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T H E S I S .

M I L K I N G M A C H I N E S .

by

W. E. Watkins.

-1906-

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MILKING MACHINES.

During the last fifty years the dairy industry has developed so rapidly that it is now regarded as one of the chief sources of revenue for the modern farmer. This is due largely to the ever increasing number of dairy machines and appliances, as well as improved methods of breeding and feeding, a more thorough knowledge of the intricate details in the production of sanitary dairy products and the business ability of the dairyman as displayed in creating and maintaining desirable markets.

As a good dairy is a constant source of revenue, maximum production at the minimum cost has ever been the goal toward which the dairy farmer has been constantly striving. Many appliances and machines have been perfected, which have completely revolutionized the dairy business. The value of the Babcock tester, milk separator and pasteurizer can scarcely be estimated; they are absolutely essential to the complete modern dairy. Although inventors have been very successful along this line, yet the difficulties have been almost insurmountable in the creation of an efficient sanitary appliance for drawing milk from the cow's udder.

Milking machines or appliances may be classified under three heads: (1). The milking tube. (2). Pressure machines operated by springs and levers. (3). Machines which extract the milk by means of pressure and suction combined.

For a long time straws have been inserted into the main duct of cows' teats to draw out the milk, but they were often the cause of injury to the udder and a source of contamination of the milk. One of the first tubes placed on the market was invented by George

of New York in 1878, and consisted of a teat tube or tubes having a number of small holes through which the milk entered and a flaring end for increasing the flow of milk without unduly stretching the teat. It also had an embracing band for holding together the lower ends of the flexible tubes and a flexible supporter for sustaining the weight of the tubes, nozzle and their contained milk. A few tubes have been patented since, but the same principle, with but slight variation, is involved in all.

As a rule milking tubes have been found to be very unsatisfactory, for if not thoroughly sterilized and carefully inserted they often injure the cow's udder, contaminate the milk amd become a menace to the health of man because of the ease by which pathogenic bacteria might enter the warm milk, which is a desirable media for a large number of disease germs. It has also been shown that the continuous use of milk tubes materially lessens the length of the lactation period. The dairyman of today seldom uses the milk tube, and then only in the case of diseased udders, where it is impossible to draw the milk by the usual method.

Several pressure machines or appliances have been produced, some of which are very simple, while others are so cumbersome, complicated and difficult to clean that their period of usefulness was of short duration. One of the earliest pressure machines was invented by Mayor of Missouri in 1878. It consisted of a long rubber tube, one end inserted in the milk pail, the other holding two slotted half tubes whose upper ends were rounded off upon the convex side. One of the tubes was stationary, the other movable and attached to a V shaped spring which pressed the half tubes against the teats. This appliance is hard to keep on the teat, is easily cleaned and is not so liable to contaminate the milk or injure the

teats as when milking by hand.

The Roth milker, patented in 1899, is similar to the one above. Two curved clamps fit around the teat and are drawn together by means of springs attached like those in the common athletic grip machines. This milker is more practicable than the one above because it is easier to manipulate, stays upon the teat better and has no closed tubes. These are two of the very simplest milking appliances, while some of the others are so complicated and cumbersome that it would be almost impossible to use them upon a cow of the slightest nervous temperament.

Dingan of Victoria in 1889 patented an appliance which consisted of a flexible bag that fitted over the teats. The milk was conveyed from the bag or cups to a closed bucket by means of a short, flexible tube. Finger and thumb loops are arranged longitudinally on opposite sides of the bag. This machine is very simple, easily cleaned and operated, keeps the milk comparatively free from dirt and filth while in transit to the vessel as well as after it is deposited therein.

The Beyer and Rhode machine, patented in 1886, consists of a milking cylinder, flexible pressure cushions stuffed with pliable material, each having an end secured to the milk cylinder. Non-porous sacks, having their mouths stretched over the cylinders, extend down between the cushions. A milk conduit is arranged to receive the milk from the sacks. This machine is very heavy, is mounted upon rollers to move from cow to cow, and is operated by hand power. The cushions, which are hard to clean, cannot be quickly raised or lowered as the cow moves, the pressure is liable to injure the udder, while the whole machine is so cumbersome that it would require too much space in the barn.

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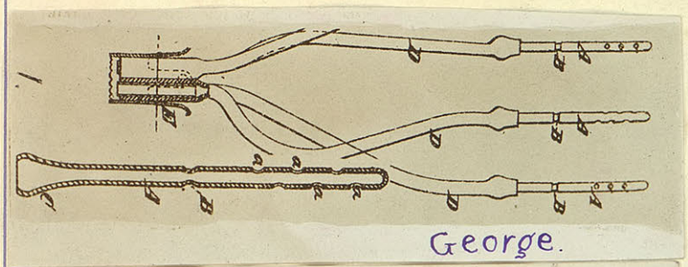
The Lefeber machine is based upon the same principles as the Beyer and Rohde. It has vertically reciprocating pressure rollers arranged in pairs, stationary plates are arranged above the rollers, in the central opening of these plates are flexible sheets which hold the teat in place. The same objections apply to this machine as to the Beyer and Rohde.

In 1890 Amspaker of Pennsylvania made a milking device which had two chambers somewhat like a teat cup into which the teat is placed. To these cups were attached a teat pulling and compressing device, arranged so that the chambers worked alternately by means of the same lever. The chambers can be easily spaced to suit different cows. As the pitman pulls the chambers down springs compress the tube, making the operation similar to calf sucking. This machine milks but two teats at a time, is easily dissembled and cleaned, but can be used only on gentle cows, as the teats would be withdrawn or the animal injured by blows from the chambers when operated too close to the cow. Many similar cushion machines have been patented but in every case they have failed to do efficient, rapid work, while some of them were so complicated and hard to operate that it would be impossible to use them even under the most favorable circumstances.

