INTRODUCTION

For several years a milking experiment has been carried on at the National Agricultural Research Center, at Beltsville, Md., in which records were kept of the milk and butterfat production of dairy cows when the udders were milked incompletely (without stripping) for at least one entire lactation period, as compared with their production for one or more lactation periods in which the udders were milked completely (with stripping) at each milking. The udders and milk were examined at frequent intervals for evidences of abnormalities.

REVIEW OF LITERATURE

At the time this experiment was started, in 1930, the belief was practically universal that leaving some of the milk in the udders of dairy cows at each milking would reduce the percentage of butterfat.
in the milk produced, cause the cows to dry off rapidly, and possibly lead to udder troubles. The discovery by Swett, Miller, and Graves (14, pp. 385, 399) that the secretion of milk is continuous instead of taking place only at the time of milking as had been thought to be the case for many years, increased the skepticism of the authors regarding the validity of certain other common beliefs about milking. For example, it did not appear reasonable that the leaving of a pound or so of milk in the udder could be very harmful in view of the fact that this amount would be secreted normally in the course of not over 2 hours after milking.

It is a matter of common knowledge that the percentage of butterfat in the last milk drawn at a milking is higher than that in the first milk drawn. The assumption, therefore, that incomplete milking will reduce the percentage of butterfat in the total milk produced is perhaps one that might naturally be expected. The work of Isachsen and his coworkers (8) lends support to this assumption. He states that the first milk drawn generally contains less than 1 percent of fat, and the last milk drawn has from 10 to 11 percent. He states also that if a part of the milk is left in the udder, the fat content of the first milk drawn in the next milking is not higher than usual, and there was no indication that the fat which is supposed to be held back in the udder until the end of the milking reappears in later milkings.

Alexander (1, p. 114) found in his work that on an average 2 ounces of milk was left in the udders when milked with a machine. The milking of four cows by machine over a period of 12 weeks without stripping gave no indications that stripping is necessary in all cases. A few cows in the rest of the herd, however, persisted in withholding considerable milk from the machine, and it is stated that such cows should be stripped.

In 1897 Nelson of the New Jersey Agricultural Experiment Station (10, p. 246) reported that incomplete withdrawal of milk from the udder is one of the exciting causes of mastitis in dairy cattle. A similar opinion has been expressed rather recently by Udall and Johnson (15), who state that in their experience incomplete milking contributes to the spread of mastitis, and it spreads less readily in herds milked by hand, because the milking is probably more thorough, than in those milked by machine. Statements by others expressing this view may also be found in the literature on mastitis.

On the other hand, Maurer and Steidle (9) found that incomplete milking did not cause mastitis in cows with healthy udders over a period of 4 months and also failed to cause the acute form in an udder infected with latent mastitis.

Since the work reported in this bulletin was started, both the Iowa and Minnesota Agricultural Experiment Stations have conducted and reported certain experiments on incomplete milking. Wilson and Cannon (18, pp. 336–338) at the Iowa Station, in work with eight cows for 4½ months, found that stripping cows by hand after they were milked by a machine required an average of 1.57 minutes per cow per day, and that 1.2 pounds of milk was obtained in the stripplings. These investigators estimated that 0.55 pound, or 46 percent, of the milk left in the udder when the cows were not stripped was recovered at subsequent milkings, and that there was a loss, therefore, of 0.65 pound, or 54 percent, of milk that would have been obtained by

1 Italic numbers in parentheses refer to Literature Cited, p. 25.
stripping. No change in the percentage of fat in the milk produced was caused by not stripping the cows.

In a study at the Minnesota Agricultural Experiment Station on methods of drying off cows, a short test by Wayne and Macy (17, pp. 88-89) indicated that incomplete milking increased the number of cells in the milk obtained but did not increase the number of bacteria in the milk. In another study at that station (16), to determine whether nonstripping affects the bacterial count of the milk, the results were negative both with cows that milk out poorly and those that milk out well with the machine. This was stated to be true for cows whose milk was normally of the high-count type as well as for those whose milk was normally of the low-count type.

PLAN OF EXPERIMENT

The objects of the work reported herein were to determine the relation of incomplete milking (nonstripping) to the quantity of milk produced, the percentage of butterfat in the milk, the persistency of milk flow, and abnormalities of the udders and milk.

The plan was to milk each cow with the machine for at least two lactation periods. In one of these she was to be milked completely (with stripping), and in the other incompletely (without stripping). Some of the cows first made their record on complete milking, and then their record on incomplete milking. Other cows made their record on incomplete milking before the one on complete milking. If a cow made three records, she was milked the same way in the third lactation as in the first. Although shorter periods no doubt would have sufficed for most of this work, they would not have yielded the desired information on quantity of milk produced and the persistency of milk flow.

Records of milk and butterfat production were kept in the usual way. Samples of milk from the individual cows were taken weekly, and examinations made in the laboratory for evidence of abnormalities. Udders were examined by palpation and the milk was examined by the strip-cup method, nearly every month.

On account of the difficulty in getting two or more lactation records of a cow that are exactly comparable in every way, it was considered necessary in this investigation to have the number of cows large enough to equalize unavoidable differences between the records made on complete milking and those made on incomplete milking.

METHODS OF MILKING AND FEEDING THE COWS

Fifteen cows were used in this work. Although the group was made up of 2 registered Jerseys, 2 registered Holstein-Friesians, and 11 grade Holsteins, it was not a part of the study to compare results on the basis of breed. Five of the cows made records for three lactations; eight for two lactations; and one cow (cow A-42) for part of two lactations. The production of these 14 cows is reported on pages 8 and 9. Cow A-53 also finished two lactation records, but developed an unthrifty condition from causes that were not apparent. Her milk production for both lactations was much below her inherent capacity. For this reason her records were not used in estimating the average quantity of milk produced, or the persistency of milk flow. Her milk, however, appeared to be more nearly normal than that of some of the other cows (p. 15).
Seven of the fourteen cows whose records are used were started on incomplete milking and seven on complete milking. Two of the cows were started in the experiment after dropping their second calves. All the rest were either of mature age or nearly so when they entered the experiment. The records of the immature cows as presented herein have been calculated to a mature basis by using factors prepared by the Bureau of Dairy Industry, and are therefore comparable with those of the mature cows. Two of the cows (no. 278 and no. A-44) were milked three times a day; all the rest were milked twice a day.

