# INVESTIGATIONS OF DETERGENCY APPLICABLE TO MECHANICAL MILK CAN WASHING

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# TO MECHANICAL MILK CAN WASHING

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by

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# INTRODUCTION

Milk cans are recognized by everyone concerned as being of major importance in sanitary milk production. Milk cans come in contact with raw milk longer than any other piece of equipment. They may, therefore, contribute sediment, flavors and odors, and bacteria to milk and adversely affect its quality. Such decrease in quality means a great economic loss to both producers and processors.

While much improvement has been made in perfecting the mechanical can washers to the extent that hot, dry cans are generally discharged from the machines, with more attention being given to the operation of can washers and to selection of effective detergent materials, the state of can cleanliness continues to be faulty.

A considerable portion of this study is an application of a detergent found to give superior detergency in washing raw milk films on farm utensils in a previous study. It was desirable to apply this detergent in can washers to determine if cleanliness and low bacteria counts of milk cans could be achieved when the chemical reaction of the detergent was disregarded, and the detergency properties only, were considered.

CAN WASHING STUDIES

Much criticism has been directed against milk can washing. Jamieson (1943) while summarizing his studies on can washing stated that there was too much complacency surrounding milk can washing. He declared that too many dairy plant operators seem resigned to the belief that they are using efficient procedures with the equipment permitted by their finances.

Scales (1937), another authority on dairy cleaning, described the can washer as being a problem in detergency, being frequently responsible for conditions that result in bacterial contamination and off flavors in milk.

Among the first work published that concerned milk cans and can washing problems was that of Webster (1919), who made a study of the bacteriological conditions of washed empty cans at a city railway platform. From his study he concluded that milk cans constitute a serious source of contamination, and such contamination was sufficient to seriously contaminate the milk that was otherwise produced under sanitary conditions. He calculated that some of the cans would have added to the milk from 24,000 to 66,000 organisms per milliliter.

A similar study was made by Smith (1920), who found that it was possible and practical to secure low counts in milk cans when the proper apparatus was installed and used. He, like Webster, also found a large majority of the cans in a wet condition. The average contamination from wet cans was reported to be approximately 548,000 per milliliter, while the average for the dry cans was 1,870 organisms per milliliter.

Prucha and associates (1918) also contributed to early studies. Essentially they determined the influence of the bacterial population of freshly washed cans on the bacterial content of milk that would be contained in these cans. One hundred and seventy cans were tested, and they found

these cans to contain large numbers of organisms. The average cans would have added to each full can of milk approximately 129,000 organisms per milliliter. In later work, Prucha and Harding (1920) were interested in eliminating bacteria from cans by rinsing with large volumes of hot water just prior to filling them with milk. Their study concluded that the bacterial content of milk cans is controlled principally by the moisture that remains in the washed cans.

The first experimental study to be reported on can washers was that of Farrall (1929-b). The principal types of continuous can washers in use at that time were designated as to form, type of circulation systems, and type of jets. As to form, can washers are usually of the rotary or straight-away types, however, a combination of the two can be obtained. He described three types of circulating systems; motor-driven centrifugal pumps, steam-driven pumps, and the so called "steam gun". The jets were classified as intermittent or continuous, as stationary or rising, or a combination of these, such as, rising-continuous. The steam consumed per can by the steam-operated washers ranged from 4.58 to 5.59 pounds, while the water requirements varied from 0.85 to 4.07 gallons per can.

Harding and associates (1922) were interested in the effect of steaming upon the number of bacteria that remain in milk cans. They were interested in determining the time and the pressure of the steam needed to render milk cans "practically sterile." This work was carried out on 1,157 cans, and it was disclosed that the destruction of bacteria was not secured until two cubic feet of steam had entered the can. It, therefore, appeared that cans should be steamed longer than 20 seconds with more than 20 pounds of steam pressure in order to secure satisfactory destruction of the living bacteria in the cans.

Further studies on the "sterilization" of milk cans were made by Ayers and Mudge (1921), who studied the effectiveness of hot air as a can sterilizing agent. Hot air temperatures of 248°F., 266°F., and 284°F. were tested. They concluded that to obtain effective sterilization a certain minimum length of exposure seemed necessary. While the holding period could be reduced as the temperature was increased, there appeared to be a point beyond which an increase in temperature did not permit a proportionate decrease in the holding time.

Farrall (1929) also studied the heat absorbing capacity of milk cans, and concluded that the capacity of cans for heat is limited by the area of the surface, the coefficient of heat transfer, and the temperature difference between the can and the heating medium. Wet and saturated steam heated the cans at higher rates, per degree difference, in temperature between the cans and the steam than did the superheated steam. Steaming with superheated steam left the cans dryer than did wet or saturated steams. He recommended using superheated steam in the last jet of the can washer to assist in the drying of the cans.

Studies that have been reported were concerned with the bacterial contents of the milk can, and the methods of securing a "sterile" can. Later studies have dealt with the relationship between the visual condition of milk cans and their bacterial content. Studies of this nature have been made by Jamieson and Chan (1942), Tuckey and associates (1946), and Weber (1938).

Weber made observations of the difference in bacterial content between machined washed and hand washed cans. He found that 47 per cent of the cans tested (322) had less than 40,000 organisms per can, which is generally considered satisfactory. Cans found in good condition and cans washed in the mechanical can washers were generally lower in bacteria content than cans that were in poor condition or that were washed by hand methods. Causes of high

bacterial counts in milk were attributed to cans that were in poor condition or to poorly performed hand washing.

The survey made by Tuckey and associates (1946), of 13 receiving stations, showed that 45 per cent of the cans contained over 40,000 organisms per can. This is quite similar to the bacterial counts reported by Weber (1938). Open seamed cans generally had high bacterial contents. Otherwise, very little relationship existed between the physical appearance of the cans and their bacteriological condition. Cans that were apparently dry, contained enough moisture to support bacterial growth, and cans containing milkstone did not seem to reflect that condition in the bacterial content of the cans.

In a very similar study earlier in Canada, Jamieson and Chan (1942) determined the counts of 354 washed cans before they were returned to the patrons. Unlike the low counts of Weber and Tuckey and associates, they found that approximately 94 per cent of the cans contained over 50,000 organisms per can. Also 52 per cent of the cans tested exceeded a count of 30,000,000 per can. These cans were also found to be high in proteolytic and thermophilic types of organisms.

The importance of a clean, well operated can washer has not been overlooked. Frequent, careful inspections for mechanical condition and physical cleanliness of can washers are recommended by; Abele (1948), Bogaerts (1948), Farrall (1949), Faust (1948), Fiske (1949), Heineman (1949), Hoyt (1941), Hunziker (1946), Moore (1945), Roadhouse (1948), Roadhouse and Henderson (1941), Schwartz (1940), Schwartzkopf (1947, 1948), Shogren (1948), and Sommer (1938).

As a means of perfecting the mechanical can washer, the addition of another pre-rinse position was studied by Carkhuff (1948). He noticed a great improvement in the milk cans, both in appearance and in bacteriological condition when they were washed with this "converted" can washer.

The importance of maintaining the proper detergent strength in the wash solution of the can washer was emphasized by Scales (1937,1938). He reported this to be the worst fault of can washers today. This was in agreement with Abele (1948), Davis and co-workers (1944), and Strong (1946).

The use of alkaline detergents in the wash solution of mechanical can washers has long been established. The following men have studied alkaline cleaning: Coulter (1942), Fiske (1949), Harding and Trebler (1947), Johnson and Roland (1947), Razee (1948), Roland (1940), Schwartz (1940), Strong(1946), and Trebler and Harding (1947). After the introduction of the new acid cleaners for mechanical can washing, several men studied and compared acid cleaning with alkaline cleaning. These men were Bryant (1946), Finley and Foter (1947), Foter and Finley (1947), Parker (1940), Parker and Shadwick (1941), Rippen and Burgwald (1941), Scales (1942-a, 1942-b), and Schwartzkopf (1942, 1943, 1947, 1948). Shogren (1949) has described a alternate alkaline, acid method of cleaning.

DETERGENTS USED IN MECHANICAL CAN WASHERS

Alkaline Detergents

Alkalies and alkaline detergents have been used primarily for washing milk cans in mechanical can washers. Although some workers have recently reported the use of acid cleaners, in the majority of cases alkaline types of detergents will be found in use. Important changes that have taken place in the detergent field in recent years have been reported by Little (1947), Parker (1943), Minor (1947), and Shogren (1948). Today alkaline compounds are usually mixed with condensed phosphates and these will also be discussed with the alkaline detergents.

While discussing the chemistry of can washing detergency, Little (1947) described the functions of alkaline detergents with respect to physical and chemical actions. The physical action was described as being the force of the wash solution being sprayed into the can, scrubbing the milk residues left in the milk can. The chemical action was described as acting on the milk soil in the following manner:

"(a) A physical action, due to wetting action of the solution penetrating through the soil, spreading out between the soil and the can, and wedging the soil from the can.

(b) Base exchange reaction in which the sodium ions from the alkalies and condensed phosphates convert the casein into a soluble sodium caseinate.

(c) Electro-chemical action by supplying poly-valent negative ions which are absorbed on the colloidal soil particles and aid in dispersing them in the cleansing solution.

(d) Saponification of the free, fatty acids present in the soil thereby removing them from the soil and breaking the continuity of the film so that the solution can more readily attack the remaining film. This action is unlikely as the pH is not high enough, and the time for this reaction is limited in the can washer.

(e) Surface activity resulting in lowered interfacial tension between the soil and the solution so that the soil is more easily dispersed in the solution."

Little (1938) also describes a procedure by which the amounts of alkaline constituents of washing detergents may be determined.

In reviewing the literature on the use of alkaline detergents, England (1947) found a wide variance in the reporting of alkalinity. In his conclusions, he recommended calling active alkalinity that alkalinity which is determined by titrating to the phenolphthalein end point; caustic alkalinity, that which is determined by titrating to the methyl orange, minus 2 times the methyl orange, minus the phenolphthalein end point (M.O. - 2(M.O.- Phenol.) ); total alkalinity, that which is titrated to the methyl orange end point; and the inactive alkalinity, that which is titrated to the methyl orange minus the phenolphthalein end point. His procedure to report the percentage alkalinity is as follows:

$$\frac{\text{Normality Factor of acid X (Volume acid) X milli. equivalent of NaOH X 100}}{\text{Weight or milliliters of sample used.}}$$

The answer thus reported will be in per cent alkalinity expressed as NaOH.

Strong (1946) recommended the use of alkaline detergents at a pH of 10.5 to 11, with an alkalinity of 0.05 to 0.1 per cent expressed as NaOH. Davies (1939) likewise recommended a pH of 11 as the minimum to use for alkaline detergents as that was the minimum tolerated by bacteria. Clarin (1947) recommended an alkalinity of above 0.05 per cent as active alkalinity.

Bryant (1946) in his can washing studies, used a commercial alkaline detergent which contained carbonates and tetra sodium pyro phosphate. He maintained an alkalinity in the wash tank between 0.08 and 0.16 per cent at the phenolphthalein end point. This according to England (1947) would be classed as active alkalinity. He observed that at this alkalinity and with this product, the wash solution was somewhat severe on well-tinned milk cans.

Fiske (1949) stated that a correct alkaline washing powder for use in a mechanical can washer should assist in the removal of fats, proteins, and mineral salts, lubricate the moving parts of the machine, have some water softening abilities, have some wetting ability to wet and penetrate the milk soil, be free rinsing and be economical in cost. Working with hot-milk films, Johnston and Roland (1947) found that a mixture of tri-sodium phosphate, sodium carbonate, sodium metasilicate and a wetting agent, above 0.1 per cent concentration, was effective in emulsifying fat.

Parker (1942) found fault with the alkaline detergents because the cans washed with them contained proteolytic and oxidizing types of bacteria. His observations show that a pH of 6.5 inhibited the growth of these organisms and thus an acid reaction in the can was considered essential to retard the growth of these objectional types. Parker (1943) does give credit to the alkaline detergents for excelling in emulsifying action, peptizing, wetting and dispersing properties, and for being non-toxic.

A study in which Scales (1942) compared alkaline and acid types of cleaners, Scales (1942-a) used an alkaline compound consisting of polyphosphates, tri-sodium phosphate, sodium metasilicate and a wetting agent, maintaining an alkalinity of 0.07 per cent. In later work, Scales (1942-b) tested two alkaline detergents; (1) 50 per cent soda ash, 7.5 per cent metasilicate, 40 per cent tetra pyro phosphate, and 2.5 per cent wetting agent; (2) 84 per cent metasilicate, 12 per cent tetra sodium phosphate, and 4 per cent wetting agent as Nacconol N.R.. He found that the number 2 detergent gave much higher washing results than the number 1 detergent. However, an acid cleaner also tested, was considered superior to both types of alkaline detergents.

Schwarzkopf (1947) found several difficulties encountered with alkaline detergents in a "conventional" type of can washer. These were, (1) continued re-use of the wash solution at a low temperature; (2) the rinse water is not treated which may cause scale formation on the cans; (3) the hot rinse and steam are wasted; and (4) bacteria grow in the alkaline wash tank at the low temperatures of operation. He also pointed out that at temperatures above 140°F., alkaline detergents formed a lime deposit on the cans and washer. Hot water above 160°F. was noted to do the same.

Shogren (1948, 1949) declared that alkaline cleaners should be used two days, followed by 5 days of acid cleaning to secure clean milk cans from mechanical can washers.

Phosphates

The first record in the literature of the higher phosphates, is that of Graham (1833) and in this country by Hall (1934). Originally the higher phosphates were used solely for softening water and for threshold treatments as shown by Buehner and Reitemeier (1940), Gilmore (1937), Reitemeier and Buehner (1940), Rice and Partridge (1939), and Schwartz and Munter (1942).

Probably the best history and the most comprehensive review of literature of the higher phosphates has been presented by Quimby (1947).

Little (1947) uses the term "condensed phosphates" as the most logical term to designate the "molecularly dehydrated phosphates". This terminology was also preferred by Roland (1942). This is used in preference to the more commonly used terms of "polyphosphate" and "complex phosphate".

The real value of these condensed phosphates as detergents was not fully realized until the work in other detergent fields such as dishwashers, Hall and Schwartz (1937) and Schwartz and Gilmore (1934); milking machines, Jensen (1944) and Mallmann and Bryan (1940).

The efficiency of the condensed phosphates in softening water has been investigated and/or reported on by a number of workers, including Harding and Trebler (1947), Jacobsen (1946), Parker (1943), Piper (1948), Scales and Kemp (1940), and Trebler and Harding (1947).

The use of condensed phosphates for can washing has been studied by Razee (1948)and described by Coulter (1942) and Roland (1942). Razee found that the condensed phosphates gave desirable properties such as emulsifying, dispersing, penetration, and protein dissolving. He found some buyer resistance to their use, due to the additional cost of the detergent containing the condensed phosphates, and an undesirable precipitate formed on the cans when excess dilution of the condensed phosphate took place. In his experience, he observed that phosphates would actually clean up cans that were in very bad condition, containing milkstone and casein encrustation.

Schwartz (1940) recommended the use of calcium-sequestering agents (condensed phosphates) with an alkali for use in mechanical can washers. The alkali referred to was sodium metasilicate. He noted that for this cleaner to be effective, 40 per cent of the detergent had to be the calcium-sequestering agent. The condensed phosphate, alkaline detergent mixture with the addition of a wetting agent was recommended by Mann and Ruchhoft (1946).

Jensen (1944) found that combination of 50 per cent condensed phosphate and 50 per cent wetting agent was a superior detergent for use in farms washing cream separators and milking machines. This was also supported by Trebler (1945). Jensen (1946) working with a laboratory washing apparatus also found that a combination of 75 per cent condensed phosphate and 25 per cent wetting agent gave superior detergency to assorted combinations of alkaline and acid detergents. He suggested that detergency of milk film was not contingent upon chemical reaction of alkalinity or acidity but on the basic properties of wetting, emulsifying, and dispersing. The combination, consisting of sufficient wetting agent for fat emulsification and wetting action plus a condensed phosphate to perform the function of dispersing milk soils and suppressing mineral salt precipitation, was considered by the author to harmonize in a manner to give superior detergency for raw milk films.

A warning note was sounded by Schwarzkopf (1947) on the use of alkaline washing compounds containing condensed phosphates. He states that temperatures of 140° to 150°F. tend to break down many of these products causing a film to form in the can and on the machine.

Also related to the condensed phosphates are the new organic chelating agents. The first to recognize the importance and to study the complex ion homologs of ethylene diamine tetra acetic acid and their alkaline earth complexes was Schwarzenbach and Ackerman (1947, 1948). In this country the use of chelating agents has been primarily for water softening, Martell and Bersworth (1948); use with soaps, Hilfer (1949); and for determining water hardness, Diehl and Hach (1949). Listing some advantages of chelating agents, Bersworth Chemical Company (1949) states, that chelating agents soften water without forming precipitates, are stable at high temperatures and over a wide pH range, dissolves scale and other mineral deposits, dissolves grease and food deposits, and have long storage life. For superior detergency they recommend a combination of condensed phosphates, chelating agents, and wetting agents.

<u>Acid Detergents</u>

The first work with organic acids was reported by Scales (1938), and at that time tartaric acid was used to clean high temperature, short time units. The first use of an organic acid in the wash solution of a mechanical can washer was also reported by Scales (1940) closely followed by the work of Parker (1940) who proposed using acidified steam as a means of inhibiting proteolytic bacterial growth. Since that time, other investigations have been carried out using organic acids, and a mechanical can washer has been developed for the exclusive use of an organic acid detergent.

Parker (1943 classified acid detergents into two groups: (1) the waterstone, milkstone removers include such acids as hydrochloric, phosphoric, tartaric, and citric; and (2) the acid cleaners contain organic acids, wetting agents, and a corrosion inhibitor.

Lennox (1946) and Shogren (1948) believed that the terminology of "acid cleaners" is a misnomer since acid solutions are not good detergents for removing milk residues, but it is the action of the wetting agents added to the organic acids that actually does the cleaning. This is also the opinion of Little (1947). He states that the action of acid detergents is hypothetical, since no investigation regarding the detergent properties of acid cleaners has been reported. He describes the detergency applied by acid-wetting agent solution to grease and protein material as being physical and as being derived from the wetting agent present and not from the acid. The detergency action was specifically described as acting on the soils as follows: (1) dissolving the milkstone and converting the insoluble deposit into a soluble salt;

(2) wetting and penetrating the soil and wedging it loose from the surface through the physical property provided by the wetting agent; (3) lowered interfacial tension between the soil and the solution, so that the soil is more easily dispersed in the solution. Beechem (1944) stated that acid detergents must contain a wetting agent to be effective in can cleaning. This has been the observation of Trebler (1945) and Shogren (1948). Shogren states that the wetting agents contribute several important values to acid cleaning. These qualities he lists as follows: (1) wetting agents are organic in nature and stable in the presence of acids; (2) they are essentially neutral; and (3) they are not affected by high temperatures.

Organic acids were used primarily to overcome certain disadvantages of the alkaline detergents. Scales (1942-a) listed the advantages of the acid cleaners over the alkaline detergents in this manner: They are free of objectional odors in the cans; they produce no ill effect upon the milk; they produce a cleaner appearing can, a "more sterile" can with less steam, detergent, corrosion and cost. Advantages in favor of acid detergents as listed by Hunziker (1946) were; their softening action on hard waters, their chemical action on deposited milk films on metal surfaces, and the possibility that they might be effective as germicidal agents. Schwarzkopf (1942, 1947) listed the advantages of the acid can washer as follows: All cans are rinsed with clean water; all water is treated to prevent scale formation; the machine is kept cleaner; the cans are "more nearly sterile", dry, and clean; the residual alkali is kept low; the cost of water and steam is also kept low; and the temperature of the wash solution can be increased without difficulty. Beechem (1944) stated that when organic acids are combined with wetting agents they will produce foam which contains many of the bacteria found in the wash solution of can washers. This bacteria laden foam is discharged through the overflow, thus aiding more sanitary washing of cans. He further stated that acid prevents

insoluble salts from forming in hard waters.

Parker (1940), and Parker and Shadwich (1941) did further work with the acidified steam and material is presented showing the improvement in the bacteria counts of the acidified cans. They concluded that this improvement in bacteria counts was not due to germicidal action but was rather due to a release of the nutrient film holding the bacteria in the cans. In all of their studies, the cans left in this "acid" condition had no offensive odors. This was also observed by Scales (1942-a) and Bryant (1946). Parker and Shadwich found that acidified steam of cans affected a reduction in bacteria as measured by proteolytic and oxidizing types as well as the "total couhts".

Unlike the work of Parker (1940) who emphasized acidified steaming, Scales (1940) worked with the organic acids in combination with wetting agents in the wash solution for washing cans. In later work, Scales (1942-a) (1942-b) used an acid can washer (Lathrop-Paulson) and an alkaline type washer (Rice and Adams). In both of these studies he was comparing the acid washed cans with the alkaline washed cans as to the visual appearance and as to bacterial contents. He (1942-a) washed a group of cans with the alkaline detergent for 17 days; the following 17 days the acid cleaner was used in the wash tank of the washers. He observed that there was no evidence of spangling and that 10 acid washed cans ranged in pH from 6.30 to 6.35. The acid washed cans were thought to be dryer than the alkaline washed cans. This has also been observed by Bryant (1946). In both studies, Scales found that the alkaline washed cans contained higher "total", proteolytic and thermoduric bacteria counts than did the cans washed with the acid cleaner.

Jamieson and Chan (1943, 1944) studied the possible use of an acid cleaner for a sanitizing agent for milk cans on the farm and in the plant. Their conclusions were that an organic acid cleaner could be effectively used as a sanitizing agent.

Contrary to the results of the above workers is the work of Bryant (1946). Although he used a different type of organic acid, he found no difference in the total counts of alkaline washed cans or acid washed cans. However, he found the acid washed cans contained a predominance of acid-forming types of bacteria, while the alkaline washed cans contained a greater portion of alkali-forming types of bacteria. Contrary to the work of Parker and Parker and Shadwich, is the work of Rippen and Burgwald (1941) who also used gluconic acid to acidify the cans in the last steam jet of the can washer. Of some 200 cans tested, both acidified and non-acidified cans, there was little difference between the total counts and the proteolytic counts of the cans. The pH range of can reactions in the acidified cans was pH 4.1 to 7.38, while the non-acidified cans had a pH range of 7.1 to 9.7. The work of Lehmkuhl (1944) and Tuckey and associates (1946) substantiates the work of Rippen and Burgwald and that of Bryant.

Foter and Finley (1947) while testing six alkaline and one acid washing compound found that the freshly prepared acid washing solution was initially acidic, but within a few minutes became alkaline. This was also observed by Lehmkuhl (1944) where the pH of the "acid" solution was found to have a pH of 8.3. Tuckey and associates (1946) found the pH of some "acid" solutions to be on the alkaline side of neutrality. Foter and Finley attributed this to the reaction of the acid with the calcium and magnesium salts of the hard waters.

The pH of the wash solution should be maintained between 6.0 and 6.5 when organic acid and wetting agents are employed for washing milk cans, state Bryant (1945) and Parker and Shadwich (1941). Trebler and Harding (1947) recommended a pH of the wash solution between 6.5 and 6.8, while Scales (1942-a, 1942-b) recommended a pH of 6.8. Schwarzkopf (1943) recommended that

the pH of the acid solution in the "conservation" type of washer should be held between 6.3 and 6.8.

A rise in pH was noted by Bryant (1946) while using hydroxy-acetic acid in a rotary type can washer. The initial pH of this washing solution was found to be 3.8 which increased to 6.4 at the end of the washing period.

Trebler (1945) and Trebler and Harding (1947) noted that it was extremely difficult to maintain the proper acidity of the wash solution with organic acid cleaners. This was also noted by Foter and Finley (1947) and Rippen and Burgwald (1941) who found certain "acid" solutions to be on the alkaline side of neutrality.

The corrosive affect on tin-plate by organic acids has been studied by Finley and Foter (1947), Kerr (1935), Little (1947), McKay and Worthington (1936), Parker (1940), and by Trebler and Harding (1947). Parker listed the following organic acids in their decreasing order of corrosiveness. They were, phosphoric, tartaric, citric, aconitic, tricarbollylic, fumaric, and gluconic. Little (1947) and Trebler and Harding (1947) found the corrosion rates of organic acids to be correlated with their pH at a certain concentration. Kerr (1935) and McKay and Worthington (1936) have found that the temperature and the dissolved oxygen content of the solution played an important role in the corrosion of tin-plate. Acids alone did not corrode the tin-plate, but in presence of oxygen, the iron used in milk can construction was rapidly pitted by neutral or weak acid solutions.

Wetting Agents

The subject of surface active agents and/or wetting agents is quite large and can not be dealt with completely in this report; however, it is hoped that as applied to the dairy industry and to particularly can washing, a few of the important considerations can be presented.

In general a wetting agent is any substance that will lower surface tension of water when dissolved at at relatively low concentration. Wetting agents are made up of two chemical radicals, namely, the hydrophobic and the hydrophilic groups. Wetting agents are also classified into three groups with respect to the charge on the alkyl radical. These include, (1) anionic, (2) cationic, and (3) non-ionics.

For a thorough background of the subject of wetting agents, the book, "Surface Active Agents", by Young and Coons (1945) and the report of Anson and associates (1946) should be consulted. A partial list of the manufactured surface active agents is given by Van Antwerpen (1939, 1941, and 1943). An early article concerning wetting agents from petroleum was reported by Flett (1942).

In the dairy industry, the first report of the use of wetting agents was Scales and Kemp (1939). They noted in earlier work that wetting power of a detergent was one of the qualifications for a good detergent. Thus, others have also reported on the use of wetting agents, until today the majority of dairy cleaners, including can washing detergents, contain wetting agents.

The use of wetting agents in combination with organic acid cleaners has been advocated by Beechem (1944), Lennox (1946), Little (1947), and Shrogen (1948). Harding and Trebler (1947) and Trebler and Harding (1947) determined that a wetting agent concentration of 80 parts per million was adequate for addition with other alkaline cleaners for superior detergency. Other authors observing and studying wetting agents are: Eaton (1944), Jensen (1944), Levowitz (1950), Mueller and associates (1946), Pendleton (1946), Smith (1948) Somers (1949), and Trebler (1945).

Superior detergency has been reported by Jensen (1944 and 1946) and supported by Trebler (1945) when the wetting agents were combined with condensed phosphates.

Methods of Testing Detergency

Phillips and associates (1928) were probably the first to compare washing powders. In so doing, they employed "practical" tests, as, water softening power, the "washing power" or the detergents (test by using dried-milk films on milk bottles), the emulsifying power, the ease of rinsing, and the action of the detergents upon metals. After testing some 36 commercial detergents, they recommended as the best cleaner a combination of 60 percent sodium carbonate and 40 per cent tri-sodium phosphate.

Several methods of testing detergents has been mentioned by Trebler and Harding (1947). These include, actual use-tests in the plant, laboratory tests which simulate actual use-tests, or indirect laboratory tests of certain properties which are generally assumed to contribute to good cleaning action. Such indirect laboratory tests as alkalinity, pH, and surface tension have been widely used.

