

HOARD'S DAIRYMAN

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HOARD'S DAIRYMAN

THE COW'S UDDER, ITS FUNCTION and ITS CARE, FUNDAMENTALS for CORRECT MILKING

by

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EX-GOVERNOR HOARD once said that the darkest place on earth is the inside of a cow. He, of course, had reference to the complex process of the making of milk. Since that time much light has been shed upon the functioning of the cow's udder, which light puts the dairyman in a better position to manage his herd for better and more efficient milk production.

There are three more or less separate and distinct phases to the phenomenon of lactation. The first is that of the growth of the udder; the second is the complex process of making milk in the developed udder; and the third is getting milk out of the udder. The last phase is a relatively new discovery, and is the one that will be given major attention in this discussion because the facts known about it lay the background for proper milking procedures. The first two phases will be dealt with only briefly in order to form a more complete picture of what a complex phenomenon the dairymen deal with.

Growth of the Udder

On the basis of work done on laboratory animals, two special hormones are required for the growth of the mammary glands. One of these is the female sex hormone, estrogen, secreted by the ovary, which causes development of the ducts in the gland. The second is the pregnancy hormone, progesterone, secreted by the yellow body of the ovary, which causes the development of the alveoli, the recesses in which the milk is secreted. After the development has taken place a hormone from the pituitary gland, known as prolactin, is needed for the secretion of milk.

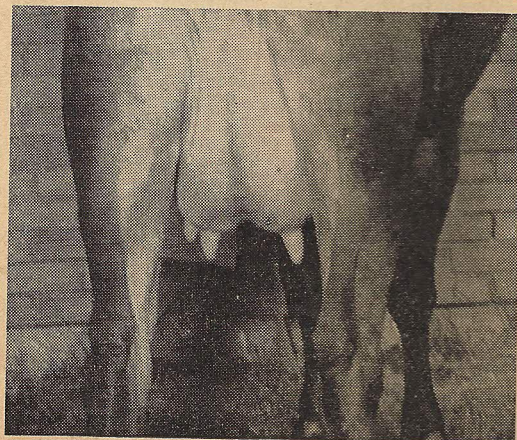
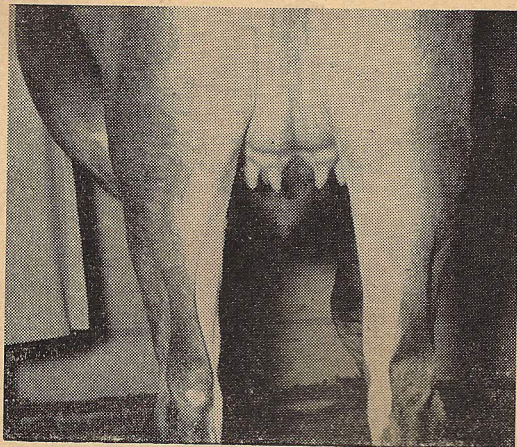
In the cow a synthetic estrogen hormone-like substance, known as diethylstilbestrol,

when injected for a period of two or three weeks not only causes the ducts to develop but also the alveoli, and lactation ensues. In most cases with sterile heifers as large udders and levels of milk flow can be attained artificially as would be expected following a normal calving. Incidentally, a fair percentage of animals so treated subsequently conceive, making the treatment practical, at least, in the case of well bred sterile heifers. In older sterile, dry cows only occasionally are large udder development and satisfactory levels of milk production obtained from the diethylstilbestrol treatment. This indicates there is some other essential lacking, which future research may solve.

In the bull and steer it should be possible, theoretically at least, to develop the udders as well as in the female. Diethylstilbestrol administration alone, while causing some development and milk secretion, is far from what is theoretically expected. So, while much progress has been made there is still much more to learn.

