CLEANING AND STERILIZATION OF MILKING EQUIPMENT ON THE FARM

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In the production of clean milk of good bacteriological quality the cleanliness and sterility of the milking equipment are the most important factors —even more so than cooling the milk. The amount of equipment used has a direct influence on the quality of the milk; satisfactory cleaning and sterilization are therefore more necessary where milking machines are used than with hand milking.

Cleaning and sterilization are complementary processes: neither alone will achieve the desired end-result, which is to leave the surface as free as possible from milk residues and from milk-souring bacteria. Cleaning and sterilization can be separate processes or they can be combined, as for example with some methods of chemical sterilization. The term "cleansed" is frequently used to indicate that equipment has been cleaned and sterilized. This is a term that is preferable to either cleaned or sterilized, because in dairy practice it is rare that both conditions are completely satisfied. Milk-contact surfaces are seldom chemically clean and seldom completely free of bacteria.

All cleaning processes in dairy work comprise the following stages: (*a*) a pre-rinse with cold or tepid water, which, if adequately performed, removes much of the soil and helps to wet the surface; (*b*) removal of soil from the surface by solution, emulsification, saponification, or mechanical action, or by a combination of these methods; (*c*) dispersion of the undissolved soiling matter; (*d*) removal of the used detergent solution together with the suspended and dissolved soil; (*e*) final rinsing to remove the last trace of detergent.

The Use of Detergents

Detergents are necessary for cleaning, but the type of detergent used and its concentration will depend on the method of washing. For example, washing may be done by hand or mechanically, as in the circulation rinsing

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of pipeline plant. When alkaline detergents are used for hand washing, the concentration should not be more than the equivalent of 0.25 % sodium carbonate, otherwise the solution will be too alkaline for the hands. With circulation cleaning this consideration does not apply.

Detergents help to free the surface of milking utensils from fat and milk residues and they should not be confused with disinfectants, whose sole function is to kill bacteria. However, strongly alkaline detergents, especially if used hot, are bactericidal. There are two main types of detergent, the inorganic alkalis and those composed principally of surface-active agents. Modern detergents usually contain a blend of several inorganic salts to achieve the desired amount of water softening, rinsing, deflocculation and emulsification, with surface-active agents to improve the wetting ability of the solution. In present-day practice, special detergents are usually manufactured for hard-water areas, and it is not normally economical for producers to mix or blend their own detergents. However, if detailed information on this question is required, the reader is referred to a work such as the memorandum on detergents published by the British Standards Institution (1956).

The way in which a detergent is used will be determined by the type of sterilization and the general method of cleansing. Accordingly, the details of the procedure for using detergents will be found under the various sections on different methods of cleansing.

Sterilization by Heat

Heat is applied to milk-contact surfaces on the farm mainly in the form of steam at atmospheric pressure, boiling water, or hot water. There are some so-called " hot-air " sterilizers, but these use moist heat and therefore sterilization cannot strictly be said to be by hot air. When heat sterilization is coupled with hand washing, the cleaning and sterilizing processes are separate; the usual method of cleaning a milking machine is such cases is given below. The same principles apply to hand-milking equipment. The necessary materials are a plentiful supply of hot and cold water, a single- or double-compartment wash-trough, additional large pails, the various types of brushes for buckets, inflations and tubes, and a pull-trough or reaming rod for the long rubber milk tube (see Fig. 1 of chapter by Solberg, page 628).

Cold-water rinse. The outside dirt and residual milk should be removed from the equipment as soon as possible after milking with a brush-rinse in cold or lukewarm water. Clusters should be agitated in this rinse-water by vacuum flushing. Rinsing should be continued until the surfaces appear to be free from milk. If it is not possible on occasion to rinse the equipment immediately, then it should be left completely immersed in water. Rinsing removes most of the soil from the equipment, but if milk solids are allowed to dry on the equipment, then the task of washing is much harder.

Hot detergent wash. This is preferably done in a wash-trough (see Fig. 1) at a temperature of about 115°F (about 46°C). If the wash solution is much hotter than this it will be too uncomfortable for the hands to allow washing to be done satisfactorily. With a 2- to 3-unit bucket machine, 10 gallons (45 litres) of hot wash are normally required. For a smaller amount of milking equipment less water may be used, e.g., 5 gallons (23 litres). Usually 4 ounces (115 g) of dairy detergent are added to 10 gallons (45 litres) of water, but the proportion may vary with the type of detergent used, and the manufacturer's instructions should be followed. The amount of detergent used should be approximately equal to 4 ounces (115 g) of soda ash or 8 ounces (230 g) of washing soda per 10 gallons (45 litres) of water; if the concentration is greater or the alkali stronger than this, defatting of the skin of the hands may take place with continual use. The equipment should be brushed in the hot detergent solution with suitable brushes to remove the remaining surface residues.

Final clean rinse. A rinse of clean water is necessary after a detergent wash to remove the final traces of detergent. It is desirable to use warm water if the water is somewhat hard, as a cold rinse may leave a deposit on the utensils.

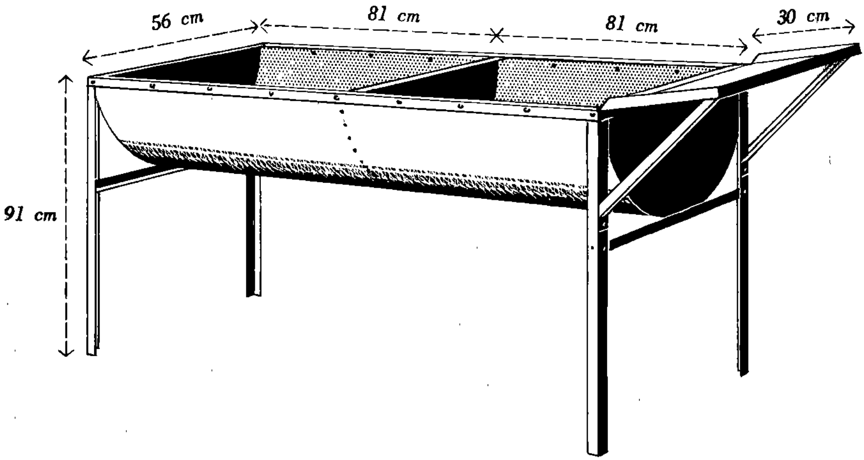
Steam sterilization

Steam ranks first in efficiency as a method of applying heat, and on large farms it is usually more convenient than scalding water.

The use of a steam chest is the usual way of applying steam, but this method should not be used for milking-machine clusters. If the clusters have been washed in a 0.25 % detergent solution they are best sterilized on a steam jet at 205°F (about 96°C) for 2-3 minutes. It is undesirable for clusters to be steamed in a chest because it would take a considerable time for the heat to penetrate to the inside of the long milk tubes, and the air inside such tubes must be replaced by steam before sterilization can be effected. The heating of a long milk tube from the outside would mean that the rubber would be subjected to much more heat than necessary. Further, since hot metal parts would be in contact with rubber for such a long period and heat transfer from metal to rubber is quicker than from air to rubber, the rubber would tend to adhere to the metal at points of contact. (If any rubber parts of a milking machine, such as lid gaskets or the rubber bungs of claws, are to be sterilized in a steam chest, it is desirable that they should be hung in a muslin bag in the chest and not laid on the metal grids.) If rubber is badly washed, steaming will accelerate oxidation caused by absorbed fat; however, with well-washed and defatted rubber normal steaming will do little to shorten its life.