Several very simple suction machines have been made in the past, yet as a rule they were lacking in some essential quality which easily prevented their universal use among dairymen. In 1878 Miss Anna Baldwin of New York made a simple suction machine which consisted of a large bowl that fitted over the udder. In this bowl were the teat cups or tubes, connected through the bottom of the bowl to an exhaust pipe and pump. The milk had to pass directly through the pump, thus making more parts to wash. With the bowl over the udder it would be impossible to tell whether the teat cups



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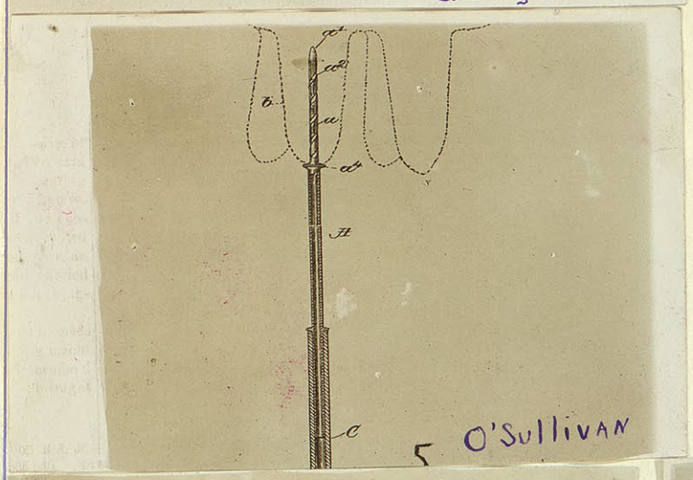

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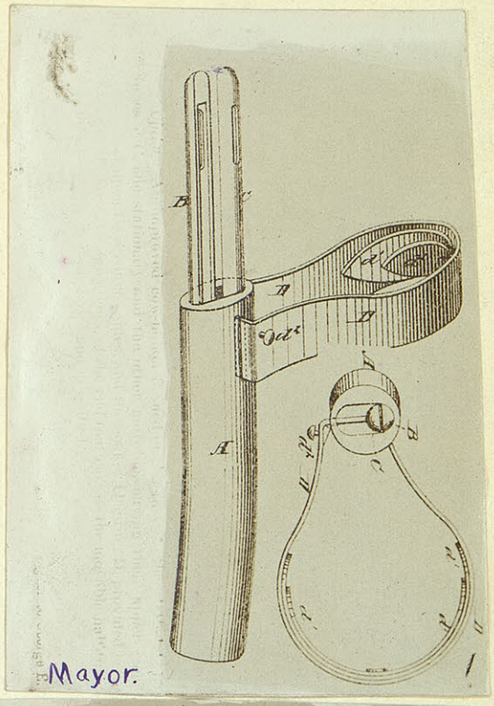

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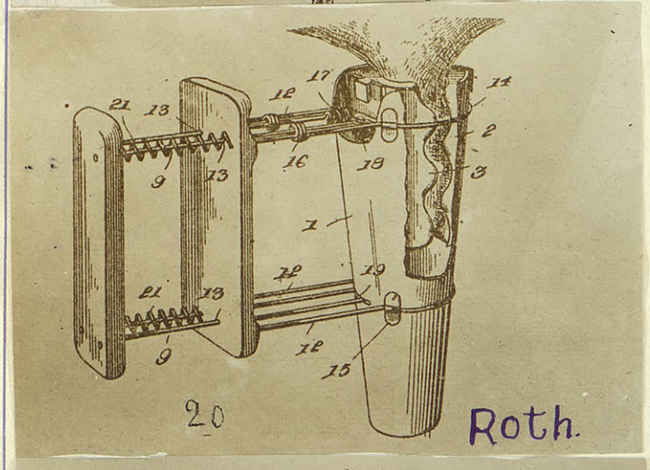

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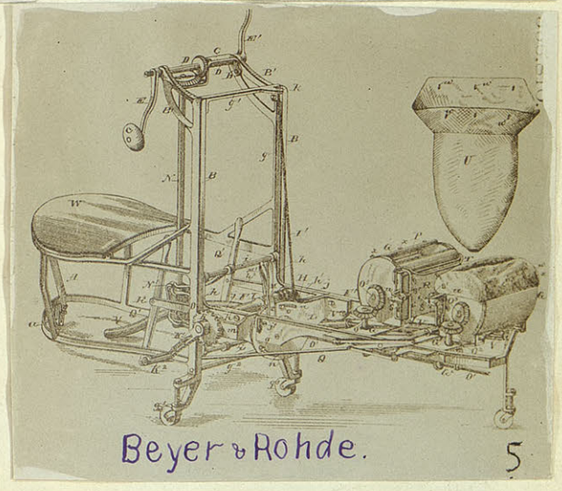
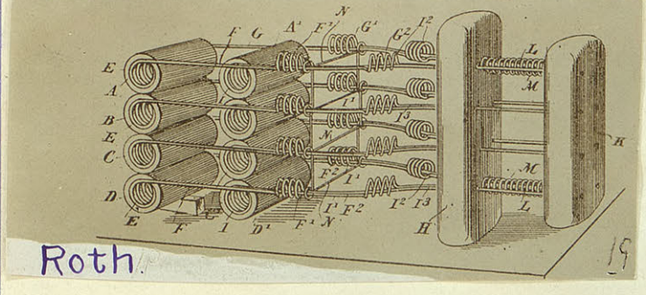


Beyer & Rohde.



