The pasteurisation and sterilisation of milk / by Albert E. Bell.

Contributors

Bell, Albert E.
London School of Hygiene & Tropical Medicine Library & Archives Service
London School of Hygiene and Tropical Medicine

Publication/Creation

London : Rebman, 1899.

Persistent URL

https://wellcomecollection.org/works/unkatuv2

Provider

London School of Hygiene and Tropical Medicine

License and attribution

This material has been provided by This material has been provided by London School of Hygiene & Tropical Medicine Library & Archives Service. The original may be consulted at London School of Hygiene & Tropical Medicine Library & Archives Service. where the originals may be consulted.
This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.

Wellcome Collection
183 Euston Road
London NW1 2BE UK
T +44 (0)20 7611 8722
E library@wellcomecollection.org
https://wellcomecollection.org

THE PASTEURISATION AND STERILISATION OF MILK

ALBERT E. BELL

SFG
1899

b. SFG

LONDON · SCHOOL · OF · HYGIENE · AND · TROPICAL · MEDICINE

LIBRARY

Date 5 OCTOBER 1950

Class Mark b SFG 1899 Accession No. 29167

LONDON SCHOOL ... TROPICAL MEDICINE
20MAR1939

aa
8

Express Dairy Company, Ltd.,

DAIRYMEN BY ROYAL WARRANT TO HER MAJESTY THE QUEEN.

STERILIZED MILK,

As prepared by the Company, will keep for an indefinite period in any climate.

It is guaranteed perfectly pure and free from Preservatives or Chemicals.

Will be found of the utmost value in long sea voyages, and in countries where fresh milk is not easily obtainable.

	Per Pint Bottle.	Per Quart Bottle.
Prices ...	**2½d.**	**5d.**

Bottles charged extra and allowed for when returned in good condition.

HUMANIZED MILK,

Also prepared by the Company, contains the same constituents as Human Milk, and in precisely the same proportion, it is therefore a valuable substitute for infants deprived of their natural food.

It is ready for use and requires no additional water or preparation, with the exception of warming before use.

As this Milk also undergoes Sterilization, and will keep until opened, it may be sent to any part of the United Kingdom and abroad.

	Per 10-oz. Bottle.	Per 20-oz Bottle.	Per 40-oz. Bottle.
Prices	**3d.**	**6d.**	**1s.**

Bottles charged extra and allowed for on return.

Further particulars of the Secretary,

40, NEW OXFORD STREET, W.C.

AA
8

THE

PASTEURISATION AND STERILISATION OF MILK

.ABERDEEN UNIVERSITY PRESS

AA
8

Friern Manor Dairy Farm,
LIMITED.

TRADE MARK

MILK STERILIZATION.

A SPECIALITY.

DR. GAERTNER'S

PROCESS FOR PREPARING

INFANT'S MILK

The Cheapest and Most Reliable Humanized Milk.

NOT OVER STERILIZED.

Works: CROUCH HILL, N.

Chief Office:

20, FARRINGDON STREET, LONDON, E.C.

THE PASTEURISATION

AND

STERILISATION OF MILK

BY

ALBERT E. BELL, F.I.C., F.C.S.

DISTRICT ANALYST FOR DORSET

LONDON

REBMAN, LIMITED

129 SHAFTESBURY AVENUE, CAMBRIDGE CIRCUS, W.C.

1899

29167

PREFACE.

In writing this little book I have been actuated by a desire to bring home to those interested in dairy work the vital importance of sterilising milk, and to set before them those methods by which this may be most cheaply and effectively accomplished.

I have endeavoured to avoid the use of such technical terms as would be likely to be unintelligible to the average reader. This little work is only intended to afford a brief description of the precautions necessary to avoid the presence of disease germs in milk, and to point out the great risk involved in using milk that has not been rendered innocuous by some process of sterilisation.

ALBERT E. BELL.

September, 1899.

A BRIEF SYNOPSIS.

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE
LIBRARY
20MAR1939

THE PASTEURISATION AND STERILISATION OF MILK.

Introductory and Historical.

During the last ten years there is perhaps no department of knowledge that has made greater advances than the science of bacteriology; with the result that the theory of fermentation, of infectious diseases, and of other similar phenomena, has undergone very considerable change. At an earlier period they were regarded as instances of purely "chemical action". But the more recent investigations of *Pasteur*, *Koch* and others have proved that they result from the activity of the smallest forms of life, *viz.*, *micro-organisms.*

This new theory is of immense importance in dairying, for the fermentations and changes which milk and its products undergo result from the action of various *micro-organisms.*

Before studying the special micro-organisms which affect milk, it is desirable to give a very brief general sketch of their structure and functions, and to gain some insight into the methods by means of which they are investigated. The chief group of micro-organisms, *viz.*, bacteria, is reckoned at the present time to include the smallest unicellular forms of microscopic plants. The merit of having first discovered bacteria belongs to *Leuwenhoek*, a private gentleman who lived some three hundred years ago at Delft in Holland. To the astonishment of the scientific world of his day, he showed (by means of a very simple microscope) that living organisms, of a kind then quite unknown, were to be found in putrefying fluids, saliva, urine, etc.

He sketched these organisms so accurately that we can recognise them without hesitation as the bacteria of to-day. Since however no means were then known of isolating and cultivating them, their nature remained quite uncertain, and they were looked upon as minute animals. Scarcely any advance was made in bacteriology till 1830, when *Ehrenberg* began a fresh study of the subject with the aid of improved microscopes, but lack of culture methods prevented him from recognising the true nature of these organisms, which he also classified as infusoria.

Some years later *Ferdinand Cohn* threw fresh light on the subject. He showed that bacteria are true plant cells, with which they agree in growth and division as well as in structure, and that they are intimately connected with the higher family of algæ.

It remained however for *Pasteur* to make the greatest advance in this department by showing how to make pure cultures of these organisms, by which an accurate study of each species was for the first time rendered possible.

Source of Bacteria.—The question as to whence these organisms come led to a prolonged controversy in the beginning of the eighteenth century. The upholders of one view regarded bacteria as originally produced from organic matter by the process of putrefaction, while those on the other side believed they were derived from living germs already present. The first theory is that of *abiogenesis* or "spontaneous generation"; the second, *biogenesis* or "life from life". *Needham* (1774) was particularly prominent among the supporters of the former theory. He believed that all simple forms of life were destroyed by boiling; he prepared meat broth, and, as he found this putrefied later on, asserted that it gave rise to the bacteria which swarmed in it. *Spallanzani* (1777), on the other hand, showed that once boiling is not always sufficient to destroy all living germs, but that repeated and prolonged boiling, coupled with exclusion of air and the organisms which it contains, will entirely prevent meat broth, milk, etc., from putrefying. In spite of this, however, the controversy continued for a long time, until *Pasteur* showed by methods which have since become classical that all putrefaction is due to bacteria present in the air, and that blood, milk, urine, etc., will "keep" indefinitely if they be collected in such a way that they cannot be contaminated by germs, and be preserved in vessels free from germs (*i.e.*, sterilised vessels), and guarded against their intrusion from the air. If the theory of spontaneous generation were correct it would be useless to fight against deleterious bacteria, as these would be generated again. Fortunately, however, bacteria only appear where their germs or spores are already present, and it is sufficient to destroy and exclude these germs to prevent putrefaction.

Structure of Bacteria.—Bacteria consist of an internal part, the *protoplasm*, surrounded by a skin or membrane, and for the most part contain no chlorophyll; and, as has been said, they are generally admitted to be plants of microscopic size; they vary from $\frac{1}{25000}$ of an inch to several times that length.

Reproduction.—Like all forms of life, bacteria are able to reproduce. This is mostly effected by a process of "fission," that is to say, the microbe divides into two parts, each of which in turn lives on, and later on divides in its turn, and so under favourable circumstances the work of reproduction goes on with marvellous rapidity.

Some species do not divide, but grow in length and give rise to branched threads (cladothrix).

Some bacteria are reproduced by the formation of "spores" which are extremely resistant even under unfavourable circumstances.

The Home of Bacteria.

Wherever organic life is found there bacteria will always abound. They are always plentiful on the surface of the ground, and in water flowing in contact with the air. They are often met with in large numbers in the air.

Earth.—Bacteria are very numerous in the superficial layers of soil, where they occur to the number of hundreds of thousands per grain. They are less abundant in the deeper layers, and at a depth of from ten to twenty feet the soil is generally free from germs (*E. Kramer*, "Die Bakteriologie").

Water.—Spring water issuing from the depths of the earth is generally free from bacteria, but after water has been exposed to the air it becomes charged with micro-organisms, as is the case with rivers, lakes, and the sea. Seven or eight hundred bacteria to one cubic centimetre are occasionally found in good drinkable water. The present writer has examined natural water containing as few bacteria as 130 to one cubic centimetre.