An effort was made to have the different records of each cow comparable, from one lactation to the next, as regards feed, length of dry period previous to calving, and her condition at time of calving. In the winter the roughage fed was alfalfa hay and corn silage. This was given each cow in such quantities as she would eat without undue waste. Supplementary concentrates were fed in such quantities that the amount of total digestible nutrients in the ration would approximate the required amounts as calculated from the feeding standards. In the summer all the cows except two (no. 278 and no. A-44) were on pasture. Grain and sometimes silage or hay were used to supplement the pastureage. The amount fed was adjusted every month or oftener and varied with the condition of the cows and the abundance of the pastureage.

Since the dates on which the cows were due to calve were known from their breeding records, it was possible to so dry them off that the average dry period of the cows when milked completely agreed very well with that of the same cows when milked incompletely. It was usually possible also, by using the system of rating for condition of flesh described in a previous publication (19) and by increasing or decreasing the quantity of grain fed, to put each cow in about the same state of flesh at calving time as she was at the previous calving.

One-day samples of milk were taken for butterfat tests on about the seventh or eighth day and again on about the twenty-second or twenty-third day of each month. The samples of each milking were tested separately and the butterfat was calculated for each milking. The pounds of butterfat for each of the 2 days were added together, and the sum was divided by the sum of the milk produced on the 2 days. The result was taken as the average test for the month.

In order to guard against udder infections from causes other than incomplete milking, the udders and teats were washed with a chlorine solution previous to milking, the teat cups were either rinsed with water or dipped in a chlorine solution before they were placed on the teats; and after each milking the teats were immersed in a non-irritating antiseptic, carried in a 10-percent soap solution. The purposes of its use were to destroy any bacteria at the openings of the teats, and to form a film that would tend to prevent the entrance of bacteria during the intervals between milkings.

**DRAWING THE LAST MILK**

In the early part of the experiment complete milking was accomplished by stripping the cows by hand after the teat cups of the milking machine had been removed. Hand stripping was soon discon-
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continued, however, and complete milking was accomplished while the

tent cups were in place by manipulating the udder with the hands

at the close of the milking period; the milk so obtained also passed

into the glass container of the milking machine. Observations had

shown that the last milk is removed as completely by manipulating

the udders as in stripping by hand.

When the cows were being milked incompletely, the tent cups

were removed from the udders as soon as the milk stopped flowing

into the glass container of the milking machine. It was the practice

at first to strip these cows on 1 day each week by hand and weigh

and record the milk thus obtained in order to estimate the quantity

of milk being left in the udder the other 6 days of the week. Later,

hand stripping was replaced by manipulation.

The manipulations practiced at Beltsville consist of pulling down

on the tent cups and at the same time gently squeezing the lower

part of the udder. Care is taken to avoid squeezing the udder so

hard as to cause bruises; bruises are generally recognized as one of

the causes of mastitis.

PHYSICAL EXAMINATION OF UDDERS AND MILK

Physical examinations of the udders were made at intervals

of a month or so and any abnormalities such as swellings, lumps,
sores, etc., were noted. When these examinations were being made,
a few streams of the milk were drawn into a strip cup in order to
detect the presence of any curd flakes.

LABORATORY TESTS OF THE MILK

COLLECTING THE MILK SAMPLES

Weekly examinations of the milk were made for chlorine content,

numbers of cells, total bacteria, and streptococci. These tests

were used as measures of the abnormality of the milk. The abnormal­

ities did not necessarily render the milk unfit for consumption.

Samples for these tests were taken from the milk of 11 cows (p. 15)
in two different lactation periods or part of a period, one series

being taken when the cows were milked completely and another

series when they were being milked incompletely. As the chlorine
determination was not made on some of the early samples, the data

for this test are not so complete as for the cells and bacteria. Occa·

sionally the weekly tests were not made or a sample was lost by

breakage or contamination.

Two samples of milk were collected for examination. The sample

for making the cell count and chlorine determination was taken

from the glass receptacle of the milking machine so as to represent

the entire milking. The sample to be used for examination for

Streptococcus mastitidis (S. agalactiae) was obtained by drawing

an equal amount of milk directly from each quarter of the udder

into a sterile tube. The latter sample was taken with proper care
to prevent contamination and from the last milk drawn so that
any abnormality would more nearly represent deep-seated infection.

3 These examinations were made by Fred W. Miller, senior physiologist and veterinarian, Bureau of
Dairy Industry.

4 Standard plate count.
DETERMINATION OF STREPTOCOCCI AND TOTAL BACTERIA

As soon as the samples of milk were drawn they were placed in chipped ice.

Plating was done within a period of 5 hours from the time the milk was drawn from the udders. Plates were prepared using both standard beef-extract medium, and a blood-agar medium. The composition of the latter was as follows (3): Infusion broth, 500 cc; peptone (Parke Davis), 10 g; NaCl, 5 g; distilled water, 500 cc; and shredded agar, 15 g. The reaction of the medium was adjusted to pH 7.5. The medium was melted, cooled to 45° C. and 0.5 to 1.0 percent of defibrinated horse blood added. The counts of streptococci and total number of bacteria were made after incubation for 48 hours at 37°.

From April 1933 until the close of the experiment, the streptococci counts were checked on esculin agar of the following composition (4):

Infusion broth, 1,000 cc; peptone, 10 g; salt, 5 g; agar, 15 g; esculin, 0.5 g; ferric citrate, 0.5 g; crystal violet diluted 1 to 200,000; defibrinated horse blood, 5 percent.

After the plate counts of streptococci had been made, a representative colony was fished and planted into a tube of infusion broth and incubated 24 hours at 37° C. Inoculations from this infusion-broth culture were made into litmus skim milk and methylene blue skim milk, the latter containing 0.005 percent of the dye. These were incubated for another 24 hours at 37° and examined for characteristic reactions of Streptococcus mastitidis. This organism does not reduce the blue color or coagulate methylene blue of the above dye content. Litmus milk is slightly reduced, acidified, and usually coagulates in about 24 hours.

CHLORIDE TEST

The chloride test was developed by Hammer and Bailey (5) for use in detecting abnormal milk. If the udder tissues are broken down either by physical or bacterial infection, the blood plasma will filter through into the milk and cause an increase in the sodium chloride content of the milk. A satisfactory comparative index of the amount of chlorides expressed as chlorine can be obtained by direct titration. This was done by placing 10 cc of milk in a beaker, diluting with 30 to 40 cc of distilled water, adding 5 drops of 10-percent solution of potassium chromate, and titrating with tenth-normal silver nitrate until the desired end point was reached. Each cubic centimeter of silver nitrate represents 0.0355 g of chlorides, expressed as chlorine, per 100 cc of milk.