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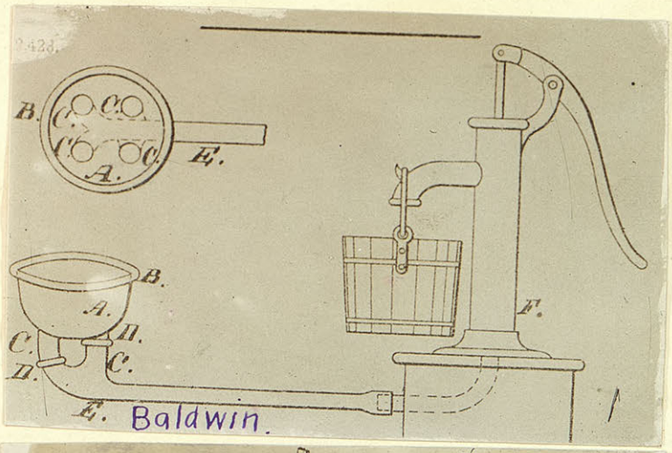
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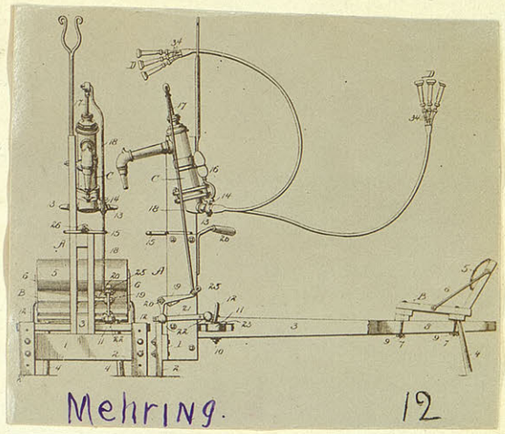
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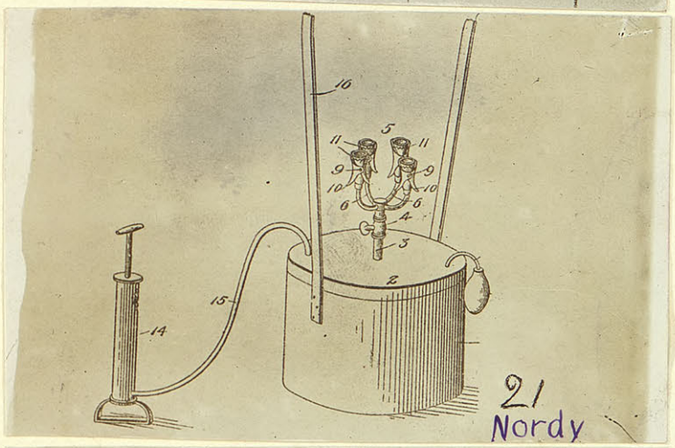
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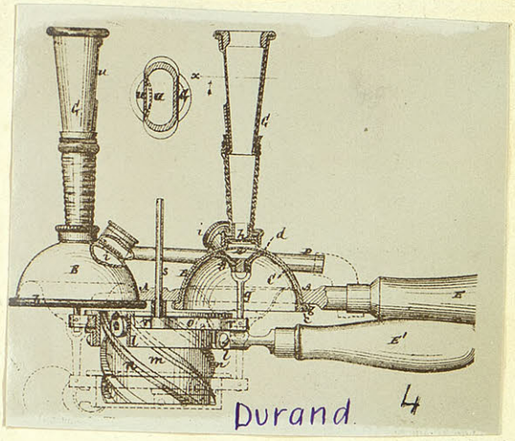
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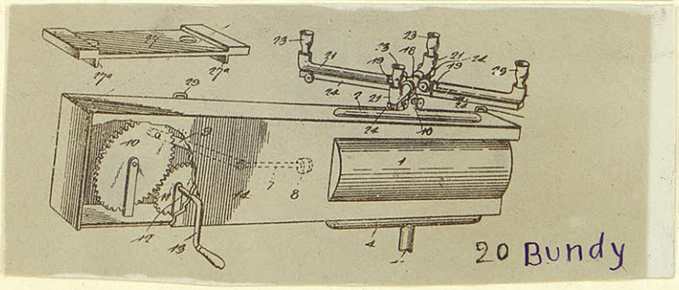
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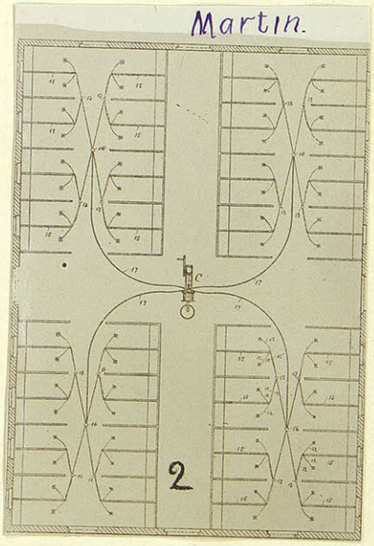
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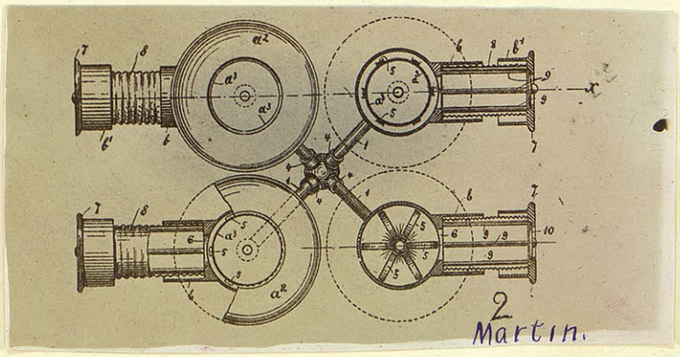
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were still in operation or not.

The Nordy machine has an air tight receptacle, provided with a small exhaust air pump. A short rigid tube leads from the top of the receptacle, at the upper end of this tube four flexible tubes are attached, in which are fastened the teat cups surrounded by flexible sheaths conical at the lower ends and embracing the lower portions of the teat cups. The cups are compressed by a pair of clamps with spring actuated pivoted jaws. The flexible tubes leading from the teat cups are not long enough for average conditions, while the teat cups are as objectionable as any hitherto mentioned.

In the Mehring appliance the suction pump is worked by treadles and levers, the teat tubes have a self-wetting device consisting of an outer ring and a soft inwardly projecting material adapted to bear gently upon the teat. This machine is objectionable because it is so complicated, difficult to move and hard to keep clean, because of the length of the milk conduits. Unsanitary open milk pails are also used.

In 1878 the first Durand machine was finished. The teat cups were of rigid material and grouped together in the form of a nest. A special stanchion was also required. In the other Durand milker, the teat cups were of irregular flexibility for the purpose of producing lateral pressure on the teat during the exhausting action of the pump. The teat socket was of reduced thickness and greater flexibility at one or more portions of its side than at the intermediate parts in the same transverse plane.

In the Bundy machine the suction is produced by a small valve run by a crank, the teat cups are carried upon an independent movable frame for adjustment to various cows. The cups are connected to a

suction tube and suction producing apparatus. The teat cups are rigid, short and difficult to keep on the teats when a break in the suction occurs. The machine is simple, easily handled and cleaned.

The Hoover-Jay machine, invented in 1891, is of as little use to the dairy farmer as the ones already mentioned because of the cost of installation, difficulty of cleaning and of keeping the teat cups on the teats because of their imperfect method of manufacture.

Of late years inventors have given more attention to teat cup construction and to the pulsating apparatus than to the other parts of the effective mechanical cow milker. It was necessary to duplicate the movements of a calf while sucking or of a man milking by hand. The calf draws out the milk by suction after the teat has been compressed by the lips and tongue.