Probably the first workers to devise a testing apparatus simulating actual washing tests were Gilcreas and O'Brien (1941) where glass microscopic slides were coated with different types of films and were then washed and evaluated by use of a photoelectric colorimeter.

Scales and Kemp (1939) prepared sheets of metal with an adhesive milk film by exposing 3 inch squares of tinned copper to milk held just below the boiling point.

Wilson and Mendenhal (1944) and Hughes and Bernstein (1945) used different methods in preparing films for washing. However, they both used a photometer for measuring the amount of light transmitted through the glass surfaces after washing.

Jensen (1946) also used a mechanical washing apparatus, while studying detergency functions of various detergents against milk films fixed into glass panes.

Mann and Ruchhoft (1946) devised a performance test for rating dish-washing detergents, wherein an apparatus was used to determine the detergency values. Other experiments followed and modifications were made by Norris and Ruchhoft (1948, 1949).

Fouts and Freeman (1947) utilized a bicycle wheel to wash milk coated microscopic slides. The washing was accomplished by this "Deter-o-meter" by passing the slides through the detergent solution and passing over a sponge rubber brush.

Practical methods of testing the cleanliness of milk cans has been attempted. Tuckey and associates (1946) scraped loose the adhering milk soil from a milk can, and found that the total soil removed weighed 8 grams.

Roadhouse (1947) demonstrated that dirt remained on the interior of cans by swabbing with clean cotton swabs, thus suggesting that dust particles were deposited from dust-laden air that was blown into the cans during the drying stage of can washing.

To secure information on the nature and extent of extraneous matter in cream shipping cans, Claydon (1948) used a pint of sediment-free water containing some wetting agent. The cans were then agitated and filtered through a sediment test disc. Although the author was not interested in the total amount of sediment found, he did find that as a result of hand scrubbing the cans, so much sediment was removed that the sediment discs became clogged and only part of the rinse water could be filtered. Claydon (1950) also noted when the cans were scrubbed with a brush, that the question arose as, "how much the brush contributed to the sediment, and how much it retained".

Unlike the interests of Claydon (1948), Jensen and Waterson (1950) determined the cleanliness of 180 milk cans by washing them with a quart of filtered water containing approximately one-half tablespoon of a condensed phosphate-wetting agent detergent. The cans were hand washed by means of cheese cloth wads to prevent any carry-over of sediment and to be certain that the sediment obtained did not contain brush fragments. The rinse water was then tested with a sediment tester, and the sediment discs thus obtained were graded.

TESTING BACTERIOLOGICAL CONDITION OF MILK CANS

To determine the performance of a can washer it is essential to find the bacteriological condition of the milk cans being discharged from the can washer. There are several methods by which the bacterial content of milk cans may be determined. They are: the swab test explained by Standard Methods (1948), the agar-plate method of Olson and Hammer (1933) and Walter and Hucker (1941), and the rinse method also described by Standard Methods (1948). The latter test has been used by the majority of the workers and thus the review of literature deals entirely with this method.

Volume and Rinse Material

The first worker to observe and test the bacteriological conditions of milk cans was Webster (1919). He determined the bacterial content of the milk cans by rinsing the cans with 200 milliliters of sterile water and plating portional samples. Cans that were wet as a result of improper drainage following washing, were tested for bacterial content by directly plating portions of the drained water. Smith (1920) used methods similar to those of Webster's.

In the majority of the studies that have been made to determine the bacteriological condition of milk cans, 100 milliliters of sterile rinse medias were used. Investigators using this amount of rinsing portions include, Ayers and Mudge (1921), Bryant (1946), Carkhuff (1948), Foter and Finley (1947), Milone (1948), Milone and Tiedemann (1949), Parker (1940), Parker and Shadwich (1941), Rippen and Burgwald (1941), Shutt (1945), and Weber (1938).

Prucha and associates (1918) determined the bacterial content of the

cans following the use of 1000 milliliters of sterile water. Some of the cans were rinsed with 1000 and 1500 milliliters of sterile water respectively, and others with 2000 milliliters of sterile water. Others using 1000 milliliters were Prucha and Harding (1920) and later Harding and associates (1922).

Working with acid and alkaline washed cans, Scales (1942-a) used 460 milliliters of sterile tap water. In later work that same year, Scales (1942-b) used 450 milliliters of sterile tap water and wasted 100 milliliters of the sample by pouring that amount over the lip of the can.

In preliminary studies of bacterial contents of milk cans, Jamieson and Chan (1942, 1943-a) followed the rinsing methods proposed by Standard Methods (1939). However, in later work, Jamieson and Chan (1944) used the agar-plate method of Olson and Hammer (1933). In later work, he combined the swab method and the agar-plate method and applied his own "seeing is believing" method described by Jamieson and associates (1946), Chamberlayne (1948) and Jamieson and McLeod (1949).

The recommendation of 500 milliliters of sterile water was given by Holmquist and associates (1937) and Sommer (1946). Sommer believed that by holding the cans for 12 to 24 hours after the time of washing, gave more significant results of the actual bacterial content, than when the determination was made as the cans came directly from the washer.

In order to check the efficiency of can washers, both rotary and straight-away types, Tuckey and associates (1946) used 400 milliliters of sterile buffered distilled water containing sodium thiosulfate.

Likely before most of these afore mentioned workers started their investigations Standard Methods was consulted. Standard Methods in (1934) recommended the use of 500 milliliters of sterile water. Later Standard Methods (1939) recommended the use of 100 milliliters of sterile sodium thiosulfate solution of approximately 0.1 N concentration. Still later, Standard Methods in (1941 and 1948) recommended the use of 100 milliliters of sterile tap water, sterile buffered distilled water, or sterile standard nutrient broth.

Several of the workers of Great Britain have recommended normal saline solution or quarter strength Ringer's solution. Barkworth (1941) recommended and used 500 milliliters of 0.9 per cent saline solution. Provan and Treble (1941) used either 500 or 1000 milliliters of sterile water, sterile saline solution, or quarter strength Ringer's solution. Neave (1943) rinsed the milk cans with 500 milliliters of quarter strength Ringer's solution 28 hours after they had been washed. The Ministry of Agriculture and Fisheries (1945) recommended that churns (cans) be tested one hour after washing using 500 milliliters or larger amounts of quarter strength Ringer's solution. Their recommendation of 500 milliliters or larger is based on the fact that volumes smaller than this will need elaborate methods of shaking, which would be cumbersome and difficult to standardize.

Shaking Procedure Used

Aside from selecting an effective rinsing material, the mode of contact is also important in order to set free and secure the highest possible number of bacteria from the cans that are tested.

Prucha and associates (1918), Prucha and Harding (1920) and Harding and associates (1922) thoroughly shook the cans after the rinse material was added. It was then poured out and plated and the number of organisms taken from the water was taken as the number present in the cans.

Three investigators reported using Standard Methods (1941), however, only Foter and Finley (1947) reported using the shaking apparatus pictured and described by Holmquist and associates (1937). Others reporting using a mechanical apparatus for their shaking determinations are Milone (1948), Milone and Tiedemann (1949) and Tuckey and associates (1946). The others following the shaking procedures of Standard Methods was Ayers and Mudge (1921), Bryant (1946), Jamieson and Chan (1942, 1943), Rippen and Burgwald (1941) and Weber (1938).

Scales (1942-a), after placing the rinse material in the cans, vigorously shook them by holding each can by one of the handles and the bottom rim. They were shaken five times from top to bottom, then rolled over and again shaken as before. The same procedure was followed in the later work by Scales (1942-b).

The shaking techniques was not mentioned by Carkhuff (1948), Parker (1940), Parker and Shadwich (1941), or by Shutt (1945); however, it is assumed that some standard procedure was used to keep this factor constant. Presumably Standard Methods (1941, 1948) were followed. Webster (1919) rinsed the interior of the cans, after adding the rinse material, by "shaking and rolling the cans", while Smith (1920) "thoroughly shook" the cans.

Only two investigators, Neave (1943) and Provan and Treble (1941), used a scrubbing agent along with the shaking techniques. Neave rolled his cans and allowed them to set five minutes after which the cans were thoroughly squeegeed with a sterile rubber squeegee attached to a metal handle. Provan and Treble used a sterile test tube brush to scrub the milk cans before shaking the cans by hand.

Standard Methods (1948) recommended shaking the cans vigorously by hand or by a suitable shaking apparatus, one of which was pictured. For hand shaking cans, the can is grasped under the cover with one hand and under the uppermost side of the bottom rim with the other. The cans are rapidly shaken lengthwise 10 times, with an excursion of about 18 inches. The can is turned one-quarter turn and the process is repeated until the solution has been agitated over the entire surface.

Number of Organisms Removed

When the rinse method is used for determination of bacterial contents of

milk cans, the total number of organisms present in the cans is not removed. Milone (1948) studied the amount of organisms that the rinse material removed from the cans. His results showed that when cans with a high bacterial content were tested, the first rinse removed from 11 to 74 per cent of the total bacteria found when the total number removed by 5 successive rinses is equal to 100 per cent. When the cans contained medium counts, he found the initial rinse removed from 4 to 48 per cent, while with low count cans, the initial rinse removed from 3 to 43 per cent. The results of Prucha and associates (1918) show that approximately 75 per cent of the bacteria are removed on the first rinse when 1000 milliliters of rinse was used. The total removal by 4 successive rinses was considered equal to 100 per cent. When the volume of rinse material was increased to 2000 milliliters, the per cent removal by the initial rinse was increased to 77 per cent. Barkworth (1941) found that approximately 45 per cent of the bacteria were removed by the initial rinse and approximately 86 per cent when two rinses were used. These figures were based on the assumption that the total number of bacteria that were removed by 4 successive rinses was equal to 100 per cent.

Factors Influencing the Rinse Test

The factors that affect the rinse test results have been outlined by Milone (1948) and they consist of the following:

a. Time and intimacy of contact of the rinse medium with the utensil milk contact area.

b. Temperature of the rinse medium and utensil.

c. Evaporation of the rinse medium and utensil.

d. Amount of rinse medium used.

e. Presence of substances not incorporated by the rinse medium.

f. Presence of clustering and chain forming organisms.

g. Presence of micro organisms embedded in insoluble deposits.

h. Adsorption of rinsing medium to the walls of utensils.

i. Adsorption of rinsing medium by deposits present in the utensils.

j. pH of the rinsing material and substances possibly present in the container.

k. Toxicity of rinse material to micro organisms present in utensil.

l. Presence of organisms which will grow in the media used and at the temperature of incubation recommended.

Type of Organisms Found in Cans

As early as 1923, Whiting (1923) studied the types of organisms found in milk cans. He classified the organisms into twenty-nine types, finding a large quantity of thermoduric types of bacteria. A similar study was made in England by Thomas et co-workers (1946), who determined that the predominant types of organisms were found to be Microbacterium, Micrococci, and spore-forming rods. Another study from England by McKenzie and associates (1946) concluded that farm milk cans were an important source of thermoduric types of bacteria. Fabian (1948) and Fiske (1949) declared that milkstone found in milk cans may well serve as an ideal focus for seeding the milk with thermophilic bacteria.

Contrary to this work, Milone and Tiedemann (1949) found that the role of the milk can in the initial, total, contamination of the milk poured therein, except in extreme cases, was not as important a source of contamination as is generally believed.

Parker (1943), Scales (1942-a, 1942-b), Schwarzkopf (1943) found alkaline washed cans to contain proteolytic and oxidizing types of bacteria. They found these organisms growing in alkaline solutions and at temperatures of 170° F.

Lehmkuhl (1944) studied the milk can as a source of coliform organisms. Of all producers cans tested for coliform, no positive tests had been found. Contrary to this work, Provan and Treble (1941) in England found large numbers of coliform organisms in shipping cans.

## PLAN OF EXPERIMENT

The work herein reported was done with the purpose of studying the bacteriological condition and physical cleanliness of washed milk cans as they are discharged from the mechanical can washers. The factors that may affect these two conditions were also considered as to their effect upon the desired results.

The specific object of this experiment consisted in:

1. Determining what type and volume of rinse material would give us the highest possible per cent removal of organisms contained in the milk cans. A desired type of shaking apparatus was also needed by which this factor could be kept constant, and still allow us to transport it to different testing points.

2. The use of a quick and effective method by which the physical cleanliness of the milk cans could be determined, and still fit into the can washing operation without disrupting it. This was to be accomplished along with the determination of the bacterial contents of the milk cans.

3. The analysis of the commercial detergents on the market as to their value in can washing detergency, and if possible to formulate some type of laboratory prepared detergent that could be used in a mechanical can washer.

4. The study of the washing solution of can washers throughout the day, as to concentration of the detergent, pH, and total hardness.

5. Putting into use the findings of 1, 2, and 3; studing them under practical field conditions.

# THE EFFECT OF VARIED AMOUNTS AND VOLUMES OF RINSE MEDIA ON THE NUMBER OF BACTERIA REMOVED FROM MILK CANS

One of the means of evaluating the sanitation of milk cans is determining their bacterial content. It is important to use methods for such determinations that are practical in application and that will be representative of the can's bacteriological condition. Also it is desirable to know how the results that are secured may compare with those of workers using various procedure as a means of determining bacterial contents of cans.

## PROCEDURE

For these experiments, six new 10-gallon milk cans were selected and marked from A through F to identify them for repeated study. The cans and covers were thoroughly and completely cleaned with a wetting agent-condensed phosphate detergent between each trial. After washing, the cans and covers were sterilized in an autoclave at 15 pounds steam pressure for 15 minutes. The cans were then cooled to room temperature and each was inoculated with 1000 milliliters of a 24 hour milk culture of Micrococcus caseolyticus, by rinsing each can sufficiently to wet the entire inside surface. After inoculation, the culture was poured out of the cans, and the cans were inverted on a wire platform to drain and dry for a twenty-four hour drying period in a 35°- 37° C. incubator room. After a twenty-four hour drying period the cans were rinsed with various kinds of rinse media. With the rinsing solutions transferred to the cans, two sterile parchment papers were placed on the pouring lip of each can before replacing the cover. All cans were shaken, unless otherwise noted, with the mechanical can shaking apparatus described and illustrated by Milone (1948) and by Figures 1 and 2. After rinsing, the rinse medium was poured into a sterile container and bacteriological determinations were made by plating the various dilutions of the rinse medium according to Standard Methods (1948) procedures.

Use of a Non-ionic Wetting Agent

It seemed desirable before further experiments were carried out on various rinse media to test whether a dilute wetting agent solution could be used since wetting agents possess detergency properties and should, therefore, aid in setting free the dried bacteria-laden films. A non-toxic, non-ionic wetting agent, Triton X-100, made by Rohn and Haas Company of Philadelphia, Pennsylvania, was selected for this experiment. Concentrations of 0.1, 0.075, 0.05, 0.025, and 0.01 were used. The cans were prepared with a dried caseolyticus film as described under the procedure. The results of this experiment are shown in Table 1.

Table 1. The effect of a non-ionic wetting agent (Triton X-100) on the removal of organisms from inoculated milk cans.*

| Can Number | % concentration of wetting agent | Bacterial counts per ml. |
|---|---|---|
| A. | control: distilled water | 1,770 |
| B. | 0.1 | 830 |
| C. | 0.075 | 620 |
| D. | 0.05 | 920 |
| E. | 0.025 | 1,110 |
| F. | 0.01 | 3,300 |

*two trials

According to Table 1, the highest removal of organisms occurs with the 0.01 per cent solution of the non-ionic wetting agent, Triton X-100. As the concentration of wetting agent was increased above a level of 0.01 per cent there occured a decided decrease in the removal of bacteria as measured by the bacteria counts obtained. Approximately twice the number of bacteria were removed by the 0.01 per cent solution than was removed by the distilled water.

It was thus apparent that the wetting agent solution has a desirable effect upon the removal of organisms. However, it appears also that there is a maximum amount of wetting agent that can be added without a reduction in bacterial count due to increased surface activity and/or poor sampling due to excessive foaming at the higher levels of concentration.

Comparing the Effects of Different Rinse Media Used in Various Quantities on Can Rinse Counts

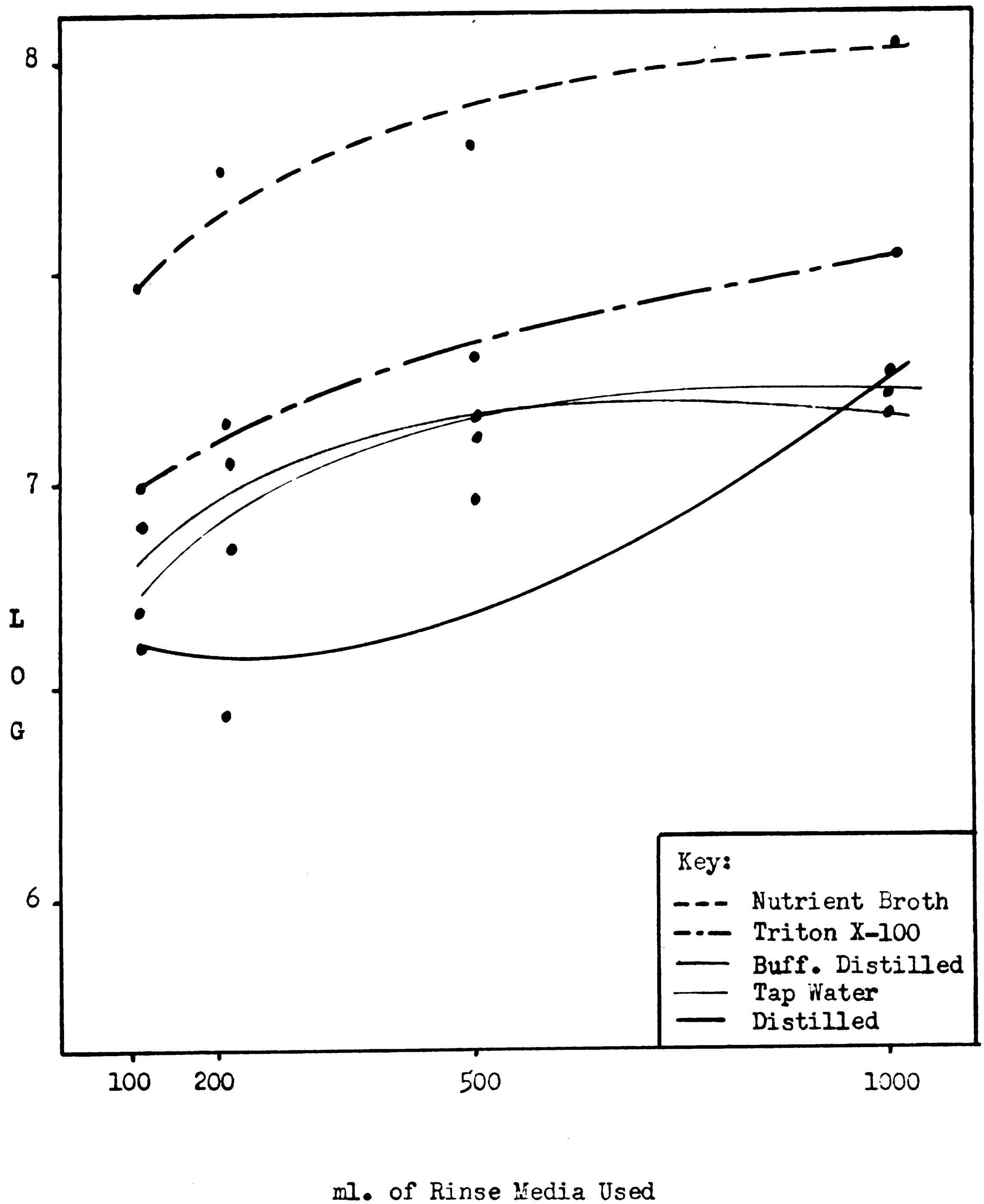
The review of literature and Standard Methods (1948) do not show that there is a difference in bacteria counts secured with different media or with different volumes of medium. It was deemed necessary to compare some of the rinse media that have been recommended in varied quantities to determine which would remove the greatest number of organisms with the initial rinse. Thus the rinse media removing the largest numbers of organisms should give a more accurate presentation of the bacteriological contamination of the cans. The method of Holmquist and associates (1937) was followed, with certain modifications as outlined in the procedure. In this study five rinse media were compared, three as recommended by Standard Methods (1948); namely, distilled water, buffered distilled water, and nutrient broth. Tap water and a 0.01 per cent solution of the non-ionic wetting agent, Triton X-100, were also used. The buffered distilled water and nutrient broth were prepared according to Standard Methods (1948) procedure. All rinse media were sterilized in an autoclave with a steam pressure of 15 pounds for 15 minutes. A control of the sterility of the media and of the dilution blanks was made. All were found to be negative, thus the controls are not shown in Table 2. Each of the five rinse media were tested in quantities of 100, 200, 500 and 1000 milliliters. Four trials were conducted on each rinse media at each quantity. During such a study, difficulties arise due to the lack of uniformity in filming cans with the M. caseolyticus cultures, thus the total number of bacteria removed by the

Table 2. The influence of different rinse materials on the removal of bacteria from inoculated milk cans.

| Rinse media | Trial | Total bacteria counts *(x 1000) of media from inoculated cans when using: 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|
| Tap water (B) | 1. | 9,449 | 6,500 | 9,333 | 19,074 |
| | 2. | 6,093 | 8,930 | 9,494 | 36,964 |
| | 3. | 2,284 | 25,455 | 12,264 | 5,063 |
| | 4. | 3,143 | 7,551 | 18,831 | 13,934 |
| | log. ave. | 4,510 | 10,280 | 11,960 | 14,940 |
| Distilled water (C) | | | | | |
| Non-buffered | 1. | 3,150 | 1,333 | 2,400 | 11,296 |
| | 2. | 2,450 | 3,070 | 11,124 | 55,357 |
| | 3. | 5,368 | 4,773 | 18,538 | 21,519 |
| | 4. | 6,000 | 2,392 | 12,468 | 15,246 |
| | log. ave. | 3,971 | 2,615 | 8,862 | 21,770 |
| Buffered (D) | 1. | 11,024 | 7,333 | 7,733 | 14,074 |
| | 2. | 2,781 | 5,023 | 58,988 | 23,214 |
| | 3. | 14,947 | 15,909 | 4,670 | 10,886 |
| | 4. | 5,821 | 2,837 | 12,208 | 10,000 |
| | log. ave. | 7,219 | 6,385 | 12,700 | 13,730 |
| Nutrient broth (E) | 1. | 37,795 | 35,000 | 40,667 | 174,074 |
| | 2. | 34,437 | 40,000 | 126,404 | 419,643 |
| | 3. | 16,421 | 88,182 | 78,302 | 43,038 |
| | 4. | 30,714 | 69,388 | 33,766 | 63,934 |
| | log. ave. | 28,460 | 54,100 | 60,710 | 119,100 |
| Non-ionic wetting agent (F) | | | | | |
| | 1. | 7,874 | 1,550 | 10,667 | 59,259 |
| | 2. | 5,629 | 34,419 | 11,742 | 62,500 |
| | 3. | 11,578 | 27,500 | 57,143 | 16,076 |
| | 4. | 12,857 | 17,143 | | 16,393 |
| | log. ave. | 9,015 | 12,600 | 19,400 | 31,440 |

* All counts have been converted to represent anoriginal inoculation of the milk can with a culture containing 1,000,000,000 organisms per milliliter.

Figure 3. Logarthmic averages, of bacteria counts showing the influence of different rinse media on the removal of bacteria from inoculated milk cans.



rinse media would depend on the bacterial population of the culture. Therefore, the bacteria counts shown in Table 2 have been converted to equal a culture count of 1,000,000,000 organisms per milliliter, thus enabling a comparison of the total number of organisms removed by the rinse media. To show more effectively the difference between the rinse media, Figure 4 has been included along with Table 2.

Table 2 and Figure 4 show that the highest total counts recorded were obtained with the nutrient broth in all volumes tested. There was a definite tendency for the rinse media to remove larger total numbers of organisms with increased quantities of media used. At the 1000 milliliters volume, the decreasing order of removal of organisms was found to be; nutrient broth, non-ionic wetting agent, non-buffered distilled, tap water, and buffered distilled. At the 500 and 100 milliliters volume, the decreasing order was found to be; nutrient broth, non-ionic wetting agent, buffered distilled, tap water and distilled water. Second best to the nutrient broth in all volumes tested was the non-ionic wetting agent. The tap and buffered distilled waters yielded lower but practically identical results. However, the non-buffered distilled water gave somewhat lower removal. Altogether, the results show that there is considerable variation in the removal of organisms by the different rinse media and at the various volumes tested.

Effect of Buffering the Triton X-100 Solution on Bacterial Removal

While a high number of organisms was shown to be present in cans when rinsing with the non-ionic wetting agent solution, it was considered that a buffered wetting agent solution might cause an increase in the bacterial counts of rinsings. In this experiment, only buffered distilled, buffered wetting agent solution and the non-buffered wetting agent solution were tested. The buffered wetting agent solution was prepared by adding non-ionic wetting agent,

Triton X-100, to buffered distilled. The results obtained are shown in Table 3.

Table 3. The effect of buffering, non-ionic wetting agent in the removal of organisms from inoculated cans.

| Rinse medium | Bacteria counts in (x 1000) in volumes of | | | |
|---|---|---|---|---|
| | 100 | 200 | 500 | 1000 |
| Buffered distilled | 7,123 | 12,440 | 51,650 | 60,000 |
| Wetting agent | | | | |
| Non-buffered | 6,900 | 31,600 | 177,500 | 40,000 |
| Buffered | 8,500 | 49,520 | 46,320 | 140,000 |

The results shown are from an average of four trials. They clearly show that by buffering the wetting agent, a higher bacterial count from the can rinsings may be expected. The non-buffered non-ionic wetting agent solution gave highest bacterial counts at 500 milliliters quantity; however, in all trials either the buffered or non-buffered wetting agent solution, gave higher counts of bacteria than did the buffered distilled water. This corresponds with the results shown in Table 2. On the basis of these results, a buffered wetting agent solution would be favored over a non-buffered solution.

The Effect of the Number of Rinsings and the Time of Drying on the Residual Bacterial Content of Cans

Trials were made to determine the effect of the drying period on the total bacterial counts of cans. Five cans were inoculated and tested for total bacterial contents at various stages of the drying period. It was also the purpose of the experiment to determine the number of organisms removed with each successive rinsing. The periods of drying used in this experiment were 6, 12, 18, and 24 hours. Control cans were rinsed immediately after a ten minute drainage period to allow the milk culture to drain from the cans. The rinse medium used was 200 milliliters of nutrient broth, each can receiving 10 successive rinses. Because nutrient broth was used, all

plating was done within 2 to 3 minutes after the rinse medium had been removed from the can. The results of the experiment are shown in Table 4.

