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Cooling, Storage, and Transporation of Milk and Cream

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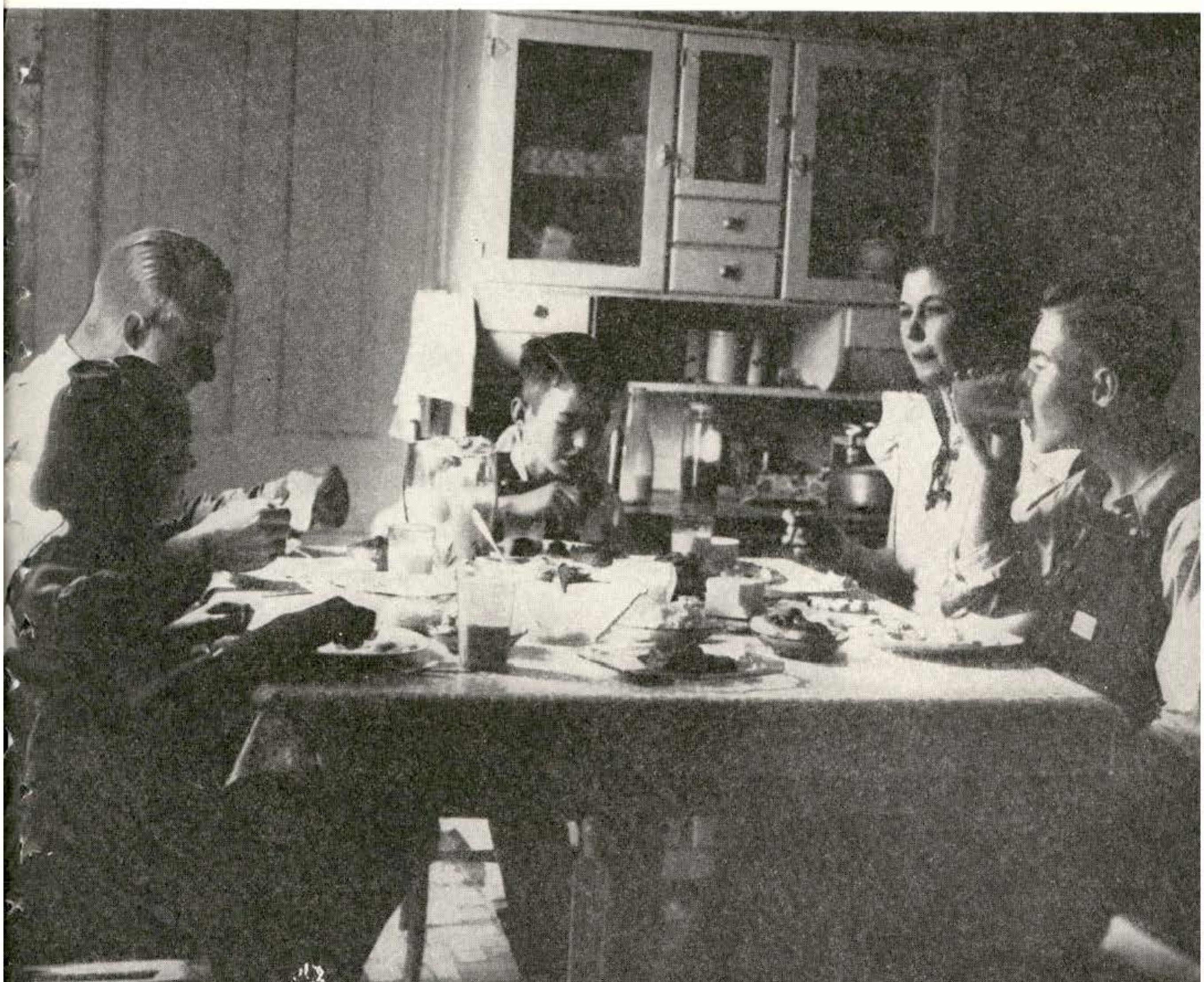

The AGRICULTURAL EXPERIMENT STATION of the
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W. W. Burr, Director LINCOLN, NEBRASKA

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Cooling, Storage, and Transportation of Milk and Cream

P. A. DOWNS and F. D. YUNG

GREATER INCOME is not the only objective in farming; greater health and enjoyment of life are important also. The man who milks cows has a product that is of value not only as a source of income but as a source of many items in the family diet.

Products consumed at the point of production do not carry the costs of processing, storage, and other distribution costs, and thus are cheaper. Not only *safe* dairy products—safe from the health standpoint—can be produced on a farm, but also *fine-tasting, wholesome products*—the kind that urban consumers must pay premium prices for.

The care given milk and milk products should be such that they will be relished by young and old alike. Greater use of milk can be encouraged by serving fresh milk cold. Cooling of milk also insures a fine product several hours after production. This is important not only for milk that is to be used, but for milk or cream that is to be sold.

The necessity of cooling milk as soon as possible after milking is an old established fact. The lower the temperature, the slower will be the development of bacteria and the longer the milk or cream will remain in

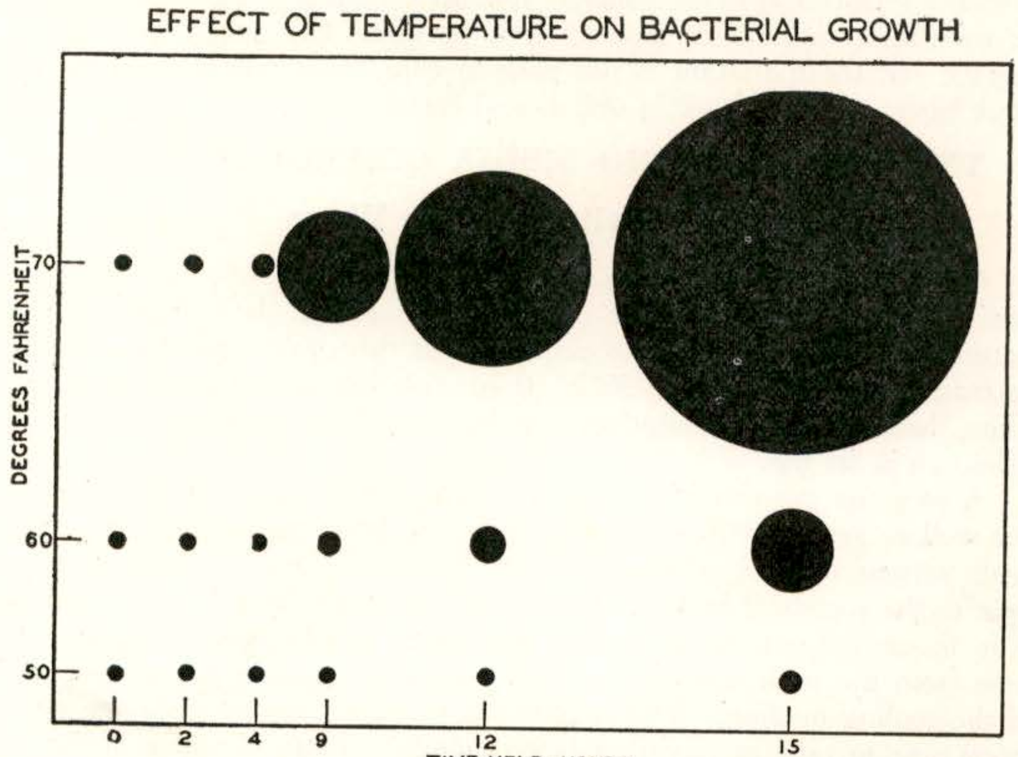

FIG. 1.—Bacterial growth proceeds at a rapid rate in uncooled milk, thus rapidly lowering quality.

a suitable condition for consumption. The accompanying diagram (Fig. 1) illustrates this fact. The true value and in the long run the value received for milk and cream sold depends upon the quality of the product offered for sale.