Air.—The number of micro-organisms in the air is subject to great variation. In uninhabited places there are generally less than 100 bacteria per cubic yard, and in thickly inhabited places as many as 400,000 per cubic foot may be found if dust be stirred up—for example, by sweeping a room.

In the streets of Paris there is an average of 4000 bacteria per cubic yard, and in those of Berne an average of 700 bacteria per cubic yard. At a height of 13,000 feet the air is free from bacteria (*Freudenreich*).

Resistance to External Influences.

Like other living organisms, bacteria are exposed to the action of external agents. Generally speaking, their powers of resistance as regards these external agents are tolerably high, especially in the form of spores. Spores are well able to withstand a dry heat of 266° F. for one hour. If any object is to be *sterilised*, it must be exposed to a temperature of 320-356° F. for half an hour if this object is to be obtained with certainty. Damp heat has a more powerful action than dry heat. Adult bacteria, without spores, are mostly killed at a temperature of 140-158° F. Many spores are killed by simply boiling, but there are, on the other hand, certain very resistant kinds which can withstand for a short time a temperature of 230-239° F.

Bacteria are extremely resistant as regards *cold*. Many bacteria apparently in the spore form are able to withstand an artificial cold of −202° F. for twenty hours.

Light, especially direct sunlight, generally exerts a weakening action on bacteria.

Bacteria easily resist a considerable *pressure*. From the researches of *Certes* on this point, it appears that the bacillus of anthrax can withstand a pressure of 600 atmospheres of compressed air.

Methods of Bacteriology.

Bacteria are chiefly studied by cultivating them outside the living organisms or dead substances which constitute their usual home. Only when this is done is it possible to accurately study their structure and functions. In the case of milk, this is effected by mixing a drop with gelatine beef-jelly, and making what is known as a *plate-culture*. This plate is kept at a temperature of 23° C. (74° F.) for twelve to twenty-four hours, when it is examined under the microscope. By this time " colonies " will have been formed. It is then found that three principal operations have taken place. At one part of the gelatine plate, excavations and gas bubbles have been formed; in another, little hillocks have been thrown up, possessing various colours; and in a third, the gelatine has become liquefied into little pools. The different colonies of bacteria which have executed these changes are further marked by differences of contour and texture. One colony alone is selected, and with this a fresh tube of gelatine is inoculated, and thus one species of bacteria is separated. When it has been found that one kind, and one only, has been thus isolated, it is cultivated under favourable conditions, and its natural history is minutely observed and recorded.

One of the chief aims of the bacteriologist is the preparation of suitable culture fluids and mediums for the growth of bacteria. And just as a farmer roots out the weeds from his field in order that the crop may not be impeded by them, so the bacteriologist begins by destroying all foreign germs in his culture fluids, so that the bacteria introduced may develop freely.

The composition of these nutritive media may vary considerably, but they must all contain the substances necessary for nourishing bacteria. Meat broths, potato plant decoctions, *milk*, etc., are admirably adapted for the purpose.

The average composition of milk may be stated as follows :—

Water	87·5	per cent.
Fat	3·6	,,
Solids not fat . . .	8·9	,,
	100·0	

Under the heading of "Solids not fat" are included (1) the albuminoids (which supply the nitrogenous portion of the food), and (2) the carbohydrates or sugars (which supply the carbonaceous parts necessary for life). It will be thus seen that *milk* forms a rich culture fluid for the growth of micro-organisms, and if it once becomes contaminated with germs, in a short time it swarms with them.

The Bacteria of Milk and their Propagation.

When in the udder milk is free from bacteria, except when the milk glands are in a diseased condition, as the result, for example, of tuberculosis or of inflammation. But these cases excepted, milk from a healthy cow is in the first instance free from micro-organisms, a fact demonstrated by *Pasteur,* and one the truth of which can easily be rendered evident by drawing milk direct from the udder into a sterilised tube by means of a cannula. If, on the other hand, milk obtained in the ordinary way is subjected to microscopical examination, it will always be found to contain very large numbers of bacteria. From whence are these bacteria derived? Of first importance are the vessels in use. A momentary application of boiling water or steam is insufficient to destroy all bacteria; to be effectual it is necessary to expose the vessels to superheated steam for several minutes at least. Vessels should be made of pressed tin, which can be easily cleaned. Wooden pails should on no account be used.

Again, the coats and udders of the cows are soiled with dung and dust, which are well known to harbour bacteria, and particles of which fall into the milk. To this it must be added that the first half-pint or so of milk obtained is always rich in micro-organisms, since after milking a little remains in the lower part of the teat, where it is not completely shut off from the exterior air, and is in consequence so infected that a rich crop of bacteria is produced by the next milking time.

According to the experiments of Dr. *Schultz*, it appears that the first-drawn milk contains about 1,360,000 micro-organisms per cubic inch, while that drawn afterwards is sterile (Prof. *Russel's* "On Dairy Bacteriology").

The hands of the milker should be thoroughly cleaned just before milking, the habit of moistening the hands with a few drops of milk is wholly indefensible, a little vaseline is recommended, as this confines and prevents any scales or impurities from being rubbed off. The value of these precautions is shown by the fact that when attention is paid to them at the time of milking the number of micro-organisms is largely diminished. Since it is the presence of bacteria which renders it difficult to preserve milk, greater cleanliness and care in milking would result in the production of milk with much improved keeping properties. With this object in view, the hands of the milker should therefore be well washed, the udder and under-part of the cow should be thoroughly moistened with water and dry sponged, taking care that there shall be no drops that could possibly fall into the milk. By these simple precautions thousands of germs could be effectually kept out of the milk.

The Nature and Action of the Bacteria Found in Milk.

The bacteria found in milk can be classed into two chief groups:—

1. Those which may be regarded as the constant inhabitants of milk. Just as there are animals which are only found in certain regions or particular climates, so there are bacteria which have become so accustomed to live in milk that they are almost constantly met with in the various dairy products.

2. There are, on the other hand, a large number of bacteria which, though frequently met with in milk, can only be looked upon as accidental. When the casually occurring bacteria belong to the pathogenic variety, they have

a very special interest, as in such cases the milk is a means of spreading various diseases.

Ordinary Milk Bacteria.

We will now pass on to consider the bacteria which usually inhabit milk, and which can therefore be looked upon as true or normal milk bacteria. They are of special interest, as they bring about numerous alterations and decompositions in milk, some of which are useful, while others are harmful for dairying purposes. The ordinary bacteria of milk are classified according to the effects they produce in milk. The following are the most important :—

Lactic Ferments.—If fresh milk is left to stand, it will be found to curdle after two to four days, and will at the same time have acquired an acid reaction. This curdling is the work of the lactic bacteria.

It is well known that a certain degree of acidity in milk causes it to curdle. In consequence of this, the lactic acid formed in milk by the action of bacteria causes curdling as soon as enough of it has been produced.

The "*Lactic bacillus*" of *Hueppe* is one of the chief representatives of this class of bacteria.

It grows at temperatures between 50° F. and 113° F., most rapidly at 95° F. Introduced into sterile milk, it produces uniform curdling within fifteen hours at a temperature of 77° F. to 86° F. (*Grotenfelt's* "Modern Dairy Practice").

There are many other kinds of lactic bacteria, but want of space will not permit even a brief description of them to be made. Speaking generally, this class of bacteria do not develop spores, and are not therefore very resistant to heat; a temperature of 158° F. will generally kill them. They exert a harmful influence in the dairy, as they are the chief cause of the spontaneous curdling. There are other lactic bacteria which exert a harmful action in the manufacture of cheese: thus, they decompose the milk-sugar with such energy that they produce large bubbles of CO_2 (carbonic acid gas); this gas produces a large number of holes in the cheese, and causes the cheese to "heave".

Ferments of Casein.—There is a second and numerous group of bacteria which are also able to curdle milk, not however by producing lactic acid, but by the formation of a rennet-like ferment. One germ of this particular kind cultivated in milk 98·5° F. was able (according to *Duclaux*) to curdle thirty times its own weight of milk in eleven minutes. They are for the most part spore-forming bacilli, and often possess very great powers of resistance. Thus one variety (tyrothrix-tenius) can withstand for about two minutes a temperature of 239° F. to 248° F. It is more especially these bacteria which make it so difficult to completely sterilise milk.

The following diseases of milk are directly traceable to special bacteria:—

Blue milk (caused by cyanogenous bacteria).

Red milk (caused by bacteria producing red pigment).

Yellow milk.

Bitter milk.

Stringy or filamentous milk.

Many others exist which have not yet been fully studied.

Pathogenic Bacteria Found in Milk.