FIG. 1

A SIMPLE INEXPENSIVE UTENSIL-WASHING SINK: (A) PHOTOGRAPH, (B) DIAGRAM *



The two compartments are for warm water with detergent and for cold sanitizing rinsing solution; shelf for scrub brush at one end.

Construction details :

The frame, legs and braces are of 1¼-in. (32-mm) angle iron. The tank proper is made from one sheet of 36-in. (91-cm) wide 20-gauge galvanized sheet, riveted to the frame, the ends and centre division riveted and soldered. The cross-braces at the ends are welded on last, so that the wash sink rests on them. The tank is then riveted and soldered to these end cross-braces, giving stability to the completed sink. The legs at one end should be about 1 cm shorter than the other pair. Holes should be cut in the bottom of each compartment at the lower ends, and a 1-in. (25.4-mm) pipe flange riveted and soldered to the underside. A 1-in. (25.4-mm) pipe plug with wings welded to it for unscrewing is used to plug the sinks.

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The steaming of cans may create a problem on a large dairy farm because the number involved would take up too much space in the steam chest. Under such circumstances it is desirable for cans to be steamed on a steaming stool. This is merely a metal plate with a central hole which admits a steam jet. After washing, the cans are inverted over the steam jet and steamed for a minimum of 2 minutes. It takes at least 1 minute for the mass of metal of the can to come up to the sterilizing temperature, and steaming for a further minute ensures virtual sterility. The lids of cans may also be steamed on the stool, but the steaming time can then be shortened to 1 minute. When many cans are to be washed and steamed it is reasonable to have multiple steaming stools, so that two or more cans may be steamed at once. A note of caution should be added here concerning home-made steaming stools. The position of the end of the steam-jet in relation to the plate of the steaming stool is important. If the tip of this jet is not level with the upper surface of the plate of the steaming stool, the hole in the plate may act as a venturi and cold air will be sucked in with the steam. This may result in such a high proportion of air being drawn in with the steam that the temperature of the cans may never rise above 175°F (79.4°C).

It is not necessary to have the temperature of the steam inside the steam chest as high as that of boiling water. Boiling-point will, of course, vary according to the altitude of the milk-house. There are many dairy farms situated on the continent of North America at 4000-5000 ft (1200-1500 metres), where the boiling-point of water is only 96° or 95°C. Most steam chests will attain a temperature equivalent to that of boiling water if left on long enough. However, moist heat a few degrees below boiling-point at sea level, i. e., at about 205°F (96.1°C), for about 10 minutes will kill all micro-organisms except resistant spores, and even 212°F (100°C) for several hours cannot be guaranteed to kill all of these. In order to allow utensils time to heat up before the holding-time of 10 minutes, and also to allow cold air to be replaced, steam should be admitted slowly to the chest so that the coming-up time is not less than 20 minutes. Steam should enter the chest at the top, so that it pushes the cold air downwards in a blanketing fashion and forces it out of a vent at the bottom which should be not less than 1¼ inches (3.2 cm) in diameter. This vent will also act as a drain for condensed water. The utensils inside the chest should be inverted so that the cold air can flow out when the heat treatment begins. The thermometer should not be placed in the direct line of a steam-jet but should be positioned where it can conveniently be read without danger of being broken.

Recorder and releaser and similar pipeline plants are readily sterilized by steam because of their small cubic capacity. Steam must reach all parts of the plant, and the caps on pipelines should be loosened to prevent dead-ends. It is desirable to steam the plant in the opposite direction to the milk flow. The duration of steaming should be for 2-3 minutes after steam is seen to issue out of the teat-cup clusters.

Steam sterilization can be done twice a day after each milking. While this may be desirable in hot weather, it is reasonable to steam only once a day in cool weather and to use a chemical rinse after milking. A later section deals with the combination of heat and chemical sterilization (see page 213).

Hot-water sterilization

Boiling or scalding water may be used on small farms where the amount of equipment is too small to warrant the installation of steam-raising plant. This method can also be used in emergencies when steam-raising plant is out of order. As with steam, scalding water is used after the cleaning process. The temperature should be as near boiling as possible but not less than 185°F (85°C). The utensils and other parts should be immersed for 1 minute, but where this is not possible boiling water should be poured over the milk-contact surfaces until they are too hot to touch.

Hot-air cabinets

So-called hot-air sterilizers have been used successfully in milk-houses in a number of cases. The heating is usually by electrical elements. The success of this method depends on placing the utensils in the chest in a wet condition. The heat from the electrical elements converts the moisture on the utensils into steam, and it is this agent that brings about sterilization. Sterilization by hot air as such is possible in the laboratory but it is not practicable on the dairy farm because of the higher temperatures needed to make up for the slowness of the rate of heat transfer as compared with steam. With most of these cabinets, the time taken to reach operating temperature is of the order of 3 hours. Some of the cabinets are controlled by a time-switch. This is undesirable because the temperature attained in the chest will then be dependent on the amount of equipment in the chest. It is preferable for such chests to be controlled by a thermoregulator which cuts off the electricity after the desired temperature has been held for 10 minutes.

Chemical Sterilization

Sterilization by chemicals has become more popular in the last two decades, particularly because it avoids the necessity for heavy capital expenditure in the installation of steam-raising plant. There is no reason why chemical sterilization should not give just as satisfactory results as steam sterilization if it is well understood and properly carried out.

Whereas sterilization by steam is governed only by time and temperature, sterilization by chemicals is dependent on a number of variables:

(*a*) the strength of the disinfectant solution; (*b*) the contact time; (*c*) the temperature; (*d*) the speed of action of the disinfectant and its specificity against various types of micro-organisms; (*e*) the ability of the disinfectant to wet and cover the surface and also to penetrate any deposit on the surface; (*f*) the type of surface.

With a method that is affected by so many factors it is not difficult to understand why unsatisfactory results are obtained unless there is strict adherence to a definite and well-established routine. Probably of greatest importance is the contact time between the disinfectant and the milk-contact surface. With the correct concentration of disinfectant, satisfactory sterilization can be effected with a contact time of 2 minutes. If the time is shorter, sterilization may be incomplete. In a routine where weaker concentrations of disinfectant are used and the contact time is several hours, the personal factor, as it affects the way in which the routine is carried out, is eliminated.

The success of any method of chemical sterilization depends on whether it is reasonable and fits in with the routine of the farm. If so, it will be carried out successfully; if not, it may not be done properly. There are three basic processes that can be done easily: (*a*) a rinse lasting a matter of seconds; (*b*) a wash lasting a matter of minutes; (*c*) a soak lasting a matter of hours or preferably the whole of the time between milkings. Most chemical sterilization processes have been built up on one of these. Recently, automatic re-circulation processes have been introduced and these can take any time that is suitable. They can be controlled by a time-switch or made to suit the farmer's routine, i.e., to extend over breakfast or supper.

