·60	8·76	4·43	3·77	0·56	0	31	+
	LB 8,950		SCHOOL FOR MOTHERS 3—	Dealer J, 14 farms in																			
26/3/17 ...	IB 2,787	18	Bulk at Dealer J	Cheshire	32	16	—	—	—	—	—	107,200	2,400	6,000	1·9	1031·1	4·40	8·41	4·43	3·36	0·62	0	31	0
	LB 8,953		SCHOOL FOR MOTHERS 4—	Dealer K, 1 farm in																			
28/3/17 ...	IB 2,788	21	Dealer K, farm 1	Cheshire	35	5	—	23	—	23	—	22,950	300	500	2·0	1030·4	3·50	8·46	4·36	3·53	0·57	0	20	0
,, ...	IB 2,789		Dealer K, farm 2	,, ,, ,,	46	5	—	20	—	20	—	25,500	1,100	1,600	2·0	1032·6	3·71	9·12	4·83	3·73	0·56	0	20	0
	LB 9,054		GENERAL SHOPS—																				
16/3/17 ...	IB 2,790	22	Shop 1	Dairy D	36	2	—	14	—	17	—	250,000	2,050	5,460	1·7	1031·4	3·94	8·43	4·03	3·85	0·55	0	25	0
,, ...	IB 2,791	23	Shop 2	,, ...	30	2	—	17	—	19	—	16,000	400	1,750	1·9	1031·8	3·50	8·52	4·21	3·78	0·53	0	30	0
	LB 9,058																						
18/3/17 ...	IB 2,792	24	Shop 3	,, ...	15	1	13	18	—	21	—	2,090,000	14,160	30,000	2·0	1031·0	3·88	8·68	4·66	3·38	0·64	0	24	0
,, ...	IB 2,793	25	Shop 4	,, ...	16	2	18	21	—	21	—	67,360	700	5,100	2·0	1031·6	3·57	8·74	4·58	3·57	0·59	0	38	0
	LB 9,068																						
21/3/17 ...	IB 2,794	27	Shop 5	Dealer L	10	7	8	12	—	12	—	66,140,000	386,000	1,700,000	2·8	1031·1	4·03	8·61	5·20	4·02	0·56	0	34	0
,, ...	IB 2,795	26	Shop 6	Dealer M	15	2	—	8	—	10	—	9,000,000	650,000	900,000	2·5	1031·7	4·02	8·67	4·91	3·21	0·55	0	34	0
	LB 9,069																						
22/3/17 ...	IB 2,796	29	Shop 7	Dealer N	30	6	12	17	—	17	—	277,500	22,700	27,600	2·1	1032·3	3·57	8·74	5·40	2·73	0·61	0	33	0
,, ...	IB 2,797	28	Shop 8	Dealer O	60	1	—	9	—	9	—	300,000,000	259,000	315,000	4·4	1030·9	3·40	8·18	4·43	3·25	0·50	H	21	0
	LB 9,074																						
23/3/17 ...	IB 2,798	30	Shop 9	Dealer P	35	12	6	12	12	14	—	24,600,000	180,000	3,335,000	3·6	1031·2	4·04	8·47	4·83	3·16	0·48	0	18	0
,, ...	IB 2,799	31	Shop 10	Dealer Q	12	1	—	14	—	12	—	3,500,000	1,196,000	2,280,000	2·5	1032·5	3·71	8·83	4·36	3·93	0·54	0	32	0

a Local Abscess. b Streptococcic Infection. c Enteritidis Infection.

TABLE II.—TABULATED SUMMARY OF THE RESULTS OF SOME OF THE TESTS CARRIED OUT FOR THE ROYAL AGRICULTURAL SOCIETY AND THE MANCHESTER SANITARY COMMITTEE IN CONNECTION WITH THE MILK COMPETITION AT THE AGRICULTURAL SHOW, MAY AND JUNE, 1916.

No. of Reference M = Morning E = Evening		District	Chemical Examination (parts per 100 parts)						Sediment per 100,000 parts		Temperature	
			Fat	Solids not Fat			Specific Gravity	Reaction +	Extraneous Products	Total "Slime"	Air F	Milk F
				Total	Lactose	Ash						
50	M	Clitheroe	4·80	9·21	4·28	0·49	1032·6	2·0	2·0 to 2·5	14	66	50
4	E	Chorlton-cum-Hardy ...	4·72	9·03	4·28	0·66	1032·0	2·0	1·5 ,, 2·0	14	66	61
13	E	Mobberley	4·60	9·45	4·74	0·67	1032·0	2·0	0·5 ,, 1·0	12	64	76
47	E	Mobberley	4·55	9·05	3·75	0·75	1032·6	2·1	0·5 ,, 1·0	14	64	80
62	E	Stockport	4·50	9·21	4·66	0·50	1032·0	1·8	0·5 ,, 1·0	14	50	56
32	E	Baguley	4·49	8·78	—	—	1031·1	2·0	0·5 ,, 1·0	16	55	78
43	E	Knutsford	4·40	9·15	4·50	0·86	1033·0	2·0	0·5 ,, 1·0	18	62	77
61	E	Over Winsford	4·33	9·33	4·58	0·46	1032·1	1·9	0·5 ,, 1·0	18	50	62
7	E	Altrincham	4·31	8·89	—	—	1032·6	2·0	2·0 ,, 2·5	18	60	84
44	E	Knutsford	4·29	9·38	4·43	0·58	1033·0	2·0	0·5 ,, 1·0	16	54	50
19	E	Stretford	4·28	9·05	—	—	1032·2	1·9	2·0 ,, 2·5	24	56	86
14	E	Bakewell	4·27	9·24	4·03	0·64	1032·9	2·1	0·5 ,, 1·0	18	62	55
11	E	Chelford	4·22	8·98	—	—	1032·0	2·0	0·5 ,, 1·0	22	62	52
66	M	Middleton	4·21	9·17	4·83	0·55	1032·4	2·0	2·0 ,, 2·5	28	62	85
18	E	Waddington	4·18	10·07	3·92	0·73	1032·6	2·2	0·5 ,, 1·0	20	66	55
8	E	Congleton	4·18	9·44	—	—	1030·9	1·9	2·0 ,, 2·5	24	58	52
21	E	Kelsall	4·17	8·66	4·74	0·60	1032·0	1·9	0·5 ,, 1·0	14	68	60
48	E	Macclesfield	4·13	9·36	4·36	0·51	1032·1	2·1	1·5 ,, 2·0	30	52	54
49	E	Macclesfield	4·09	8·79	4·66	0·52	1031·7	2·2	0·0 ,, 0·5	10	60	62
40	E	Pendleton	4·04	11·37	3·46	0·75	1032·9	2·2	0·5 ,, 1·0	26	66	56
66	E	Middleton	4·02	9·30	5·00	0·57	1033·4	4·4	0·5 ,, 1·0	22	62	58
			4·32	9·28	4·38	0·61			0·9 to 1·4	18		

TABLE II.—*continued.*

No. of Reference M = Morning E = Evening		District	Chemical Examination (parts per 100 parts)				Specific Gravity	Reaction +	Sediment (per 100,000 parts)		Temperature	
			Fat	Solids not Fat					Extraneous Products	Total Slime	Air F	Milk F
				Total	Lactose	Ash						
58	M	Tarporley	3·98	8·92	5·00	0·62	1033·0	2·2	0·5 to 1·0	18	58	52
41	E	Knutsford	3·96	9·67	4·09	0·68	1031·3	2·0	0·5 ,, 1·0	20	50	52
3	E	Clitheroe	3·94	8·66	—	—	1031·6	2·1	0·0 ,, 0·5	22	62	58
57	E	Macclesfield	3·91	9·03	4·74	0·51	1032·4	2·3	0·0 ,, 0·5	16	68	60
46	E	Chelford	3·90	9·16	4·43	0·69	1032·0	1·8	2·0 ,, 2·5	26	54	54
34	E	Gisburn	3·90	9·44	4·74	0·64	1033·2	1·8	0·5 ,, 1·0	15	60	54
51	E	Frodsham	3·90	8·68	5·10	0·56	1031·6	1·9	0·0 ,, 0·5	16	68	58
29	E	Sandbach	3·89	8·77	—	—	1030·8	1·8	0·5 ,, 1·0	16	58	55
48	E	Macclesfield	3·86	9·26	4·83	0·62	1033·5	2·0	1·5 ,, 2·0	30	56	54
65	M	Knutsford	3·85	8·97	4·83	0·50	1033·0	1·8	0·0 ,, 0·5	20	56	58
63	E	Rimington	3·84	9·25	3·65	0·78	1033·6	2·2	1·0 ,, 1·5	19	66	54
15	E	Barrow	3·84	8·80	—	—	1032·7	2·0	0·5 ,, 1·0	25	60	58
54	E	Macclesfield	3·83	8·87	—	—	1032·6	2·1	1·0 ,, 1·5	16	58	52
45	E	Tarporley	3·83	9·01	5·20	0·48	1033·0	2·0	0·5 ,, 1·0	16	50	56
50	E	Clitheroe	3·83	9·55	4·28	0·73	1033·2	2·2	0·0 ,, 0·5	21	66	56
11	M	Chelford	3·81	8·38	4·16	0·59	1032·6	2·0	0·5 ,, 1·0	14	62	57
60	E	Ewood Bridge	3·81	9·51	—	—	1033·6	2·3	2·0 ,, 2·5	25	62	56
20	E	Kelsall	3·81	8·94	4·16	0·61	1032·8	2·0	0·5 ,, 1·0	14	68	57
63	M	Rimington	3·80	9·00	4 43	0·50	1032·9	2·4	2·0 ,, 2·5	30	66	57
24	E	Audlem	3·80	8·67	—	—	1032·0	1·8	1·0 ,, 1·5	26	52	48
27	E	Winsford	3·80	7·97	4·50	0·57	1031·7	1·9	2·0 ,, 2·5	20	50	62
			3·86	8·97	4·54	0·60			0·7 to 1·0	20		

TABLE II.—*continued.*

No. of Reference M = Morning E = Evening		District	Chemical Examination (parts per 100 parts)				Specific Gravity	Reaction +	(Sediment per 100,000 parts)		Temperature	
			Fat	Solids not Fat					Extraneous Products	Total Slime	Air F	Milk F
				Total	Lactose	Ash						
64	M	Chelford	3·76	8·82	3·75	0·58	1032·0	1·8	0·5 to 1·0	22	54	56
5	E	Goostrey	3·75	9·18	4·43	0·65	1032·7	1·9	0·5 ,, 1·0	12	54	55
26	E	Holmes Chapel	3·75	8·82	3·86	0·60	1032·1	1·8	2·0 ,, 2·5	22	54	54
40	M	Clitheroe	3·74	9·21	4·36	0·51	1033·4	2·2	0·5 ,, 1·0	16	66	50
9	E	Holmes Chapel	3·72	9·33	4·43	0·70	1031·6	1·9	0·5 ,, 1·0	18	54	54
67	E	Whaley Bridge	3·70	9·28	—	—	1032·2	1·9	0·5 ,, 1·0	14	58	51
19	M	Stretford	3·65	9·13	4·74	0·64	1032·8	2·1	0·5 ,, 1·0	10	52	87
2	M	Macclesfield	3·64	9·14	4·36	0·63	1032·5	1·9	0·5 ,, 1·0	19	54	56
58	E	Tarporley	3·63	8·75	—	—	1032·6	2·0	0·5 ,, 1·0	18	58	52
16	E	Knutsford	3·62	9·01	3·70	0·60	1033·2	2·0	0·0 ,, 0·5	18	54	56
7	M	Altrincham	3·61	8·79	5·20	0·56	1032·7	1·9	2·0 ,, 2·5	12	58	80
35	E	Mickle Trafford	3·60	8·95	4·50	0·61	1032·5	1·8	0·5 ,, 1·0	16	60	62
4	M	Chorlton-cum-Hardy ...	3·60	9·00	4·50	0·61	1032·8	2·0	0·5 ,, 1·0	16	46	88
30	E	Macclesfield	3·60	8·57	4·21	0·54	1031·7	1·8	0·0 ,, 0·5	26	56	52
3	M	Clitheroe	3·60	9·12	4·74	0·90	1032·3	2·0	0·5 ,, 1·0	12	66	58
57	M	Macclesfield	3·60	8·78	4·83	0·55	1032·6	2·0	1·0 ,, 1·5	14	62	60
20	M	Kelsall	3·59	9·30	4·03	0·57	1033·0	1·9	0·5 ,, 1·0	18	46	54
21	M	Kelsall	3·59	7·40	4·50	0·58	1032·8	1·9	2·0 ,, 2·5	20	46	56
33	E	Blackburn	3·59	8·95	—	—	1033·0	2·2	0·5 ,, 1·0	20	62	60
24	M	Audlem	3·58	9·15	4·03	0·65	1032·9	2·0	0·5 ,, 1·0	22	52	49
48	M	Macclesfield	3·58	8·98	4·66	0·74	1033·4	1·8	1·5 ,, 2·0	22	56	60
34	M	Gisburn	3·58	9·10	4·50	0·67	1033·2	1·9	0·5 ,, 1·0	15	60	57
42	E	Chelford	3·58	8·89	4·58	0·61	1032·0	3·3	1·0 ,, 1·5	22	62	64
31	M	Withington	3·57	9·11	4·21	0·56	1033·0	1·8	0·5 ,, 1·0	15	54	54
2	E	Macclesfield	3·55	9·09	4·74	0·57	1033·0	2·0	0·0 ,, 0·5	15	54	52
39	E	Northwich	3·55	8·99	4·43	0·54	1033·0	2·0	0·5 ,, 1·0	11	56	52
13	M	Mobberley	3·56	8·81	4·28	0·56	1033·0	2·0	0·5 ,, 1·0	15	53	58

TABLE II.—*continued.*

No. of Reference M = Morning E = Evening	District	Chemical Examination (parts per 100 parts)						Sediment per 100,000 parts		Temperature	
		Fat	Solids not Fat			Specific Gravity	Reaction +	Extraneous Products	Total "Slime"	Air F	Milk F
			Total	Lactose	Ash						
43 M	Knutsford	3·55	8·79	5·10	0·62	1032·6	2·0	0·5 to 1·0	16	56	78
17 E	Macclesfield	3·52	9·08	—	—	1032·5	1·9	0·5 ,, 1·0	10	48	52
26 M	Holmes Chapel	3·52	8·90	3·86	0·63	1033·0	1·9	1·0 ,, 1·5	22	54	56
56 E	Northwich	3·52	9·14	4·74	0·49	1033·5	2·0	1·0 ,, 1·5	11	60	52
51 M	Frodsham	3·51	9·43	4·74	0·51	1033·3	2·0	1·0 ,, 1·5	14	46	65
		3·60	8·97	4·42	0·60			0·7 ,, 1·1	16		
56 M	Northwich	3·47	8·97	5·10	0·50	1033·9	2·0	0·5 to 1·0	16	60	53
28 E	Alderley	3·46	8·75	4·28	0·55	1032·5	1·9	2·0 ,, 2·5	48	54	63
14 M	Bakewell	3·46	9·18	5·00	0·60	1033·5	2·2	1·0 ,, 1·5	20	62	53
61 M	Over Winsford	3·46	8·92	4·43	0·64	1033·0	2·0	0·5 ,, 1·0	18	60	61
25 E	Holmes Chapel	3·45	8·86	4·36	0·60	1032·5	1·8	0·5 ,, 1·0	16	54	52
9 M	Holmes Chapel	3·45	9·09	4·74	0·71	1032·3	1·9	1·0 ,, 1·5	15	54	60
15 M	Barrow (Chester)... ...	3·43	9·02	4·50	0·81	1033·0	2·1	1·0 ,, 1·5	34	68	60
36 M	Plumbley	3·43	8·66	4·43	0·56	1033·0	1·8	0·0 ,, 0·5	18	56	58
37 M	Plumbley	3·41	8·83	4·58	0·62	1033·1	2·0	0·0 ,, 0·5	22	56	57
54 M	Macclesfield	3·41	8·91	4·43	0·69	1032·7	2·0	1·0 ,, 1·5	12	58	56
28 M	Alderley	3·41	8·67	4·03	0·58	1031·7	1·8	2·0 ,, 2·5	28	54	60
33 M	Blackburn	3·40	9·21	4·28	0·60	1033·7	3·0	2·0 ,, 2·5	25	66	58
41 M	Knutsford	3·38	8·77	4·16	0·51	1032·2	1·9	0·5 ,, 1·0	20	50	58
18 M	Waddington	3·38	9·06	4·09	0·58	1033·2	2·2	1·5 ,, 2·0	18	66	54
6 M	Knutsford	3·37	9·06	4·74	0·73	1033·0	2·0	1·0 ,, 1·5	21	56	62
47 M	Mobberley	3·34	8·71	5·10	0·60	1032·8	1·9	0·5 ,, 1·0	9	56	80
60 M	Ewood Bridge	3·33	9·37	4·66	0·50	1033·9	2·4	0·5 ,, 1·0	20	66	53
17 M	Macclesfield	3·33	9·07	5·00	0·68	1032·6	1·9	0·5 ,, 1·0	15	48	56
65 E	Knutsford	3·33	9·04	4·43	0·58	1033·3	2·0	0·5 ,, 1·0	14	56	56
48 M	Macclesfield	3·33	9·36	4·50	0·50	1032·8	1·8	1·5 ,, 2·0	22	52	54

TABLE II.—*continued.*

No. of Reference M = Morning E = Evening		District	Chemical Examination (parts per 100 parts)						Sediment (per 100,000 parts)		Temperature	
			Fat	Solids not Fat			Specific Gravity	Reaction ×	Extraneous Products	Total Slime	Air F	Milk F
				Total	Lactose	Ash						
36	E	Plumbley	3·32	9·03	—	—	1031·9	1·8	0·5 to 1·0	14	60	57
5	M	Goostrey	3·32	9·13	4·28	0·67	1033·0	1·9	2·0 ,, 2·5	16	54	58
42	M	Chelford	3·31	8·96	4·36	0·57	1032·7	1·8	1·0 ,, 1·5	14	54	60
35	M	Mickle Trafford	3·31	8·96	4·50	0·64	1032·5	1·9	2·0 ,, 2·5	20	54	60
6	E	Knutsford	3·28	8·79	—	—	1033·0	2·2	0·5 ,, 1·0	14	55	62
29	M	Sandbach	3·25	9·01	5·20	0·64	1032·4	1·8	0·5 ,, 1·0	12	58	56
25	M	Holmes Chapel	3·23	8·88	4·36	0·62	1032·8	1·8	0·5 ,, 1·0	14	54	54
23	E	Gawsworth	3·21	8·99	4·09	0·60	1033·4	2·1	1·0 ,, 1·5	18	54	54
46	M	Chelford	3·21	8·97	4·36	0·68	1032·7	1·6	1·0 ,, 1·5	16	54	58
27	M	Winsford	3·20	9·01	4·21	0·75	1033·0	2·1	0·0 ,, 0·5	15	63	62
37	E	Plumbley	3·19	9·36	—	—	1033·0	1·9	1·0 ,, 1·5	18	60	58
67	M	Whaley Bridge	3·17	9·91	4·58	0·58	1032·7	1·8	0·5 ,, 1·0	16	58	53
39	M	Northwich	3·16	9·33	4·28	0·61	1033·1	1·9	0·5 ,, 1·0	12	56	52
16	M	Knutsford.....	3·15	8·88	4·21	0·67	1033·0	1·8	1·0 ,, 1·5	20	54	60
30	M	Macclesfield	3·15	9·11	4·66	0·53	1032·3	2·0	0·0 ,, 0·5	22	56	56
38	E	Macclesfield	3·14	8·62	4·83	0·58	1032·0	1·8	1·0 ,, 1·5	20	54	58
44	M	Knutsford	3·12	9·23	4·50	0·63	1033·9	1·9	0·5 ,, 1·0	14	54	58
49	M	Macclesfield	3·11	8·88	4·58	0·64	1032·4	1·9	0·5 ,, 1·0	16	48	58
32	M	Baguley	3·11	8·96	4·50	0·60	1032·8	1·9	0·5 ,, 1·0	10	58	78
45	M	Tarporley	3·11	9·09	4·36	0·80	1032·1	2·1	0·5 ,, 1·0	14	58	56
23	M	Macclesfield	3·07	8·89	4·03	0·57	1033·0	1·9	1·0 ,, 1·5	18	54	62
62	M	Stockport	3·06	9·03	4·74	0·58	1032·4	1·9	0·0 ,, 0·5	10	62	56
64	E	Chelford	3·03	8·87	4·50	0·57	1033·4	1·9	0·5 ,, 1·0	34	54	54
8	M	Congleton	3·02	9·42	4·74	0·75	1033·3	2·0	2·0 ,, 2·5	24	58	56
			3·27	9·01	4·50	0·62			0·81 ,, 1·3	18		
38	M	Macclesfield	2·77	8·36	4·16	0·58	1031·8	1·8	0·5 to 1·0	14	54	56

TABLE III.—ROYAL AGRICULTURAL SOCIETY. SUMMARY OF THE RESULTS OF THE CHEMICAL AND SEDIMENTATION TESTS
(Grouped according to the percentage of fat).