It has been established that several diseases may be communicated to man through milk; one of the commonest is tuberculosis. It was found that about 5 per cent. of samples of London milk contained tubercle bacilli. The tubercle bacillus was discovered by *Robert Koch* in 1882; it is remarkable for the narrow limits of temperature within which its growth will take place, *viz.*, 86°

F. to 104° F. Although quickly killed by cold it readily withstands drying; direct sunlight soon destroys it. Tuberculosis is more prevalent with dairy stock than with any other. It must be remembered that in the case of tuberculosis, as with other infectious diseases, the number of bacilli introduced into the body is of importance, for infection takes place more readily when this is large. In practice the chances of infection are consequently diminished by the fact that milk from a number of cows is generally mixed together before sale in the market, so that any infected samples are diluted; this dilution, however, recent experiments have shown, only reduces the risk of infection, and does not do away with it altogether. Although tuberculous milk when consumed does not necessarily cause disease, such milk is nevertheless a grave source of danger to health, and many instances can be quoted where the appearance of consumption in children is directly traceable to this cause.

Tubercle bacilli can live a considerable time in dairy products. After a month, however, they appear to be attenuated, so that their presence in *cheese* does not seem to be a great source of danger. It is always advisable, however, to boil milk before using it as food, with the object of destroying any tubercle bacilli that may happen to be present.

In Fig. 1 is seen a careful drawing of a specimen of tubercle bacilli isolated from a sample of milk, and grown on glycerin agar at 38·5° C. (101·3° F.) for about a month, prepared by and in the possession of the present writer.

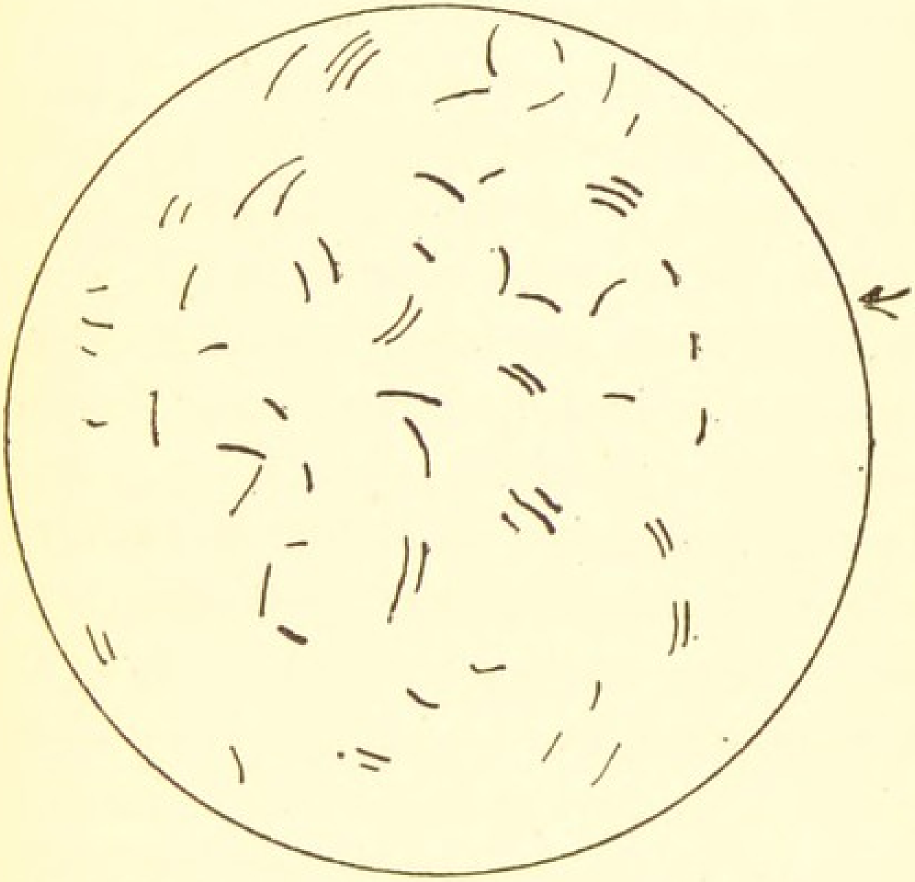


Fig. 1.—Tubercle bacilli from pure culture (using $\frac{1}{12}$ oil immersion and stained with carbol fuchine).*

Typhoid fever usually spreads through the water supply. This leads to infection of the milk if the milk-can and other dairy utensils are washed with the contaminated water.

* Magnified several hundred times.

Dr. *Jaccoud*, in France, out of 106 cases of typhoid traced seventeen to milk as the cause of infection; and in England, Dr. *Hart* cites that out of fifty cases of typhoid twenty-eight were traceable to infected milk. The bacillus of typhoid appears to retain vitality for from five to eight days in butter and cheese ("*Freudenreich* on Bacteriology").

Diphtheria.

Diphtheria is another pathogenic organism which finds favourable conditions for growth in milk, and there are many instances on record where contaminated milk has produced and spread this epidemic.

In Fig. 2 is shown a drawing of a cover glass specimen of the bacillus of diphtheria from the throat, grown on blood serum at 38·5° C. for twelve hours only.

Cholera.

The cholera bacillus has been traced to contaminated milk. It is a curious fact in connection with this organism that it does not live in unboiled milk for more than twenty-four hours; the lactic acid formed by the numerous lactic bacteria present seem to overpower it; but in boiled milk it is able to multiply abundantly, since the lactic bacteria have been killed by the process of boiling.

There are also strong reasons to believe that scarlet fever is spread by infected milk. Again, diseases of animals, such as pleuro-pneumonia,

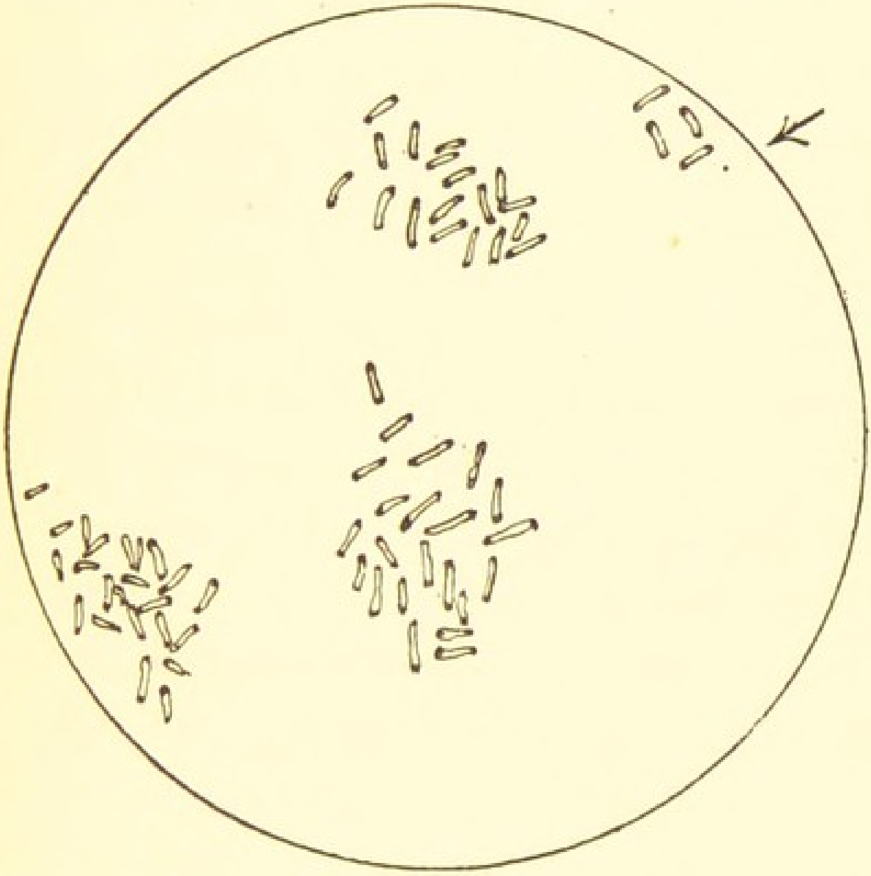


FIG. 2.—Diphtheria bacilli, showing polar staining with Löffler's methylene blue ($\frac{1}{12}$ oil immersion).*

foot-and-mouth disease, can also be spread by means of milk.

In addition to the pathogenic organisms before mentioned, milk occasionally contains certain germs which form poisonous products.

* Magnified several hundred times.

These poisons are called "ptomaines". It is these products that have produced the serious and sometimes fatal results that occasionally follow the consumption of milk, cheese, and ice-cream.