When this test is used, normal milk is generally assumed to have a chloride content equivalent to 0.08 to 0.18 g of chlorine per 100 cc. On account of the fact that slight variations in titrating are possible, it is thought that 0.15 g of chlorine per 100 cc of milk should be taken as the point denoting an abnormal condition. Hucker, Trudell, and Jennings (7) in a study of milk from over 100 quarters of udders of dairy cows concluded that the above test was very accurate in detecting udders which have become fibrotic or indurated to some degree.

1 The defibrinated horse blood was obtained from the Bureau of Animal Industry.
MILK PRODUCTION AND UDDER TROUBLES IN DAIRY COWS

CELL COUNT

The cell count of each cow's milk taken from the receptacles of the milking machine, was made by direct microscopic examination according to the standard procedure given by the American Public Health Association (2, p. 30). In this work both leucocytes and epithelial cells were counted.

The cell count alone does not necessarily indicate udder infection, as other factors such as slight injuries may cause excessive numbers of cells. However, when used in conjunction with the streptococcus count and chlorine content, the cell count serves as an indication as to the normality or abnormality of both the udder and the milk.

FACTORS INFLUENCING PRODUCTION

Table 1 shows the quantities of milk and butterfat produced by each cow under the conditions of this experiment in lactation records made equal in length, for complete and incomplete milking, together with breeding and other data related to production.

ORDER IN WHICH RECORDS WERE MADE

Seven of the fourteen cows whose production is reported in table 1 made their records in the herd at Beltsville that was negative to the agglutination test for infectious abortion (Brucella abortus). For some unknown reason, each of six cows (nos. A-27, A-33, A-43, A-36, A-46, and 619) from the abortion-free herd produced less milk during her second lactation period than during her first lactation period in this experiment, regardless of the method of milking. The cow that gave more was no. 277. Cow no. 619 had three successive lactations in this experiment. Assuming a progressive decline in production the average of the first and third lactations should be comparable with the second lactation. Therefore, in her case, the possible influence of this unknown factor causing the decline in production may be considered as eliminated. Three of the six other cows from this herd made their first record on complete milking, and three made their first record on incomplete milking.

Seven cows made their records in the herd which is segregated because of abortion disease on a separate part of the farm. All of these cows dropped normal full-time calves. Six of the cows (nos. A-14, A-20, A-13, A-42, 629, and A-44) each produced less milk in her first lactation, and one cow (no. 278) made her lower record in her second lactation during this work. Four of these seven cows made their first records while being milked completely, and the other three made their first records while being milked incompletely. Four of them (A-14, A-20, A-13, and 629) each had three calves and finished three full lactations. Of the three remaining two made their first records on incomplete milking and one made her first record on complete milking.