Group	No. of Samples	Fat			Solids not Fats									Sediment per 100,000 parts					
					Total			Lactose			Ash			Extraneous Products			Total Slime		
		Max.	Min.	Average	Max.	Min.	Average	Max.	Min.	Average	Max.	Min.	Average	Max. under	Min. under	Average	Max.	Min.	Average
1. Fat 4% and over...	21	4·80	4·02	4·32	11·27	8·66	9·28	5·00	3·46	4·38	0·86	0·46	0·61	2·5	0·5	1·1	30	10	18
	Morn... 2																		
	Even...19																		
2. Fat 3·75 to 4·0%...	21	3·98	3·80	3·86	9·67	7·97	8·97	5·20	3·65	4·54	0·78	0·48	0·60	2·5	0·5	1·0	30	14	20
	Morn... 4																		
	Even...17																		
3. Fat 3·50 to 3·75%..	32	3·76	3·51	3·60	9·43	7·40	8·97	5·20	3·70	4·42	0·90	0·49	0·60	2·5	0·5	1·9	22	10	16
	Morn...18																		
	Even...14																		
4. Fat 3·0 to 3·50%...	44	3·47	3·02	3·27	9·91	8·62	9·01	5·20	4·03	4·50	0·81	0·50	0·62	2·5	0·5	1·0	48	9	18
	Morn...35																		
	Even... 9																		
	118																		

CLEAN MILK INVESTIGATION. SUMMARY OF RESULTS OF THE CHEMICAL AND SEDIMENTATION TESTS
(Grouped according to the place of collection).

Place of Collection																			
5 Dairies, untreated milk...	7	4·07	3·74	3·94	9·08	8·49	8·70	4·66	4·36	4·52	0·73	0·60	0·65	5·0	1·5	2·3	31	18	21
5 Dairies, treated milk	6	3·95	3·39	3·80	9·36	8·80	9·08	4·82	4·49	4·57	0·68	0·59	0·61	8·0	1·5	2·7	41	15	29
8 Hospitals supplied by Dairy A	24	4·21	3·02	3·38	9·13	8·31	8·71	4·88	4·22	4·50	0·77	0·37	0·55	22·0	3·0	8·2	290	24	80
2 Hospitals supplied direct from various farms	9	4·86	2·63	3·27	8·93	7·94	8·67	4·92	4·20	4·60	0·61	0·28	0·50	35·0	2·0	10·8	55	10	29
1 Hospital supplied direct from one farm...	4	4·15	2·35	3·20	8·93	6·13	8·17	4·80	3·21	4·36	0·54	0·37	0·47	10·0	6·0	7·2	40	25	30
5 Institutions supplied by 5 different dealers	7	*5·60	3·40	4·02	9·12	8·41	8·66	4·83	4·36	4·51	0·69	0·56	0·60	16·0	5·0	13·1	95	18	49
10 General Shops—6 supplied by 6 different dealers, 4 supplied by Dairy D ...	10	4·03	3·50	3·76	8·83	8·18	8·58	5·40	4·03	4·61	0·64	0·48	0·55	12·0	1·0	3·6	60	10	25
	67																		

* Probably due to faulty taking of sample.

Table III., which is an appendix to Table I. and II., shows that the samples of milk collected for the clean milk investigations were from a chemical point of view on an average within the range of good quality milk as indicated by the Agricultural Society figures. Some of the samples collected in certain ward kitchens were undoubtedly poor in fat and solids, but this was not generally attributable to the quality of the milk as delivered by the dealer.

2.—Samples representing some parts of the milk supply previous to 1916.

In order to find out whether the results of the examinations made under the exceptional conditions created by the War differed materially from those obtained under usual circumstances, I have brought together some of the figures collected between the years 1896 and 1916 in connection with milk investigations conducted for various purposes.

I have selected for this purpose 100 samples regarding which information comparable with some of that given in Tables I. and II. was available, and this has been summarised in Table IV. The selected samples are arranged in several groups :—

A.—Samples of the mixed milk of 2 to 4 cows collected at small farms at no great distance from Manchester.

B.—Samples of mixed milk collected at large farms by officers of two local authorities in Lancashire and sent by rail to the Laboratory.

C.—Samples of mixed milk supplied to a milk depot and to a co-operative stores in two other Lancashire districts.

D.—Samples of mixed milk collected on its arrival at railway stations in Manchester and Salford from places situated at various distances from the town.

E.—Samples of mixed milk as supplied to customers in Manchester and six small towns.

F.—Samples of mixed milk supplied to three of the Manchester hospitals (A, B, and C in Table IV.).

In each of these groups the examinations are arranged in the order of the dates on which they were made, except in group A, in which they are arranged according to the number of cows. Nearly all the samples dealt with in the table were examined during the 10 years preceding 1916. Only a few of the samples examined previous to that period are given for comparison purposes.

TALBE IV.—TABULATED RESULTS OF SOME OF THE SEDIMENTATION AND CULTI-
MIXED MILK COLLECTED IN VARIOUS TOWNS, AT

No.	Reference	Time of Collection		Number of Cows	Place of Collection
		Month	Year		
A					
1	LB 5102	Jan.	1912	2	Farm, Altrincham ... ...
2	,, 8389A	July	1916	2	,, Didsbury
3	,, 8389B	,,	,,	2	,, ,,
4	,, 8389C	,,	,,	2	,, ,,
5	,, 8389D	,,	,,	2	,, ,, ...
6	,, 8394A	,,	,,	2	,, ,, ...
7	,, 8394C	,,	,,	2	,, ,, ...
8	,, 8398A	,,	,,	4	,, ,, ...
9	,, 8398B	,,	,,	4	,, ,, ...
10	DM 52	Sept.	1908	3	,, Near Knutsford ...
11	Old series	Dec.	1896	3 or 4	Byre of small dairy, Hulme.
					11 samples, 4 small farms...
B					
12	Old series	Dec.	1896	Many	Farm, Chorlton ... ...
13	LB 2016A	March	1907	7	,, L.A. 1 ... ...
14	,, 2016B	,,	,,	8	,, ,, ...
15	,, 2017A	,,	,,	16	,, ,, ...
16	,, 2017B	,,	,,	14	,, ,, ...
17	,, 2022A	,,	,,	16	,, ,, ...
18	,, 2022B	,,	,,	16	,, ,, ...
19	,, 2023A	,,	,,	5	,, ,, ...
20	,, 2023B	,,	,,	9	,, ,, ...
21	,, 2099	May	,,	7	,, ,, ...
22	,, 2100	,,	,,	12	,, ,, ...
23	,, 2101	,,	,,	8	,, ,, ...
24	,, 2102	,,	,,	14	,, ,, ...
25	,, 2110	,,	,,	5	,, ,, ...
26	,, 2329	Nov.	,,	16	,, ,, ...
27	,, 2466	Jan.	1908	7	,, L.A. 2 ... ...
28	,, 2466	,,	,,	6	,, ,, ...
29	,, 2465	,,	,,	6	,, ,, ...
30	,, 2724	July	,,	5	,, ,, ...
31	,, 2725	,,	,,	6	,, ,, ...
					19 medium-sized farms ...
C				Situation of Farm	
32	1820	Oct.	1906	Farm A	Milk Depot L.A. 3 ... ...
33	1821	,,	,,	,, B	,, ,, ...
34	1822	,,	,,	,, C	,, ,, ...
35	3616	Dec.	1909	,, I.	Co-operative Stores, L.A. 4
36	3617	,,	,,	,, II.	,, ,, ,,
37	3618	,,	,,	III.	,, ,, ,,
38	3619	,,	,,	,, IV.	,, ,, ,,
39	3634	,,	,,	,, V.	Station ,, ,,
				8 farms	Milk Depot and Co-op. Stores

Blackburn District

Formby District

Ashton-under-Lyne District.

Bolton District.

VATION TESTS CARRIED OUT BETWEEN THE YEARS 1894 AND 1916. SAMPLES OF FARMS, RAILWAY STATIONS, AND OTHER PLACES.

Approximate distance from the Laboratory by road or rail—miles	Sediment (slime)			Bacteria per 1 cc.	
	Total	Cellular Products	Extraneous Products	Growing at 20° C. in 3 or 4 days. G.P.B.	Growing at 40° C. in 2 days. L.L.A.
8	10	—	—	15,650	—
short	—	—	—	424	1,400
,,	—	—	—	5,100	295
,,	—	—	—	2,200	1,255
,,	—	—	—	3,250	—
,,	—	—	—	1,360	180
,,	—	—	—	1,113	1,115
,,	—	—	—	1,023	2,755
,,	—	—	—	1,376	1,960
14	20	14	6	—	10,000
½	—	—	—	2,900	—
				3,439	2,370
2	—	—	—	90,200	—
25	10	—	—	over1,000,000	—
,,	10	—	—	1,720,000	—
,,	20	—	—	43,570	—
,,	20	—	—	3,920,000	—
,,	14	—	—	46,600	—
,,	10	—	—	51,000	—
,,	10	—	—	50,500	—
,,	14	—	—	81,500	—
,,	10	—	—	2,065,000	—
,,	14	—	—	over 500,000	—
,,	10	—	—	905,000	—
,,	10	—	—	1,020,000	—
,,	—	—	—	278,000	—
,,	16	—	—	102,666	—
over 40	27	—	—	237,000	—
,,	71	—	—	815,000	—
,,	27	—	—	227,000	—
,,	14	—	—	4,965,000	—
,,	14	—	—	9,400,000	—
	18			1,375,901	
7	—	—	—	—	656,000
,,	—	—	—	—	915,000
,,	—	—	—	—	47,500
12	81	—	—	710,000	203,000
,,	50	—	—	2,600,000	273,000
,,	44	—	—	1,700,000	120,000
,,	25	—	—	7,800,000	272,000
,,	25	—	—	—	195,000
	49			3,202,500	335,187

TABLE IV.—

No.	Reference	Time of Collection		Situation of Farm	Place of Collection
		Month	Year		
D					
40	DM 46	May	1908	Stoke-on-Trent	Station, L.A. 5 ... ...
41	,, 47	,,	,,	Leek	,, ,, ...
42	,, 48	,,	,,	Bosley	,, ,, ...
43	,, 49	,,	,,	Rudyard	,, ,, ...
44	,, 54	,,	,,	Stoke-on-Trent	,, ,, ...
45	,, 55	,,	,,	Leek	,, ,, ...
46	,, 56	,,	,,	Stoke-on-Trent	,, ,, ...
47	,, 57	,,	,,	Macclesfield ...	,, ,, ...
48	,, 58	July	,,	Downham... ...	,, ,, ...
49	,, 59	,,	,,	Gisburn	,, ,, ...
50	,, 60	,,	,,	Clitheroe	,, ,, ...
51	,, 61	,,	,,	,, ...	,, ,, ...
52	,, 62	,,	,,	Gisburn	,, ,, ...
53	,, 63	,,	,,	Chatburn	,, ,, ...
54	,, 64	,,	,,	Downham... ...	,, ,, ...
55	,, 65	,,	,,	Waddington ...	,, ,, ...
56	,, 66	Sept.	,,	Chester	,, ,, ...
57	,, 67	,,	,,	Norton	,, ,, ...
58	,, 68	,,	,,	Preston Brook...	,, ,, ...
59	,, 69	,,	,,	Frodsham ...	,, ,, ...
60	,, 70	,,	,,	Gisburn	,, ,, ...
61	,, 71	,,	,,	Clitheroe	,, ,, ...
62	,, 72	,,	,,	Wellington ...	,, ,, ...
63	,, 73	,,	,,	Clitheroe	,, ,, ...
64	,, 74	,,	,,	Pickmere	,, ,, ...
65	,, 75	,,	,,	Northwich ...	,, ,, ...
66	,, 76	,,	,,	,, ...	,, ,, ...
67	,, 77	,,	,,	Barrow for Tarvin	,, ,, ...
68	,, 78	,,	,,	Delamere	,, ,, ...
69	,, 79	,,	,,	Lostock Gralam	,, ,, ...
70	,, 80	,,	,,	,,	,, ,, ...
71	,, 81	October	,,	Whalley	,, ,, ...
72	,, 82	,,	,,	Clitheroe	,, ,, ...
73	,, 83	,,	,,	,, ...	,, ,, ...
74	,, 84	,,	,,	Whalley	,, ,, ...
75	,, 85	,,	,,	Skipton	,, ,, ...
76	,, 86	,,	,,	Whalley	,, ,, ...
77	,, 87	,,	,,	Clitheroe	,, ,, ...
78	,, 88	,,	,,	,, ...	,, ,, ...
79	,, 89	Nov.	,,	Lostock Gralam	,, ,, ...
80	,, 90	,,	,,	Frodsham ...	,, ,, ...
81	,, 91	,,	,,	Plumbley	,, ,, ...
82	,, 92	,,	,,	,, ...	,, ,, ...
					43 Railway Station samples

continued.

Approximate distance from Laboratory by road or rail—miles	Sediment (slime)			Bacteria per 1 cc.	
	Total	Cellular Products	Extraneous Products	Growing at 20° C. in 3 or 4 days. G.P.B.	Growing at 40° C. in 2 days. L.L.A.
37	30	25	5	—	205,000
31	20	10	10	—	195,000
25	15	12	3	—	50,000
29	17	15	2	—	165,000
37	10	4	6	—	1,635,000
31	26	12	14	—	5,000
37	10	0	10	—	450,000
19	14	0	14	—	195,000
37	20	4	16	—	67,500
42	24	2	22	—	10,000
35	14	—	—	—	427,000
35	18	10	8	—	42,500
42	20	8	12	—	77,500
37	16	6	10	—	25,000
37	28	8	20	—	52,500
39	40	18	22	—	552,000
38	10	—	—	—	47,500
26	66	26	40	—	52,500
27	120	80	40	—	15,000
30	50	30	20	—	2,372,000
42	32	12	20	—	27,500
35	14	—	—	—	27,500
62	20	—	—	—	10,000
35	20	14	6	—	7,500
22	12	—	—	—	24,500
20	16	8	8	—	21,500
20	24	20	4	—	32,000
34	40	20	20	—	10,000
28	20	12	8	—	2,750
19	20	10	10	—	35,000
19	16	—	—	—	419,000
31	30	8	22	—	6,500
35	20	4	16	—	15,750
35	18	4	14	—	82,000
31	16	8	8	—	27,000
45	100	90	10	—	426,750
31	10	6	4	—	under 500
35	30	18	12	—	32,000
35	40	20	20	—	61,750
19	28	16	12	31,000	1,500
30	24	12	12	33,500	2,500
17	20	8	12	35,000	750
17	16	4	12	27,000	5,500
	29	15	13	31,620	184,203

TABLE IV.—

No.	Reference	Time of Collection: Month	Time of Collection: Year	Situation of Farm	Place of Collection
E					
83	LB 225	Nov.	1894	Manchester ...	Customer, Victoria Park ...
84	,, 2091	May	1907	Urmston	,, Stretford ... ...
85	,, 2756A	July	1908	?	,, Newcastle-u-Lyme
86	,, 3191	April	1909	Bowdon	,, Bowdon ... ...
87	,, 4170	October	1910	Chirk	,, Chirk ... ...
88	,, 4939	,,	1911	Leigh	,, Leigh ... ...
89	,, 5353	June	1912	Northwich ...	,, Northwich ...
90	,, 5401	,,	1912	— ...	,, Ramsbottom ...
					7 Customers ... ...
F					
91	LB 8370	July	1916		Hospital A ... ...
92	,, 8461	August	,,		,, ...
93	,, 8511	Sept.	,,		,, ...
94	,, 8576	October	,,		,, ...
95	,, 8600A	,,	,,	Tarporley	Hospital B ... ...
96	,, 8600B	,,	,,	,, ...	,, ...
97	,, 8600C	,,	,,	,, ...	,, ...
98	,, 8600E	,,	,,	,, ...	Hospital C ... ...
99	,, 8600F	,,	,,	,, ...	,, ...
100	,, 8600G	,,	,,	,, ...	,, ...
					3 Hospitals ... ...

Column 4—*No. of Cows.*—When only the number of cows is given it means that the sample was collected at the farm.

Column 5—*L.A.* = *Local Authority.*—Each Local Authority has been given a separate number. Hospitals are designated by letter.

Column 11—*G.P.B.* = *Gelatine peptone bouillon* (incubation at moderate summer temperature).

Column 12—*L.L.A.* = *Litmus lactose agar* (incubation at blood temperature).

continued.

Approximate distance from Laboratory by road or rail—miles	Sediment (slime)			Bacteria per 1 cc.	
	Total	Cellular Products	Extraneous Products	Growing at 20° C. in 3 or 4 days. G.P.B.	Growing at 40° C. in 2 days. L.L.A.
1	Abundant	—	—	5,765,000	—
1	10	—	—	40,000,000	—
40	—	—	—	over1,000,000	1,020,000,000
9	—	—	—	4,200,000	—
61	200	—	—	2,000,000	—
12	—	—	—	126,000,000	—
21	10	—	—	180,000	—
13	100	—	—	60,000,000	—
	80			34,020,700	—
—	25	21	4	2,030,000	410,000
—	20	16	4	9,000,000	1,125,000
—	25	13	12	6,000,000	2,225,000
—	15	2	13	2,700,000	280,000
41	12	12	—	—	2,300,000
,,	16	16	—	—	1,260,000
,,	11	11	—	—	26,000,000
,,	70	60	10	—	107,100,000
,,	16	14	2	—	36,200,000
,,	20	18	2	—	176,400,000
	23	18	6	4,932,500	35,300,000

N.B.—When the number of bacteria is very low, this may have been due to the presence of preservatives. The samples were tested for preservatives in a small proportion of cases only. When the number of bacteria is excessively high, this may have been due to the admixture of the fresh milk with stale milk remaining in the milk pails or cans; this complication cannot be excluded when the milk is taken from churns or other farm vessels at the farm or in transit.

3.—General review of the results of the various tests.

Generally speaking the samples of milk collected for the clean milk investigation during the years 1916 and 1917 were, as regards their chemical composition, quite satisfactory.

The same cannot be said of their bacterial contents, nor of the extent to which they were infected with tubercle bacilli.

The number of clean samples was small, and the keeping quality of the milk was low. A large number of samples were already sour after 10 to 14 hours incubation at 30° C. (85° F.) (*i.e.*, hot summer temperature).

Several important points are brought out by comparison of the state of the milk on its arrival from country farms to large dairies, to hospitals supplied directly by farms, and after distribution to various hospitals or general shops and customers.

Already rich in bacteria growing at summer and blood temperature when it reaches the town, the milk becomes loaded with a very much greater number of organisms as it reaches its final stage of distribution. As the samples were collected in winter, these results are particularly significant.

There is evidence that the amount of dirt is not diminished during the passage of the milk through the dairies.

The large proportion of tuberculous samples arriving at the dairies, and the fairly large amount of it reaching hospitals and schools for mothers is also an unsatisfactory feature.

All these things are brought out clearly in Section A of Table V. (pages 38–39), which give *averages of some of the results recorded in more detail in Table I.*

That this state of things is not peculiar to the present period is shown by the averages given in B of Table V., which is based upon the data collected in Table IV., referring to the state of the milk supply previous to 1916.

The effect of treatment of the milk by heat (Table V., C.) at 5 dairies is shown to have been generally beneficial, and this is particularly clear with regard to milk which has been heated to more than 210° F.

None of the samples of heated milk were found capable of conveying tuberculosis.

The two samples representing milk which had only been filtered and cooled at one of the dairies did not show evidence of a similar improvement, and were both capable of conveying tuberculosis.

As regards milk which was collected in various hospital wards, the averages given in D (Table V.) show that the deterioration which had taken place from the time of the arrival of the milk at Manchester dairies had continued after distribution within the hospital. The proportion of samples of tuberculous milk collected at certain hospitals is a striking feature of the records. It may be noted that at the time when the samples were collected, those taken at 5 hospitals were markedly tuberculous, and that 3 other hospitals supplied by the same dairies were not affected in the same way.

There was also evidence that the milk was capable of conveying at times other kinds of infection, more particularly septic infection.

The milk of the 3 hospitals (Table V., D) which were supplied directly by their farms was not so bad on an average as the milk supplied to other hospitals by large dairies.

I have dealt with these points in a very cursory fashion, because the object of this report is to discuss the question of standards of purity. It seems, however, impossible to disconnect the question of standards from that of their bearings upon health.