Although in what has gone before only a very

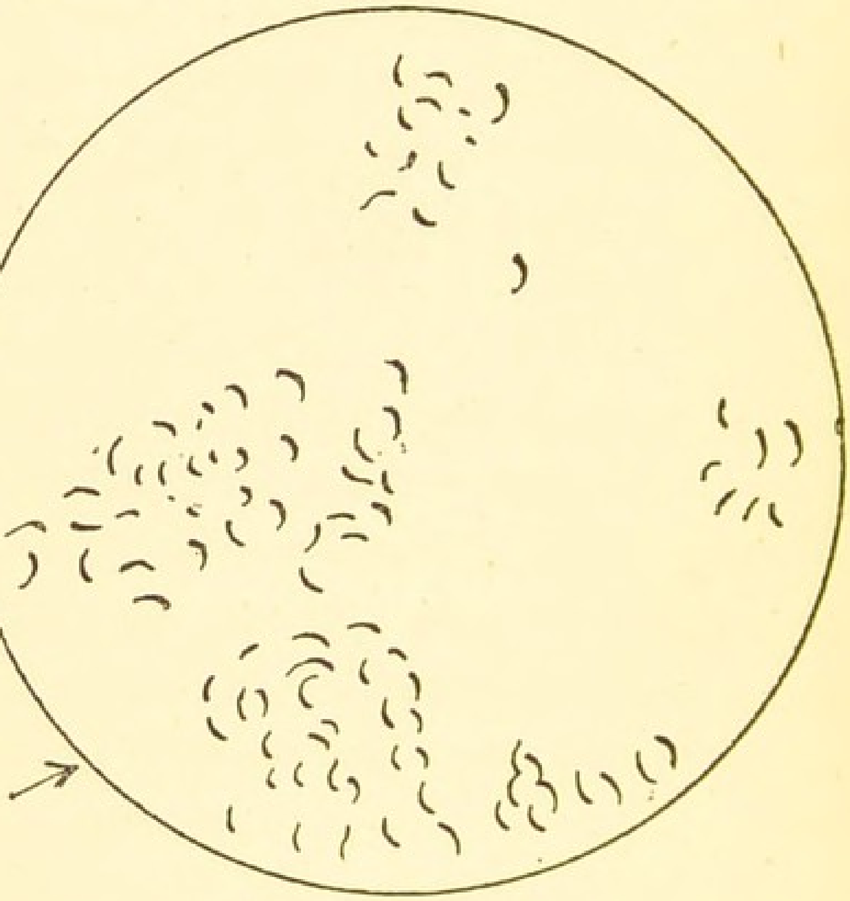


FIG. 3.—Cholera bacilli (spirilla), from culture eighteen hours old, stain carbol fuchine ($\frac{1}{12}$ oil immersion).*

few of the organisms which influence milk have been considered, yet enough has been said to show what hurt to public health and what damage to dairying these organisms are in many cases able to effect, and it now remains

* Magnified several hundred times.

to consider the means by which we can confront and disarm these minute enemies.

Milk may be preserved either by chemical or physical agents. The chemical agents most generally in use are formalin, salicylic acid, boracic acid, hydrogen peroxide, sodium carbonate and quicklime. The latest researches, however, seem to point for the most part against chemical preservatives as they exert a harmful effect on living tissues.

Pasteurisation of Milk.

Pasteur in his researches on fermentation found that certain defects of wine and beer could be prevented if these liquids were heated to about 140° F. This process has also been applied to milk, and it is found that by submitting milk to "pasteurisation" its "keeping" properties are considerably increased, although it still contains bacteria. The temperature at which the process is conducted is sufficient to destroy most of the bacteria which produce sourness in the milk or cream, and those which survive multiply less readily.

Many experiments have been made to ascertain the keeping power of milk thus treated, and, according to *Fleishmann*, pasteurised milk when kept at 54° F. to 57° F. keeps forty hours longer than ordinary milk. It would be beyond the scope of this small book to describe all the apparatus that has been devised for pasteurising milk, reference will only be made therefore to the newest and most approved form of the apparatus.

The pasteurising apparatus of to-day consists of a vessel in which the milk is heated to 160° F. by steam and is kept in a state of motion by a stirrer, by which means all burning is obviated and no change in the taste of the milk is noticed. The duration of the heating process is about twenty minutes.

It has been recently shown that pasteurisation at this temperature for twenty minutes is sufficient to destroy the bacilli of tuberculosis, and other pathogenic organisms which occasionally find their way into milk.

In the accompanying diagram will be seen the newest form of apparatus for pasteurising milk and the rapid cooling of the same after pasteurisation.

The milk is raised to 160° F. in the pasteuriser (A), and it is maintained at this temperature for fifteen to twenty minutes; the vessel is then emptied of its contents without removing the lid, by simply turning on the stopcock of the discharge tube which has hitherto been closed, and if necessary by admitting a little more steam until the milk flows out freely.

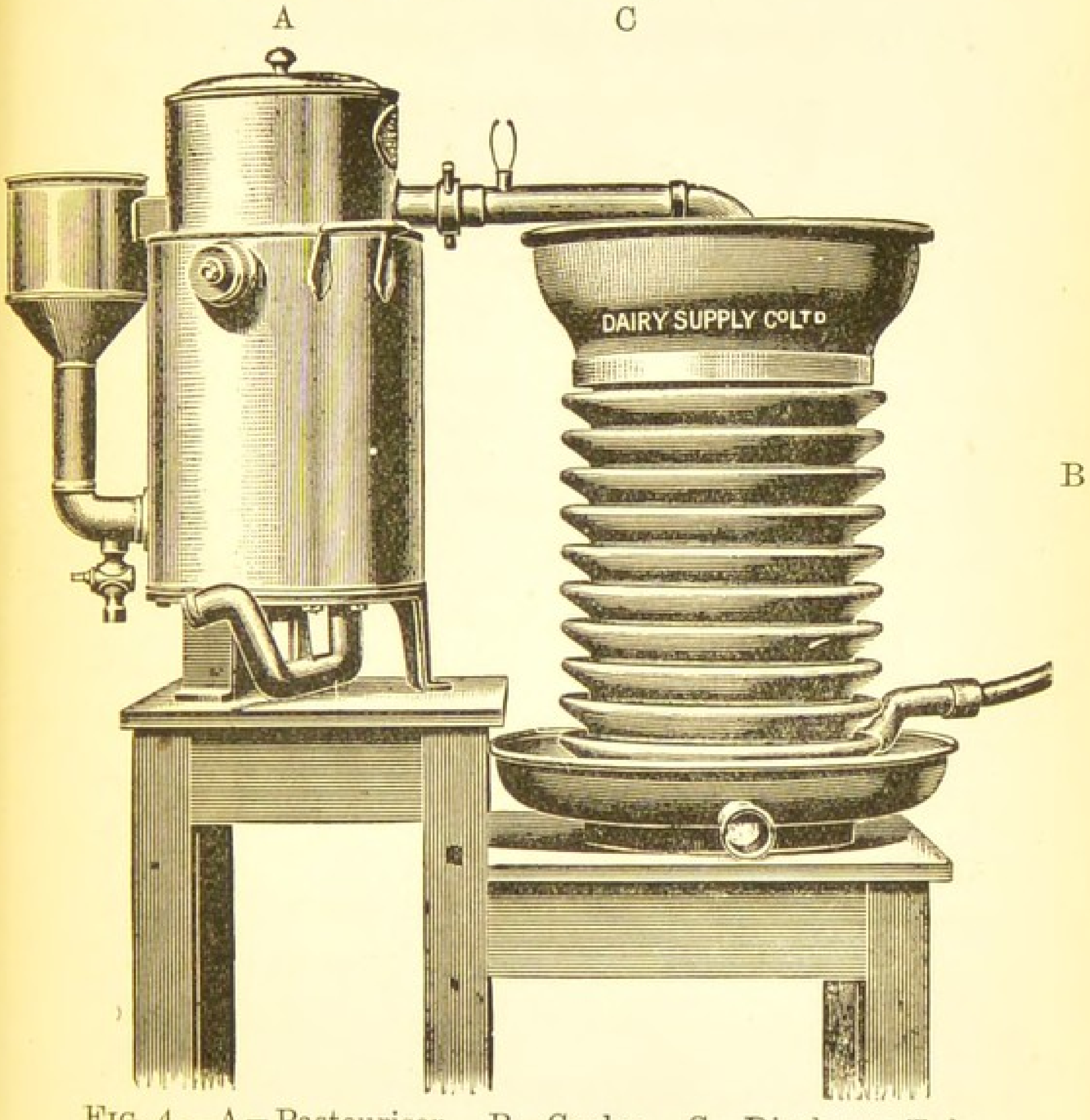


FIG. 4.—A = Pasteuriser. B = Cooler. C = Discharge Tube.

It is highly necessary to cool the milk as quickly as possible to avoid giving it a cooked flavour. Of course this could be done in the pasteuriser itself; it is preferable, however, for quickness to place a "cooler" under the outlet, and so cool the milk rapidly, and receive it into a clean and well-steamed receptacle.