Making Milk in the Udder

With the exception of a relatively small portion, the ingredients of milk are manufactured by the alveolar cells in the udder. The major ingredients of milk, such as milk fat, milk sugar, casein, and albumin, are different from the substances found in the body. Each of these is manufactured from raw materials taken out of the blood. The processes involved are complex. Not only must these special milk substances be manufactured but, in the case of milk sugar and other substances, other forces must be overcome. The concentration of milk sugar in the milk is such that there is a great deal of pressure exerted for it to go back into the blood.



THE UDDER DEVELOPED IN A STERILE JERSEY HEIFER
 Above, when treatment began. Below, two months later when she produced 26 lbs. milk daily. Eight injections over a period of two weeks were made.

While many calcium and phosphorus compounds are common in milk and in blood, it is significant to note they are ten to twenty times as concentrated in the milk as in the blood. Or, in other words, special forces are required to build them up in such high concentrations. Other blood substances are either completely or partly prevented from passing into the milk. Sodium bicarbonate, which makes the blood alkaline, does not pass into the milk except when there is some disturbance in the udder, such as mastitis, in which case it passes into the milk freely. This fact is responsible for the bromthymol blue reaction in the case of mastitis. The udder that is functioning normally will only permit relatively small amounts of the common salt of the blood from passing into the milk.

Certain substances of the blood pass freely into the milk to produce the same concentration in both fluids. While these are small in quantity, some of them are very important from a practical standpoint. Flavoring constituents of feedstuffs find their way into milk by first getting into the blood from the digestive tract, thence from the blood into the milk. The free passage of some of these feed flavoring substances back and forth between the blood and the milk accounts for the prevention of off-flavors in milk from some flavor-producing feeds when fed after rather than before milking. If enough time is allowed, the flavoring substance will gradually disappear from the blood and the substance will pass from the milk into the blood as the levels therein become lower.

Feed is not the only source of flavors in milk. When certain odors are inhaled they also find their way into the blood through the walls of the lung, and from the blood into the milk. Barn odors can get into the milk just

from the cow inhaling them. Odors from moth balls, silage, turpentine, etc., can in this manner find their way into the milk. The flavoring constituent of the onion, garlic, etc., when taken in by mouth flavors the milk but cannot pass through the lung into the blood. This is strange as the onion odor passes out through the lung in the breath. Another anomaly is that of the vanilla flavor. It has no effect when fed but if atomized so the cow inhales it, the milk will be vanilla flavored. There are good possibilities of finding substances that, when fed to cows, will enhance the flavor of milk.

Getting Milk Out of the Udder

The facts found in studies of this phase of lactation have enabled us to formulate rules for better milking procedure. In the main, these newly found facts support the principles that good dairymen have always insisted upon as being essential to good dairy husbandry. Major among these principles are: treat cows gently, milk cows rapidly, milk cows dry, and be regular. Reasons why these old principles are essential will be understood after considering the well established facts, as will also the reason why the following rules for good milking will improve production and udder health. By following these rules milking is done in less time, an increase in production will result, and the incidence of mastitis will be lowered. The directions are:

1. Avoid excitement of the cows, either before or during milking. Excited cows do not respond well to the milking stimulus.

2. About one minute before milking begins stimulate let-down of the milk by a warm water wash of the teats and udder. The water should be about 125° F.

3. In hand milking, the full hand grasp of the teat should be used. Avoid any point compression, such as digging in with the finger tips, or the knuckle of the thumb, as such is likely to injure the delicate lining on the inside of the teats.

In machine milking operate the milker according to the recommendations of the manufacturer and, above all, see that it is in good running order. Dirt in the pipe line, leaks in the air lines, or distorted inflations are responsible for poor results often obtained by farmers in the use of the milking machine.

4. In hand milking cows should be milked as rapidly as possible.

With machine milking, begin stripping as soon as the teat cups have crawled upward by pulling down on them with sufficient force to reopen the passageways for the milk that were closed by the crawling and, at the same time, properly massage each quarter with the free hand. Every bit of milk that has been let down can be gotten by the proper manipulation of the teat cups.