TABLE V.—AVERAGE RESULTS YIELDED

Nature of Milk sample	Season when collected	Sediment per 100,000 Total
A—*Bulk Milk as supplied in* 1916-17 *to Dairies, Hospitals, Schools for*		
5 large Dairies (A, B, C, D, and E)—Milk in bulk on arrival from over 167 farms	Winter	23
9 Hospitals—Milk on arrival from dairies (eight hospitals supplied by Dairy A and one by Dairy F)	,,	73
3 Hospitals—Milk on arrival from 21 farms	,,	34
7 Schools for Mothers—Milk from 30 farms supplied by four dealers (G, H, J, K)	,,	35
10 General Shops—Milk supplied to four by Dairy D and to six by dealers (L, M, N, O, P, Q)	Spring	25
B—*Bulk Milk, tested previous to Autumn*, 1916 (see Table IV.).		
3 Hospitals during 1916	Summer and Autumn	23
— Milk Depot 1906 and Co-operative Stores 1909 (eight farms)	Winter	49
7 Customers in various towns 1894 to 1912	Summer and Autumn	80
43 Samples of Milk arriving at Railway Stations from a distance of 17 to 45 miles, 1908 (62 miles in one case) ...	Summer and Winter	29
A few samples collected at small Farms (11 farms) between 1896 and 1916 ...	——	—
C—*Milk treated at Dairies* (see Table I.).		
Milk heated to 210° to 212 °F. from 30 minutes to 1 hour	Winter	29
Milk heated to from 60° to 183° F. for 1 minute to 6 minutes	,,	29
Milk filtered and cooled at dairies	,,	18
D—*Milk Samples taken in Hospital Wards* (see Table I.).		
17 Hospital Wards in nine hospitals (eight supplied by Dairy A)	Winter	84
9 Hospital Wards in three hospitals, supplied by 21 farms	,,	30

BY EACH GROUP OF SAMPLES.

Sediment per 100,000 Dirt	Souring time at 30° C. Max. hours	No. of Bacteria per 1 cc.		Tuberculous samples per cent. of total	Fat	Laboratory evidence of heating
		Growing in 72 hours at 20° C.	Growing in 48 hours at 37° C.			
Mothers, and General Shops (see Table I.).						
				per cent	per cent	per cent
2·7	14	426,710	36,490	60 to 80	3·94	0
7·2	10	2,806,740	615,500	22	3·33	22
10	12	544,300	13,370	33	4·12	0
9	17	396,150	13,092	20	4·12	0
3	10	40,634,000	859,990	0	3·75	10
6	—	4,932,500	35,300,000	—	—	—
—	—	3,202,500	335,180	—	—	—
—	—	34,020,700	—	—	—	—
13	—	—	184,203	20	—	—
—	—	3,439	2,310	—	—	—
3·3	56	7	1	0	3·95	100
2	17	9,700	560	0	3·67	100
1·5	16	326,900	61,675	100	3·91	0
10	11	8,174,295	1,576,000	41 to 64	3·45	23
11	15	983,777	603,933	11 to 44	3·02	0

The averages given in Table V. supply useful general information, but do not clearly indicate what would be the effects as regards administrative action of applying various tests to the milk supply at the present time. In order to obtain this kind of information I have analysed the results of the cultivation and of the souring tests in Table VI.

Table VI.—Milk after arrival at Town.

Analysis of the Results of Culture Tests (Bacterial Counts) at 20° and at 37° C. for 48, and 72 Hours.

Samples grouped according to the number of Bacteria.

		No. of Bacteria in 1 c.c.							
		Under 100	100 to 1,000	1,000 to 10,000	10,000 to 50,000	50,000 to 100,000	100,000 to 1,000,000	Over 1 Million	No. of Samples examined
		Bacteria growing on Gelatine at 20° C. in 3 days.							
Dairies	Winter, 1916—17	0	0	0	1	2	3	1	7
Hospitals	,, ,,	0	0	0	1	3	9	25	38
Schools for Mothers	,, ,,	0	0	0	2	0	2	1	5
General Shops	Spring, ,,	0	0	0	1	1	2	6	10
Hospitals	Summer, 1916	0	0	0	0	0	0	4	4
Milk Depot and Co-operative Stores	Winter, 1906—07	0	0	0	0	0	1	3	4
Customers	Summer and Winter, 1894—1912	0	0	0	0	0	1	7	8
Railway Stations and milk sent from a distance	Summer and Winter, 1907—08	0	0	0	6	4	7	7	24
Small Farms at a short distance	1916 and before	0	1	8	1	0	0	0	10
	Totals	0	1	8	12	10	25	54	110
	Percentages	0	0·9%	7%	10%	9%	22%	49%	—
		Bacteria growing on Agar at 37° C. in 48 hours.							
Dairies	In Winter	0	0	1	2	4	0	0	7
Hospitals	,, ,,	0	0	0	3	5	19	11	38
Schools for Mothers	,, ,,	0	1	2	2	0	0	0	5
General Shops	,, Spring	0	0	3	2	0	2	3	10
Hospitals	,, Summer	0	0	0	0	0	2	8	10
Milk Depots, etc.	....	0	0	0	1	0	7	0	8
Railway Station or distant Farm	....	0	2	10	14	6	10	2	44
	Totals	0	3	16	24	15	40	24	122
	Percentages	0	2·4%	13%	19·6%	12·3%	32·8%	19·6%	—

Analysis of the Results of the Souring Test when the Milk is Incubated at 30° C.

Samples grouped according to their keeping quality.

Souring Time.

		Over 40 hours	30 to 40 hours	20 to 30 hours	10 to 20 hours	Less than 10 hours	No. of Samples examined
Dairies	Winter	0	0	0	6	1	7
Hospitals	,,	0	0	2	24	12	38
General Shops	,,	0	0	0	6	4	10
	Totals	0	0	2	36	17	55
	Percentages	—	—	3·62%	65·%	30·9%	—

From this table it will be seen that 49 per cent. of the samples of milk examined contained more than 1,000,000 bacteria growing at 20° C. in 3 days and that 71.8 per cent. contained more than 100,000 bacteria. The few specimens which contained less than 10,000 bacteria had been collected at small farms during the summer 1916, and more than half of the specimens containing from 10,000 to 50,000 bacteria had been collected at railway stations on the arrival of the milk from the country.

If instead of using the gelatine plate method one resorts to the cultivation of the milk on agar at 37° C. the number of specimens containing more than 100,000 bacteria amounts to 52.4 per cent., those containing more than 50,000 bacteria number 64.7 per cent. Only 2.4 per cent. of the specimens contained less than 1,000 bacteria: most of these had been collected at railway stations on arrival from the country. Very similar results are yielded by cultivation on agar after 24 hours' cultivation (but the results of the 24 and 48 hours' tests do not agree in all particulars).

With regard to the souring tests, they show that when the milk is incubated at 30° C. (*i.e.*, high summer temperature), 30.9 per cent. of the milk obtained at dairies, hospitals, and general shops (unless immediately boiled on arrival) became useless on account of souring and clotting in less than 10 hours, and that only 3.6 per cent of the milk could be kept for from 20 to 30 hours. None kept good for over 30 hours.

I will show that clean milk should not sour as rapidly as these samples did, and the fact that 95 per cent. of the samples tested were distinctly sour in less than 20 hours is as clear an indication of the impurity of the milk as the large number of bacteria growing at summer and blood temperatures respectively.

SECTION III.

Results of the examination of samples of milk collected and handled at the farm under definite conditions.

In order to understand how it is that the milk supply is so generally and so heavily polluted, it is necessary to study closely what happens to the milk from the time when it leaves the udder to that when it reaches the town and consumer.

I propose therefore to refer briefly to a few of the experiments which I have conducted since 1894, when an outbreak of epidemic diarrhœa, clearly traceable to milk, occurred in Manchester and attracted my attention to the matter.—(James Niven: Report on the Health of Greater Manchester, 1894, page 104).

It will not be necessary for me to relate all my observations, for they have yielded very uniform results.

Four sets of experiments will suffice for my purpose: one was conducted in 1908 at a farm situated in Rusholme, the second carried out in the same year bears upon the influence of tuberculosis of the udder on the state of the milk, the third was made in connection with an outbreak of diarrhœa at Newcastle-under-Lyme in 1914, and the fourth was conducted at the Cheshire County Council Agricultural College at Holmes Chapel specially for the purpose of this report.

The assistance given by the Chairman with regard to the latter has already been referred to. Mr. Simon took a keen interest in the Holmes Chapel experiments, and was present at some of them.

1.—Observations made at Birch Farm during the winter 1908.

This experiment was conducted at Mr. C. Radcliffe's farm, where the conditions were neither the best nor the worst observable in dairy farms in the Manchester area.

The shippon in which the 5 cows selected for the experiment were kept was satisfactory from a structural point of view, and was moderately clean. There was an abundant supply of town water available for the purpose of cleaning the pails, churns, and other dairy utensils. Hot water was also available for the purpose of scalding the dairy vessels. The farm had been more than once inspected by the Veterinary Inspector to the Health Committee, and the usual precautions recommended for preventing the production of dust through disturbance of the fodder or litter were observed. The cows were fairly well groomed, and their udder and flanks were rubbed with a clean dry piece of cloth a few minutes before milking.

On the occasion of my visit the cows were milked in the usual way by Mr. Radcliffe himself, and by one of his men. About $\frac{1}{8}$ ounce of the first milk (fore milk) was wasted and not allowed to get into the milk pail, which when nearly full was emptied into a churn resting on the floor of the shippon, at a distance of 4 or 5 feet from the cows. There was a strainer over the opening of the churn so that the milk was strained as it was poured from the pails into the churn.

For the purpose of my experiment I had brought with me a number of wide-mouth sterilized bottles, and while Mr. Radcliffe or his man was milking each of the 5 cows I handed to him one of my sterilized bottles to be filled with equal parts of milk from the 4 quarters of the udder. After allowing the froth to subside sufficiently, which usually took 5 to 10 minutes, during which time the air of the stable had access to the surface of the milk, the bottle was again securely closed by means of its sterilised stopper.

In the case of 4 of the cows, the milk was collected when the udder was about half empty, each of these samples being therefore one of *middle*

milk. A second sample was taken from one of these cows after the udder had been emptied as usual. To obtain this sample of *after milk*, or strippings, manipulation of the udder was required, and the bottle was filled more slowly than those in which the middle milk was taken. In the case of the fifth cow, the sample was taken when the udder was nearly empty, and may be described as a sample of *end milk:* this sample was obtained without difficulty.

After filling the 6 sterilized bottles with milk obtained direct from the cows, I took from the churn a seventh sample of the mixed milk of the 5 selected cows. Previous to taking this last sample the contents of the churn had been thoroughly stirred. As has been pointed out, all the milk contained in the churn had passed through one strainer.

On returning to the Laboratory I poured into a sterilized flask about $\frac{1}{5}$ of the contents of each of the bottles containing the samples of unmixed milk, so as to obtain a sample of mixed milk corresponding to that contained in the churn, but *not having come in contact with any farm vessel or strainer*.

These 8 samples were then submitted to a number of tests, which extended over a period of four days.

At the time of the experiment the condition of the five selected cows was as follows :—

Cow A.—Brown, shorthorn, healthy, calved 11 or 12 weeks previously, yielded on an average 12 to 14 quarts of milk :—

Sample A1 ... ... middle milk.
Sample A2 ... ... after milk.

Cow B.—White, shorthorn, healthy, calved 11 to 12 weeks previously, yielded on an average 12 to 14 quarts of milk :—

Sample B ... ... middle milk.

Cow C.—White, shorthorn, healthy, calved 11 to 12 weeks previously, yielded on an average 12 to 14 quarts of milk :—

Sample C ... ... middle milk.

Cow D.—Brindled, white and brown, shorthorn, calved $1\frac{1}{2}$ weeks previously, yielded 8 quarts of milk :—

Sample D ... ... middle milk.

Cow E.—Brown and white, shorthorn, calved 11 to 12 weeks previously, retained placenta, sharp attack of fever, good milker :—

Sample E ... ... end milk.

The examination of the samples of milk obtained from these cows was conducted according to the methods described in Section I. of this report. The results are tabulated in Tables VII., A, B, and C (pages 44–46).

TABLE VIIa.

D.M. 100, 107–113.

BIRCH HALL EXPERIMENT, WINTER, 1908.

UNMIXED MILK COLLECTED DIRECT IN STERILIZED VESSELS, NOT STRAINED.

	Cow A 1 Middle Milk	Cow A 2 After Milk (Strippings)	Cow B Middle Milk	Cow C Middle Milk	Cow D Middle Milk	Cow E End Milk
Bacteria growing on Litmus Lactose Agar at 40° C. *in* 48 *hours.*	Under.	Under.	Under.	Under.	Under.	Under.
A—Milk tested 2 hours 45 minutes after milking .	100	400	100	200	100	100
B—Milk tested 55 hours after milking, viz. :—46 hours refrigeration and 9 hours incubation at 20° C. ...	100	—	200	200	200	1000
Bacteria growing on Peptone Bouillon Gelatine in 96 *hours.*						
A—2 hours 45 minutes after milking	1,000	3,000	1,000	1,000	1,000	3,000
B—55 hours (*see* above) ...	1,000	—	2,000	3,000	2,000	4,000

The dilutions used in making the plates were $\frac{1}{100}$, $\frac{1}{200}$, $\frac{1}{400}$, $\frac{1}{1000}$, $\frac{1}{2000}$, $\frac{1}{8000}$, and $\frac{1}{4000}$

Under 100 = any number between 0 and 100.
,, 200 = ,, ,, ,, 100 ,, 200.
,, 1,000 = ,, ,, ,, 400 ,, 1,000, and so on.

Table VIIb.

Birch Hall Experiments, Winter, 1908.

Mixed Milk of Five Cows, A, B, C, D, and E.

	Collected in Sterilized Vessels not strained. Mixed at the Laboratory	Collected in Farm Vessels, strained and mixed at the farm
Bacteria growing on Litmus Lactose Agar at 40° C. *in* 48 *hours.*	Under.	Under.
A—Milk tested 2 hours 45 minutes after milking	100	10,000
B—Milk tested 55 hours after milking, viz. :—46 hours in refrigerator, and 9 hours at 20° C.	200	46,000
Bacteria growing on Peptone Bouillon Gelatine at 20° C. *in* 96 *hours.*		
A—Milk tested 2 hours 45 minutes after milking	3,000	14,000
B—Milk tested 55 hours after milking (as above)	4,000	90,000

The increase of bacteria growing at 40° C. must be chiefly due to multiplication of soil and fæcal bacteria, very few of the water bacteria grow and multiply at that temperature. The increase in the bacteria growing at 20° C. is partly due to water bacteria, partly to soil and fæcal bacteria.

Table VIIc.
Birch Hall Experiment, Winter, 1908.

Amount and Characters of Separated Slime per 100,000 parts of Milk. Reaction and evidence of clotting after keeping Milk at a temperature of 20° C. for about 10 hours, after removal from refrigerator, where it had been kept for two days.

	I. Unmixed Milk collected in clean Laboratory Bottles						II. Mixed Milk Laboratory Vessels	III. Mixed Milk Farm Vessels
	Cow A		Cow B	Cow C	Cow D Recently calved.	Cow E	A, B, C, D, & E	A, B, C, D, & E
	A 1 Middle Milk	A 2 After Milk Strippings	Middle Milk	Middle Milk	Middle Milk	End Milk	Mixed Milk	Mixed Milk
Total Sediment (slime).								
1. Cellular products from udder. Whitish translucent or creamy.	15	20	15	18	30	18	18	28
2. Part of slime coloured by extraneous products (dirt).	0?	7 (a little cigar ash added to milk) pale grey	2 greyish white	0?	2? greyish white	2? greyish white	2? greyish white	12 greenish brown, and black
Reaction and Coagulation Tests.								
Original reaction	Amphot.	Amphot. or slightly acid	Amphot.	Amphot.	Amphot. or slightly acid	Amphot.	Amphot. or slightly acid	Amphot. or slightly acid
Reaction after 10 hours at 20° C.	do.	do.	do.	do.	do.	do.	do.	Acid
State after 10 hours at 20° C.	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Clotted

2.—Observations made at Birch Hall in 1908.

In order to obtain accurate information regarding the changes taking place in the milk of a tuberculous cow, I made in 1908 a series of observations which are summarised in Table VIII (pages 48–49).

I purchased this cow during the month of August, 1908, and kept it under daily observation in a stable attached to my house until the end of December.

This cow had been isolated for the purpose of observation. It was suffering when first seen (August) from tuberculosis of the right hind quarter of the udder, and also from tuberculosis of the lungs. After a short time the disease spread to two other quarters, and to the intestine and during the last month the cow was suffering from incoercible foetid diarrhoea. Samples of milk taken from time to time in sterilized bottles were tested by various methods: some of the results are summarised in this table.

TABLE VIII.—BIRCH HALL COW

Date	Reference	Part of the Udder and Evidence of Disease on Inspection
1908.		
Sept. 10th	7474	Four quarters mixed (right quarter diseased) ... ...
	7475	Right hind quarter (clearly diseased)
	7476	Right fore quarter (diseased) ... ...
	7477	Left hind quarter (no evidence of disease) ... ...
	7478	Left fore quarter (no evidence of disease) ... ...
Sept. 26th ...	7504	Right hind and fore quarters (clearly diseased) ... ...
	7505	Left hind and fore quarters (partly diseased) ... ...
Sept. 28th ...	7506	Right hind quarter ... ...
	7507	Right fore quarter ... ...
	7508	Left hind quarter ... ...
	7509	Left fore quarter ... ...
Oct. 1st (before injection of tuberculin)...	7520	Left hind quarter ... ...
	7521	Left fore quarter ... ...
	7522	Right hind quarter ... ...
	7523	Right fore quarter ... ...
(After injection of tuberculin)	7524	Left fore quarter ... ...
	7525	Left hind quarter ... ...
	7526	Right hind quarter ... ...
	7527	Right fore quarter ... ...
Dec. 28th	D.M. 113	Right hind quarter (extensively diseased) ... ...
		Right fore quarter (extensively diseased) ... ...

* The number of tubercle bacilli visible under the microscope in the altered of the fluid containing a very large number of bacilli. I calculated that the yet ordinary plate cultures revealed only from 30 to 70 bacteria per c.c.

EXPERIMENT, SEPTEMBER TO DECEMBER, 1908.

Part of the Milk Examined	Reaction to Litmus (1 = Slightly Alkaline 2 = Markedly Alkaline 0 = Amphoterous)	Amount of Sediment in parts per 100,000 parts of Milk	No. of Bacteria Growing on Litmus Lactose Agar at 40° C. in 2 days	Result of Inoculation (0 = No Tuberculosis + = Clear Tuberculosis + + = Extensive Tuberculosis
			under	
Whole	1	14	200	—
Cream	—	—	—	+
Sediment ...	—	—	—	+ +
Whole	2	210	100	—
Cream	—	—	—	+ +
Sediment ...	—	—	—	+
Whole	2	300	100	—
Cream	—	—	—	+ +
Sediment ...	—	—	—	+ +
Whole	0	10	100	—
Cream	—	—	—	0
Sediment ...	—	—	—	0
Whole	2	24	1,200	—
Cream	—	—	—	+ +
Sediment ...	—	—	—	+ +
Whole	2	220	—	+ +
,, ...	2	50	—	+ +
Fore milk ...	2	280	100	+ +
End milk ...	2	210	100	+ +
Fore milk ...	2	210	1,000	+ +
End milk ...	2	10	2,000	+ +
Fore milk ...	0	50	100	0
End milk ...	0	48	100	0
Fore milk ...	2	180	100	+ +
End milk ...	2	210	4,000	+
Whole	0	38	100	0
,, ...	?	85	100	+ +
,, ...	?	175	100	+ +
,, ...	?	92	100	+ +
,, ...	?	18	100	+
,, ...	?	18	100	0
,, ...	?	60	100	+ +
,, ...	?	82	100	+ +
,, ...	2	1,020*	30	+ +
,, ...	2	980*	70	+ +

secretion of these much diseased quarters was very considerable the minutest drop number per c.c. was not less than 150,000, and at times reached 20,000,000, and

3.—Observations made at Newcastle-under-Lyme.

During the last three days of October, 1914, some 280 persons out of 750 supplied with milk coming from one farm were affected with diarrhœa. In the course of my enquiry into the cause of the outbreak I found that death in one fatal case was due to infection by a virulent type of bacillus enteritidis, and also that the blood of 1 out of 33 cows kept at the suspected farm agglutinated this bacillus. This cow had suffered from an attack of fever, said to be "milk fever." The blood of none of the other cows had a similar action on the bacillus.

On further investigation I found that this bacillus was abundant in the urine and sometimes also in the uterine discharges of the cow with the reacting blood. The milk obtained direct from the udder of the same cow was found on several occasions to be free from bacillus enteritidis, but from a sample of milk contaminated with blood this bacillus was recovered once with some difficulty.

The number of bacteria (growing in 3 days on gelatine) in that milk was 8,650. From the way in which the milk was handled at the farm and distributed among customers it was clear that if only the milk of the infected cow had been the source of infection very few persons could have been infected. To account for the infection of 280 persons, it was necessary that the infecting bacillus should have infected the whole of the milk produced on the farm.

