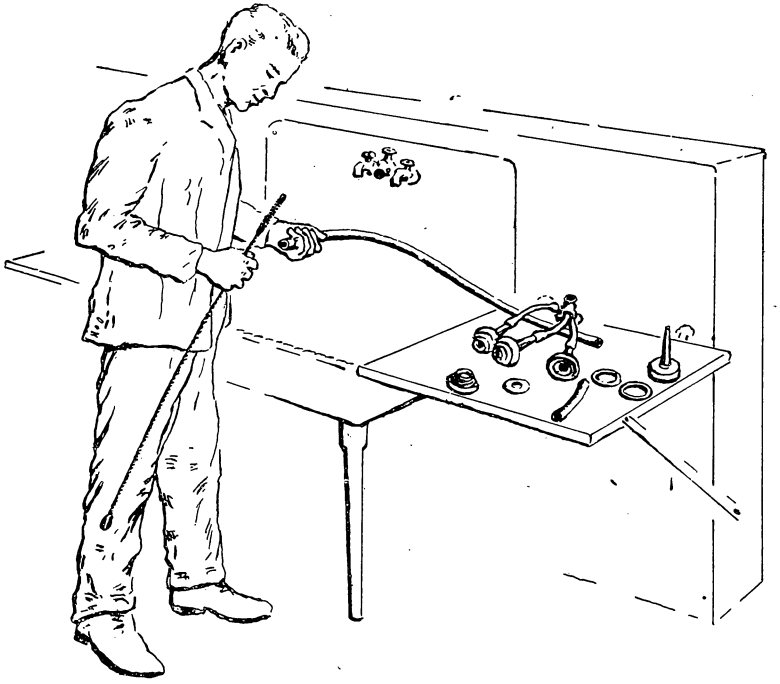
POPULAR EDITION.

BULLETIN NO. 450. JULY, 1918.

New York Agricultural Experiment Station.

GENEVA, N. Y.



CONTROL OF BACTERIA IN MILKING MACHINES

SUMMARIZED BY
F. H. HALL
FROM BULLETIN BY
G. L. A. RUEHLE
ROBERT S. BREED AND
GEORGE A. SMITH

PUBLISHED BY THE STATION.

BOARD OF CONTROL.

GOVERNOR CHARLES S. WHITMAN, Albany.
COMMISSIONER CHARLES S. WILSON, Albany.
IRVING ROUSE, Rochester.
FRANK M. BRADLEY, Barkers.
CHARLES C. SACKETT, Canandaigua.
ALFRED G. LEWIS, Geneva.
JOHN B. MULFORD, Lodi.
C. FRED. BOSHART, Lowville.
PARKER CORNING, Albany.

OFFICERS OF THE BOARD.

COMMISSIONER CHARLES S. WILSON, *President.*
WILLIAM O'HANLON, *Secretary and Treasurer.*

STATION STAFF.

WHITMAN H. JORDAN, Sc.D., LL.D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*
REGINALD C. COLLISON, M.S., *Agronomist.*
JAMES E. MENSCHING, M.S., *Associate Chemist (Agronomy).*
†WILLIAM W. BAER, B.S., *Assistant Chemist (Soils).*
JAMES D. HARLAN, B.S., *Assistant Agronomist.*
WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
ROBERT S. BREED, PH.D., *Bacteriologist.*
HAROLD J. CONN, PH.D., *Associate Bacteriologist.*
‡GODFREY L. A. RUEHLE, M.S.,
JOHN BRIGHT, M.S., *Assistant Bacteriologists.*
FRED C. STEWART, M.S., *Botanist.*
WALTER O. GLOYER, M.A., *Associate Botanist.*
MANCEL T. MUNN, M.S., *Assistant Botanist.*
LUCIUS L. VAN SLYKE, PH.D., *Chemist.*
†RUDOLPH J. ANDERSON, B.S.,
ARTHUR W. CLARK, B.S.,
JOHN C. BAKER, PH.D., *Associate Chemists.*
MORGAN P. SWEENEY, A.M.,
OTTO MCCREARY, B.S.,
RICHARD F. KEELER, A.B.,
WILLIAM F. WALSH, B.S.,
WALTER L. KULP, M.S., *Assistant Chemists.*

GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B.S., *Vice-Director; Editor and Librarian.*
PERCIVAL J. PARROTT, M.A., *Entomologist.*
HUGH GLASGOW, PH.D.,
*FRED Z. HARTZELL, M.A., (Fredonia), *Associate Entomologists.*
HAROLD E. HODGKISS, B.S.,
BENTLEY B. FULTON, M.S., *Assistant Entomologists.*
ULYSSES P. HEDRICK, Sc.D., *Horticulturist.*
ROY D. ANTHONY, M.S.A.,
*FRED E. GLADWIN, B.S., (Fredonia),
ORRIN M. TAYLOR, *Associate Horticulturists.*
†GEORGE H. HOWE, B.S.A.,
JOSEPH W. WELLINGTON, B.S.,
WILLIAM C. STONE, M.S., *Assistant Horticulturists.*
F. ATWOOD SIRRINE, M.S., (Riverhead), *Special Agent.*
JESSIE A. SPERRY, *Director's Secretary.*
FRANK E. NEWTON,
WILLARD F. PATCHIN,
LENA G. CURTIS,
MAE M. MELVIN,
MAUDE L. HOGAN,
K. LORAINE HORTON, *Clerks and Stenographers.*
ELIZABETH JONES, *Computer and Mailing Clerk.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

*Connected with Grape Culture Investigations. † On leave. ‡ Resigned July 1, 1918.

POPULAR EDITION *

OF

BULLETIN NO. 450.

CONTROL OF BACTERIA IN MILKING MACHINES.

F. H. HALL.

Machines of service in war-time dairying.

Previous to the war, the scarcity of labor turned the attention of dairymen toward the milking machine as an aid in economical production. Under the present intensified demand for labor and its high cost, the demand for machines would be still greater could herd owners feel that they can lessen labor charges by using milking machines and readily produce milk of satisfactory bacterial quality with them. So far as mere drawing of milk is concerned, in herds of considerable size and in careful hands, there is no question that cows may be more economically milked by machine than by hand; but when to this cost it may be necessary to add more labor expense to keep the machines in satisfactory bacterial condition and there is a common doubt whether machines under ordinary conditions can be made to furnish milk with as few germs as that drawn by hand, the problem becomes more complex. The use of machines is increasing gradually in the State since a recent agricultural census reported more than 4600 of them on the farms; but too often the report is heard that owners abandon the use of the machines after trial for two or three years. Part of these unsuccessful attempts are doubtless due to defects in the machines, as yet not wholly corrected; but probably more abandonments result from finding that the machines are difficult to keep clean by ordinary methods.

Early Station studies.

The Station has been continuously studying some phase of the milking machine problem since 1906, when a Globe machine was used for a short time, to be discarded for very evident defects. This was succeeded in our stables by the Burrell-Lawrence-Kennedy milker; and with this machine in its modified and improved forms as developed during the ten years, all subsequent experiments at the Station have been made.

---

* This is a brief review of Bulletin No 450 of this Station on Milking Machines: III. As a Source of Bacteria in Milk; IV. Methods of Maintaining in a Bacteria-Free Condition, by G. L. A. Ruehle, Robert S. Breed, and George A. Smith. Anyone especially interested in the detailed account of the investigations will be furnished, on request, with a copy of the complete bulletin. Names of those who so request will be placed on the Station mailing list to receive future bulletins as issued, either popular or complete edition as desired.

In our first milking machine bulletin issued (No. 317), tests of a 10 per ct. brine solution as an antiseptic for the rubber parts showed good results; and with certain modifications of the air filters on the machines and careful handling of the apparatus, the bacteria in the milk were almost always kept down to 10,000 or less per cubic centimeter. This bulletin emphasized the necessity of avoiding carelessness in handling, but held that " when machines of the better type are run properly they will deliver milk of low germ content." In a later bulletin (No. 353), it was stated that " the milking machine is of interest mainly because of the labor problem. Using two machines one man can milk fifty cows." The influence of the machine method of milking upon the flow of milk was too small to be detected in a series of tests lasting over four year and including 71 lactation periods; all of the cows milked well with the machine when provided with properly fitting teat-cups, and two cows that were failures with hand milking were milked successfully by the machine. " Machine milking has proved practicable. The problem now is to develop the machines along helpful lines and to learn how to handle them most efficiently." This was the final conclusion relative to Station experience with the machines up to 1912. The present bulletin discusses a great amount of work done since that time in the effort to learn how to so handle them as to simply and easily produce milk containing few bacteria.