There are at least three reasons why stripping by machine, rather than by hand, should be followed:

a. Saves time. An extra trip to the cow is avoided.

b. Prevents extra contamination of the milk such as comes from hand stripping, and

c. It keeps the cow in good milking habits. Hand stripping, especially if prolonged, develops a tendency for the cow to depend upon it for complete let-down.

5. Lastly, and of great importance, is to remove the machine when milk ceases to flow. As long as milk flows through the opening in the teat no force is exerted upon the delicate inside lining but at this point the vacuum ex-

tends inside to exert two damaging effects. One is a congesting effect over the entire inner lining of the teat and the second is a shearing action on the soft tissues compressed in the upper part of the teat as a result of the pulsations.

When cows are milked according to these directions most herds should not average over $3\frac{1}{2}$ minutes per cow. Some cows will be milked in $1\frac{1}{2}$ minutes. Some hard milkers may require 10 or more minutes.

Fundamental Facts for Correct Milking

The fundamental facts that need to be known in order to properly understand correct milking procedures may be divided into six heads.

The first important fundamental is that of recognizing the need for milking cows dry at each milking. The idea is not new because one of the requisites long insisted on by dairy-men is that cows must be milked out completely. The explanation, however, as to why cows dry up when not milked out is rather recent. It is due to pressure developing within the udder from the secreted milk.

The alveolus in which the milk is secreted is a very tiny hollow bulb-like structure lined with a layer of cells that secrete the milk. About a million of them are contained in a cubic inch of udder tissue. The milk, as it is manufactured, is secreted into the hollow space in the center of the alveolus. Contrary to the old idea that most of the milk is secreted during the milking process, there is no secretion at that time but secretion does begin as soon as the udder is emptied.

At first there is no pressure inside the alveolus but as it fills up from the newly formed milk, pressures begin to form which first slow

down the rate of milk secretion and, finally, the secretion is stopped because of the pressure that has developed. Stoppage of secretion occurs when the pressure reaches about one-fourth that of the blood pressure.

When milk secretion is stopped because of the high pressure a reverse process sets in. Instead of raw materials coming out of the blood and going into the cells for the making of milk, some of the ingredients of the milk go back into the blood in exchange for some blood constituents not normally found in the milk or found only in small quantities. This fact accounts for the changes in the characteristics of the milk which occur when cows are being tried up. When this reverse process occurs, the drying up process sets in. When a cow is not milked out completely pressure is built up sooner because the alveoli are already partly filled when secretion begins after milking. This explains the importance of milking cows dry each time.

Another pronounced effect of the pressure developing inside the alveolus is a slowing down of secretion because of the developing pressure. From these facts it can be seen why the quickest way to dry up a cow is not to milk her. The next quickest way is to only remove part of the milk and skip milkings, such as has been the practice when cows are to be given a rest period. Likewise, a poor milker who does not get all of the milk will speed up the drying up process.

An understanding of this pressure relationship to the rate of milk secretion and the drying up process also explains why cows must be milked at least twice daily and why more milk is gotten when they are milked three and four times daily. As a matter of fact, when cows are milked but once a day

less than half as much milk will be produced for the lactation as when milked twice daily.

Why Cows Dry Up

Large numbers of cows are dried up prematurely because they are not milked so as to get all of the milk each time. Others are short-timers because they will not respond properly to the milking stimulus. "Meaty udders" in some cows may be due to incomplete response to the milking stimulus, the retained milk being responsible for the "meaty" texture. One such cow that milked the same at each milking was found to retain more than eight pounds of milk as was shown by injecting a hormone into the blood which caused the forcing out of the milk. Needless to say, this cow dried up prematurely.

Another type of cows that invariably dries up rapidly is that of erratic response — only once in a while will they let down the milk completely. In many cases the erratic response is due to the milker not recognizing that the animal is more sensitive than others. This can make a great difference in production. One Jersey, for instance, with ordinary milking produced only 4,413 lbs. milk for the lactation because, under those conditions, she only let down all of her milk at infrequent intervals. When milked by a milker in whom she had confidence she produced 7,000 pounds in 305 days under otherwise like conditions.