The hypochlorites

As the hypochlorites are probably used more than any other chemical disinfectant for sterilizing milking utensils, these agents will be discussed here as an example of chemical sterilization. The variations necessary when other materials are used will be referred to later. The two hypochlorites mainly used in dairying are sodium hypochlorite and calcium hypochlorite. Sodium hypochlorite is the more convenient material to use because it is a liquid that can be added direct to the water in the wash-trough and it leaves no sediment on the utensils that have been washed. However, the fact that it is in liquid form is a disadvantage in a country where it would be uneconomic to haul water over long distances. Sodium hypochlorite is mainly sold at concentrations between 10% and 17% of available chlorine, the latter being about the strongest preparation that can be made. Some preparations are available in which sodium hypochlorite has been incorporated in the water of crystallization of inorganic detergents, such as trisodium phosphate. The maximum amount of chlorine that can be contained in such a crystalline material is about 3%. This material can be made suitable for cleaning in place but it is not suitable for hand washing. As mentioned earlier, the detergent concentration used for hand washing should not be greater then 0.25 %, otherwise it will have an adverse effect on the hands. A 0.25 % solution of chlorinated trisodium phosphate will yield a solution containing only about 100 parts per million (p.p.m.) of available chlorine. This is not a sufficiently strong disinfectant solution for chemical sterilization by the hand-washing process. It has not been found possible to prepare sodium hypochlorite in a dry stable form in a concentration stronger than this.

Calcium hypochlorite is a solid material which makes it easily transportable and hence popular with certain sections of the farming community. It is a fairly stable compound and was the form of hypochlorite first used for chemical sterilization of dairy utensils. Its chief disadvantage is that it may leave a residue on the utensils if it is dissolved directly in the wash-tank. It is possible to avoid this by making up a strong stock liquor, letting the deposit settle in this, and using only the supernatant liquid. A supply for several days can be made up in this way.

Strength of solution. The speed at which bacteria are killed rapidly increases with the strength of the hypochlorite, e.g., on smooth metal surfaces a 1-minute contact with a solution containing 200 p.p.m. of available chlorine is equivalent to a 7-minute contact with a solution containing 25 p.p.m. The use of solutions of adequate strength is therefore imperative, because the time that can be allowed for the treatment of utensils is limited. A minimum of 2 minutes should be given each article. This is the contact time that has been established by research to be the minimum with a 300 p.p.m. solution of hypochlorite; this strength will allow for some loss during the washing procedure. Further increase above 300 p.p.m. for utensil washing does not necessarily shorten the time for disinfection, but stronger solutions are certainly liable to cause corrosion (particularly with tinned steel) and are also unsuitable for hand washing.

Different methods of treatment. Chlorine sterilization for the hand washing of dairy utensils was first introduced as a sterilizing rinse after washing or cleaning. This practice is still recommended with hypochlorite by some manufacturers on the North American continent, but combined detergent sterilizers based on disinfectants other than hypochlorite are becoming more popular. The combined use of detergent and hypochlorite has been practised in Great Britain for the past 15 years to the virtual exclusion of the separate cleaning and sterilizing process. The combined method is used after a preliminary rinse and the utensils are scrubbed in a hot detergent-chlorine wash, e.g., 0.25 % detergent and 300 p.p.m. hypochlorite in water at 115°F (46°C). Ten gallons (45 litres) of such a solution in a wash-trough are sufficient to wash all the equipment of a three-unit milking-machine bucket plant. With this method the chlorine disinfectant is sterilizing the utensils during the whole of the period that the utensils are being brushed in the detergent-disinfectant solution. According to one school of thought, the use of the combined method is unsatisfactory because the presence of milk solids will dissipate the strength of the hypochlorite. While this is correct in theory to a certain extent, the combined method has been found sound in practice and was only accepted after extensive farm trials. In fact 10 gallons of a solution containing 300 p.p.m. of available chlorine used to wash a three-unit bucket plant for 30 minutes will still contain about 200 p.p.m. of available chlorine.

The advantages of the combined detergent-hypochlorite wash are as follows:

(1) It helps to ensure the minimum contact time of 2 minutes in the sterilizing solution. Without some such automatic control of contact time the disinfectant might not be given sufficient time to act, with the result that a build-up of micro-organisms could occur on the utensils in a few days. Under such circumstances only really efficient cooling of the milk would prevent it from souring rapidly.

(2) The presence of an alkaline detergent in the disinfectant solution (or of a synthetic detergent containing alkali) reduces corrosion of tinned steel, which is still used extensively for such articles of equipment as milk cans.

(3) There will be a saving of time as, if a separate sterilizing rinse is used, the rinsing time (which should be a minimum of 2 minutes for each tankful of equipment) will be additional to the washing time.

(4) Although the germicidal power of hypochlorite in an alkaline solution is increased as the pH is lowered, in practice the germicidal power of hypochlorites against a soiled surface is increased when mixed with a detergent because the detergent solution confers greater penetrating power on the disinfectant.

The differences between the separate and combined treatments are shown in the table. The use of a sanitizing rinse just before milking is to be recommended. It must be noted, however, that this rinse is used cold and, moreover, that this is the only occasion on which the disinfectant is used with the separate method. This almost invariably means that the contact between the utensil and the sanitizing rinse is a matter of a few seconds only. It is true that the utensils will remain wet with the solution for a short time afterwards, but this is not the same thing as being in contact with the disinfectant solution for a period of 2 minutes. With the separate treatment, it will be noticed also that the same procedure is used after the evening as after the morning milking, whereas with the combined process the evening treatment consists merely of a simplified chemical rinse. This

DIFFERENCE BETWEEN THE SEPARATE AND COMBINED CLEANING AND STERILIZING ROUTINES

Time	Method used with	
	Separate detergent and chlorine treatment	Combined detergent and chlorine treatment
After morning milking	Pre-rinse, then *hot* detergent wash followed by plain rinse	Pre-rinse, then *hot* detergent chlorine wash followed by chlorine rinse
Before evening milking	*Cold* chlorine rinse	—
After evening milking	Pre-rinse, then *hot* detergent wash followed by plain rinse	Pre-rinse, then *cold* chlorine rinse
Before morning milking	*Cold* chlorine rinse	—

is in keeping with the practice mentioned earlier of a simplified chemical rinse and once-a-day steam treatment.

It has been shown experimentally that if the treatment after the morning milking is thorough, a simplified treatment is all that is necessary after the evening milking. Micro-organisms take time to grow on utensils, and providing a thorough cleaning has been done in the morning a simple chemical rinse is all that is necessary to keep them in check after the evening milking until the next thorough treatment. If a simplified treatment is to be given it is preferable for this to be after the evening milking for several reasons: (1) This is the time when the operator is tired from the day's work and when there is more likelihood of cleaning being skimped. (2) Any short cuts introduced in the morning treatment would be disastrous because there would then be no satisfactory chemical treatment at all. (3) The evening treatment prepares the utensils for the morning milking and it is the morning milk which has to last the shorter time before arriving at the dairy where it is usually processed. Therefore lower standards are normally accepted for morning milk than for evening milk.