These studies necessary.

That such added studies were necessary is plainly shown by the great difference in results secured at the Station during the past ten years, and the results observed by our bacteriologists on dairy farms near the Station, or reported by other investigators in securing milk of low germ content. Under our Station conditions, with machines thoroly cleansed, with the metal parts scalded or steamed, and with the rubber parts well rinsed after each milking, vigorously cleansed once per week and kept in carefully prepared antiseptic solutions between milkings, practically all of the examinations of the milk have given low germ counts, usually as good as or better than required for certified milk. About two dozen reports of experiment stations or other investigators were found dealing with the bacterial quality of milk in machine tests. In many cases the comparisons were between hand-drawn and machine-drawn samples, in others between milk drawn with and without special precautions to secure good conditions of the machines and tubes, and in others to show the effect of different antiseptic solutions in which the teat-cups and tubes were kept between milkings.

In the reported tests, whether made at experiment stations or similar research institutions, or on ordinary or commercial dairy farms, there is practically unanimous agreement that the suction type of milking machines must be cared for by special methods of cleaning if they are to be maintained in a sufficiently germ-free

condition to yield milk with as few germs as that obtained by careful hand milking. Under practical conditions where dairymen use no machines, only methods similar to those they would employ in cleaning simple metal utensils, such as pails, strainers and the like, the investigators have frequently drawn milk from the machines with millions of germs per cubic centimeter; and where steam was available for sterilizing the pails and metal parts of the machines, the counts, tho lower, have not been satisfactory; and even at high grade farms, as at colleges and stations, the counts from machine-drawn milk have usually been higher than from hand-drawn milk from the same stables. But where bacteriological tests have been made and special methods of caring for the machines developed, several investigators have found, as at this Station, that as good or better results can be secured than by hand milking. In three such cases,— at the Wisconsin and Kentucky Stations, and in the certified milk supply of Brooklyn,— where the tests have been extensive, the machine-drawn milk has been found very satisfactory in germ content.

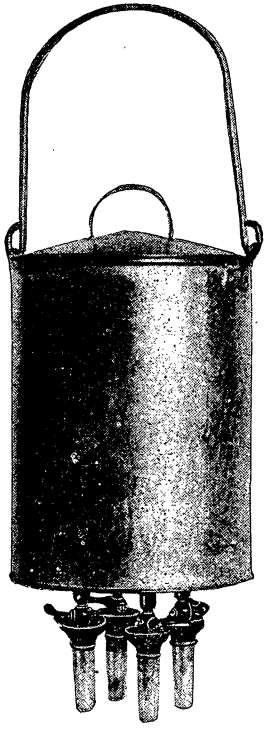
In these studies different factors have been considered important in controlling the bacteria counts of machine-drawn milk: Most investigators have given first place to the difficulty of keeping the rubber tubes and teat-cups free from germs between milkings and have called attention to various antiseptic materials or antiseptic measures for aiding this purpose; stable air has been considered a most important source of germs, and its entrance into the pail when the vacuum relief valve was opened at the end of milking, the cause of high germ counts which were favorably modified by various types of filters; the continuous entrance of air during milking in machines of the B-L-K type has also been mentioned as a factor; other students have held that condensation water from the metal suction pipes is a more important source of bacteria than the air, and that the filters have been more important as moisture retainers than as removers of bacteria from the air; still other investigators call attention to the vacuum-cleaner effect of the teat-cups when dropped during the operation of the machines and think such accidents the cause of many high counts; it is believed by some, also, that the bacteria may be drawn by the suction from the outer surfaces of the udder or washed by the milk from the outer surfaces of the teats.

Because of the somewhat contradictory ideas held in regard to the sources of the bacteria, and the need for exact knowledge before remedial measures could be successfully applied, the first step taken in the present studies was to make an intensive and detailed study of the B-L-K machines in use at the Station. In these the contamination from the udder or teats has been eliminated by the method of "milking," but the other points mentioned above have been considered, with special reference to the effect each may have upon the germ content of the milk, and with careful study of the means by

which the entrance of bacteria into the milk from any of these sources may be prevented or greatly reduced.

