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Preliminary Report on the Milking Machine

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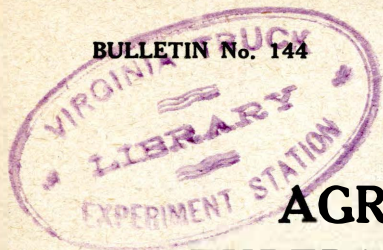
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AGRICULTURAL EXPERIMENT STATION

SOUTH DAKOTA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

DAIRY HUSBANDRY DEPARTMENT

Preliminary Report on the MILKING MACHINE

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Preliminary Report On Milking Machines.

C. Larsen, Wm. White and J. W. Fuller.

INTRODUCTION.

With a view of testing the practicability of the milking machine, the South Dakota experiment station, two years ago last February, installed the Hazelwood milking machines in the college dairy barn. These machines, with the exception of one day out of each month when the machine-milked cows were milked by hand, and also in a few instances when the gasoline engine used for power underwent repairs, have been in continuous operation since that time, or for nearly two and one-half years. The cows were milked by hand one day of each month to ascertain the approximate production of individual cows. The Hazelwood machine milks two cows at a time, and has no partition in the pail. Two machines were installed, as one man can attend to two as well as to one.

The data on hand at the present time are not complete, but on account of the demand for information regarding milking machines, this preliminary report giving the results to date with this particular make of milking machine is issued.

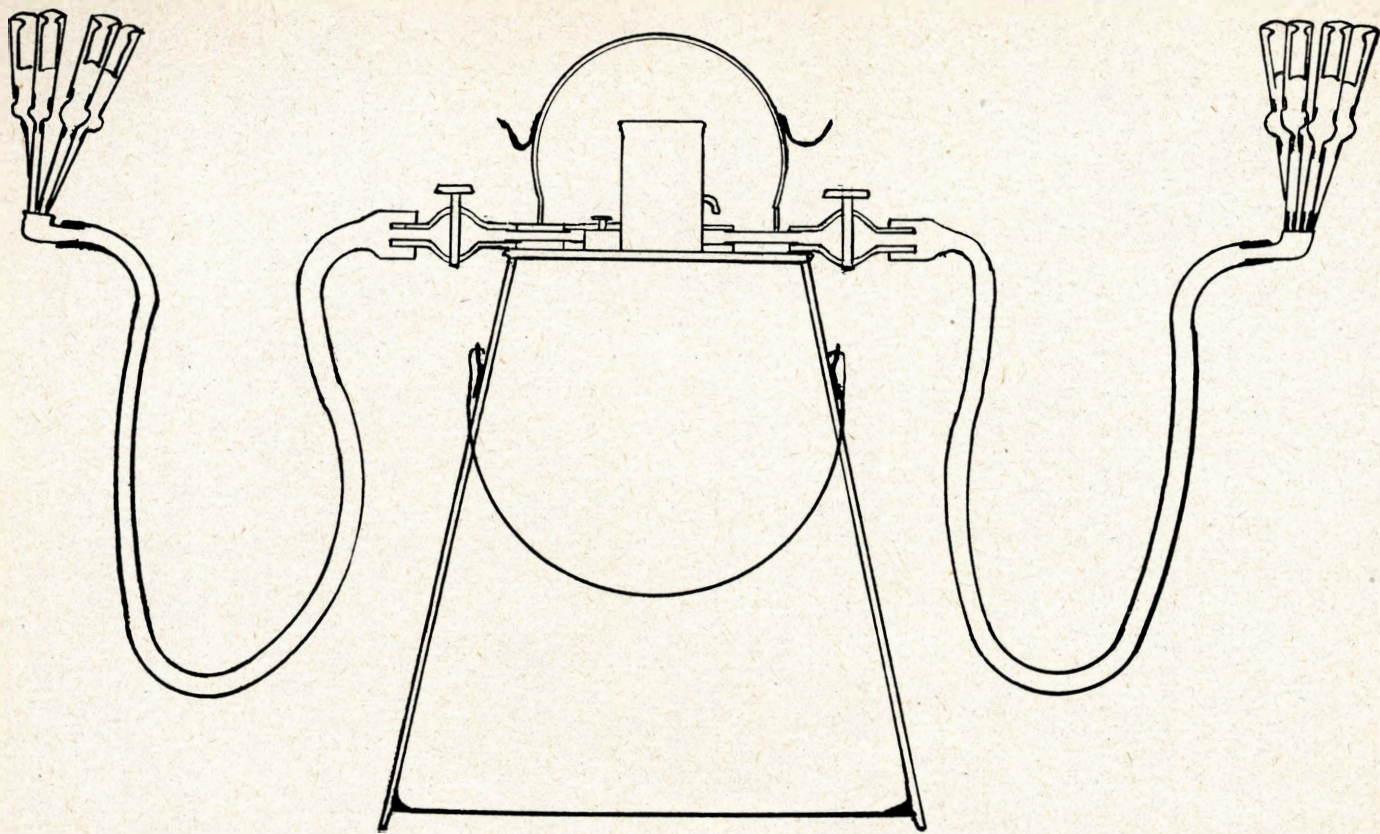
CHIEF PARTS OF MILKING MACHINE

THE PAIL AND PULSATOR

The pail includes the cover, the pulsator, and the rubber tubing connecting the pail with the vacuum pipe and with the teat-cups.

The pail is conical in shape, wide at the bottom and narrow at the top. It is somewhat heavier in structure than the average tin pail. This is necessary to withstand the greater outside air pressure when the machine is in operation. The vacuum, or suction on the inside of the pails, is equal to about one-half atmosphere or nearly seven and one-half pounds. The capacity of the pail is about fifty-six pounds. The pail, however, will hold only about forty-seven pounds, as the milk will be drawn into the vacuum connections if entirely filled. The capacity is not great enough for two of the heaviest milking cows. Pail capacity was lacking in the case of the two Holstein cows milked together. These cows, however, are unusually heavy milkers during the first part of their lactation period.