Length of Time Milk Was Held at Different Temperatures and Still Had a Count of Less than 1,000,000 Bacteria per Cubic Centimeter.

Type of Milk	Original count per c.c.	Holding temperature					
		40°	50°	60°	70°	80°	98°
		Hrs.	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
Good	5,500	Over 15	Over 15	Over 15	Over 15	6	3
Medium	55,000	Over 15	Over 15	12	6	5	2
Poor	535,000	Over 15	Over 15	9	6	3	2

This would indicate that it is necessary that such milk be cooled as close to 50°F. as the available cooling medium will permit. Where lower temperatures are possible, their use will extend the keeping time of the milk.

The methods used to cool milk or cream on the farm will vary greatly, depending upon conditions and equipment available. The fundamental principle of making use of what one has is very important and the old saying that "a penny saved is a penny earned" holds true in this case. Use the facilities available and be sure to cool milk and cream quickly as soon after milking or separating as possible. Keep them cool during storage and transportation if you wish to enjoy the greatest benefits from your labors, in health and in dollars and cents.

TYPES OF COOLING MEDIA COMMONLY FOUND

Cold Well or Spring Water

Of all the types of cooling media used throughout the United States, well or spring water probably is the most common. It is fortunate that nature has supplied us with an abundance of this cooling medium ranging in temperature from 50° to 55°F. It is made use of in various ways and often, because of the abundant supply, very little attention is paid to efficiency in its use.

A common practice is to lower the can of milk or cream directly into the well or spring. Other systems utilize insulated tanks of various types, with various degrees of insulation. It should be kept in mind that the heat of the sun must be kept out of the cooling medium if proper cooling is to be carried out. Some arrangement must also be made to absorb the heat from the milk or cream without excessively raising the temperature of the cooling medium. This necessitates either the replacing of the water from time to time or having a large enough volume of water in the insulated tank for proper cooling. The tank should hold at least four gallons of water to each gallon of milk or cream where the water is not to be replaced.[1] It should further be kept in mind that under these conditions, even with water at 50°F., it will be difficult to cool the milk or cream much under 60°F.

The relative values of different types of tanks for holding temperatures are: properly insulated tanks the best, wooden tanks next, and concrete last. Inefficient insulation permits a more rapid flow of heat from the sur-

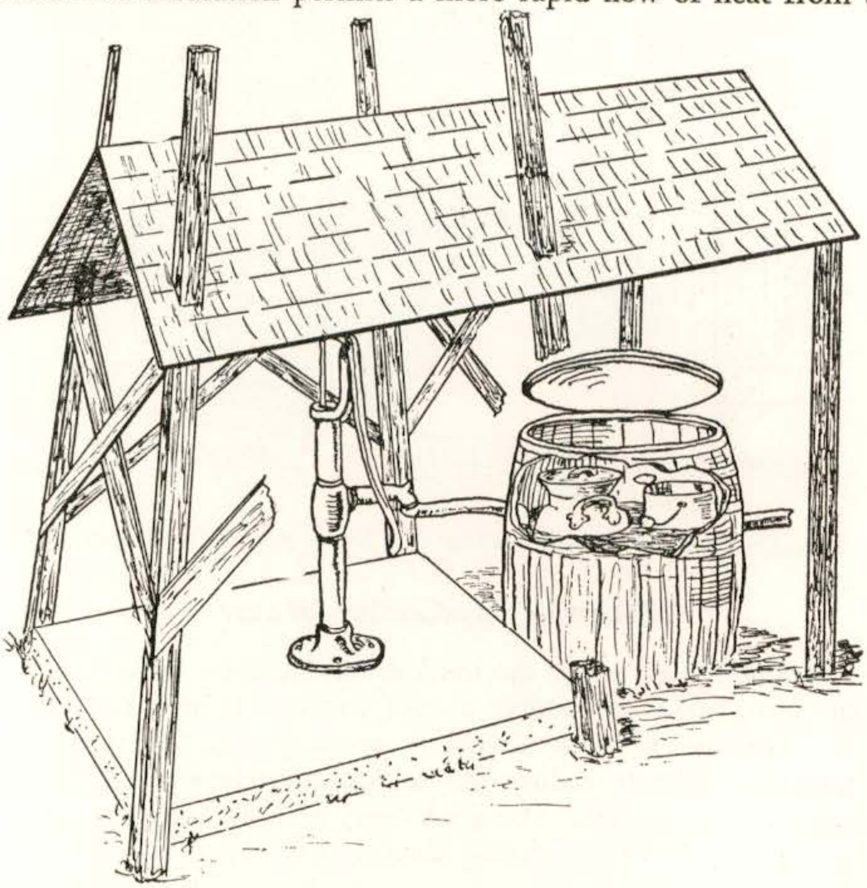

FIG. 2.—A simple method of using cold well water for cooling milk and cream. The tank should be protected from the direct rays of the sun.

rounding air into the cooling medium than does good insulation. Because of this fact the volume of water necessary to absorb the additional heat is materially increased; for instance concrete tanks require much more water to cool milk and cream effectively than do well-insulated tanks.

Water and Ice

In territories where natural ice is available, water and ice are used very extensively. The use of ice naturally encourages the use of the better-type insulated tanks in order to conserve ice. For water and ice a tank holding four gallons of water to one of milk is generally satisfactory. This allows room for the ice and at the same time provides sufficient water to cool the milk or cream.

[1] U. S. D. A. Farmer's Bul. No. 976, Cooling Milk and Cream on the Farm, May, 1918.

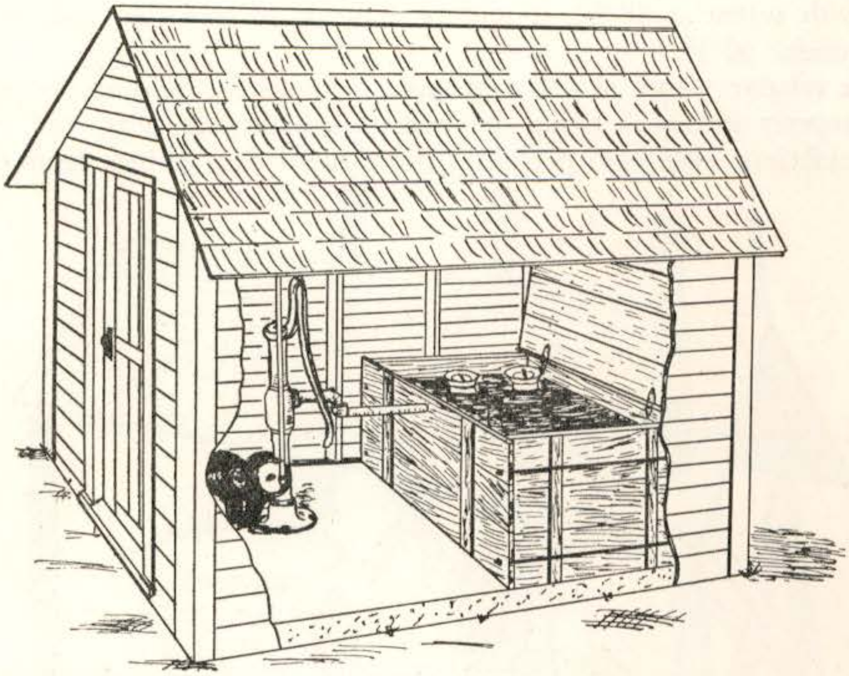

FIG. 3.—Milk house with cooling tank using flowing well water.