The Cushman, placed upon the market in 1896, consists of a vacuum producing apparatus, an air compressor, an automatic vacuum regulator composed of an expansible air box having a movable portion which is adapted to close the outlet pipe connected with the air box and a means for resisting such closure. The pulsator is composed of a main air cylinder having an air inlet and outlet, a piston spring for holding it normally depressed, piston sylinders, one having an air inlet and air cut off, pistons slidable therein. There are tubular connections between the two cylinders and lever connections between the several pistons, whereby any movement of the main piston causes a movement of the others. The teat cups are composed of an outer rigid tube, flexible inner tubes, a ring fitted on the rigid tube and having an inwardly projecting portion provided with a series of perforations opening on the under side within the flexible tube which is joined to the ring. This machine is not very complex, is easily attached to the cow, not difficult to clean,

while the buckets can be placed some distance away from the animal being milked, thus minimizing the danger of upsetting the pail or contaminating its contents.

The Lawrence-Kennedy, which made its appearance in Scotland, in 1896, is operated by suction, a pipe connecting the suction apparatus and milk pails with an interposed pneumatic pulsating apparatus comprising a valve mechanism actuated automatically by the suction itself to intermittently alter the pressure of suction in the pipes connected to the milk pails. This machine is too complicated and difficult to operate, takes up too much room, is hard to clean and keep in a very sanitary condition.

The following year Lawrence made a suction machine which is a combination of two cisterns alternately filled with water which descends from each through a pipe whose length corresponds to the suction desired. In one of the cisterns is an automatic distributing valve and float. A minimum suction reservoir, having a suitably loaded valve, is connected to a branch pipe from the maximum suction pipe. The maximum suction pipe is controlled by a valve to which is fixed a flexible diaphragm which is acted upon externally by atmospheric pressure. A similar valve and diaphragm controls an air inlet pipe. The pulsator consists of a cylinder, having a double ended or elongated piston, provided with a valve recess controlling the parts, one to the teat cups, another to the milk receptacle in which is the maximum suction and a third to the pipe in which minimum suction is kept. The teat cups, one of the chief necessities in mechanical milking, are stationary.

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This machine is very simple, readily cleaned and it is claimed that it requires less power to operate than any of the other late cow-milkers. When using the Globe it is difficult to determine when all the milk is drawn, only one sight glass being placed in the cover of each can while there should be one for each cow so that the teat cups could be removed from the udder as soon as possible.

The drawings show the methods of arranging this and the following machine in the dairy barn. The accompanying pictures show the Burrell-Lawrence-Kennedy while in operation, the method of attaching, and the dissembled parts. The first view is the vacuum pump and the following in order are the machine being attached, in operation, the milk cans and attachments, the cover showing the escapement spring and sight glasses, the pulsators and the last of all the different

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One of the late machines is the Globe which is operated by compression and vacuum. This machine requires two sets of piping, one for the vacuum the other for compressed air; although the machine is cheap, the extra piping makes the cost of installation some-what high. The milk cans are attached to the lead pipes by rubber hose. The vacuum pump is operated by compressed air and is arranged similarly to the common steam pumps, one cylinder operated by compression, the other simultaneously producing a vacuum. The pump induces a pulsation at each stroke, the forward movement of the piston creates an intensified vacuum while the backward stroke releases this vacuum thus giving the cow a sensation similar to that produced when man is milking or the calf sucking. The teat cups are of rubber, somewhat pliable at the top but quite rigid at the base, hence by inducing a vacuum the pliable top is drawn together while the rigid section remains permanent, producing a pressure at the top of the teat, closing the milk duct and extracting the milk.

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teat cups and their rubber mouth pieces. This machine was first placed on the market in 1904 but has been improved to such an extent and has done such effifient work that its use is becoming general among the well known dairymen of the U. S. These milkers are operated by vacuum or suction created by vacuum pumps or steam jets. A 4½ inch, two cylinder pump is generally used and is capable of maintaining sufficient vacuum to operate five machines milking ten cows at a time and requires about two to three mechanical horse power. The pump makes from seventy to seventy-five strokes per minute. The vacuum tank may be placed any place in the system. It is best to use two vacuum gauges, one in the milking barn, the other located near the pump so that one will act as a check upon the other. The suction pipes lead from the vacuum tank along the upper front part of the stanchions, and at every other stall a stanchion cock should be placed in the pipe. It is absolutely necessary to know that all joints are tight and it is best to test them occasionally to see that no leakage occurs. The suction pipes should be inclined toward the vacuum tank in order to draw off the moisture which is condensed from the warm air drawn from over the milk. The milk pail, to which are attached the pulsator, teat cups and connections, is connected to the stanchion cocks by a rubber hose. The pulsator consists of a piston and valves placed in the lid or cover of the milk can. Just above the piston is a bellows and when the air is drawn from the can the air in the bellows expands, forces the piston downward, cuts off the milk flow and at the same time pulls down an escapement spring which operates a small reversing valve letting the air into the can and causing the piston to be raised thus producing the pulsating movements characteristic of a calf sucking. The air is drawn from the can through

a cotton filter to take out the impurities and moisture. A throttle screw is placed on top of the pulsator dome to regulate the number of pulsations per minute. The teat cups are metallic, tapering and of different sizes to closely fit the teats of different cows, with mouth pieces of pliable rubber having a small opening in the center so that they will fit closely to the teats. If the teat cup is too large it does not give good results, lets air escape, causes the teat to swell and hinders the milk flow. The success of this machine depends largely upon the method of teat cup construction. During the summer months it has been found necessary to be especially careful in the use of teat cups and their rubber mouth pieces. While cows are on pasture and giving a large milk flow the udder and teats are larger and more tender and often sunburned and chapped so that it is advisable to use teat cups and mouth pieces that are a little large so as not to injure the teats.

For a limited time the writer made careful comparisons between hand milking and milking by machine - the Burrell-Lawrence-Kennedy being used -. The cows, seventeen in number, belonged to the college herd, their feed and attention being similar both before the machine was applied and while it was being used. In making this comparison the time required to milk a cow, variations caused by different pulsations of the machine or hand strokes of the men, the number of pounds of milk drawn per minute, the effect upon the cow, and the cleanliness of milking were noticed. No data was taken for the first three days that the machine was in operation, in order to let the cows return to their normal milk flow, if perchance the sudden change of milking should cause any discrepancy in the daily yield, but nothing of the kind occurred.