Methods of study.

In earlier Station studies, as in those of most other workers along these lines, counts of the bacteria were made from the milk as drawn from the cow; but this involves danger of many variable factors. The milk from the udder contains bacteria, in some cows normally many, in others few, but in both cases liable to change in numbers from day to day; and germs from the surface of the teats and udder might also be drawn into the machine in varying numbers.



ARTIFICIAL UDDER USED IN EXPERIMENTAL WORK.

Accordingly for the cow, there was substituted an artificial udder (see figure) consisting of a covered metal can with four faucets projecting from the bottom on which the teat-cups could be slipped. As this apparatus could be readily sterilized and sterile water placed in and "milked" from it, the danger of accidental contamination was greatly reduced; and the bacteria found in the water thus "milked" could well be ascribed to the whole milking machine or to the parts thru which it was drawn. Five liters (about five quarts) of sterile water were used for each milking which took from three to four minutes, and the bacteria counted in cubic centimeter samples which were treated by standard bacteriological methods of taking, plating, incubating and counting.

Under supervision of the Dairy Expert, the care of the machines at the barn and their cleansing at the dairy room have been, from almost the first, in charge of the regular dairy attendants, the two men principally responsible remaining unchanged during the entire time.

The routine of cleaning has been as follows: Immediately after each milking a large pailful of clean cold water was drawn into each machine thru the teat-cups, followed by a pailful of hot soda water and a final pailful of clean hot water. After the evening milking the pails of the machines were emptied, rinsed with cold water and left until morning; but after each morning milking the pails and heads of the machines were sent to the dairy where they were more thoroly washed and all metal parts but the pulsator piston steamed for a few minutes in a steam chest. The covers were then placed on the

pails and the machines stood in the dairy room until the evening milking. During the earlier experimental work the teat-cups were kept in a brine solution, but during the later work other antiseptic solutions were also tried. On Tuesday of each week these teat-cups and tubes were sent to the dairy and scrubbed with spiral brushes and warm soda solution and again returned to the antiseptic solution.

" Milking " tests at Station.

The first series of tests using the artificial udder was to ascertain the efficacy of the treatment outlined above on the germ content of the machines. Twenty-two tests were made in March, May and June, 1916, ten of them with four successive " milkings " of sterile water thru a machine, ten others with two " milkings," and two with but a single milking. The results proved that the machines were well freed of germs by the washings, steamings and use of antiseptic solutions (a solution of chloride of lime in water having been used in this case). The germ counts rose as high as 10,000 at only two tests and averaged from about 1400 to a little over 2000.

In a later series, still without change in the method of cleaning the machines and with chloride of lime as an antiseptic, an attempt was made to find what part or parts of the apparatus were the source of the germs. By introducing a sampling device between the teat-cup tubes and the head of the machine, and another just below the head of the machine, separate portions of the water were taken at these points as well as from the body of the pail. These tests were made in mid-summer, and gave somewhat larger counts than the first series, averaging from 2800 to more than 8000 for the entire machine. The tests made to discover the source of the germs were somewhat disappointing as they gave irregular results, some of which may have been due to faulty sampling of the water as it passed thru the tubes. The indications were, however, that more than one part of the machine harbored germs, tho never in large numbers since the final counts, while higher than before, were still low.

Subsequently, an attempt was made to secure complete sterilization of one of the machines, the Assistant Bacteriologist himself cleaning and handling the parts, separating the rubber tubes and metal parts completely and sterilizing the rubber in a very strong chloride of lime solution, while the metal parts were steamed, all except the pail being held under 15 pounds steam pressure for fifteen minutes. In many milkings made with such carefully handled machines, the germ content of the water in the " udder " and that taken from the machine differed but slightly, both being practically sterile, a result which showed that all of the sources of bacteria had been found and placed under control.

Condensation water from vacuum pipes.