Limitations and safeguards

It has been found in practice and by experiment that old metal utensils with cracked seams and rusted patches cannot be sterilized by chemicals in a reasonable time. If it is not possible to repair such utensils, they should be replaced. Wire-gauze strainers are almost impossible to keep clean and sterile by chemical means and should be replaced by perforated metal plates. After the rubber parts of a milking machine have been in use for a few weeks they become increasingly difficult to clean and sterilize because of an accumulated film on the surface and in the pores and crevices. Such a condition requires special treatment.

There is less likelihood of resistant milk-stone formation with the use of chemicals than with heat, which will precipitate and bake the protein and mineral material on incompletely washed surfaces. However, chemicals do not penetrate in the same way as heat, and an even greater degree of cleanliness is necessary with chemical sterilization. It cannot be too strongly emphasized that chemical sterilization will not give the desired result on surfaces that have been allowed to become unclean by previous neglect.

Neither sterilizing nor cleaning is 100 % efficient in normal dairy practice. This is particularly true with chemical sterilization. The residue of micro-organisms surviving disinfection from day to day, and the residue of milk solids not removed after cleaning, will increase, though perhaps not at an arithmetic rate. Such a process can continue for a time without there being any noticeable deterioration of the milk. However, after a certain period the accumulation of milk solids will provide a suitable habitat for those micro-organisms that have survived chemical sterilization. Sooner or later a stage will be reached when the bacteriological quality of the milk is affected. This change may be quite dramatic in hot weather, and with particular supplies the milk may change from being of reasonable bacteriological quality to quite unsatisfactory bacteriological quality in the course of two or three days. The deposit of milk solids or film assists the accumulation of micro-organisms by affording them protection from chemical sterilization. It is therefore necessary to institute periodically as safeguards (*a*) heat treatment, which will penetrate the film and kill the micro-organisms therein, and (*b*) descaling, to remove the film and thus eliminate the safety-zone for the micro-organisms.

Heat treatment. Except in very soft water a film or scale will gradually form on milk utensils, and after a few days chemical disinfectants will be unable to penetrate this film. It is then necessary to sterilize the film right through and this is best done by heat. With metal utensils, this treatment should be weekly and can be effected either by steam or by scalding water. Rubber can also be treated in the same way, although it is usually more convenient to give rubber parts a weekly soak for 30 minutes in hot, strong detergent (1 %) at an initial temperature of 160°-170°F (71°-77°C). This will loosen the film, so that it can be scraped off. The combination of alkalinity and temperature will provide adequate sterilizing treatment. This method also keeps rubber in good condition.

Descaling. The film or scale that collects on milk utensils after they have been in use for some time may be a result of interaction between milk solids, detergent and hard water. Although little trouble may be experienced in soft-water areas, in places where there is any trace of hardness in the water a film will occur sooner or later despite good cleaning methods. Fig. 2 shows an enlargement of such a deposit.

This deposit must be periodically removed. Mild organic acids may be used or proprietary materials, some of which are in a convenient powder form. One of the common organic acids used is phosphoric acid. Concentrated phosphoric acid (specific gravity 1.75) can be diluted in a plastic or stainless steel bucket for use. It is most undesirable to dilute this in a galvanized wash-trough, which would be attacked by the acid.

FIG. 2

ENLARGEMENT (×2½) OF MILK-STONE DEPOSIT ON INSIDE OF MILKING-MACHINE RUBBER

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All descaling materials cause some corrosion, and this is to be expected. However, it is less detrimental than allowing milk-stone to accumulate on the utensils. Corrosion can be minimized if the solution is kept in motion, and for this reason the application of the solution with an old brush for a short time is preferable to a long soak in a correspondingly weaker solution. Rubber gloves and a nylon scrubber may be preferred to an old brush. Removal of milk-stone is more effective if the acid treatment is alternated with an alkaline detergent scrub. The alkaline treatment will attack the proteinaceous matter, and the acid treatment will attack the mineral matter of milk-stone or film, which together form a kind of matrix. Descaling with one type of treatment may not be able to proceed beyond a certain point unless it is alternated with the other type of treatment.

With phosphoric acid, a 4% solution should be prepared in reasonably hot water (150°-160°F; 66°-71°C). A 1-gallon (4.5-litre) quantity is sufficient if it is passed from one utensil to another, so that all are kept reasonably well wetted. It is essential to see that all surfaces of the utensils are entirely wetted with the acid solution, either by a brush or a nylon scrubber. It is necessary for the surfaces to remain wetted with the acid solution for a period of 30 minutes. The film may be quite invisible when the acid treatment is commenced, but as it becomes hydrated it expands and becomes visible. In fact, the film usually remains invisible until 20-30 minutes after the acid treatment has started. At the end of 30 minutes the utensils should be rinsed in plain water and then washed once more in a warm detergent solution. This will neutralize the acid and assist in bringing off the remainder of the film. If there are some particularly tenacious areas of film, the acid treatment should be repeated, followed of course by a plain-water rinse and then an alkaline wash. Fig. 3 and 4 show expanded film which has become visible following a 30-minute acid treatment on utensils which showed no evidence of film whatsoever before treatment.

The care and treatment of rubber

The rubber components of milking machines are expensive, and unless proper care is given their life will be short. Knowledge of how rubber deteriorates enables suitable preventive measures to be adopted.

Rubber can deteriorate through the action of light, oxygen, or fat. Therefore, the best possible treatment that can be given to rubber is to store it in the dark, to exclude air from it, and to keep it in a solution that will extract and saponify any absorbed fat. Rubber left in the air will be oxidized as a result of attack by ozone. Small cracks in rubber at right angles to the direction of tension are characteristic of ozone cracking. Ultra-violet light increases oxidation of rubber and therefore hastens cracking. This is the reason why ozone cracking is usually noticed on the side of rubber which has been exposed to light. Rubber can absorb 30 % of its own weight of fat, and this is responsible for the swelling of rubber and the resultant softening. Absorbed molecules of fat penetrate in between the hydrocarbon chains of the rubber, lubricating them and causing the rubber to become too elastic and to lose tension. An excellent account of the make-up and decomposition of rubber can be found in the chapter by Berridge in a publication on machine milking (Great Britain, Ministry of Agriculture, Fisheries and Food, 1959).

The rubber parts of a milking machine that deteriorate most rapidly are the teat-cup liners or inflations. Very little fat will be absorbed by rubber from milk during the course of milking, because the fat particles in milk are very stable. It is only when milk residues are left on the rubber surface that the fat emulsion breaks and much fat is absorbed. However, even with good cleaning methods some fat absorption will take place during milking, mainly from the sebaceous glands of the teat. More fat will be absorbed by rubber under tension than when tension is relaxed.