Table 4. The effect of drying period on the number of organisms removed from inoculated cans, and the number of organisms removed by successive rinsings.

| Rinse Control | Control | Bacteria counts (x 1000) per ml. Drying period in hours 6 | 12 | 18 | 24 |
|---|---|---|---|---|---|
| 1. | 6,600,000 | 40,000 | 60,000 | 25,400 | 14,600 |
| 2. | 620,000 | 20,000 | 40,000 | 7,600 | 5,200 |
| 3. | 70,000 | 4,000 | 2,000 | 3,060 | 1,000 |
| 4. | 29,000 | 1,080 | 444 | 1,800 | 400 |
| 5. | 25,000 | 220 | 140 | 900 | 100 |
| 6. | 20,000 | 180 | 71 | 520 | 67 |
| 7. | 3,780 | 120 | 41 | 173 | 26 |
| 8. | 938 | 144 | 28 | 78 | 40 |
| 9. | 400 | 110 | 30 | 74 | 38 |
| 10. | 102 | 62 | 14 | 33 | 30 |
| TOTAL | 7,370,920 | 65,916 | 102,768 | 39,638 | 21,501 |
| Per cent of total removed in 5 rinses | 99.7 | 99.1 | 99.8 | 97.8 | 99.1 |

The results of Table 4 show that as the period of drying of the inoculated cans increased, the total number of bacteria removed from the cans decreased. Although the bacteria counts after 6 hours of holding was less than at 12 hours, there is, nevertheless, a marked decrease when the 24 hour holding period is considered. Although the bacteria counts after 6 hours of holding was less than at 12 hours there is nevertheless a marked decrease when the 24 hour holding period is considered. There was a high number of organisms that were removed from the control can when compared with the counts from the cans in the drying period. This indicates that the control can contained a larger volume of the culture and thus gave a higher bacterial content. There may be three conditions that are responsible for the reduction in bacteria counts of the cans when compared with that of the control. These are, (1) the loss of culture due to added drainage, (2) inhibitive action of bacterial growth due dessication and (3) the bacteria-laden film was more difficult to remove with increased drying time. From the results it seems logical to expect a large percentage of the total bacterial content of the cans should be removed by the initial rinses of the rinse media. Table 4 also shows that for all practical purposes, five successive rinses will give the approximate total bacterial content of the cans. Thus five successive rinses removed approximately 99 per cent of the total bacteria when the total removed by ten successive rinses is equal to 100 per cent. The results also show that when the bacteria-laden film is in a moist or wet condition, such as found in the control can, a larger percentage of the total organisms would be removed by the initial rinses, than when the bacteria-laden film is dry.

Percentage of Bacteria Removed From Initial Rinses

The data secured by previous workers have not been consistant in regard to the total bacteria in a can that are removed with the first rinse. However, most workers have found that over 50 per cent of the bacteria are thus removed. Milone (1948) found the removal of organisms depended on the total number of bacteria present in the cans. In this experiment, the cans were inoculated as previously described and 1000 milliliters of distilled water was used as the rinse medium. The per cent of bacteria that were removed on the initial rinse was determined on the basis that the total numbers removed by five successive rinses was considered equal to 100 per cent. The results that were secured on the first rinse of 15 cans are shown in Table 5.

Table 5 shows that the initial rinse removed from 31 to 83 per cent of the total bacteria present in the inoculated cans, with an average of 56.2 per cent. This percentage is based on the fact that the total number of organisms removed by five successive rinses is equal to 100 per cent. The range of removal by the initial rinse is rather wide, being from 31 to 83

Table 5. The percentage removal by the initial rinse from inoculated cans.

| Trial Number | Per cent removal by initial rinses* |
|---|---|
| 1. | 83 |
| 2. | 43 |
| 3. | 61 |
| 4. | 51 |
| 5. | 31 |
| 6. | 52 |
| 7. | 76 |
| 8. | 55 |
| 9. | 59 |
| 10. | 60 |
| 11. | 64 |
| 12. | 52 |
| 13. | 47 |
| 14. | 61 |
| 15. | 48 |
| | Average 56.2 |

*Based that the total of five successive rinses is equal to 100 per cent.

per cent; however, this may be expected on a group of cans, such as were tested according to the conclusions of Milone (1948). The average of 56.2 per cent is in accord with the findings of Milone (1948), Milone and Tiedeman (1949), and Tuckey and associates (1946).

Comparing the Bacterial Removal of the Milone Apparatus with a Devised Experimental Shaking Apparatus

Because of the difficulty one might have in transporting the machine constructed by Milone (1948), (Figures 1 and 2), an apparatus was designed that could be transported by automobile. This apparatus was built by the Building and Utilities Department of Michigan State College. It was patterned somewhat similarly to the one built by Tuckey and associates (1946). The apparatus as constructed is shown in Figures 4, 5, and 6. A comparison of rinse counts were made when the cans were shaken by the Milone apparatus and the one built for this study. Twenty-four cans were prepared, handled, and inoculated with the 24 hour milk culture as previously described. Duplicate cans were rinsed with the same type of rinse medium and at the same volume; the only variation being the apparatus used to shake the cans. The apparatus devised was rotated at a speed of 40 r.p.m. for 30 revolutions. Milone's apparatus, run by an electric motor, was operated as outlined by Milone (1948). The total counts were then compared and are shown in Table 6.

Table 6. A comparison of counts from inoculated cans of two shaking apparatuses

| Trial Number | | Bacterial counts per ml. rinse medium | |
|---|---|---|---|
| | | Milone's (1948) | Experimental |
| 1. | | 360,000 | 500,000 |
| 2. | | 480,000 | 920,000 |
| 3. | | 1,080,000 | 1,400,000 |
| 4. | | 1,120,000 | 1,740,000 |
| 5. | | 1,400,000 | 1,150,000 |
| 6. | | 2,020,000 | 1,860,000 |
| 7. | | 2,050,000 | 4,300,000 |
| 8. | | 2,320,000 | 1,540,000 |
| 9. | | 3,400,000 | 2,650,000 |
| 10. | | 6,800,000 | 12,100,000 |
| 11. | | 8,800,000 | 12,300,000 |
| 12. | | 9,500,000 | 7,500,000 |
| | Log. ave. | 3,277,000 | 3,996,000 |

Table 6 shows that of twelve trials, the experimental shaking apparatus gave higher bacterial counts in seven trials, than did Milone's apparatus. The logarthmic average of the experimental apparatus was 3,996,000 compared to 3,277,000 for Milone's apparatus. It, therefore, appears that equal or slightly higher bacterial counts may be expected with the experimental apparatus, when compared with Milone's apparatus.

Discussion and Summary

The preceding series of experiments show that the bacteria counts that are secured from milk cans depends a great deal on the kind and amount of rinse media that is used. This appeared to be a more important consideration than the manner of rinsing.

While nutrient broth as a rinse medium gave the highest bacteria counts of the media tested, it was not a practical product to use in field testing, for cans had to be quickly handled without opportunity for re-washing before returning them to the producer. A nutrient broth solution provided food for growth of bacteria in cans that would be decidedly objectionable from the scope of sanitation, when it is considered that cans are held approximately 24 hours before they are put to use. Also, it was not possible to plate the rinsings immediately after they were made. This is highly important when nutrient broth is used, since bacteria growth would be encouraged.

The buffered non-ionic wetting agent solution at 0.01 per cent concentration gave results that were close to those secured from nutrient broth. This solution did not provide food for bacteria outside of that possibly made available from the cans that were tested. Thus, it is believed a buffered, non-ionic wetting agent solution at 0.01 per cent concentration may be practically applied without the hazzards that follow the use of nutrient broth.

Consideration was given to reasons why increasing wetting agent concentration in rinse solutions above 0.01 per cent gave decrease bacteria counts. It was thought most likely that the higher concentrations of surface active agent which caused increased sudsing, lessened the possibility of securing representative samples, possibly because the bacteria were concentrated in the foam. These solutions were not considered to be germicidal.

The other rinse media used gave highly inconsistent removal of organisms. This was surprising, since Standard Methods (1948) recommends sterile tap,

sterile buffered distilled or sterile nutrient broth for rinse solutions to be used in securing can sterility tests.

The volume of rinse media used also had to be considered. Although Standard Methods (1948) procedure calls for 100 milliliters, this amount did not appear to give as effective rinsing as larger amounts. The highest total counts of cans were secured when 1000 milliliters of media were used. This amount was not used because of having to process and transport amounts of media that were unwieldy.. The data show that there was a marked increase in the total bacteria count as the amount of rinse medium was increase from 100 milliliters to 200 milliliters. The increase from using 500 milliliters or 1000 milliliters over that of using 200 milliliters of rinse medium was not as significant. Thus, the amounts of rinse media were established at 200 milliliters.

The shaking apparatus that was devised for this study was found to give equal or slightly higher bacteria counts than a special mechanical shaking apparatus that was designed by Milone (1948). Although the Milone shaking machine may be more precise in covering all parts of the cans being tested, and in performing shaking technique, it must be considered that exact precision in these respects was of less consequence than the items of amount and kind of solution that have been studied.

# AN EVALUATION OF DETERGENTS APPLICABLE TO MECHANICAL CAN WASHING

The aim of mechanical can washing is to secure clean, dry, sanitary milk cans that may be used either for farm delivery of raw milk or for storage and transport of a finished pasteurized dairy product. The detergent used in the wash tank of mechanical can washers is a primary consideration given by most plant owners and operators. Most operators desire to use the best possible detergent; consequently, they are continuously looking for another "better" compound that will secure the desired results. A thorough study was obviously needed of can washing detergents, thereby enabling the selection of good detergents for can washing use.

## PROCEDURE

The detergent qualities of all of the detergents tested was determined by preparing raw milk films on glass panes and by washing with a mechanical washing apparatus to measure the efficiency of the detergents.

### Preparation of Raw Milk Films on Glass Panes

In these experiments, a double strength, B-type glass made by the Pittsburg Glass and Paint Company was used and was cut into 3 inch square panes. All glass panes were washed between trials with a condensed phosphate-wetting agent detergent, rinsed with distilled water and allowed to air dry at room temperatures. The milk used for these experiments was well mixed, fresh, whole, raw milk from the college herd. It was held at a temperature of 40° - 50° F. for the preparation of the milk films.

### Air-Dried Milk Films

The air-dried milk films were prepared by twice immersing the glass panes into the milk, thoroughly covering the glass surfaces. The coated panes were then placed on a metal frame at approximately at 45° angle to permit draining and drying for a period of 15 minutes at room temperatures before washing. The

air-dried films were repeatedly coated and after each washing treatment the panes were examined for per cent light transmission. By repeated coating and washing of the panes, it was felt that the efficiency of the detergents could best be determined.

Heat Treated Films

The heat treated films were prepared by twice immersing the glass panes into the milk, thoroughly covering the glass surfaces. The coated panes were then placed on a metal frame at approximately a 45° angle to permit draining and drying for a period of 15 minutes in a hot-air drying oven held at 180°-185° F. They were then taken out of the oven and twice immersed in a 0.3 per cent detergent solution at a temperature of approximately 100°F. The detergent consisted of 49 per cent tri-sodium-phosphate, 49 per cent sodium carbonate, and 2 per cent wetting agent (Nacconol). They were not agitated to remove all of the film, but simply immersed to remove the soluble portion of the film. The panes were placed back on the metal frames at the 45° angle and replaced in the oven for a 15 minute drying period. This sequence was followed until the panes had been immersed in the milk 5 times, and in the detergent solution 4 times. It was felt that such a film produced would simulate a milkstone film that would be left after several incomplete washings with a detergent that had low detergent qualities.

Chlorine-Protein Complex Films

The chlorine-protein complex film was prepared by twice immersing the panes into the milk, thoroughly covering the glass surfaces. The coated panes were then placed on a metal frame at approximately a 45° angle to permit draining and drying for a period of 15 minutes at room temperatures. After the drying period, the coated panes were immersed in a 250 p.p.m. sodium hypochloride* solution, and replaced on the frames at approximately a 45° angle to permit

*Manufactured by Klenzade Inc., Beloit, Wisconsin draining and drying for a period of 15 minutes. This sequence was followed until the panes had been immersed in the milk 5 times, and in the chlorine solution 4 times. A fresh chlorine solution was prepared for each immersion. This type of film was found to be present in milk cans, where excessive use of chlorine solutions were used on the farm as the sanitation step.

Washing the Panes

All panes were washed with the mechanical washing apparatus previously described by Jensen (1946) and as shown by Figure 7. The washing was accomplished by use of a motor-impelled bar to which the glass panes were attached in a manner that each was washed in a separate water bath containing 1500 milliliters of the different washing detergent solutions. The glass panes were propelled at a rate of 45 oscillations per minute and for one minute washing time, preceded by one minute of soaking. Pre-rinsing and after-rinsing consisted of impelling the milk-coated glass panes 5 complete oscillations through the rinse water at a distance of 3 inches in a manner to force the water across the face of the glass. After washing and pre-rinsing and/or after-rinsing, the panes were returned to the metal frames for drying at room temperatures before the measuring of the light transmission.

Measuring Light Transmission of the Washed Glass Panes

Following the drying period, the per cent light transmission was determined on the washed glass panes. Four readings were obtained on each pane by placing the corners of each square in the filter position of a Cenco-Sheard Spectrophotelometer. Readings were made with adjustments of entrance slit at 2 mm., exit slit at 20mm., and a 400 mm. wave length. After a 15-20 minute warming up period, the galvanometer was adjusted for zero reading with no light transmitted and for 100 with light transmitted through a clean glass pane. This pane served as the standardizing control throughout the experiments.

Hydrogen ion Concentration

All pH determinations on the detergent solutions were made by means of a Beckman pH meter, Model G (laboratory model), equipped with a glass electrode. The potentiometer was standardized immediately before each use with a buffer solution at pH 7 plus or minus 0.02 at 30° C., made by adding one Coleman certified buffer tablet to 100 milliliters of carbon dioxide free water. All readings were recorded at a temperature of 23° C.

Surface Tension

When determined, the surface tension readings were made by a DuNouy tensiometer. The procedure followed in all cases was that recommended by the manufacturer. All readings were made at 23° C. and in each case the tensiometer was standardized by double distilled water. Three readings were made and the average of the three has been recorded.

Types of Water Used

The tap water used for washing, pre-rinsing, and after-rinsing contained a total hardness of between 370-400 p.p.m. calculated as calcium carbonate, as determined by the Versenate method, Diehl and Hach (1949). Zeolite water was taken directly from the Zeolite softener and contained a total hardness of less than 50 p.p.m. calculated as calcium carbonate. The water was treated to contain 0 hardness by addition of Versene or Versene-wetting agent combination or a combination of 75-25 sodium hexametaphosphate-wetting agent. Versene is an organic chelating agent, chemically known as ethylene diamine tetra sodium acetate and manufactured by Bersworth Chemical Company, Framingham, Massachusetts. All dry detergents were tested using a 0.3 per cent solution while the liquids were tested using a 0.2 per cent solution.

Source and Composition of Commercial Detergents

The composition of the following listed detergents with the exception of the Mikro-San, was secured from the Cherry-Burrell Corporation handbook.

The composition of the Mikro-San was secured through Beechem Laboratories.

| Detergent | Composition % | Component | Manufacturer |
|---|---|---|---|
| Dreadnaught | 50 | sodium metasilicate | Cherry-Burrell Corp. |
| | 40 | sodium tripolyphosphate | |
| | 5 | sodium bicarbonate | |
| | 5 | wetting agent | |
| Mikro-San | 45 | wetting agent | Lathrop-Paulson Corp. |
| | 34 | water | |
| | 10 | hydroxyacetic acid | |
| | 8 | gluconic acid | |
| | 3 | leulinic acid | |
| NU-Foam | 91 | water | Beechem Laboratories |
| | 7 | wetting agent | |
| | 3 | tetra-sodium-pyrophosphate | |
| Seco 10 | 30 | tetra-sodium-pyrophosphate | Seco Milk Plants |
| | 25 | sodium tripolyphosphate | |
| | 25 | borax | |
| | 12 | tri-sodium-phosphate | |
| | 2 | wetting agent | |
| Calgonite | 60 | sodium metasilicate | Calgon Inc. |
| | 40 | sodium hexametaphosphate | |

## EXPERIMENTAL

Previous investigations, as reported in the literature review, have found condensed phosphates highly valuable as detergent components. When reported in levels of 50 or 75 per cent, it was reported by Jensen (1946) to be highly effective as a detergent against air-dried raw milk films. Also, this investigator reported that the manner of washing as relating to rinsing before and after washing with various detergent solutions affected washing quality. Further studies were conducted to re-evaluate these conditions and to ascertain washing practices that might affect can washing.

A series of laboratory washing tests were made of glass panes that were prepared by coating previously cleaned panes with raw milk films as described

by procedure. These films were washed variously by different detergent components and pre-rinsing and after rinsing practices as shown in Tables 7 through 11.

Washing in Sodium Hexameta-Phosphate-Wetting Agent Detergent Combinations

Ten successive milk pane preparations were made, each of which was followed by washing at 120° F. in detergent solutions consisting either of wetting agent detergent, or wetting agent detergent and sodium hexametaphosphate. The latter detergent combination compounded to contain 75 per cent sodium hexametaphosate and 25 per cent wetting agent.

The results of these washings are shown in Table 7. High or practically complete detergency was obtained throughout all the ten trials with the "75-25" combination. An accumulation of milk and detergent solids occurred with successive treatments when the wetting agent detergent alone was used. This was illustrated by photometer readings that started at 95 following the first washing and after ten treatments only 59 per cent light was transmitted through the glass. Also, an average of 100 per cent light transmission for the ten treatments was secured when the "75-25" wetting agent, metaphosphate, detergent was used in contrast to an average reading of 73 per cent when a wetting agent detergent alone was used. These results support earlier investigations by Jensen (1946).

Effect of the Nature of Pre-Rinsing on Detergency

To determine the effect of the type pre-rinse on detergency, hard water and solutions of sodium hexametaphosphate and wetting agent, Versene, and Versene and wetting agent, were used. Versene was mentioned in the review of literature and was described as a chelating agent. These chemical agents were applied in sufficient amounts to produce 0 hardness in water as measured by the versenate titrative method, Diehl and Hach (1949). Wetting agent was also used in a pre-

Table 7. The effect on detergency when sodium hexametaphosphate replaces a wetting agent in the wash solution.

Washing at 120° F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.

| Nature of Detergent: Per cent used | | Per cent light transmission after successive treatments and washing | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| wetting agent | sodium hexameta-phosphate | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | Average |
| 25 | 75 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 100 | 99 | 100 |
| 100 | -- | 95 | 91 | 85 | 77 | 72 | 68 | 65 | 58 | 58 | 59 | 73 |

rinsing series, using a 0.1 per cent solution. In this series, the panes were not rinsed following the washing treatment. Ten cycles of washing treatments were applied in these studies and the results are shown in Tables 8 and 9. The pre-rinsing as shown in Table 8 was carried out at 95° F., while the pre-rinsing shown in Table 9 was carried out at 60° F.

There appeared to be no important difference in detergency when pre-rinsing was applied using the various pre-rinsing materials when followed by washing in detergent solutions containing the "75-25" combination. However, when wetting agent only was used in the wash solution, the treatments of the pre-rinse improved the detergency results. The hard water pre-rinse gave the lowest results of the three treatments studied.

The effect of treating the pre-rinse with 0.1 per cent wetting agent or using a "75-25" Versene-wetting agent combination is shown in Table 9. Either treatment gave excellent results when the "75-25" detergent combination was used in the washing solution. This was observed to be superior to any of the pre-rinse treatments shown in Table 8. No benefit was derived by pre-rinsing with a wetting agent when the detergent used for washing consisted of a wetting agent only. The Versene-wetting agent pre-rinse combination gave similar results to that secured when using Versene only or a combination of 75 per cent sodium hexametaphosphate and 25 per cent wetting agent.

Effect of the Nature of the After-Rinse on Detergency

Rinsing after washing is a general practice in order to remove washing solutions and to give further assurance of cleanliness. The effect of this rinsing on cleanliness was studied here, using rinsing solutions similarly prepared to those used from the pre-rinsing studies. The temperature of after-rinsing solutions were maintained at 150° F., while the washings were carried out at 120° F. In this series the pre-rinse was not used. The results are shown in Table 10.

Table 10. The effect on detergency of the type of after-rinse material when sodium hexametaphosphate replaces a wetting agent in the wash solution.

Washing at 120° F.; after-rinsing at 150° F.; no pre-rinsing; using a 0.3 per cent detergent solution.

| Nature of Detergent: Per cent used | | Nature of after-rinse used | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| wetting agent | sodium hexametaphosphate | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | Ave. |
| 25 | 75 | Hard water | 99 | 99 | 100 | 100 | 100 | 97 | 98 | 97 | 97 | 96 | 98 |
| | | Versene | 100 | 100 | 100 | 97 | 100 | 100 | 99 | 99 | 99 | 99 | 99 |
| | | Hexa-w.a.* | 99 | 100 | 99 | 100 | 100 | 98 | 98 | 100 | 100 | 100 | 99 |
| 100 | — | Hard water | 97 | 93 | 92 | 90 | 85 | 83 | 81 | 80 | 78 | 75 | 85 |
| | | Versene | 100 | 100 | 99 | 96 | 92 | 93 | 94 | 94 | 94 | 95 | 95 |
| | | Hexa-w.a.* | 98 | 96 | 94 | 92 | 91 | 86 | 81 | 80 | 83 | 78 | 88 |

*Sodium hexametaphosphate and wetting agent (75 - 25)

When the "75-25" combination was used in the washing solution, the after-rinse treatments had little effect on the detergency. This was very similar to the results found with the pre-rinse treatments as shown in Table 8. It appeared that the "75-25" combination treatment was more beneficial when added to the after-rinse than when added to the pre-rinse water. When a wetting agent was used for washing, very similar results were found with the after-rinse treatments, as were found with the pre-rinse treatments. This was perhaps due to the high washing qualities of these pre-rinse and after-rinse solutions. The Versene treated after-rinse again gave the highest detergency results.

Effect of Nature of Rinsing on Detergency When Pre-Rinsing and After-Rinsing

In the immediately preceding tests, various combinations of pre-rinse after-rinse solutions were used. In this series of tests, the same type of solution was used for pre-rinsing as for after-rinsing. Ten successive treatments and washings were made and the cleanliness of these panes as measured by the per cent light transmissions are shown in Table 11. The washings were carried out at 120° F., pre-rinsing at 95° F., and after-rinsing at 150° F.

Excellent results were obtained with all treatments of pre-rinse and after-rinse, when the "75-25" detergent combination was used for washing. Lower detergency results were secured when hard water was used for pre-rinsing and after-rinsing, when the wetting agent alone was used for washing. However, fairly high detergency readings were obtained with the wetting agent wash, when the Versene or the "75-25" combination rinse solutions were used for the pre-rinse and after-rinse.

The Effect of Adding Various Amounts of Versene to Calgonite, a Can Washing Detergent

Calgonite is a can washing detergent containing 60 per cent sodium metasilicate and 40 per cent sodium hexametaphosphate. The latter being an inorganic sequestering agent. Tests were made to determine the washing properties that would be secured when Versene, an organic chelating agent, was used in

Table 11. The effect on detergency of the type of pre-rinse and after-rinse material when sodium hexametaphosphate replaces a wetting agent in the wash solution.

Washing at 120° F.; pre-rinsing at 95° F.; after-rinsing at 150° F.; using a 0.3 per cent detergent solution.

| Nature of Detergent: Per cent used — wetting agent | Nature of Detergent: Per cent used — sodium hexametaphosphate | Nature of after-rinse and pre-rinse used | Per cent light transmission after successive treatments and washing — 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 75 | Hard water | 100 | 97 | 97 | 96 | 95 | 97 | 94 | 96 | 94 | 95 | 96 |
| | | Versene | 98 | 99 | 100 | 98 | 98 | 98 | 98 | 98 | 95 | 96 | 98 |
| | | Hexa-w.a.* | 98 | 99 | 94 | 99 | 98 | 100 | 100 | 100 | 100 | 100 | 99 |
| 100 | -- | Hard water | 99 | 95 | 74 | 74 | 62 | 50 | 45 | 44 | 36 | 31 | 60 |
| | | Versene | 98 | 97 | 97 | 95 | 94 | 94 | 94 | 91 | 86 | 85 | 93 |
| | | Hexa-w.a.* | 95 | 93 | 93 | 90 | 87 | 87 | 84 | 81 | 80 | 78 | 87 |

*Sodium hexametaphosphate and wetting agent (75 - 25) various combinations with this can washing detergent. Versene and Calgonite were used respectively in the following combinations, 10-90, 15-85, and 20-80. A series of laboratory washing tests were made on glass panes that were prepared by coating previously cleaned panes with raw milk films as described by the procedure. These films were variously washed by different detergent components and pre-rinsing and after-rinsing practices as shown in Tables 12 through 16.

Washing in Calgonite and Calgonite-Versene Combinations

Ten successive milk pane preparations were made, each of which was followed by washing at 120° F. in detergent solutions consisting either of Calgonite, or Calgonite-Versene combinations of 10-90, 15-85, and 20-80. In this series of tests, the pre-rinse or after-rinse was not used.

The results of Table 12 show that as the per cent of Versene increased, in combination with Calgonite, there was a tendency toward higher detergency values. The 20-80 combinations giving the highest values of light transmission.

Effect of the Nature of Pre-Rinsing on Detergency

In this series of experiments, the glass panes were pre-rinsed with various pre-rinse solutions before they were washed with the Calgonite or Calgonite-Versene combinations. The pre-rinsing solutions used were hard water and water treated with Versene, Versene-wetting agent, sodium hexametaphosphate-wetting agent, and wetting agent only. Ten successive treatments and washings were made and the cleanliness of these panes was measured as shown by Tables 13 and 14. Washings were carried out at 120° F. with no after-rinsing. The pre-rinsing as shown in Table 13 was carried out at 95° F., while the pre-rinsing as shown in Table 14 was carried out at 60° F.

The results of Table 13 show that the treatment of the pre-rinsing solutions influenced the final detergency results. As the per cent Versene was increased in the Calgonite-Versene combinations, an increase in detergency resulted. This

Table 12. The effect on detergency of adding various quantities of Versene to Calgonite solutions.
Washing at 120°F.; no pre-rinsing or after-rinsing, using a 0.3 per cent detergent solution.

| Per cent Versene replacing Calgonite | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | ave. |
| 0 | 99 | 98 | 96 | 97 | 72 | 76 | 65 | 65 | 55 | 55 | 77 |
| 10 | 98 | 98 | 91 | 87 | 85 | 77 | 65 | 75 | 64 | 58 | 80 |
| 15 | 99 | 98 | 96 | 95 | 87 | 88 | 73 | 81 | 68 | 66 | 86 |
| 20 | 98 | 99 | 96 | 93 | 90 | 85 | 83 | 83 | 76 | 72 | 88 |

Table 13. **The effect on detergency of the type of pre-rinse material when various quantities of Versene are added to Calgonite solutions.**

Washing at 120°F.; pre-rinsing at 95°F.; no after-rinsing; when using a 0.3 per cent detergent solution.

| Per cent Versene Replacing Calgonite | Nature of pre-rinse used | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
| 0 | Hard water | 92 | 61 | 57 | 43 | 45 | 37 | 40 | 38 | 44 | 35 | 49 |
| | Versene | 95 | 82 | 73 | 68 | 62 | 54 | 60 | 54 | 58 | 51 | 66 |
| | Hexa-w.a.* | 99 | 88 | 79 | 67 | 61 | 54 | 61 | 51 | 60 | 56 | 68 |
| 10 | Hard water | 97 | 66 | 59 | 52 | 48 | 40 | 37 | 40 | 44 | 35 | 52 |
| | Versene | 95 | 81 | 76 | 69 | 63 | 65 | 61 | 57 | 69 | 62 | 70 |
| | Hexa-w.a.* | 99 | 94 | 95 | 88 | 76 | 67 | 67 | 60 | 66 | 60 | 77 |
| 15 | Hard water | 99 | 74 | 69 | 66 | 57 | 52 | 51 | 46 | 47 | 41 | 60 |
| | Versene | 98 | 85 | 90 | 76 | 71 | 65 | 67 | 68 | 75 | 63 | 76 |
| | Hexa.-w.a.* | 98 | 95 | 96 | 88 | 88 | 75 | 82 | 86 | 92 | 83 | 88 |
| 20 | Hard water | 98 | 88 | 75 | 64 | 60 | 56 | 46 | 49 | 46 | 42 | 62 |
| | Versene | 96 | 89 | 82 | 77 | 71 | 64 | 61 | 61 | 71 | 64 | 73 |
| | Hexa-w.a.* | 97 | 95 | 97 | 93 | 91 | 84 | 92 | 88 | 94 | 85 | 91 |

* Sodium hexametaphosphate and wetting agent (75-25)

Table 14. The effect on detergency of combining Versene with a wetting agent as a pre-rinse, when various quantities of Versene are added to Calgonite solutions.