Certain investigators have found that the condensation water returning from the pipes when the vacuum was relieved in the pail at the end of milking brought with it many germs. So the manufacturers of the B-L-K machines have in later models substituted for the cotton filter on the head of the pails a suction trap which retains this water. The Station machines in use were fitted with this trap; but because some germ counts were obtained which were difficult to explain, many tests were made to determine its thoroness of operation. Very severe tests failed to show that even a trace of moisture from the pipes passed back thru the trap into the machine. That it served a very useful purpose was proved by substituting an older head with the cotton filter, " milking " sterile water thru the machines and measuring the effect on the water in the pail, all other known sources of bacteria being placed under control. By using a glass jar in place of the ordinary machine pail, it could be plainly seen that several teaspoonsful of condensation water might be sucked thru the cotton when the vacuum was relieved; and the counts showed that this water was full of bacteria and increased the number in the samples taken from the water in the glass jar some hundred or even thousand fold over those found when the vacuum was broken thru the teat-cups, thus avoiding the " sucking back " effect.

Dust in stable air.

It having been claimed by several previous investigators that many germs entered with the air during and at the close of milking, and cotton filters having been recommended for use at the points where the air enters, tests were made to determine the number of germs thus entering. At the same time, the efficiency of the cotton filters was tested. By attaching a device for filtering the air at the two openings where air enters the B-L-K machines, all of the germs in the air were retained on fine sand. This sand was then examined by the usual methods of analysis and the number of organisms in the air computed. Altogether 54 tests were made. In this way it was determined that between 10 and 9800 germs were drawn in with the five liters of sterile water from the air which entered at the teat-cup connector during artificial milking; while between 6100 and 157,000 germs were drawn in from the dustier air near the cows during actual milking.

Opening the vacuum relief valve on the head of the machine to relieve the vacuum at the end of milking was found to draw between 20 and 1750 germs into the pail after artificial milking, or between 40 and 11,400 after actual milking, 24 trials being made in the former and 33 in the latter case. While these numbers appear to be significant in size, yet when they are transformed to the basis of a cubic centimeter of milk, the standard unit of measurement, it is found that these numbers are relatively insignificant. Under the

worst conditions noted, the air contributed less than 37 germs per cubic centimeter, while the average numbers added from the air was less than ten per c.c.

As several investigators have placed much emphasis upon the use of cotton filters to prevent the entrance of germs from the air, 14 tests were made under artificial and nine under actual milking conditions to determine the efficiency of cotton filters used in the teat-cup connectors. Fourteen tests were also made of the efficiency of the filters used in the vacuum relief valves on the head of the pails. All of these indicated that the cotton removed a little dust and about two-thirds of the germs. Since, however, as already explained, the total number of germs from the air is so small as to be scarcely detectable when mingled with the much larger numbers of germs in the milk from other sources, the use of these filters is a relatively unimportant matter.

Dropping teat-cups during milking. Several investigators have attributed unexpected increases in the germ content of machine-drawn milk coincident with accidental dropping of the teat-cups to the floor, to the bacteria drawn in with dirt under such circumstances. So far as known, however, no previous tests have been made to determine the relative importance of this source of bacteria. In making the tests, the machines were completely sterilized by the methods previously shown to be efficient and five liters of sterile water drawn into them as before. As a check upon the efficiency of the sterilization, the first milking in each series of four milkings was performed as usual; but during the second milking the teat-cups were held for 30 seconds vertically over and lightly touching the bedding. Without cleaning the teat-cups unless this was made necessary by the dirt clogging them, a third milking was carried out, followed by a fourth in which the teat-cups were again dropped to the floor and allowed to lie on their sides for 15 seconds.

The results showed that the machines were practically sterile when the experiments were started, and that the bacteria sucked in with the dirt were numerous enough to cause counts between 60 and 24,400 per cubic centimeter. However, only four of the 15 counts exceeded 10,000 and none reached the size previously thought to be obtainable from this source. The largest of the counts were secured under very bad and dirty conditions, as is shown by the fact that in two cases where the dirt was filtered out of the water and dried it was found to weigh .014 and .026 grams per liter.

Conclusions. Excluding consideration of the teat-cups and rubber tubes for the moment, these experiments show that the comparatively small number of germs derived in the water drawn into the Station machines came from several places; and that the relative importance of each as

a source of germs varied with the conditions present. Under the conditions of the earlier Station studies reported in Bulletin No. 317, where machines were used in which there was a large cotton filter placed at the junction between the connecting hose and the head of the machine, it is probable that at times quite large numbers of germs entered the pails with the condensation water at the close of milking. Since the use of an efficient trap on the later models has brought the matter of contamination from this source under control, it is probable that the condensation water was the source of the high numbers occasionally obtained in the earlier work when there was no observed occasion for them.