The cover fits on the top of the pail like a lid. A rubber ring acts as a cushion between the top of the pail and the under part of the cover. As soon as a vacuum is created in the pail, the cover is tightly drawn against the edge of the pail, making it entirely air tight. When the suction in the pail is released the cover with all of its attachments can be easily removed.



Cross-section view of the Hazelwood Milking Machine.

The pulsator is a small, cylindrically-shaped device, two and one-fourth inches in diameter, and four and one-half inches high. One end of it snugly fits into a socket or opening on the top and in the center of the cover. It operates similar to an engine cylinder. This pulsator operates by vacuum, and not by pressure. As soon as the vacuum is generated in the pail, the head, inside of the cylinder begins to move up and down. An attachment extends through the wall of the cylinder, and moves up and down in a slot in the cylinder wall. This attachment is connected with a small plunger, which in turn releases and brings on the suction. This alternate suction and release cause the pulsation. Milking machines having constant suction have been found to give unsatisfactory results.

In a few instances, during real cold weather, the pulsator did not work well. This perhaps was the fault of the operator more than of the milking machine. By using thin machine oil, no more trouble was encountered from this source.

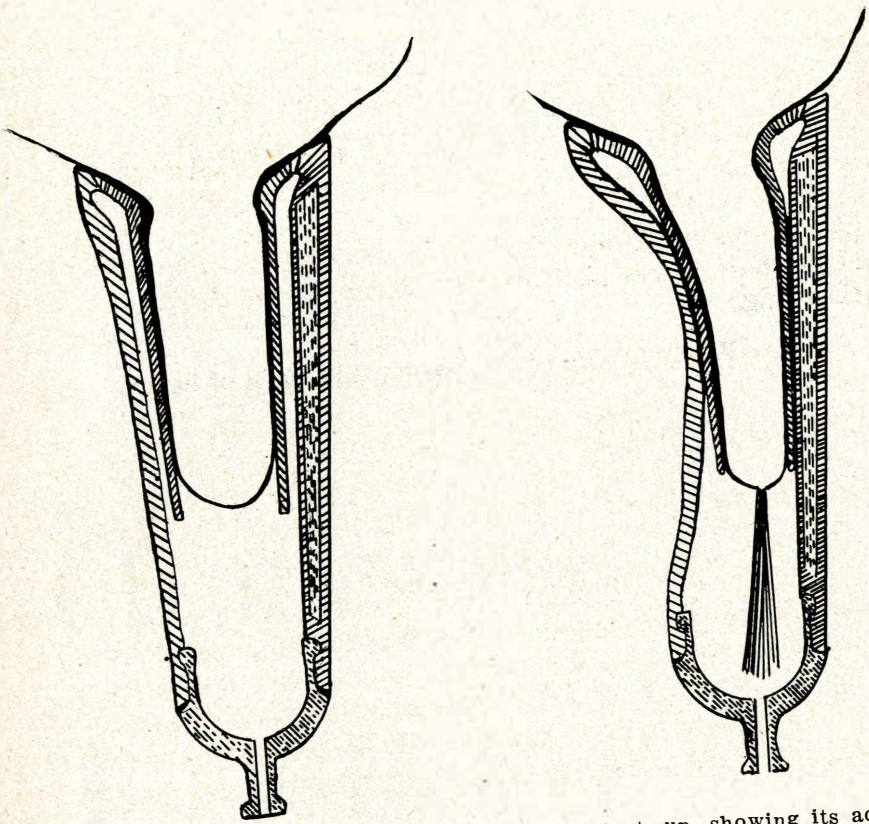
The tubing connecting the pail with the vacuum pipe is made of heavy black rubber. This tubing does not come in touch with any milk, except when the pail is too full and some milk is drawn from the pail. It is therefore easy to keep in condition and does not easily wear out.

The rubber tubes connecting the teat-cups with both sides of the pail are exposed to harder use. Each of these tubes is about four feet in length, with an opening of about one-half an inch in diameter. They naturally require considerable care in order to keep them sanitary and to prolong their life. Two sets of tubes have been used during the nearly two and one-half years the machines have been in operation. They are made of heavy rubber to prevent the walls from caving in when the suction is applied. When not in use they hang on hooks on each side of the pail cover.

THE COLLAPSIBLE TEAT-CUPS

There are two sets of teat-cups to one pail, thus making one set of four for each of opposite sides of pail. When connected and ready for milking, they terminate the rubber tubes mentioned in preceding paragraph and fit on to the cow's teats. Two cows can thus be milked at the same time with one pail or machine. These teat-cups are made of rubber. They are conical in shape, being wider at the top than at the bottom. They are about one and one-half inches in diameter, and three and one-half inches long.

The wall on one side of the teat-cups is made of heavy rubber, thus insuring a stiff, almost non-flexible wall. The wall on the opposite side of the teat-cup is made of thinner and more flexible rubber. This construction permits one side to collapse against the side of the cow's teat each time there is a pulsation. This action of the teat-cup comes nearer imitating a calf's sucking than any other teat cup ever tried by the investigators. Cows with sore teats can be milked very easily with such a teat-cup. One of the cows on the milking machine accidentally had a deep gash cut diagonally across the teat. By placing the stiff side of the teat-cup over the wound, she was milked without trouble, and the wound healed in a short time. To milk this cow by hand would have been almost impossible.



Cross-sectional view of the collapsible rubber teat-cup, showing its action when in operation during one complete pulsation.