The second fundamental is that the let-down of milk is the result of a positive reaction of the cow. The idea the cows "hold up" their milk is wrong. There is no mechanism in the udder by which a cow can willfully, or otherwise, hold her milk. What happens is that she fails to let it down. The milk is stored (except for the relatively small

amounts that drain into the milk cisterns) in the alveoli where it is secreted. When full each alveolus contains a small fraction of a drop of milk, which is not enough to let it drain out by its weight. It must, therefore, be squeezed out, much as one squeezes fluid out of a medicine dropper by compressing the rubber bulb, which may be likened to an alveolus greatly magnified.

The squeezing is affected by contraction of muscle cells through the action of a hormone secreted by the pituitary gland. This hormone is secreted by a milking stimulus, of which the nursing act of the calf is the original and the most effective. Studies have revealed that there are two nerve endings in the teat that need to be stimulated for the most prompt and complete response of the let-down. These are those that perceive warmth and those that perceive touch. The calf stimulates both of these by applying a warm, moist mouth with a lot of massaging action. The most effective substitute that we now know is a wash with warm water, about 125° F. All cows respond more completely and promptly to the warm water, and some will not respond at all unless this method is used.

Plenty of warm water for the entire milking may be provided in the coldest of weather by the use of two wooden pails. One is filled with the hottest water obtainable while the other is used for the washing—warm water being added as it cools.

The Milking Stimulus

The third fundamental is that of interference with the response to the milking stimulus. Response to the milking stimulus may be partly or completely blocked by exciting the cow. Strong excitation — caused by sticking

the cow with needles, a cat on her back, exploding inflated paper bags, or placing a cage of rats before her — completely blocked the response to the milking stimulus. Only the milk that had drained into the larger ducts and cisterns was obtained. Milder excitation, such as placing a feed cart where it could be seen but not reached without special effort, caused a slow response without a complete milk-out. Experiments like the above support the contention long held by good dairymen that cows must not be excited, especially at

milking time.

The fourth fundamental that cows must be milked fast if all the milk is to be gotten out of the udder is also in direct support of a long established "must" for good dairy husbandry. The blood destroys the let-down hormone once it is secreted therein, consequently, the milking must be completed before this destruction takes place. It has long been held that a slow milker dries up cows. Experimental evidence supports this contention. When cows were stimulated to let down their milk 20 minutes

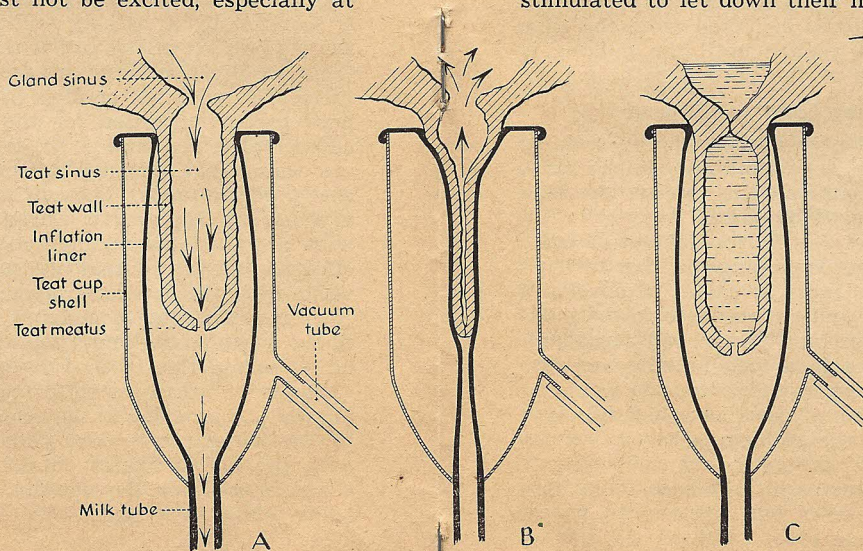


ILLUSTRATION OF THE ACTION OF THE MECHANICAL MILKER UPON THE TEAT

A. Vacuum applied in teat cup shell when the gland is full of milk. The teat meatus is opened and milk streams through it.