The purpose of this discussion is to show that, although the tendency in one herd was toward lower production from one lactation to the next and in the other the trend was toward greater production, the groups were well balanced in respect to the order in which the records were made and this has reduced any possible error to a minimum.
| Cow no. and lactation | Method of milking | Age at calving | Dry period before calving | Condition at calving | Days taken to calve | Weight at end of lactation period | Gain (+) or loss (-) in body weight | Lactation period | Days from calving to conception | Days pregnant at end of lactation | Average milk left in udder per milking | Total milk in lactation period | Butterfat | Total butterfat in lactation period | Production calculated to mature basis |
|-----------------------|-------------------|----------------|--------------------------|---------------------|--------------------|-------------------------------|-------------------------------|-----------------|---------------------------------|-----------------------------------|--------------------------------|---------------------------|-----------------------------|------------------------------------------------|
| A-14 | First | Complete | 5 0 | 126 | 86 | 75 | 1,163 | 1,210 | +77 | 120 | 107 | 147 | 1.2 | 7,999 | 3.35 | 275.8 | 282.9 |
| Second | Incomplete | 6 6 | 117 | 1,180 | 1,251 | +54 | 200 | 103 | 61 | 0 | 8,191 | 3.25 | 295.9 | 298.9 |
| Third | Complete | 7 6 | 117 | 1,180 | 1,251 | +54 | 200 | 103 | 61 | 0 | 8,191 | 3.25 | 295.9 | 298.9 |
| A-20 | First | Complete | 4 9 | 83 | 1,211 | 1,298 | +87 | 290 | 87 | 127 | 0 | 5,856 | 3.46 | 262.7 | 263.7 |
| Second | Incomplete | 6 9 | 89 | 1,255 | 1,372 | +177 | 290 | 72 | 122 | 0 | 6,435 | 3.60 | 291.7 | 291.7 |
| Third | Complete | 6 9 | 92 | 1,312 | 1,459 | +177 | 260 | 52 | 125 | 2 | 6,052 | 3.55 | 285.8 | 288.8 |
| A-13 | First | Incomplete | 6 5 | 379 | 1,215 | 1,370 | +55 | 300 | 333 | 0 | 2.1 | 11,655 | 4.08 | 475.8 | 475.8 |
| Second | Complete | 8 1 | 132 | 1,378 | 1,340 | -38 | 300 | 122 | 132 | 0 | 12,620 | 4.12 | 519.9 | 519.9 |
| Third | Incomplete | 9 2 | 85 | 1,313 | 1,216 | -33 | 300 | 205 | 90 | 1.5 | 12,561 | 4.05 | 508.7 | 502.7 |
| A-12 | First | Complete | 3 6 | 48 | 1,090 | 1,149 | +59 | 120 | 97 | 27 | 1.7 | 4,552 | 3.80 | 173.0 | 170.0 |
| Second | Incomplete | 4 5 | 81 | 1,205 | 1,191 | -14 | 120 | 97 | 27 | 1.7 | 4,552 | 3.80 | 173.0 | 170.0 |
| O29 | First | Complete | 6 10 | 85 | 1,012 | 1,031 | -8 | 290 | 212 | 42 | 0 | 5,186 | 4.82 | 260.0 | 260.0 |
| Second | Incomplete | 5 3 | 111 | 1,044 | 971 | -73 | 290 | 87 | 123 | 1.2 | 9,603 | 4.57 | 438.9 | 438.9 |
| Third | Complete | 9 1 | 74 | 1,050 | 993 | -57 | 290 | 201 | 63 | 0 | 9,476 | 4.55 | 431.2 | 431.2 |
| 610 | First | Incomplete | 7 9 | 100 | 986 | 926 | -59 | 240 | 37 | 207 | 1.1 | 5,764 | 4.94 | 374.5 | 374.5 |
| Second | Complete | 7 7 | 80 | 1,039 | 977 | -63 | 290 | 56 | 130 | 0 | 1,725 | 4.76 | 226.1 | 226.1 |
| Third | Incomplete | 9 6 | 77 | 975 | 955 | -20 | 210 | 91 | 133 | 0 | 4,793 | 4.63 | 221.9 | 221.9 |
| 27S | First | Complete | 9 1 | 65 | 1,335 | 1,433 | -102 | 300 | 208 | 224 | 0 | 14,998 | 3.12 | 467.9 | 467.9 |
| Second | Incomplete | 10 1 | 46 | 1,337 | 1,447 | +110 | 300 | 208 | 224 | 0 | 14,998 | 3.12 | 467.9 | 467.9 |
| A-41 | First | Complete | 3 9 | 72 | 1,120 | 1,162 | +42 | 310 | 129 | 155 | 1.3 | 14,262 | 3.37 | 405.6 | 405.6 |
| Second | Incomplete | 4 10 | 68 | 1,190 | 1,220 | +30 | 310 | 129 | 155 | 1.3 | 14,262 | 3.37 | 405.6 | 405.6 |
| A-27 | First | Complete | 6 8 | 54 | 1,305 | 1,436 | +51 | 290 | 78 | 183 | 0 | 9,836 | 3.75 | 358.5 | 358.5 |
| Second | Incomplete | 7 8 | 59 | 1,402 | 1,463 | +61 | 260 | 61 | 203 | 1.0 | 7,636 | 3.76 | 287.1 | 287.1 |
| 277 | First | Complete | 9 7 | 116 | 1,440 | 1,577 | +137 | 210 | 43 | 171 | 1.4 | 9,255 | 3.19 | 159.0 | 159.0 |
| Second | Incomplete | 10 6 | 101 | 1,400 | 1,373 | -25 | 210 | 165 | 49 | 0 | 7,247 | 3.07 | 222.5 | 222.5 |
| A-12 | First | Complete | 6 6 | 90 | 1,430 | 1,539 | +109 | 270 | 65 | 209 | 0 | 10,542 | 3.29 | 356.7 | 356.7 |
| Second | Incomplete | 7 5 | 93 | 1,345 | 1,403 | +113 | 220 | 117 | 157 | 1.1 | 7,813 | 3.30 | 257.8 | 257.8 |
|          | First            | Second          | Average         |          |          |          |          |          |          |          |          | Average for 4 cows. | Average for 11 cows. |
|----------|------------------|-----------------|-----------------|----------|----------|----------|----------|----------|----------|----------|---------------|----------------------|
| A-43:1   |                  |                 |                 |          |          |          |          |          |          |          |               |                      |
|          | do               | Complete        |                 |          |          |          |          |          |          |          |               |                      |
|          | 4 8              | 58 65           | 1,063 1,164     | +131 290| 70 221   | 9 0     | 8,630 3,56| 157.2 9,148| 325.7    |          |               |                      |
| A-46:1   |                  |                 |                 |          |          |          |          |          |          |          |               |                      |
|          | do               | Incomplete      |                 |          |          |          |          |          |          |          |               |                      |
|          | 4 6              | 33 61           | 1,089 1,128     | +39 270| 62 212   | 1,0     | 8,496 3,63| 325.4 9,091| 348.2    |          |               |                      |

1 Grade Holstein.  
2 Not pregnant.  
3 Registered Jersey.  
4 Registered Holstein-Friesian.  
5 Average for 10 cows.  
6 Average for 11 cows.
LENGTH OF DRY PERIOD BEFORE CALVING

The number of days each cow was dry before freshening in this experiment is given in table 1. On an average the cows were dry 80 days previous to the lactation periods in which they were milked completely, and 87 days before the lactation periods in which they were milked incompletely. If the results for cow no. A-13, whose dry periods were abnormally long, are omitted, the averages are 75 and 76 days, respectively. Investigations in England (12) have shown that the production of milk increases with the length of the dry period until a dry period of from 90 to 100 days is attained. A dry period longer than this does not affect the production. How much of this increase in the milk is due to the length of the dry period, and how much to a possible improvement in the state of flesh is not apparent. In any event, it appears that in the work at Beltsville the differences in the dry periods of the cows, shown in table 1, are sufficient to be measurable in subsequent production with only four cows—A-42, 629, 278, and A-46. Two of these had the shorter dry period when milked completely, and two when milked incompletely. It seems, therefore, that the groups are well balanced in respect to the dry period.

AGE AT TIME OF CALVING

The average age of the cows at calving when they were to be milked completely was practically the same as when they were to be milked incompletely. The highest correction for age in any case was 15 percent in the yields of milk and butterfat calculated to maturity in table 1. Eight of the fourteen cows were over 6 years old when the experiment was started. No correction was made for the production of these eight cows.

CONDITION AT TIME OF CALVING

Since a cow may lose weight rapidly after calving, any observations as to her condition of flesh at the beginning of the lactation period should be made before or shortly after the calf is born. For various reasons several observations were missed. Those that were made are given in table 1, and indicate that the cows calved in slightly better condition when milked completely than when milked incompletely.

FIRST WEIGHT AFTER CALVING

The regular practice at Beltsville is to weigh all cows for 3 consecutive days on the first, second, and third day of each month. It was also the practice during part of the period covered by this investigation to keep cows quarantined for about 10 days after calving. For these reasons, the cows were not weighed at any certain number of days after calving. However, the average period that elapsed after a calving until the cow was weighed was 15 days when she was milked completely and 16 when she was milked incompletely. The first weights taken after calving are shown in table 1. These weights bear out the observations regarding the condition of the cows in that the cows when completely milked were a little heavier. When the cows were to be completely milked, the average of the first weights after calving was 1,250 pounds; when they were to be incompletely milked, the average was 1,211 pounds. A small part of this
difference of 39 pounds can be explained by the immaturity of two of the cows milked incompletely.