Washing at 120°F. pre-rinsing at 60°F; no after rinsing; using a 0.3 per cent detergent solution.

| Per cent Versene replacing Calgonite | Nature of pre-rinse used | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | ave. |
| 0 | Wetting agent | 98 | 97 | 92 | 92 | 91 | 86 | 77 | 74 | 67 | 61 | 83 |
| | Versene-w.a. | 98 | 99 | 98 | 97 | 97 | 96 | 98 | 96 | 93 | 93 | 96 |
| 10 | Wetting agent | 97 | 98 | 95 | 96 | 99 | 93 | 91 | 92 | 78 | 70 | 91 |
| | Versene-w.a. | 96 | 100 | 97 | 99 | 97 | 98 | 99 | 98 | 96 | 96 | 98 |
| 15 | Wetting agent | 96 | 98 | 96 | 96 | 97 | 97 | 95 | 93 | 91 | 87 | 95 |
| | Versene-w.a. | 94 | 98 | 97 | 96 | 95 | 96 | 96 | 95 | 93 | 92 | 96 |
| 20 | Wetting agent | 95 | 98 | 94 | 96 | 97 | 96 | 95 | 95 | 95 | 91 | 95 |
| | Versene-w.a. | 94 | 97 | 96 | 95 | 95 | 97 | 98 | 98 | 94 | 96 | 96 |

was similar to the results as shown in Table 12. The hard water pre-rinse seemed to be detrimental on detergency, however, the "75-25" combination or the Versene treated pre-rinse improved detergency over that of the hard water. Similar results were obtained when these treatments were applied to the after-rinse water as shown by Table 15.

When a Versene-wetting agent treatment was applied to the pre-rinsing water, as shown by Table 14, a improvement in the detergency resulted. The effect of pre-rinsing with wetting agent alone also had a greater effect than was expected. This improvement can be partially explained as being due to the absence of a surface active agent in the Versene-Calgonite combinations.

<u>Effect of the Nature of After-Rinsing on Detergency</u>

The effect of after-rinsing on cleanliness was studied using rinsing solutions similarly prepared to those used from the pre-rinsing studies. The temperature of the after-rinsing solutions was maintained at 150° F. while the washings were carried out at 120° F. In this series, the pre-rinse was not used. The results are shown in Table 15.

Data on Table 15 show that the detergency obtained with these after-rinsing solutions are similar to those obtained when these solutions were used for pre-rinsing (Table 13). Similarity was noticed in the fact that the hard water gave the lowest readings, Versene treated, the next highest, and the "75-25" combination the highest detergency readings.

<u>Effect of the Nature of Rinsing on Detergency When Pre-Rinsing and After-Rinsing</u>

The same type of pre-rinsing and after-rinsing solutions were used in this experiment as was used in studying the after-rinsing only. The temperature used for the pre-rinsing solutions was held at 95° F., while the after-rinsing solutions were held at 150° F. All washings were carried out at 120° F.

The results of Table 16 show that the ideal pre-rinse and after-rinse treatment would be with the "75-25" combination, although good results were

Table 16. **The effect on detergency of the type of pre-rinse and after-rinse material when various quantities of Versene are added to Calgonite solutions,**

**Washing at 120°F.; pre-rinsing at 95°F.; after-rinsing at 150°F.; using a 0.3 per cent detergent solution.**

| Per cent Versene replacing Calgonite | Nature of pre-rinse, after-rinse used | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
| 0 | Hard water | 100 | 97 | 94 | 92 | 92 | 89 | 88 | 78 | 73 | 75 | 88 |
| | Versene | 99 | 96 | 98 | 94 | 96 | 93 | 87 | 81 | 77 | 78 | 90 |
| | Hexa-w.a.* | 94 | 100 | 94 | 100 | 98 | 99 | 99 | 99 | 99 | 100 | 97 |
| 10 | Hard water | 91 | 94 | 90 | 94 | 94 | 92 | 86 | 80 | 74 | 79 | 87 |
| | Versene | 94 | 97 | 98 | 95 | 96 | 96 | 90 | 81 | 72 | 80 | 90 |
| | Hexa-w.a.* | 95 | 98 | 89 | 99 | 97 | 100 | 100 | 99 | 99 | 100 | 98 |
| 15 | Hard water | 95 | 92 | 91 | 92 | 90 | 89 | 86 | 82 | 78 | 80 | 87 |
| | Versene | 98 | 97 | 98 | 96 | 98 | 96 | 91 | 90 | 84 | 87 | 93 |
| | Hexa-w.a.* | 97 | 99 | 91 | 99 | 97 | 100 | 99 | 99 | 97 | 98 | 98 |
| 20 | Hard water | 97 | 97 | 94 | 95 | 94 | 94 | 90 | 85 | 81 | 83 | 91 |
| | Versene | 96 | 96 | 93 | 93 | 92 | 93 | 89 | 87 | 85 | 85 | 91 |
| | Hexa-w.a.* | 97 | 99 | 91 | 99 | 97 | 100 | 99 | 99 | 97 | 98 | 99 |

* Sodium hexametaphosphate and wetting agent (75-25)

obtained with the Versene treated rinses. The hard water rinses gave the lowest values of the three rinses tested. As the per cent Versene increased in the Calgonite-Versene combinations, the detergency values also increased. This has been shown also in the preceding table.

The Detergency Action of Six Commercial Detergents Under Varied Washing Conditions

Six commonly used commercial detergents were selected and tested under varied washing conditions that could be found with practical mechanical can washing operations. The tests were conducted to determine the influence of the temperature of washing, a wetting agent pre-rinse, and the addition of raw milk to the wash solution, on the final detergency of these commercial detergents. These detergents included, Dreadnaught, Mikro-San, single and double strength, Nu-Foam, Seco 10, and Calgonite. They were selected because they were typical of the range of can washing detergents in use. They represented the alkaline compounds, the organic acids, and the near neutral compounds, which appear on the market. All washings, unless otherwise noted, were carried out at 150° F. A series of laboratory washing tests were made of glass panes that were prepared with the air-dried raw milk films as described by the procedure. These films were washed with the six commercial detergents, using different rinsing practices as shown in Tables 17 through 19.

Influence of Washing Temperature on Six Commercial Detergents

To determine the effect of the washing temperature on the detergency of these six commercial detergents, two washing temperatures were studied in this experiment, 120° F., and 150° F. The results of this study, without pre-rinsing or after-rinsing of the glass panes are shown by Table 17.

Seco 10, Nu-Foam, and both Mikro-San's show no influence of temperature of washing on detergency. The temperature did have an influence, however, on the Dreadnaught and the Calgonite. The Dreadnaught gave the higher results

Table 17. The effect of the wash water temperature on the removal of air-dried milk film by various commercial can washing detergents.
Washing at 150°F.; no pre-rinsing or after-rinsing.

| Detergent: Name | Conc. | pH | Temperature of Washing °F. | Per cent light transmission after successive treatments and washings: 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dreadnaught | 0.3 | 10.09 | 120 | 90 | 85 | 86 | 80 | 81 | 80 | 79 | 78 | 80 | 78 | 81 |
| | | | 150 | 89 | 88 | 90 | 92 | 82 | 84 | 84 | 82 | 77 | 71 | 75 |
| Mikro-San single | 0.2 | 7.00 | 120 | 96 | 97 | 93 | 95 | 91 | 91 | 91 | 90 | 87 | 86 | 92 |
| | | | 150 | 97 | 96 | 96 | 95 | 93 | 92 | 91 | 90 | 87 | 87 | 92 |
| Mikro-San double | 0.2 | 6.80 | 120 | 91 | 92 | 88 | 81 | 78 | 82 | 78 | 77 | 74 | 70 | 81 |
| | | | 150 | 88 | 87 | 85 | 85 | 82 | 78 | 76 | 72 | 65 | 67 | 79 |
| Nu-Foam | 0.2 | 7.30 | 120 | 92 | 90 | 86 | 76 | 72 | 69 | 67 | 59 | 58 | 54 | 72 |
| | | | 150 | 94 | 89 | 84 | 79 | 72 | 66 | 62 | 56 | 50 | 47 | 70 |
| Seco 10 | 0.3 | 8.70 | 120 | 90 | 92 | 92 | 92 | 91 | 90 | 90 | 89 | 89 | 89 | 90 |
| | | | 150 | 86 | 91 | 94 | 93 | 91 | 80 | 90 | 92 | 87 | 89 | 89 |
| Calvonite | 0.3 | 9.75 | 120 | 99 | 98 | 95 | 96 | 91 | 82 | 73 | 65 | 74 | 59 | 83 |
| | | | 150 | 97 | 97 | 99 | 99 | 96 | 96 | 98 | 95 | 85 | 75 | 94 |

at the lower temperature (120° F.), while the Calgonite gave the best results at the higher temperature (150° F.).

Effect of Nature of Pre-Rinse on Detergency of Six Commercial Detergents

To determine the effect of the type of pre-rinse on detergency, two pre-rinsing solutions were studied - hard water, and a 0.1 per cent wetting agent solution. These pre-rinsing solutions were held at 60° F., while the after-rinsing was accomplished at 150° F. The results of this study are shown in Table 18.

The wetting agent pre-rinse did not influence the results of the Dreadnaught, single-strength Mikro-San, and the Seco 10. The Nu-Foam was greatly aided by the wetting agent pre-rinse, while the double strength Mikro-San and the Calgonite were only slightly aided.

Effect of the Treatment of the Wash Solution on Detergency of Six Commercial Detergents.

In many mechanical can washers, the same wash solution is used throughout the entire days operation, thus milk solids are constantly being added to the solution. Therefore, it was considered that a study should be made to show the influence on detergency of raw milk additions to the washing solution. In addition, Versene was added to the milk-wash-water solution in order to determine whether a chelating agent used in this manner would prolong the detergency of washing solutions. No pre-rinsing or after-rinsing solutions were used in this trial. Ten successive treatments and washings were made and the cleanliness of these panes as measured are shown in Table 19.

The results of Table 19 show that in all cases, the addition of 10 per cent raw milk decreased the detergency values of the six commercial detergents. However, the decrease was noted to be more rapid when the double-strength Mikro-San and the Nu-Foam were used. By adding Versene to the wash water, excellent results were obtained with the six detergents, and these values were

Table 18. The effect of adding 0.1 per cent wetting agent to the pre-rinse solution on the removal of air-dried films by various commercial can washing detergents.

Washing at 150°F.; pre-rinsing at 60°F.; and after-rinsing at 150°F.

| Detergent | | Nature of pre-rinse used | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | Conc. | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
| Dreadnaught | 0.3 | Hard water | 100 | 96 | 99 | 99 | 99 | 98 | 97 | 99 | 99 | 98 | 98 |
| | | Wetting agent | 100 | 98 | 100 | 100 | 98 | 99 | 99 | 99 | 98 | 97 | 99 |
| Mikro-San single str. | 0.2 | Hard water | 98 | 95 | 95 | 94 | 92 | 89 | 89 | 89 | 87 | 86 | 91 |
| | | Wetting agent | 96 | 95 | 95 | 94 | 92 | 93 | 92 | 91 | 88 | 89 | 92 |
| Mikro-San double str. | 0.2 | Hard water | 95 | 88 | 84 | 81 | 71 | 68 | 71 | 68 | 63 | 61 | 75 |
| | | Wetting agent | 95 | 86 | 83 | 78 | 79 | 78 | 80 | 71 | 69 | 68 | 79 |
| Nu-Foam | 0.2 | Hard water | 100 | 88 | 78 | 68 | 64 | 53 | 59 | 52 | 51 | 52 | 66 |
| | | Wetting agent | 96 | 89 | 85 | 80 | 76 | 68 | 75 | 70 | 65 | 64 | 77 |
| Seco 10 | 0.3 | Hard water | 96 | 96 | 98 | 97 | 96 | 95 | 94 | 95 | 91 | 88 | 95 |
| | | Wetting agent | 98 | 96 | 97 | 96 | 97 | 96 | 96 | 96 | 93 | 90 | 95 |
| Calgonite | 0.3 | Hard water | 97 | 93 | 95 | 91 | 92 | 90 | 87 | 79 | 82 | 77 | 88 |
| | | Wetting agent | 99 | 99 | 96 | 93 | 95 | 92 | 91 | 93 | 83 | 82 | 93 |

Table 19. The effect of adding raw milk and Versene to hard water wash solution on the removal of air dried raw milk film when using various commercial can washing detergents.
Washing at 150°F.; no pre-rinsing or after-rinsing.

| Detergent Name | Conc. | Milk % | Versene % | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
| Dreadnaught | 0.3 | 10 | 0 | 96 | 91 | 86 | 82 | 87 | 85 | 85 | 85 | 85 | 85 | 87 |
| | | 0 | 0.25 | 100 | 100 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 |
| | | 10 | 0.25 | 98 | 97 | 96 | 98 | 96 | 94 | 96 | 97 | 95 | 96 | 96 |
| Mikro-San single | 0.2 | 10 | 0 | 91 | 90 | 88 | 84 | 87 | 85 | 92 | 92 | 81 | 77 | 85 |
| | | 0 | 0.25 | 96 | 96 | 95 | 97 | 95 | 96 | 95 | 95 | 95 | 95 | 95 |
| Mikro-San double | 0.2 | 10 | 0 | 97 | 86 | 80 | 74 | 77 | 71 | 71 | 62 | 65 | 62 | 75 |
| | | 0 | 0.25 | 99 | 98 | 100 | 98 | 98 | 99 | 99 | 98 | 99 | 99 | 99 |
| | | 10 | 0.25 | 98 | 96 | 97 | 98 | 97 | 96 | 97 | 97 | 96 | 97 | 97 |
| Ni-Foam | 0.2 | 10 | 0 | 96 | 81 | 75 | 66 | 67 | 52 | 56 | 55 | 52 | 47 | 66 |
| | | 0 | 0.25 | 100 | 99 | 100 | 99 | 100 | 100 | 99 | 99 | 100 | 99 | 99 |
| | | 10 | 0.25 | 97 | 95 | 95 | 96 | 94 | 93 | 93 | 90 | 93 | 95 | 94 |
| Seco 10 | 0.3 | 10 | 0 | 84 | 87 | 82 | 83 | 84 | 85 | 89 | 83 | 87 | 85 | 85 |
| | | 0 | 0.25 | 99 | 98 | 98 | 99 | 98 | 98 | 98 | 96 | 99 | 99 | 99 |
| | | 10 | 0.25 | 98 | 92 | 94 | 90 | 88 | 84 | 87 | 89 | 90 | 91 | 90 |
| Calgonite | 0.3 | 10 | 0 | 97 | 96 | 87 | 85 | 80 | 77 | 83 | 72 | 63 | 63 | 81 |
| | | 0 | 0.25 | 99 | 97 | 99 | 98 | 98 | 95 | 95 | 91 | 91 | 89 | 95 |
| | | 10 | 0.25 | 99 | 95 | 95 | 97 | 92 | 84 | 80 | 77 | 68 | 66 | 85 |

only slightly reduced when 10 per cent raw milk was added. This shows that the Versene does possess some property that will disperse, and dissolve the milk solids, and still aid in the removal of milk soils.

The Effect of Various Types of Soft Water on Detergency

Many milk plants throughout the country have difficulty with hard waters and many times the question is raised, "Is it advantageous to soften water for the washing of milk cans in a mechanical can washer"? This, of course, is a difficult question to answer, as a good many factors are involved. However, one of the considerations would be the reaction of the detergent in the softened water to further aid in detergency. Four types of water softening treatments were studied; namely, Zeolite, distilled water, sodium hexametaphosphate softened, and Versene softened waters. Comparisons were made on five commercial detergents and one laboratory prepared the "75-25" combination. The glass panes were prepared with an air-dried raw milk film as previously described. Ten successive treatments and washings were made and the cleanliness of these panes as measured by the per cent light transmissions are shown in Table 20.

The Breadraught, Nu-Foam, Seco 10, and the "75-25" combination gave approximately the same detergency results when used in distilled, Versene, or sodium hexametaphosphate softened waters. In some instances, the Zeolite treated water gave lower detergency results than the other three treatments tested. The Calgonite gave the lowest detergency with the Versene treated water and the highest detergency with distilled water. A surprisingly rapid decrease in detergency resulted when distilled water was used with Mikro-San.

In an effort to explain this action, the pH of the detergent solutions were taken and were found as shown in Table 20. These pH readings were as follows: Zeolite, 6.56; Distilled, 4.10; Hexametaphosphate, 6.82; and Versene, 7.32. The cause of low detergency is undoubtedly explained by the low pH of 4.10, causing a precipitation of the milk proteins.

Table 20. **The effect of water softening treatments applied to the wash water on the removal of air-dried raw milk films by various commercial can washing detergents.**

**Washing at 150°F.; no pre-rinsing or after-rinsing.**

| Detergent Name | Conc. | pH | Water Softening Treatment | Per cent light transmission after successive treatments and washings: 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dreadnaught | 0.3 | | Zeolite | 97 | 86 | 89 | 89 | 98 | 100 | 96 | 98 | 98 | 99 | 95 |
| | | | Distilled | 98 | 98 | 99 | 97 | 99 | 99 | 97 | 99 | 96 | 100 | 98 |
| | | | Hexameta | 97 | 95 | 97 | 97 | 95 | 97 | 97 | 96 | 98 | 99 | 97 |
| | | | Versene | 100 | 98 | 100 | 99 | 99 | 99 | 98 | 99 | 99 | 98 | 99 |
| Mikro-San | 0.2 | 6.56 | Zeolite | 98 | 98 | 96 | 95 | 98 | 99 | 98 | 99 | 99 | 99 | 98 |
| | | 4.10 | Distilled | 12 | 4 | 3 | 3 | 3 | 3 | 6 | 2 | 4 | 3 | 4 |
| | | 6.82 | Hexameta | 96 | 91 | 98 | 94 | 91 | 95 | 89 | 93 | 93 | 92 | 93 |
| | | 7.32 | Versene | 99 | 89 | 94 | 85 | 97 | 99 | 99 | 99 | 98 | 98 | 96 |
| Nu-Foam | 0.2 | | Zeolite | 100 | 98 | 91 | 81 | 95 | 99 | 100 | 99 | 99 | 99 | 96 |
| | | | Distilled | 100 | 99 | 99 | 100 | 98 | 98 | 98 | 98 | 97 | 94 | 98 |
| | | | Hexameta | 100 | 98 | 99 | 100 | 99 | 100 | 100 | 100 | 100 | 100 | 99 |
| | | | Versene | 100 | 99 | 99 | 100 | 99 | 99 | 99 | 99 | 99 | 99 | 99 |
| Seco 10 | 0.3 | | Zeolite | 89 | 90 | 84 | 85 | 93 | 94 | 92 | 91 | 90 | 91 | 90 |
| | | | Distilled | 99 | 92 | 96 | 94 | 96 | 96 | 95 | 93 | 93 | 93 | 95 |
| | | | Hexameta | 98 | 94 | 96 | 93 | 96 | 97 | 95 | 93 | 92 | 96 | 95 |
| | | | Versene | 99 | 96 | 98 | 95 | 96 | 93 | 96 | 95 | 95 | 96 | 96 |
| Calgonite | 0.3 | | Zeolite | 97 | 98 | 96 | 91 | 91 | 81 | 85 | 75 | 79 | 71 | 86 |
| | | | Distilled | 98 | 96 | 98 | 99 | 94 | 93 | 89 | 88 | 84 | 84 | 92 |
| | | | Hexameta | 98 | 93 | 96 | 95 | 90 | 82 | 82 | 70 | 70 | 60 | 84 |
| | | | Versene | 99 | 98 | 94 | 91 | 79 | 67 | 74 | 72 | 70 | 64 | 81 |
| Hexa-w.a. (75-25) | 0.3 | | Zeolite | 98 | 100 | 97 | 98 | 99 | 100 | 99 | 99 | 98 | 100 | 99 |
| | | | Distilled | 99 | 98 | 99 | 98 | 97 | 98 | 96 | 98 | 97 | 99 | 98 |
| | | | Hexameta | 100 | 99 | 99 | 100 | 99 | 98 | 100 | 99 | 99 | 99 | 99 |
| | | | Versene | 98 | 100 | 100 | 100 | 99 | 99 | 99 | 100 | 99 | 100 | 99 |

An attempt was made to study conditions under which the Mikro-San would aid detergency. This was done by preparing 0.2 per cent Mikro-San solutions, this being approximately the concentration recommended by the manufacturer. To this solution, chemicals were added in quantities varing from 50 to 500 p.p.m. When these solutions were used for washing air-dried raw milk films variations in detergency were secured and are shown in Table 21.

It will be noted that sodium hydroxide even in 50 p.p.m. quantities gave clear glass panes. Sodium carbonate also materially aided detergency at 50 and 75 p.p.m. This was increased, however, when 100 and 500 p.p.m. was used. Sodium bicarbonate improved detergency when 500 p.p.m. was used to approximately the same extent as 50 p.p.m. sodium hydroxide. However, when only 100 p.p.m. was used, there was only cleaning to some degree, however, less cleaning was observed than when using the untreated Mikro-San solution in hard water.

It thus appeared that the hydrogen ion concentration adversely affected the detergency, whether from acid or sodium bicarbonate. Likewise, it would be noted that potassium hydroxide increased detergency as did calcium carbonate, magnesium carbonate, and tri-sodium phosphate at 500 p.p.m. quantities. There was some improvement in detergency when such products as sodium chloride, sodium sulfate, potassium chloride, calcium chloride, and magnesium bicarbonate were used at 500 p.p.m.

Evaluation of Commercial Dairy Detergents

It was not possible to make a complete washing study of all of the detergents that are being marketed for can washing purposes and to determine their manner of use that would yield the highest detergency. However, a washing performance study was made of 35 additional commercial dairy detergents. In previous studies, only air-dried raw milk films have been used. Also, in

Table 21. The effect of adding basic ions to a 0.20 per cent Mikro-San solution in distilled water.

| Chemicals added | Amount of chemicals added in p.p.m. | | | |
|---|---|---|---|---|
| | 500 | 100 | 75 | 50 |
| $Na\ H\ CO_3$ | **** | ** | | |
| $Na_2CO_3$ | **** | **** | *** | *** |
| $Na_6(PO_3)_6$ | **** | | | |
| $NaOH$ | **** | **** | | **** |
| $NaCl$ | *** | *** | | |
| $NaSO_4$ | *** | | | |
| $KOH$ | **** | **** | | |
| $KCl$ | *** | *** | | |
| $Ca\ CO_3$ | **** | *** | | |
| Ca gluconate | - | | | |
| $Ca\ Cl_2$ | *** | *** | | |
| $Mg\ H\ CO_3$ | *** | | | |
| $Mg\ CO_3$ | **** | | | |

Key:
**** cleaned milk soiled glass panes
*** cleaned as well as Mikro-San alone in hard water
** cleaned to some degree
- added to soil formation

these trials air-dried films were used as well as heat treated and the chlorine-protein complex films. These detergents are listed by name in Table 22. No determinations was made of the composition other than to note the pH and the surface tension of the detergents at a 0.3 per cent concentration (powder), or 0.2 per cent concentration (liquid).

It will be noted that pH or surface tension in the detergents that are generally classed as alkaline products materially affected their washing quality. In this group of detergents, two products were outstanding; namely, Sequet, and Flo-tron. These products were known to consist of essentially the same ingredients as the "75-25" combination that has been extensively studied.

The majority of the alkaline detergents gave good results on the air-dried milk films. However, many detergents failed to clean the heat treated or the chlorine-protein complex films. Such films are believed to be quite prevalent in producers shipping cans and detergents for can washing must process detergent qualities that will remove them.

The acid and the non-ionic detergents were generally low in washing qualities. It can be stated that generally as the pH of the acid solutions decreased there was also a decrease in detergency.

Since Versene had been shown to have some beneficial detergent properties when in combination with other components, tests were conducted to determine what effect small additions of this compound would have on the various commercial detergents that were used. These results are also shown in Table 22 and are indicated by the double asterisk in the heat treated and chlorine-protein complex films columns. Except in one instance, there was an increase in detergency when 40 per cent of the detergent was replaced with the Versene.