Mechanically Cooled Water

The introduction of small mechanical refrigeration units in the home and on the farm makes it possible to cool water to temperatures approaching 32°F. The use of such a cooling medium again requires well-insulated tanks in order to reduce the refrigeration loss and keep the cost of operation to a minimum. The availability of lower temperatures of the cooling medium gives lower cooling temperatures in a shorter time.

COOLING MILK AND CREAM IN THE CAN

Most of the milk and cream that is cooled on the farm is cooled without being removed from the can. The process varies from the simple evaporation method to the more complicated systems with agitation and refrigeration.

Of all the methods in use the wet-sack or jacket method is probably the simplest, but should be used only where there is a very limited supply of water (Fig. 4). The principle of utilizing the cooling effect of evaporating water has long been known and used extensively in the warmer parts of the country. The cloth-covered water jug has been used for years. Here we are applying the evaporation principle by placing a wet sack or jacket around the container and at the same time providing some way of keeping it moist. The movement of air around the covered can aids the evaporation of the water, which absorbs heat from the can and contents, thus lowering the temperature. The sack-covered can must be placed where a strong breeze or draft will circulate around it if best results are to be obtained. It should also be kept out of the direct rays of the sun. This method does not cool rapidly and should only be used where other methods are not available.

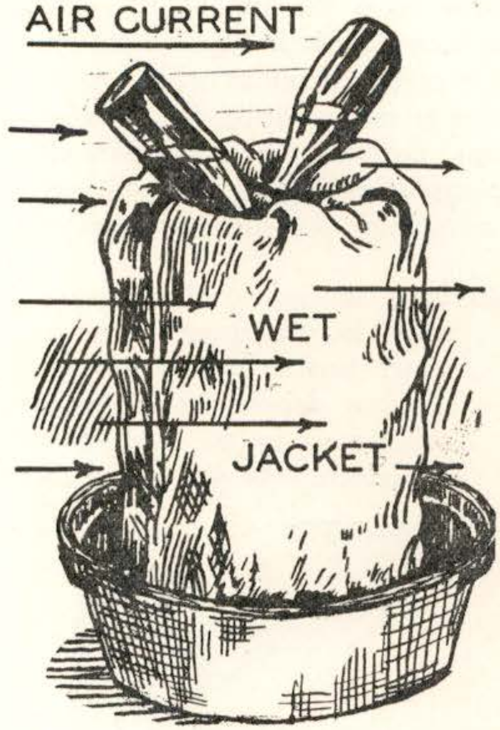

FIG. 4.—Wet-jacket method of cooling milk and cream.

The placing of a can of unagitated milk or cream in a container of still water, regardless of temperatures available, is not a rapid method of cooling. Where time is not a factor it can be used with low-temperature cooling media such as ice water or mechanically cooled water. It is not especially successful with well or spring water. If the method is used, at least four times as much cooling medium as cream to be cooled should be available. At best only partial cooling will result.

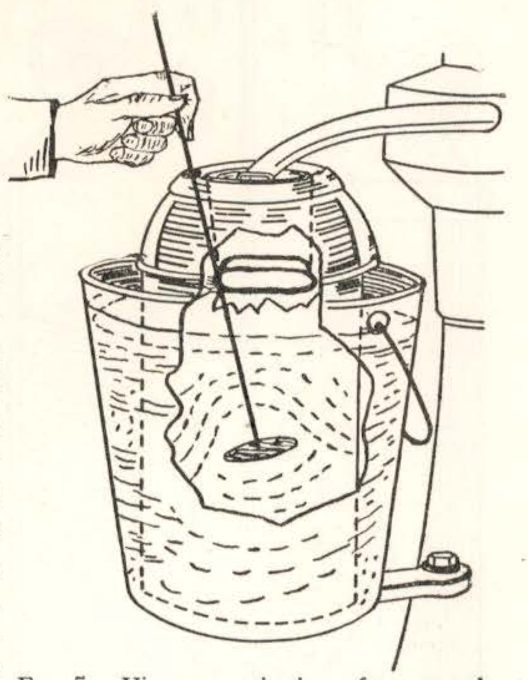

FIG. 5.—Vigorous agitation of cream when separated into a container surrounded by cold water increases the rapidity of cooling.

The agitation of milk or cream in a can standing in a container of still water increases the rate of cooling. Agitation breaks up or prevents the forming of the blanket of colder milk on the inside of the can, thus allowing a faster transfer of heat. From a sanitary standpoint this form of agitation introduces a serious hazard in the form of additional surfaces with which the milk or cream comes in contact. These surfaces must be kept scrupulously clean if satisfactory results are to be obtained. The milk or cream may be agitated by one of the following methods: hand stirring, spring motor, water motor, and cooling coil in the can. Probably the oldest and simplest method of agitating milk or cream is stirring it with a hand stirrer (Fig. 5). The simple process of stirring the milk or cream while cooling materially aids in the rapidity of heat transfer and reduces the cooling time. The stirrer should be of such a type that it can be readily cleaned so as to prevent contamination.

In order to remove the manual labor from the stirring of milk or cream while cooling, many devices have been designed. One simple device consists of a strong spring encased in a metal container which rests on top of the can (Fig. 6). After the spring is wound up it propels a small agitator submerged in the milk or cream. Keeping the spring wound results in continuous stirring and more rapid cooling of the contents of the can. The spring has the added advantage of being inexpensive to operate.

A common type of power that has been applied to the stirring of milk is waterpower. A small water motor located on top of the can drives a small agitator submerged in the can of milk or cream. As the water flows

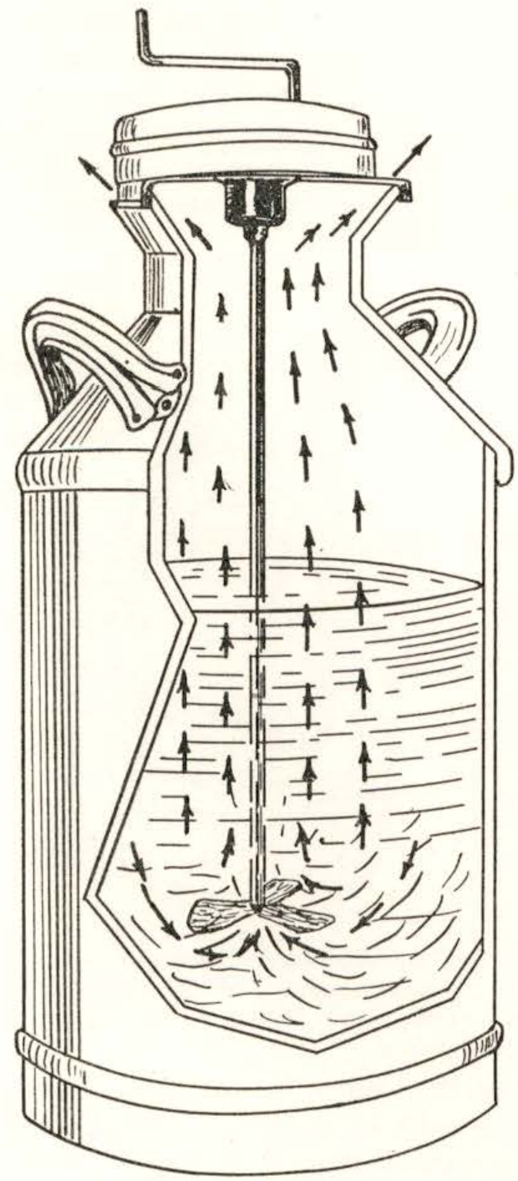

FIG. 6.—The spring motor may be used for continuous stirring within the can.