FIG. 3

FILM EXPANDED AS A RESULT OF 30-MINUTE TREATMENT WITH PHOSPHORIC ACID ON INSIDE OF LID OF MILKING-MACHINE BUCKET

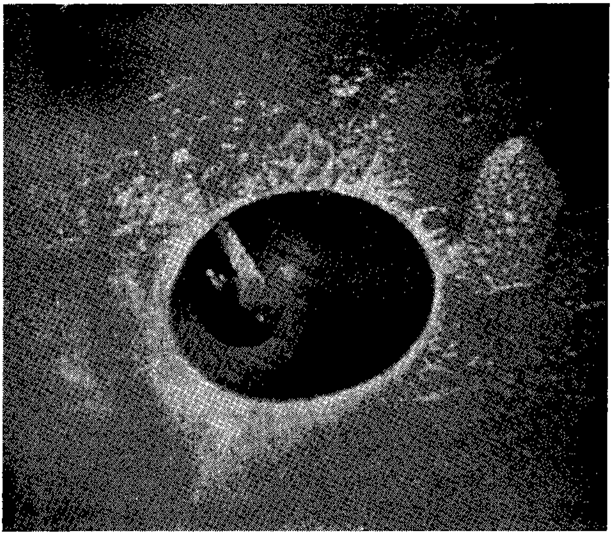


FIG. 4

FILM EXPANDED AS A RESULT OF 30-MINUTE TREATMENT WITH PHOSPHORIC ACID ON INSIDE OF TAP OF LID OF MILKING-MACHINE BUCKET

For this reason alone it is good practice, if possible, to slacken the tension on liners between milkings. Greasy udder-salves also aggravate the problem of fat absorption. Non-greasy udder-salves can be obtained.

To keep the rubber parts in good condition they must be constantly defatted. In this way the elasticity of new rubber will be maintained for a long period. Liners that have absorbed fat can still be defatted satisfactorily providing oxidation has not gone too far. Heating rubber has very little effect on its physical and chemical condition, providing oxidation has not commenced. Heat accelerates oxidation, and subjecting fat-impregnated rubber to a severe heat treatment will rapidly bring about a softening of the rubber. Satisfactory washing of rubber in detergent will reduce fat absorption by removing residues and fat from the surface. However, no detergents at the concentrations used for hand washing can actually defat rubber. This requires organic solvents or caustic soda (lye). Usually, a 5 % caustic soda solution is advocated. The action of this solution can only take place on the surface of the rubber as the NaOH molecule will not penetrate normal rubber. NaOH will form a soap with fat on the rubber surface. This will allow more fat to diffuse to the surface, and more soap will be formed which can be scraped off or washed off with warm water. The methods recommended below for treatment of rubber do not necessarily comprise any of the safeguards described earlier. Although they may assist in this respect, they are primarily designed to lengthen the life of the rubber. Any one of the following three methods will give satisfactory results.

Hot detergent soak

The rubber parts are immersed in a 1 % detergent solution at an initial temperature of 180°F (about 82°C) for 30 minutes. This can be done in a large bucket or tank, and at the end of the soaking period the solution can be tipped into a wash-trough, diluted to 0.25 % detergent, cooled if necessary, and the rubber brushed or scraped with a blunt instrument to remove any loosened film. Long rubber milk tubes are best cleaned after soaking with suitable cleaning rods. These rods should be fitted with a smooth metal scraper of the correct size, which will not damage the interior surface of the tube.

Wet storage of clusters

This process has proved its worth for more than 25 years. It was introduced by Johns in 1933 and consists of filling the teat-cup clusters and long milk tubes with a 0.5 % solution of caustic soda, and keeping the milk-contact surfaces completely covered throughout the period between milkings. Special racks can be bought, or simple racks can be made, to hold the clusters in position. The claw-pieces of some makes of machine allow the solution to leak out between milkings, and it may be necessary to fit a special rubber washer to prevent this.

Wet-storage of liners is not really successful unless they are first washed in a detergent solution. The action of 0.5 % NaOH alone without the aid of mechanical brushing will not keep the milk-contact surfaces free of film (Great Britain, Ministry of Agriculture, Fisheries and Food, 1959).

An alternative to the 0.5 % NaOH solution is a 2 % alkaline detergent solution containing, in addition, 125 p.p.m. of hypochlorite. A 2-weeks' supply of solution can be made up in an old milk can. The method of making up the solution in bulk is preferable because the salts present in hard water will then precipitate in the can. If the solution is made up daily, the precipitation will occur in the clusters and may cause a deposit there. The solution should only be used once. There is no need to rinse before milking. If the solution is allowed to run to waste and drain out through the long milk tube 10 minutes before milking, there will be insufficient detergent left either to be noticeable in the milk or to cause damage to the cow's teats. However, if a sanitizing rinse is normally given as part of the routine it may be more convenient to do this rather than let the clusters drain.

Wet-storage should not be started with rubberware that has been in use for some time. Otherwise there will be a danger that a soapy film will form on the surface of the rubber, making it slippery. If the ends of the long milk tube tend to slip off the vacuum store tubes, this indicates that they contained fat before wet-storage was commenced. The remedy for such slipping is to dip the ends of the tubes in hot water to remove the soapy film. With new rubber the net fat intake will be small, because the fat gained at each milking will be largely removed between milkings.

Defatting of rubber

The defatting of rubber in 5 % caustic soda has been mentioned above. It can conveniently be done with a resting set of liners which are allowed to soak for one week in the caustic solution. After this period the liners are washed in warm water to remove the soap which will have formed on the outer and inner surface of the liners.

The vacuum line

Before considering other methods of chemical sterilization it is perhaps desirable to digress a little to consider the cleaning of the vacuum line. This will enable a complete method of cleaning a milking machine by chemical sterilization to be discussed in one section.

Stall taps on the vacuum line are now almost invariably fitted on the top of the line; this prevents moisture from draining down the long milk tube. Vacuum lines should be installed at an inclination to the horizontal, and drainage cocks should be fitted at intervals. To check the slope of any system, a pint of water can be poured in at the highest tap. If most of the water runs out of the drainage valve or cock furthest away from the point of entry in about two minutes the slope may be considered satisfactory. If the water is not clear when it comes out, this indicates that the pipeline should be washed. Drainage cocks should always be fitted at any point where the slope is interrupted to go across a passageway. Pipelines should be frequently examined for sagging, as this constitutes a danger.

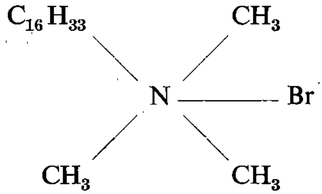
Most manufacturers give instructions regarding the washing of the pipeline. Frequently these stipulate monthly washing and additional washing each time it is known that milk has entered the pipeline. Milk can gain access to the pipeline when the milking bucket or glass jar is overfilled during milking or cleaning, or when a bucket is overturned. A 1 % detergent solution at 160°-170°F (about 71°-77°C) may be used to wash or flush the pipeline. Two gallons should be used for each branch line. Most of the solution should be drawn to the furthest tap, a portion being drawn through each of the other taps. If the line has been badly neglected, washing should be continued until the wash-water in the trap comes through clear. It is important not to overfill the sanitary trap, otherwise liquid may be drawn into the vacuum pump. If the line smells, it may be necessary to sterilize it with a chemical disinfectant. A solution of about 300 p.p.m. should be used (steam can of course be used if this is available). Drain-cocks and stall taps should be left open for several hours after washing to assist drainage. When a new plant is being erected it is worth while to ensure that drainage valves empty on to a washable floor and not into a feeding-trough.