Table 22. An evaluation of commercial dairy detergents.
Washing at 120°F.; no pre-rinsing; after-rinsing at 140°F.; using a 0.3 per cent detergent solution (dry), 0.2 per cent solution (liquid).

| Detergent: Name | Detergent: pH | Detergent: Surface Tension | Per cent light transmission after washing — Milk films: Air-dried trials 5 | Air-dried trials 10 | Heat treated trials I | Heat treated trials I** | Chlorine-protein trials I | Chlorine-protein trials I** | pH # |
|---|---|---|---|---|---|---|---|---|---|
| **Alkaline** | | | | | | | | | |
| Calglo | 7.15 | 32.2 | 93 | 82 | 86 | 98 | 58 | 81 | 10.20 |
| Surf | 7.27 | 30.2 | 95 | 87 | 52 | 78 | 52 | 95 | 9.33 |
| Calgon | 7.60 | 51.5 | 93 | 81 | 95 | | 85 | | |
| Kelvar | 7.76 | 29.1 | 99 | 99 | 56 | 95 | 48 | 94 | 9.11 |
| Nytron | 7.79 | 34.6 | 97 | 88 | 49 | 50 | 48 | 73 | 9.00 |
| Flo-tron | 8.08 | 32.5 | 99 | 99 | 95 | | 96 | | |
| Kleer-mor | 8.64 | 31.3 | 94 | 90 | 49 | 65 | 48 | 76 | 9.28 |
| Tide | 8.80 | 26.4 | 98 | 97 | 85 | | 86 | | |
| Seco 10 | 8.86 | 48.1 | 99 | 99 | 77 | 96 | 58 | 98 | 9.40 |
| Sequet | 8.86 | 32.7 | 99 | 99 | 99 | | 99 | | |
| Super 88 | 9.00 | 31.5 | 94 | 90 | 48 | 72 | 49 | 93 | 9.47 |
| Farm Dairy | 9.46 | 32.6 | 95 | 89 | 59 | 91 | 51 | 78 | 9.61 |
| M.C. 3 | 9.68 | 33.1 | 99 | 99 | 65 | 99 | 47 | 93 | 9.58 |
| G.L.X. | 9.88 | 42.7 | 93 | 83 | 63 | 69 | 53 | 68 | 9.40 |
| H.C. 66 | 9.90 | 34.5 | 95 | 90 | 63 | 92 | 51 | 87 | 9.89 |
| Solvay 600 | 10.00 | 39.7 | 97 | 91 | 60 | 84 | 69 | 79 | 10.10 |
| Sup. cleaner | 10.09 | 32.1 | 95 | 92 | 57 | 92 | 48 | 93 | 9.91 |
| C.M.K. | 10.09 | 42.4 | 97 | 93 | 68 | 63 | 47 | 58 | 10.70 |
| N.D. AB | 10.14 | 35.5 | 99 | 93 | 62 | 77 | 48 | 98 | 10.36 |
| H.C. 6 | 10.37 | 41.3 | 91 | 87 | 71 | 69 | 53 | 87 | 10.12 |
| Tykor 31 | 10.39 | 38.4 | 96 | 92 | 62 | 67 | 48 | 85 | 10.36 |
| Tykor 51 | 10.44 | 39.7 | 98 | 96 | 66 | 88 | 54 | 84 | 10.22 |
| Dreadnaught | 10.55 | 41.9 | 98 | [illegible] | 63 | 95 | 55 | 98 | 10.20 |
| Calgonite | 10.57 | 70.2 | 97 | 91 | 62 | | 72 | | |
| Hi-speed | 10.60 | 38.1 | 98 | 96 | 62 | 83 | 47 | 87 | 10.32 |
| Can cleaner | 11.10 | 47.7 | 98 | 93 | 69 | 69 | 45 | 66 | 10.70 |
| **Acid** | | | | | | | | | |
| C.B. acid* | 2.70 | 39.4 | 49 | 45 | 47 | | 47 | | |
| Milkstone* | 3,25 | 37.7 | 69 | 66 | 80 | 59 | 46 | 47 | 4.12 |
| Nu-kleen* | 5.70 | 32.1 | 77 | 71 | 48 | 51 | 47 | 59 | 6.12 |
| Penn-salt* | 6.08 | 43.7 | 52 | 49 | 46 | 51 | 45 | 51 | 6.25 |
| Mikro-san* | 6.57 | 32.0 | 83 | 80 | 50 | 50 | 47 | 59 | 6.89 |
| single str.* | 6.69 | 31.2 | 84 | 79 | 49 | 49 | 47 | 55 | 7.01 |
| double str.* | 6.68 | 43.7 | 73 | 61 | 46 | 49 | 47 | 55 | 7.09 |
| **Non-ionic** | | | | | | | | | |
| No-Foam* | 7.27 | 32.0 | 70 | 57 | 46 | 48 | 46 | 95 | 9.02 |
| Sharples 218* | 7.81 | 32.7 | 87 | 80 | 48 | 52 | 50 | 79 | 9.09 |

Key: * Liquid detergent, ** Versene added to detergent in 40-60 combination,
# pH of Versene-detergent combination solution.

Effect of Combinations of Versene, Condensed Phosphates and Wetting Agent as Applied to Detergency

The preceding experiments indicated that the addition of Versene to condensed phosphates and wetting agents might prove to be a combination that would give desirable detergency results. Therefore, a study was made of laboratory prepared combinations of these products and their application to other detergent components. As was shown by Table 22, different detergency values could be expected with the three types of raw milk films.

Effect of Versene Combinations on Detergency on Two Raw Milk Films

One set of glass panes was prepared with air-dried raw milk film and the other set prepared with a heat treated raw milk film. Ten successive treatments and washings were made on these panes to determine cleanliness as measured by the light transmissions are shown on Table 23. Washings were carried out at 140° F., with no pre-rinsing or after-rinsing.

The results of Table 23 show the influence of these laboratory prepared detergent combinations on the two films. Here also detergency was secured on all the air dried films. Highest detergency of the heat treated films was secured with detergents 1, 5 and 6. It seemed significant that the one common ingredient absent in these detergent combinations was trisodium phosphate. It was speculated that this product interfered with certain functions of detergency that was provided by sequestering-chelating-wetting agent combinations.

A Comparison of Two Wetting Agents on Detergency When in Combination with Versene and Condensed Phosphates

The glass panes were again prepared with the air-dried raw milk film. Two wetting agents, Nacconol (alkyl aryl sulfonate) and Dreft (sodium laural sulfate), were compared in this study. Two washing solutions were used in the comparisons of the two wetting agents, hard water, and 10 per cent raw milk addition. Ten successive treatments and washings were made on these

Table 23. **The detergency effect of Versene, wetting agent and condensed phosphates combinations* on the type of film.**

**Washing at 140°F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.**

| Detergent No.* | Detergent pH | Nature of Film | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
| 1. | 8.10 | Air-dried | 100 | 99 | 99 | 99 | 100 | 99 | 100 | 100 | 100 | 99 | 99 |
| | | Heat treated | 98 | 99 | 99 | 97 | 97 | 97 | 97 | 96 | 94 | 95 | 97 |
| 2. | 8.54 | Air-dried | 99 | 99 | 99 | 99 | 99 | 99 | 100 | 100 | 99 | 99 | 99 |
| | | Heat treated | 80 | 78 | 76 | 54 | 50 | 50 | 41 | 33 | 26 | 23 | 51 |
| 3. | 8.52 | Air-dried | 98 | 98 | 96 | 98 | 98 | 98 | 98 | 99 | 99 | 96 | 98 |
| | | Heat treated | 86 | 85 | 69 | 59 | 50 | 47 | 40 | 32 | 20 | 18 | 51 |
| 4. | 8.69 | Air-dried | 97 | 96 | 96 | 96 | 95 | 97 | 97 | 98 | 97 | 95 | 96 |
| | | Heat treated | 88 | 95 | 93 | 67 | 57 | 55 | 48 | 43 | 39 | 35 | 62 |
| 5. | 8.32 | Air-dried | 98 | 98 | 99 | 98 | 97 | 98 | 98 | 98 | 98 | 98 | 98 |
| | | Heat treated | 98 | 98 | 98 | 97 | 97 | 97 | 97 | 97 | 97 | 96 | 97 |
| 6. | 8.20 | Air-dried | 99 | 98 | 98 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 |
| | | Heat treated | 97 | 98 | 98 | 97 | 97 | 98 | 97 | 96 | 96 | 96 | 97 |

* Key to detergent numbers

| | Versene | Wetting agent | Hexameta. | Tri poly | Tetra | T.S.P. |
|---|---|---|---|---|---|---|
| 1. | 20 | 20 | 60 | -- | -- | -- |
| 2. | 20 | 20 | 40 | -- | -- | 20 |
| 3. | -- | 20 | 30 | 30 | -- | 20 |
| 4. | -- | 20 | 20 | 20 | 20 | 20 |
| 5. | 20 | 20 | -- | 60 | -- | -- |
| 6. | 20 | 20 | 30 | 30 | -- | -- |

panes to determine cleanliness as measured by light transmissions are shown by Tables 24 and 25. Table 24 shows the results using Nacconol; Table 25 shows the results using Dreft. Washings were carried out at 140° F. with no pre-rinsing or after rinsings.

There seemed to be no difference between the two wetting agents when in combination with the condensed phosphates and Versene. A slight reduction in detergency was noticed in both wetting agents when raw milk was added to the detergent solutions. However, this was not as great as the reduction that was previously described when using commercial detergents (Table 22). The combination of 20-40-40, wetting agent, sodium hexametaphosphate, and Versene, shown in Table 24, gave the highest possible light transmissions in all 10 trials.

Evaluation of Several Laboratory-Prepared Detergent Combinations

A more complete analysis of the detergent qualities of the laboratory prepared combinations was deemed worthy of investigation. The glass panes were prepared with three raw milk films, (1) air-dried, (2) heat treated, and (3) chlorine treated. These have been described previously. Three detergent components, tri-sodium phosphate, sodium metasilicate, and sodium bicarbonate were used with the Versene-condensed phosphates-wetting agent combinations. All of the prepared detergents were thoroughly mixed, in the percentage indicated, by means of a Waring Blendor. Washings were carried out at 120° F., after-rinsings at 150° F., with no pre-rinsings. The results of this investigation are shown in Table 26.

All combinations, without the components, gave good detergency results on the air-dried milk films. A decrease in detergency was noticed on the heat treated and chlorine treated films when the components were added. The first three combinations of Versene, condensed phosphates and wetting agents gave the best all-around detergency readings. Throughout the results, there seemed

Table 24. The effect of raw milk on detergency when added to combinations* of Versene, condensed phosphate, and Nacconol on air-dried raw milk films.

Washing at 140°F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.

| Detergent No.* | Treatment of Wash solution | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
| 1. | Hard water | 100 | 96 | 97 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 98.6 |
| | 10% raw milk | 94 | 94 | 92 | 96 | 96 | 95 | 93 | 94 | 95 | 95 | 94.4 |
| 2. | Hard water | 100 | 100 | 98 | 99 | 100 | 100 | 100 | 100 | 100 | 99 | 99.6 |
| | 10% raw milk | 98 | 96 | 97 | 98 | 97 | 97 | 97 | 98 | 98 | 97 | 97.3 |
| 3. | Hard water | 98 | 98 | 98 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 98.7 |
| | 10% raw milk | 97 | 96 | 94 | 96 | 98 | 96 | 97 | 96 | 97 | 97 | 96.4 |
| 4. | Hard water | 100 | 99 | 99 | 100 | 100 | 100 | 99 | 100 | 100 | 100 | 99.7 |
| | 10% raw milk | 96 | 97 | 95 | 96 | 98 | 97 | 97 | 97 | 99 | 97 | 96.9 |
| 5. | Hard water | 100 | 99 | 99 | 100 | 100 | 100 | 100 | 99 | 100 | 99 | 99.6 |
| | 10% raw milk | 96 | 95 | 95 | 96 | 98 | 95 | 97 | 98 | 96 | 96 | 96.2 |
| 6. | Hard water | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100.0 |
| | 10% raw milk | 99 | 95 | 95 | 98 | 97 | 95 | 96 | 97 | 96 | 95 | 96.3 |

* Key to detergent numbers

| | Nacconol: | Hexameta.: | Versene: |
|---|---|---|---|
| 1. | 10 | 90 | |
| 2. | 20 | 80 | |
| 3. | 10 | 70 | 20 |
| 4. | 20 | 60 | 20 |
| 5. | 10 | 45 | 45 |
| 6. | 20 | 40 | 40 |

Table 25. The effect of raw milk on detergency when added to combinations* of Versene, condensed phosphate, and Dreft on air-dried raw milk films.
Washing at 140°F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.

| Detergent No.* | Treatment of wash solution | Per cent light transmission after successive treatments and washings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | average |
| 1. | Hard water | 99 | 99 | 100 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99.2 |
| | 10% raw milk | 97 | 97 | 98 | 97 | 94 | 95 | 97 | 95 | 95 | 94 | 95.9 |
| 2. | Hard water | 98 | 99 | 99 | 99 | 99 | 99 | 98 | 98 | 99 | 99 | 98.7 |
| | 10% raw milk | 96 | 96 | 96 | 98 | 94 | 96 | 97 | 97 | 95 | 96 | 96.1 |
| 3. | Hard water | 99 | 99 | 99 | 98 | 99 | 99 | 98 | 98 | 98 | 98 | 98.6 |
| | 10% raw milk | 96 | 97 | 95 | 96 | 95 | 96 | 96 | 97 | 96 | 95 | 95.8 |
| 4. | Hard water | 99 | 99 | 99 | 99 | 99 | 99 | 98 | 98 | 99 | 98 | 98.6 |
| | 10% raw milk | 96 | 86 | 97 | 98 | 96 | 95 | 97 | 97 | 96 | 94 | 96.5 |
| 5. | Hard water | 99 | 100 | 99 | 99 | 99 | 99 | 100 | 99 | 99 | 99 | 99.2 |
| | 10% raw milk | 96 | 97 | 95 | 98 | 97 | 95 | 96 | 97 | 96 | 95 | 96.2 |
| 6. | Hard water | 99 | 100 | 100 | 99 | 99 | 98 | 98 | 99 | 99 | 100 | 99.3 |
| | 10% raw milk | 97 | 98 | 95 | 98 | 98 | 96 | 97 | 97 | 96 | 95 | 96.7 |

* Key to detergent numbers

| | Dreft | Hexameta | Versene |
|---|---|---|---|
| 1. | 10 | 90 | |
| 2. | 20 | 80 | |
| 3. | 10 | 70 | 20 |
| 4. | 20 | 60 | 20 |
| 5. | 10 | 45 | 45 |
| 6. | 20 | 40 | 40 |

Table 26. The detergency effect of Versene, wetting agent and condensed phosphates and various components on three raw milk films. Washing at 120°F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.

| Per cent of products | | | | | | | | | | Washing results when milk films were: | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Wetting Agent | Versene | Sodium hexa-metaphosphate | Sodium tri-polyphosphate | Sodium tetra-phosphate | Tri-sodium phosphate | Sodium meta-silicate | Sodium bicarbonate | pH | Air-dried trials 5 | Air-dried trials 10 | Heat treated | Chlorine-protein complex |
| 1. | 20 | 40 | 40 | | | | | | 8.94 | 99 | 98 | 89 | 99 |
| 2. | 20 | 40 | | 40 | | | | | 9.27 | 99 | 96 | 96 | 91 |
| 3. | 20 | 40 | | | 40 | | | | 8.89 | 99 | 98 | 93 | 94 |
| 4. | 25 | | 75 | | | | | | 7.63 | 99 | 96 | 80 | 97 |
| 5. | 20 | 40 | | | | 40 | | | 10.55 | 97 | 95 | 24 | 20 |
| 6. | 20 | | 40 | | | 40 | | | 10.21 | 97 | 89 | 25 | 29 |
| 7. | 20 | | | 40 | | 40 | | | 10.43 | 97 | 90 | 24 | 47 |
| 8. | 20 | | | | 40 | 40 | | | 10.12 | 98 | 95 | 28 | 27 |
| 9. | 20 | | | | 40 | | 40 | | 9.77 | 93 | 84 | 32 | 27 |
| 10. | 20 | | | 40 | | | 40 | | 9.91 | 93 | 84 | 31 | 40 |
| 11. | 20 | | 40 | | | | 40 | | 9.69 | 94 | 83 | 33 | 37 |
| 12. | 20 | 40 | | | | | 40 | | 10.50 | 93 | 87 | 29 | 52 |
| 13. | 20 | 20 | 40 | | | 20 | | | 9.79 | 99 | 98 | 28 | 53 |
| 14. | 20 | 20 | 20 | | | 20 | 20 | | 10.09 | 97 | 91 | 28 | 34 |
| 15. | 17 | | | | 66 | | 17 | | 8.59 | 96 | 96 | 75 | 95 |
| 16 | 10 | | | | 90 | | | | 7.59 | 99 | 98 | 66 | 87 |
| 17. | 10 | | | 90 | | | | | 9.00 | 99 | 98 | 74 | 94 |
| 18. | 10 | | 90 | | | | | | 7.76 | 99 | 97 | 78 | 97 |
| 19. | 10 | 90 | | | | | | | 9.92 | 99 | 99 | 96 | 98 |
| 20. | 20 | 20 | 20 | 20 | 20 | | | | 9.82 | 98 | 98 | 96 | 94 |
| 21. | 20 | | | | 80 | | | | 7.74 | 97 | 96 | 96 | 82 |
| 22. | 20 | | | 80 | | | | | 8.89 | 99 | 98 | 96 | 68 |
| 23. | 20 | | 80 | | | | | | 7.82 | 99 | 99 | 74 | 98 |
| 24. | 20 | 80 | | | | | | | 9.79 | 98 | 97 | 89 | 96 |
| 25. | 20 | 20 | 30 | | 30 | | | | 8.42 | 98 | 98 | 86 | 94 |
| 26. | 20 | 20 | 30 | 30 | | | | | 8.80 | 98 | 98 | 87 | 81 |
| 27. | 20 | 20 | | 30 | 30 | | | | 8.88 | 98 | 98 | 87 | 84 |
| 28. | 20 | | | | 40 | | | 40 | 7.71 | 96 | 94 | 30 | 31 |
| 29. | 20 | | | 40 | | | | 40 | 8.82 | 96 | 91 | 23 | 30 |
| 30. | 20 | | 40 | | | | | 40 | 7.88 | 95 | 93 | 27 | 25 |
| 31. | 20 | 40 | | | | | | 40 | 8.58 | 98 | 95 | 20 | 18 |
| 32. | 10 | 15 | 75 | | | | | | 8.33 | 99 | 99 | 85 | 94 |

to be a tendency for the Versene to give the better detergency readings on the chlorine treated film, while the condensed phosphates gave better results on the heat treated films. Thus a combination of these two would be more effective on all types of films than either would be alone.

The Effect of Various Detergent Components When Added to a Standard Detergent

The results of Tables 23 and 26 seem to indicate that when some detergent components, commonly used in commercial detergents as buffers and/or fillers are added, decreased detergency resulted. This was especially true with the heat treated and chlorine-protein complex films. Thus this study dealt with a more thorough investigation of these various components when they replaced or were added to a "75-25" combination of condensed phosphate-wetting agent. This "75-25" combination has been found in preceding studies to give excellent detergency results. The components tested in this study were sodium hydroxide, sodium carbonate, tri-sodium-phosphate, sodium metasilicate, sodium bicarbonate, tetra-sodium-pyrophosphate and sodium chloride. The results of this study are shown in Table 27.

In general, the findings of Table 27 show that low detergency results were obtained when the components were added to the "75-25" detergent combination, however, much lower detergency results were obtained when the "75-25" detergent combination was replaced with the components.

When the "75-25" detergent was used in combination with any of the components and the level of detergent used was regulated to 0.3 per cent, either by addition or replacement, the resulting detergency was lowered over that secured with the "75-25" detergent. As the amount of the components was increased by either method of using, there was a corresponding decrease in washing quality. Approximately the same low readings were obtained when 40 per cent of the "75-25" detergent was replaced with any of the above named components. When the components were added to the "75-25" detergent, at the

Table. 27. The effect of replacing various detergent components to a standard condensed phosphate-wetting agent mixture on the removal of an air-dried milk film.

Washing at 120°F.; after-rinsing at 150°F.; no pre-rinsing; using a 0.3 per cent detergent solution on the trials marked "R".

| Detergent | | | | Per cent light transmission | |
|---|---|---|---|---|---|
| | | | | Films | |
| Component | Added (A) or Replaced (R) | % | pH | Air-dried * | Heat treated |
| Control | - | 0 | 7.97 | 99.6 | 99 |
| NaOH | R | 10 | 9.57 | 99.4 | 59.5 |
| | R | 20 | 10.46 | 98.1 | 39.5 |
| | R | 40 | 11.60 | 95.8 | 17 |
| | A | 10 | 9.98 | 99.1 | 80 |
| | A | 20 | 10.81 | 98.1 | 67.5 |
| | A | 40 | 11.60 | 98.7 | 25 |
| $Na_2CO_3$ | R | 10 | 9.08 | 98.8 | 65.5 |
| | R | 20 | 9.57 | 97.1 | 43 |
| | R | 40 | 9.90 | 94.2 | 21.5 |
| | A | 10 | 9.13 | 98.9 | 95.5 |
| | A | 20 | 9.58 | 97.0 | 88 |
| | A | 40 | 9.89 | 96.9 | 37 |
| $Na_3PO_4$ | R | 10 | 8.89 | 98.8 | 94 |
| | R | 20 | 8.91 | 97.8 | 48.5 |
| | R | 40 | 9.54 | 90.4 | 23 |
| | A | 10 | 8.56 | 98.7 | 96 |
| | A | 20 | 9.06 | 97.8 | 96 |
| | A | 40 | 9.60 | 97.6 | 25 |
| $Na_2SiO_3$ | R | 10 | 9.00 | 98.8 | 70.5 |
| | R | 20 | 9.50 | 96.0 | 34 |
| | R | 40 | 10.36 | 97.2 | 22 |
| | A | 10 | 9.20 | 97.8 | 84.5 |
| | A | 20 | 9.60 | 96.8 | 77.5 |
| | A | 40 | 10.11 | 98.5 | 35 |
| $NaHCO_3$ | R | 10 | 7.95 | 98.2 | 92 |
| | R | 20 | 8.00 | 98.3 | 60 |
| | R | 40 | 8.27 | 77.5 | 27.5 |
| | A | 10 | 7.90 | 98.4 | 96.5 |
| | A | 20 | 8.04 | 97.5 | 97 |
| | A | 40 | 8.28 | 97.7 | 64 |
| $Na_4P_2O_7$ | R | 10 | 8.15 | 94.1 | 96 |
| | R | 20 | 8.40 | 93.3 | 81.5 |
| | R | 40 | 8.88 | 94.3 | 31.5 |
| | A | 10 | 8.18 | 96.4 | 96.5 |
| | A | 20 | 8.46 | 94.9 | 92.5 |
| | A | 40 | 8.85 | 97.5 | 83 |
| NaCl | R | 10 | 7.83 | 98.7 | 93 |
| | R | 20 | 7.89 | 98.4 | 59 |
| | R | 40 | 7.89 | 97.6 | 26 |
| | A | 10 | 7.80 | 97.1 | 94 |
| | A | 20 | 7.90 | 97.6 | 91.5 |
| | A | 40 | 8.10 | 98.7 | 81 |

* Average of ten successive washings.

rate of 40 per cent, then the detergency readings were not comparative, but depended solely on the component used.

A Study of the Chlorine-Protein Complex Milk Films

Before an explanation could be made of the difficulty of removing the chlorine-protein complex film by the commercial detergents and the laboratory prepared detergents, a thorough study of the film was deemed necessary. An attempt was made to determine what constituent or group of constituents in milk was responsible for the film that was formed when chlorine solutions came in contact with the milk film.

## PROCEDURE

The various constituents of milk were roughly separated by the following procedure. Fresh raw milk was separated at approximately 75° F. with a No. 518 DeLaval Separator, whereby the cream portion and the skim portion were saved. The cream portion was washed with equal volumes of water at 110° - 115° F. and re-separated to secure a lecithoprotein-free fat and the lecithoproteins. The lecithoprotein-free fat portion was re-separated and re-washed six times, while the lecithoproteins were collected and saved. The re-washing and re-separation was carried out to extract the highest amount of lecithoproteins from the fat. The skim milk obtained was divided into two parts. To one, lactic acid was added until a separation of the casein took place; and the other was saved. The casein was filtered to secure the whey portion, and this was neutralized back to a pH of 6.8. The neutralized whey portion was divided into two portions. To one, ammonium sulfate was added to saturate the solution and to salt out the whey proteins and to secure upon filtration the serum portion; the other portion was saved. Thus by this procedure, the following constituents were received; lecithoprotein-free fat, lecithoproteins, whey, whey proteins, and the serum.

These constituents were not considered to be pure, but merely a rough separation to get some idea of their reaction with the hypochloride solution. The constituents were used to coat duplicate glass panes. One set was prepared for test washing with air-dried raw milk film, and the other set was immersed in chlorine, similarly to the preparation of the chlorine-portein complex film. The results of this experiment are shown in Table 28.

Table 28 shows the results when these films were washed with two commercially produced detergents, "Tide" and "Tykor 51." The product, "Tide" had been shown by Table 22 to yield high detergency on both heat treated and chlorine-protein treated films. "Tykor 51" represented a detergent giving high detergency on air-dried raw milk films, but low detergency on heat treated and chlorine treated films. Thus using "Tide" as a detergent and using the various constituents of milk that reacted with the chlorine solution to form resistant films. The most resistant milk constituent-chlorine film could be determined. The less resistant films could be determined with "Tykor 51". High detergency results were obtained when a lecithoprotein free-fat was used to coat the glass panes, however, films produced with whipping cream, which contained some lecithoprotein, were harder to remove. Skim milk and skim milk plus lecithoprotein-free fat also gave high detergency results. The whey, whey plus fat, and whey fat, and lecithoprotein gave low readings, thus showing that the whey proteins are also a factor in the forming of the chlorine-protein complex film. When the lecithoprotein was used alone or was mixed with the whey proteins (serum) a greatly reduced detergency reading was recorded. Thus from the experiment, it is shown that some reaction must take place between the chlorine solution and the lecithoproteins and whey proteins of milk.

Table 28. **The influence of the constituents of raw milk applied to glass panes and immersed in a hypochloride solution.**

Washing at 120°F.; no pre-rinsing or after-rinsing; using a 0.3 per cent detergent solution.

| Constituents | Per cent light transmission | | | |
|---|---|---|---|---|
| | Detergent | | | |
| | Tide | | Tykor 51 | |
| | Air-dried | Chlorine | Air-dried | Chlorine |
| Normal milk | 99 | 96 | 99 | 66 |
| 30 % fat in distilled water | 98 | 90 | 95 | 72 |
| Whipping cream (35 %) | 99 | 63 | 99 | 47 |
| Skim milk | 99 | 98 | 99 | 93 |
| Skim milk plus 4 % fat | 99 | 99 | 99 | 95 |
| Whey | 91 | 44 | 99 | 88 |
| Whey plus 4 % fat | 98 | 41 | 99 | 49 |
| Whey plus 4 % fat, 10 % lecithoprotein | 77 | 47 | 99 | 48 |
| Serum | 99 | 91 | 99 | 58 |
| Serum plus 4 % fat | 95 | 97 | 99 | 53 |
| Serum plus 4 % fat, 10 % lecithoprotein | 95 | 93 | 99 | 48 |
| Serum plus 4 % fat, 48 % skim milk | 99 | 98 | 99 | 44 |
| Serum plus 50 % skim milk | 98 | 97 | 99 | 50 |
| Lecithoprotein | 94 | 52 | 99 | 45 |
| 10 % lecithoprotein plus 90 % skim | 98 | 88 | 99 | 45 |
| 10 % lecithoprotein plus 90 % whey | 75 | 46 | 99 | 48 |
| 10 % lecithoprotein plus 90 % serum | 95 | 92 | 99 | 49 |
| Whey proteins and distilled water | 98 | 89 | 94 | 66 |
| Lecithoprotein plus 50 % whey proteins | | | 94 | 46 |
| Condensed lecithoproteins (4tol) | 98 | 80 | 98 | 45 |

Discussion and Summary

The commercial detergents prepared and marketed for can washing vary considerably in detergency qualities. The detergency results depend to a great extent on the type of film that is to be removed by the detergents. The majority of detergents used can largely remove the air-dried milk films, however, when milkstone or a chlorine-protein complex film is present, a reduction in detergency is observed. It is evident that these two latter films are present in milk cans that are used for shipping raw milk to the receiving plants. Thus, if the detergent being used in mechanical can washers does not possess certain detergent qualities, these types of films will build up, causing a decrease in quality of the raw product. If these films are to be removed, it appears from this study that a combination of condensed phosphates, Versene, and wetting agents must be used in the wash tank of the mechanical can washers.