It was equally evident that a large portion of the mixed milk had been infected through the intermediation of the milk pails, strainers, and cans, and that the milk pails had been exposed to excretal pollution while being used at the shippon.

I was led to the same conclusion with regard to two other extensive outbreaks, but was not able to trace the way in which the milk had been infected as clearly as in the Newcastle-under-Lyme outbreak.

These facts are of great importance in showing how large masses of milk may become infected, and how dirt may convey infection.

4.—Observations made in 1916-17 at the Agricultural College Farm at Holmes Chapel.

The objects of the investigation carried out at Holmes Chapel were :—

(1) To check the results obtained at various farms in previous years.

(2) To determine more fully the share taken by the cow, stable, milk pails, and other farm appliances in the contamination of milk collected under the present conditions.

(3) To ascertain whether the adoption of improved types of farm vessels and the substitution of sterilization of these vessels for ordinary methods of cleaning were practicable in the case of small farms, and also what would be the effect of these improved methods upon the bacterial contents and keeping qualities of milk on its arrival to town.

The Principal of the College, Mr. W. J. Young, took a very keen interest in the work, and gave me every facility and very valuable assistance.

The first set of experiments was conducted in the month of June, 1916. Mr. Young placed at my disposal a small shippon, which for the purpose of the experiment was left in a state of cleanness resembling that of a shippon at a small farm not particularly well kept.

The second set of experiments was made in January, 1917, and on that occasion the cows and shippon were allowed to become actually dirty.

The third set of experiments was conducted also during the month of January. The shippon had been cleaned and the cows groomed in the usual way.

A fourth visit was paid to the farm in March, 1917, when the shippon and cows were in a condition similar to that in which they were on the occasion of the first visit.

After each visit to the farm, samples of milk were examined 2½ hours to 3 hours after milking, *i.e.*, after a lapse of time similar to that which would on an average occur between milking and the collection of samples at Manchester railway stations in the case of milk arriving by rail from country districts 20 to 40 miles from town.

The samples were submitted to the same tests as the samples examined in connection with the Birch Farm and the Clean Milk investigations.

The data relating to each experiment and the main results are summarised in Table IX (pages 52–55).

The results of some special examinations are recorded in the additional Tables X. to XVI (pages 56–62).

TABLE IX.—HOLME

Date	Laboratory No.	State of Shippons and Cows	Designation of Cow	Milk taken for examination	Vessels into which Cows Milked
2/6/16	8304A	Conditions of shippons and cows not better than would be the case in a small farm, not very well kept. Milker A	Cow 55 yield 14 lbs.	End milk of 2 quarters Middle milk of 2 quarters	Sterilized bottle
	8304B	Same as A, but milker B	Cow 8 yield 16 lbs.	Middle milk of 4 quarters	"
	8304C	Same as A, but milker C	Cow 88 yield 9 lbs., nearly dry	Strippings of 4 quarters	"
	8304E	Same as A	Cows 55, 8, and 88	A, B, and C mixed milk	"
	8304D	Same as A	"	"	Farm pails
8/1/17	8789A	Shippon and cows not cleaned for 2 days to imitate the conditions of a badly kept small farm. Cows not groomed. Hay given them at the beginning of milking; straw, litter, and dung abundant. Milker D	Cow 101 nearly dry	Whole milk from 4 quarters including strippings	Sterilized bottle (while sample C being taken)
"	8789B	Same as A	Cow 99 nearly dry	"	"
"	8789C	"	Cows 101 and 99	"	Milked into covered sterilized milk pail with own strainer
"	8789D	"	Cow 100 nearly dry Cow 84 in milk and clean	" Middle milk	Sterilized uncovered pail
"	8789E	"	Cows 84, 99, 100, and 101 (see above)	Mixed milk	Two pails used for collecting C and D

CHAPEL EXPERIMENTS.

Treatment of Milk before Sample taken	Time Sample taken after Milking	Keeping of Sample before Examination		No. of Bacteria per 1 cc.		Additional Tests
		Time	Temp. C.	Growing at 20° C. on gelatine	Growing at 37° C. on agar	
				In 72 hours.	In 24 hours	
None	0 hrs.	2½ hrs	20°	—	80	See effects of keeping on souring and on the number of bacteria, Table X.
None	"	"	"	—	Under 10	
None	"	"	"	—	6,100 (plate spoilt)	
Equal parts of A, B and C mixed in sterilized laboratory vessel	2½ hrs.	"	"	—	1,500	
Strained through the common strainer used for that afternoon's milking into farm churn	15 min.	"	"	"	432,000	
					In 48 hours	
None	0 hrs.	2½ hrs	Under 15°	20	55	See effects of incubation at various temperature, Table XI. Bacteria in air and water at the farm, Table XV.
None	"	"	"	255	285	
None	15 min.	"	"	835	585	
None	"	"	"	55,400	139,400	
All strained through strainer used for C	"	"	"	38,800	83,100	

TABLE IX.—HOLMES

Dates	Laboratory No.	State of Shippons and Cows	Designation of Cow	Milk taken for examination	Vessels into which Cows Milked
21/1/17	8812A	Shippon cleaned in the usual way. The 8 clean cows had been groomed the same morning, and had not been out. Milker E.	Cow 86 and "Pearl." Clean shed	Whole milk of four quarters of two cows	Sterilized covered pail with own strainer (lid came off 2 minutes after beginning)
"	8812B	Dirty shed with 3 cows. Cows not groomed, and had not been out. Milker E.	As above and "Orange Choice." Dirty shed	Whole milk of four quarters of three cows	Same pail as above
"	8812C	Same as A and B	As A and B	"	"
"	8812D	Same as A and B	"	"	"
24/3/17	8945B	Shippon not specially cleaned. Milkers B and C.	Cow 88 " 55 " 83	First milk After milk and strippings* First milk	Two covered sterilized pails with strainers
"	8945C	" "	Cow 88 " 55 " 83	"	"
"	8945D	" "	Cow 88 " 55 " 83	"	"
"	8945A	" "	Cow 88 " 55 " 83	After milk and strippings First milk After milk	Open dairy pails
"	8946A	" "	Cow 88 " 55 " 83	First milk After milk and strippings* First milk	Two covered sterilized pails with strainers
"	8946B	" "	Cow 88 " 55 " 83	After milk and strippings First milk After milk	Open dairy pail

* The stripping of Cow 55 was pushed to the utmost, and occupied much time.

CHAPEL EXPERIMENTS—*Continued.*

Treatment of Milk before Sample taken	Time Sample taken after Milking	Keeping of Sample before Examination		No. of Bacteria per 1 cc.		Additional Tests
		Time	Temp.	Growing at 20° C. on gelatine	Growing at 37° C. on agar.	
				In 72 hours.	In 24 hours	
None	10 min.	2½ hrs.	Under 15°	Under 100	100	See effects of incubation at 27° C. Table XII. Examination of air in clean and dirty shippons, and "rinsing" of dairy pail, Table XIV.
None	"	"	"	400	500	
Strained through the dairy strainer (used previously to strain 23 lbs. of morning milk) into the dairy pail (also used in the morning)	15 min.	"	"	112,000	2,000	
As above, and passed over the dairy cooler, which had been rinsed the previous night, and not used since	"	"	"	10,600	200	
Poured into model sterilized churn, without general straining	15 min.	2½ hrs.	10-12°	1,300	30	
Passed over dairy cooler (clean but not sterilized)	20 min. (Milk 20° C.)	"	"	25,900	400	
Passed through clean dairy strainer and cooler, and received in sterilized pail	"	"	"	23,000	300	
Strained through clean dairy strainer into clean dairy pail	15 min.	"	"	44,200	6,350	Samples 8946AB, taken at the Laboratory after journey between farm and Laboratory in model churn and dairy cans respectively. Effects of keeping and of incubation, Table XIII.
Poured into model sterilized churn, without general straining, and kept in model churn in transit	2½ hours	2½ hrs.	"	3,700	30	
Strained through clean dairy strainer into clean dairy pail, and kept in dairy can in transit	2½ hours (Milk 17° C.)	"	"	55,000	2,720	

Table X.—Experiment L.B. 8,304.

Incubation Test applied to Milk collected in sterilized bottles, to the same Milk mixed in sterilized vessels, and to the same Milk mixed, strained, and collected in ordinary farm vessels.

Acidity (souring) test and bacterial counts compared.

	Time after Milking hours	Cow A End Milk of 2 quarters	Cow B Middle Milk of 4 quarters	Cow C Strippings of 4 quarters	Milk of A, B, & C Mixed in Sterilized Bottle	Milk of A, B, & C Strained through common strainer used for the whole of the Milk immediately before Milk A, B, C was strained
Bacteria growing on agar at 37° C. in 24 hours	2½	80	10	6,100	1,500	43,200
Milk incubated for 23 hours at 20° C.	25	10	10	2,100	800	236,000,000
Milk incubated at 20° C.	2¾	Acidity 0	Acidity 1	Acidity 0	Acidity –	Acidity 1
	14	,, 0	,, 1	,, 0	,, –	,, 2
	25	,, 0	,, 1	,, 0	,, –	,, 2
	46	,, 0	,, 1	,, 0	,, –	,, 3
	70	,, 1	,, 1	,, 0	,, –	,, 4
	90	,, 1	,, 1	,, 0	,, –	,, 4
					Detailed records of observations lost, but the Milk was sweet and tasted fresh at the end of 48 hours.	The Milk was sour and partly clotted at the end of 14 hours.

N.B.—Slight differences in acidity are not indicated in the above Table.

Table XI.—Experiment L.B. 8,789.

Incubation Test applied to Milk collected in sterilized bottles, sterilized covered pails, and sterilized open pails; also to the same strained in the usual way.

Acidity (souring) test compared with bacterial counts.

	Time after milking Hours	Cow 101 (nearly dry) Whole milk and strippings. A Collected in a sterilized bottle	Cow 99 (nearly dry) Whole milk and strippings. B Collected in a sterilized bottle	Cows 101 and 99. Mixed milk including strippings. C Collected in a sterilized covered pail	Cows 100 and 84 (in milk). Mixed middle milk. D Collected in a sterilized open pail	Cows 101, 99, 100, and 84. Mixed milk. E Strained through a sterilized strainer not used before
Bacteria growing at 20° C. in 72 hours...	2¾	20	255	835	55,400	38,800
Bacteria growing at 37° C. in 48 hours...	2¾	55	285	585	139,400	83,100
Incubated at 30° C.	2¾	Acidity 0	Acidity 0	Acidity 0	Acidity 0	Acidity 0
	14	,, 0	,, 0	,, 0	,, 1	,, 1
	18	,, 0	,, 0	,, 0	,, 2	,, 2
	21	,, 0	,, 0	,, 0	,, 3	,, 3
	23	,, 0	,, 0	,, 0	,, 3	,, 3
	26	,, 0	,, 0	,, 0	,, 4	,, 4
	41	,, 0	,, 1	,, 1	,, 4	,, 4
	49	,, 1	,, 2	,, 2	,, 4	,, 4
	60	,, 1	,, 2	,, 3	,, 4	,, 4
Incubated at 40° C.	2¾	Acidity 0	Acidity 0	Acidity 0	Acidity 0	Acidity 0
	14	,, 0	,, 0	,, 0	,, 0	,, 0
	18	,, 0	,, 0	,, 0	,, 1	,, 0
	21	,, 0	,, 0	,, 0	,, 2	,, 1
	23	,, 0	,, 0	,, 0	,, 3	,, 2
	26	,, 0	,, 0	,, 1	,, 4	,, 3
	41	,, 0	,, 1	,, 1	,, 4	,, 3
	49	,, 1	,, 1	,, 2	,, 4	,, 4
	60	,, 0	,, 2	,, 3	,, 4	,, 4

N.B.—Slight differences in the degree of acidity are not indicated in the above table.

Table XII.—Experiment L.B. 8,812.

Incubation Test applied to Milk collected in a clean and in a dirty shippon in sterilized covered pails, and to part of the same milk passed through the dairy strainer used for general straining immediately before, and to another part of the same milk passed over the "clean" and unused dairy cooler.

Acidity (souring) test and bacterial counts compared.

	Time after milking hours	Clean shippon. Sterilized covered pail A	Dirty shippon. Sterilized covered pail B	Milk A and B passed through used dairy strainer C	Milk A and B passed over unused "clean" dairy cooler. D
Bacteria growing on gelatine at 20°C. in 72 hours	2½	100	400	112,000	10,600
Bacteria growing on agar at 37° C. in 48 hours	2½	100	500	2,000	200
Milk incubated at 27° C.	2½	Acidity 0	Acidity 0	Acidity 0	Acidity 0
	4	,, 0	,, 0	,, 0	,, 0
	17	,, 0	,, 0	,, 1	,, 0
	19	,, 0	,, 0	,, 2	,, 0
	22	,, 0	,, 0	,, 3	,, 2
	24	,, 0	,, 0	,, 3	,, 3
	41	,, 1	,, 2	,, 4	,, 4
	51	,, 3	,, 4	,, 4	,, 4
	66	,, 4	,, 4	,, 4	,, 4

N.B.—The number of Bacteria are given in maxima round figures multiples of 100.
Slight differences in the acidity are not indicated in the above Table.

TABLE XIII.—EXPERIMENT L.B, 8,946.

INCUBATION TEST APPLIED TO PART OF THE MIXED MILK OF THREE COWS COLLECTED IN STERILIZED COVERED PAILS AND CARRIED TO TOWN IN STERILIZED MODEL CHURN; AND TO PART OF THE MIXED MILK OF THE SAME COWS COLLECTED IN OPEN DAIRY PAILS, STRAINED THROUGH "CLEAN" DAIRY STRAINER AND CARRIED TO TOWN IN "CLEAN" DAIRY CAN.

	Time after milking Hours	Cows A, B, & C. Covered pails, model churn	Cows A, B, & C. Open pails, clean strainer, and dairy can
No. of bacteria growing at 20° C. in 72 hours	2½	3,700	55,000
No. of bacteria growing at 37° C. in 48 hours	2½	30	2,720
Milk kept at 12° to 15° C. for 25 hours ...			
No. of bacteria growing at 41° C. in 48 hours	25	30,000	1,870,000
Milk kept at 12° to 15° C.	25	Acidity 0	Acidity 0
	30	,, 0	,, 0
	*45	,, 0	,, 1
	50	,, 0	,, 2
	67	,, 0	,, 2
	80	,, 1	,, 3
Taste	—	Sweet	Very sour, cheesy
*Milk kept at 12° to 15° C. for 45 hours and then incubated at 27° C.	45 + 0	Acidity 0	Acidity 1
	45 + 2	,, 0	,, 1
	45 + 4	,, 0	,, 2
	45 + 5	,, 0	,, 3
	45 + 6	,, 0	,, 3
	45 + 10	,, 0	,, 3

N.B.—Slight differences in acidity are not indicated in the above table.

Table XIV.

Bacteria in the Water used at the Dairy at the Agricultural College Farm, Holmes Chapel.

Reference	Agricultural College, Holmes Chapel	No. of Bacteria per 1 c.c.	
		Growing on Gelatine at 20° C. in 72 hours	Growing on Agar at 37° C. in 48 hours
8,788 A	Hot water tap in dairy	0	0
B	Cold water tap in dairy... ... ... N.B.—No bacillus coli found in 100 cc. of the water obtained from Taps A and B.	40	0
8,813	270 cc. of sterilized water used to rinse one of the dairy pails reputed clean and taken from the drying rack (pail quite dry). The contact of the water with the bottom and sides of the pail was very short, only a few seconds, and the whole of the inner surface was not wetted by the small amount of water used	over 1,690	156
	Calculated number of bacteria removed from the pail by 270 cc. of water. The pail had a capacity of over 10,000 cc., that amount of milk remaining in the pail for ¼ of an hour would be capable of removing a much larger number of bacteria	(over 456,300)	(42,120)

Table XV.

Bacteria in the Air of the Shippons and Dairy at the Agricultural College Farm, Holmes Chapel.

Reference	The surface exposed to the air measured in every case about 65 square centimetres	Duration of the exposure	No. of Bacteria growing on gelatine at 18° C.
	Place of Exposure.		
8,787	Dirty stable, shelf 3 feet above floor	18 minutes	834
		30 ,,	1,626
		50 ,,	2,850
8,814	Dairy, shelf close to cooler while milk 8,812 D was being cooled (*see* Table IX.) ...	2 ,,	33
	Clean shippon, over manger in front of cow 8,812 A while milking was proceeding. (Plates exposed 5 feet above floor) ...	2 ,,	72
	Dirty shippon, 6 feet above the floor—over head of cow while milking was proceeding	2 ,,	840
	Clean shippon, plate exposed under the belly of a cow (8,812 A) while milking was proceeding	2 ,,	1,050*
	Dirty shippon, plate exposed under the belly of a cow (8,812 B) while milking was proceeding	2 ,,	486*

*The small number of bacteria in the air under the cow kept in the dirty shed, as compared with the larger number found under the cow in the clean shed, indicates a great inequality in the distribution of dirt. A few particles of dirt falling from the skin of a cow would produce a great increase in the number of bacteria.

Table XVI.

Milk at the Farm.

Analysis of the Results of Bacterial Tests.

Samples grouped according to the No. of Bacteria.

	Under 100	100 to 1,000	1,000 to 10,000	10,000 to 50,000	50,000 to 100,000	100,0000 to 1,000,000	Over 1 million	No. of Samples Examined
2½ to 3 hours after milking.			*Bacteria growing on gelatine at 20° C. in 3 days.*					
Milk from single cows collected in sterilized vessels	1	5	2	0	0	0	0	8
Mixed milk from same cows collected and mixed in sterilized vessels	1	2	3	0	0	0	0	6
Milk from same cows collected and treated as usual at the farm	0	0	0	6	2	1	0	9
								23
			Bacteria growing on agar at 37° in 2 days.					
			1,000 to 2,000	2,000 to 10,000				
Milk from single cows collected in sterilized vessels	25	4	3	2	0	0	0	0	34
Mixed milk from the same cows collected and mixed in sterilized vessels ...	4	2	2	0	0	0	0	0	8
Mixed milk from same cows collected and treated as usual at the farm	0	3	0	4	0	1	2	0	8
								50
After 23 hours at summer temperature.								
Mixed milk in sterilized vessels	—	—	—	1	—	—	—	1
Mixed milk in farm vessels, same milk as above	—	—	—	—	—	—	1	1
								2

SECTION IV.

Average state of the Milk Supply under present conditions.

State practically attainable under improved conditions.

From the figures given in Table V. it is possible to ascertain what the state of the milk is on an average from the time it arrives from the country to that when it is available for immediate consumption. A study of the minima and maxima which are recorded in the detailed tables is needed to obtain an exact idea of the present state of things, the averages supply information as to the general tendency indicated by the collected data. (See Table V.)

I propose to deal with each group of averages separately to facilitate the comparison of the results and of the methods of testing.

1.—Sedimentation and Souring Tests.

	Sediment		Souring time. Hours
	Total	Dirt	
Winter, 1916—1917.			
Milk supplied by 30 farms to 7 schools for mothers ...	35	9	17
21 ,, to 3 hospitals	34	10	12
167 ,, to 5 dairies...	23	2·7	14
5 dairies to 9 hospitals	73	7·2	10
7 dealers to 10 general shops ...	25	3	10
Summer and Autumn, 1916.			
Milk supplied by farms, etc., to 3 hospitals	23	6	?

2.—Cultivation Tests.

	Bacteria growing at 20° C.	Bacteria growing at 37° C.
Winter, 1916—1917.		
Milk supplied by 30 farms to 7 schools for mothers ...	396,150	13,092
21 ,, to 3 hospitals	544,300	13,370
167 ,, to 5 dairies...	426,710	36,490
5 dairies to 9 hospitals	2,806,740	615,500
7 dealers to 10 general shops ...	40,634,000	859,990
Summer and Autumn, 1916.		
Milk supplied by farms, etc., to 3 hospitals	4,932,000	—
Samples collected before 1914.		
Winter—Supplied by farms to a milk depot and a co-operative stores	3,302,500	335,180
Summer and Autumn—Customers in various towns ...	34,020,700	—

3.—Inoculation Test and evidence of heating.

	No. of clearly tuberculous samples, per cent of total.	No. of samples showing evidence of some heating
Winter, 1916—1917.		
Milk supplied by 30 farms to 7 schools for mothers ...	20%	0
21 ,, to 3 hospitals	33%	0
167 ,, to 9 dairies...	60%	0
5 dairies to 9 hospitals	22%	22
7 dealers to 10 general shops ...	0%	10

The results of the two cultivation tests and of the souring tests are in general agreement, and show that on arrival from the country the milk contains less bacteria than when it reaches the consumer.

This is what could be expected from the difference in the interval between the time of milking and that when the samples were taken.