In the accompanying diagram will be seen

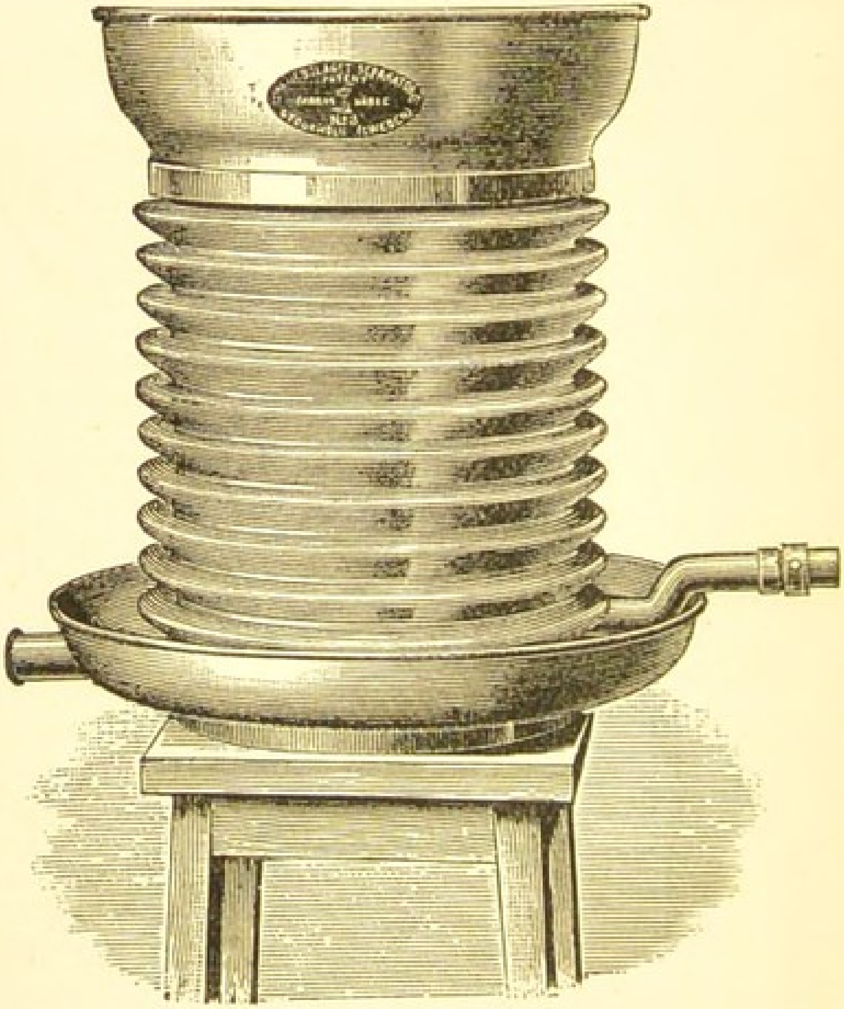


FIG. 5.

the "Laval Cooler," recommended by the Express Dairy Company, and manufactured by the Dairy Supply Company.

The special advantage of the "cooler" in question is that it has a corrugated surface on both the inner and outer faces of the cylinder.

Thus it possesses almost twice the cooling surface of other types of cooler, in which the milk flows over the outside face only.

The Sterilisation of Milk.

It may be taken as an axiom that ordinary milk always contains germs, which spoil it sooner or later, the time depending on the temperature and the number of micro-organisms present. We have seen also that *disease* germs are often present in milk, sometimes from the first, as in the case of tubercle bacilli, and sometimes introduced later on, as in the case of typhoid and cholera.

There is a need which has long been felt for some means of preserving milk in such a way that it shall be absolutely free from disease germs, and at the same time have almost unlimited keeping properties.

This can be accomplished by "sterilisation". By sterilisation is meant the use of heat *at* or *above* the boiling-point of water (212° F.), *whereby all the bacteria as well as their spores are destroyed.*

By some methods milk is sterilised at one operation at a temperature considerably above its boiling-point; by other methods the milk is subjected to an alternation of heat and cold, *viz.*, the temperature of boiling water, 212° F., and of ice, 32° F.

The method which produces the most satisfactory results is the intermittent sterilisation at the boiling-point; by this method the milk does not undergo any decomposition, and its taste is not perceptibly altered.

This method is extensively used on the continent.

Sterilisation.—As already stated, by this process is meant one which ensures the absence of all germs in a liquid. To make milk absolutely germ free is somewhat difficult, owing to the very resistant nature of some of the bacteria which it always contains; and to attain complete success it is necessary to expose it for about fifteen to twenty minutes to a temperature of 230° F. to 239° F. The apparatus necessary for conducting sterilisation must obviously be so constructed as to withstand considerable pressure.

The arguments against this method lie in the fact that exposure to these high temperatures, more than the mere boiling, alters the composition of the milk, and the soluble salts of lime which it contains are converted into the insoluble condition; it also becomes brownish in colour and acquires a burnt taste, owing to the action of the heat on the milk-sugar. People who are used to the taste of fresh milk seldom get accustomed to the burnt flavour, and up to the present milk thus highly sterilised is chiefly used for feeding infants, for whom absolute freedom from germs is highly necessary. The process has now, however, been modified and improved in various ways, with a view of obviating too much alteration in the milk and thereby removing the above objections.

In the first place, great importance is attached to cleanliness of the milk before sterilisation. It is found that the process of sterilisation is much easier, even at a lower temperature, when the number of bacteria is comparatively small than when the milk swarms with them owing to carelessness at the time of milking.

The best method of cleansing milk at present known is that of filtration through gravel. The accompanying sketch shows the filtering apparatus ("Jahresbericht," "Gaehrungs-Organismen," *Koch*, 1893, p. 179).

The milk enters from below through the tube

(A) from a reservoir placed considerably above the filter, the pressure consequently enables it to flow through the gravel contained in the cylinder

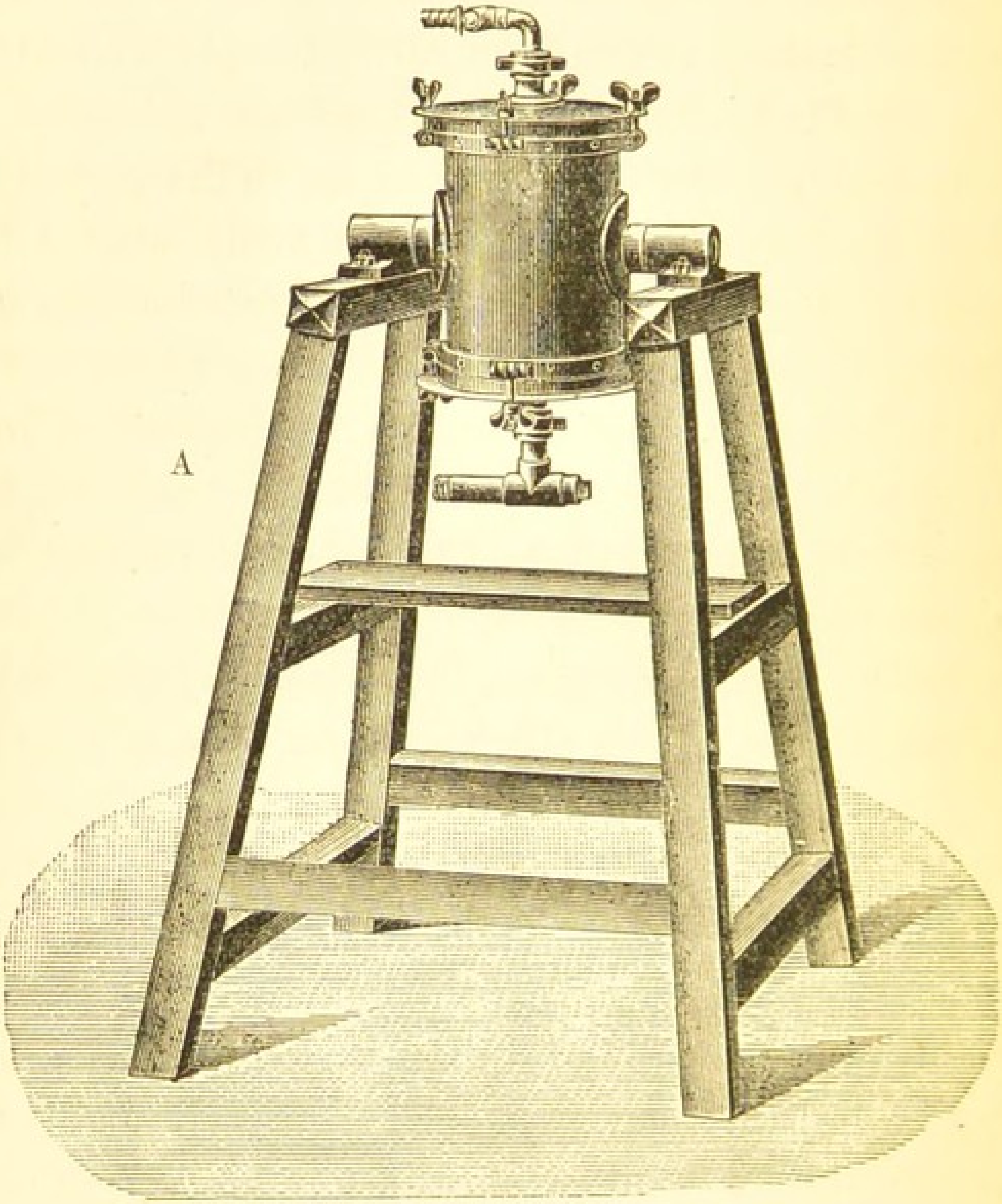


Fig. 6.—Gravel filter for filtering milk.

and out at the top. When the reservoir is empty, and consequently the flow of milk ceases, the cylinder is turned through 180° F., and the mil k still retained in the filter, for want of sufficient pressure to expel it, runs out in the same direction as did all the other milk. By this means none of the dirt or bacteria first retained by the gravel are carried back to the filtered milk. It has been proved that by this means all dirt is removed, and that the number of bacteria is reduced from 40 to 50 per cent. After this preliminary filtration the process of sterilisation can be proceeded with.