Other chemical disinfectants

In addition to the hypochlorites, there are three main types of chemical disinfectant used in dairying: the organic chlorine-containing compounds, the quaternary ammonium compounds and the iodophores.

Organic chlorine-containing compounds. Probably the most widely used of these materials are the compounds of chlorine and ammonia, the chloraamines, of which there are several. Two other organic chlorine-containing compounds are commonly used, namely, dichlordimethyl hydantoin and trichloroisocyanuric acid. All three materials are in solid form and can be combined with detergents. They are more stable than the hypochlorites, but slower in action. Some formulations may be slow in going into solution, but providing they are dissolved satisfactorily before washing commences, a contact time of two minutes between these disinfectant solutions and the surfaces to be disinfected gives an adequate time for disinfection.

The quaternary ammonium compounds (QAC's). These are cationic materials, one of the commonest being cetyltrimethylammonium bromide (CTAB).



There are hundreds of QAC's but only a few of them have disinfectant properties. The most useful are colourless, virtually odourless, tasteless and non-corrosive, and therefore very suitable as disinfectants for food plant. These compounds are highly surface-active and therefore produce considerable reduction in surface and interfacial tension. Since the cationic part of the molecule is hydrophobic, the disinfectant tends to form a layer one molecule thick on any surface—for example, the cell wall of a bacterium. Thus the disinfectant is automatically concentrated at the point required. QAC's are said to have good bacteriostatic properties, because the molecules are not readily detached from the surfaces to which they have become adsorbed, and as they are very stable, disinfected surfaces may remain sterile for many hours after treatment.

Because the QAC's are cationic they can be inhibited by certain anionic detergents. Therefore, manufacturers usually prefer to formulate QAC's with a compatible detergent rather than supply them as separate sterilizers which might be used in the combined washing and sterilizing process with an incompatible detergent. Soda-ash is usually compatible with these materials, but wetting agents sometimes are not. Some of the phosphates are not compatible, but there is no rule to act as a guide. Usually the QAC's are more effective against Gram-positive than against Gram-negative bacteria, especially in low concentration.

The iodine compounds. Iodine is an excellent bactericide, but its use as a disinfectant for dairy equipment is new. Hitherto, its corrosiveness, toxicity, and low solubility have made it unsuitable for the food industry. These difficulties have largely been overcome in the new products called " iodophores ", in which the iodine is loosely combined with a suitable non-ionic wetting agent, which acts as a carrier; an acid, generally phosphoric acid, is also added to increase the germicidal activity and to promote stability. The carrier or wetting agent acts as a solubilizing medium for the iodine, favourably modifying its undesirable properties. In this combination the germicidal activity of iodine is enhanced and the vapour pressure reduced to a very low value—a necessary requisite for stability. The characteristic odour of iodine is reduced to a minimum, permanent staining prevented, and the intense stinging sensation, which accompanies the use of tincture of iodine, is eliminated. Hard water does not affect the germicidal efficiency of the iodophores.

Usually, these materials are recommended for use at a strength of 25 p.p.m., but Cousins, Clegg & Hoy (1959) have shown that it requires 50 p.p.m. of this material to be equivalent to 100 p.p.m. of hypochlorite in laboratory tests. No large-scale field trials have yet been made on these materials, but they have been used fairly extensively in North America with apparent success. Because of the inclusion of phosphoric acid with some of these materials, a build-up of milk-stone is prevented; under these circumstances it is possible that the disinfectant can act more readily. With pipeline plant a low concentration of disinfectant can easily be overcome by increasing the contact time.

The iodophores would appear to be well suited for udder washing and in the prevention of spread of mastitis, since they have strong bacteriostatic properties and give a much more lasting effect on the skin of the cow's udder than do hypochlorites.

The Combined Use of Heat and Chemicals

What is the best method of cleansing farm utensils? How can this be done most efficiently? Many producers ask these questions. Without doubt steam is the best method, but of course it is not popular because of the cost of installing steam-raising equipment. However, if this is a secondary consideration then steam will undoubtedly give the best results. With regard to efficiency, there is now considerable evidence that once-a-day steaming is adequate if a chemical rinse is used after the second milking, except perhaps in the hottest weather (Great Britain, Ministry of Agriculture, Fisheries and Food, 1959).

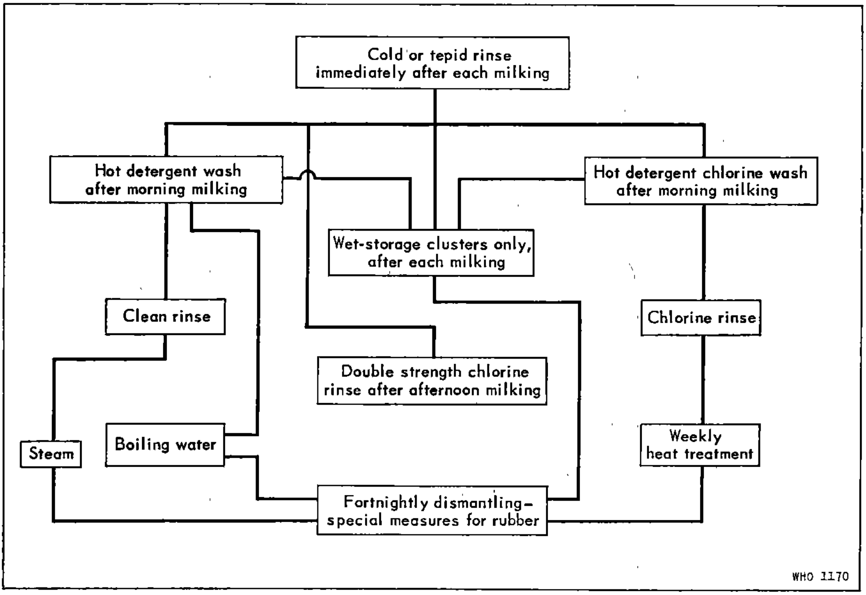
The different methods of cleaning equipment are represented graphically in Fig. 5. This shows that the double-strength chlorine rinse is recommended as adequate for chemical sterilization. This is also based on experimental evidence (Clegg, 1955). Since this method has proved satisfactory with chemical sterilization it is obvious that it will be at least as satisfactory with steam. The combined use of heat and chemical sterilization has been practised in the dairy at the National Institute for Research in Dairying, Reading, England, for over a decade with excellent results.

Immersion Cleaning

The development of immersion cleaning in Great Britain (Thiel, Clough & Clegg, 1955) was designed primarily to cut out the personal factor, which is the biggest variable in the cleaning of utensils, and by this means to pro-

FIG. 5

THE COMBINED USE OF HEAT AND CHEMICALS FOR THE STERILIZATION OF MILKING EQUIPMENT *



* After Great Britain, Ministry of Agriculture, Fisheries and Food (1959)

duce a milk of better bacteriological quality. Further, by simplifying the process of cleaning, it has been made more economical.