" Milking " tests at dairy farms.

While the experiments thus far discussed were in progress with the Station machines, observations were also being made upon milking machines of the B-L-K, Hinman and Empire types in use on 10 dairy farms in the neighborhood of the Station. While it was not possible to make these tests under perfectly controlled conditions, analyses were made by our bacteriologists which showed the amount of contamination which milk would receive if drawn with these machines, cleaned and cared for, as they were, by practical dairymen. In making these tests sterile water and the other necessary supplies were prepared in the Station laboratory and taken to the farm where the tests were to be made. After the machines were prepared by the dairyman in the regular way for the afternoon milking, one or two successive " milkings " were performed in which five liters of water were drawn from the artificial udder. In the case of the B-L-K and Hinman machines, samples were taken not only from the pail at the close of milking but also of the water as it entered the pail, the analytical results showing whether the principal contamination came from the teat-cups and head or whether it came from the pail. The antiseptic solution in use on these farms was found to be either chloride of lime alone, or in combination with brine.

The germ content of the water in the pails after being drawn thru the machines was found to be highly variable. In 13 instances the counts were less than 10,000 and compared well with those obtained at the Station. In 16 cases, however, the counts were in excess of this number tho still less than 1,000,000, while in 8 cases the counts exceeded 1,000,000, reaching a maximum of 59,300,000 in one instance. The most significant thing, however, was that in each instance where samples were taken before the water entered the pail, it was found to have practically the same germ content as it had after it reached the pail, showing that the majority of the bacteria were added to the water in its passage thru the teat-cups and head of the machines. Good and bad results were obtained with all three types of machines, indicating that it was the care given the machines rather than the construction of the machines

which was at fault. Samples taken of the antiseptic solutions showed that the strength of the available chlorine in many of the solutions was much too low to be effective, tho relatively high counts were obtained in some instances where brine and chloride were both in use and the solution was apparently in good condition. In all cases where the excessively high counts were obtained, an examination of the separate parts of the teat-cups and tubes showed that these were not kept in as cleanly condition as were the same parts at the Station.

Hand-drawn vs. machine-drawn milk.

In connection with our work upon the milk supply of the City of Geneva, reported in a preliminary way in Bulletin No. 443, the use of machines on the dairy farms producing milk for the City was found to exert a generally unfavorable influence upon the germ content of the milk. Still more extended data of the same sort is presented in the present bulletin. It was found that in one list of 44 dairymen none of the six men supplying machine-drawn milk was in the first third of the list. An examination of 3013 cans of milk from these six dairymen showed them to have approximately the same germ content as 3051 cans of milk from the nine poorest dairymen sending hand-drawn milk. On six farms where direct comparisons were possible, only two dairymen produced milk of as low germ content during the period when the machines were in use as when the milk was hand-drawn; while the introduction of machine milking did not improve the germ content of the milk in any case. However, in a second list of 36 dairymen, one of the users of a machine, who stood near the head of the list when he practised hand milking, maintained an equally high rank after he began using a machine. On the farms where the results were the poorest, the herds were large and the milking was done by hired labor of an indifferent character.

Antiseptic solutions.

Our bacteriologists, as well as other investigators, having found that the rubber teat-cups and tubes completely overshadow all other possible sources of bacteria, have made extended tests to determine which of several suggested antiseptic solutions are satisfactory for use on these rubber parts. The antiseptic solutions or antiseptic procedures which have been tested are (1) brine, (2) solutions of chloride of lime, (3) a combination of brine and chloride of lime, (4) lime water, (5) cold running water, and (6) a proprietary germicide sold under the trade name of "montanin." Each of these has been used for weeks, or more commonly months, in our dairy, and the efficiency of each as a means of keeping the tubes free from germs has been tested by "milking" tests carried out as previously described. All sources of germs

other than the stable air and the teat-cups and tubes were controlled by the measures previously tested and found effective. Contamination from the air was reduced to a negligible minimum by doing the work under practically dust free conditions.