The diagram on p. 30 shows the construction of an apparatus for sterilising milk on the large scale and at the same time filling the cans (Sterilisator Werke, Frankfurt-am-Main).

The apparatus consists of three principal parts :—

A, The heater.
B, The steriliser.
C, The cooler.

In the heater the milk is raised to the boiling-point by means of steam ; it then flows into the steriliser. During the process of sterilisation a second quantity of milk is being warmed in the heater, in readiness to replace the first in the steriliser when that has passed into the cooler. The heater is thus ready for a third charge, and so on till any quantity of milk has been sterilised. The milk flows straight from the cooler (C) into the sterilised cans (D). For

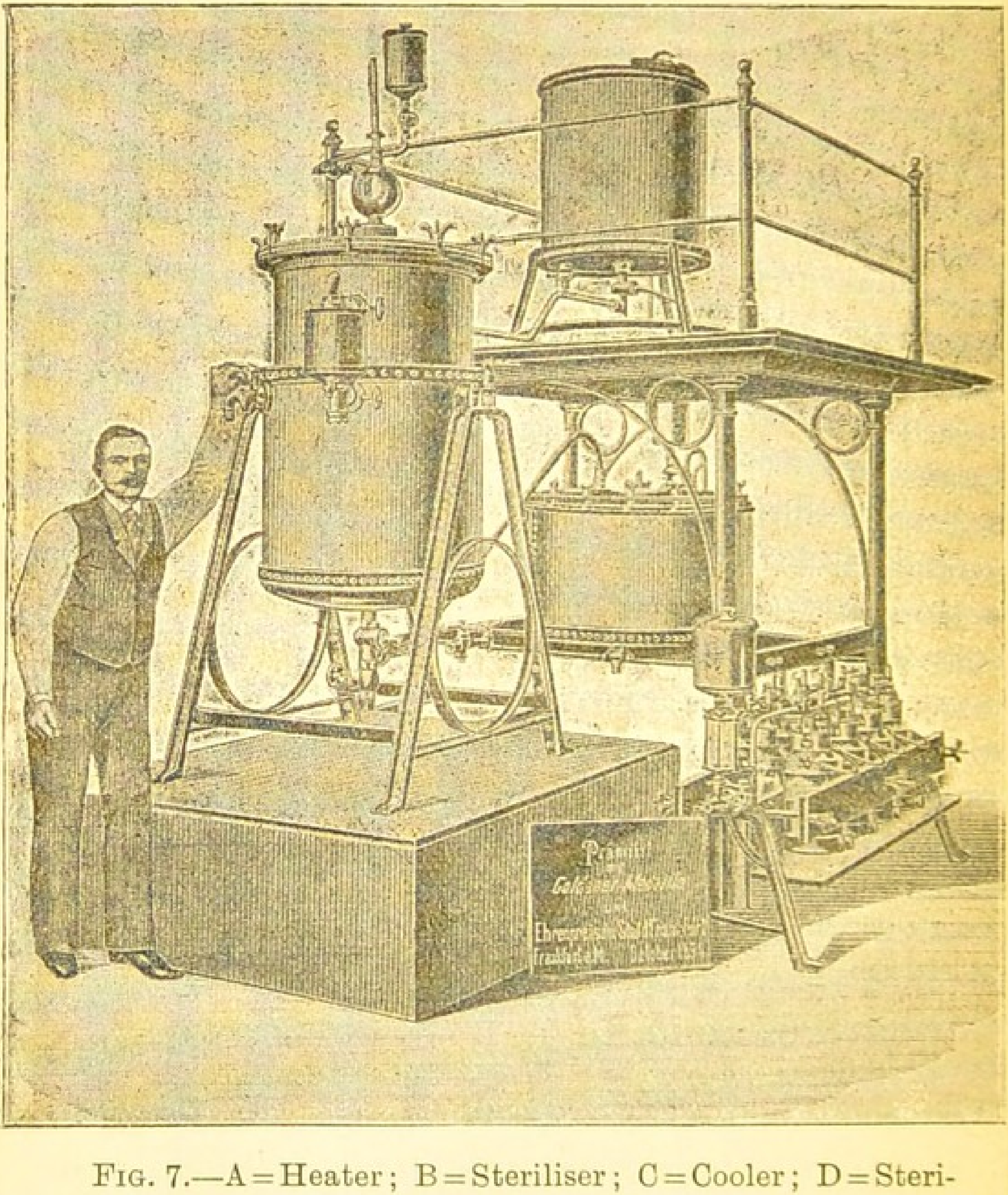
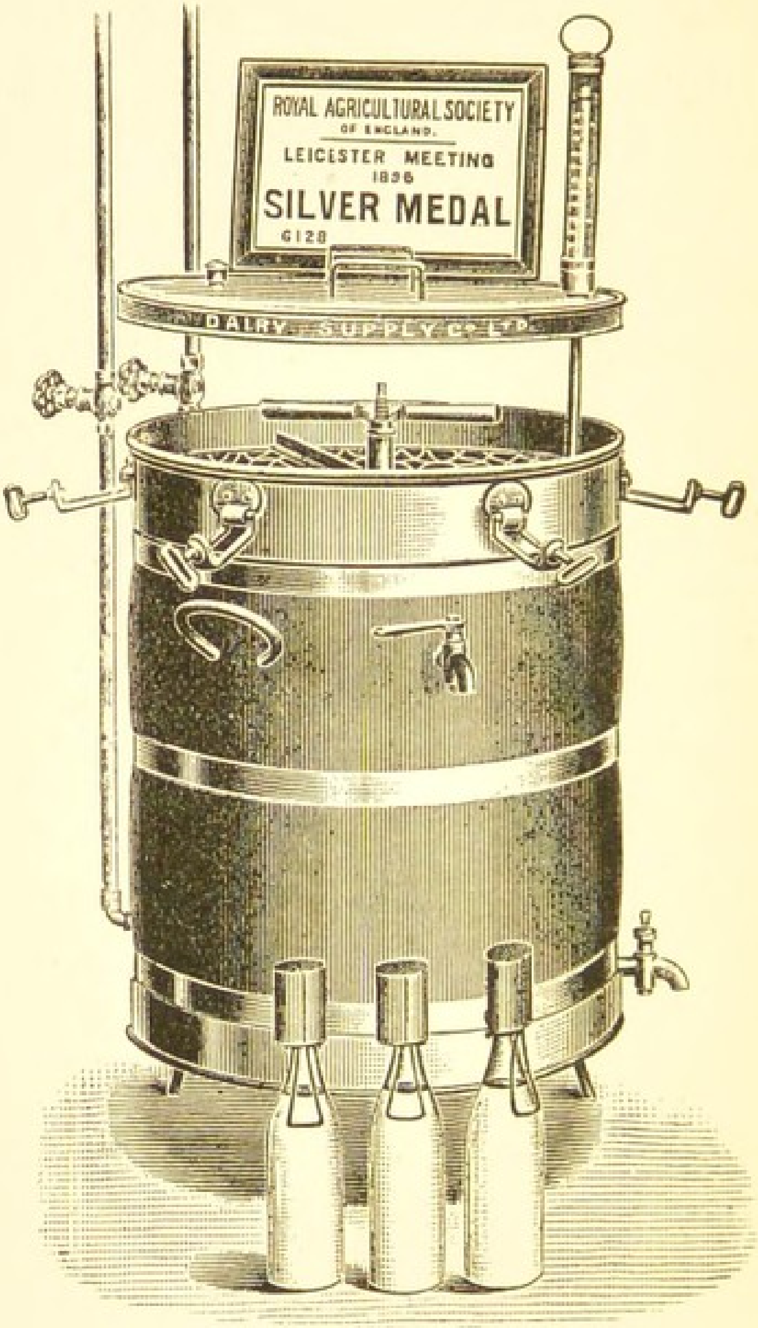


FIG. 7.—A = Heater; B = Steriliser; C = Cooler; D = Sterilised cans; E = Pressure gauge; F = Thermometer.

the purpose of sterilising the empty cans, the mechanism is so arranged that the cans are turned upside down, which allows the condensed water which results from the steam passing through them to escape. When this "steaming-out" of the cans has been accomplished, the cans are reversed by the same mechanical arrangement. Each can is fitted with a "two-way" tap; this is so adjusted that the air which is drawn into the cans, owing to the cooling of the latter, has to pass through an air filter which retains the bacteria, thereby maintaining the sterile condition of the cans. The sterilised and cooled milk is then allowed to flow through the same hollow axis by which the steam has previously passed, and so enters the cans without being contaminated. This system is known as the Popp-Becker system, from the names of the inventors. The rationale of the process depends on the sterilising action of steam at a high pressure, the temperature reaching 250° F.