The passage of the milk through the dairies does not appear to be beneficial except as regards tuberculous infection. The reduction in the infectivity of the milk after passage through the dairies appears to be partly due to the fact that part of the milk has been sterilized at the dairy. The absence of tuberculous samples among those taken at the general shops must be looked upon as the result of fortuitous circumstances.

With regard to the amount of slime and dirt, the milk received by the dairies appears to be better than that supplied by them to the hospitals.

The results of the sedimentation tests do not appear to bear a definite relation to those of the cultivation and souring tests. The explanation of this is to be found partly in the effects of straining.

The total amount of sediment present in milk supplied by dairies is more than double that separable from milk arriving from the country; this I think is probably due to admixture of heated stale milk to the bulk of fresh milk.

The amount of sediment found in the milk received by dairies is greater than that found in the milk which was sent to the Agricultural Show in 1916.

If standards based upon the present averages were adopted, these standards would have to be very low or else most of the milk would have to be classed as below standard.

If the grading system was adopted, most of the milk would have to be placed in the lowest possible grade.

Most of the milk supply would be below standard if the following limits were adopted :—

Bacteria growing at 20° C. in 3 days on gelatine	... 500,000.
,, ,, ,, 37° C. in 2 days on agar	... ... 50,000.
Souring time at 35°	12 hours.
Dirt	2 per 100,000.
Tubercle bacilli	None.

It is important to realise that many samples of milk passing any one of these standards might be rejected under one or more of the other standards.

The data summarised in Table VI. give the means of calculating the exact number of specimens which would be below the above standards.

The state indicated by these figures cannot be said to be satisfactory, and calls for improvement.

The data given in Section III. furnish the means of finding where improvement is most needed, for they show where contamination of the milk is taking place. They also prove that, three hours after milking, cows' milk, even when it is not refrigerated in transit, need not contain more than 10,000 bacteria growing on gelatine at 20°C. in 3 days, or 2,000 bacteria growing on agar at 37° C. in 2 days, and that such milk should remain sweet at an ordinary summer temperature for over 48 hours, if not 60 hours.

A careful consideration of the facts brought out by observations at Birch Farm and at Holmes Chapel shows that the chief sources of bacterial contamination of the milk are :—

(1) The dirt falling into the open pail during milking.

(2) The use of unsterilized milk pails.

(3) The straining of a large amount of milk through a common strainer.

(4) The use of unsterilized coolers of the ordinary type.

(5) The use of unsterilized churns.

(6) Admixture of fresh with stale milk.

Even when the pails and churns *appear* to be "clean" they harbour a fairly large number of bacteria, and this is particularly the case when they are of the types generally in use, which provide chinks and other recesses permitting the accumulation of dirt. It is practically impossible to remove entirely this dirt by the usual methods of cleaning. The same remark applies to "clean" strainers and coolers, but even if these were sterilized they would still be important means of contamination. Thus when several gallons of milk are passed through the same strainer, the dirt which has been separated from the milk first strained is broken up by, and passes into, that subsequently treated.

In the case of the usual type of cooler, the milk is made to expose a very large surface to air and to the extensive unsterilized surface of the cooler itself.

An idea of the share taken by " clean " pails in bacterial contamination can be formed from the results recorded in Table XIV.

The effects of the use of unsterilized vessels, strainers, and coolers are brought out in the various sections of Table IX. Table XVI. may also be consulted to obtain a general view of the influence which the vessels and the methods of handling have upon the bacterial contents of cows' milk.

SECTION V.

Conditions promoting the cleanness and keeping quality of cows' milk.

The observations recorded in previous parts of this report show that in order to obtain clean milk of good keeping quality it is necessary to take certain precautions and to avoid some current practices.

The importance of some of the precautions has been generally understood for many years, others are either unknown to farmers and many of their advisers or are not fully appreciated by them.

The points requiring special attention may be summarised as follows :—

(1) Cleanness of the shippons, cows, milkers, dairy utensils, and dairy hands.

(2) Protection of milk against dirt during milking.

(3) Sterilization of milk pails, churns, or any other article with which the milk comes in contact; protection of the vessels against reinfection pending their being used.

(4) Protection of fresh milk against any admixture with stale milk, fluid or dry.

(5) Avoidance of straining through a common strainer.

(6) Avoidance of cooling by methods causing large surfaces of milk to be exposed to the air or to unsterilized surfaces (as when the milk is cooled in the usual way or when it is poured into, or stored in. unsterilized vessels).

(7) Cooling of the milk by keeping churns in cold stores or places.

The question of the health of the cows or dairy hands does not fall within the scope of this report.

I propose to offer a few remarks with regard to each of these points :—

1.—Cleanliness at the farm and at the dairy.

The importance of the general cleanliness has been frequently insisted upon, and would require no further remark if it were not that *apparent* is often mistaken for *absolute* cleanliness.

With regard to the stable and cows absolute cleanness is an impossibility. The skin of a well-groomed cow remains loaded with bacteria, which are liable to contaminate the milk more specially at the time of milking, and particularly when the udder is freely manipulated in order to obtain the after milk or strippings. When the cow is clean, and the clean dry udder has been freed from dust and adhering particles by rubbing it with a dry clean cloth a few minutes before milking, milk containing very few bacteria and very little dirt can be obtained provided that the duct of the teat is cleared from the bacteria and small amount of dirt which generally accumulate in it. This dirt is swept away by the first few drops of milk which pass through the duct at the beginning of milking and this contaminated milk should not be allowed to pass into the milk pail.

The results of the microscopical examination of the sediment of samples of milk collected in town show that most of these samples contained hairs and cells coming from the skin of the cow, fibres from the clothing of the milkers, and vegetable debris derived from the fodder and litter. It seems impossible to prevent the loosening of some cutaneous products, including hairs, during the act of milking. It is possible to prevent the fall of fibres from the clothing of the milker by the use of overalls with sleeves made of some *dustless* material (such as oil silk or cloth) capable of standing repeated washing and disinfection.

I need not insist upon the bad effects of the objectionable habit which many milkers have to press their head against the side of the cow during the act of milking. Dust from fodder and litter can be avoided only by conducting the operation of milking in suitable milking sheds ; open-air milking, when possible, is better than milking in the stable ; but in many farms milking in the shippon is almost a necessity. By exercising a moderate amount of care it is possible (as I have shown by several of the experiments recorded in previous sections) to obtain milk which is free from excessive contamination and capable of meeting fairly stringent standards, even when cows are milked in shippons moderately clean. To obtain this result, it is necessary to take various precautions, which I will now discuss.

2.—Protection of the milk against dirt during milking.

The fall of dust from the air and from the cow and milker can be considerably reduced if covered milk pails or cans with a small inlet are used instead of the ordinary open milk pail. Cans with a comparatively small opening have been used for over sixty years in Jersey, where they appear to have been imported from Normandy. Mr. Ernest Mathews, Member of the Council of the Royal Agricultural Society of England, has used them for many years at his farm at Little Shardeloes, Amersham.

These Jersey milk cans have a spherical shape and a short neck, they are smooth internally and easy to clean, they have a capacity of two and a half to three gallons. During milking it is the practice at Mr. Mathews' farm to cover the opening of the can with a straining cloth, through which the milk is strained on entering the can.

In more recent years various types of covered pails have been introduced in America. In some of these the opening of an ordinary pail is partly closed by a fixed incomplete cover.

There is another type of American covered pail which resembles the Jersey can in that it is bottle shaped, but the opening is situated laterally so that the jet of milk has to enter it obliquely. The shape of the American is, however, not so good as that of the Jersey can.

Although this last American type of can prevents the penetration of dirt more completely than is the case with other partially covered milk pails, it has the disadvantage of not being easy to clean, a disadvantage which I will show later to be of great importance.

When consulted by Mr. Henry Simon in 1896, at the time when he was interested in a company the object of which was to promote the production of clean milk supply for Manchester, I advised the adoption of pails and churns constructed so as to make thorough cleaning and disinfection easy and the penetration of dirt difficult. With this object I recommended the use of seamless pails and churns with a rounded bottom, doing away with the recess existing between the bottom and sides of the pails in common use, and of overhanging covers suitable respectively for pails and churns.

The official appointed by the company did not share my views regarding the importance of these details, and preferred to rely upon purification by filtration at the dairy. His results were unsatisfactory.

For the purpose of this report I had some full-sized pails and a two-gallon model churn made according to my original patterns. I would have liked these pails and can to be made without seams, but this could not have been done without special tools. I have, however, ascertained from a leading firm that, if there was a sufficient demand, seamless pails and cans could be made at a cost which would not exceed that of ordinary pails or cans, and might be less.

The absence of any recess or irregularity of surface is of great importance, for a perfectly smooth surface is easier to keep perfectly clean and sterile than an uneven surface.

The accompanying diagrams and photographs show the special features of the various pails and cans to which I have alluded (plates V. to IX.).

A very simple arrangement allows a small sterilized strainer to be fixed to each of my covered pails. This consists of two short lengths of tubing fitting into the opening in the lid of the covered pail. By means of these tubes a small piece of sterilized flannelette can be stretched across the opening through which the milk enters the pail. This is all that is required to prevent a few stray hairs and other particles falling into the pail ; by this simple device straining in bulk becomes unnecessary.

To protect the milk against contamination during milking various milking machines have been invented. The object of these machines is to convey the milk from the teat into closed vessels by means of tubes. In some of these machines there are mechanical contrivances which imitate the action of the hand of the milker, in other machines the milk is drawn from the teat by producing a vacuum in the milk vessels and tubes.

Practical men have found milking machines less advantageous than had been expected. Even if it were proved that the working of these machines is satisfactory from a mechanical point of view, that the cows get easily accustomed to them, and that the persons in charge learn rapidly how to carry out the operations without frequent mishaps, there would still remain a very serious objection to their use, and that is the difficulty of sterilizing them thoroughly. Unless all the tubes, valves, and vessels forming parts of these machines are kept thoroughly clean and sterilized, they are capable of seriously contaminating large quantities of milk.

It appears therefore that, for practical purposes, the use of the covered pails is indicated ; it is also obvious that the more completely the pails are covered the less chance there is of contamination during milking. It is, therefore, desirable that milkers should learn how to direct the milk through as small an opening as possible. A lateral opening preventing completely the direct fall of dust into the pail is preferable to one turned upwards.

3.—Sterilization of dairy vessels.

The precautions taken to protect milk at the time of milking is in great part wasted if care is not taken that the fluid does not come afterwards in contact with pails, coolers, strainers, or churns which are not free from bacterial contamination.

Polishing, washing, and even scalding of dairy utensils are not sufficient protection against bacteria.

I have shown that pails, coolers, and churns which had been cleaned with very pure cold and hot water, and which were apparently clean and well polished, were still capable of imparting a large number of bacteria to milk. This is due to the difficulty of removing the last traces of the milk which has previously been contained in the vessels, and which remain as an invisible film adhering to the surface of these vessels. This difficulty is increased by the irregularities, recesses, fissures or chinks found in dairy vessels of usual construction (*see* plate VII.).

After the pails have been cleaned they are usually, and quite properly, turned mouth downward and allowed to dry on a rack, but the water draining from the pail wets the rack, which though apparently clean is not sterile (it is usually contaminated with some traces of organic matter teaming with bacteria). While the pail is drying, the bacteria, either by their own motion or as a result of capillarity, ascend from the rack in the thin layer of water covering at first the inside of the vessel (*see* plates XIA. and XII.).

It is also difficult to remove all the organic matter which accumulates in the chink between the bottom and sides of a pail of the usual pattern. Mere scalding with hot water or even boiling water is not sufficient to kill all the bacteria protected by this organic matter, which is little else than stale, more or less decomposed, milk. The same remarks apply to cans and churns.

As regards coolers, these are generally left exposed to dust for several hours before being used. In a good dairy there is very little dust in the air, but I have shown that even in a clean dairy enough dust can accumulate on the surface of a clean cooler to contaminate materially milk passed over it (*see* plate IIIc. and plate XIb.).

In small farms the cooler must often be the source of serious contamination.

In order that the surface of ordinary coolers should be capable of being disinfected and protected against dust, important alterations would be required; fortunately, I do not think that cooling as it is usually carried out at the farm is indispensable if milk is protected against dirt from the first. I will, therefore, confine my remark, to sterilization of milk pails, cans, and churns.

I have already stated that scalding—*i.e.*, the pouring of water boiling or nearly boiling into these vessels—is inadequate. It is impossible by such methods to bring the walls of the vessels to a temperature sufficiently high to produce disinfection.

The plunging of the vessels into boiling water would give better results but is impracticable, not only on account of the difficulty of the operation but also because of the great amount of fuel which would be required to boil the necessary quantity of water and of the considerable amount of time which is needed to raise a large amount of water to the boiling point.

A similar objection can be offered to the idea that pails and churns could be disinfected by boiling water in them.

Disinfection by steam is the only method which is at the same time rapid, easy to carry out, inexpensive, and absolutely efficient.

This has been realised for a long time in large farms and dairies where steam boilers are kept for various purposes, but the steam generated in these boilers is not always used so as to secure the desired effect, owing to the mistaken idea that steam under pressure is needed for the purpose in view. A small jet of steam at high pressure injected into a vessel with a large opening may entirely fail to disinfect that vessel if care has not been taken that the opening of the vessel is so guarded as to force the steam to fill entirely the vessel before it condenses or escapes from it.

A clean milk pail which has been completely filled for ten minutes with steam at atmospheric pressure is sufficiently disinfected for dairy purposes. Therefore, unless a steam boiler is already available, it is unnecessary to incur for disinfection purposes the expenses which such a boiler would entail. Even when a large boiler is at hand it may often be found more economical to produce the steam necessary for disinfection in a smaller, lighter, and more rapid boiler.

This is fortunate, for disinfection would be beyond the means of many small farmers if an ordinary steam boiler were necessary. Even if the cost of the boiler itself was not prohibitive, that of the fuel would be a source of difficulty.

The difference in the cost of fuel necessary to fill a vessel with boiling water and with steam respectively is rendered obvious by a few elementary theoretical considerations.

The weight of the water contained in a one-gallon can is 10lbs.

To raise 10lbs. of water from a temperature of 32° F. to 212° F. an expenditure of 1,809 B.T.U. is necessary.

The volume of water which it would be necessary to boil in order to obtain enough steam to fill the space occupied by the water would be, when the temperature of the vessel was 212° F., 1,700 times less than that occupied by the 10lbs. of water. This volume of water would weigh about 41.41 grains or $\frac{1}{170}$ part of a pound.

To heat 1lb. of water from 32° F. to 212° F. requires	180.9 B.T.U.
To change 1lb. of water at 212° F. to steam at 212° F. requires	965.7 B.T.U.
To change 1lb. of water at 32° F. to 1lb. of steam at 212° F. requires	1,146.6

The number of thermal units needed to produce enough steam to fill a gallon vessel would therefore be approximately $\frac{1146.6}{170} = 6.7$ B.T.U. This does not take account of the amount of heat necessary to heat the vessel itself.

Some of the advantages of disinfection by steam can be demonstrated by the following experiment :—

A milk-can of a capacity of a little over 2 gallons, and containing 20lbs. of water, is placed over a powerful gas burner.

A recording thermometer is plunged into the water, and the can is closed by a cover with a small opening for the escape of steam. The time necessary to raise the temperature of the water to 100° C. (212° F.) is recorded.

The same can containing only 1lb. of water is placed over the same source of heat, the recording thermometer is fixed in the same position, and the can is covered in the same way as in the previous experiment. The temperature of the water and of the air is the same at the beginning of each experiment.

Time necessary to fill the can with steam at 212° F., 6 minutes.

,, ,, ,, ,, ,, boiling water at 212° F., 60 minutes.

Although the amount of water heated to generate steam was 85 times greater than that theoretically necessary, the amount of time and heat expended in filling the can with steam was 10 times less than that necessary to fill the same vessel with boiling water.

When a suitable method of generating steam is used, and several vessels are sterilized at the same time, the economy of the fuel and time is much greater than that indicated by this rough experiment.

To produce steam rapidly in a large quantity and with no unnecessary expenditure in fuel it is necessary to use boilers with comparatively thin walls, in which the water is spread in a thin layer over a large heated surface. For the purpose of current disinfection of dairy vessels, steam at ordinary atmospheric pressure is sufficient; the boiler does not require to be of heavy construction, in fact a kettle (1 gallon in capacity) may supply all the steam necessary to disinfect sufficiently in less than a quarter of an hour at least six pails of about 2 gallons capacity each. An ordinary kettle is, however, not so advantageous for the purpose as a small boiler of very low shape providing a large heating surface, and adapted to the various means of heating available.

A large steam outlet is also necessary in order to allow a free exit for the large amount of steam which is generated very rapidly.

For the sake of economy and as a matter of convenience it is also desirable to allow the hot water resulting from the condensation of steam in the dairy vessels to return to the boiler.

To generate steam rapidly it is necessary that the heating arrangements should make it possible to secure rapid and complete combustion of whatever fuel is used. Slow fires are not suitable for the purpose, and are not economical.

In order to meet these various requirements, I have used for many years a simple kind of boiler or kettle which can be heated by gas or paraffin burners, or over wood, coke, or fuel fires. The portable model I have used for demonstration purposes and for the experiments at Holmes Chapel is shown in the photograph accompanying this report, and permits of the disinfection of three 2-gallon pails and one 2-gallon can at the same time; it also provides enough steam for a steam cylinder suitable for the disinfection of various articles such as straining cloths. All these articles can be disinfected at one operation of fifteen to twenty minutes' duration and at an expenditure of less than 1d. of paraffin oil (at pre-war prices). The cost of various fuels and other circumstances would determine whether paraffin oil, gas, coke, coal, or wood would be the best fuel to use at a given place. The boiler is so constructed that any of these fuels could be used. Paraffin and gas when available are undoubtedly the most convenient sources of heat for the purpose.

The apparatus shown in the photograph (Plate IX.), though convenient for demonstration and experimental purposes, is not the form I would recommend for general use. It is composed of a boiler and of a series of tubes with suitable shields, all of the same pattern, interchangeable, and

forming the connecting link between the boiler and the dairy utensils undergoing disinfection. For practical purposes these connecting tubes and shields should be fixed to a firm table or bench and connected to the boiler by rigid tubes instead of the articulated tubes used in the model. The essential parts are :—

(*a*) A flat boiler with a large heating bottom plate and a large outlet tube allowing free escape of steam and free return of condensation water. The arrangements for feeding such a boiler with water may be intermittent or continuous, automatic or not.

(*b*) A series of wide tubes arising from the upper side of the main steam channel and directed vertically upwards. Round the base of each of these tubes there is a shield upon which pails, cans, or churns can be placed mouth downwards, so that when these vessels are in position their mouth is fairly completely closed by the shield. This shield is funnel-shaped, so that the water of condensation can by means of suitable openings return to the steam pipe, the size of which is such that the pressure of the steam is not sufficient to prevent the return of the condensation water (Plate VIII., A, B, C, D, E).

The number of disinfecting tubes and shields which can be connected with one boiler depends on the size of the boiler and on the amount of heat that is available for heating the water.

With a boiler holding six quarts of water and a source of heat capable of causing this amount of water to boil in six minutes, I have connected 6 disinfecting tubes with the boiler in my experimental apparatus and this combination allows six 2-gallon pails or cans to be disinfected in 15 to 20 minutes from the time of lighting the paraffin furnace and starting with cold water. A larger number of pails or cans could be sterilized with the same apparatus, which would also be applicable to the sterlizatiion of full-size churns. I do not wish, however, to state exactly the capacity of an apparatus of the size used in my experiments without making some practical trials. I hope the Committee will give me the opportunity of having this part of the work carried out under my direction.

After sterilizing the milk pails, churns, or other utensils they should, if not used immediately, be dried as rapidly as possible and in such a way as to prevent their being recontaminated by any dust floating in the air: this result is obtained by turning them mouth downwards. In most dairies the pails and cans are placed bottom upwards upon sloping shelves or racks. I have seen churns allowed to drain mouth downwards upon a stone or tiled floor. Some trouble is no doubt taken to keep shelves, racks, and floors clean in the ordinary sense of the word, but these after a short exposure to the air are generally covered with a thin layer of dust partly composed of bacteria. Moreover, ordinary washing does not completely remove the remnants of organic matter which is in great part derived from the diluted milk which has drained off on previous occasions from incompletely washed vessels. This thin film contains a large number of bacteria such as are found in stale milk.

When a damp vessel is dried over these apparently clean and dry shelves, the water running from the vessel moistens the support, and wherever contact is established between the lips of the vessel and the rack supporting it the bacteria contaminating the rack rise by capillarity or by their own motion in the thin layer of water lining the inside of the vessel. These bacteria contaminate in this way a large part of the internal surface of the vessel, where they remain fixed when the vessel is dry. Very few of these bacteria are killed by drying, and when milk is poured into such a vessel these living bacteria get loose and contaminate the fluid (*see* Table XIV. and Plate XII).