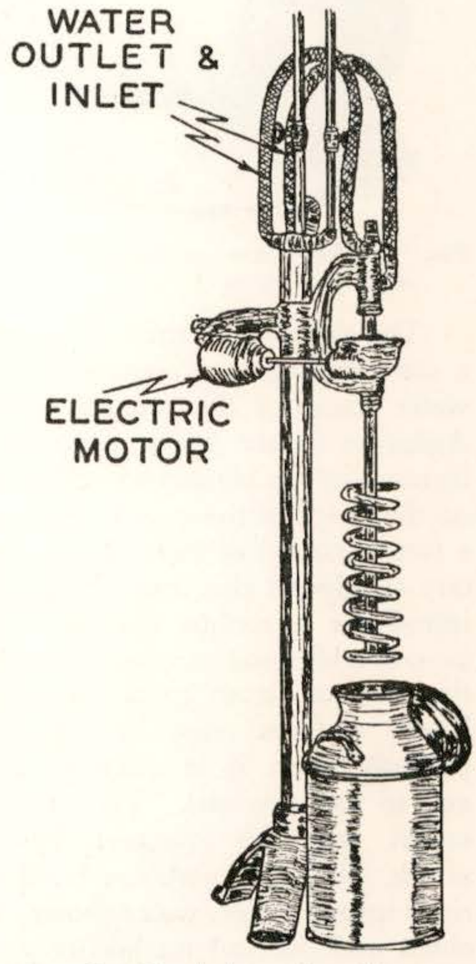

FIG. 7.—Circulation of cold water through a revolving coil which agitates the milk greatly increases rapidity of cooling.

through the motor from the faucet the milk or cream is agitated (Fig. 11). This source of power is very convenient where water under pressure is available.

Where electric power is available a type of equipment can be used which consists of an electrically driven rotating cooling coil submerged in the can of milk or cream. As the coil agitates the milk the cooling medium in the form of well or spring water, ice water, or refrigerated water flows through the coil (Fig. 7). In this way rapid cooling takes place as a result of agitation and increased cooling surface exposed to the milk.

Flowing water direct from wells or springs (Figs. 2 and 3) furnishes the most common type of agitation of the cooling medium. The circulation of water around the cans removes the warmer water. If the cold water enters the bottom of the tank and the overflow or outlet is at the top a definite circulation is established.

When an abundant supply of cold flowing water is available the type of tank and the amount of insulation are less important. Concrete tanks, while not efficient from the standpoint of heat insulation, are used extensively. The use of this type of tank necessitates ample size so that the volume of water is sufficient to hold the gain made in cooling the milk or cream should the water stop circulating for a short time. A smaller tank may cool a little more rapidly but there is less reserve for holding the milk or cream and the water must flow continuously if satisfactory results are to be obtained.

The wood-barrel type of cooling tank, with many modifications, furnishes an inexpensive and efficient type of cooler on the average farm where only a small amount of milk or cream is produced.

Mechanical agitation of the cooling medium in such a manner as to cause a positive circulation is very satisfactory if power is available. Any type of agitator that will cause a rapid circulation will increase the rate of heat transfer and thus cool faster.

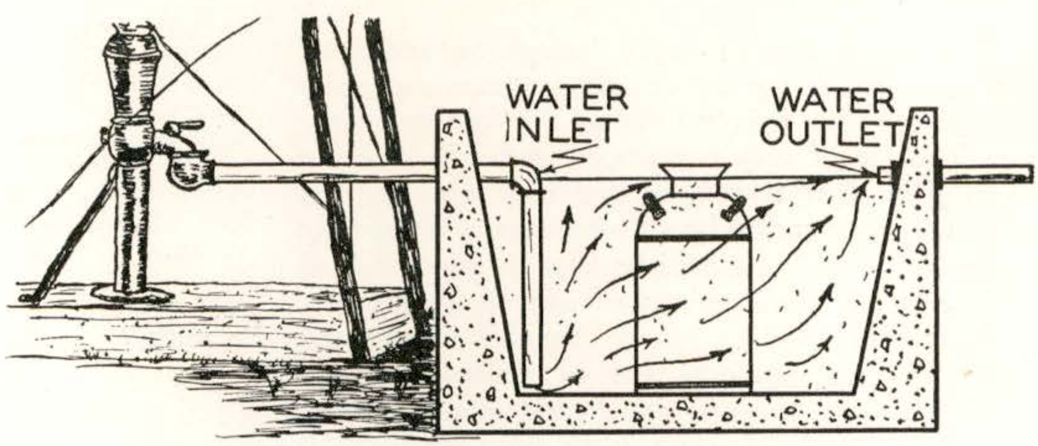

FIG. 8.—Forcing circulation by means of the pump.

The use of a pump to circulate the water in the cooling chamber is quite common where rapid cooling is desired. The pump should be large enough to set up a definite circulation in the tank. The use of a double tank with the pumping of the water into one from the other makes constant water level possible. This feature is made use of in some cooling tanks with satisfactory results.

The use of air bubbling from the bottom of the tank past the cooling coils agitates the water in some of the newer types of mechanically refrigerated cooling tanks. It gives efficient agitation of the water without the use of moving equipment submerged in the cooling medium.

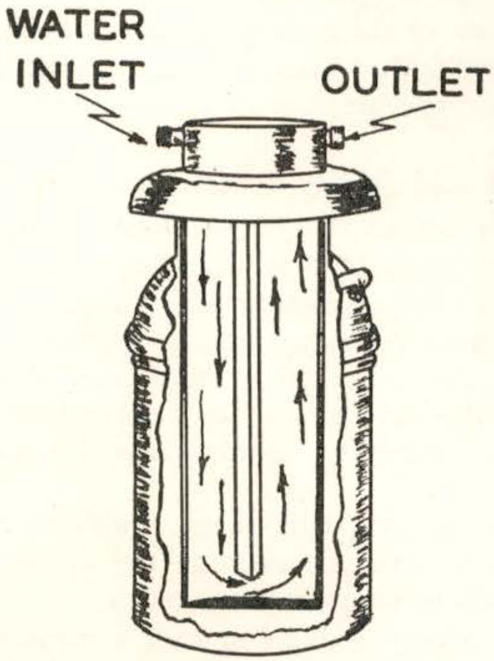

FIG. 9.—A cooling surface in the can without agitation of the contents aids in cooling.

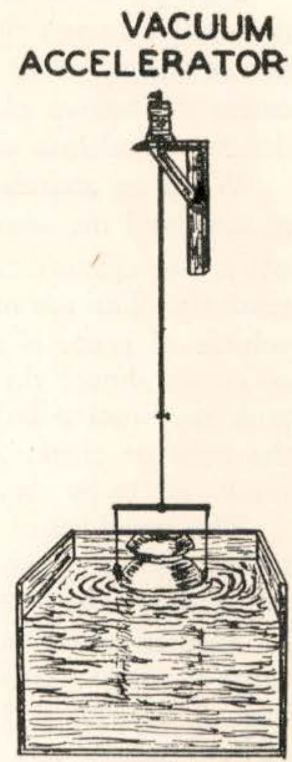

FIG. 10. — Mechanical rotation of the can in a tank of cold water agitates contents of can as well as the cooling medium at the same time. Rapid cooling results.

The use of flowing water through an additional cooling surface in the can of milk or cream materially shortens the time required to cool the contents of the can. The use of such equipment while the cans are standing in some type of cooling tank with agitated water will be found to be an advantage in shortening the cooling time. It should be kept in mind that all equipment that comes in contact with the milk must be kept clean.

More rapid cooling can be obtained by agitating the milk or cream while the can stands in a tank of agitated cooling medium.

Hand stirrer, spring motor, water motor, and cooling coil as methods of agitating milk and cream in the can have been described. Since the use of this type of equipment may be the means of contaminating the milk or cream, attention is again called to the importance of utmost cleanliness.