GAIN OR LOSS IN WEIGHT

When the cows were milked incompletely the average live weight at the end of the lactation period was 1,273 pounds per cow, and when they were milked completely it was 1,263 pounds. Although a few cows lost weight during the lactation period, most of them gained both on incomplete and complete milking, as shown in table 1. If the total live weight of all 14 cows at the beginning of the lactation periods, when they were milked incompletely, is subtracted from the total live weight at the end of the lactation periods the difference indicates an average increase or gain of 62 pounds per cow under this method of milking, as against an average increase of 13 pounds when the weights of the cows at the beginning and end of the complete-milking lactations are taken. The greater gains of the cows when milked incompletely tend to offset the disadvantage of their smaller initial weights.

LENGTH OF LACTATION PERIOD

The length of the lactation periods is admittedly short. Some of the cows used were short milkers. Other cows continued to give milk beyond the periods stated in table 1 for certain lactations, but in order to make the two or three lactation periods of any individual cow the same length, the longer lactation or lactations were curtailed as explained on page 12, to equal the shortest. Cow A-42 had a growth in her throat which was first noticed about 4 months after she had calved for her second record. For this reason, both of her records were cut to 120 days. The shortness of the lactation records was not due to the rapid drying off of the cows milked incompletely. This is explained in the discussion on persistency of milk flow.

PRODUCTION OF MILK FROM COMPLETE AND INCOMPLETE MILKING

The average actual production of milk for lactation periods was 9,134 pounds per cow when milked completely and 8,682 pounds when milked incompletely. This represents a difference of 452 pounds in favor of complete milking. Eight of the fourteen cows gave more milk when milked completely.

On the basis of the records calculated to maturity, 9 of the 14 cows gave more milk when milked completely than when milked incompletely. The average quantity produced by complete milking was 9,281 pounds per lactation, and that produced by incomplete milking was 8,910 pounds, or about 96 percent as much. This is a difference of 371 pounds in favor of complete milking.

By making a final correction, as explained later, for the length of pregnant period, the difference is brought down to 306 pounds in favor of complete milking.

YIELD CORRECTED FOR PREGNANT PERIOD

Results of certain investigations in England by Hammond and Sanders (6), and those of unpublished calculations based on data from the Beltsville herd records, show that pregnancy hastens the decline
in milk production and that such hastening may begin about 120 days after the time of conception. Ragsdale, Turner, and Brodie (11) state that the decline due to pregnancy starts at about 5 months after conception. Staff (13) indicates that the decline starts at 110 days after conception.

In this investigation the cows carried calves on an average 130 days during the lactation periods when they were being milked completely, and 153 days during the periods when they were being milked incompletely. Of the 14 cows, 7 were pregnant longer when being milked incompletely than when being milked completely; 5 were pregnant longer when being milked completely; 1 was pregnant the same length of time in each case; and with 1 cow pregnancy was not a factor as the lactation period was only 120 days in length.

As it appeared that the lactation records made on complete milking and those on incomplete milking are not strictly comparable as regards the matter of pregnancy, the milk yields were recalculated using only the number of days milked up to 120 days after conception. This curtailed the average number of days milked from 258 days to 184 days. Figured to maturity the average production in 184 days of complete milking was 7,635 pounds, and under incomplete milking it was 7,366 pounds or 96.7 percent of that under complete milking. The average production on a mature basis for whole lactation periods averaging 258 days on incomplete milking was 96.0 percent of that on complete milking. Possibly the slight difference (96.7-96.0) may be attributed to the difference in length of pregnant periods.

If it is assumed that the cows when being milked incompletely carried calves the same number of days as when milked completely, and would have produced 96.7 percent as much milk during the whole lactation period, or at the same rate as in the 120 days after conception, then the production would have been 9,281 pounds for complete milking, as before, and 8,975 pounds for incomplete milking, or they would have yielded 306 pounds more milk in the former case. This difference of 306 pounds represents an increase of 3.4 percent due to complete milking, which is a little more than the 2.5 percent increase obtained at the Iowa Agricultural Experiment Station (18).

There are so many environmental factors that may affect one of two or three lactation periods that the slight difference in production noted in this investigation might conceivably be caused by some factor other than incomplete milking. However, the fact that 9 of the 14 cows gave higher yields on complete milking is an indication that incomplete milking was the cause of the lower yield.

**QUANTITY OF MILK LEFT IN THE UDDEr BY INCOMPLETE MILKING**

The average quantity of the milk that remained in the udder after an incomplete milking varied more with the different cows than with the stage of lactation or any other factor. It seemed natural for some cows to milk out fairly well and for others to retain a somewhat larger quantity.

The average quantity left in the udder after an incomplete milking, as determined by weighing the milk obtained just before and after massaging the udder on 1 day each week, ranged from 0.8 to 2.1 pounds for different cows, the average for all cows being 1.2 pounds per milking for the entire lactation period. The average
quantity left in the udder was twice the average quantity obtained at the Iowa Station (18) by stripping after a milking machine.

If no part of the milk left in the udders after each incomplete milking were recovered in subsequent incomplete milkings, there would have been a permanent loss of 576 pounds of milk per cow per lactation (480 incomplete milkings times 1.2 pounds) as a result of incomplete milking. But since the total production obtained by incomplete milking was only 306 pounds less per cow per lactation than that obtained by complete milking, it is evident that 270 pounds, or 47 percent of the 576 pounds, was recovered in subsequent milkings and only 306 pounds, or 53 percent was permanently lost.

The Iowa results indicate a loss of 54 percent of the milk that would have been obtained in the stripplings. In making these calculations from the Beltsville data, it is recognized that there are many factors any one of which by exerting a slight effect would materially change the figure showing the percentage lost.

TIME SPENT IN MANIPULATING THE UDDERS FOR COMPLETE MILKING

The time spent in manipulating the udders to accomplish complete milking, as recorded at random intervals, averaged 39 seconds per milking. At this rate 5.2 hours of additional time was required for 480 complete milkings as compared to that required for the 480 incomplete milkings. Since complete milking resulted in 306 pounds more milk than incomplete milking, there was a return of 59 pounds of milk per hour spent in manipulating the udders.

PERCENTAGE OF BUTTERFAT IN THE MILK

The average percentage of butterfat in the milk of the cows when they were being milked completely was 3.71, and that in the milk of the same cows when milked incompletely was 3.72 percent. The difference on an individual basis did not exceed one-tenth of 1 percent except in the cases of four cows. In two cases the higher test followed complete milking; in two cases, incomplete milking. The greatest difference in the percentage of fat between complete and incomplete milking, for any individual cow, was 0.21 percent. This finding agrees with the Iowa statement to the effect that no change in the fat percentage of the milk was caused by not stripping.