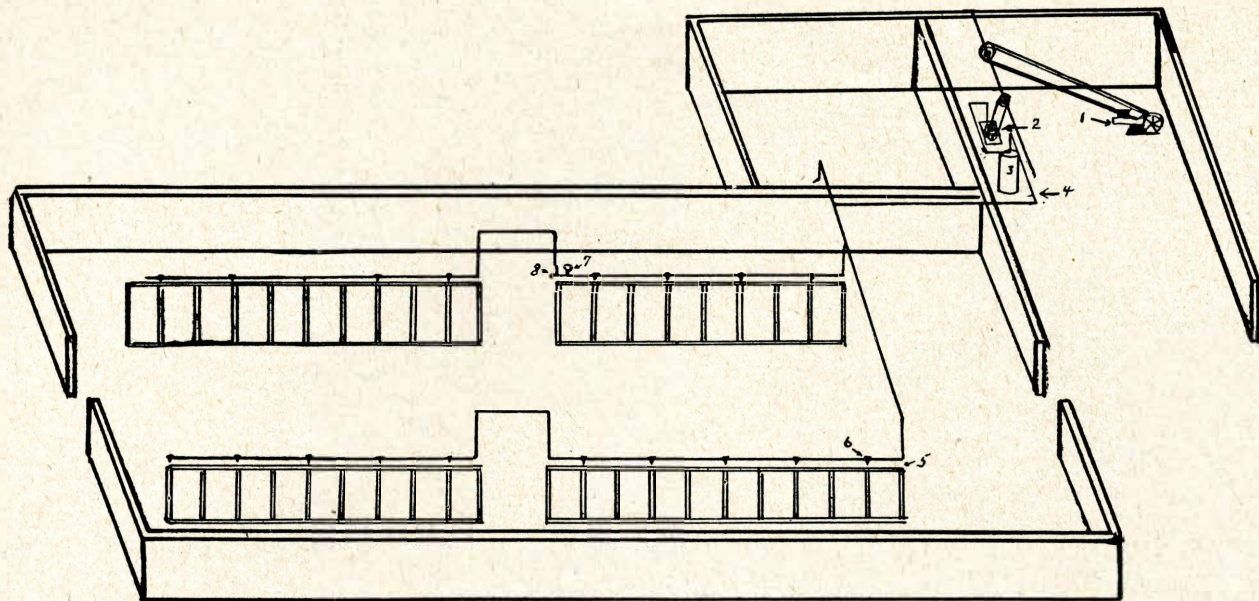
On the inside of the teat-cup there is a sleeve or a tubing extending into the teat-cup from the top. This tube extends into the teat-cup almost as far as the length of the average cow's teats. It is not quite as large in diameter as is the teat-cup itself. A space is left between the wall of the sleeve and the wall of the teat-cup, thus permitting the suction to extend up on the side of the teat. Such a construction causes one side of the cup to collapse and press on the side of the teat. This sleeve is about one and three-fourths inches long.

Teat-cups with two kinds of sleeves have been in use. One kind has a full opening at the lower end of the sleeve, while the second kind has only a small opening in the end. The latter kind does not stay on the teats so well as do the cups having the large opening.

VACUUM PIPES

The vacuum pipes running in front of the cows are ordinary one-inch piping, and are connected with the vacuum pump in the engine room. They were installed by a local plumber. Between every other cow there is a stop-cock in the vacuum pipe. During the milking period, the rubber tube previously mentioned, connects the pail with this cock.

At the remote end of the vacuum pipe there is a gauge and a safety valve. The safety valve can be set to admit air when a certain vacuum has been obtained. This obviates all danger of applying too much suction in the teat-cups.



1 Gasoline Engine.
 2 Vacuum Pump
 3 Vacuum Tank

4 Main Pipe Line.
 5 Stanchion Frame.
 6 Stanchion Cock Connection.

7 Vacuum Gauge.
 8 Vacuum Safety Valve.

Inside view of Dairy barn showing the manner in which the milking plant was installed.

VACUUM TANK

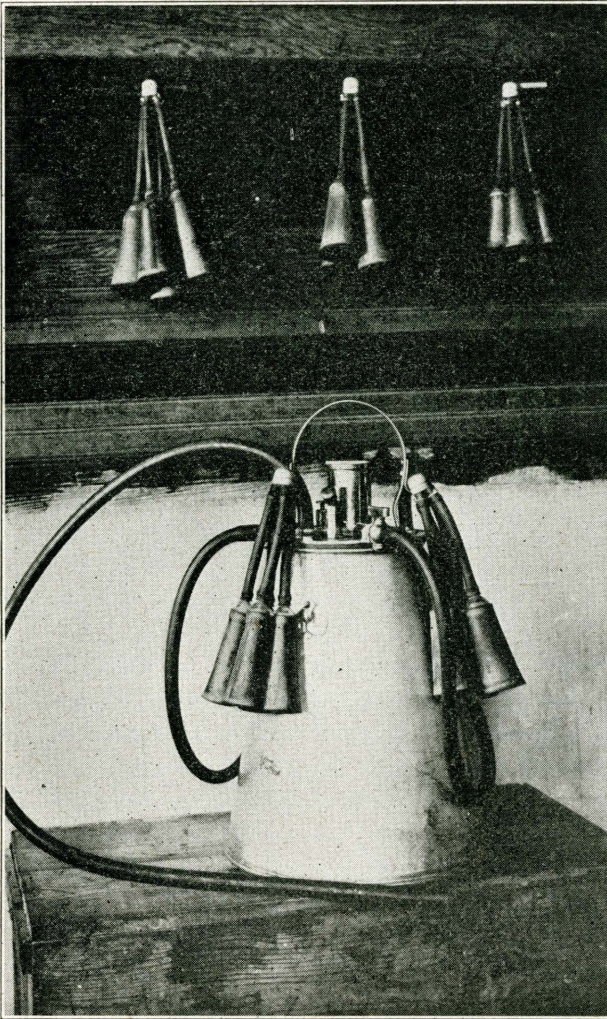
The vacuum tank is placed between the vacuum pump and the vacuum pipes and near the former. This tank serves two purposes: first, to make the suction more uniform; and second, as a vacuum supply tank. It is made of galvanized iron and has a cubical content of about 3.16 cubic feet.