In order to prevent this source of contamination, I have found it necessary to hang the pails, cans, churns, etc., during drying so as to avoid any contact of the border of the pail with any solid object. To do this I have had pails made with three feet of strong wire, forming loops, by which the pails can be hung mouth downwards whilst they are drying, the same loops can be used to hold the pails and cans in position while they are disinfected, so that at the end of the disinfection they can be pulled up for drying without being touched by the hand. Lids may be sterilized *in situ* by the adoption of certain devices, or they may be disinfected separately in a special steam cylinder connected also with the boiler.

4.—Protection of fresh milk against admixture with stale milk (fluid or dry).

It seems hardly necessary to point out the injurious effects of the addition of stale milk to fresh milk, but there is evidence that fresh milk is often spoilt in this way. The very bulky sediments obtained from some of the samples examined in the course of this investigation were due to the presence of small curds such as would be produced by the mixing of milk partly soured and on the verge of clotting with an excess of fresh milk. It is probable that in the cases in which this was observed the souring milk had been heated before being mixed with the fresh milk. It is possible that this mixing of fresh and stale milk is done quite innocently and in ignorance of the consequences. This might occur for instance if a dairyman mixed the apparently good remnants of his morning delivery with the fresh milk received by him in the afternoon or on the following morning. The consequence of such an act is an immediate increase in the number of bacteria, and a considerable reduction of the period during which the milk remains useful.

Good milk may also be spoilt by being poured into a churn which has not been thoroughly cleaned and sterilized after containing contaminated milk or milk which has been allowed to become sour. I have shown that this is also one of the ways in which a small quantity of milk may infect many gallons of milk with pathogenic bacteria.

I have proved that a milk pail, can, or churn which has been dried without being sterilized, or which has been recontaminated, may contain bacteria originally derived from stale milk.

The chief remedies against these sources of contamination are :—

(1) The sterilization of all milk vessels each time they have been or are going to be used.

(2) The keeping of fresh milk and of older milk in separate vessels.

(3) The avoidance of unnecessary handling and transference from vessel to vessel.

The milk of healthy cows collected cleanly in sterilized bottles at the farm generally remains sweet for 48 to 72 hours, even when not refrigerated at the farm.

The same is not true of milk which has been collected in ordinary milk pails, strained in bulk, cooled over an ordinary cooler, conveyed to town in an ordinary churn, mixed with other milk, separated and reconstituted, etc., etc., at a town dairy, and distributed often with gross carelessness by the milkman.

Milk messed in this way has a very short life, and in summer is often sour in less than 12 hours.

5.—Avoidance of straining through a common strainer.

I think it unnecessary to insist more than I have done already upon the bad effects of straining as it is conducted at present. The improvement in the appearance of the milk from which gross contaminations such as hairs, various fibres, bits of straw or hay, grit, etc., have been removed by straining in bulk is bought at the expense of a dissemination of bacteria which is very detrimental to the life of the milk, and may be the means of infecting a large quantity of good by a small amount of bad milk.

Careful milking in covered pails should reduce considerably the amount of these gross impurities, and a few unavoidable hairs can be stopped at the time of milking if the milk of each cow is made to pass through a small piece of sterilized straining cloth as it enters the sterilized pail.

6.—Avoidance of cooling by methods causing large surfaces of milk to be exposed to air or to contact with extensive unsterilized surfaces.

Milk collected with proper care generally contains fewer bacteria than the same milk immediately after passage over coolers of the usual type.

Milk *originally clean* does not keep so long after passage over an ordinary cooler as the clean milk left alone.

When the milk is *originally very dirty*, it is probable that cooling is always advantageous, and that cooled dirty milk keeps longer than uncooled dirty milk.

The object of cooling is to prevent the rapid multiplication of bacteria. When the bacteria present in quite fresh milk are as few as is the case when proper care is taken, there is no appreciable increase in the number of bacteria during the three or four hours immediately following milking.

7.—Cooling of the milk by keeping the churns in cold stores or places.

Cooling at the farm itself appears therefore to be unnecessary. If proper arrangements were devised for conveying milk from farm to town and receiving it without delay at suitable distribution centres, the milk coming from considerable distances should arrive quite fresh to the consumer. It would, however, be a matter of advantage if the milk were cooled as soon as this can be done in a proper way.

As the process of cooling milk in bulk is a slow one, it would be preferable to adopt churns smaller than those in general use at present.

The cooling of the churns should begin in transit. There should be covered cool sheds at all railway stations where farmers bring their milk, the railway companies should provide special clean, cool, vans for the transport of milk to town. The type of churns in general use is very objectionable, and should be replaced by a form of churn more easily cleaned and protecting the milk more efficiently against contamination by dust, water, etc., while in transit.

8.—Distribution of milk to consumers.

For the reasons already stated, the milk should be handled with great care and as seldom as possible. It would therefore be a matter of advantage if the milk for small consumers were bottled in sterilized bottles or cans, sealed if thought necessary at controlled distribution centres under constant supervision. By using three sizes of bottles, the quantities required by each customer could be supplied and varied within certain limits. Large institutions should receive the churns as they arrive from the country.

9.—Utilisation of unused remnants.

It is obvious that milk capable of keeping sweet over 48 hours, distributed as explained above, and not sold by the end of the day, should still be good when returning to the distribution centre on the same day. This milk could then be utilised in various ways, *i.e.*, sterilized, dried, made into cheese, etc.

The amount of milk wasted at the present time owing to the short life which it owes to bad handling is very considerable. Both on hygienic and commercial grounds, such a loss is greatly to be deplored. Close observance of the precautions I have indicated would prevent such a loss.

The observance of these precautions is not difficult. I have no doubt that even small farmers would learn rapidly what has to be done. Large farmers should not require to be instructed on those matters, but many of them do. The practice I recommend is in many respects simpler than the present practice, and the expense connected with it is small. It is probable that by reducing the losses incurred at present through premature souring this outlay would be more than covered.

GENERAL REMARKS AND CONCLUSIONS.

This report deals only with the clean milk standards question. The connection of cows' milk with various diseases has purposely been left out of consideration.

It is, however, well to remember that while certain diseases affecting cows alter the characters and bacterial contents of milk, there are other diseases, such as tuberculosis, which would remain undetected in the large majority of cases if special tests were not used.

With regard to the conveyance of human diseases by milk, this is specially liable to happen when the milk is carelessly handled and dirty. The securing of a high standard of cleanness would, therefore, reduce the danger of the conveyance of infection from person to person by milk.

This report deals only with the evidence collected in Manchester. Several reports and other publications have appeared in America and England in the course of the last eight or ten years: these deal with evidence collected in other parts of the country and abroad.

Some of these publications show evidence that the work which had previously been done in Manchester has not been without influence outside Manchester. Generally speaking, the views of other observers have become more and more concordant with those which I have held for more than 25 years, and this agreement may be taken as supporting the soundness of these views. I am still inclined to go somewhat further than most British and American authorities.

It did not appear to me necessary to burden this report with a review of outside work, as first-hand evidence seemed to be what the Committee had asked me to supply them with.

Relative value of various methods of testing as regards the grading of milk according to cleanness.

Of the six groups of methods discussed in this report, there are several which would not supply the means of estimating the cleanness of milk for purposes of grading, or of fixing cleanness standards suitable for administrative purposes. These are :—

(1) The chemical methods.

(2) The filtration or sedimentation methods.

(3) The microscopical methods

(4) The inoculation methods.

All these methods yield valuable information, some of which is indispensable for special investigation and administrative purposes, but for reasons given in the body of the report they do not supply the required means of classification as regards cleanness.

The only two methods which can be recommended as bases for the administrative control of the cleanness of milk are :—

(5) The cultivation method.

(6) The incubation method.

The cultivation method (bacterial counts) is already used extensively, is comparatively simple, and, in careful hands, supplies clear data. The chief objections which may be offered to it are that when a large number of samples have to be tested—

(1) The amount of apparatus and culture media required is considerable.

(2) The services of a bacteriologist with some experience and accustomed to work quickly and accurately are needed.

(3) Much time is required.

A classification of the milk sample examined in the course of the investigation on the basis of bacterial counts is given in the following table.

CLASSIFICATION OF SAMPLES DEALT WITH IN THE REPORT ACCORDING TO THE NUMBER O BACTERIA PER CUBIC CENTIMETRE OF MILK GROWING ON NUTRIENT AGAR AT 37° C IN 48 HOURS.

PLACE OF COLLECTION OF SAMPLES	BACTERIA GROWING ON AGAR AT 37° C. IN 48 HOURS.						
	Under 100	100 to 1,000	1,000 to 10,000	10,000 to 50,000	50,000 to 100,000	100,000 to 1,000,000	Over one million
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
A—Railway stations, large dairies and dealers. Samples collected on arrival at town ...	0	4	20	29	15	26	3
Hospitals and milk depots. Samples collected at these Institutions	0	0	0	6	10	43	39
General shops. Samples collected at shops	0	0	30	20	0	20	30
B—Milk collected and conveyed to town in sterilized vessels ...	69	14	16	0	0	0	0

The figures given in Section A of this tabulated summary bring out the fact that the milk supplied to Manchester generally contains a very large number of bacteria, and that under any system of grading a large proportion of it would have to be classed very low. The figures given in Section B show that this state of things would be remedied if the methods used at the farm and in transit were improved.

The results obtained by *the incubation method* (*souring test*) are in general agreement with those of the cultivation method.

CLASSIFICATION OF SAMPLES DEALT WITH IN THIS REPORT ACCORDING TO THE SOURING TIME.

NUMBER OF SAMPLES SOURING WITHIN EACH OF EIGHT STATED TIME PERIODS.

	Over 55 hours per cent.	45–55 hours per cent.	35–45 hours per cent.	25–35 hours per cent.	20–25 hours per cent.	15–20 hours per cent.	10–15 hours per cent.	Under 10 hours per cent.
Milk treated as usual and collected at :—								
A—Dairies. (99 samples) ...	0	0	0	0	0	85	0	14
Hospitals ,, ...	0	0	0	0	5	13	55	26
General shops. (100 samples)	0	0	0	0	0	20	40	40
B—Milk collected and conveyed to town in sterilized vessels. (Not strained, not cooled.) (100 samples.)	20	60	20	0	0	0	0	0

This method is based upon the effects which the number of some of the most common dirt bacteria has upon the state of the milk.

The advantage of this method is that it is simple, gives clear and important results, requires very little apparatus, no cultivation media, and that a careful accurate person can be trained to carry it out successfully in a very short time. The objections are that the method is not in general use, and that the evidence which I have collected so far is not considerable.

A comparison of the figures in Sections A and B of this table shows that in summer the life of milk supplied to Manchester under the present conditions seldom exceeds 20 hours, and is often less than 10 hours, but that, when properly collected and distributed, cows' milk should remain good for over 45 hours in 80 per cent. of the cases and for more than 35 hours in all cases.

Conditions which promote a dirty state, bacterial contamination, and rapid souring.

These may be summed up as follows :—

Dirty shippons, cows, and farm hands.

Unsterilized uncovered milk pails.

Straining in bulk.

Cooling at the farm by surface coolers.

Unsterilized churns of unsuitable construction.

Non protection of churns against dirt and heat in transit.

Unnecessary handling at the town dairies.

Careless and faulty handling during distribution.

Conditions which promote cleanness of milk.

Special milking sheds or open-air milking.

Clean shippons, cows and farm hands.

Sterilized covered milk pails.

No handling of milk at the farm beyond transfer from sterilized pail to sterilized churn.

Rapid transit from farm to town.

Protection of churns against dust and heat in transit.

Distribution of milk to consumer with as little handling as possible.

With regard to this last recommendation, what I mean is that the milk from farms having a clean bill of health, on arrival at distribution centres (under the close control of the Sanitary Authority), should be transferred (automatically if possible), after equalisation, to sterilized bottles or other vessels which would be sealed aseptically at once. All the milk should be supplied to consumers who require fresh milk bottled in this way. Any milk not sold should on return to the distributing centre be utilised by being sterilized, dried, or turned into various dairy produce. As the life of clean milk is over 24 hours, the surplus fresh milk could thus be utilised and waste would be prevented.

It appears that until such arrangements are available, all milk should be boiled at the consumer's house or sterilized before being distributed.

Several of the practices which I have condemned are so prevalent and are so much sanctioned by authorities on dairying that the average farmer could not be expected to supply regularly milk capable of passing even a low bacterial standard unless the faultiness of some of the methods in use had previously been clearly demonstrated and explained to him.

On the other hand, as the precautions which are necessary are easily learnt and carried out, it would be reasonable to expect a duly instructed farmer to supply milk satisfying a fairly high standard of purity. Further administrative action and progress would naturally follow.

ADDENDUM 1.

For the convenience of the members of the Committee I have prepared a short synopsis of the main recommendations relating to the *grading of raw milk* made by the American Commission on Milk Standards. This Commission was appointed in 1911, and issued its 3rd report in 1917. (Public Health Reports (issued by the U.S. Public Health Service), Vol. 32, p. 271—Washington, 1917.)

The recommendations relating to the grading of *raw milk* on the basis of bacterial counts are summed up in the following passages taken from the report :—

P. 274.—Standard milk should contain not less than 8.5 per cent. of solids not fat, and not less than 3.25 per cent. of milk fat.

P. 282.—The Commission believes that all milk should be classified by dividing it into three grades.

Raw Milk.—*Grade A.*—Milk of cows free from disease as determined by tuberculin tests and physical examination by a qualified veterinarian.

Milk produced and handled by employees free from disease, as determined by medical inspection of a qualified physician, under sanitary conditions such that the bacterial count shall not exceed 10,000 per cubic centimetre at the time of delivery to the consumer.

Grade B.—Milk from cows free from disease as determined by physical examination, of which one each year shall be by a qualified veterinarian, and produced and handled under sanitary conditions, such that the bacterial counts at no time exceeds 1,000,000 per cubic centimetre.

Grade C.—Milk from cows free from disease as determined by physical examinations produced under conditions such that the bacteria count is in excess of 1,000,000 per cubic centimetre.

Whenever any large city or community finds it necessary on account of the length of the haul or other peculiar conditions to allow the sale of *grade C milk*, its sale shall be surrounded by safeguards such as to insure the *restriction of its use to cooking and manufacturing purposes.*

P. 277.—The standard methods of the American Public Health Association, Laboratory Section, to be adopted as standards for making the bacterial counts. (The medium recommended by this Association is nutrient agar containing 1 per cent. of agar and of a reaction of +1.5. The plates are incubated at 37° C. for 40 to 48 hours.)

P. 291–293.—The first meeting of the Commission was held at the New York Academy of Medicine on May 22nd, 1911. Conferences leading to it had previously been held in 1907 at Washington, and in 1910 at New York.

Addendum 2.

I have often in past years attempted, without great success, to estimate the loss due to premature souring of milk. The only information I have been able to obtain on this point will be found in the second interim report of the Committee on the Productions and Distribution of Milk (London, November 30th, 1917), from which the following lines are quoted (22, p. 6.) :—

> " One firm stated that the quantity of milk received in a sour
> " condition between April and August, 1917, was over 4,000 churns—
> " approximately 68,000 gallons, with a value of about £4,000—and
> " several independent witnesses gave it as their opinion, based on

" their own experience, that the average percentage of London milk
" lost through souring was from one per cent. in winter to at least two
" per cent. in summer. As the total quantity of milk sent by rail to
" London annually has been estimated to be some 90,000,000 gallons,
" a loss of even one per cent. annually would amount to 900,000
" gallons, which at 1s. 2d. per gallon amounted to £52,000 before the
" war, and now at 2s. per gallon would total £90,000."

This estimate does not appear to take account of the loss incurred after the milk has reached the consumers.

Addendum 3.

The Souring Test in relation to the Cleanness of Milk.

I have devised a method by which, with very little apparatus and no reagent or cultivation media, it is possible to estimate the extent to which cow's milk is contaminated and at the same time its keeping quality—that is, the duration of its period of usefulness as a fresh product.

The principle of the method is explained at p. 16 of the report.

The apparatus required consists of :—

A series of small test tubes of a capacity of about ½ ounce.

An incubator or water bath kept at a constant temperature by a heat regulator, and containing a rack with numbered holes for the test tubes.

A second water bath to which the rack and tubes are transferred after incubation, and kept at the boiling temperature for 10 minutes. (When the number of samples to be tested is small, a single water bath may serve both for incubating and boiling.)

If, say, twenty samples have to be tested, about ¼ of an ounce of each sample is poured into a tube, numbered so as to make the identification of the samples easy.

These twenty samples are then incubated at 35° C. for 15 hours, at the end of which the tubes are immersed in the bath of boiling water and left there for 10 minutes.

On removal from this boiling water the contents of the tubes are examined. All the badly contaminated samples will be found clotted. The characters of the clots and the amount of gas given off (indicated by the amount of frothing) show within certain limits the degree of contamination.

To estimate more exactly the degree of contamination, it is necessary to incubate three or four tubes of each sample. One of the tubes is placed in boiling water at the end of 10 hours ; if this is not coagulated, a second tube is boiled at the end of 16 hours, a third tube at the end of 20 hours,

and, if occasion arises, the fourth at the end of 24 hours. Very few samples of milk will stand incubation at 35° for 24 hours without clotting when heated to 100° C. at the end of that period.

By incubating the milk at 25° C. or 30° C. instead of 35° C. the tests can be spread over a longer period, and finer differences in the degrees of contamination may thus be brought out.

After 15 to 20 hours incubation at 35° C. most of the samples of milk show no apparent change before being heated to 100° C. After being heated various changes are observable, which may be taken as indication of more or less extensive pollution. The most striking among these changes are :—

(1) A disengagement of gas, which causes the formation of froth on the surface.

(2) The formation of small curds, which thicken the milk.

(3) The production of a dense clot, which renders the whole milk solid, without separation of whey.

(4) The production of more or less broken up clot, with separation of whey.

After incubation at 35° C. for 15 to 20 hours, and boiling for 10 minutes, various degrees of pollution are indicated by the extent ot these changes.

	Gas	Clot	Whey
Very pure milk ...	No excess ...	None	None
Slightly polluted milk	Abundant .	Very small (milk thick)	,,
Polluted milk	,, ...	Large (milk solid) ...	,, or scanty
Heavily polluted milk	,, ...	Broken up (contracted)	Abundant

The following experiments show how the test brings out the differences caused, in the same milk, by the addition of measured quantities of polluting bacteria (Bacillus coli communis).

They show that milk which is materially *polluted* coagulates rapidly when heated to 100° C. :

A—After it has been incubated at 30° C. for 20 to 24 hours.

B— ,, ,, ,, ,, at 35° C. for 15 to 20 hours.

When the milk is very *heavily polluted*, coagulation is brought about in 15 hours when incubated at 30° C., and in 12 hours or less when incubated at 35° C.

Experiment 853.

Fresh clean Milk refrigerated for 3 days at + 4° C. after the addition of definite numbers of Bacillus Coli Communis.

Degree of clotting observed after heating to 100° C. for 10 minutes the various test samples incubated at 30° and at 35° C.

	Number of B.C.C. added to the Milk per C.C.	Incubated at 30° C.			Incubated at 35° C.		
		8hrs. Clot	12hrs. Clot	24hrs. Clot	8hrs. Clot	12hrs. Clot	24hrs. Clot
A—Cow milked in sterilized can 3 days before testing ...	0	0	0	0	0	0	2
B—Ditto	4,000,000	0	0	2	0	0	3
C—Ditto	40,000	0	0	1	0	0	3
D—Ditto	400	0	0	0	0	0	3
E—Ditto	4	0	0	0	0	0	3

In this experiment the difference between the samples incubated at 35° was not clearly brought out because no observation was made between the 12th and the 24th hour. In the samples incubated at 30° C. the amount of infection is more clearly indicated by the degree of clotting. (*See* explanation of signs at the foot of the following table.)

Experiment 856 (S.D.)

Fresh clean Milk and the same Milk after the addition of definite numbers of Bacillus coli communis. Degree of clotting and amount of gas observed after heating for 10 minutes the various test samples incubated at 30° C. and at 35° C.

	No. of Bacteria in Fresh Milk	No. of B.C.C. added per c.c. in millions	Incubation at 30°								Incubation at 35°							
			12 hours		15 hours		20 hours		21 hours		12 hours		15 hours		20 hours		21 hours	
			Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas
A.—Cow milked in sterilized can 5 hrs. before test begun	700	None	0	1	0	1	0	2	0	2	0	1	0	1	1	1	1	1
B. Ditto ...	„	20,000,000	0	1	2	3	3	3	3	3	2	1	3	2	3	3	3	3
C. Ditto ...	„	200,000	0	1	0?	3	3	3	3	3	1	1	2	3	3	3	3	3
D. Ditto ...	„	20,000	0	1	0?	3	2	2	2	2	0?	1	2	3	2	2	3	2
E. Ditto ...	„	2,000	0	1	0	1	1	1	1	1	0	1	1	1	2	1	2	2

None of the incubated specimens showed evidence of clotting before being heated to 100° C.