The first set of data is that taken from the cows milked by

hand, three men milking the different cows.

Milker.	No. of Cow.	Strokes per min.	Time.	Pounds.
No. 1	11	100	9	12.4
	17	74	8½	14.9
	16	70	6½	9.9
	11	104	9½	12.
	9	120	10½	10.9
	17	96	7	14.2
	16	102	5½	8.7
	11	122	7	9.5
	9	114	8	12.9
	17	96	9½	14.2
	11	98	8½	10.5
	10	108	9½	13.7
	11	98	8	10.9
	16	102	5	9.7
	11	110	7½	11.2
	9	104	8½	14.2
	10	114	8	12.9
Average		96	8	12.

According to the above table 1.5 pounds of milk were drawn per minute.

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Milker.	No. of Cow.	Strokes per min.	Time.	Pounds.
No. 2	9	140	12	12
	10	134	16	12.7
	10	130	16½	14
	9	130	13	11.5
	11	134	11½	9.6
	10	132	8	12.2
	9	130	7	12.5
Average		133	12 min.	12.1# or 1# per min.
No. 3	10	91	10	12.4
	10	104	14	10.
	10	112	11	14.5
	11	116	10½	11.
Average		106	11.4	12.

or 1.05 pounds of milk were drawn per minute.

For the three men the average number of strokes was 106.6, time to milk a cow 9.4 minutes, pounds of milk 12 or an average of 1.27 pounds per minute.

The best individual time was made by milker No. 1 on cow 16 (a Jersey) the average of three milkings being 1.7 pounds per minute. The slowest time was made by the last man when milking cow No. 10, only .71 pounds being drawn per minute, which was almost the identical time of No.2 while milking the same cow, but not more than one half as fast as No.1.

From the data given it appears that the more rapidly the strokes of the hand, the less will be the amount of milk drawn in a given time.

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In the following data the vacuum gauge on the machine was left at 17 although this might have been altered and the effect noticed if there had been sufficient time.

No. of Cows.	Pulsations	Lbs. of Milk	Time	Average for different pulsations.
	53	14.8	5½	
	54	24.8	7½	
	53	13.3	9½	
	52	10.	4	
Average	53	15.7	6.6 min. or 2.4# per min.	
1 & 2	64	16.2	11	
7 & 8	67	20.5	8	
14 & 15	68	18.5	8	
1 & 2	58	17.7	9½	
1 & 2	60	15.1	8½	
7 & 8	62	14.7	8½	
14 & 15	62	16.5	5	
12 & 13	64	15.6	9	
5 & 6	56	10.8	6½	
12 & 13	60	15.1	6	
3 & 4	61	11.1	4	
5 & 6	58	18.8	7	
12 & 13	60	18.5	11	
Average	61	16.26	7.8 or 2.16# per min.	

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No. of Cows.	Pulsations.	Lbs. of Milk.	Time	Average for different pulsations.
	46	11.8	8	
	46	19.4	5½	
	45	23	9	
	46	16.8	6	
	47	16.7	9	
	46	15.8	7	
3 & 4	41	11.5	6½	
5 & 6	48	16.7	8½	
12 & 13	48	18.3	7½	
1 & 2	45	15.4	8	
7 & 8	38	21.7	7	
14 & 15	41	16.2	4	
3 & 4	46	11.7	5	
5 & 6	45	15.5	6½	
4 & 4	38	11.2	3½	
5 & 6	38	12.7	5½	
7 & 8	44	20	10	
14 & 15	45	13	3½	
1 & 2	40	13.5	9	
7 & 8	38	18.5	8	
14 & 15	42	18.8	7	
Average	43	16.1	6.8	or 2.36# per min.

From the data given we find that it requires a little over 7 minutes to milk two cows with the machine, milking 2.3# per minute.

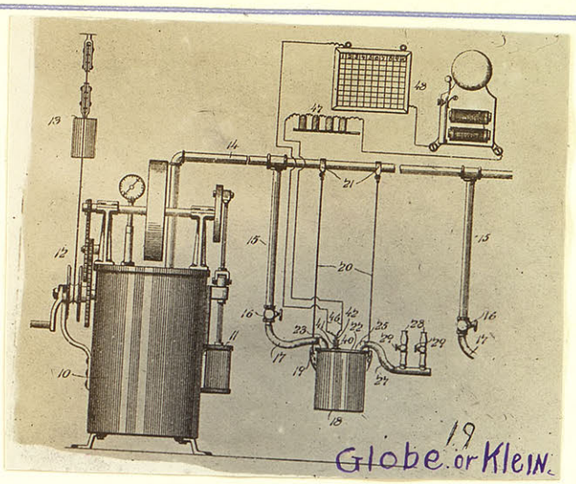
The company advocates the running of the machine at about 55 pulsations per minute to secure the best results. At 53 pulsations 2.4# were milked in one minute. The pulsators were changed so that one machine gave an average of 61 strokes per minute while the other made but 43. The slower speed gave the better results for .36# more milk were drawn at 43 pulsations than at 61, although the former was running 12 pulsations below the average while the other had been increased but 6. The best time was made at 41 pulsations, 4.05# of milk being drawn in a minute.

In one minute the machine will milk 1.03# more than a man, and if weighing and sampling were eliminated one man could attend to three buckets thus drawing 3.09# more than by hand in the same time, equivalent to a saving of two men, which in a year's time if practiced on a large dairy farm would more than pay for the machine.

At the College the milk is weighed and a sample taken at each milking causing a loss of almost 1/3 of the time. If samples were taken but once a week or if an extra can could be kept in the barn so that the machine could be immediately attached to other cows this loss of time would be largely eliminated.

The machine milks fairly clean and after repeated trials it has been found unprofitable to strip the cows as the butter fat thus obtained would not be sufficient to pay for the labor involved. The yearly expenses for the B. L. K. are very slight only a few dollars being required to get new rubber caps for the teat cups.