VACUUM PUMP

The vacuum is generated by means of an ordinary rotary air pump. The pump installed was too small in size to supply regularly the needed vacuum for two machines or pails. Most of the time it was necessary to operate with about twelve inches of vacuum instead of with fifteen, the latter being the proper amount. Because of this low vacuum, and on account of experimenting with differently constructed teat-cups, some difficulty was encountered with the teat-cups falling off during the milking process.

POWER USED

A twelve horse gasoline engine is used for running the vacuum pump. This engine is much larger than is necessary, and was installed with a view of also running a feed grinder. It is now the intention to install an electric plant and generate and store electricity during milking hours. This to some extent will overcome the loss incident to the use of so large an engine for operating the milking machines.



View of Hazelwood milking machine and showing the manner of draining and hanging the various sized teat-cups when not in use.

COST OF MILKING OUTFIT

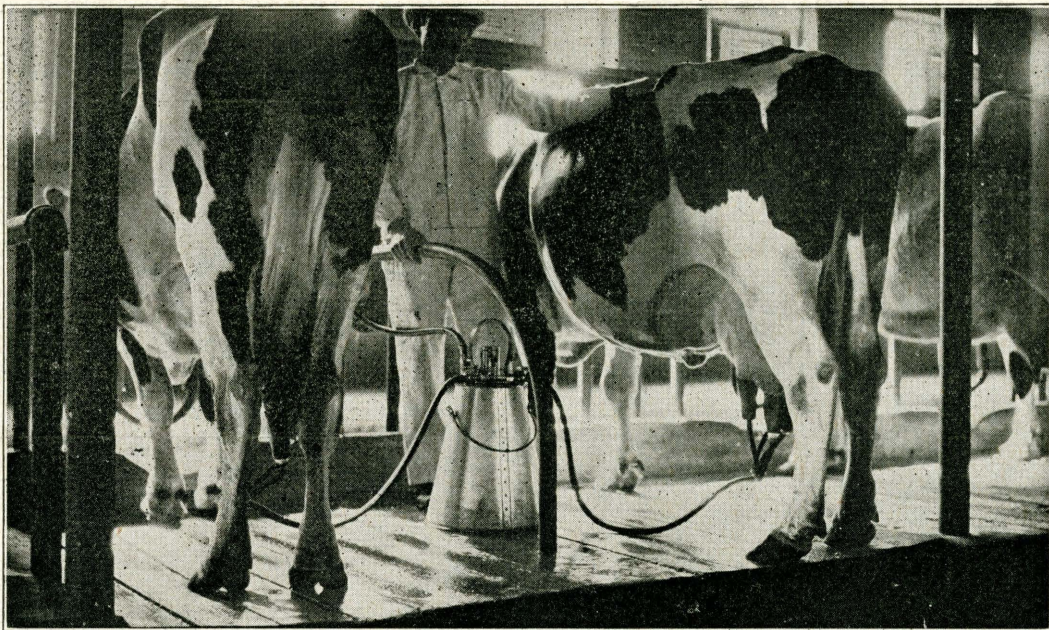
The cost of two pails with pulsator, teat-cups and rubber tube connection is about \$200. The cost of vacuum pump, vacuum tank and vacuum pipes with stop-cocks is about \$100. The cost of a milking machine plant without the power is therefore about \$300. One man with such an outfit can milk about 25 cows in one hour.

OPERATION OF THE MILKING MACHINE

In the month of February, 1911, ten fresh cows were put on the milking machine. Two of these cows were pure-bred Holstein Friesians giving a large quantity of milk; four of them were Jersey cows giving a medium flow of rich milk; two of them were pure-bred Shorthorn cows giving a small amount of milk; and two were common grade cows giving only a small flow of milk.

BREAKING THE COWS TO MILKING MACHINE

These cows were easily broken to the use of the milking machine. Some of them, however, became accustomed to it more readily than others. Briefly, it may be stated that the more milk the cows gave the easier it was to get them used to the milking machine. Two more cows were started on the milking machine, but one of these two absolutely refused to be milked by it. The expert representing the milking machine company tried for about three weeks to milk this cow but finally was obliged to give up. Apparently she did not care much for the action of the teat-cups, but the clicking noise of the pulsator at her side was a great annoyance to her. As soon as the machine began to operate she would turn her head to one side, look excitedly at the pail, and then kick. This she continued until the pulsator was stopped. The milking expert stated that in all of his experience this was the only cow that had refused to be milked by the machine. In explanation of this it may be stated that this cow was a three-year-old grade. Some Hereford and Red Poll blood was represented in her. She was also difficult to break to hand-milking.



View showing the Hazelwood milking machine in operation, milking cows 1 and 2 in table.

The pure-bred Shorthorn cows and the grade cows regarded the milking machine with suspicion for about one week, after which time they were perfectly at ease during the milking process. The Holsteins and Jerseys apparently accepted the machine as a matter of course. They readily gave down their milk from the beginning.