PERSISTENCY OF MILK FLOW

As a measure of the persistency of milk flow the production of milk in the 10-day period at the peak was compared with that of a 10-day period taken just before gestation had progressed for 120 days in the longer or longest pregnant period for the two or three lactation records of the individual cow. The purpose was to select 10-day periods which would be as far apart as possible and yet avoid the influence of pregnancy. For example, cow A-14 had three lactations in which she conceived 61, 107, and 193 days, respectively, after calving. Since in the first case she had been milking only 181 days after carrying the calf 120 days, the production in the eighteenth 10-day period was used for each of the three lactations. Table 2 shows the production of milk at the peak and subsequently, for each cow when milked by the two methods.
Table 2.—Production of milk in 10 days at the peak and at a period not more than 120 days after conception

<table>
<thead>
<tr>
<th>Cow no.</th>
<th>Complete milking</th>
<th>Incomplete milking</th>
<th>Cow no.</th>
<th>Complete milking</th>
<th>Incomplete milking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milk at peak</td>
<td>Subsequent period</td>
<td></td>
<td>Milk at peak</td>
<td>Subsequent period</td>
</tr>
<tr>
<td></td>
<td>Pounds</td>
<td>Pounds</td>
<td></td>
<td>Pounds</td>
<td>Pounds</td>
</tr>
<tr>
<td>A-14</td>
<td>467.3</td>
<td>472.2</td>
<td>A-13</td>
<td>410.1</td>
<td>411.1</td>
</tr>
<tr>
<td>A-26</td>
<td>423.9</td>
<td>323.6</td>
<td>A-53</td>
<td>462.2</td>
<td>376.8</td>
</tr>
<tr>
<td>A-31</td>
<td>463.8</td>
<td>372.1</td>
<td>A-40</td>
<td>432.6</td>
<td>387.9</td>
</tr>
<tr>
<td>A-42</td>
<td>597.5</td>
<td>429.5</td>
<td>A-42</td>
<td>571.0</td>
<td>372.9</td>
</tr>
<tr>
<td>62-</td>
<td>562.9</td>
<td>177.7</td>
<td>A-40</td>
<td>571.0</td>
<td>372.9</td>
</tr>
<tr>
<td>278</td>
<td>788.1</td>
<td>365.8</td>
<td>A-42</td>
<td>463.5</td>
<td>468.9</td>
</tr>
<tr>
<td>A-14</td>
<td>720.6</td>
<td>360.9</td>
<td>A-53</td>
<td>462.2</td>
<td>376.8</td>
</tr>
<tr>
<td>A-27</td>
<td>599.2</td>
<td>291.4</td>
<td>A-42</td>
<td>571.0</td>
<td>372.9</td>
</tr>
<tr>
<td>A-33</td>
<td>477.6</td>
<td>259.2</td>
<td>A-42</td>
<td>571.0</td>
<td>372.9</td>
</tr>
<tr>
<td>A-34</td>
<td>517.7</td>
<td>313.5</td>
<td>A-42</td>
<td>571.0</td>
<td>372.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average decline, percent</td>
<td>42.5</td>
<td>42.4</td>
</tr>
</tbody>
</table>

1 Average of first and third records.

The average daily production at the peak for the completely milked cows was 50.9 pounds; for the incompletely milked cows, 47.7 pounds. Ten of the fourteen cows gave more milk at the peak when milked completely than when milked incompletely, three gave less, and with one the difference was less than 0.5 pound a day.

The 10-day period selected for comparison with the peak production began on an average at 178 days after calving. During this period the average daily production of the cows when they were being milked completely was 29.3 pounds, and when milked incompletely it was 27.5 pounds. The average decline from the peak production when the cows were completely milked was 42.5 percent, and when incompletely milked, 42.4 percent. Seven cows gave more at the latter 10-day period when milked completely, five gave less, and with two the difference was less than 0.5 pound a day.

There is nothing in these data to indicate that incomplete milking affects the persistency of milk flow adversely in any way. It is true, however, that the cows when milked completely gave slightly more milk on an average, both at the peak of production and at a subsequent period. The figures shown in table 2 are for actual productions. If the records were calculated to maturity, the average production by incomplete milking would approach more nearly the average obtained by complete milking, but the calculation would not affect the percentage of decline.

RESULTS OF THE PHYSICAL EXAMINATIONS OF THE UDDERS AND MILK

Altogether there were 76 examinations of the udders and milk of 11 cows when they were being milked completely and 93 when they were being milked incompletely. When the cows were milked completely, 1 percent of the udder examinations (made by palpation) showed abnormalities, and 17 percent of the milk examinations (by strip cup) showed abnormalities; when the cows were milked incompletely, 8 percent of the udder examinations showed abnormalities, and 5 percent of the milk examinations showed abnormalities. One or two cows appeared to have less udder trouble when milked completely and the same number appeared to fare better when milked incompletely. With the other seven cows the udder
troubles, if any, were about the same under the two methods of milking. The list of abnormalities found by palpation includes the following: Front quarters harder, hard lump beneath skin between right teats, left rear quarter smaller, several hard lumps in left rear quarter, right front quarter harder, and right rear quarter larger. As these abnormalities invariably cleared up before the next examination it is evident that they were not due to the formation of indurated glandular tissue, a condition quite common in severe cases of mastitis. No active cases of inflammation were found at the time of any regular examination. However, one cow when being completely milked developed a clinical case of mastitis which persisted for a few days in the interval between regular examinations.

RESULTS OF MILK EXAMINATIONS IN THE LABORATORY

AVERAGE RESULTS FOR LACTATION PERIODS

Table 3 shows the averages of weekly examinations made during each of two lactation periods (except where part of a third lactation period is shown for cows 619 and 629) for content of chlorides, expressed as chlorine, number of cells, number of total bacteria, and number of streptococci (S. mastitidis) in the milk of 11 cows. Data on the other four cows were omitted because the milk of three cows (A-14, A-20, and A-46) was not examined at the start of this investigation, and one cow (A-42) did not finish two lactation records in this experiment. On the other hand, the data from examinations of the milk of cow A-53 were not discarded, although, on account of her lack of thrift, her production records were not used in any calculations having to do with quantity of production.