It would be better in this machine if the pulsator was



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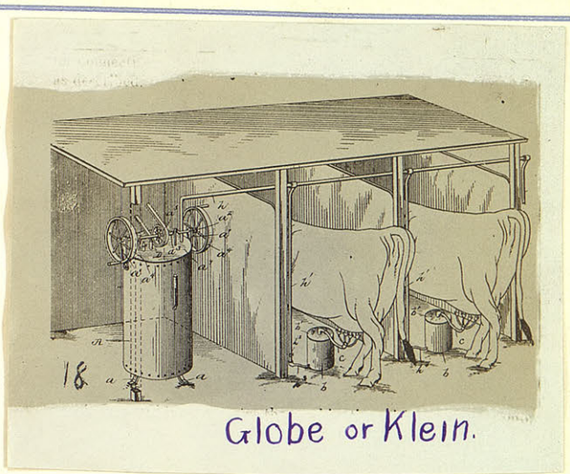
Globe or Klein.



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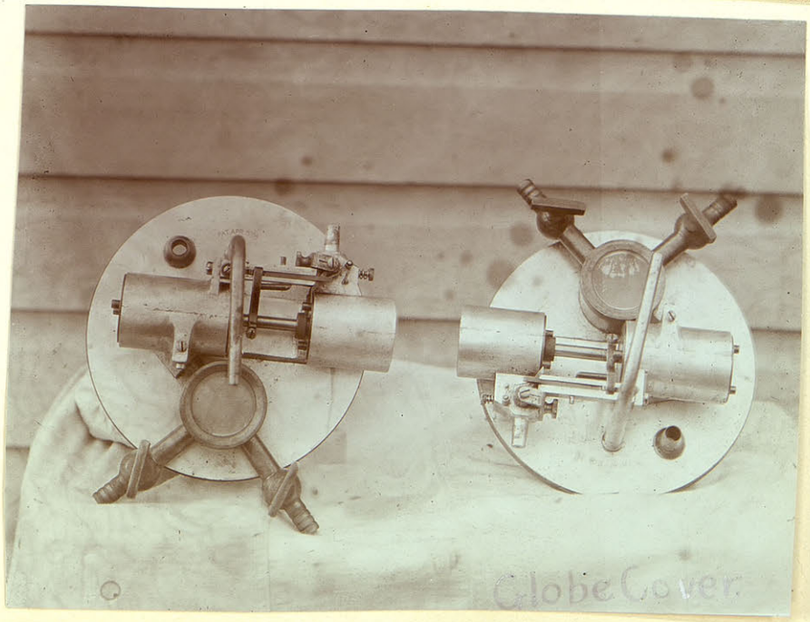
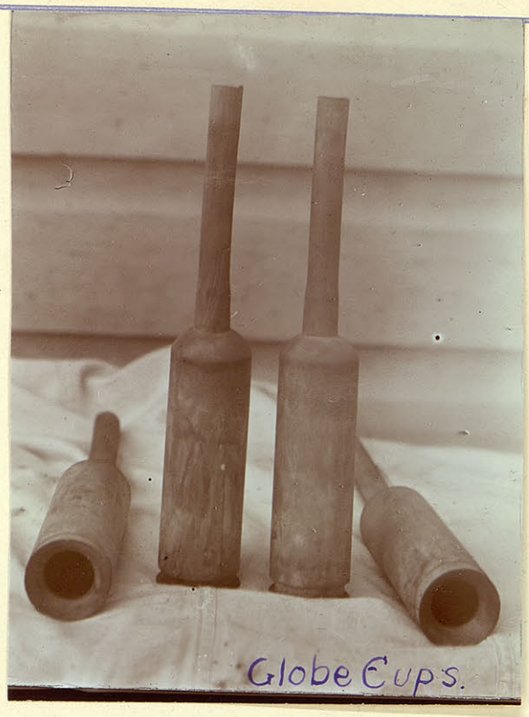
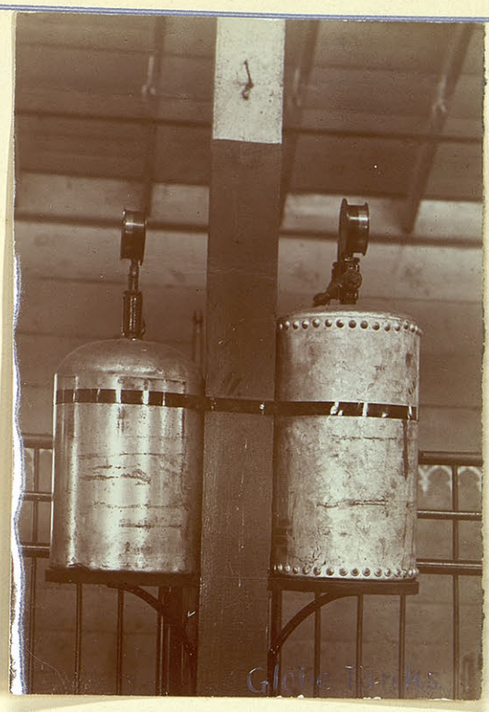
Globe or Klein.