Whether or not a cow gives down her milk for the milking machine during its first usage depends on the milker and on the individuality of the cow. When the milking machine is first used the operator should be the herdsman or a man with whom the cows are acquainted. If this strange machine, with a strange operator attempts to do the milking, the cows will be much more suspicious and even afraid, than if the regular attendant accompanies the milking machine. The regular herdsman knows the temperament of the different cows, and he can approach each cow sympathetically. By gently handling the cow's teats and udder she gives down milk before the milking machine is attached. The teat cups are then put on and the milk is extracted before the cow realizes what did it. As soon as the cows had been milked a few times with the machine no difficulties were encountered by reason of any of the cows refusing to give down their milk.

The individuality of the cow needs to be considered in this connection. One of the writers demonstrated the operation of the milking machine on the stage before a gathering of about 1800 people. The cow used in the demonstration had never seen a milking machine before, yet she readily gave down her milk. She was an intelligent appearing, high grade family Jersey cow, used to being handled, and giving a large flow of milk. She was docile, gentle, and had implicit confidence in people.

• Generally speaking, it may be said that the cows of the dairy breeds, which yielded a fairly large flow of milk, readily gave down their milk from the very beginning. The cows which had more or less of the range-cattle blood in

them, and which gave only a small flow of milk, needed to be handled with tact and understanding during the first week to obtain the best results from the use of the milking machine.

ATTACHING THE TEAT-CUPS

Some experience is necessary before the operator can properly attach the teat-cups. In the first place the operator should use care to allow as little barn air as possible to enter the cups while there is vacuum in the pail, thus allowing dust and organisms to enter. During the attachment of the teat-cups the barn air is prevented from entering the pail by bending the rubber tube between the teat-cup and the connector. By using care, and with a little experience practically no barn air need to be drawn into the pail.

If the teat-cups are not properly attached they are more likely to fall off during the last part of the milking period when the udder is limp.

CONDITION OF COWS' TEATS

Before the cups are attached to the teats the operator should see that the teats are in proper condition and that they enter the teat-cups straight without being turned and twisted.

The teats of the cows are not always in equally good condition to be milked by the machine. If the cows have been exposed to damp and cold surroundings, the teats are short, and the covering of the teats is curled and contracted. When the teats are in such a condition it is important that the operator brings them into normal condition before the teat-cups are attached. This can be done by gently rubbing and slightly pulling the teats with the warm hands of the milker. The teats should be clean before the teat-cups are attached. Unclean teats are usually contracted as mentioned above, and contaminate the milk.

Such contracted teats milk with difficulty. The teat-cups do not get a firm grip nor a good symmetrical hold and they are likely to give trouble by falling. As a result one side of the teat may be pulled into normal length before the other, and thus cause the end of the teat to turn and partially prevent the proper discharge of the milk.

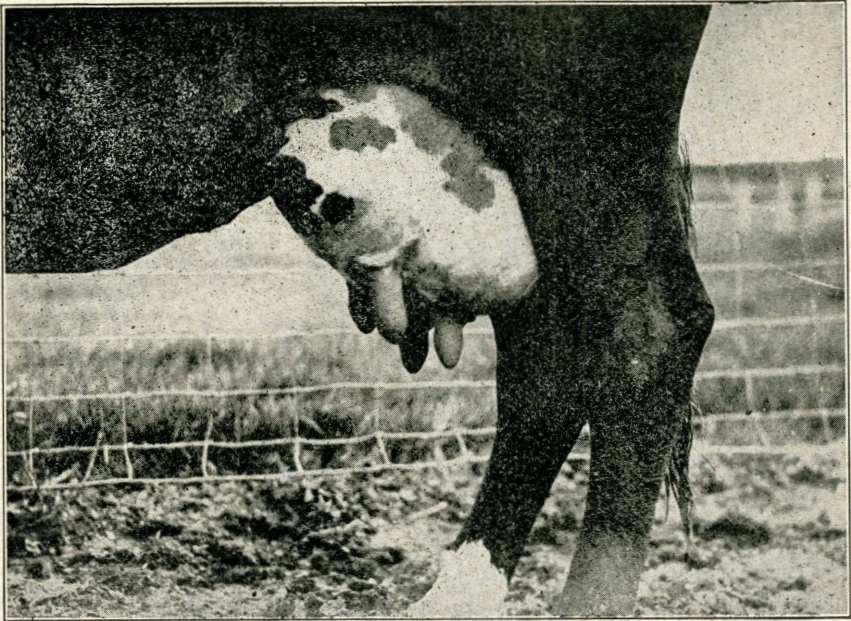
In this experiment the cows were kept out doors in a yard during the day, except in stormy and cold days. At night the cows were kept in the barn except during the warm summer months.

The milking machine was found to need less attention during the morning milking, than it did at night. The poorer condition of the cows' teats in the evening was found to be the cause. In the morning the teats of the cows were usually warm and normal in shape. In such a condition it is easier for the operator to properly attach the teat cups.