A device for mechanical turning of the can is available that makes use of the vacuum which operates the milking machine. It agitates both the milk or cream and water. This is done by suspending a can of milk in the cooling tank by a rod from the ceiling. A vacuum-driven mechanism rotates the rod a fraction of a turn, causing the contents of the can as well as the water to be agitated, thus producing rapid cooling of the milk.

Under some conditions where an abundance of low-temperature water under pressure is available milk and cream can be cooled without placing the can in the cooling tank. The rate of cooling will depend upon the system used. The process must continue or the cooled milk or cream will absorb heat from the surrounding air.

The simple method of placing a fine spray nozzle above several cans of milk or cream to be cooled is sometimes used in an emergency. The water flows over the cans, slowly removing the heat. The warmer water flows from the can down the drain. A large number of cans can be cooled at the same time by this method but only partial cooling can be expected. The cooling process is slow as the contents of the can are not agitated.

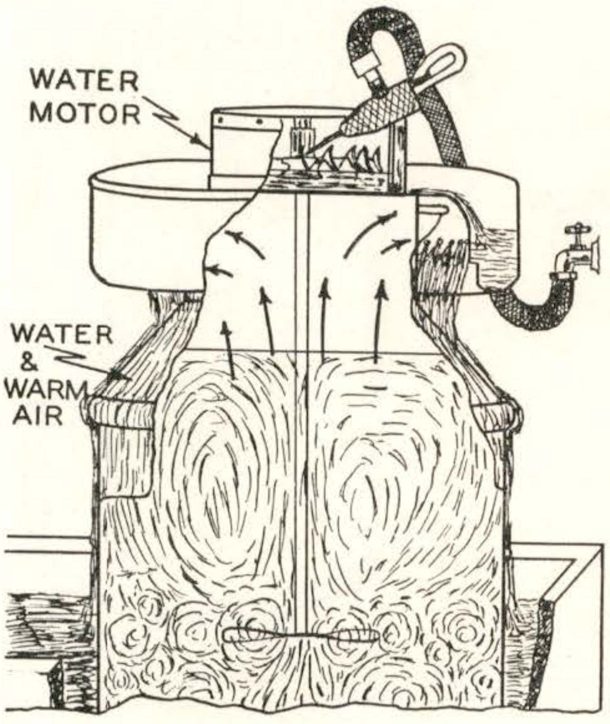

FIG. 11.—A water motor may be used to stir the contents of the can and to remove warm air from within the can. The discharge water flows over the outside of the can and aids in cooling.

A simple system suitable for a single can of milk or cream consists of a ring of small pipe that will slip over the neck of the can and rest on the breast. Small holes are drilled in the bottom of the pipe so that water is sprayed over the surface of the can. The water flowing over the can runs to the drain. Results reported by Oregon Experiment Station[2] showed fair results with this type of cooler. The process must be continued if the milk or cream is to remain cooled.

Combining the use of flowing water over the outside of the can after the water has passed through a water motor which agitates the milk has been used successfully (Fig. 11). One system further uses the water to draw the air out of the can, which helps remove odors from the milk

[2] G. H. Wilster, Hans Hoffman, and F. E. Price, Oregon Agricultural Experiment Station Bulletin 331, 1934.

while being cooled. This type of cooler, because it combines the flowing of cold water on the surface of the can and agitation of the milk, cools quite rapidly. When it is used, some additional storage facilities must be provided.

Increasing the cooling surface by submerging in the can of milk either a cooling coil or cooling cylinder produces even faster cooling than with agitator alone in the can. The agitation of the milk is obtained by either the rotation of the cooling coils or a small propeller or stirrer which brings the milk in contact with the cooling cylinder within the can (Figs. 12 and 13). The power is usually produced by a water motor and the increased cooling is satisfactory where cold water under pressure is available.

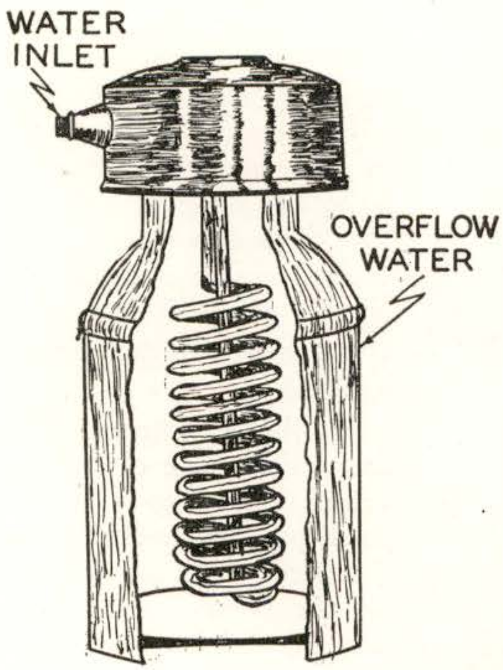

FIG. 12.—A cooling coil in the can is rotated by a water motor which discharges water over the surface of the can.

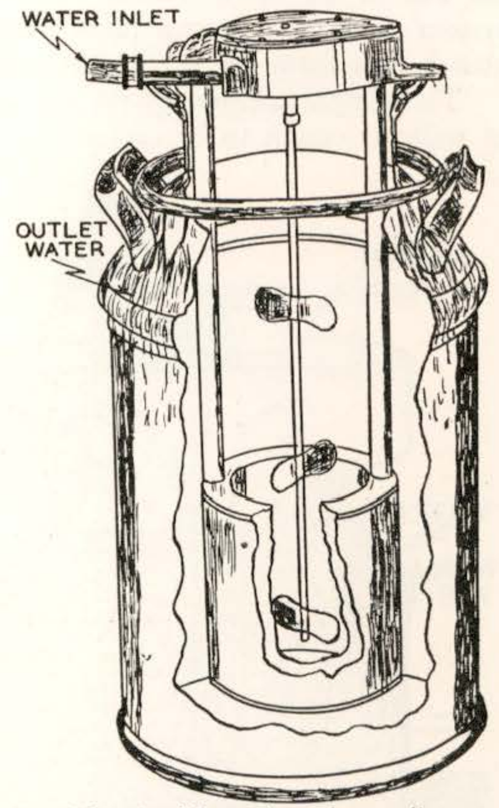

FIG. 13.—An illustration of a cooling surface and agitator within the can combined with a water motor which discharges water over the surface of the can.

The question of equipment that comes in contact with the milk as a possible cause of contamination must not be overlooked. Cooling equipment, like all other types which come in direct contact with milk or cream, must be kept clean.

SURFACE COOLERS FOR MILK AND CREAM

The designs of open-type surface coolers for use on the farm vary greatly. The main principle to be kept in mind is that the cooling medium in the surface cooler must be flowing (Figs. 14, 16, 17 and 18). The amount of flow will determine in part the amount of heat that will be removed from the milk as it flows over the cooling surface. Likewise if the milk flows over too rapidly it will not be properly cooled. Cleanliness is of prime importance in the use of a surface cooler, and the exposed milk and cream should be protected from dust in the air.

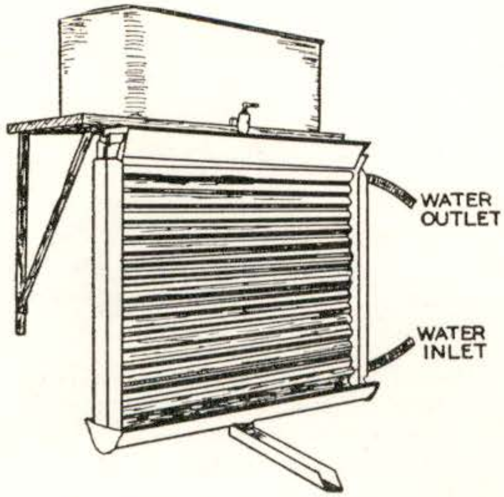

FIG. 14.—A common wall-type tubular surface cooler.