	Number of Bacteria in fresh Milk	Number of B.C.C. added per c.c. in millions	Incubation at 30°				Incubation at 35°			
			12 hours		24 hours		12 hours		24 hours	
			Clot	Gas	Clot	Gas	Clot	Gas	Clot	Gas
A.—Same samples as above tested after being kept in refrigerator at + 4° C. for 6 days	700	None	0	2	2*	2	0	2	0	2
B. Ditto ...	„	20,000,000	1	3	3	3	3	3	3	3
C. Ditto ...	„	200,000	0	3	3	3	1	3	3	3
D. Ditto ...	„	20,000	0	3	2	2	0	3	3	3
E. Ditto ...	„	2,000	0	2	2	2	0	1	3	3

Explanation of Signs. Clotting—1, Milk thickened. 2, Milk solid without clear separation of whey. 3, Milk with clots and whey.
Gas—1, About equal to normal amount. 2, Marked excess over normal. 3, Considerable excess causing much frothing.
* Apparently the result of accidental contamination.

PLATE I.

A, B, C—*Cells in Milk from a Tuberculous Udder* (× 1,000).

Milk from left fore quarter, enlarged and indurated.

Specific gravity—1,037. Reaction—Amphoterous.

No tubercle bacilli found microscopically.

Typical tuberculosis produced in 22 days by inoculation.

Sediment—very bulky.

Large, degenerated, granular and vacuolated cells—numerous.

Medium-sized epithelial cells, with one nucleus staining faintly—less numerous.

Small round or irregular cells (lymphocytes or small epithelial cells) with nucleus staining deeply and sometimes dividing—numerous.

Photographs—1,072, 1,073, 1,074. M.B.—8,747. A,B,C.

D—*Cells in Milk from Tuberculous Udder* (× 1,000).

Milk from left and right hind quarters, enlarged and indurated.

Specific gravity—1,031. Reaction—Amphoterous.

No tubercle bacilli found microscopically.

Typical tuberculosis produced in 22 days by inoculation.

Sediment—75 per 100,000.

Large epithelial cells—few.

Medium-sized epithelial cells with nucleus, staining faintly—few.

Small round cells (lymphocytes or small epithelial cells) with deeply stained nucleus—abundant.

Polymorpho-nuclear leucocytes (pus cells)—moderately abundant.

Red blood corpuscles—a few.

Photograph—1,071. M.B.—8,510. D.

PLATE I.

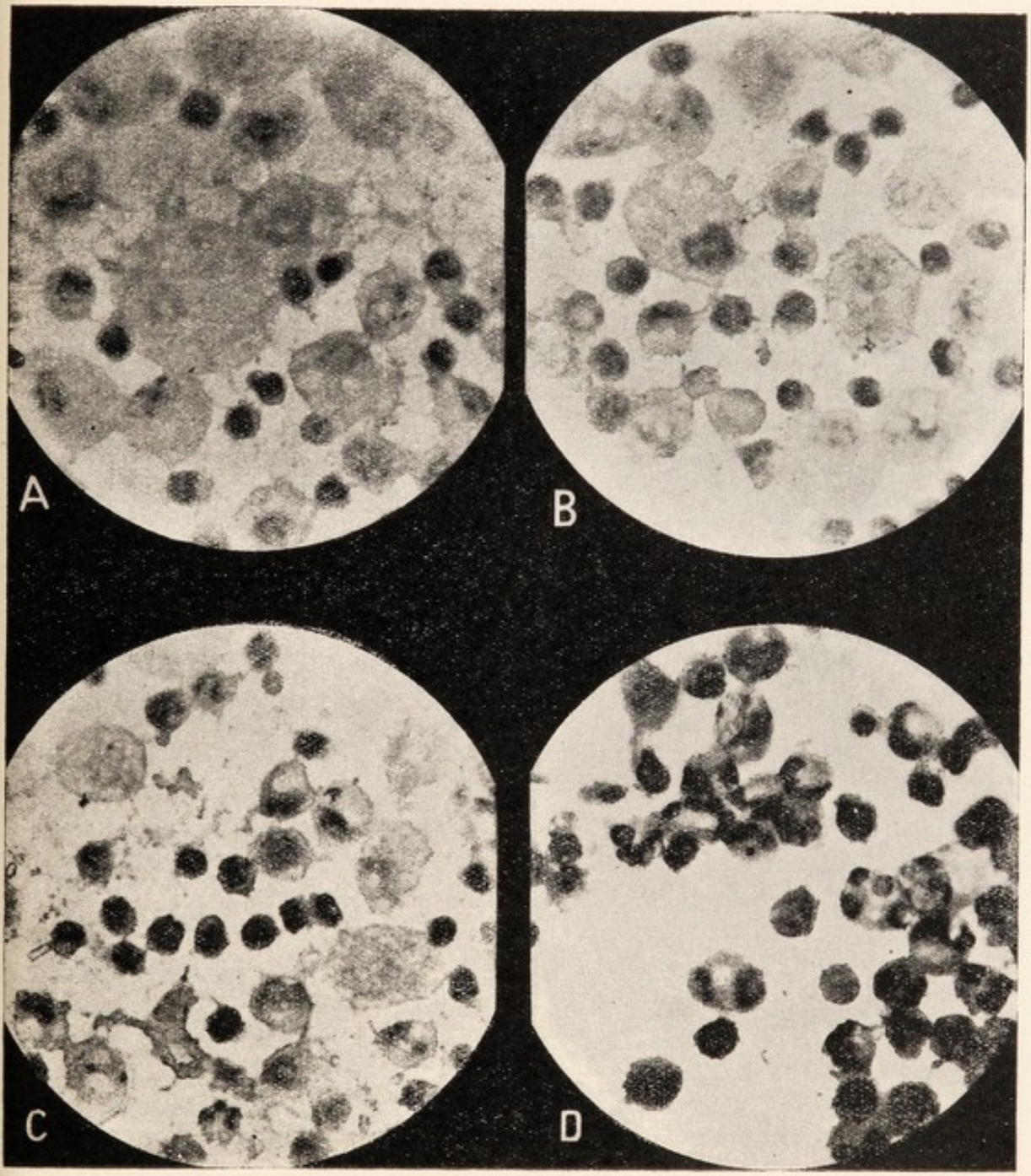


Plate II.

Some of the most common extraneous products (dirt) found in the sediment of Milk separated by centrifugalisation.

(*Slime separated at a large town dairy.*)

A—One hair and several fibres from clothing.

B—Carbonaceous and mineral particles.

C—Vegetable débris from fodder or litter.

D—Cells and large clumps of bacteria.

(As seen under a low power of the microscope.) (× 43.)

L.B.—1,038.

PLATE II.

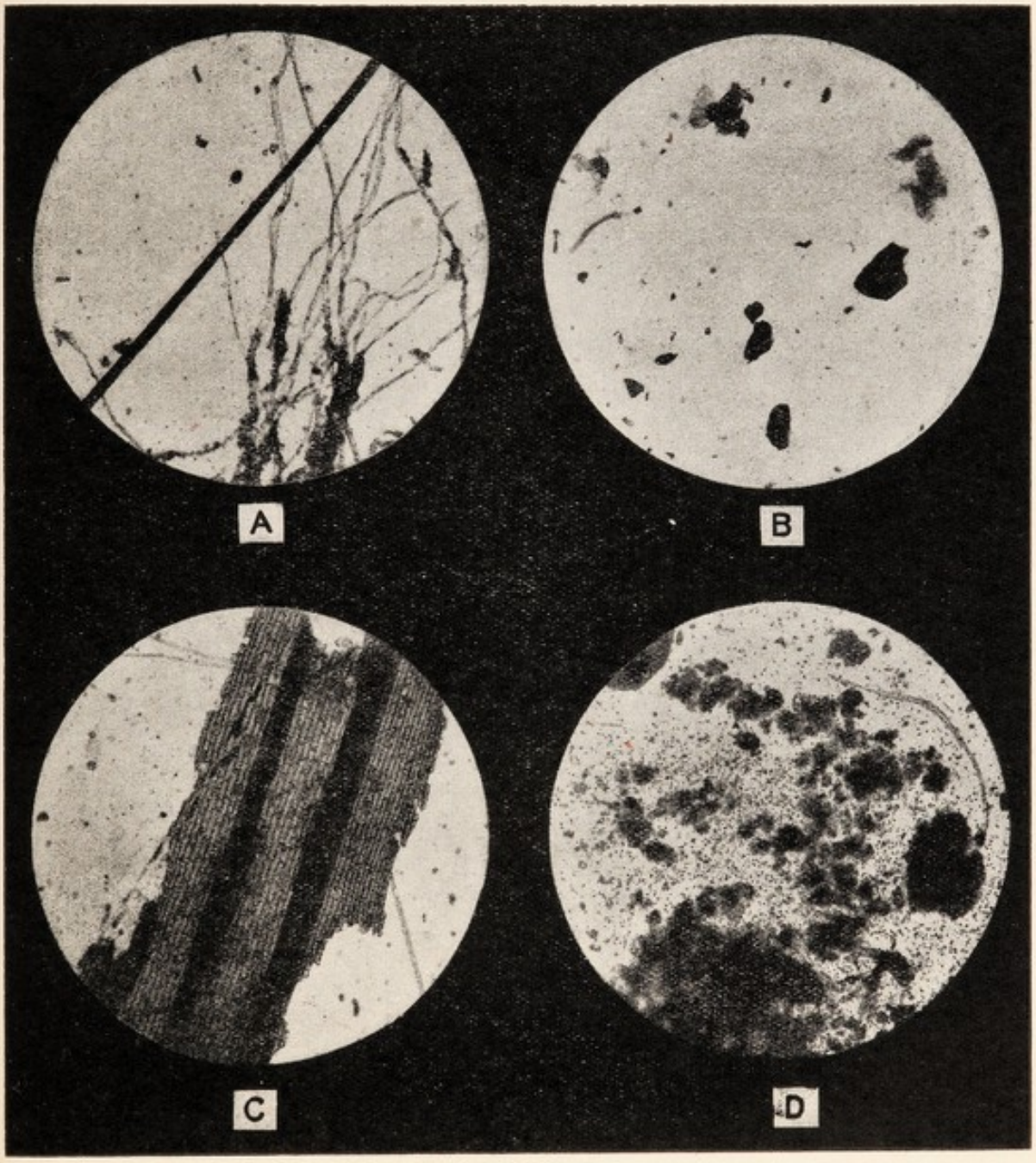


PLATE III.

Some of the sources of the bacteria introduced into Cows' Milk at the farm in the first quarter of an hour after milking.

Each of the Plates A, B, and C was made with $\frac{1}{100}$ cc. of Milk taken about quarter of an hour after milking.

A—Milk from a covered sterilized pail. Cow milked in a dirty shippon.

B—The same milk immediately after passage through a strainer which had been used as usual for the bulk of the milk.

C—The same milk passed over the cooler, apparently clean, and not used since last cleaned.

D—$\frac{1}{2000}$ part of a small amount (270 cc.) of water used to rinse a milk pail reputed clean, and which had been allowed to dry mouth downwards over an apparently clean draining board of the usual type. The mouth of the pail was in contact with the wood rails of the drainer. (Owing to over-crowding the colonies have remained very small, many of them being only visible with the help of the microscope.)

L.B.—8,812.

PLATE III.

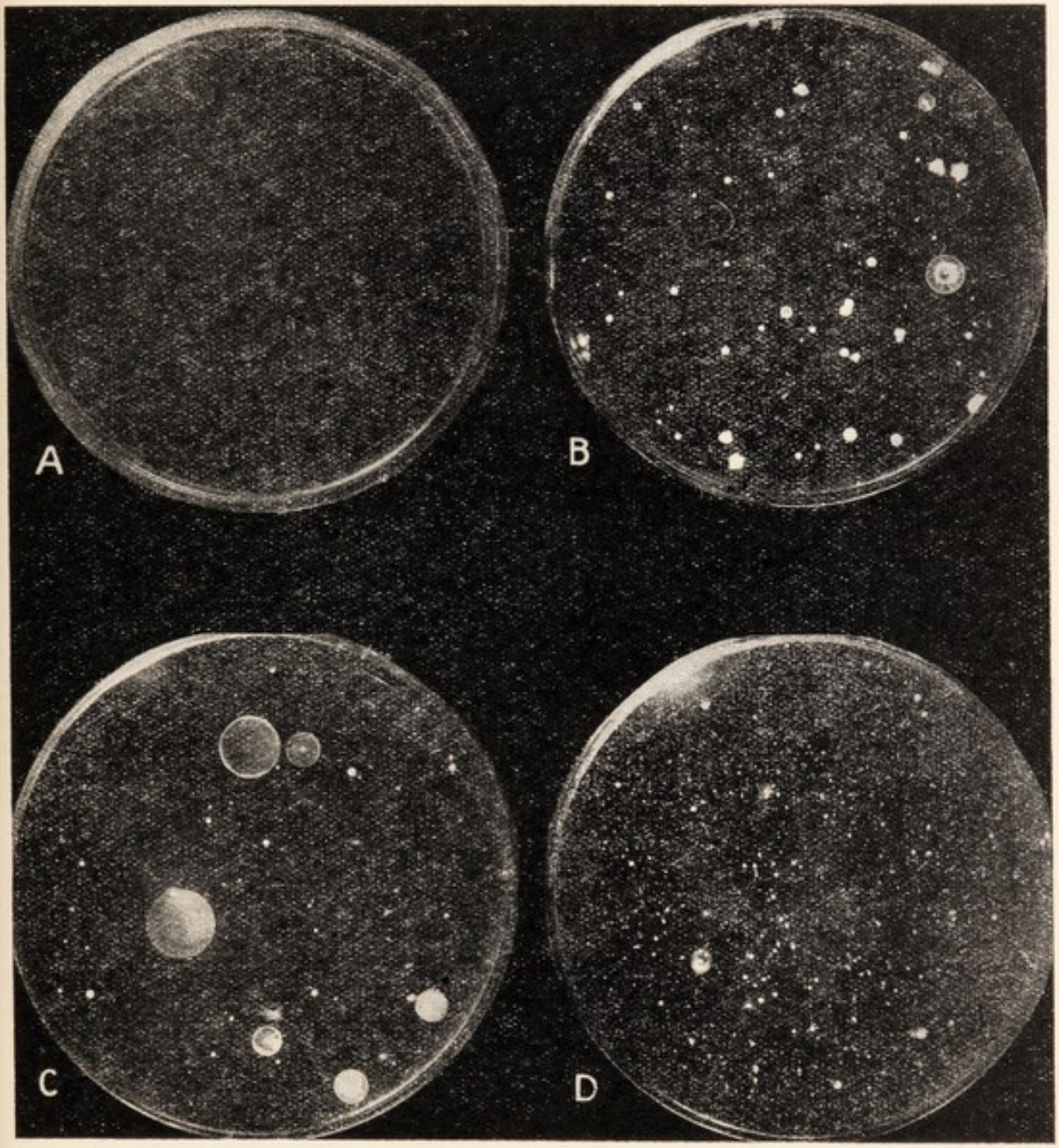


PLATE IV.

Bacteria in the Air at a Dairy Farm.
Each of the Plates was exposed to the air for two minutes.

A—Air near the cooler in the clean dairy.

B—Air at a height of 6 feet in a dirty shippon.

C—Air under the belly (1 foot from udder) during milking in a clean shippon.

D—Air under the belly (1 foot from udder) during milking in a dirty shippon.

L.B.—8,814.

PLATE IV.

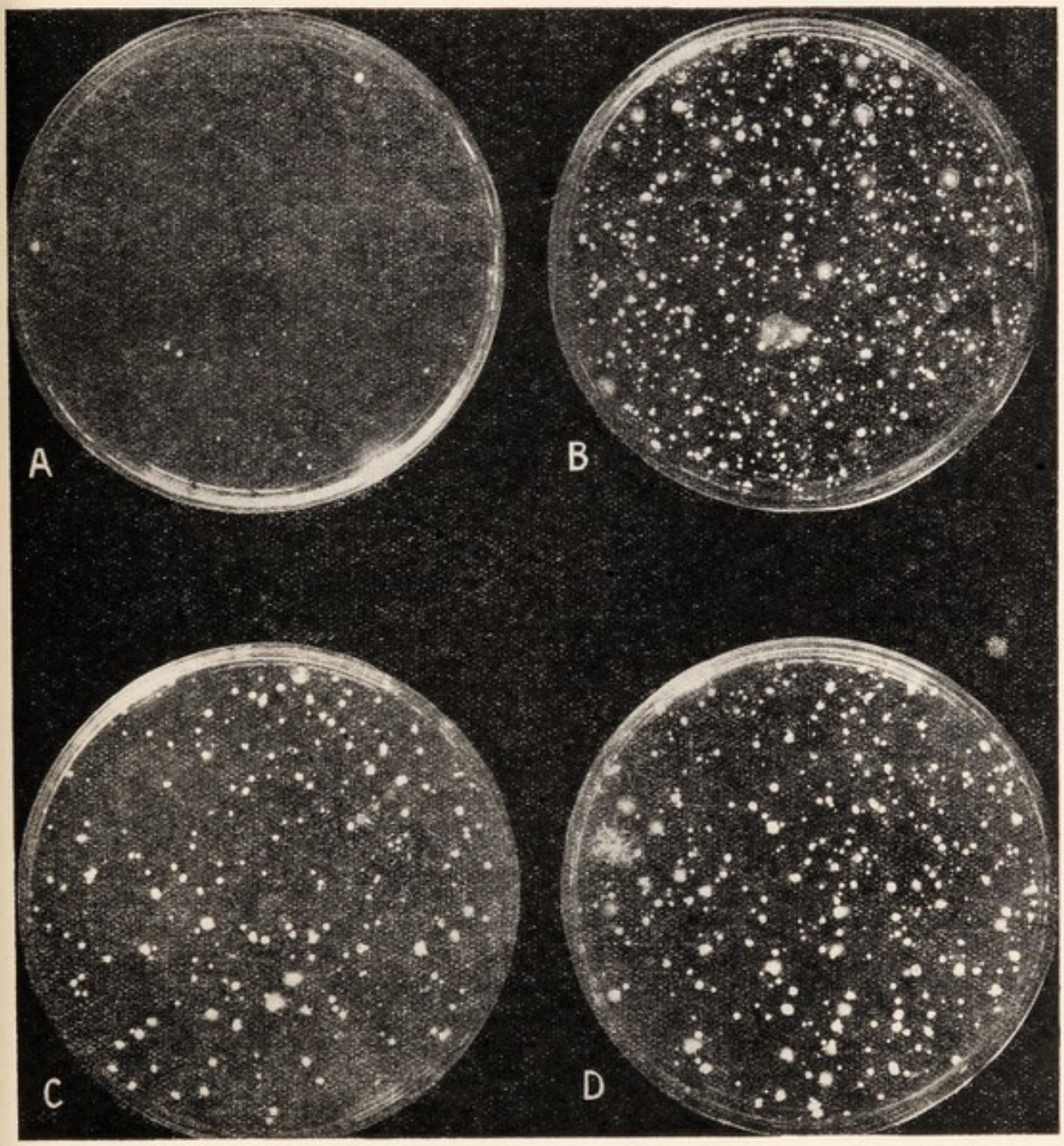


PLATE V.

The Jersey Milk Can or Pail.

A prototype of the modern milk pail. The shape of this can is preferable to that of most modern milk pails.

1—A milker holding a Jersey milk can, the mouth of which is covered with a straining cloth (open-air milking).

2—Side view of the Jersey milk can.

PLATE V.

1

2

From photographs by E. Mathews Esq.

PLATE VI.

Milk Pails used in America.

The Milk Question, p. 281.—M. J. Rosenau (1913).

One open and eleven covered milk pails.

Some of the covered milk pails prevent fairly completely access of dirt to the pail during milking.

Their construction is, however, generally faulty, and the fixed lids make cleaning difficult.

In some cases the shape of the lid would make efficient disinfection very difficult.

PLATE VI.

FIG. 1. ATLANTIC PAIL

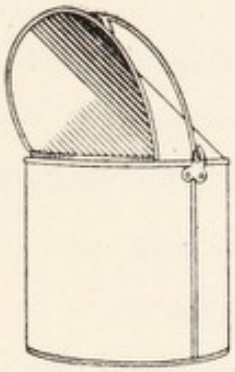


FIG. 2 CHAMPION PAIL.

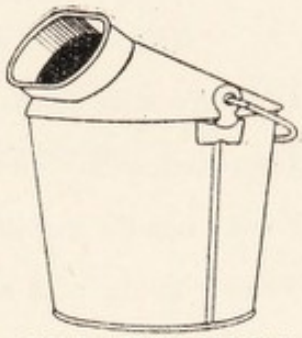


FIG. 3. FRANCISCO PAIL

FIG 1 OPEN PAIL.