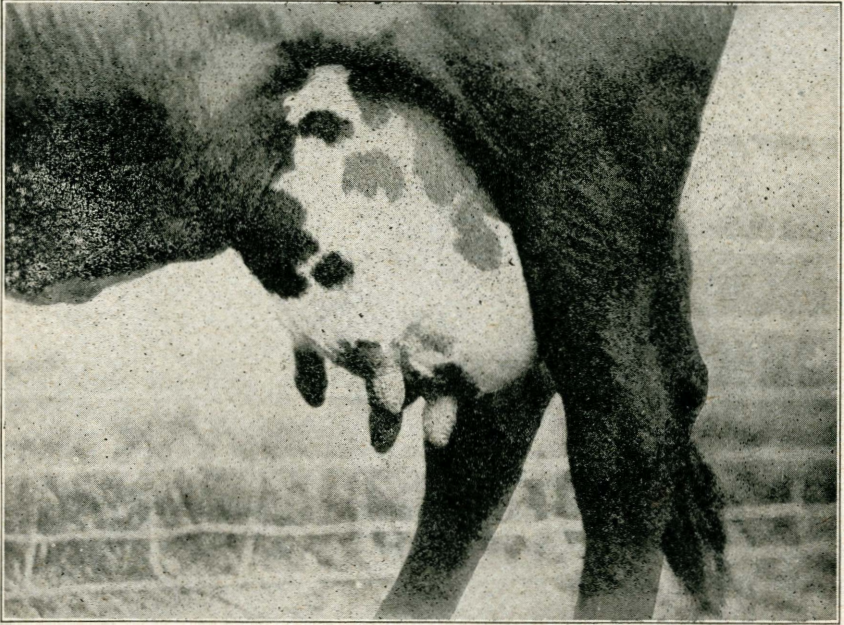
SPEED OF PULSATOR

No rules can be laid down for governing the speed of the pulsator for the different cows. The speed of the pulsator will vary with the size of the teats and to some extent with the ease or difficulty with which the cows milk, and the manner in which the cow gives down her milk.

An easy milking cow permits of a trifle higher speed of the pulsator than does a hard milking cow. This is in accord with reason. When the pulsator works at high speed the suction period is short. This does not give enough time for the milk in the teat to be extracted from a hard milking cow. This rapid alternate release and suction of a hard milking cow results in slow milking. With a short teated and easy milking cow, the pulsator can be operated faster, and at about 110 strokes per minute. With a medium hard milking cow around 90 strokes per minute is about proper. The speed of the pulsator can also be greater with a cow giving a large flow of milk than with one giving a small flow. The former usually gives down her milk faster.



View showing normal and ideal condition of cows teat. In this condition the teat-cups can be properly attached.



View of the same cow's teats as shown on opposite page. This view was taken after the cow had been exposed to wet and cold conditions. If the teat-cups are attached to teats while in this abnormal condition they are likely to fall off.

During the latter part of the milking or during the stripping period, the speed of the pulsator may be slightly reduced. In a short time an observing operator gets used to the cows and to the machine, and the proper speed of the pulsator will soon be learned.

The speed of the pulsator can be regulated by means of a little screw on the pail cover. It is not necessary to adjust it every time the vacuum varies. During the change of the pail from one set of cows to the other there will be a slight variation in the amount of vacuum. When the teat-cups are detached the vacuum rises slightly, and the speed of the pulsator is somewhat increased. When the teat cups are again attached to two other cows the vacuum is temporarily slightly lowered.

The vacuum safety valve is not sufficiently sensitive nor is the vacuum pump of sufficient capacity to maintain an exact amount of vacuum during these changes. So far as learned nothing serious results from a variation of the speed of the pulsator. However, better milking results when the proper speed of the pulsator is maintained.

DETACHING THE TEAT-CUPS

When the operator learns the action of the milking machine on the different cows, and the appearance of each cow's udder when full and empty, he can tell without much watching when the milking is completed. An inexperienced operator should watch the glass bulbs or inspection glasses at the bottom of each teat-cup. When the milk stops flowing into these glass bulbs, probably the cow is dry. The fact that the milk has stopped flowing is not a sure indication that the cow is milked dry. Occasionally the teat will get into such a position that the milking can not be completed. Before the teat-cups are detached, the operator should gently pull on them to slightly displace the teat. If there is any more milk in the udder, it will then be extracted. When the operator is satisfied that there is no more milk in the udder, the vacuum is shut off with one hand, and with the other hand the teat cups are removed.

STRIPPING THE COWS

In this experiment the milking machine was not relied on to do the stripping. As soon as the teat cups were detached, the milk was stripped by hand into the teat cups. Usually no more milk was obtained than the tube and cups would hold. When the stripping was completed the milk was let into the pail by opening the stop-cock. In some instances practically no milk was obtained, while in other cases one or more of the teats yielded more than should be left in the cow's udder.

Some recommend that one man attend to the milking machine and another do only the stripping. By this method the man who does the stripping may not get to strip the cow till some time after the milking machine has done its work. This interval of time may cause the cow to take the milk again. It may be the means of drying up the cow, and it may cause diseased udders.

When the milking of a cow once has started, it should be continued without intermission. For this reason all the cows were stripped as soon as the teat cups were detached.

EFFECT ON YIELD OF MILK AND BUTTERFAT

It is very difficult to secure data which may safely be regarded as an index to the effect of a milking machine on the yield of milk and butterfat. One cow can not be compared with another as there is so much difference in the individuality of the different cows. The yield during a definite period by machine cannot be compared with the yield from another period of equal length by hand in the same lactation period of the same cow, since alternating from machine to hand milking and vice versa is too disturbing and unnatural to the cow.

In this experiment the yield of the same cows while milked by hand during the lactation period preceding the milking machine, has been compared with the yield during the succeeding lactation period with the milking machine. Several disturbing factors enter in to make even this com-

parison unreliable. The length of the succeeding lactation periods of the same cows can not be entirely controlled, due to the failure of some cows to conceive when mated. It is a well known fact that most cows have an "off" lactation period. The difference in age also makes it difficult to compare the yield of one lactation period with that of another period.

The following table shows the amount of milk and butterfat given by each two cows during the lactation period when milked by hand, and the two succeeding lactation periods when milked with the milking machine.