<table>
<thead>
<tr>
<th>Cow no.</th>
<th>Complete milking</th>
<th>Incomplete milking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chlorine per 100 cubic centimeters</td>
<td>Cells per cubic centimeter</td>
</tr>
<tr>
<td>Group 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-36</td>
<td>0.182</td>
<td>892</td>
</tr>
<tr>
<td>A-43</td>
<td>0.182</td>
<td>1,362</td>
</tr>
<tr>
<td>A-53</td>
<td>0.182</td>
<td>500</td>
</tr>
<tr>
<td>A-62</td>
<td>0.182</td>
<td>1,362</td>
</tr>
<tr>
<td>Average</td>
<td>0.182</td>
<td>1,501</td>
</tr>
</tbody>
</table>

Group 2:

<table>
<thead>
<tr>
<th>Cow no.</th>
<th>Complete milking</th>
<th>Incomplete milking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-36</td>
<td>0.182</td>
<td>892</td>
</tr>
<tr>
<td>A-43</td>
<td>0.182</td>
<td>1,362</td>
</tr>
<tr>
<td>A-53</td>
<td>0.182</td>
<td>500</td>
</tr>
<tr>
<td>A-62</td>
<td>0.182</td>
<td>1,362</td>
</tr>
<tr>
<td>Average</td>
<td>0.182</td>
<td>1,501</td>
</tr>
</tbody>
</table>

Average of all cows: 0.182  | 1,501  | 12,505 | 12,800

1 Latter part of period.  
2 Early part of third lactation period.  
3 Beginning with fourteenth week.  
4 Cow no. 278 developed a clinical case of mastitis between the third and the fourth week of lactation period on complete milking.
DISCUSSION OF AVERAGE RESULTS

The averages for all cows of all tests of the milk, given in the last line of Table 3, show very little difference in the abnormality of the milk produced in both periods of complete milking and incomplete milking. The average chloride content of the milk produced in the lactation period when the cows were being milked incompletely was slightly higher than that of the milk produced in the period when they were being milked completely, but the average number of cells, number of total bacteria, and streptococci (S. mastitidis) were slightly lower than in the period of complete milking.

In Table 3 the cows are separated into two groups, according to whether the cows were first started on a lactation period of complete or incomplete milking. The cows in group 1 made their record on incomplete milking first. The average for this group of the milk produced when the cows were being milked completely shows a slightly lower content of chlorides, a smaller number of cells, and a decided increase in the number of total bacteria and Streptococcus mastitidis, as compared with the milk produced by incomplete milking. In group 2 the cows made their record on complete milking first. The average for this group of the milk produced by complete milking shows a lower chloride content, a larger number of cells, and a smaller number of total bacteria and streptococci than was found in the milk produced by incomplete milking. This decrease in total bacteria and streptococci is all the more pronounced when it is considered that cow no. 278 developed a clinical case of mastitis during the third and fourth weeks of her lactation period on complete milking.

A comparison of the average results for each individual cow in group 1, Table 3, when being milked completely and when being milked incompletely shows the following facts: Three of the cows (A-36, A-43, and A-44) in group 1, or 50 percent of the number in this group, each show a higher average chloride content on complete milking than on incomplete milking. However, while cows A-44, A-53, and 277 were being milked incompletely their milk was tested for chloride content only during the latter part of the lactation period, and in the case of cow no. 619 the chloride content of the milk from incomplete milking represents the average of tests made during the early part of the third lactation period, which followed one on complete milking. Four, or 66 percent, of the cows in this group show higher average cell counts; five, or 83 percent, show higher numbers of total bacteria; and 100 percent show higher counts of streptococci in the milk produced during complete milking as compared with that produced during incomplete milking.

Of the individual cows in group 2, Table 3, the averages of the chloride determinations, which were made on the milk of four cows, indicates that one cow (no. 629) had a higher content in the milk from complete milking, and three (A-27, A-32, and 278) had a higher chloride content in the milk from incomplete milking. Here again, it should be taken into consideration that the chloride averages for cows A-27 and 278 on complete milking represents only the latter part of the lactation period, and the chloride average for cow 629 on complete milking is an average from the early part of her third lactation period, which followed a lactation period on incomplete milking. Of the five cows two, or 40 percent, showed higher average cell counts.
in the milk from complete milking. This is probably accentuated by
the clinical case of mastitis of cow 278. One cow, or 20 percent,
showed higher numbers of total bacteria in the milk from complete
milking, and two cows, or 40 percent, showed higher counts of
*Streptococcus mastitidis* in the milk from complete milking.

**Variations during lactation periods**

Inasmuch as averages do not tell the whole story in regard to the
normality or abnormality of the milk, the data showing the variations
in the milk of the individual cows are presented graphically in figures
1 to 11.

On examining the graphs of the 14 lactation periods in which the
chloride content was determined throughout the entire period, it is
seen that in all but 2 lactations there was a decided tendency for the
chloride content to increase gradually as the stage of lactation pro­
gressed. One of the two exceptions is the milk of cow no. 629 during
her period on incomplete milking (fig. 11). The other is the milk of
cow no. A-43 during her lactation period on complete milking (fig. 2)
and it showed a decided increase in chloride content during the last
few weeks of the period.

This tendency for the chloride content to increase during the lacta­
tion period partly explains the apparent discrepancies in the chloride
averages shown in table 3, as in some cases the average represents
only part of the lactation period. In the first lactation period of five
cows (figs. 3, 4, 5, 8, and 10) the chloride test was not made on the
milk at the start of the experiment, and the graphs on which these
averages are based are for the latter part of the lactation period, when
the chloride content, according to the data covering whole periods, is
likely to be at its highest level.

The increases or decreases in the number of cells, *Streptococcus
mastitidis*, and total bacteria do not appear to have any relationship
to the stage of lactation during the lactation period, but most of these
graphs show high peaks with intervals of low counts.

On further examining the data for the cows in the group that was
started on incomplete milking, in figures 1 to 6, it will be noted that
three cows, A-36 (fig. 1), A-43 (fig. 2), and A-44 (fig. 3), showed a
tendency to maintain higher cell counts, higher numbers of *Strepto­
coccus mastitidis* organisms, and higher counts of total bacteria, dur­
ing the period on complete milking than in the preceding period on
incomplete milking. The milk of cow no. 277 (fig. 5) and cow no. 619
(fig. 6) generally showed higher numbers of *S. mastitidis* and higher
numbers of total bacteria during the period on complete milking. Figure 6 also shows the results obtained by following cow no. 619 into
her third lactation period.