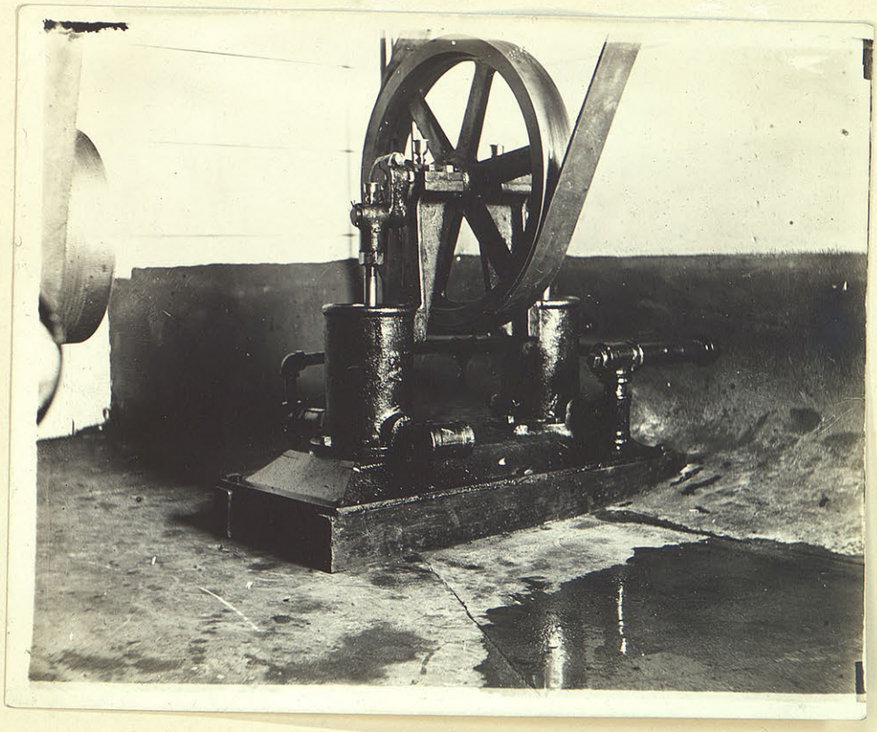
Globe Cover

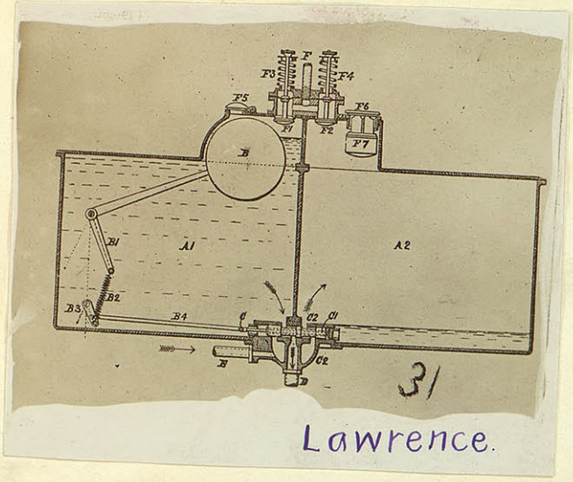


Globe Cups.

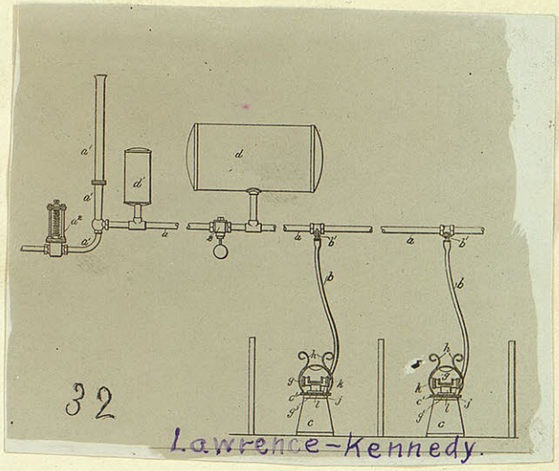


Globe Tanks.

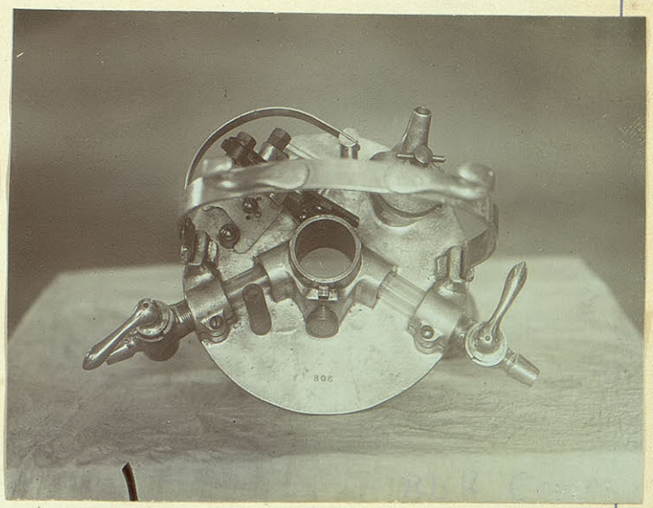


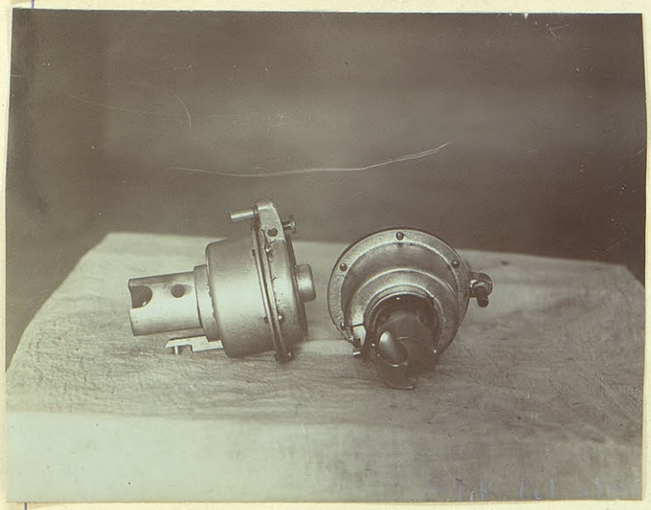


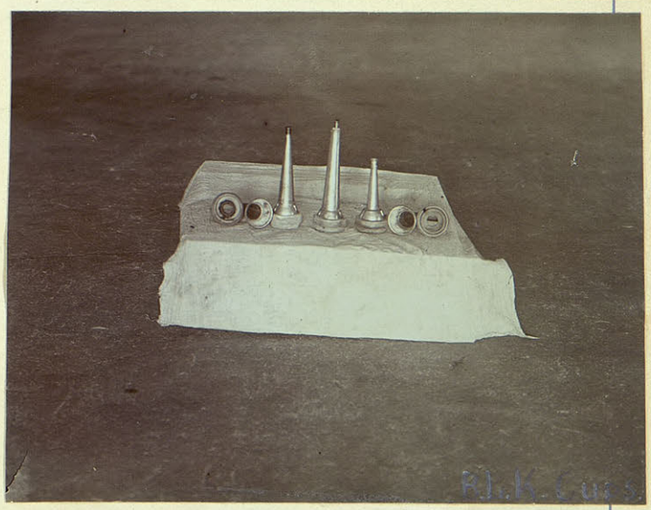
Lawrence.