Flowing water will give very good results when used in the surface cooler. Milk and cream may be cooled to within two degrees of the temperature of the water if properly handled.

The temperature to which the milk or cream is cooled depends upon the temperature of the cooling medium. Where low temperatures are necessary and where ice is available, ice water is often circulated

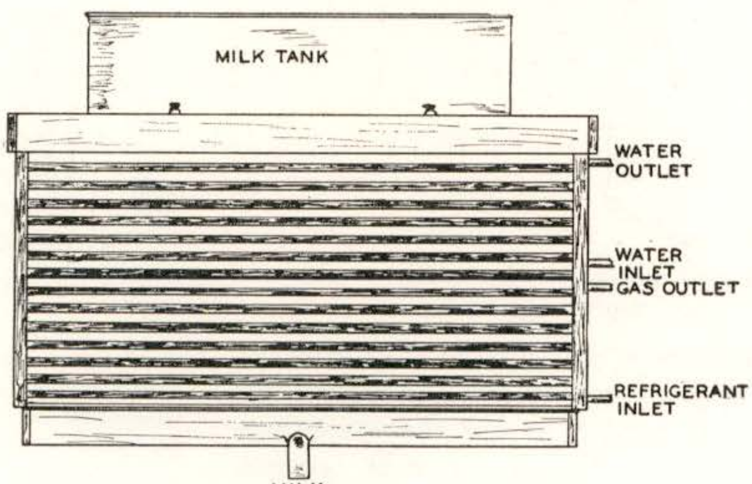

FIG. 15.—A two-section tubular surface cooler using circulating cold water or brine in the upper section and direct expanding refrigerant in the lower section.

through the surface cooler by means of a small pump. Cold well or spring water may be used in the upper section and ice water in the lower section for greatest efficiency. If temperatures are desired below 32°F. a brine may be made by the addition of salt to the ice water. The use of mechanically cooled water or brine is common in larger dairies.

The small mechanical refrigerator for farm use has also made this type of milk cooling available on the farm. The development of kerosene-burning refrigerators makes it possible to have mechanical refrigeration even where electricity is not available. Gasoline-operated units are also available.

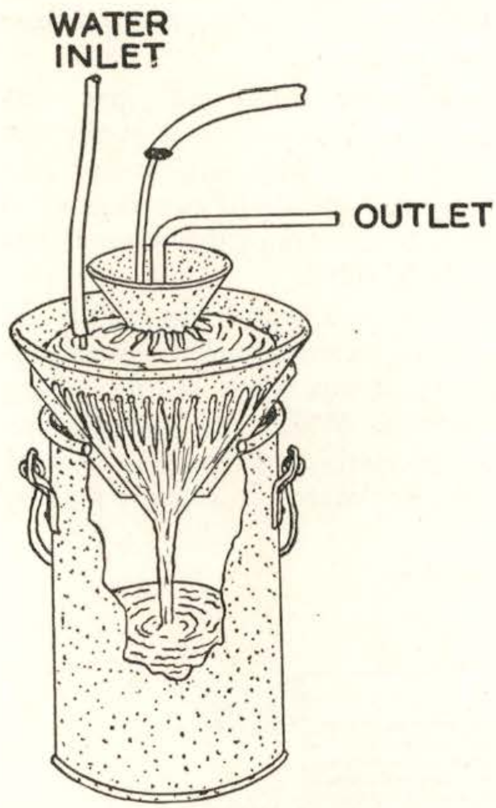

FIG. 16.—A small modified surface cooler for cream direct from the separator.

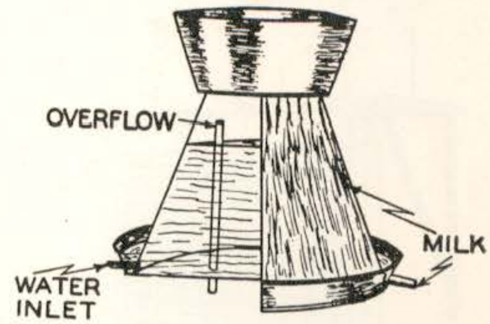

FIG. 17.—A conical type cooler is effective only when the cooling medium is positively agitated or circulated. This one is not very efficient.

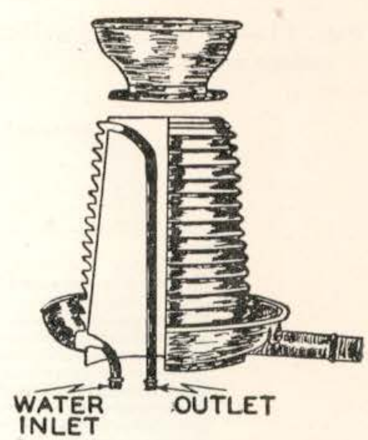

FIG. 18.—An efficient type of conical cooler with positive circulation of the cooling medium.

Developments in the application of mechanical refrigeration on dairy farms and milk plants have made it possible to use the expanding-liquid refrigerant directly in milk coolers. Usually it takes the place of brine or refrigerated water in the lower half of the surface cooler (Fig. 15). Very satisfactory results are obtained in this manner when the refrigerating unit is large enough to carry the load.

COOLING MILK AND CREAM IN BOTTLES

The complete or partial cooling of milk or cream in the bottle is often practiced. Bottled milk should be cooled to 50°F. or below when delivered to the consumer. Experimental results indicate that satisfactory results can be obtained when milk is cooled in the bottle; however, when milk is bottled directly after being drawn from the cow, feed flavors are very likely to be more noticeable in the milk. Objectionable flavors can be avoided by partially cooling the milk before it is bottled. This can be done in the can or by means of a surface cooler by methods previously described. The partial cooling can usually be accomplished by the use of water without refrigeration.

To complete the cooling process the bottles of partially cooled milk can be set in cold well water or ice water which is deep enough to come well up on the necks. Care should be taken to see that proper sanitary conditions are maintained to prevent contamination.

A more rapid removal of the heat will be obtained if the cooling medium can be kept in motion around the bottles. Water cooled to a low

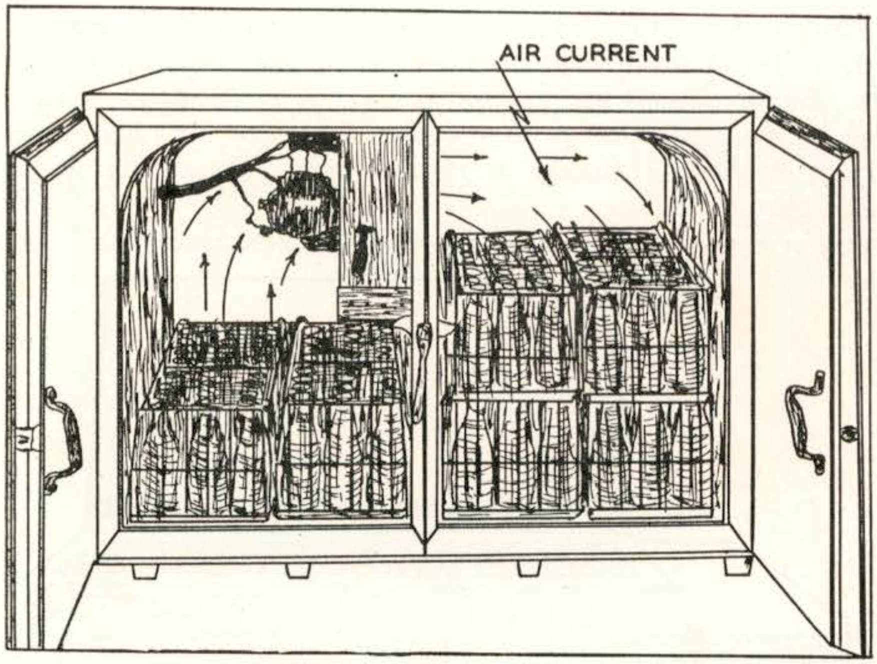

FIG. 19.—A portable dry type cooling cabinet.

temperature by mechanical refrigeration may be used. Rapid agitation of the cooling medium will increase the rate of heat transfer. Care should be taken to see that the temperature of the cooling medium is not below the freezing point of the milk.