B. Release of vacuum in the teat cup shell. The teat meatus is closed and a part of the milk in the teat sinus is forced back as a result of compression of the teat caused by the collapse of the inflation liner.

C. Teat cup has crawled upward. The orifice between the gland and teat sinus is closed preventing passage of milk into the teat.

before the milking began, as much as 20 per cent drop in milk production was observed in two weeks. Another method was to milk out completely each quarter in rotation and, then, after the milking was completed the let-down hormone was injected and the retained milk forced out. The last quarter milked still had about 30 per cent of the milk left because too much time had intervened between the stimulus for the let-down and the completion of the milking. On the basis of observation made on this type of experiments, not more than seven minutes must be taken from the time the stimulus is applied until the milking is completed if all of the milk is to be gotten.

Training Cows to Respond

The fifth category deals with the training of the cow for good milking habits. Here, again, experimental studies support the long held idea by good practical dairymen that slow milkers develop "strippers" out of cows. If the milking act is prolonged, either by hand or by machine, the cow comes to develop a tolerance for it and the response to the milking stimulus becomes slower and more prolonged, resulting in a long milking and also an incomplete emptying of the udder.

A large portion of cows have had this type of milking and the problem is how to retrain them to respond promptly and completely to the milking stimulus. It has been found that most of these cows will respond to proper training methods except toward the end of the lactation period when the desire to be milked is not as great as in the early part of the lactation. Nearly all of those that do not respond can be satisfactorily trained at the beginning of the lactation.

To train cows it is important that the following directions be carried out in detail:

First, the udder is vigorously washed with water at about 125° F. about one minute before the milking begins.

Second, the milking machine is attached.

Third, as soon as there is evidence that the teat cups crawl upward, stripping is begun by the machine as previously directed. Hand stripping should be avoided.

Fourth, when the milk ceases to flow freely the machine must be removed, regardless of the amount of milk left in the udder. It is important that no hand stripping is done after the removal of the machine or the cow will come to depend upon this stimulus for let-down of the milk.

If the cow does not respond in three or, at the most, four days, to this type of training, it should be stopped. Incomplete milking for three days will not have a permanent depressing effect upon milk production but longer will do so, except right after freshening when as much as a week may be taken without any harmful effects. Caution: if a cow has mastitis infection, a flareup may occur when all of the milk is not gotten.

There are many interesting possibilities in training cows for easier handling that may be of considerable practical importance, but space will not permit extended discussion of these. Among these are proper handling of heifers from the very start, breaking kicking cows, having cows come in in the same order into the milking parlor, and many others.

The sixth, and last, category deals with the mechanics of milking and the injuries that may be effected by improper force applied to the teat. The basic principle of milking, whether done by the calf, hand, or machine, is the same. It is to effect a sufficiently higher pressure of the milk inside the teat than

on the outside in order to force open the sphincter muscles surrounding the opening in the end of the teat to let the milk out.

Hand vs. Machine Milking

In hand milking the top of the teat is first compressed to close off the channel and then pressure is applied to increase the pressure on the inside of the teat. The outside pressure—atmospheric—is left constant. In machine milking or the calf nursing the pressure inside the teat is not changed but, by what is commonly called vacuum, the pressure on the outside is lowered so that, in relation, the pressure on the inside is higher, forcing an opening and the escape of the milk.

The forces exerted in hand and machine milking were studied on udders suspended in the laboratory, hooked up with a reservoir of skim milk so that as quickly as milk was withdrawn it was replenished from the reservoir at approximately the same pressure as when let down in the living animal. The forces exerted by calves in nursing were measured directly with a vacuum gauge and found to vary from nine to 18 inches of mercury vacuum.