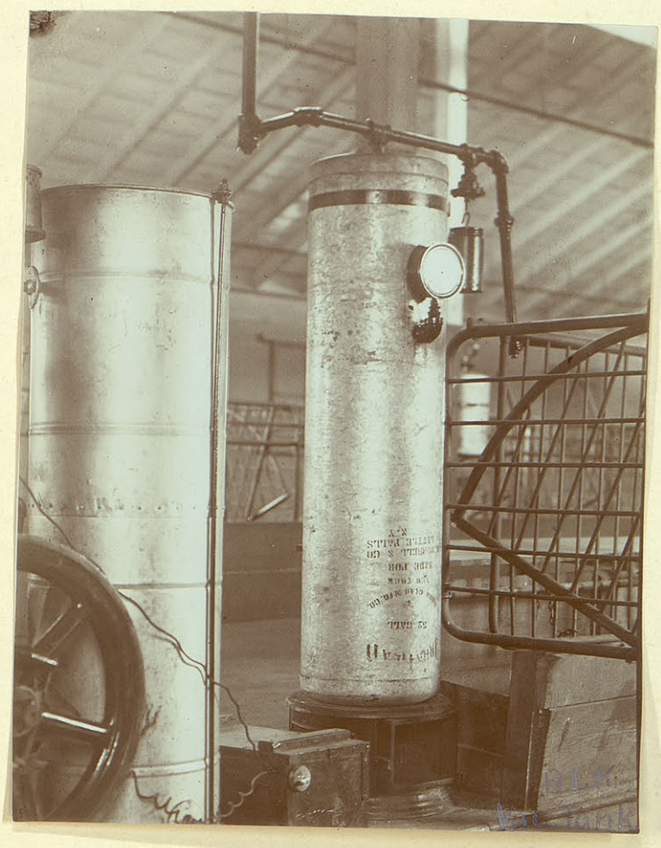


Lawrence-Kennedy.









immediately beneath the teats, the pulsating cylinder might also be changed and a division made in the can so that the milk from the two cows would not be mixed and then one might easily determine his unprofitable animals.

The use of this machine caused no material lessening of the milk yield, although there was 16 per cent less in the milk flow two weeks after the machine was first used; it was due to some other cause for the cows milked by hand suffered practically the same loss, influenced probably by the dry weather and the shortage of grass.

Gurler, the well known dairyman of Illinois, ordered his first machine in December, 1905, and after giving it a fair and thorough test he bought enough machines to milk his entire herd of over two hundred cows; a good indication of the efficiency and desirability of the milking machine when one considers the high grade of dairy products which Mr. Gurler has the reputation for producing.

At the time the preceding data was taken a similar test was made with the Klein or Globe machine. At first, because of the leakage of air, enough pressure could not be secured to operate both buckets. After the pipe connections had been carefully painted and the pressure and vacuum tanks connected, 42 pounds pressure and 17 inch vacuum was secured and the following data taken:

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No. of Cow	Pulsations	Time	Pounds of Milk
3 & 4	72	6	7.4
1 & 2	76	7	14.7
3 & 4	76	7	13.2
5 & 6	82	8½	13.2
1 & 2	76	6⅓	7.4
3 & 4	80	9	9.8
5 & 6	84	5	10.4
3 & 4	86	6	11.9
5 & 6	80	9	16.2
1 & 2	86	8	9.3
3 & 4	86	6	11.4
1 & 2	56	11	10.0
3 & 4	86	6	13.8
3 & 4	84	6	4.5
3 & 4	84	6	7.2
1 & 2	86	14	11.2
3 & 4	88	6	11.2
1 & 2	60	15	8.0
3 & 4	60	5	10.8
5 & 6	60	5	8.0
1 & 2	64	5⅓	10.8
Average	77	7.5	10.5 or 1.4# per min.

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No. of Cows	Pulsations	Time	Pounds of Milk
5 & 6	90	8	13.5
1 & 2	92	13	7.5
3 & 4	92	6	8.5
5 & 6	92	5⅓	10.5
1 & 3	96	10	10.2
3 & 4	96	4½	15.1
5 & 6	92	7⅓	11.5
5 & 6	100	8	14.2
1 & 2	92	9	5.5
5 & 6	92	5	8.5
1 & 2	100	12	11.3
3 & 4	96	7	14.2
5 & 6	96	6	14.4
Average	94	7.8	11.2 or 1.43# per min.

From the data given we find that it requires about 7½ minutes to milk two cows with the Globe, drawing 1.4 pounds of milk per minute, a little over one-half the amount drawn by the B.L.K. in the same time and slightly less than the amount which milker No. 1 milked by hand. No material difference was noticed by changing the number of pulsations per minute, for practically identical results were secured at 77 and 94 pulsations.

The best individual time was made at 96 pulsations, when 3.35 pounds were drawn in one minute, while the slowest time was .53 pounds per minute, at 60 pulsations, the reverse of the results obtained by changing the pulsator on the B.L. K.

At this rate the Globe machine is but little better than milking by hand. This is due largely to the teat cups, which are

of uniform size and cannot be varied to suit different cows, for in some cases the teats were so small that the cups would scarcely stay on and would permit air to escape, lessening the amount of milk drawn, or the cows teats would be so large that they filled the cup and prevented the suction from reaching the upper part of the cup so as to operate the pliable rubber to extract the milk. When the cups were too large they irritated the cow, and when too small the teats soon became cracked and swollen so that the animal became restless whenever the machine was attached to her.

That the inefficiency of the Globe machine is due to the teat cups was easily proven, for when B.L.K. cups were used on the Globe machine none of the undesirable results given above were secured, indeed the Globe then did almost as good and as rapid work as the B.L.K. itself.

For a time the compression valve of the Globe was closed and the machine operated by suction alone. Although there were no pulsations, yet the amount of milk drawn per minute averaged almost four pounds, better by far than any results previously obtained, although this experiment was not continued long enough to determine what the final effect upon the cow would be.

It was found to be absolutely necessary to strip most of the cows after the Globe was detached, as an average of one-half to one pound of milk was usually secured from each animal, enough to pay for the extra labor necessary as well as to lessen the length of the lactation period.

As in the B.L.K. there was a lessening of the milk flow, but not to so great an extent. Taking everything into consideration the Globe does not seem to be nearly so practical a machine as

the B.L.K. While the latter is very expensive, yet it would undoubtedly be profitable for those who have large herds to use them in place of human labor for milking, as there would be a saving of time and expense, the cows suffer no ill effects because of the machine, the milk is cleaner, the milking more uniform as the pulsations are varied only at will, and lastly, it is far more pleasant for a dairyman to watch and experiment with a mechanical cow milker while in operation than to draw the milk by the old method.