The other cow (A-53) that was started on incomplete milking was
milked incompletely 30 weeks, then changed to complete milking. In
her second lactation period she was continued 30 weeks on complete
milking, then changed to incomplete milking for the rest of the period.
The results obtained from examining the milk of this cow are shown
in figure 4. Cows A-36 (fig. 1) and A-43 (fig. 2), which were the only
ones in this group with complete data on chloride content for both
periods, were generally higher in chloride content when they were
FIGURE 1.—Changes in the milk of cow no. A-30 during a lactation period on incomplete milking (broken lines) and a lactation period on complete milking (solid lines). Dots show milk examination points.

FIGURE 2.—Changes in the milk of cow no. A-13 during a lactation period on incomplete milking (broken lines) and a lactation period on complete milking (solid lines).
MILK PRODUCTION AND UDDER TROUBLES IN DAIRY COWS

FIGURE 3.—Changes in the milk of cow no. A-44 during a lactation period on incomplete milking (broken lines) and a lactation period on complete milking (solid lines).

FIGURE 4.—Changes in the milk of cow no. A-53 during a lactation period when she first milked incompletely and then completely, and during a lactation period when she was continued on complete milking and then changed to incomplete milking. Incomplete milking (broken lines); complete milking (solid lines).
Figure 5.—Changes in the milk of cow no. 27 during a lactation period on incomplete milking (broken lines) and a lactation period on complete milking (solid lines).

Figure 6.—Changes in the milk of cow no. 810 during a lactation period on incomplete milking (broken lines), then one on complete milking (solid lines), and part of the third lactation, on incomplete milking (dotted lines).
FIGURE 7.—Changes in the milk of cow no. A-3 during a lactation period on complete milking (solid lines) and a lactation period on incomplete milking (broken lines).

FIGURE 8.—Changes in the milk of cow no. A-27 during a lactation period on complete milking (solid lines) and a lactation period on incomplete milking (broken lines).
Figure 9.—Changes in the milk of cow no. A-32 during a lactation period on complete milking (solid lines) and a lactation period on incomplete milking (broken lines).

Figure 10.—Changes in the milk of cow no. 278 during a lactation period on complete milking (solid lines) and a lactation period on incomplete milking (broken lines).
being completely milked until about three-fourths of the lactation period was covered.

Data from results of the weekly examinations of the milk of each cow in the group that was started on complete milking are presented in figures 7 to 11. Comparison of the results for this first period, when the cows were on complete milking, with those for the succeeding period on incomplete milking, shows the following:

Cow A-13 (fig. 7) during her period on complete milking had a lower number of cells, number of Streptococcus mastitidis, and number of total bacteria than in the period on incomplete milking. The milk of cow A-27 (fig. 8) during complete milking was usually lower in number of S. mastitidis and number of bacteria. Cow 278 showed larger variations in the streptococcus count, bacterial count, and cell count. The milk of cow A-32 (fig. 9) showed about the same trend in both periods for the streptococcus count and also the bacterial count. Cow 629 (fig. 11) in her first lactation period on complete milking showed higher cell counts throughout this period than when milked incompletely, but for the most part a lower number of S.
mastitis. The small amount of data on chloride content in the milk of these cows during the first period on complete milking shows, where a comparison can be made, that it was lower during complete milking. Figure 11 also shows the results obtained by examining the milk of cow 620 for 20 weeks during the early part of her third lactation period when she was again on complete milking following her lactation period on incomplete milking.

**SUMMARY AND CONCLUSIONS**

The results of 33 lactation records made by 14 cows are reported. Each cow had at least one lactation record when she was being milked completely, and at least one other record when milked incompletely. Five cows each had three lactation periods.

The cows being milked incompletely were milked completely on 1 day each week, in order to estimate the quantity of milk being left in the udder the other 6 days.

The udders were examined every month or so by palpation for lumps, swellings, and other abnormalities. At the same time some of the milk from each teat was drawn into a strip cup and examined for curd flakes.

Samples were taken of the milk from the individual cows once a week and examined in the laboratory to determine the chloride content, the number of cells, the number of total bacteria, and the number of streptococci.

The quantity of milk left in the udder by an incomplete milking varied with the different cows from 0.8 to 2.1 pounds at a milking, the average being 1.2 pounds.

If the lactations are calculated to maturity, and the slight differences due to pregnancy are eliminated, the milk production of the cows when they were being milked incompletely was equivalent to 96.7 percent of the production when milked completely. Nine of the 14 cows produced more milk when they were being milked completely.

When the cows were being milked incompletely they gave on an average 306 pounds less milk per cow in a lactation period, than when they were milked completely. This quantity is equivalent to 53 percent of the total quantity left in the udder by the 480 incomplete milkings in a lactation period.

Incomplete milking had no apparent effect on the average percentage of butterfat in the milk during entire lactation periods.

Incomplete milking did not hasten the decline in milk flow.

Incomplete milking did not increase either the number of cells, the number of total bacteria, or the number of streptococci in the milk when the averages of all lactations are considered.

There appeared to be a progressive increase in the chloride content of the milk from the beginning to the end of the lactation period, as shown by curves plotted from results of weekly milk examinations.

The graphs indicate that the method of milking had little influence on the frequency of the high and low points reached in the tests conducted for determining the normality of the milk. Neither was there any tendency in either system of milking to force the animals into clinical cases of mastitis and other udder troubles.

Since leaving a pound or two of milk in the udder at each milking does not affect the percentage of fat in the milk, the normality of the
milk, the persistency of lactation, nor the health of the cow, the only questions having a bearing on whether or not stripping should be practiced on a dairy farm are the value of the milk obtained by stripping, the cost of stripping, and the sanitation of the product.

Manipulation of the udder to accomplish complete milking, as practiced at Beltsville in lieu of hand stripping, required an average of 39 seconds per milking. This effort yielded a net return of 0.64 pound of milk or at the rate of .59 pounds per hour of time spent in manipulating or massaging the udder. Under ordinary conditions it is unlikely that 1 hour of labor will cost more than 59 pounds of milk is worth. As a rule therefore, it will pay to practice manipulating or massaging the udder to complete the milking process.

While these experiments have been conducted with machine milking, it appears that the results may be applied to hand milking. This experiment would indicate that one should not leave much milk in the udder but neither should he spend much time trying to get the "last drop" of milk; otherwise, the cost of stripping may exceed the value of the "strippings."

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