The above setup in the laboratory allowed for the insertion of instruments into the teats to measure the forces exerted in either hand or machine milking, and also permitted of incisions whereby the action could be observed. In a test of seven hand milkers it was found that the force exerted with each squeeze varied from 22 to 35 inches in mercury pressure. With machine milking no force was exerted on the inside of the teat as long as milk flowed out through the opening in the end. This is what would be expected.

When milk ceases to flow out of the teat the vacuum extends inside to register the same level of vacuum found in the milk tube. This vacuum causes damage to the lining on the inside of the teat in two ways. First, there is a uniform congestion due to engorgement of blood and, secondly, there is shearing action due to the pulsation action upon the soft tissues compressed in the top part of the teat. These facts explain the reason why it is so important to remove the milking machine when milking is done.

The damage resulting from leaving the milking machine on too long are threefold. The first is that it has a tendency to make slow milkers. Second, it causes breaks in the delicate lining of the teat which predisposes to mastitis; and, third, it produces growths inside the teats that partly and in some cases completely block the passageways for the milk. This last fact explains why older cows so often present more problems in stripping by machine than first calf heifers.

Udder Injured by Improper Milking

Improper hand milking produces similar damage. Digging in with the finger tips, particularly if the fingernails are long, or milking with thumb knuckle against the teat produces injuries with similar end results to that of leaving the milker on too long. Too strong squeezing, and particularly the vicious attacks used by some milkers in stripping, is equally damaging. A properly operated and managed milking machine will exert less force on the inside of the teat than will hand milking. The chief difference between the two methods in poor milking is the most stupid of hand milkers will quit milking when no more is to be gotten, while the machine continues its vigorous action as long as it is left on the cow.

At this point too strong emphasis cannot be laid upon the importance of beginning stripping as directed, when the teat cups crawl upward, and removal of the machine when milk ceases to flow. When the teat cups crawl upward there is, at first, a partial and then a complete closure of the passageway for the milk into the teat. At this point the vacuum enters the teat first for just part and later for the whole of the vacuum application. When these principles are appreciated the importance of proper management of the milking machine becomes obvious. It means that with few exceptions not more than two units should ever be operated by one man. He should never be out of the sight of the machines when they are in operation.

A good method to follow in milking is, as follows:

1. Wash and stimulate cow No. 1.
2. Then wash and stimulate cow No. 2.
3. Attach machine to cow No. 1.
4. Attach machine to cow No. 2.
5. Wash and stimulate cow No. 3.
6. Machine strip cow No. 1.
7. Attach machine to cow No. 3.
8. Wash and stimulate cow No. 4.
9. Machine strip cow No. 2.
10. Attach machine to cow No. 4, etc.

Mastitis

People who have followed these principles have not only reduced the labor and time taken to milk, but, also, report increased milk production and much less mastitis.

As to why good milking and management practices should lower the incidents of mastitis requires some explanation in addition to what already has been said. First, mastitis means inflammation of the udder, regardless of the cause. Therefore, it is not a simple entity but



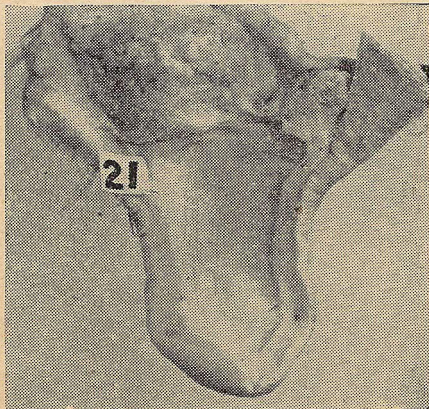
**GROWTH IN UPPER INSIDE WALL OF A TEAT
DUE TO THE PRESSURE CAUSED BY THE
KNUCKLE OF THE THUMB.**



**CIRCULAR GROWTH AROUND UPPER INNER
WALL DUE TO LEAVING THE MACHINE ON
TOO LONG. NOTE ALSO THE DAMAGE TO
WALL BELOW THIS POINT DUE TO VACUUM.**



**INFLAMMATION ON THE INSIDE OF THE TEAT
DUE TO SEVERE INJURY. THIS USUALLY WILL
RESULT IN ACUTE MASTITIS.**



**THE INSIDE LINING OF THE TEAT OF A FIRST
CALF HEIFER IS SMOOTH AND FREE FROM
ANY STRUCTURES.**

rather is a group name including a large number of diseases because many different bacteria can cause mastitis and some cases, although relatively few perhaps, are caused by factors other than bacteria.