Although attention has been given to the manner of pre-rinsing and after-rinsing in these studies, it is not to be assumed that pre-rinsing or after-rinsing should be eliminated in practical washing. The purpose of this study was rather to determine the quality of the detergents, as observed under these conditions.

It becomes apparent also that the detergents used in mechanical can washing should contain enough wetting agent to give lowered surface activity. Many of the commercial detergents either do not contain enough wetting agents or they are not present.

A soft water would be recommended for can washing, such as were used for the experiments, Zeolite, Versene or "75-25" softened waters would have beneficial effects if used for the wash solution of mechanical can washing alone with the commercial detergent.

It would seem highly desirable to use a combination of the condensed phosphates, wetting agents, and Versene for mechanical can washing. The pH is not highly caustic and the detergents could be used in mechanical can washing where either high alkalinity or acid are tolerated. This combination would be beneficial on all types of films that might be found in milk cans. With this combination, the addition of raw milk, such as might be found under practical conditions, would not seriously decrease the detergency readings.

A further study of the chlorine-protein complex film showed that the lecithoproteins and/or the whey proteins of milk are responsible for the formation of a film when milk solids come in contact with hypochloride solutions. This is thought to be due to protein denaturation by the nascent oxygen present in the hypochloride solutions.

## A STUDY OF WASHING SOLUTIONS AND OF VISUAL APPEARANCES OF MILK CANS WASHED WITH VARIOUS CAN WASHING DETERGENTS

### Visual Observations of Milk Cans from Plants Using Various Types of Detergents and Can Washers

Before any study was made concerning can washers, it was decided to observe washed milk cans as to their physical condition from the two types of can washers, Lathrop-Paulson and Rice and Adams. These can washers were using either one of three types of detergents, alkaline, acid, or non-ionic wetting agent. For this study, four plants scattered throughout the State of Michigan were selected and are designated as Plants A. B, C, and D.

Plant A was using an organic acid detergent, Mikro-San, and was not entirely satisfied with the conditions of the washed milk cans. On observation, the cans were found to be rusty around the pouring lip and gave a poor appearance for use as a food container. Plant C was also using the same organic acid as Plant A; however, due to the fact that the cans had been previously hand washed, a reliable observation of the condition of these cans could not be made. Cans coming from the washer were "wet", showing droplets of water. This was observed to be due to a lack of steam pressure in the can washer. The cans that had been used for transporting high testing milk were left in a "greasy" condition around covers, necks, and shoulders.

Plant B had been using organic acid previously, however, at the time the test was made, a non-ionic detergent had been used for over a year's time. The majority of the cans contained rust spots, broken seams, or were badly spangled.

Plant D had been using an alkaline type cleaner at all times and at the time of the test was using an alternate method of clearing with alkaline, acid treatments. The personnel were not satisfied with the results and were at the time looking for another "better" detergent.

In all, some 411 washed milk cans were observed in this study and the results are shown in Table 29.

Table 29. Visual observations of washed milk cans from four plants.

| Can Condition | Detergent solution used: | | | | | |
|---|---|---|---|---|---|---|
| | Alkaline | | Acid | | Non-ionic | |
| | No. | % | No. | % | No. | % |
| Rusty | 10 | 9.8 | 50 | 40 | 79 | 42.9 |
| Milkstone | 30 | 29.4 | 39 | 31.2 | 41 | 22.3 |
| Spangled | 16 | 15.7 | 25 | 20 | 37 | 20.1 |
| Normal | 46 | 45.1 | 11 | 8.8 | 27 | 14.7 |
| Total Cans | 102 | | 125 | | 184 | |

The results of Table 29 show that the majority of the alkaline washed cans were "normal" in condition, and gave the highest percentage in this condition of all cans observed. By the description "normal", it is intended to convey that the cans that were examined had none of the apparent defects that were listed in Table 29. More cans were spangled in the acid and non-ionic washed groups than in the alkaline washed group. Also, a higher percentage was found to be rusty among the acid and non-ionic washed groups, than was found in the alkaline. All of the cans contained milkstone. This condition was observed to be about equal in all detergent groups examined.

Condition of the Detergent Solution as Affected by the Operation of the Can Washer

Most can washers operate in such a manner that from one-half to one pint of the detergent solution is lost as each can passes through the washer. At the same time, one-half to one pint of water passes from the sterile rinse tank into the wash tank, thus continual dilution of the detergent solution takes place. To overcome the dilution, feeder tanks have been placed on can washers to continually feed a concentrated detergent solution into the wash tank. If the concentration of the detergent solution is not maintained at the proper level, either the detergent is wasted or incomplete washing results. It was the purpose of this study to observe the changes that might take place in concentration, pH, total water hardness, and active alkalinity of washing solutions of mechanical can washers.

## PROCEDURE

### Concentration Readings

The concentration of the wash solutions was taken at time intervals throughout the day. A representative sample of the wash solution was secured from the wash tank. An electrolytic Conductivity Solu-Bridge (Model R.D.-5) made by Industrial Instruments, Inc. was used to obtain concentration readings. This Solu-Bridge consists of an A.C. wheatstone circuit with a cathode-ray "eye tube" null indicator, and a dial calibrated in terms of concentration of a specific electrolyte or in conductance (microhms). The concentration was used solely for the purpose of determining the change in concentration of detergent solutions. Thus the concentration readings of one solution can not be compared with another, unless the same detergent is used in the same water.

### Hydrogen ion Concentration

The pH determinations were made as previously described.

### Versenate Hardness

The Versenate method of titration for total hardness as outlined by Diehl and Hach (1949) and Bersworth Chemical Company (1949) was followed in all trials.

### Active Alkalinity as Per Cent NaOH

The active alkalinity of the wash solution were made following the recommendations of England (1947).

Alkaline Solutions

Two can washers operated by Plants D and E were using alkaline detergents and were used for this study. Plant D was using 4 pounds of Dreadnaught washing powder in the wash tank, and 5 pounds in the feeder system. During the course of this study a change was made to a non-ionic detergent, Nu-Foam, which was used at the rate of 5 ounces to the wash tank, 4 ounces to the sterile rinse tank, and 1 quart to the feeder system. A temperature of 140°-145° F. was used in the wash tank, and 160° F. was used for the sterile rinse tank, and approximately 1300 cans were washed per day. Plant E had been using Calgonite washing powder in the wash solution for approximately four years without any definite control over the amount used. The feeder system was turned on and off at the descretion of the operator. In later studies of this plant, a controlled automatic feeder system was installed, wherein the concentrated supply was fed into the wash tank as the can washer was operated. Three pounds of Calgonite was added to the wash tank and three pounds was added to the feeder system. The temperature of the washing solution was maintained at 140° F., and approximately 450 cans were washed per day. The results of these studies are shown in Tables 30, 31, 32, and 33. The results shown by these tables are characteristic of several analyses of these wash solutions.

The results of Table 30 show the analysis of the wash solution of Plant D when using the Dreadnaught detergent. This table shows that the concentration readings of the washing solution increased as the days operation progressed from a reading of 750 (1015) to 1200 (1345). For the most part, the pH of the solution remained constant, varing only from a pH of 8.60 to 9.20. The Versenate hardness tests show that the total hardness of the solution increased as the days operation progressed from 144 p.p.m. (1015) to 370 p.p.m. (1345). This was most likely due to the milk solids that were being added to the wash solution

Table 30. Analysis of the washing solution of a straight-away Rice and Adams can washer, using Dreadnaught can washing detergent, Plant D, July 27, 1949.

| Time | Conc. Reading | pH | Versenate Hardness p.p.m. | Active alkalinity % as NaOH |
|---|---|---|---|---|
| 1015 | 750 | 8.60 | 144 | 0.012 |
| 1045 | 970 | 9.20 | 200 | 0.012 |
| 1115 | 1120 | 9.20 | 280 | 0.012 |
| 1145 | 1000 | 9.20 | 310 | 0.008 |
| 1300 | 1100 | 9.20 | 315 | 0.008 |
| 1345 | 1200 | | 370 | 0.004 |

Table 31. Analysis of the washing solution of a straight-away Rice and Adams can washer, using Nu-Foam can washing detergent, Plant D, September 22, 1949.

| Time | Conc. Reading | pH | Versenate Hardness p.p.m. |
|---|---|---|---|
| 0920 | 670 | 7.85 | 296 |
| 0955 | 590 | 7.55 | 245 |
| 1015 | 560 | 7.55 | 240 |
| 1030 | 560 | 7.41 | 240 |
| 1050 | 600 | 6.90 | 255 |
| 1110 | 580 | 7.25 | 245 |
| 1130 | 570 | 7.10 | 346 |
| 1155 | 570 | 6.40 | 261 |
| 1217 | 590 | 6.20 | 279 |
| 1232 | 620 | 6.10 | 272 |
| 1300 | 590 | 6.10 | 287 |
| 1330 | 590 | 6.20 | 272 |
| 1355 | 610 | 6.00 | 290 |

Table 32. Analysis of the washing solution of a rotary Rice and Adams can washer, using Calgonite can washing detergent, Plant E, July 28, 1949.

| Time | Conc. Reading | pH | Versenate Hardness p.p.m. | Active alkalinity % as NaOH |
|---|---|---|---|---|
| 0800 | 2800 | 11.40 | 0 | 2.22 |
| 0900 | 2250 | | 0 | 0.32 |
| 1100 | 1380 | 10.40 | 36 | 0.048 |
| 1145 | 1300 | 10.40 | 36 | 0.038 |
| 1300 | 1190 | 10.40 | 40 | 0.032 |
| 1330 | 1090 | 10.20 | 50 | 0.032 |
| 1400 | 1000 | | 55 | 0.020 |
| 1530 | 900 | | 60 | 0.020 |

Table 33. Analysis of the washing solution of a rotary Rice and Adams can washer, using Calgonite can washing detergent, Plant E, February 9, 1950.

| Time | Conc. Reading | pH | Versenate Hardness p.p.m. | Active alkalinity % as NaOH |
|---|---|---|---|---|
| 0800 | 1400 | 9.82 | 0 | 0.058 |
| 0900 | 1500 | 9.80 | 0 | 0.054 |
| 1000 | 1450 | 9.84 | 0 | 0.056 |
| 1100 | 1400 | 9.78 | 0 | 0.052 |
| 1200 | 1350 | 9.81 | 0 | 0.050 |
| 1300 | 1350 | 9.78 | 0 | 0.050 |
| 1400 | 1300 | 9.72 | 0 | 0.046 |
| 1530 | 1160 | 9.40 | 65 | 0.032 |
| 1700 | 1120 | 9.38 | 70 | 0.024 |

from the milk cans. The active alkalinity was extremely low and varied from 0.004 to 0.012 per cent calculated as sodium hydroxide. Table 31 shows the can washer solution change at Plant D when Nu-Foam was used as the detergent in the washing solution. In this case, the concentration reading remained constant. However, both the pH and the total hardness were slowly decreasing as the days operation progressed. It is possible that the pH decreased due to the action of acid-milk solids that were constantly being added to the washing solution.

The results of Table 32 show the analysis of the washing solutions of the can washer from Plant E. This analysis was made prior to the adjustment of the automatic feeder system. The concentration reading was found to be decreasing quite rapidly, until at the end of the day (1530) a reading of 900 was observed. The pH of the solution from the start of the day (0920) to the end (1555) remained constant. The total hardness expressed as calcium carbonate was never found to be over 60 p.p.m. This low total hardness was due to the Zeolite softened water used in the wash tank. Although the active alkalinity at the start of the day was extremely high, very little alkalinity was left at the end of the washing period. Table 33 shows the use of this same detergent under controlled conditions. With this operation, no excess of detergent was noticed.

The concentration reading decreased slowly, giving readings from 1400 to 1120, while the pH and the total hardness remained constant. The active alkalinity also decreased slowly, however, the proper alkalinity was maintained throughout the day.

Acid Solutions

Detergent solutions from two mechanical can washers, Plants A and C, using an organic acid cleaner, Mikro-San were studied in this trial. Plant A was using the Mikro-San by adding one-half pint of the detergent to both the wash tank and the sterile rinse tank. Plant C was not adding any detergent to the wash tank, and the feeder system was depended on to supply enough detergent to the wash tank. In both Plants, a 2.5 per cent detergent solution was used in the feeder system. Both washers were using a temperature of 170° F. in the wash tank. Plant A was using a sterile rinse water of 180° F. Plant C, using a rotary washer, did not have a sterile rinse tank. Plant A was washing approximately 1600 milk cans per day, while Plant C was washing approximately 400 cans per day. The results of these studies are shown in Tables 34 and 35. Table 34 also is characteristic of several analyses of the wash solution.

The results of the analysis of the washing solution of the can washer located in Plant A are shown in Table 34. The concentration reading of the wash solution decreased slowly as the days operation progressed. This was noticed with a reading of 2700 at the beginning of the day (0900) and a reading of 1800 at the close of the day, (1500). The pH at the beginning of the can washing operation, 6.7, was ideal according to directions of the detergent manufacture. However, in one hour's time, (1000) the pH was on the alkaline side of neutrality and this was noticed to increase as the day's operation progressed. Thus at the end of the day (1500), a pH of 9.0 was observed. The total hardness of the wash solution slowly decreased throughout the day. This is the opposite of what was found with the alkaline detergent (Tables 30, 32, and 33). The results of Table 35 show the analysis of the wash solution from Plant C. Here again a slow reduction in the concentration reading is noticed as the day progressed, and again the pH of the "acid" solution was found to be on the alkaline side of neutrality. The pH was observed to be 7.30, 8.30, and 8.40. With an addition of the acid detergent, a reduction was noticed in the pH. However, the wash solution was still alkaline, pH 7.6.

The total hardness likewise slowly decreased as the day progressed. This was very similar to the results obtained from Plant A.

Table 34. Analysis of the washing solution of a straight-away Lathrop-Paulson can washer, using Mikro-San, an organic acid detergent, Plant A, September 22, 1949.

| Time | Conc. Reading | pH | Versenate Hafdness p.p.m. |
|---|---|---|---|
| 0900 | 2700 | 6.70 | 430 |
| 1000 | 2600 | 7.20 | 440 |
| 1100 | 2500 | 8.30 | 392 |
| 1200 | 2100 | 8.80 | 350 |
| 1300 | 2000 | 8.80 | 337 |
| 1400 | 1950 | 8.90 | 324 |
| 1500 | 1800 | 9.00 | 331 |

Table 35. Analysis of the washing solution of a rotary Lathrop-Paulson can washer, using Mikro-San, an organic acid detergent, Plant C, October 4, 1949.

| Time | Conc. Reading | pH | Versenate Hardness p.p.m. |
|---|---|---|---|
| 0900 | 900 | 7.30 | 350 |
| 0930 | 825 | 8.30 | 333 |
| 1030 | 825 | 8.40 | 321 |
| | More Mikro-San | added to washer | |
| 1130 | 925 | 7.60 | 331 |
| 1200 | 900 | 7.30 | 311 |

Study of Mikro-San, An Organic Acid Can Washing Detergent

It was noticed in the preceding study (Tables 34 and 35) that when Mikro-San, an organic acid can washing detergent, was used in the wash solutions of the mechanical can washers, the pH of the wash solution was on the alkaline side of neutrality. Other investigators, as reported in the review of literature, have also noticed this; however, none have given reasons for this reaction. The producer of organic acid detergents recommends that an acid reaction should be maintained, and also that the ideal pH of the wash solution should be 6.5 - 6.8. Whether or not an alkaline reaction is desirable for acid washing has not been determined in past studies; however, it was the purpose of this study to determine the cause of this phenomenon.

As a means of determining the chemical reactions that may be secured with one standard organic acid detergent (Mikro-San), potentiometric-titration curves were determined on Hydroxyacetic acid and Gluconic acid, both know to be present in this acid. These curves are shown in Figures 8, (Hydroxyacetic acid); 9, (Gluconic acid); and 10, (Mikro-San).

The Hydroxyacetic acid gave a typical weak-acid, strong-base curve as shown by Figure 8; however, a modification of this curve is noticed when Gluconic acid was titrated, Figure 9. This modification is characterized by a hump which starts at pH 6.6 and ends at pH 7.2, and then continues following the same pattern as that produced by the natural weak-acid, strong-base curve. When the Mikro-San was titrated, (Figure 10), the same modification in the curve was noticed to be similar to that secured for the Gluconic acid. This modification is interesting because of the fact that this plateau appears at approximately the detergent solution pH that is recommended by the manufacturer of this acid. When just a small amount of base is added after reaching a pH of 7.2, a sharp up-swing takes place in the curve. This may explain the reason for the observed alkaline reaction that is secured with the use of Mikro-San. A reaction between basic ions of the water and the Mikro-San would be expected to take place, causing this rise in the curve and as a result an alkaline pH. Determinations should be made of the pH to be maintained in the detergent solution that would yield the highest detergency readings.

This modification of the typical weak acid-strong base curve that occurs with gluconic acid is explained according to Leermakers (1950) by the presence of delta and gamma lactones which are in equilibrium with the gluconic acid. It is thus possible that slow hydrolysis of the lactones during the titration modifies the curve which would normally be expected. A partial explanation of delta and gamma lactones is given by Isbell and Frush (1933).

Survey of Home Sanitation Treatment

The nature of the home sanitation treatment that producers follow may greatly affect the condition of the cans, and either aid or decrease the detergency action of the can washer detergent. This home sanitation program has been blamed by plant operators for the abnormalities of cleanliness noticed in washed milk cans. A brief survey was made in Plant D, to determine the producers home sanitation program used for milk cans.

Only a limited group of producers were contacted, however, it was interesting to note that a majority of these producers were hand washing their cans, either weekly or monthly. A majority of these producers were rinsing the cans just prior to milking. Approximately 50 per cent were rinsing with clear water, and 40 per cent were using chlorine solutions. These results, although limited to one plant, gives a trend regarding the method whereby producers are handling their cans on the farm.

Figure 8. Potentiometric-titration curve of Hydroxyacetic acid.

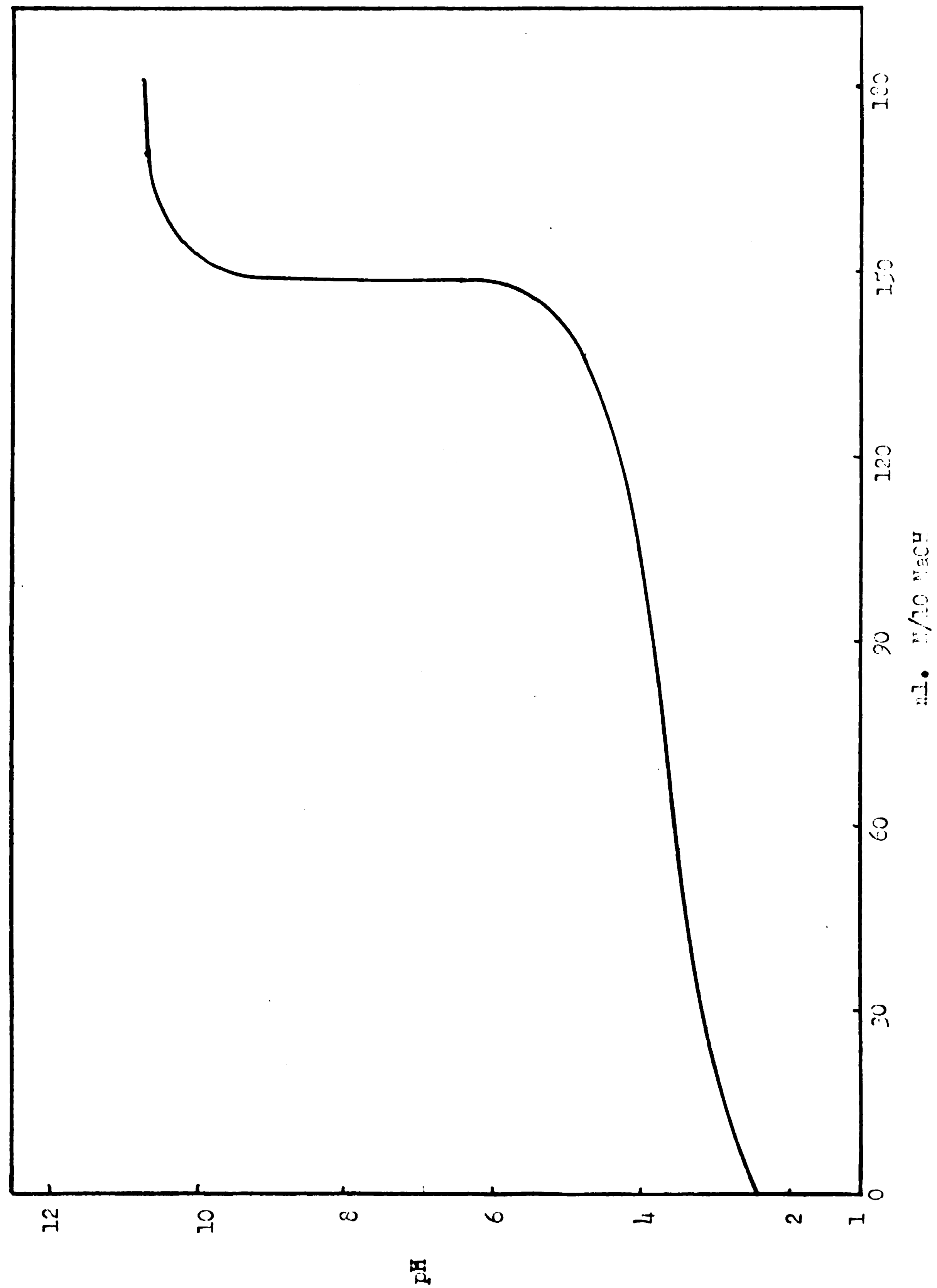


Figure 9. Potentiometric-titration curve of Gluconic acid.

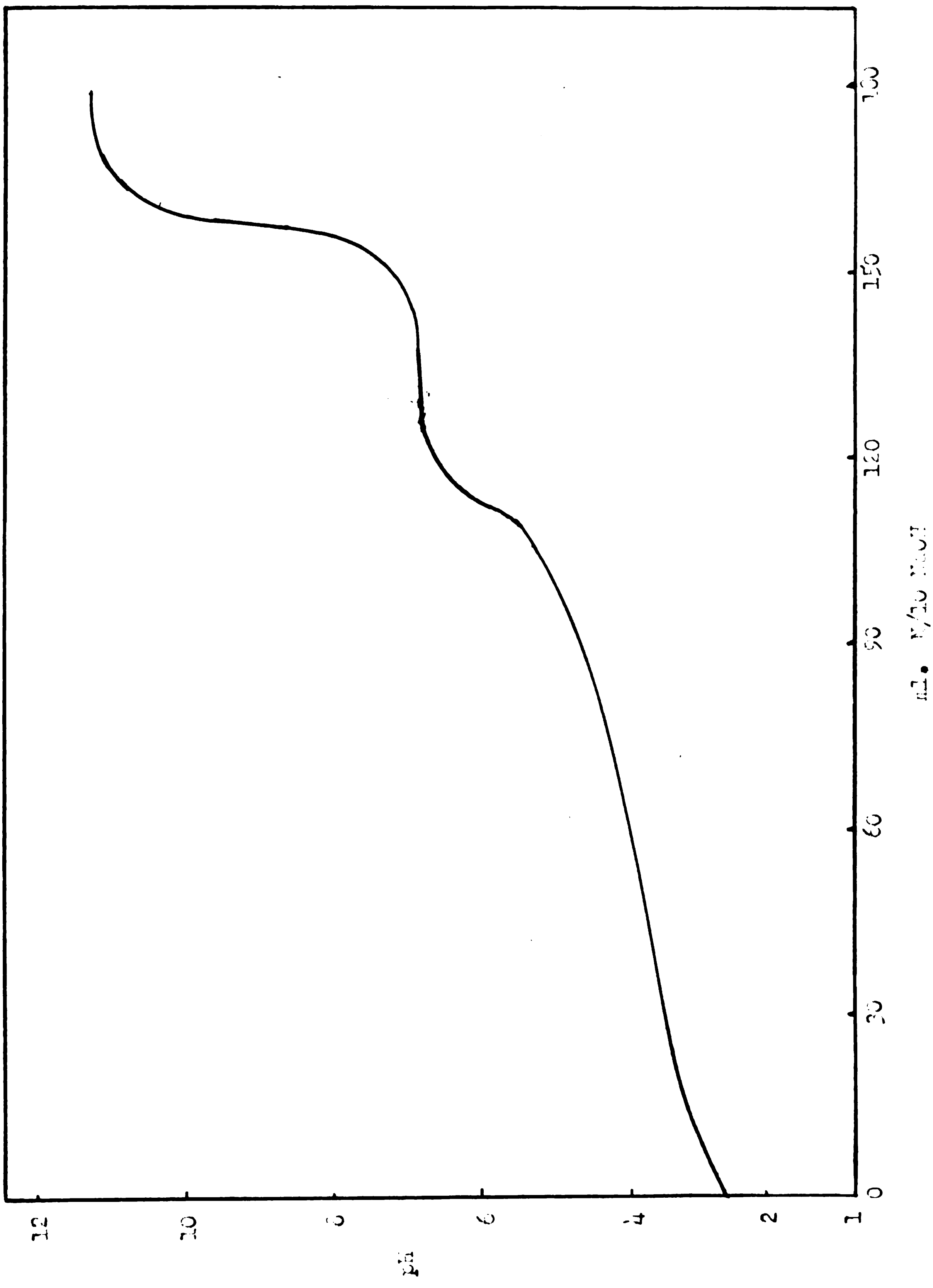
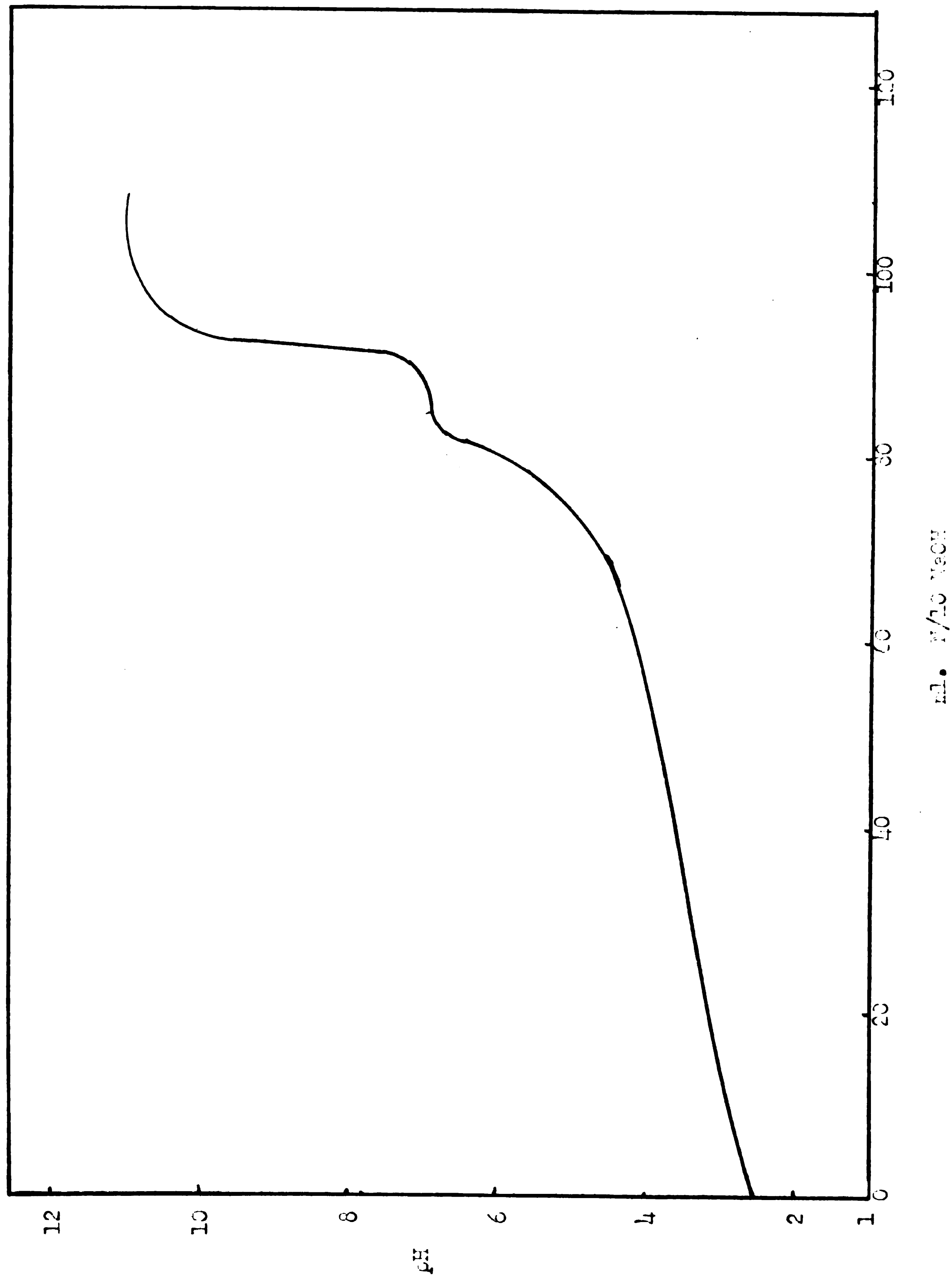


Figure 10. Potentiometric-titration curve of Mikro-San, an organic acid detergent.