FIG 2 FREEMAN PAIL
(BETTER FORM)

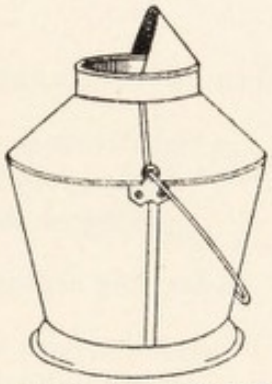


FIG 3 FREEMAN PAIL
(POORER FORM)

FIG 1 STORRS PAIL

FIG 2 LOY PAIL

FIG 3 MODIFIED LOY PAIL

FIG. 1 GURLER PAIL

FIG 2 STADTMUELLER PAIL

FIG. 3. NEWBURGH PAIL

MODERN MILK PAILS

Plate VII.

Milk Churns and details of Milk Churns and Pails.

A—Ordinary milk churn very faulty.

B—Improved milk churn (would be better if seamless).

C—Faulty handle and lid of a milk can.

D—Faulty handle of a milk pail.

E—Faulty angular joint at bottom of milk pail or churn.

F— " " " " " " "

G—Form of seam which not infrequently harbours dirt.

1—Ventilating device allowing penetration of dust and sometimes of the polluted rain water collected by the funnel-shaped opening of the churn.

2—Locking arrangement difficult to clean.

3—Angular joint between bottom and side, or other parts, of churn or can difficult to clean and to sterilize.

4—Seam which when not tinned carefully is a receptacle for dirt.

5—Rivetted parts. The rivets, even when well bedded in and covered with tin, produce unevenness. When carelessly tinned they provide recesses for dirt.

6—Rim of pail, can, or churn, strengthened by iron wire. The space left between the wire and the turned-over edge is often left unprotected against dirt through imperfections in the finish.

7—Handle which when wet and dirty is a source of contamination by draining on to the edge of, and then into, the pail.

8—Rounded corners of can and lid, without seam, and easy to clean.

9—Well-finished rim (space between edge and side of neck well filled with tin (black)).

10—Flange protecting mouth of can against dust and rain.

PLATE VII.

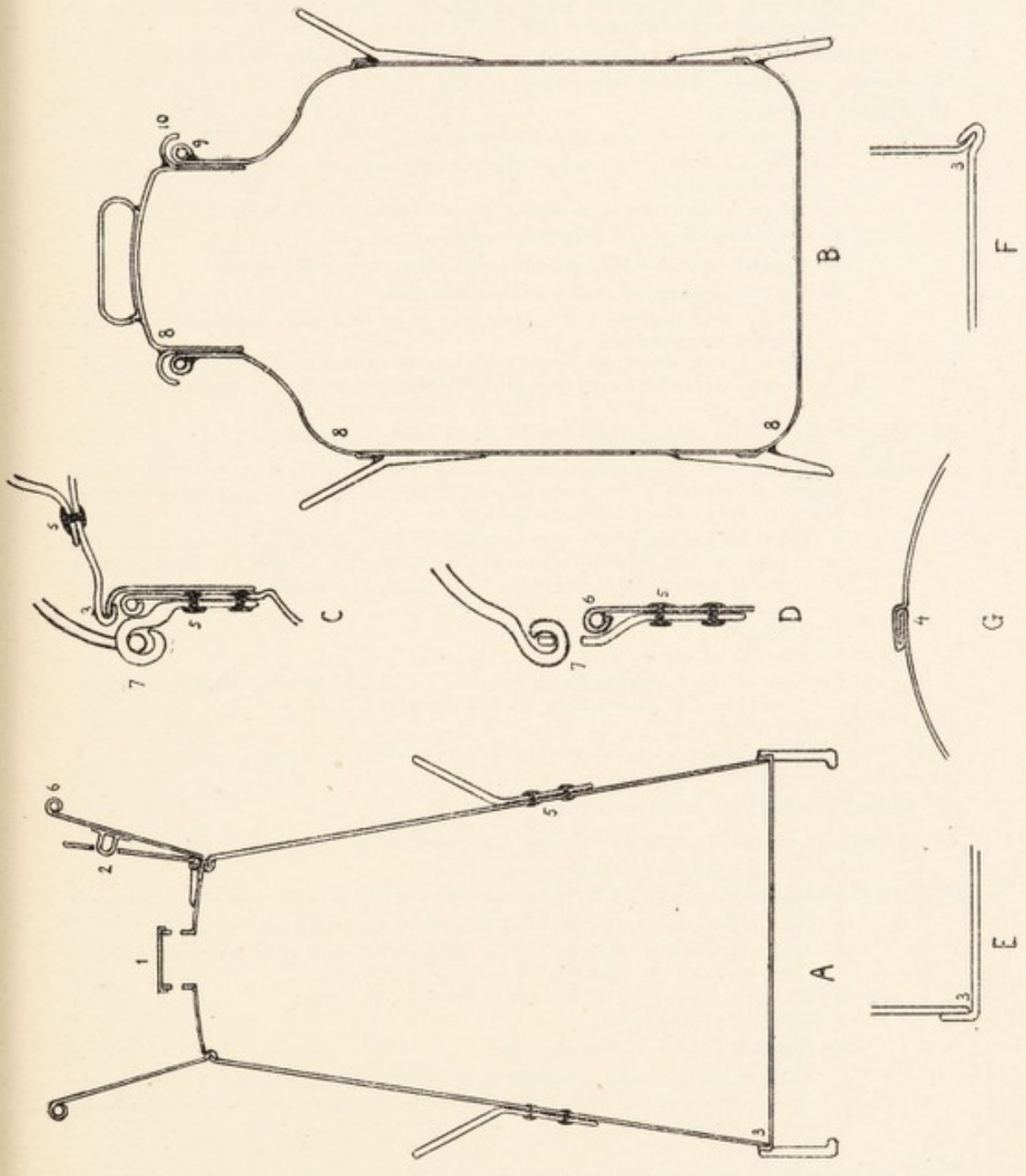


Plate VIII.

Diagrams of the essential parts of covered milk pails and cans and of a simple sterilizing apparatus similar to that used in the experiments recorded in the report.

A—Stand for sterilizing and drying four pails or cans at the same time.

An additional steam nozzle for a sterilizing cylinder or fifth pail may be connected with the upper end of the tube 3.

The boiler shown in the diagram is large enough to supply two stands.

B—Section of Stand. (Scale larger than in A.)

C—Plan of Stand:—

1—Frame or table to which four sterilizing units can be fixed.

2—Steam nozzle with conical obstructing support for dairy vessel during sterilization.

3—Large steam tube connecting steam nozzles with boiler.

4—Boiler holding ten quarts of water.

5—Funnel used for filling boiler and observing level of water.

6—Upper opening of boiler with screw cap.

7—Hooks and pulleys for suspending pails and cans mouth downwards after sterilization.

8—Framework made of angle iron or gas tubing. (Nearly all the parts can be made of stampings and spinnings, easily put together.)

D—Plan of one of the steam nozzles with obstructing support.

E—Section of one of the of the steam nozzles, showing its connection with the steam supply tube, and a can suspended a little above the obstructing support ready to be lowered for sterilization.

2—Obstructing support, preventing the free escape of steam from the pail or can resting upon it, and allowing return of condensation water into the supply pipe 3, through the space kept open around the steam nozzle by three wires.

4—Milk can.

5—Handle of same.

6—Two of the supports made of strong wire and serving also to hook the can mouth downwards during drying.

F— 7—Lid of can.

8—Rim shaped so as to prevent access of dust or water to the can.

G—Lid of covered pail seen from above.

H—Section of covered pail, with strainer and dust shield inserted in the lid.

1—Opening in lid of milk pail.

2—Springs holding lid in position.

3—Rim turned down to prevent access of dust or fluid.

4—Upper side of shield protecting opening of milk pail and used also to fix strainer in opening of pail.

5—Strainer stretched across lower opening of shield.

6—Handle of milk pail.

7—Supports made of strong wire.

(N.B.—No rivets are used to fix the parts together. There are no angular recesses. All the parts are easily accessible for cleaning.)

I—*A covered pail in position for sterilization.*

1—Supporting table or frame.

2—Obstructing support, with a small conical adaptor, allowing the pail and lid to be sterilized together.

3—Steam supply tube.

4—Body of pail (the shield and strainer can be sterilized in the pail itself or in a separate steam cylinder).

5—Hook and cord for lifting the pail up after sterilization.

Plate VIII.

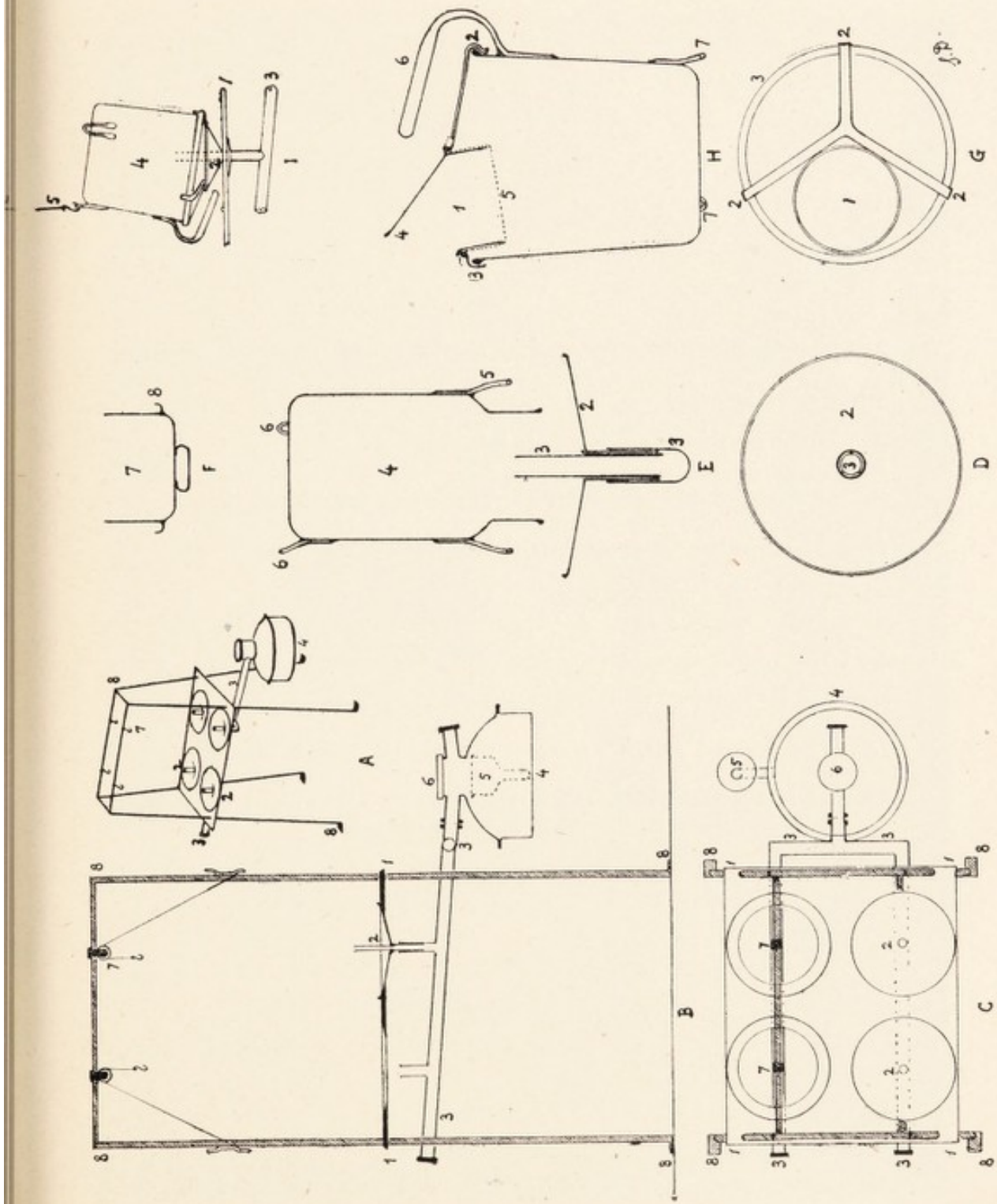


PLATE IX.

Experimental portable apparatus used for sterilizing pails, cans, etc., at farm.

From left to right :—

A covered pail in position for disinfection.

An open pail of good construction in position for disinfection.

A pail suspended for drying after disinfection.

Small boiler and paraffin stove.

On the board under the pails :—

Strainer for covered pail.

Lid for a covered pail, the strainer fits into the hole in the lid.

The lid is sterilized in position, the strainer is sterilized in another pail, and fixed in the lid hole just before use.

PLATE IX.

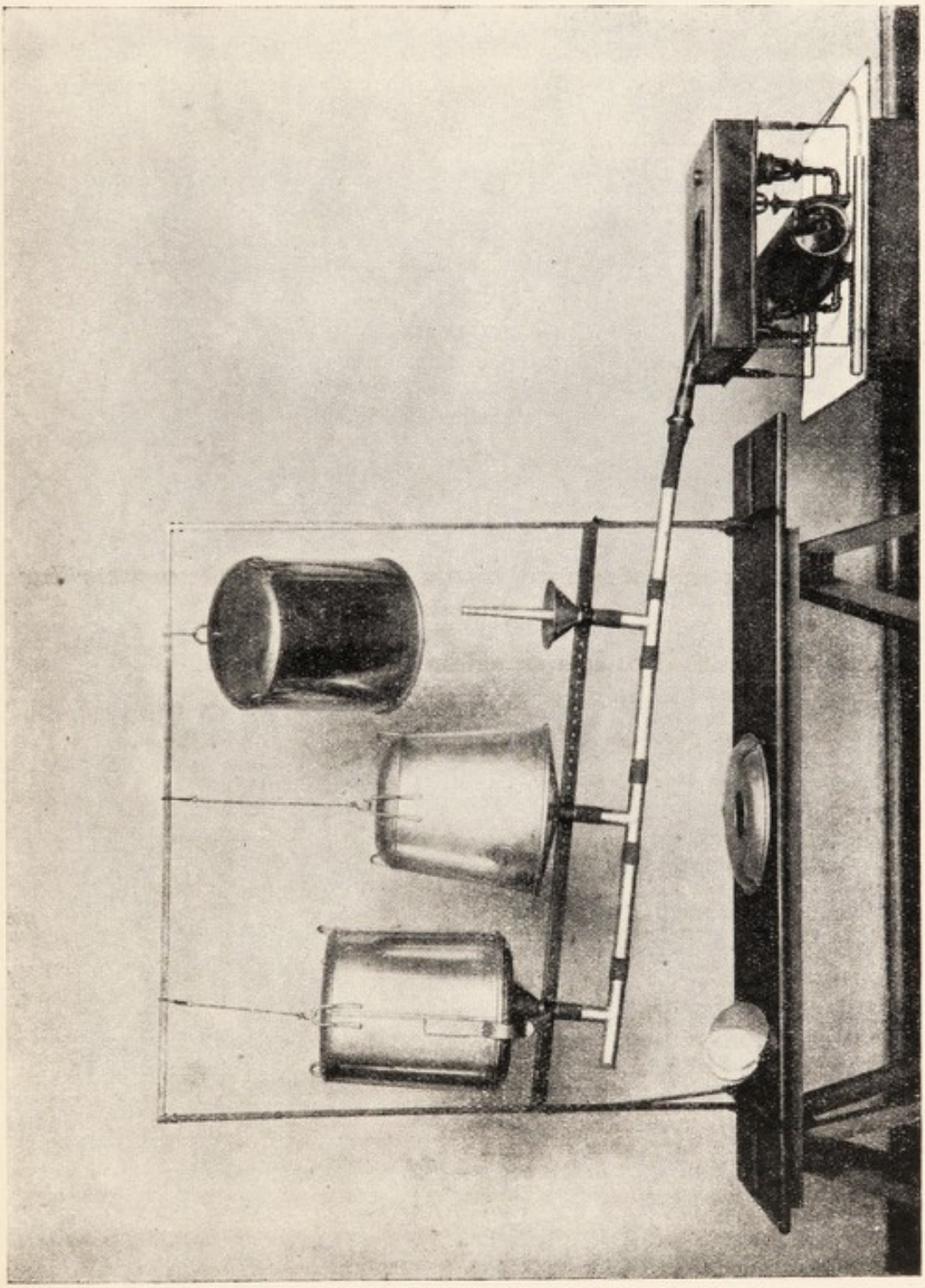


PLATE X.

Milking of a cow in a sterilized covered pail fitted with its own sterilized strainer.

A newly sterilized strainer should be used for each cow.

PLATE X.

PLATE XI.

*An inexpensive milk house.**

A—Outside view.

B—Interior.

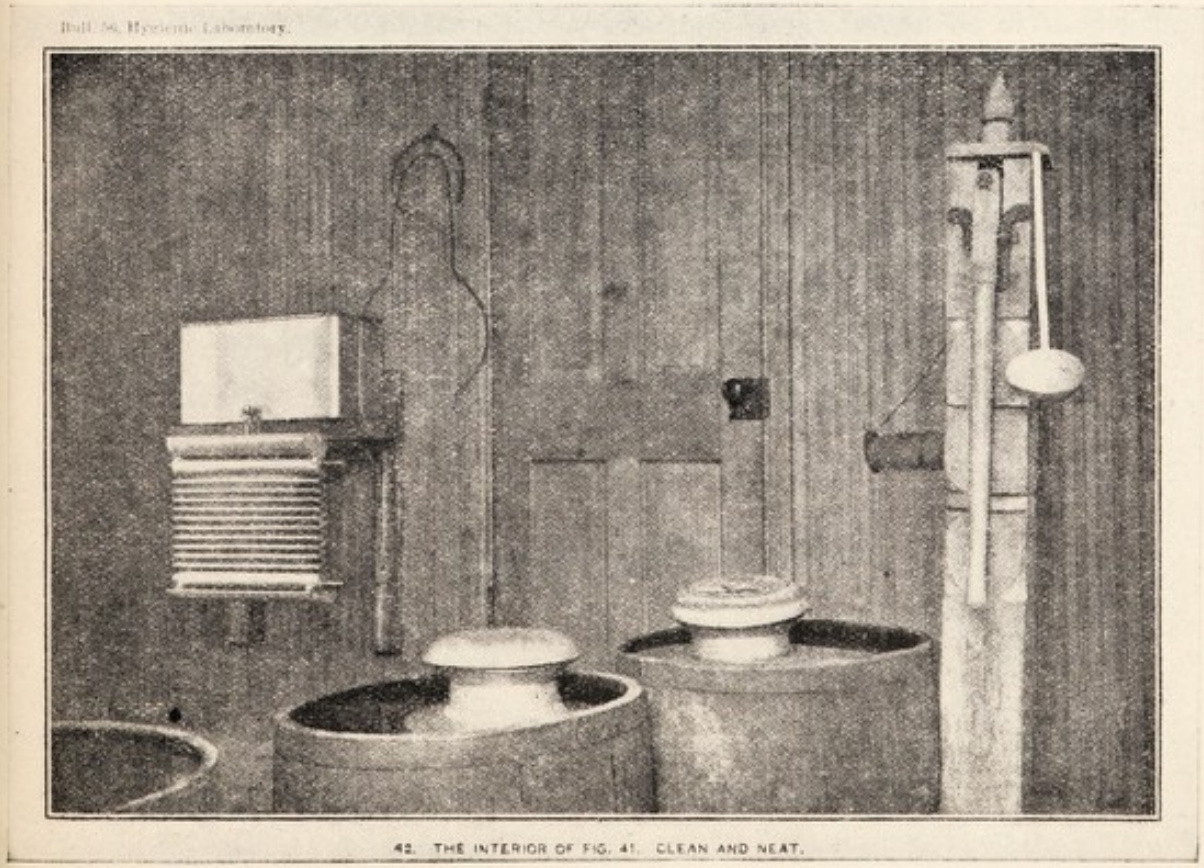
The arrangements for cooling the milk and for draining the cans and pails are of the type deprecated in this report.

* "Sanitary Inspection and its Bearing on Clean Milk," by Ed. H. Webster, Hygienic Laboratory - Bulletin No. 56, p. 59, Public Health and Marine Hospital Service of the United States, Washington, 1909.

Plate XI.

41. A GOOD TYPE OF INEXPENSIVE MILK HOUSE.

A



42. THE INTERIOR OF FIG. 41. CLEAN AND NEAT.

B

PLATE XII.

Experiment showing how milk pails, etc., are contaminated by draining boards or racks.

Glass jar lined with a thin layer of dry organic matter rinsed rapidly with some sterilized water and placed mouth downwards upon two wood rails infected with typhoid bacilli. (A little under $\frac{1}{2}$ size.)

When the jar was dry it was placed *mouth downwards* in a moist chamber and incubated at blood temperature. The whole of the internal surface was contaminated with bacilli up to a height of 5 to 6 inches. After 48 hours' incubation, the parts invaded by the bacilli were covered with colonies visible to the naked eye, and which are recognisable as small white patches in the photograph. These colonies represent millions of bacteria.

PLATE XII.