Brine. Brine solutions varying in strength from 10 to 13 per ct. were in use from 1910 to 1916 and nearly 500 analyses were made of this solution in order to determine the amount and kind of bacteria present under the varying conditions. These showed that the brine was not free from bacteria, and that at times very large numbers were present. The kinds of bacteria present, however, were those adapted to life in salt brines; and failed to grow, or grew poorly, under conditions favorable to ordinary bacteria. This fact explains why it is that in spite of the fact that the tubes contain bacteria in appreciable numbers, strong brines are useful as a means of keeping the rubber tubes in fit condition for use when milk of low germ content is to be produced. Even tho brine bacteria get into the milk they have no effect on it and soon die.

Chloride of lime. In using chloride of lime (bleaching powder) solutions our bacteriologists found that they could completely sterilize the teat-cups and tubes provided these were completely separated into their component parts, thoroly cleansed and then placed in a strong solution of the antiseptic solution. This procedure is not practicable, however, even on certified farms nor is it necessary in order to secure excellent results. In a nine months test extending from December, 1916, to August, 1917, the machines were washed and cared for by the ordinary dairy attendants using the methods of cleaning the machines previously described, and keeping the teat-cups and tubes in a solution of chloride of lime between milkings. This solution was kept in a 25 gallon crock, and was prepared by adding a pint of a stock solution of chloride of lime to the jar full of water twice per week. The stock solution was kept in a smaller glass jar, and was prepared by adding the contents of one 12-ounce can of commercial chloride of lime to one gallon of water. After stirring thoroly, the white precipitate was allowed to settle, leaving a clear, greenish colored liquid. Only this liquid was added to the larger jar, tho no harm would have resulted if the white powder in the bottom of the jar had been used as well.

The results of 66 "milkings" of sterile water made before June 1, thru tubes kept in this solution, showed excellent results, only one of the germ counts exceeding 100 and that one being only 157. As soon as the warm weather started, however, the counts increased until out of the 36 trials made, 29 gave counts in excess of 1000 and 17 exceeded 10,000, the highest being 180,000. Supplementary tests were made to determine the cause of this increase and it was

found that the chloride of lime lost its strength so rapidly in the warm solutions that the interiors of the rubber tubes were not sterilized. This explained also why many of the highly advertised germicidal solutions advocated for use on teat-cups and tubes have failed to give satisfaction under practical conditions. The majority of these are either ordinary chloride of lime (calcium hypochlorite) in solution, or are the closely related but more expensive sodium hypochlorite.

Brine and chloride of lime. Other investigators have previously suggested that the good qualities of both brine and chloride of lime could be retained in a mixed solution and that their weaknesses offset each other. Consequently during six months, extending from August, 1917, to January, 1918, an antiseptic solution was used in the crock consisting of a saturated brine to which a quart of the stock solution of chloride of lime was added twice per week as before. In order to make the test severe, summer conditions were maintained by keeping the crock in a warm place. Analyses made under these circumstances showed that the brine was completely sterilized by the chloride of lime, and that while the chloride of lime lost its strength rapidly in the warm solutions, the presence of the sterile brine prevented the development of bacteria in the tubes.

During the six months, 76 trials were made in which sterile water was "milked" thru the tubes into the machines. The greatest increase in germ count noted was only 1920, this being the only count in excess of 1000. In the majority of instances the bacterial counts were so small that the increases found could not have been detected with any certainty if the analyses had been made from milk drawn in actual milking.

These results show the combined solution to be more effective in its action than is either solution used separately; and the results secured where the cleanliness of the tubes is maintained, are as perfect as can be desired.

Lime water. Other experiment stations and many practical dairymen have reported good results from using lime water prepared by slaking fresh lime. Accordingly tubes were kept in a saturated lime water solution from August to December, 1917. Summer conditions were maintained as before by keeping the crock in a warm place. Sixty-three trials were made where sterile water was "milked" thru the tubes. The number of bacteria found in the water was low in every case, tho slightly larger counts were secured than in the previous series of tests. In seven instances only was the count in excess of 1000, the largest being 2270. These results confirm the findings of others and show that lime water may be successfully used to keep the tubes in a satisfactory condition.

Other solutions tested.