Most of the discussion about mastitis deals with the so-called infectious mastitis caused by the bacterium *Streptococcus agalactiae* which has led many people to believe that this is the only type of the disease. The importance of this organism and taking steps to eliminate it from a herd is not to be depreciated but it is important to realize that there are about the cow at all times plenty of bacteria that can produce mastitis of the most severe type. As a matter of fact, the incidence of mastitis in a herd may be just as great after the elimination of *Streptococcus agalactiae* as when it was present. There are also records of herds in which cows carry *Streptococcus agalactiae* without ever having mastitis; that is, inflammation of the udder.

The question naturally arises as to why all cows do not have mastitis when there is always present about them bacteria that can produce the disease. The answer takes us to a fundamental involving resistance to infection. This is a complex subject in its entirety, but one of the basic principles is simple and of the greatest importance to the control of mastitis. This principle is that the first line of defense against infection is the unbroken epithelium, the skin, lining of the mouth, lungs, gastro-intestinal tract, and the inside lining of the teat and udder. Man has bacteria on his person that will produce infection provided the skin is broken but that otherwise need cause no worry.

Dairymen know very well that when cows' udders or teats are visibly injured the in-

volved quarter more often than not develops mastitis. What is not so generally recognized is that the delicate lining on the inside of the teat may be broken from improper milking or other causes, and which cannot be detected by the most careful examination but that is equally effective to permit bacteria that may be present to enter the tissue and produce infection. Many hundreds of dissections of teats have revealed these injuries present on the inside of the teat wall, which injuries are often infected but in many instances the infection stays localized. In other cases there is good evidence that the once local infection has spread to involve the entire quarter.

From studies of this kind and field observations, one must conclude that the most prominent predisposing factor to mastitis is injury to the teat and the udder. Even in the case of *Streptococcus agalactiae* mastitis this must, also, be at least partly true because records show that a large number of cows carrying the organisms do not have mastitis. One recent extensive study in England revealed that out of 1,977 cows that shed *Streptococcus agalactiae* only 283 showed signs of clinical mastitis.

Other factors than injury, although it is the most prominent, predisposes to mastitis. Over-feeding; wet, cold stall floors; and cold, chilling drafts are also factors in lowering resistance. While, as a general rule, breaks in the protective lining are essential for the production of infection, it should be borne in mind that sometimes strains of bacteria become so virulent that they can invade tissues like those on the inside of the teat without any injury being present. So it is essential to practice good sanitation and milk infected cows last, taking all possible precautions against spread-

ing the disease. However, this alone is not enough.

In some quarters there has developed the idea that we now have some new marvel drugs that will solve the mastitis problem by waiting for the development of a case and then administering treatment. It must be said that treatment by the new methods is helpful and is to be advised for cases of mastitis that develop, but treatment alone is not a solution of the mastitis problem. When an acute case of mastitis has developed, irreparable damage has been done and recurrence can be expected at frequent intervals. Also, a large percentage of the cases do not respond to treatment.

The solution of the mastitis problem is one of prevention and a problem of management. That mastitis can be reduced to a low minimum we find evidence of in well-milked and well-managed herds that have only occasional cases from accidents that are bound to occur. On the other hand, almost without exception herds that depend upon unskilled milkers with frequent changes have a heavy incidence of mastitis, regardless of the sanitary measures they may employ. The great increase in the incidence of mastitis in many places can be attributed to the use of labor that is not skilled with dairy cattle that so often has been resorted to to replace the "cowman" that has gone to war.