It is claimed for this process that it does not burn the milk or alter its taste, and, owing to the fact that the milk in the steriliser is always above the boiling-point of water, it is impossible for any condensation of the steam to take place and thereby cause a thinning of the milk. The steam makes its exit through a pipe in the cover

A A Thermometer.



B B B

FIG. 8.—A A = Pipes through which the steam passes to the steriliser from a steam generator.

B B B = Bottles fitted with automatically closing stoppers, by which they are closed while still in the sterile vapour in the entire absence of air.]

of the steriliser, and with it escape the evil-smelling gases contained in the milk. Fixed to this apparatus is an electric control appliance, which notes the time on a "check sheet" as well as the temperature, and warns the workman of any irregularity in the process by the ringing of a bell. In this way it is possible to sterilise large quantities of milk at small expense.

When milk is sterilised in smaller quantities a different form of apparatus is used.

In the foregoing sketch is shown an apparatus devised by the Dairy Supply Company, London, by which bottles are filled with milk and then sterilised.

These sterilisers are constructed to hold from 100 to 200 half-pint bottles, such as could be used by retail dairymen. The bottles are not opened till the milk is wanted, so that in the meantime no bacteria can get in from outside, as is the case when all the milk is sterilised in a single vessel.

Fig. 9 (from the Dairy Supply Co.) represents a vertical section of the foregoing steriliser, and Fig. 10 a horizontal section along the line I. to II. and III. to IV. in Fig. 9.

A is the outer vessel, closed with a lid (A^1), and clamped air-tight by screws (A^3) ; the lid is provided with holes through which a thermometer and safety valve may be inserted.

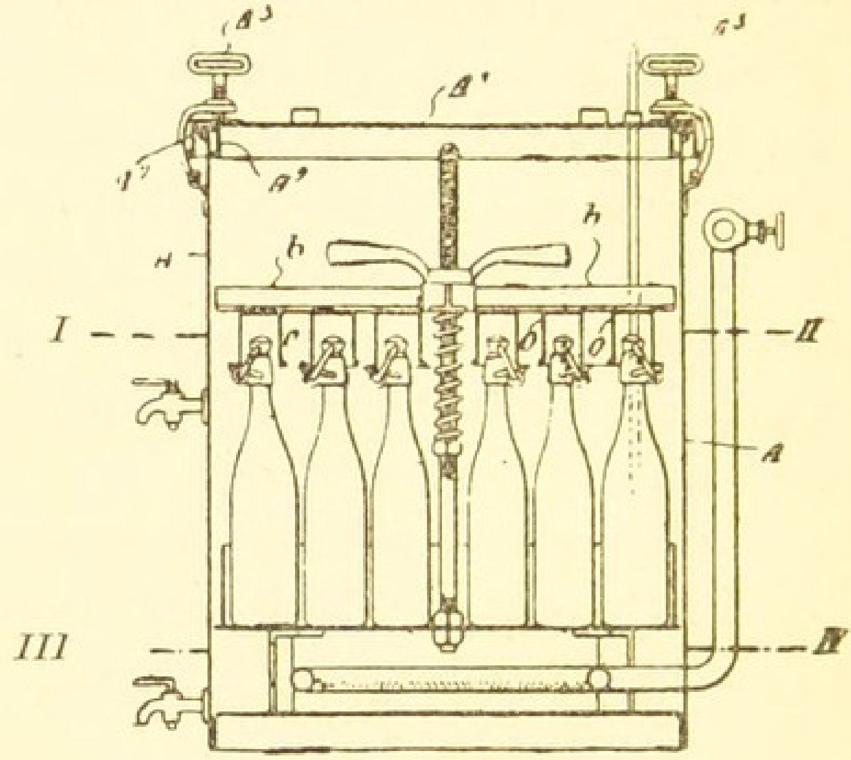


FIG. 9.

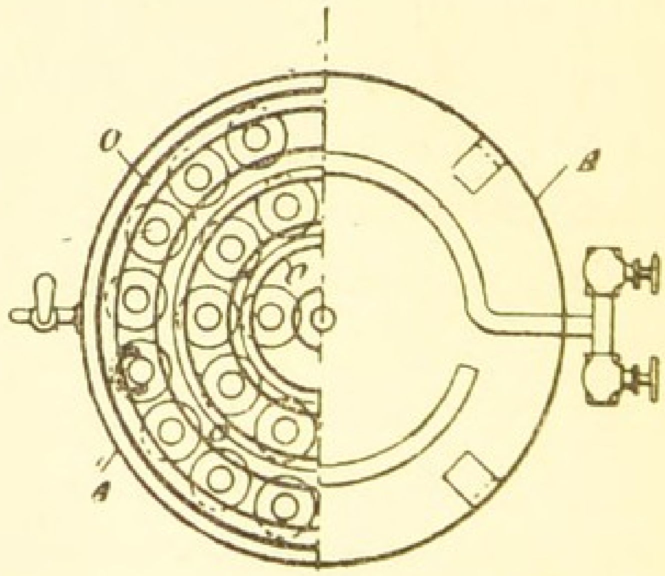


FIG. 10.

In these diagrams the bottles for sterilising in small quantities are shown. The apparatus is also

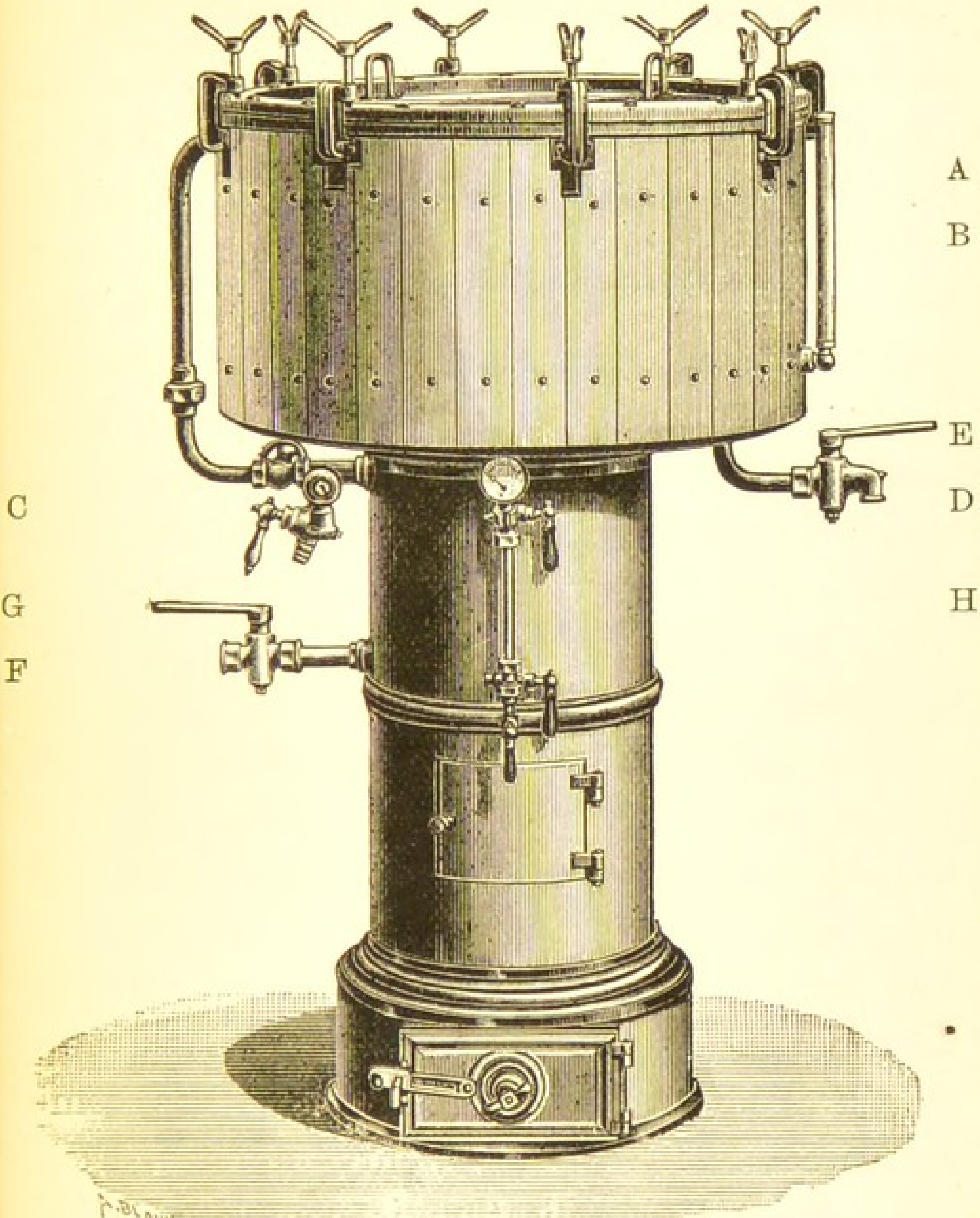


FIG. 11.—Dr. Alt's Steriliser and Steam Generator.