TABLE I

No. of Cows	Lactation period previous to use of milking machine (hand milked)				First lactation period on milking machine				Second lactation period on milking machine			
	Pounds of milk	Av. per cent fat	Pounds of fat	Av. length of lactation period (days)	Pounds of milk	Av. per cent fat	Pounds of fat	Av. length of lactation period (days)	Pounds of milk	Av. per cent fat	Pounds of fat	Av. length of lactation period (days)
Holsteins												
Cows 1 and 2...	19626.2	3.40	657.98	248	22381.7	3.36	753.01	248	18918.1	3.62	685.66	248
Jerseys												
Cows 3 and 4...	7005.5	5.05	353.92	218	*10154.0	5.15	*523.86	218	†7863.0	4.87	†383.15	191
Jerseys												
Cows 5 and 6...	11997.5	4.68	561.76	295	12472.2	4.56	569.33	295	9957.5	4.82	480.69	218
Shorthorns												
Cows 7 and 8...	‡3522.0	4.50	‡158.81	‡291	4319.5	4.94	213.68	266	5343.0	4.09	218.73	197
Grades												
Cows 9 and 10...	6387.2	4.07	260.20	244	6513.5	4.12	268.84	244	5824.5	4.05	236.41	187
Average per cow	5393.1	4.09	221.41	271	5584.1	4.17	232.87	254	4790.6	4.18	200.46	208

*No. 3 we were unable to get in calf, which probably accounts for the increased production.

†No 57 was substituted for No. 3. The latter cow we were unable to get in calf.

‡No. 8 is not included as she is a heifer and had no hand-milked lactation period before she was put on the milking machine.

The average production of each cow per day during the hand milked period was 19.9 pounds of milk and 0.82 pounds of butterfat. During the first period with the milking machine the same cows produced on an average per cow, per day, 22 pounds of milk and 0.92 pounds of butter fat. The increased age of four of the cows and the fact that cow No. 3 did not get in calf undoubtedly account for the slightly higher results.

During the following period when the milking machine was in use the average production per cow per day was 23 pounds of milk and 0.96 pounds of butter fat. These averages include the production of cow No. 57 instead of cow No. 3. The latter cow was eliminated on account of not being in calf. The substitute cow No. 57 is also a Jersey cow, and in production she about equals No. 3 while in normal condition.

The number of cows and the length of period they have been milked by the milking machine, do not warrant drawing any conclusions as to the effect of the milking machine on the persistency of milk production and the amount of milk and butterfat produced. It is quite safe, however, to conclude that the daily yield of milk and butterfat is not affected by the use of the milking machine, when properly operated.

In these experiments the data and observations indicate that cows producing a small quantity of milk, say less than 3000 pounds during a lactation period, have their lactation period slightly shortened by the use of the milking machine. The results of the use of the milking machine also indicate that the lactation period of large producing cows is prolonged. It was found difficult to dry up persistent milk producers when the cows were milked by machine.

SANITARY CONDITION OF MACHINE-MILKED MILK vs. HAND-MILKED MILK

In considering the sanitary condition of milk, two factors need to be considered:

First, the visible impurities.

Second, the number of bacteria or germs.

VISIBLE IMPURITIES

The machine milked milk was at all times remarkably free from visible impurities. The machine-pail is closed during the milking process. There is no opening large enough to admit the entrance of any foreign matter visible to the naked eyes. The possibility of obtaining milk containing sediments of any kind or other material suspended in the milk is removed almost entirely by the use of the milking machine.

BACTERIAL OR GERM CONTENT

All samples of milk from which counts were made in this experiment were secured at the barn as soon as the cows had been milked. In the case of milk drawn by hand, the sample was taken from the pail when brought into the milk room. The milk room is near the stable. Milk drawn by the milking machine was also sampled when brought into the milk room. The samples were placed in sterile flasks and immediately taken to the laboratory, and at once plated. Lactose agar was the medium used. The plates were incubated at 98 degrees Fahrenheit for 48 hours, then counted. A small hand lens was used in counting.

TABLE II.

Showing number of bacteria in milk drawn by hand as compared with milk drawn by the milking machine

Period 1 Covered pail Milked by hand Bacteria per C. C.	Period 2 Ordinary care Milked by machine Bacteria per C. C.	Period 3 Salt solution Milked by machine Bacteria per C. C.	Period 4 2 1-2 per cent Formalin solution Milked by machine Bacteria per C. C.	Period 5 5 per cent Calcium chloride Milked by machine Bacteria per C. C.	Period 6 Cotton filters Milked by Machine Bacteria per C. C.
3,000	1,215,000x	305,000	45,000	29,000	3,500
1,500	520,000	308,000	60,000	31,000	4,000
4,000	720,000	285,000	80,000	36,000	3,500
2,000	710,000	220,000	25,000	47,000	5,800
300	4,800,000x	200,000	130,000	13,000	2,100
1,500	670,000	285,000	40,000	20,000	6,600
1,100	620,000	185,000	85,000	260,000	40,000
2,100	610,000	430,000	90,000	102,000	65,000
250	450,000	335,000	80,000	122,500	130,000
350	420,000	195,000	100,000	38,500	100,000
550	830,000	415,000	85,000	78,000	280,000
250	550,000	230,000	115,000	94,000	47,000
600	510,000	60,000	50,000	73,300	
800	450,000	125,000	95,000	900,000x	
3,000	1,300,000x	285,000	40,000	800,500x	
3,000	550,000	170,000	40,000	43,300	
2,000	300,000	195,000	65,000	43,500	
3,000	190,000	320,000			
17,000	460,000	110,000			
30,000	530,000	180,000			
13,000	430,000	2,600,000x			
18,000	490,000	350,000			
20,000	720,000	1,210,000x			
23,000	430,000	450,000			
22,000	460,000	800,000			
12,000	390,000	340,000			
35,000	390,000	100,000			
25,000	390,000	150,000			
24,000	600,000	60,000			
12,000	450,000	70,000			
11,000	390,000	400,000			
22,000	425,000	190,000			
18,000	460,000	320,000			
17,000	530,000	120,000			
16,000	490,000	160,000			
12,000	500,000	140,000			
13,000	520,000	300,000			
15,000	670,000	290,000			
Average					
10,739	509,285	252,166	72,058	134,070	57,708

"x"—Not included in average. Teat-cups fell off into bedding.