The practice of placing the partially cooled bottled milk in circulating cold air in a closed room or box is fast becoming a popular method of handling bottled milk. This type of equipment not only furnishes a method of cooling but also provides storage after the cooling process is completed. The air temperature should not be below the freezing point of the milk and the air must have positive circulation. The bottles of milk should be in open crates, preferably metal (Fig. 19).

STORING MILK AND CREAM

After milk and cream are cooled it is essential to keep them cold durin the storage period on the farm. The simplest method is probably the use of the dry insulated jacket (Fig. 4) which slips over the can and is closed by straps. If the jacket is of proper construction and made of good insulating material the can and contents can be protected from the heat of the surrounding air for several hours. The wet sack or jacket method can also be used where other equipment is not available. The results obtained will depend largely upon the atmosphere conditions, because rapid evaporation must take place if the temperature is to be kept low.

The use of caves and wells for the storage of food products has long been an unsatisfactory practice. The limiting factor here is the temperature. A dry well or pit furnishes a possible but unsatisfactory means of storage.

A similar use of the dug well in which a can may be partially submerged in the cold water offers a more satisfactory way of storing cream or milk. Where natural ice is stored the use of a well or pit which is surrounded by a quantity of ice stored in a larger pit or cellar furnishes a satisfactory method of storage at much lower temperatures without the usual handling of the ice.

A very common method of storing milk and cream on the farm makes

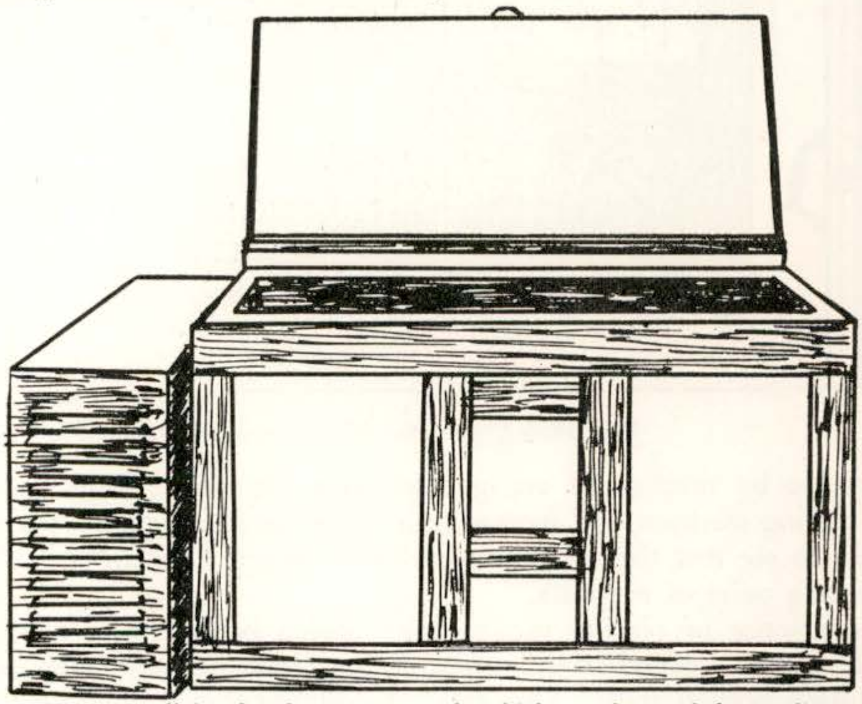

FIG. 20.—A well insulated wet type tank which can be used for cooling and storing milk and cream.

use of some type of tank (Fig. 20). In many cases the same tank that is used for cooling is used for storage purposes. The effectiveness of the tank will depend upon the size, material used, insulation, tightness of cover, and temperature and quantity of cooling medium available.

In the absence of a better cooling medium, circulating fresh spring or well water can be used to some advantage. Its usefulness in storage as in the cooling of milk and cream is limited by the temperature of the water, the amount available, and its continuous circulation. When ice is used with water or brine a well insulated tank will effect a very worthwhile saving over an uninsulated tank or one that is poorly insulated.

It is a common practice to store cans of milk or cream in the same mechanically cooled tank in which the initial cooling was done. No further attention is necessary since the cooling medium is automatically maintained at the desired temperature. It is essential to maintain constant level of the

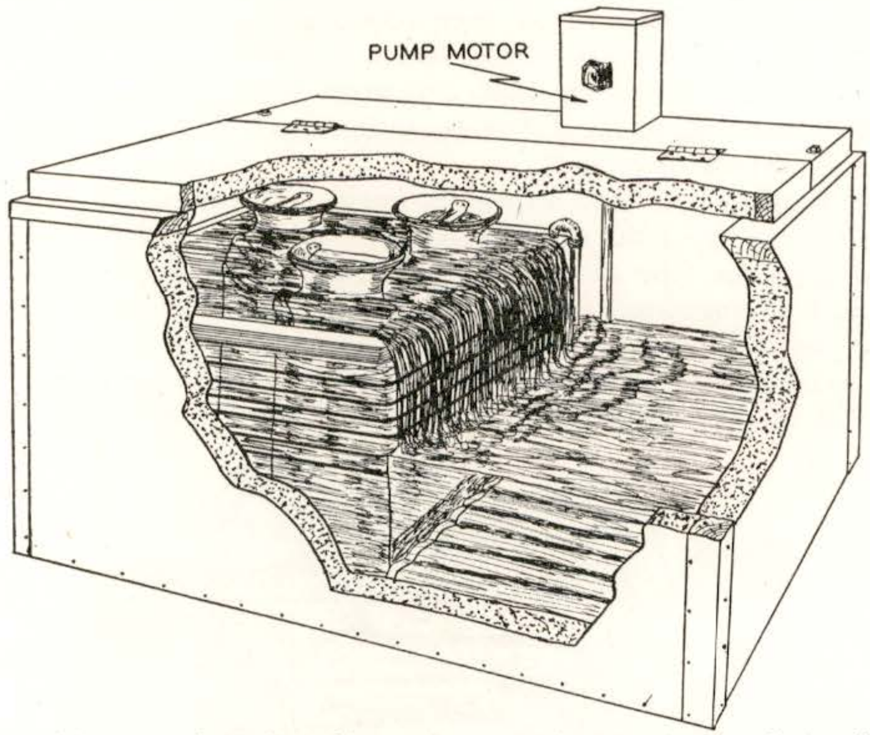

FIG. 21.—A mechanically refrigerated constant-level insulated cooling and storage tank.

cooling medium at the necks of the cans (Fig. 21). Yung's[3] milk-cooling studies begun in 1932 showed effective cooling and storage under conditions of constant level.

Refrigerated rooms of the walk-in type and smaller dry-type boxes and cabinets offer a convenient means of storing milk or cream after cooling. Since air is the cooling medium the containers may be of various sizes and shapes as long as the milk or cream is cooled before storing. These storage units may be divided into two groups, depending on the movement of air within the storage space.

In the still-cold-air type no provision is made for circulating the refrigerated air within the storage space other than such natural circulation as may be due to location of cooling coils or baffles.

In the circulated-cold-air type the use of a fan to circulate the cold air around the containers makes it possible to maintain a more uniform

[3] F. D. Yung, Unpublished thesis: An Automatic Constant Level Immersion Type Milk Cooler, University of Nebraska, December, 1936.

temperature throughout the storage space. It is not necessary to precool milk and cream to quite as low a temperature when stored in circulated cold air since moving air will complete the job of cooling more rapidly than still air.