A = Steriliser; B = Thermometer; C = Cock for getting rid of condensed water or steam; D = Steam gauge; E = Water-outlet-cock; F = Water-inlet-cock; G = Water-gauge-glass; H = Steam generator.

used for sterilising much larger quantities. The milk is then heated and sterilised in the vessel A. In order to fill and empty the vessel a hole is provided in the lid (Fig. 9), through which a funnel for filling or a syphon for emptying may be inserted. When sterilisation is complete, the cock is opened and the pressure of the steam in the vessel A drives the milk through the syphon into a suitable receptacle; the syphon is then removed and a funnel inserted and the vessel refilled.

In the figure on p. 35 is shown Dr. Alt's steriliser.

This apparatus is used for sterilising milk in bottles, and is the same in principle and action as that just described, the only difference is that the steam generator is attached to the steriliser. The steriliser is fitted with revolving shelves to hold 150 to 200 pint bottles. The bottles are almost filled with milk and subjected to a temperature of 240° F. for twenty minutes, then the process of sterilisation is complete. It is highly essential that the bottle should be fitted with effectual stoppers; the automatically closing stopper is perhaps the simplest and most efficient, and it has the additional advantage of being inexpensive and durable.

In the accompanying figure is shown a section of the most improved form of automatically closing stopper as it fits into the necks of the bottles for containing sterilised milk. It is made of india-rubber, and it has a aluminium tube (B)

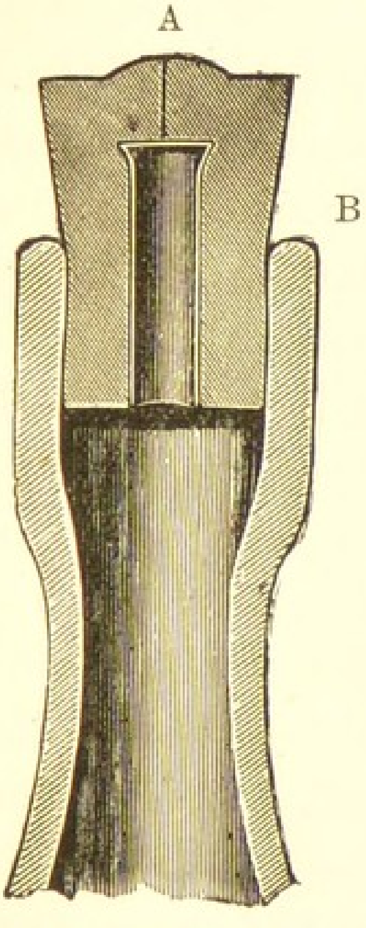


Fig. 12.—Automatically closing Stopper.

to withstand pressure and to give a free passage to the air and to allow the gases derived from the milk to escape through the slit A. During the cooling of the bottles the vapour inside the bottle condenses and causes a vacuum ; the outer pressure of the air then closes the slit, thus protecting the sterilised milk from germs contained in the air.

The stoppers are kept under water till required, as by this means the india-rubber is prevented from hardening.

It has been pointed out that the health of infants and children is largely influenced by the milk which they consume; and as this food plays such an important part in their dietary, it is absolutely necessary that it should be pure and free from harmful bacteria. Bearing this fact in mind, it may not be out of place to conclude this essay with a brief description of a simpler steriliser for the nursery and home use.

The bottles should be scrupulously clean, and the milk should be put into them as soon as it arrives. The milk should not completely fill the bottle, an air space of about an inch being left between the milk and the stoppers, and the latter should be automatically closing after the manner of those already described.

The bottles being filled and closed are placed on the stand, and the whole is placed in the sterilising pot. Cold water is then poured into the pot so as to be on a level with the milk in the bottles. After the lid has been placed on securely, it is brought to the boiling-point, and kept at that temperature for three-quarters of an hour. The lid must then be taken off and the stand lifted out and put in a cool place. During the cooling of the bottles the vapour condenses and thereby causes a vacuum. The outer pressure of the air then closes the slit in

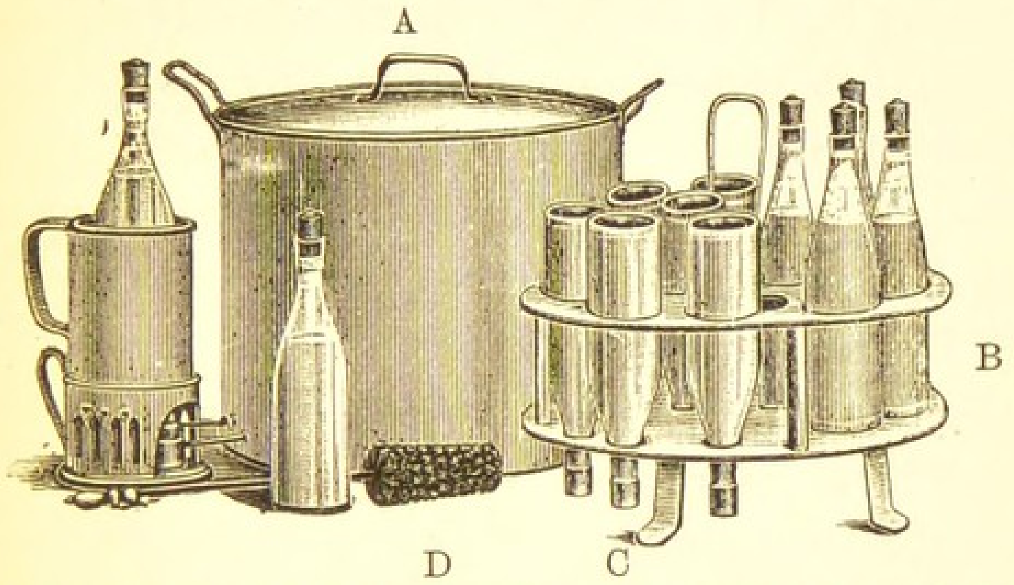


FIG. 13.—A = Sterilising pot (tinned iron); B = Bottles filled with milk ready for sterilisation; C = Washed bottles draining previous to being filled with milk; D = Brush for cleaning the inside of the bottles.

the stopper. After the milk has cooled down to the temperature of the outer air, any bottle when shaken produces a distinct sound like a water hammer, showing that a considerable vacuum has been obtained and that the stopper acts properly. When a bottle has once been opened and again corked the above sound cannot be produced, and thus it is easy to detect when a bottle has been previously opened.

The sterilised milk should be kept in a cool place. When given to infants and children the milk should be taken directly from the bottle, by removing the stopper and replacing the latter by a "teat" of india-rubber for suction. The empty bottles ought to be thoroughly cleansed with hot water immediately after being used, and then placed neck downwards in the stand; the stoppers must also be immediately placed in hot water and well shaken till cleansed.

By following the above simple directions it is possible to destroy all pathogenic bacteria, and should any spores survive they are so enfeebled by the treatment that they are unable to germinate.

During the past year there have been most conflicting statements concerning the advantages and disadvantages of sterilised milk. It has, for instance, been stated by scientific chemists that sterilised milk has lost many of its nourishing qualities, and that the destruction of the pathogenic bacteria includes the slaughter of other most beneficent micro-organisms. Medical men having seen the enormous saving of infant life since the introduction of sterilised milk, are compelled to attach but small importance to the above objections.

Still more recently evidence has been adduced "that the process of sterilisation alters very slightly, if at all, the nourishing qualities of milk" (Dr. *Weigman*).

There is, however, a tendency in a dietary composed exclusively of sterilised milk to produce scurvy. It has been proved that this can be safely avoided by the daily use of a little fruit and fresh vegetables.

It has been known for some time that tuberculosis in cattle is rather increasing than decreasing. It is therefore most probable that the milk sold in large towns, which is a mixture of milk from numerous cows, contains tubercle bacilli. Quite recently the experiments and researches made by Dr. *Obermüller* established this fact beyond all doubt.

The summing up of all the foregoing facts seems to point to the conclusion that the sterilisation of milk is absolutely necessary, and its general adoption only a question of time.

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE
LIBRARY
20MAR1939

b. SFG
1899.

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE
LIBRARY
20MAR1939