Normal Conditions The bacteriological determination in periods 1 and 2 were carried out at the same time, extending over a period from October 2nd to December 11th.

The cows were kept in the barn during nights, and in the day were turned out into a well bedded run-shed having a clean open yard in connection with it.

No unusual care was observed in the case of hand or machine milking. Partially covered pails were used for hand milking.

The teat-cups and rubber tubes were cared for as recommended by the expert who installed the machine. This consisted of rinsing the rubber parts in two sets of water every evening immediately after milking. The machine was attached to a vacuum pipe extended into the milk room. With the suction turned on, the tubes and teat-cups were raised up and down in the cold water. This thoroughly rinsed the rubber parts. Every morning the teat-cups and rubber tubes were thoroughly cleaned in warm water containing some Wyandotte cleaning powder and long handled brushes made to fit the rubber tubing. Then all rubber parts were scalded in hot clean water, and hung up to drain and dry.

Use of Sodium-chloride or common salt During period 3 all the conditions in the barn and of the cows and their surroundings were the same as described above. The parts of the milking machine were also cleaned as described above. Instead of hanging the rubber parts up to dry between milkings, they were soaked in a saturated solution of sodium-chloride or common salt during the intervals between milkings.

Use of formalin In period 4 the condition of the cows, of the barn surroundings, and the care of the parts of the milking machine were as described under period 1 and 2. The only difference was the soaking of the rubber parts in a 2½ per cent solution of formalin between milkings, instead of hanging the parts up to drain and dry.

Calcium chloride and salt. In period 5 the teat-cups and rubber tubes were cleaned in the usual way, and kept in a brine solution containing 5 per cent of calcium chloride and then saturating this solution with common salt.

Even though the parts of the machine were well washed and kept in a sterile solution during the time intervening the milking, the germ content of the machine-milked milk is higher than that obtained by hand-milking.

Use of cotton filters In the period 6 cotton filters were placed over all intakes. The small pneumatic engine on the top of the pail is operated by suction. Barn air is continuously drawn into the pail in the form of exhaust from this engine or pulsator. This barn air contains a large number of germs and evidently is one of the chief sources of the relatively large germ content of milk drawn by the milking machine.

To overcome this, cotton filters were placed over all of the air inlets to the pail. One filter used was made by using a small funnel filled with non-absorbent cotton. Cheesecloth was tied over the mouth of the funnel. With a small piece of rubber tubing this funnel filter was fastened to the small extensoin air tubes on the pneumatic engine. Since the small air-vents in the engine have no extension, they were supplied with filters by fastening a suitable thickness of cotton filter wrapped in cheesecloth directly over the opening.

These cotton filters reduced the bacterial count of the milking machine milk to a considerable extent. The increase of the bacterial content during the latter part of period 6 is undoubtedly due to the filters being little too loose. Considerable care is necessary to have the filter properly made. It must not be so firm as not to permit the proper amount of air to pass through, and thus interfere with the proper work of the pulsator, and yet it must be sufficiently packed to thoroughly filter the air and retain the dust particles.

From these studies, it is clear that although the pail

of the milking machine is covered to exclude visible dirt, the constant suction of barn air through the pneumatic engine or pulsator into the pail is one of the chief sources of the large number of germs in milk drawn by the milking machine. This difficulty may be partially overcome by filtering the air through properly constructed filters.

Another important source of germ content of milk drawn by milking machine is the condition of the rubber tubes and teat-cups. The trouble from this source can be lessened in two ways. First, all the rubber parts should be well cleaned in lukewarm water and rinsed in hot water. Steam and extremely hot water shorten the life of the rubber. Keeping these parts in a solution of calcium-chloride and common salt between milkings is an effective method of handling these parts in a sanitary condition. Second, when the rubber begins to crack and check, new parts should be secured. Old overheated and cracked rubber is sticky. When in use this rubber spreads and allows milk to enter the openings. These crevices are difficult to properly clean and become a dangerous source of infection.

SUMMARY.

1. Viewed from a mechanical standpoint, the milking machines used in this experiment caused very little trouble in operating. It is safe to conclude that with reasonable care this type of milking machine can be successfully and profitably operated on the average farm having at least twenty cows.

2. Cows giving a large flow of milk were easily broken to the use of machine. In general, little difficulty was experienced in getting any of the cows accustomed to the milking machine. The operator, in order to operate most successfully, should study the individuality of the cows.

3. It is best to strip the cows at once after the teat-cups are detached to make sure that no milk remains. If the teat-cups are properly attached very little milk remains in the udder after the cow is milked by the machine.

4. No definite statement can be made as to the effect of machine milking upon milk and butterfat yield, as the experiments have not extended over a sufficient period of time. Results of these experiments indicate that if the machine and cows are properly handled, the amount of milk and butterfat is not materially affected by machine milking.

5. Milk drawn by machine was free from sediment and other visible impurities. It, however, contained more bacteria than did the milk drawn by hand into a partially covered pail.

6. The barn air drawn in by the machine proved an important source of contamination. By filtering this air through cotton filters the bacterial content of the machine-milked milk can be greatly reduced.

7. The germ content of machine-milked milk can also be reduced by soaking the various rubber tubes and teat-cups in an antiseptic solution. A five per cent solution of calcium-chloride saturated with sodium-chloride proved to be effective in these experiments, and can safely be recommended.