Immersion cleaning was first introduced with direct-to-can milking, because this allowed the milking equipment to be reduced to the minimum. Direct-to-can milking is most advantageous where the dairy owns the cans and fulfils its obligation of returning satisfactorily cleansed cans to the producer. However, failure of the dairy to return cans in a satisfactory condition is no reason for not using direct-to-can milking. Further, immersion cleaning has not been confined to direct-to-can milking. Clusters of milking machines are the most difficult part of the plant to clean and sterilize, yet if this part of the equipment is cleansed satisfactorily, little difficulty should be experienced with the rest. For example, with bucket plant, immersion cleaning can be substituted for wet-storage and the buckets can be cleaned and sterilized in the usual manner, by either steam or hypochlorite. This effects considerable saving of time. Similar considerations apply to pipeline milking plant. Such plant is more suitable for large milking herds than direct-to-can milking because of the labour that would otherwise be involved in the handling of cans. If the clusters were cleaned by immersion cleaning then the pipeline could be flushed with detergent and sterilized with either chemicals or steam. Where an automatic recirculating process has been installed, of course, immersion cleaning would not be worth considering.

The following is a description of the material and procedure required for immersion cleaning for the type of machine with long milk tubes.

Equipment

This consists of a mild-steel or rubber bin with a capacity of about 18 gallons; a fitting mild-steel basket with a perforated bottom, fitted with a jig to accept equipment in a definite position so as to avoid airlocks; and stainless steel claw-pieces and shells. If direct-to-can milking is used, then a special stainless steel vacuum can lid will be required. With some types of rubber liners or inflations it is necessary for special lugs to be moulded on to the short milk tubes during manufacture (see Fig. 6). The purpose of this is to relax the tension on the liner during immersion and allow it to remain loosely inside the shell. This permits the liners to be rinsed free from the immersion solution after treatment. With those types of liner that have a deep lip around the mouth, the moulded lugs are not needed on the stem, since the liner shell can be suitably loosened from the liner (see Fig. 7).

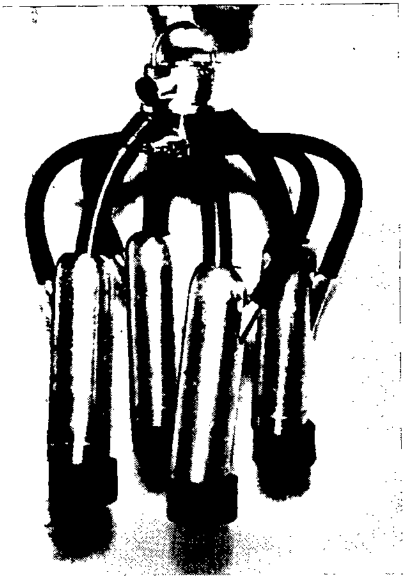
FIG. 6

STRETCHED (TWO-PIECE) AND MOULDED LINERS SHOWING SPECIAL LUGS ON STEMS TO ALLOW LINERS TO BE DE-MOUNTED DURING IMMERSION

Reproduced from Thiel, Clough & Clegg (1955) by kind permission of the editors

FIG. 7

LINERS WITH DEEP MOULDED LIPS DEMOUNTED FROM SHELLS



Such liners do not require special lugs moulded on the milk stems.

The solution

This is made up once a month by dissolving 3 lb. (1.4 kg) of caustic soda (lye) in 12 gallons (55 litres) of water. To this is added 2, 4 or 6 oz (56, 12 or 225 g) of ethylenediaminetetraacetic acid (EDTA), depending on whether the water is moderately hard, hard or very hard. The solution will normally become diluted with rinse water from the equipment to the extent of 30 % by the end of one month. However, this is still a satisfactory immersion solution, though a concentration of less than 2 % caustic soda has a smaller margin of safety.

Daily procedure

At the beginning of the day, the clusters and long milk tubes will have been immersed in caustic soda since the previous milking. The basket containing this equipment is lifted free from caustic soda solution in the bin and allowed to drain for a minute or so (see Fig. 8). The metal basket (shown separately in Fig. 9) can then be stood on the floor and the equipment hosed to remove most of the caustic soda. The equipment is then transferred by hand to a wash-trough containing 5 gallons (23 litres) of water to which has been added hypochlorite at a concentration of 50 p.p.m. The liners are mounted in the shell ready for milking, and the long milk tubes are rinsed in the tank and attached to the claw-pieces. It is quite easy to effect adequate rinsing of caustic soda from the equipment, but inadequate rinsing will mean that the clusters will not stay together during milking.

After milking, any dung should be brushed off the outside of the clusters with a wet brush. The long milk tubes should be disconnected from the clusters, which are put into the tank of water previously used before milking. The long milk tubes are butted up to a tap and water is allowed to flow through. The liners are de-mounted from the shells, and the whole of the equipment is placed in the correct positions in the basket (see Fig. 10), which is lowered into the bin of caustic soda.

Monthly procedure

The solution should be rejected each month and any sludge should be cleaned from the bottom of the bin. A fresh solution should be prepared and all the equipment disassembled and brushed in a detergent solution. This is the only time during the month when the milk-contact surfaces are brushed, and therefore it is essential that a thorough job should be made. During this process the rubber parts should be examined for wear and replacements effected where necessary.

Caustic soda solutions are not dangerous except to the eyes, and practice has shown that accidents with this type of treatment are no greater than with either steam or chemicals.

FIG. 8

INNER BASKET AND EQUIPMENT LIFTED FREE FROM THE CAUSTIC SODA SOLUTION AND ALLOWED TO DRAIN BEFORE RINSING IN TANK AT REAR