It having been reported that dairymen were getting good results by immersing their teat-cups and tubes in cold running water, and that the practice was being introduced into New York State, our bacteriologists made a test of this method also. The crock was placed where running water from the city water supply could pass thru it at a rate of about 12 gallons per hour. At the time the experiment was started in April, 1917, the temperature of this water was 43° F., but it gradually became warmer as the summer approached until it was 68° F. in August. Seventy-nine "milking" trials were made during this time and it was found that excellent results were secured so long as the temperature of the water was less than 62° F. In no case was the count in excess of 400. But as soon as the water became warmer than 62° F. all counts were large, varying between 8000 and 53,000. The results indicate that the cold temperature was the essential factor for success and suggest that refrigeration of the tubes might accomplish the same purpose. The tubes and jar presented a more cleanly appearance than where antiseptic solutions were used and the whole procedure was so simple that the dairy attendants were much disappointed when the practice was discontinued.

Because of its use on some of the certified dairies of the State, and because of its entirely different chemical nature from the other solutions tested, montanin, a proprietary germicide, was included in the series of tests made by our bacteriologists. Since, however, it was found to be unsatisfactory when carelessly used, and since many dairymen are known to be careless in rinsing their machines, this solution is not recommended for general use.

Recommended antiseptic solutions.

The results of this work have shown that there are several entirely satisfactory solutions which can be used to keep the teat-cups and tubes free from germs, *provided they are properly and intelligently used.* Some of these are cheaper than others, are more convenient to use, or are more desirable for other reasons. The solution which we now use and which we recommend for general use is a saturated brine to which is added chloride of lime at least once a week and preferably twice per week. The chloride of lime keeps the brine sterile and aids the brine in keeping the tubes free from bacteria. The observations made by our bacteriologists on neighboring dairy farms show, however, that good results will not be secured with this solution unless the teat-cups and tubes are kept thoroly clean at all times.

Cleaning of teat-cups and tubes.

As has been stated, it is our custom not only to copiously rinse the machines successively with cold water, with hot soda water, and clean hot water after each milking, but to steam the metal parts daily and once a week to take the teat-cups

and tubes completely apart and give each part a thoro cleansing. In order to determine whether this weekly cleansing was sufficient to maintain the tubes in a germ-free condition, 29 comparisons were made between the condition of the machines on the day before (Monday) and the day on which (Tuesday) the machines were cleaned. The net result of these tests was to show that our machines were as free from bacteria on Mondays as on Tuesdays. It is necessary, however, to practise this weekly cleaning if the tubes are to be kept clean and bright, as there is a small accumulation of sterile dirt in them each week which may in time be sufficient to afford protection to the bacteria.

Where the teat-cups and tubes are coated with germs when first used, it is to be expected that these will be gradually dislodged as milking progresses. The results of 81 series of milkings, where the water drawn thru the tubes was sampled after each of four successive milkings, showed that while there was a slight diminution in numbers as milking proceeded, yet this was not large if the original number of germs present was small. However, in 16 series of milkings in which the original counts were in excess of 1000, there was a constant tho not rapid diminution in numbers during the successive milkings, the counts from the fourth milking averaging 9000 as contrasted with an average of 27,000 for the first milking.

Conclusions. These findings corroborate the general impression that milking machines very readily become so seeded with bacteria that all of the milk drawn thru them contains large numbers of bacteria. Under bad conditions machines may become one of the most prolific sources of bacteria with which fresh milk ordinarily comes in contact. On the other hand these analyses show without any possibility of doubt that milking machines may be so cared for as to make them practically free from bacteria of all kinds, making it possible to draw milk by machine which contains no bacteria other than those originally present in the udder or on the teats of the cow. While extreme precautions are necessary in order to accomplish a result as perfect as this, it is possible for any dairyman by the intelligent use of simple and practicable means of cleaning and caring for the machines to secure results as satisfactory as are those obtained where cleanly hand milking is practised. The care of the machines should include washing, scalding and thoro drying of the metal pails and heads of the machines, the immersion of the teat-cups and tubes in a mixture of brine and chloride of lime between milkings, combined with methods of cleansing the tubes which maintain them in a sufficiently clean condition to allow the antiseptic solutions to come into intimate contact with the bacteria.