Summary and Discussion

In this study of can washing, it was apparent from the observations made, defective can washing resulted partly as a result of the detergent used. It was particularly noticed that cans washed in acid detergents became rusty to a greater extent than when cans were washed in alkaline detergents. Although the detergent used in the can washer plays an important role, this does not mean that the detergent alone plays the only role in securing clean milk cans. The condition of the cans when washed with the non-ionic detergents was similar to those when acid detergents were used.

Mechanically controlled feeding of a concentrated detergent solution to the wash tanks was found to be essential to maintain proper detergent strength.

When potentiometric-titrations curves were made on Mikro-San, an organic acid detergent, a modification of a weak-acid, strong-base curve was found. This modification was noted by a hump at the pH where the manufactuers recommend that the washing solutions of the mechanical can washer by held. It is thus expected that on this short plateau is the area where most washing solutions are found at the beginning of the washing period. It is apparent that when the basic ions of the hard waters react with the Mikro-San, the solutions follow the pH curve upward, and alkaline solutions are found. It would appear that at a pH of 6.8 to 7.2, several concentrations could exist, and give an identical pH. It would also be logical to assume that at the above pH range, or on this hump, the best detergency results would be received with this organic acid. This modified curve is noticed to a greater extent with the Gluconic acid and not with the Hydroxyacetic acid. The Hydroxyacetic acid giving a typical weak-and, strong-base curve. Thus, the products being formed with the basic ions of the hard waters and the Mikro-San might be Gluconates.

# PRACTICAL APPLICATION OF THE PRECEDING STUDIES TO MECHANICAL CAN WASHING

The proof of actual detergency in can washing is measured only by determining the washing performance that is secured with mechanical can washers on producer-used cans, using specific detergent compounds under carefully operated conditions. Fortunately it was possible to secure cooperation of dairy plant operators who permitted can washing operation with such detergents as were considered desirable to test. These detergents were purchased by the dairy plant operators. Guidance and tests made on cans for the extent of detergency and for bacteria counts, were made by the author.

Three can washing operations were given particular attention. For convenience, these are designated by the letters A, D, and F and also refer to these machines in the section of the report that dealt with analysis of the wash solutions. Plant A employed an acid type can washer (Lathrop-Paulson) while Plants D and F both employed alkaline type washers.

## PROCEDURE

### Bacteriological Condition

The bacterial content of all washed milk cans was determined by the rinse method that was found most satisfactory in the early portion of this study. The rinse media used was 200 milliliters of a sterile buffered 0.01 per cent Triton X-100, non-ionic wetting agent solution. The media was added to cans selected at random after they emerged from the can washer. Next the cans were placed in the shaking apparatus shown in Figures 4, 5, and 6. The lid was replaced after a sterile parchment paper was placed on the pouring lip. The shaking apparatus was revolved for 30 rotations at a rate of 40 r.p.m. At the end of this time, the cans were removed from the shaking apparatus and

the rinse media poured back into the sterile container. The rinse media was then plated according to Standard Methods (1948) procedures on Tryptose Glucose Extract agar, and incubated at 35° - 37° C. for 48 hours. The counts shown in the following tables represent the total count of the cans. The counts were secured by multiplying the colonies that developed on the plate after 48 hours incubation by the dilution factor and by 200 (milliliters).

Physical Cleanliness

The physical cleanliness of the milk cans could not be entirely determined through visual examination, thus a more accurate method of determining the soil in the milk cans was needed. In these studies, the procedure of Jensen and Waterson (1950) was followed. The sediment or physical cleanliness of the washed cans was determined by adding one quart of sediment-free tap water at a temperature of approximately 100°F. with approximately one-half tablespoonful of a wetting agent-condensed phosphate mixture to the washed milk can. New, clean, cheese cloth squares were then used to hand wash the entire inside surface. By use of a Lansingkamp-Wheeler sediment gun, a sediment disc was secured of the wash water in the cans. The discs thus obtained were graded from one to four, according to the standard established by Jensen and Waterson (1950) and as shown by Figure 11. Class 1 and 2 sediment scores were considered to indicate cans that were in a good state of cleanliness, while the Class 3 and 4 sediment pads were considered to indicate cans that contained excessive filming of milk soil.

Use of a combination of Versene, condensed phosphates and wetting agent for can washing

The acid type can washing machine (Lathrop-Paulson) had been using Mikro-San from the time the machine was placed in operation. This was the first machine under study. As the acid type can washers are constructed with an aluminium coating, covering the wash tank and the sides, an alkaline detergent

could not be used for a caustic solution would destroy this coating. The detergent selected for this study consisted of 10 per cent Versene, 15 per cent wetting agent, and 75 per cent sodium hexametaphosphate. This combination has been shown in previous studies to be a superior detergent for three types of raw milk films (Table 26). This combination was added to the wash tank January 5, 1950 at the rate of 0.3 per cent, while the same combination was added to the feeder tank at the rate of 7.5 per cent. The rinse tank was treated with sodium hexametaphosphate at the rate of 0.2 per cent. The temperature of the wash tank was held at 160° - 165° F., while the sterile rinse tank was held at 185° - 190° F. The can washer was operating at the rate of 16 cans per minute. No other changes were made in the washing procedure with the exception that a new wash tank was installed January 25, 1950 due to a leak that had developed while the can washer was using the recommended acid detergent.

Bacteriological counts and sediment tests were made on the following dates, January 4, 14, and 25, February 11, March 1, April 1, and 14, and May 31, The results of these tests are shown in Table 36. Photographs of the sediment discs are also shown in Figures 12, 13, and 14. Another photograph of sediment discs from cans washed in Plant G with the same acid detergent and same type of can washer as Plant A are shown in Figure 22.

The sediment scores of the washed cans before any change was made in the detergent are shown in the January 4, column of Table 36 and by Figure 12. At this time the sediment scores show 92 per cent of the cans were graded either 3 or 4. As the trial period progressed, no definite improvement in the cans was noticed in physical cleanliness until February 11. At that time, it was observed that for the first time a majority of the cans (60 per cent) were graded 1 or 2. After that time, a majority of the cans were graded 1 or 2. Sediment discs taken April 1, and April 29, are shown by Figures 12 and 13

Table 36. Summary of sediment scores and bacteria counts of Plant A.

| Sediment Scores | Jan. 4 No. | Jan. 4 % | Jan. 14 No. | Jan. 14 % | Jan. 25 No. | Jan. 25 % | Feb. 11 No. | Feb. 11 % | Mar. 1 No. | Mar. 1 % | Apr. 11 No. | Apr. 11 % | Apr. 29 No. | Apr. 29 % | May 1 No. | May 1 % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Classification of cans as to sediment scores | | | | | | | | | | | | | | | |
| 1. | — | — | — | — | — | — | 1 | 5. | 6 | 32 | 7 | 35 | 4 | 19 | 4 | 20 |
| 2. | 2 | 8. | 1 | 6. | 6 | 30 | 11 | 55. | 9 | 47 | 10 | 50 | 6 | 29 | 10 | 50 |
| 3. | 13 | 48 | 4 | 27 | 7 | 35 | 7 | 35 | 3 | 16 | 1 | 55 | 7 | 33 | 5 | 25 |
| 4. | 12 | 44 | 10 | 67 | 7 | 35 | 1 | 5 | 1 | 5 | 2 | 10 | 4 | 19 | 1 | 5 |
| **Bacteria Counts** | Classification of cans as to bacteria counts | | | | | | | | | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| 0-10T | | | 6 | 40 | 10 | 50 | 16 | 80 | 13 | 65 | 7 | 35 | 17 | 85 | 9 | 45 |
| 10T-20T | | | 2 | 13 | 5 | 25 | 4 | 20 | 4 | 21 | 7 | 35 | 3 | 15 | 5 | 25 |
| 20T-40T | | | - | — | 3 | 15 | - | — | 2 | 10 | 5 | 25 | - | — | 6 | 30 |
| over 40T | | | 7 | 47 | 2 | 10 | - | — | 1 | 5 | - | — | - | — | - | — |

respectively. A definite improvement in the bacterial content of the cans was noticed after the "10-15-75" detergent combination was started. It was noticed that on January 14, 47 per cent of the cans contained over 40,000 organisms per can and 53 per cent contained less than 40,000 organisms per can. After January 14, a large majority of the cans contained less than 40,000 organisms per can. It was also observed that on February 11, March 11, April 29, and May 1, no cans were found to contain over 40,000 organisms per can. Besides these two tests, visual examinations of the cans show a marked improvement of the cans. The outsides were brighter than at the start of the tests. The inside of the cans and covers did not contain a "greasy" film and only a few contained milkstone.

On March 2, 1950, the addition of the 0.02 per cent sodium hexametaphosphate was omitted from the sterile rinse tank as a precipitate of calcium polyphosphate was forming on the walls of the sterile rinse tank. This was presumably due to the high temperature used in the sterile rinse tank. It was also assumed that some of the "10-15-75" detergent combination would be carried over by the cans from the wash tank to give threshold treatment. On April 1, 1950, it was recommended that a cotton filter cloth be placed on the air-intake of the can washer. From the conditions of the receiving room, it appeared that some of the sediment might be due to this source as suggested by Roadhouse (1948). This filter was changed every three days for the duration of the study. The condition of this filter cloth after a three day operation is shown by Figure 15.

<u>In An Alkaline Washer</u>

Two alkaline can washers (Rice and Adams) were used, one of which (Plant D) was using an alternate cleaning method using alkaline, acid washing solutions every second day. The other washer (Plant F) had been using Nu-Foam for approximately a six months period prior to the change to the "10-15-75" detergent combination. The washer in Plant D was changed to the "10-15-75" combination March 30, 1950 and was used until May 8, 1950. At that time, due to running out of the test detergent, Dreadnaught can washing detergent was used until May 26, 1950, when again the "10-15-75" detergent combination was used. This resulted in a delay in establishing data on detergency results and less results are available for study than were presented with the acid type can washing machine. The "10-15-75" detergent combination was added at the rate of 0.3 per cent to both washers. At Plant D a 22.5 per cent solution was prepared for the feeder system, while in Plant F, a 7.5 per cent solution was used. The feeder system concentration of Plant D was not used according to the directions that were given, but was the washing procedure that the plant operator desired. No other changes in the operation of the can washer were made during the duration of the study. Both can washers were using a temperature of 145° F. in the wash tank, and 160° F. for thesterile rinse solution.

The results of Table 37 show the sediment scores and bacteria counts of washed cans from Plant D. Photographs of the sediment discs secured March 16, April 22, and June 27, are shown in Figures 16, 17, and 18 respectively. On March 16, only 15 per cent of the cans were graded and 55 per cent were graded 4. March 29, results show that 30 per cent of the cans were in the 1 or 2 grades, while 70 per cent were 3 or 4. After approximately a months operation with the "10-15-75" detergent combination, 45 per cent of the cans were graded 1 or 2 and 35 days later on June 27, again 45 per cent were graded as 1 or 2. As marked, an increase in physical cleanliness was not noticed as occurred with the use of the acid type can washer, however, the bacterial contents show a great improvement over these secured at the start of the tests when the Dreadnaught detergent was used. Before the start of the trial, March 16, and March 29, from 15 to 20 per cent of the cans contained

Table 37. Summary of sediment scores and bacteria counts of Plant D.

| Sediment Scores | Dates when examined | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mar. 16 | | Mar. 29 | | Apr. 22 | | June 27 | |
| | Classification of cans as to sediment scores. | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % |
| 1. | 3 | 15 | 2 | 10 | 1 | 5 | 2 | 10 |
| 2. | - | -- | 4 | 20 | 8 | 40 | 7 | 35 |
| 3. | 6 | 30 | 10 | 50 | 7 | 35 | 6 | 30 |
| 4. | 11 | 55 | 4 | 20 | 4 | 20 | 5 | 25 |
| **Bacteria Counts** | Classification of cans as to bacteria counts. | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % |
| 0-10T | 6 | 30 | 8 | 40 | 7 | 35 | 14 | 70 |
| 10T-20T | 3 | 15 | 5 | 25 | 8 | 40 | 2 | 10 |
| 20T-40T | 7 | 35 | 2 | 10 | 5 | 25 | 1 | 5 |
| over 40T | 4 | 20 | 5 | 25 | - | -- | 3 | 15 |

over 40,000 organisms per can. At the first test, no cans were found to be over 40,000 per can and the last test, June 27, only 15 per cent of the cans contained over 40,000 organisms per can. As the decrease in per cent cans containing over 40,000 was noticed, accordingly, an increase in the per cent cans containing less than 40,000 organisms per can was observed.

The results of Table 38 show the sediment scores of washed cans from Plant F. Photographs of the sediment discs secured April 24, and June 13, are shown by Figures 19 and 20 respectively. In this study, no bacterial contents of the washed cans were made, because no counts were taken before the change in the detergent was made. However, improvement in the physical cleanliness of the washed cans is shown by the sediment discs. The sediment scores presented in Table 38 from April 18, 19, 24, and 25, and of May 10, are of the washed cans when Nu-Foam was being used. Only one test was made after the "10-15-75" detergent combination had been in use. The cans from Plant F, were in the poorest condition of cleanliness of all plants studied. This is shown by the fact that 50, 78, 68, 77, and 92 per cent of the washed cans tested were graded 4. In these studies, when NuFoam was used, the highest percentage of 1 or 2 grade cans was found to be 14 per cent. After approximately one month's use of the "10-15-75" detergent combination in the wash solution, 24 per cent of the cans were graded 1 or 2. However, 57 per cent were graded 4. This shows that an improvement in the physical cleanliness of the cans was being made and that a greater length of time was needed to completely free the films contained by these cans.

Use of a Wetting Agent in Combination with Calgonite

A rotary Rice and Adams can washer which had been using Calgonite for a period of approximately three years was used in Plant E. A washing temperature of 140° F. was used in the wash tank. The machine was operated at a rate of 6 cans per minute, washing approximately 450 cans per day. On February 7, 1950,

Table 38. Summary of sediment scores of Plant F.

| Sediment Scores | Dates when examined | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. 18 | | Apr. 19 | | Apr. 24 | | Apr. 25 | | May 10 | | June 13 | |
| | Classification of cans as to sediment scores | | | | | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| 1. | 1 | 5 | - | -- | 1 | 5 | - | -- | - | -- | 1 | 5 |
| 2. | 2 | 9 | - | -- | 2 | 9 | 1 | 5 | 1 | 8 | 4 | 19 |
| 3. | 8 | 36 | 5 | 22 | 4 | 18 | 4 | 18 | - | -- | 4 | 19 |
| 4. | 11 | 50 | 18 | 78 | 15 | 68 | 17 | 77 | 12 | 92 | 12 | 57 |

an addition of 0.025 per cent wetting agent (Nacconol) was added to the wash tank, along with 3 pounds of Calgonite. No other changes were made in the washing procedure. Sediment scores were made of the washed cans January 19, and 21, February 7, and March 11, 1950. A photograph of these discs are also shown in Figure 21. The results of this study is shown by Table 39.

The data from Table 39 show that before the addition of the wetting agent to the Calgonite, the majority of the cans were graded 3 or 4, (January 19, and January 21); however, on February 7, the majority were graded 1 or 2, and 38 per cent were graded 3 or 4. A partial explanation of this seemly improvement is given by the fact that during the month of January and February, the detergent strength was maintained at a uniform level. Approximately one after the Nacconol was added, March 11, 80 per cent of the cans were graded 1 or 2, and only 20 per cent were graded 4.

Table 39. Summary of sediment scores of Plant E.

| Sediment Scores | Dates when examined | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Jan. 19 | | Jan. 21 | | Feb. 7 | | Mar. 11 | |
| | Classification of cans as to sediment scores | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % |
| 1. | - | -- | - | -- | 2 | 9 | 9 | 45 |
| 2. | 3 | 25 | 3 | 17 | 13 | 62 | 7 | 35 |
| 3. | 5 | 42 | 9 | 50 | 4 | 19 | 2 | 10 |
| 4. | 4 | 33 | 6 | 33 | 4 | 19 | 2 | 10 |

## Summary and Discussion

The results of these can washing studies show that high improvement can be expected in can cleanliness when properly selected detergents materials are used. Such materials as were found effective in laboratory washing studies appear to yield similar washing results with mechanical can washing.

The combination of 10 per cent wetting agent, 15 per cent Versene and 75 per cent sodium hexametaphosphate used as the detergent in one acid and two alkaline mechanical can washers has been shown previously in the laboratory washing tests to give excellent results on three raw milk films. A combination of the organic chelating agent, Versene, and condensed phosphate seemed to be desirable for the removal of all types of films present in producer cans.

Versene also has some additional advantage in use for can washing by being stable to 190° F. temperature, therefore, it can be used to advantage over condensed phosphate in the final rinse. In this manner, liming of cans and can washer piping would be avoided.

It has been observed at times, when the detergent is changed in any mechanical can washer that the film that is present is removed in two to four weeks operation. Thus, this new detergent would be classed by the operator as one which had excellent detergency action. However, immediately after this old film is removed, another is formed. Thus, before the "10-15-75" combination was used in other can washers, the results of Plant A were studied over a period of time. It was observed in Plant A and the other plants that the films were being removed, with no new film being formed.

It was noted in these studies that some cans contained a heavy coating of a milk film which appeared on the cans and on the sediment discs as a yellow film. This film could be found on all cans of the same producer. When the sanitation program of these producers were checked, all were using an excessive amount of chlorine for rinsing the milk cans prior to milking. This type of film did not appear on producers cans where chlorine was not used as a rinse prior to milking. It was thus assumed that this film was a chlorine-protein complex similar in nature to that used in previous washing studies. This was substantiated by the milk plant fieldman and by haulers of milk, who investigated the producer methods. In two instances, where direct check-up was made following testing the cans and heavy discs were secured, the producer-prepared rinse solution was found to contain above 500 p.p.m. chlorine. It may be of interest to note that none of the producers cans coming into a plant handling only manufacturing milk, contained this film, whereas it could be found at any time in the plants handling fluid milk.

These observations show again the importance of using a detergent in the wash tank of mechanical can washers that will be effective in removing all types of milk films that may be found in producers cans.

It appears that the "10-15-75" detergent combination consists of materials that together will remove most types of films found in producers cans. At the same time, there seems to be no reason why cans washed with this combination should have excessive high bacterial contents.

# CONCLUSIONS

The effectiveness of the removal of bacteria from milk cans by the rinse method depends largely on the nature and the amount of the rinse medium used. Nutrient broth gave the highest removal of organisms, while tap water, distilled, and buffered distilled all gave approximately the same removal. A buffered non-ionic wetting agent, Triton X-100, gave high removal of organisms, corresponding to nutrient broth. When the largest volume of each media was used, the highest percentage of organisms was removed. Lower numbers of bacteria per can were removed with 100 ml. than with 500 or 1000 ml.

A mechanical rinsing apparatus was devised that was studied in comparison with a mechanical machine devised by Milone (1948). This devised apparatus gave higher and equally comparable counts on the various media to that secured by the Milone machine. It had the advantage of being simple and dismountable for transporting by automobile.

Commercial detergents marketed for can washing varied considerably in detergency qualities. When the commercial detergents were used to wash three different raw milk films; namely, air-dried, heat treated, and chlorine treated, a wide variance was noted between the cleaning quality of these detergents. The heat treated and chlorine treated films were extremely difficult to remove. Only two commercial prepared detergents, Sequet and Flo-tron removed all three films effectively.

When the detergent qualities of laboratory prepared detergents consisting of a combination of the condensed phosphates, chelating agent, and wetting agent, were studied on these three raw milk films, varied results were also obtained. When tri-sodium phosphate, sodium metasilicate, sodium hydroxide, sodium bicarbonate, sodium carbonate, sodium chloride, and tetra sodium pyrophosphate

were used to supplement or replace the basic combination of condensed phosphate-chelating agent-wetting agent detergent, a reduction in detergency resulted. The greatest reduction was found when 40 per cent of the detergent solution consisted of these alkaline components. Combinations of "20-40-40", "10-45-45", wetting agent, Versene, and condensed phosphates gave excellent detergency results on all three films. The organic chelating agent, Versene, was observed to have advantages over those of the sequestering agents in tying up water hardness salts. It was stable at high temperatures, effective over a wide pH range, and did not precipitate hard water salts at any of the concentrations used. Versene increased detergency when combined with condensed phosphates and wetting agents.

A study of the chlorine-protein filming revealed that chlorine solutions react with the lecithoprotein and/or the whey protein of milk to form a denatured film that is extremely hard to remove by ordinary detergents. This film was observed on producer cans where excessive amounts of chlorine were used for a rinse of the cans prior to milking.

Under simulated washing tests, it was shown that soft water or softened water was highly advantageous with commercial detergents for use in the wash tank of mechanical can washers. There was no significant difference between the results obtained when Zeolite, distilled, and Versene or sodium hexameta-phosphate treated water was used for washing milk films with commercial detergents. A wetting agent, as a supplement to one commercial can washing detergent, was found to improve can washing. When a detergent without a surface active agent was used for can washing, films were present on the can washer and on the cans. This condition was corrected in a month's time by the addition of a wetting agent.

When an organic acid detergent was used for mechanical can washing, an alkaline pH was found. The pH recommended by the manufacturer for the washing solution was extremely difficult to maintain. It was shown that this phenomenon was likely due to the gluconic acid that was present in the acid detergent. This resulted in a modified weak-acid, strong-base curve upon a potentiometric-titration. It was proposed that the basic ions of the waters reacted with the acid to form gluconates.

Under practical application, it was observed that commercial detergents do not contain the proper detergent qualities to remove all the films found in producer's cans. However, when a combination of a chelating agent, sequestering agent, and wetting agent were used in these same can washers, superior detergency resulted. It was evident that cans in poor physical cleanliness could be cleaned by the mechanical can washer without using hand methods by use of this detergent. On the whole good detergency as measured by clean milk cans and low bacteria counts was secured with detergent compounds that were low in alkalinity and that were shown by laboratory washing measurements to produce high detergency.

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# APPENDIX

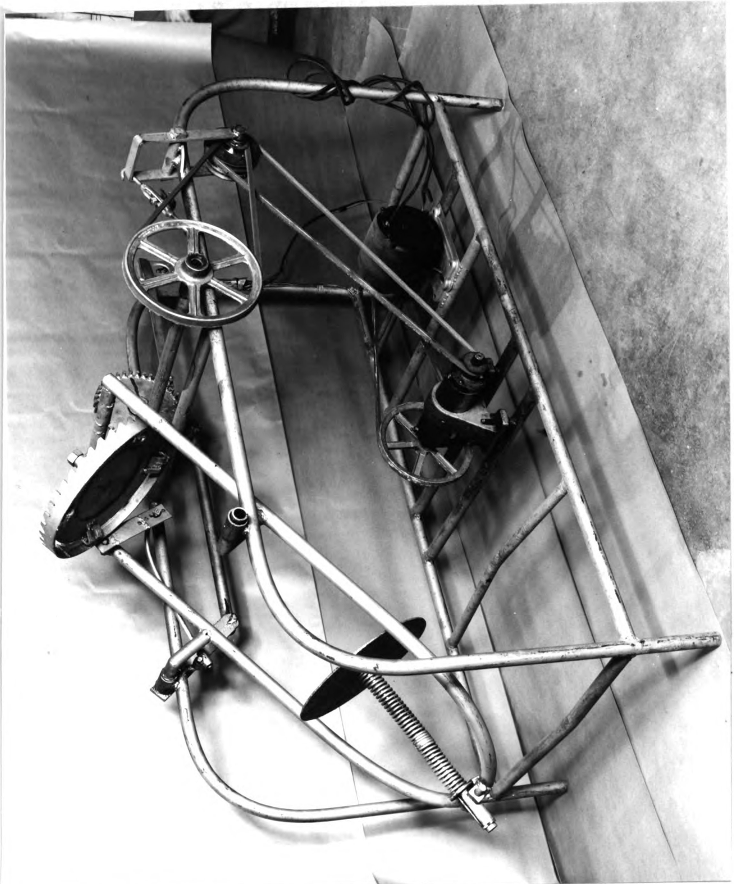

Figure 1. Mechanical shaking apparatus, Milone (1948).

Figure 2. Mechanical shaking apparatus showing can position, Milone (1948).

Figure 4. Constructed mechanical shaking apparatus.

Figure 5. Constructed mechanical shaking apparatus showing method of rotating.