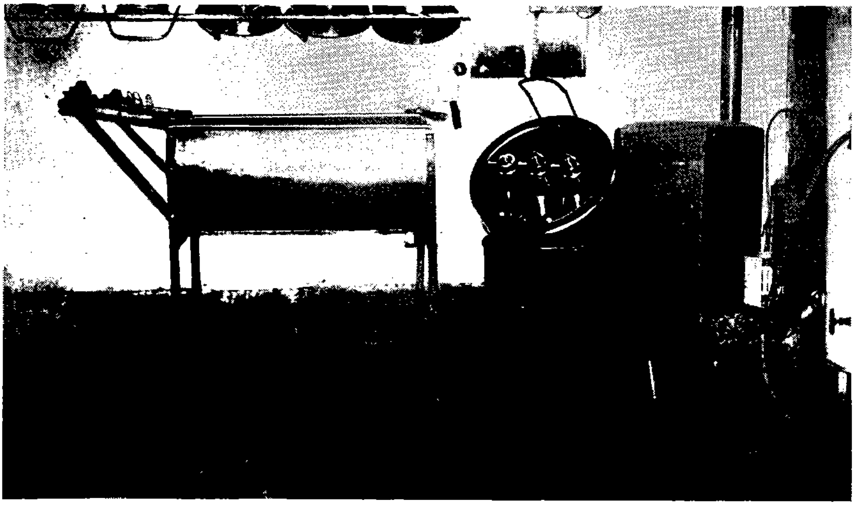
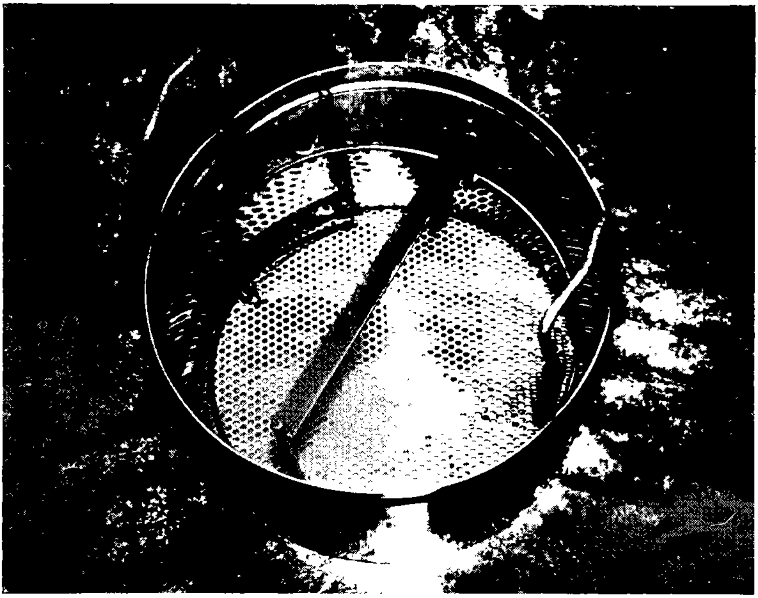


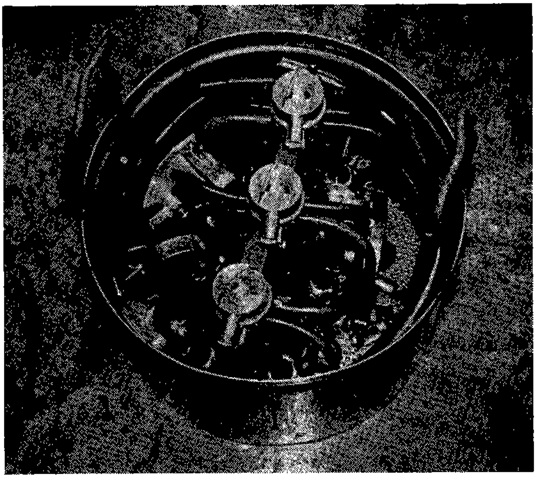
FIG. 9

IMMERSION CLEANING : METAL BASKET SHOWING PERFORATED BOTTOM, RACK TO ACCEPT LONG MILK TUBES, AND BRIDGE TO SUPPORT CLUSTERS



The time taken by an experienced worker for the preparation of the equipment is 3 minutes before milking and another 3 minutes after milking. He will take 30-35 minutes to effect ordinary chemical cleaning and sterilization of a three-unit milking-machine bucket plant.

FIG. 10
IMMERSION CLEANING: CLUSTERS, LONG MILK TUBES AND BUCKET LIDS IN POSITION IN METAL BASKET



Extensive trials (Carreira, Clegg, Clough & Thiel, 1955; Thiel, Clegg, Clough & Cousins, 1956; Cousins, Clegg, Thiel & Akam, 1957) have shown that this method gives results comparable with the best results obtained by other methods of cleaning milking equipment. While it is true that unsatisfactory results can be obtained with immersion cleaning, this is usually only brought about by gross negligence. However, one practice which can give rise to unsatisfactory results is the excessive use of greasy udder-salves. Non-greasy salves are available, and they should be used sparingly as their effect is not improved by excessive use.

Recent studies

More recent work (Whitehouse & Clegg, 1960) has demonstrated the suitability of immersion cleaning with free-standing bucket plant with long milk tubes and with the suspended bucket type of machine where there is no long milk tube (Clegg, 1962, unpublished data). With this type of machine it is undesirable to allow any moisture to get behind the liner because such moisture would soon find its way to the pulsator during milking. With long-milk-tube machines this is not important, because a small amount of liquid would fail completely to wet the long milk tube and would therefore never reach the pulsator. With the suspended-bucket machine, before immersion, two short air tubes on the shells are cross-connected, but the tension on the liners is not released. The pulsator is then removed from the lid, which is immersed in the caustic solution with the shells attached. The buckets are washed and sterilized in the normal manner.

Pipeline Milking

The purpose of pipeline milking is to avoid the transport of milk in containers to the milk-room and cooler. Thus pipeline milking is a necessity with large herds of 60-100 cows. Pipelines can be installed in stanchion barn systems or parlours. With the former, much more piping is required; with the latter the cow does some of the transport itself. Pipelines can be of either stainless steel or glass. The advantage of glass is that the effectiveness of the cleaning can be judged by the clarity of the glass. Some producers have one section of glass and the rest of stainless steel. The two materials cost about the same. Pipelines should be taken down only seldom, otherwise the advantage is partly lost. The more frequently they are taken down the poorer will be the fit of the gaskets between the lengths of pipe. Under pressure the gaskets will then become deformed and tend to protrude into the bore of the pipe, thus interfering with the flow of the flushing or circulating solutions. This difficulty is now being overcome by the use of plastic gaskets.

Rinse-water can be circulated by gravity, by pressure from a supply pump or pressure tank, by pressure from a circulating pump, or by the vacuum pump. The rate of passage of rinse-water should not be less than 5 ft (1.5 m) per second. Each 10 ft (3 m) of 1.5 in. (3.8 cm) glass piping and each 12 ½ ft (3.8 m) of 1.5 in. stainless-steel piping holds 1 gallon (4.5 litres) of solution. (Glass piping sizes are determined by the inside diameter, and stainless-steel piping by the outside diameter.) The cleaning procedure should be by usual methods of (*a*) pre-rinsing, and (*b*) detergent-sterilizer wash or detergent wash followed by sterilization. Sometimes cleaning is assisted by passing a rubber ball or sponge of a slightly larger diameter than that of the pipe through the pipe while the solution is being circulated. The detergent solution should be 1 %-2 % concentration, and its temperature should be at least 150°F (about 66°C) initially. Depending on the size of the installation 25-40 gallons (114-182 litres) of the rinse are required for flush-rinsing. For circulation cleaning 15-20 minutes' treatment is desirable.

Bulk Milk Tanks

Chemical sterilization is usually practised with bulk milk tanks, after a pre-rinse. In some ice-bank types of tank it is desirable to have the detergent or detergent sterilizer in a rubber or plastic bucket to avoid unnecessary cooling of the solution. Proper manual brushing with a detergent sterilizer will take 15 minutes if all surfaces of the tank are to be brushed twice. Manual cleaning followed by a misting of disinfectant as an aerosol is effective, but built-in sprays for pre-rinsing, cleaning and sterilizing are becoming more popular and are very effective.

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