KEEPING MILK AND CREAM COOL DURING TRANSPORTATION

After milk and cream have been cooled and stored on the farm the problem of getting them to market in a cool condition still has to be considered. The problem is especially important during the summer months and in climates where the air temperature is well above the temperature of the cooled milk or cream.

The simplest and least expensive method of transporting individual cans is by the use of the dry insulating jacket. The results obtained will depend upon the type of insulation, the tightness with which it fits the can, and the temperature conditions of the air surrounding it.

The use of the wet sack or jacket gives fairly good results where the jacket can be kept wet during transportation and can be carried where there will be good circulation of air around the wet jacket and can. If

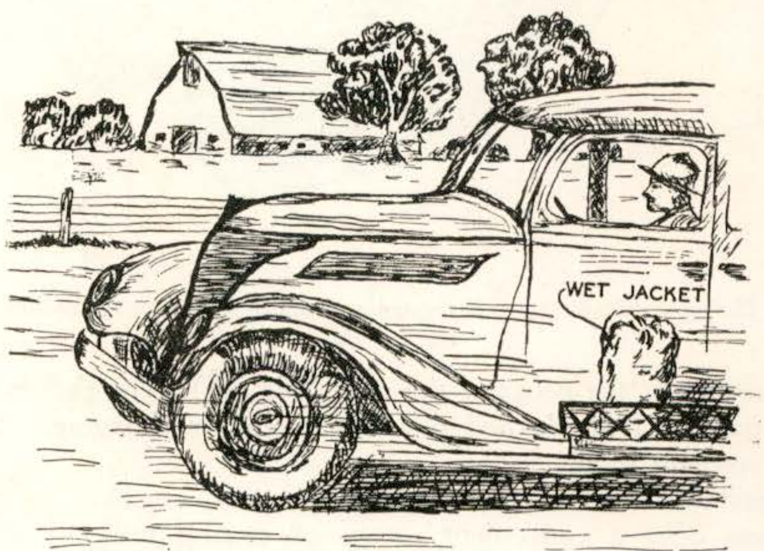

FIG. 22.—Common use of the wet sack or jacket in transporting cold milk and cream.

carried on the running board of the car with a supply of water in the lid, satisfactory results can be obtained especially when transporting milk and cream short distances (Fig. 22).

When a large number of cans of cold milk or cream are to be transported the use of a dry insulating blanket is an advantage. If the loading body is tight so that air cannot circulate through the cans the covering of the cans with a blanket will aid materially in keeping them cool. If the cans are well cooled at loading time, well packed in a tight body, and covered with an insulating blanket, they can be satisfactorily transported considerable distances without a material rise in temperature.

The wet blanket can be used in the same manner but has the difficulty of gathering dust quickly.

Where a truck or a railroad car is used extensively for handling cold milk or cream in cans, insulated closed bodies are used. This condition really makes a refrigerator box on wheels and should be considered as

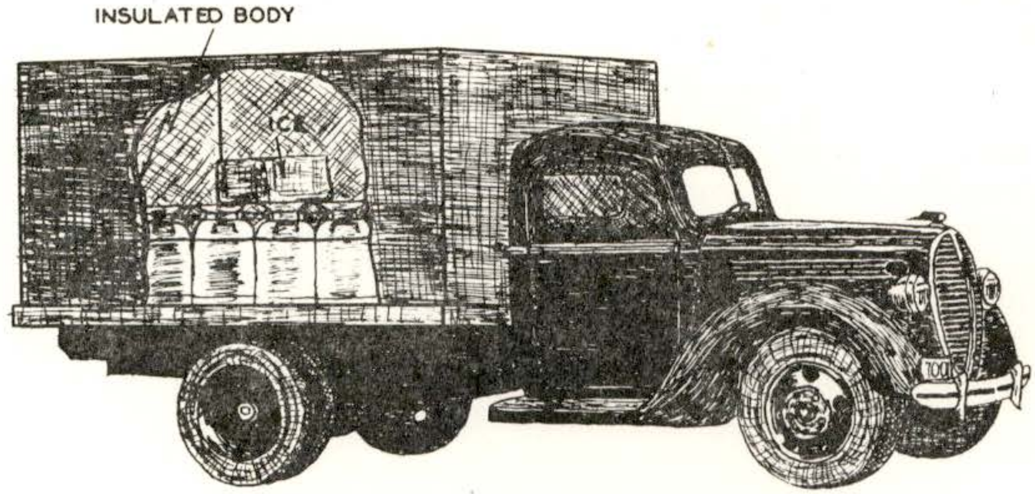

FIG. 23.—A truck with insulated body for transportation of cold milk and cream.

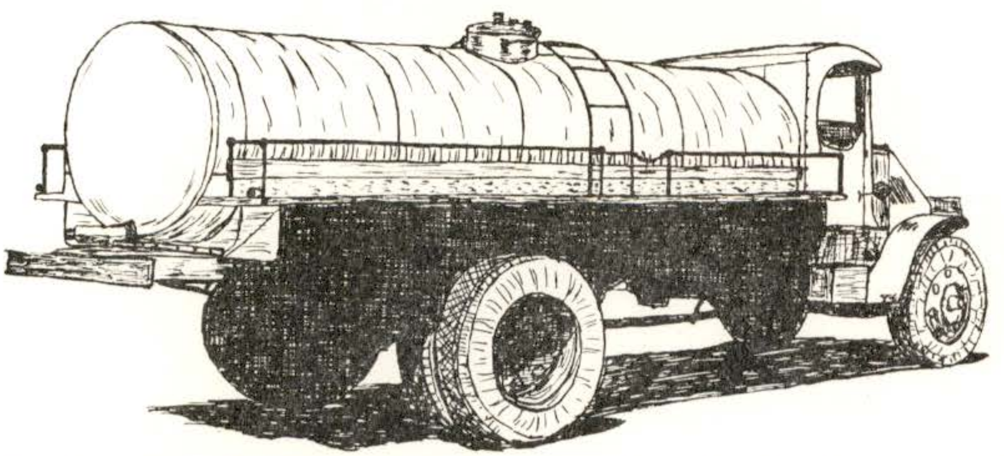

FIG. 24.—A truck with insulated tank for transportation of cold milk and cream in bulk.

such (Fig. 23). Most methods that can be used to refrigerate a walk-in type of refrigerator box can be used here. The most common methods of keeping such a truck body cold during transportation of milk or cream use ice or some type of mechanical refrigeration. When large volumes of cold milk are transported the milk is commonly carried in bulk in a suitable tank properly insulated, mounted either on trucks or railroad cars (Fig. 24).

METALS USED FOR COOLING EQUIPMENT

Metals used in the construction of cooling equipment are important as they affect the durability, ease of cleaning, and often the flavor of the milk. Iron or copper as well as copper alloys should be avoided because of the solubility of these two metals in the milk and the possible effect upon its flavor.

Nickel, while quite soluble, has but little effect upon the flavor. Aluminum is not soluble in milk but shows heavy corrosion when washed with alkali washing powders. Zinc and lead are unsatisfactory because of their toxic properties.

Tin is widely used in cooling equipment because it is resistant to corrosion and has no effect upon flavor. Tinned copper is widely used and is satisfactory as long as the thin coat of tin remains over the copper. The durability of the tin coating is not great and it often wears through, which exposes the copper to the milk. Alloys of iron have been made which resist corrosion of milk and produce no effect upon the flavor. One of the common alloys known as stainless steel, chrome nickel steel, or "18 and 8" is very satisfactory but somewhat expensive. Tin is still the most common and economical metal for common dairy equipment on the farm.

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