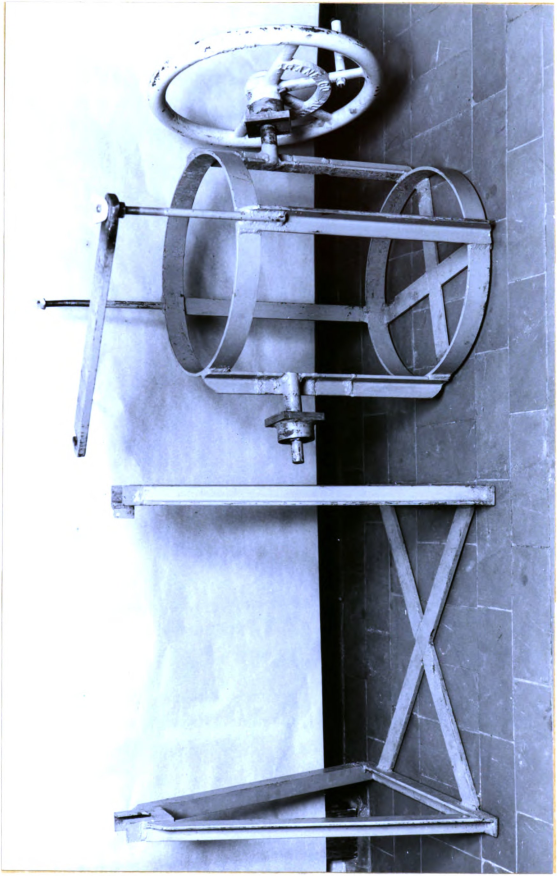

Figure 6. Constructed mechanical shaking apparatus showing the apparatus disassembled.

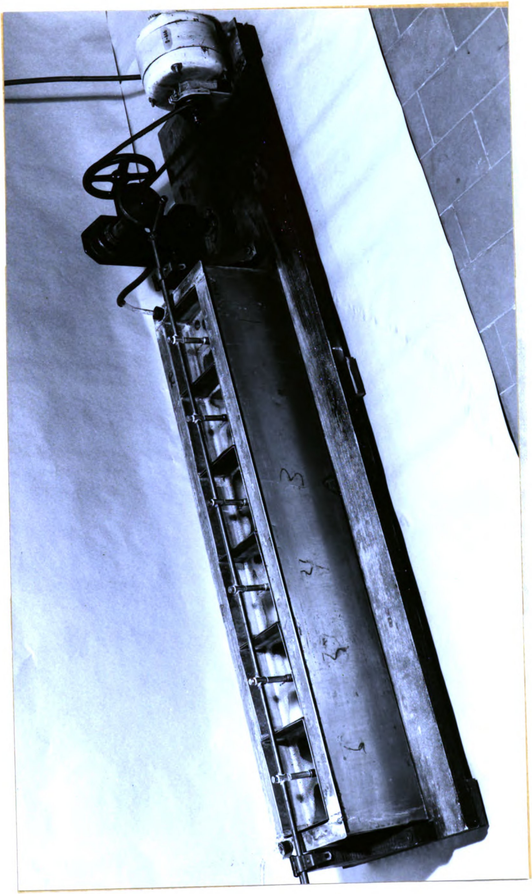

Figure 7. Mechanical washing apparatus, Jensen (1946).

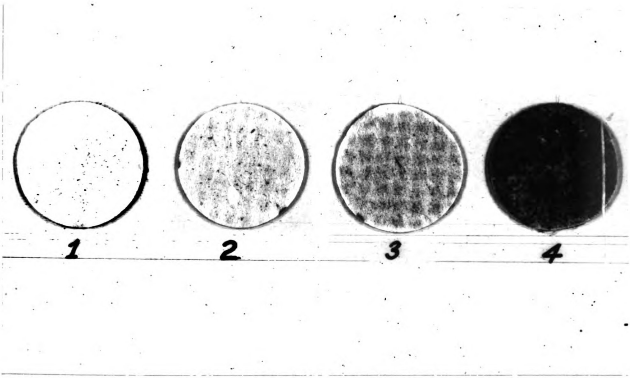


Figure 11. Sediment disc grading card, Jensen and Waterson (1950).

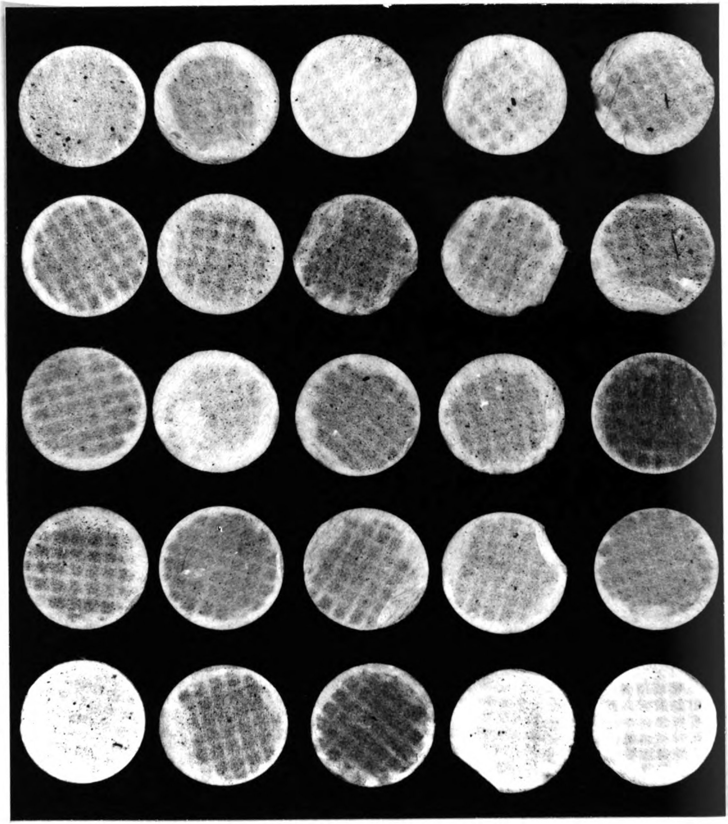

Figure 12. Sediment discs of washed milk cans, Plant A, January 4, 1950.

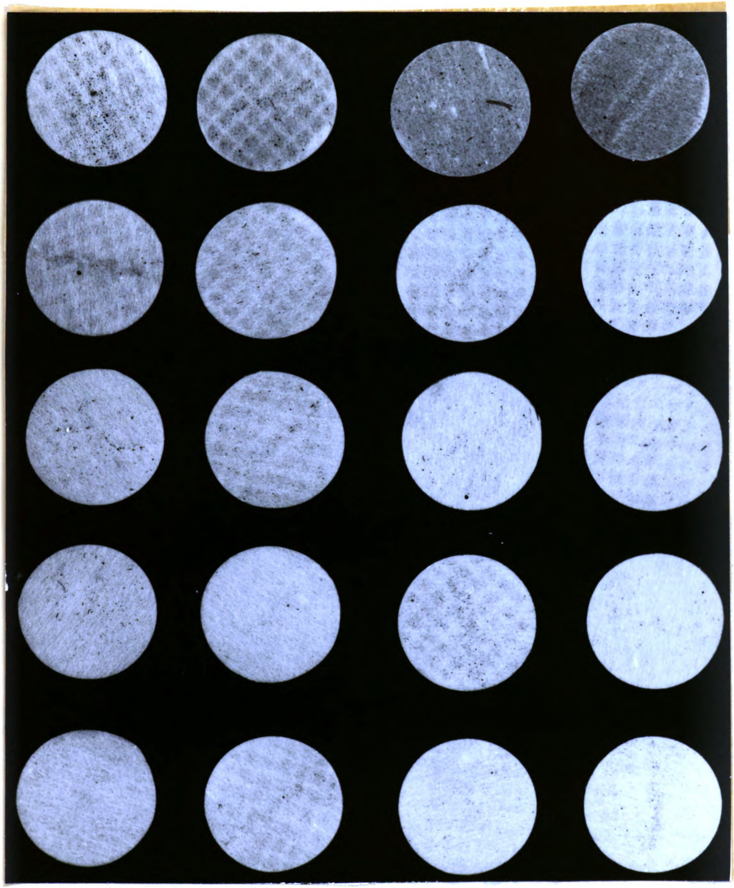

Figure 13. Sediment discs of washed milk cans, Plant A, April 1, 1950.

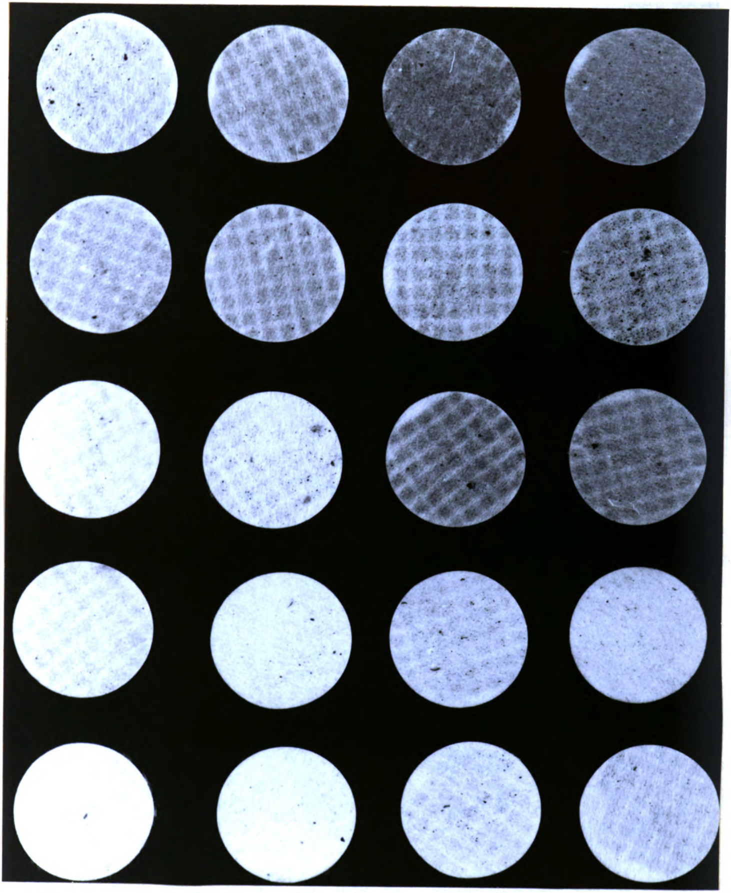

Figure 14. Sediment discs of washed milk cans, Plant A, April 29, 1950.

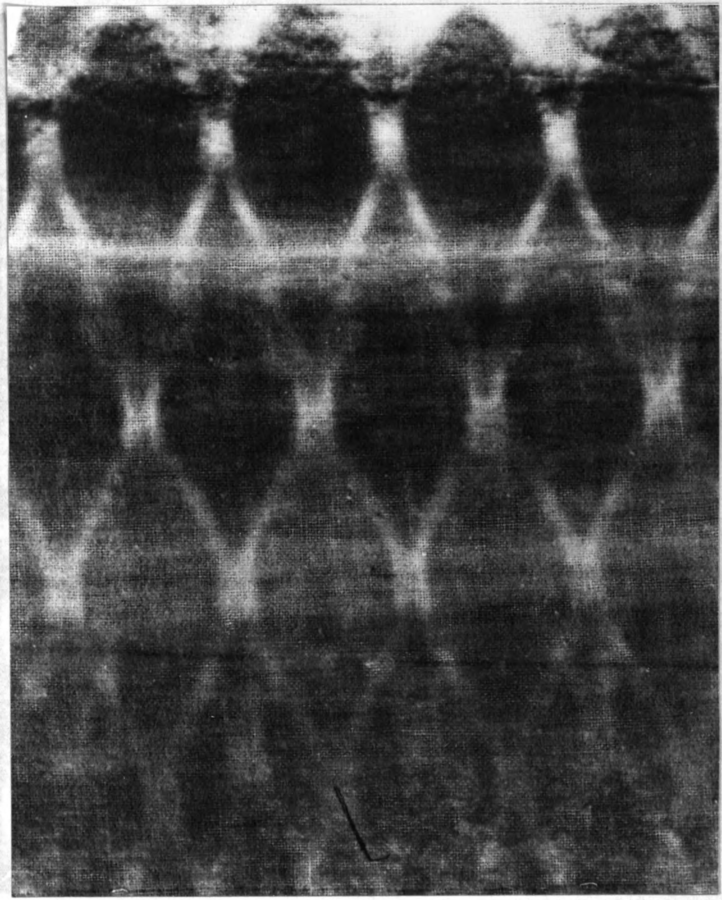

Figure 15. Filter cloth from air-intake of can washer, Plant A.

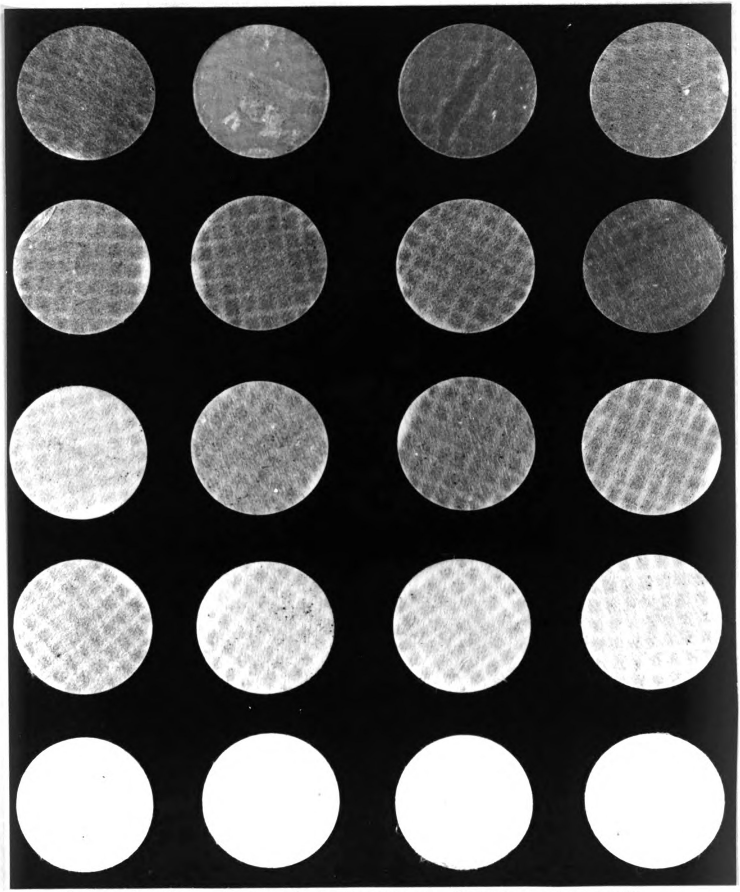

Figure 16. Sediment discs of washed milk cans, Plant D, March 16, 1950.

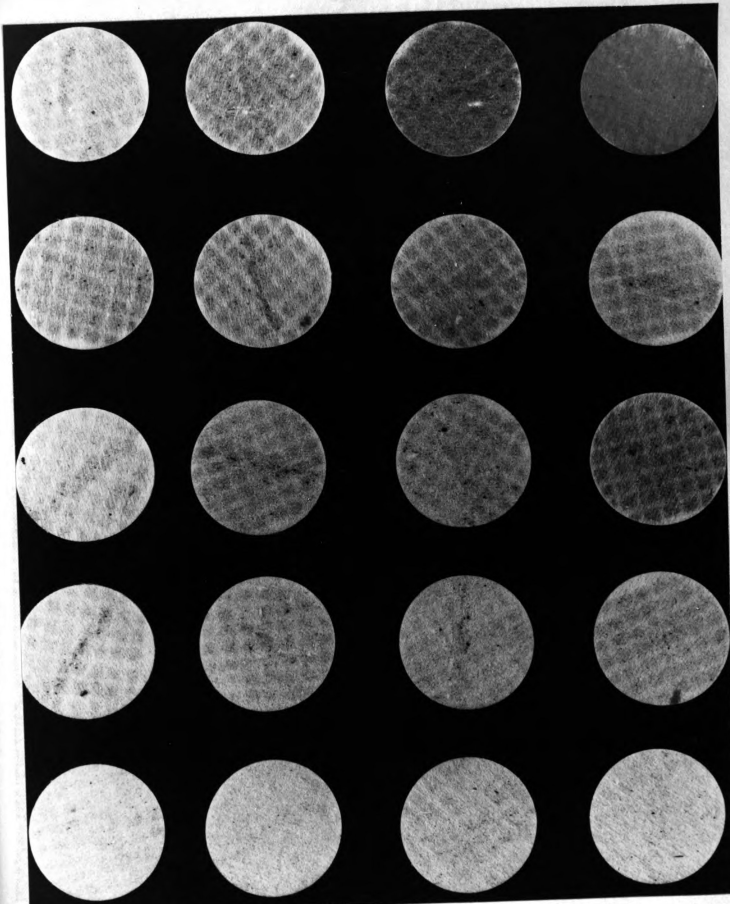

Figure 17. Sediment discs of washed milk cans, Plant D, April 22, 1950.

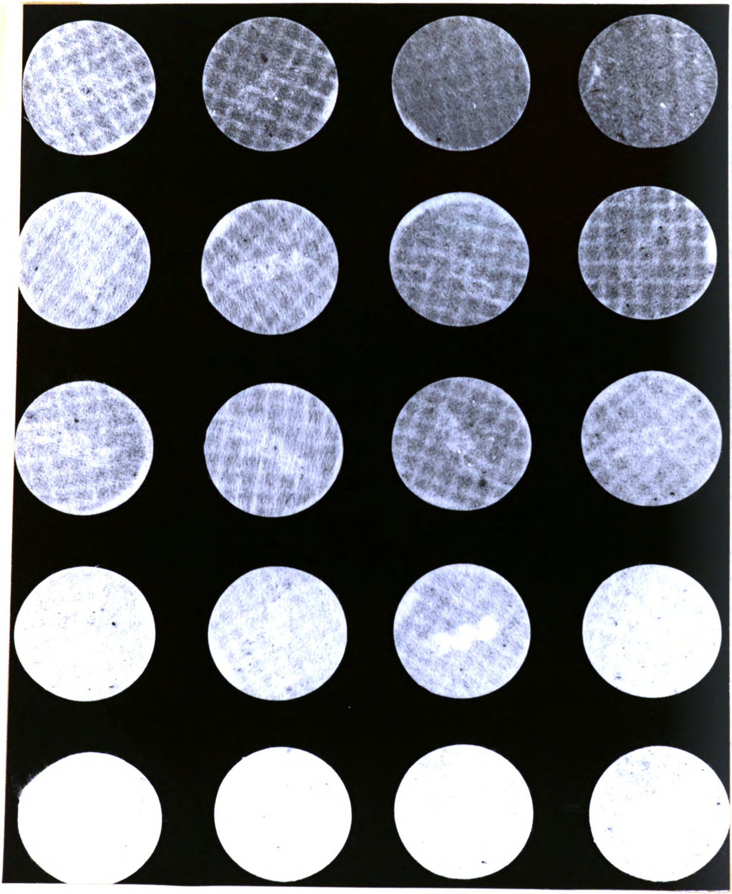

Figure 18. Sediment discs of washed milk cans, Plant D, June 27, 1950.

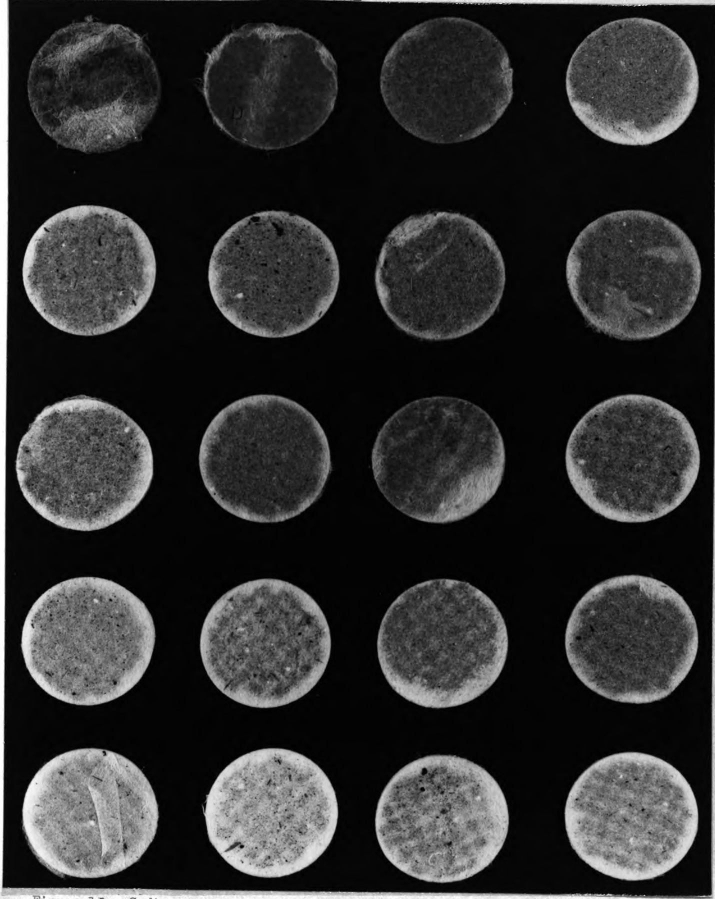

Figure 19. Sediment discs of washed milk cans, Plant F, April 24, 1950.

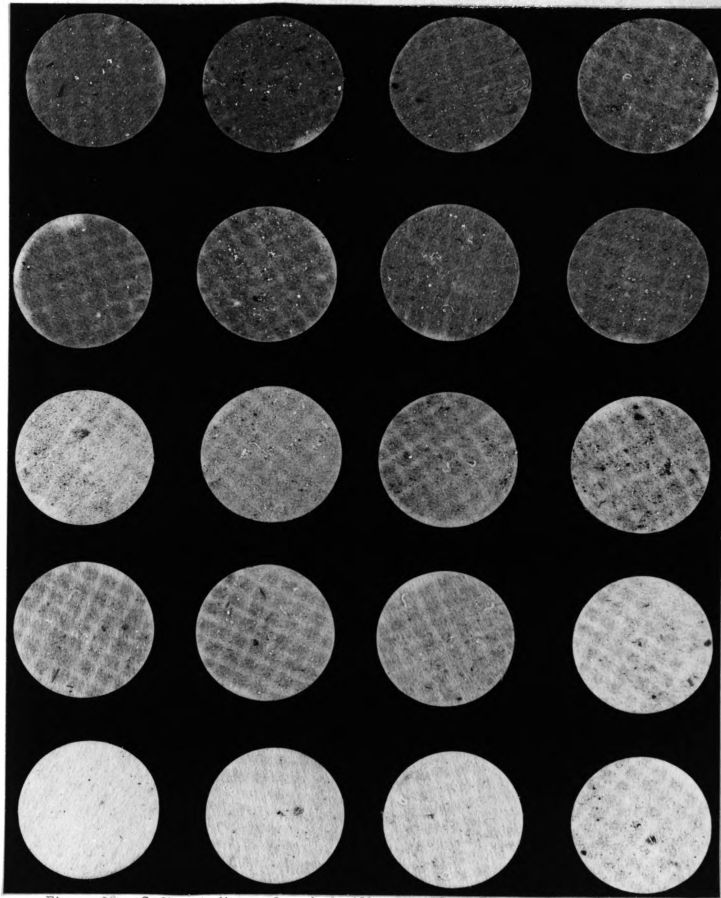

Figure 20. Sediment discs of washed milk cans, Plant F, June 13, 1950.

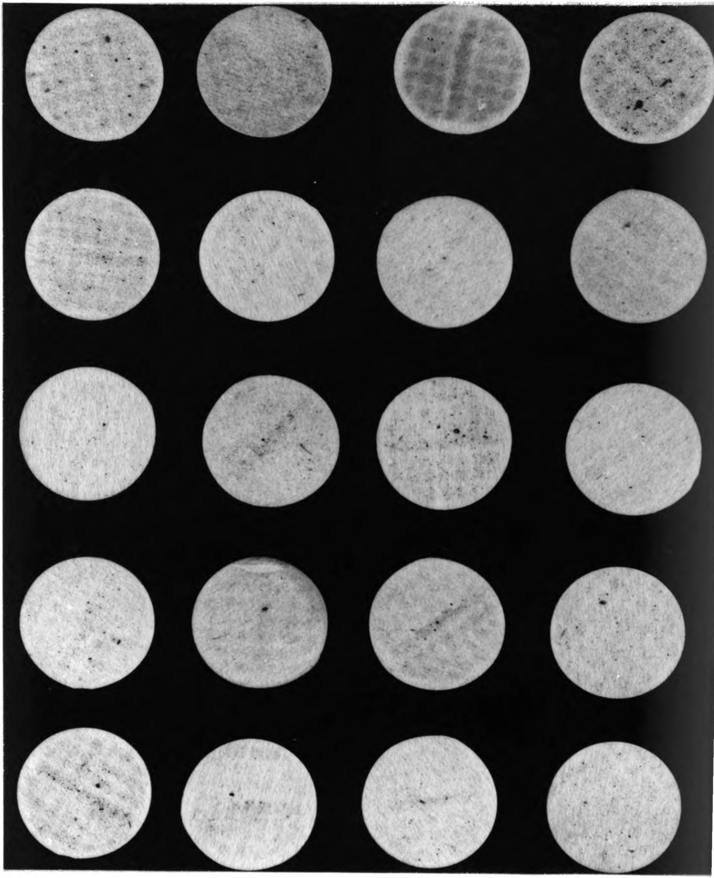

Figure 21. Sediment discs of washed milk cans, Plant E, April 13, 1950.

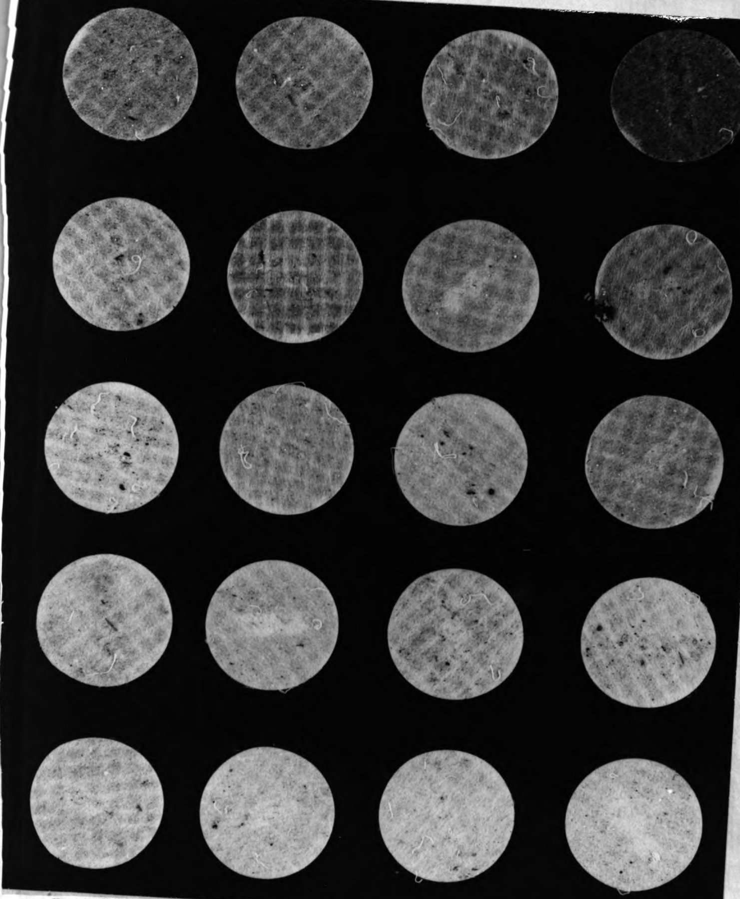

Figure 22. Sediment discs of washed milk cans, Plant G, June 13, 1950.