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TRANSPORTING AND HANDLING MILK IN TANKS
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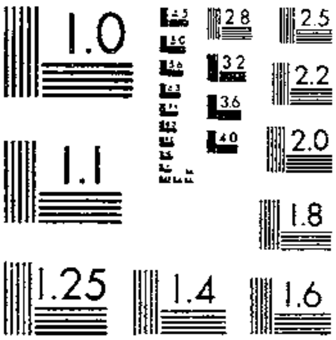

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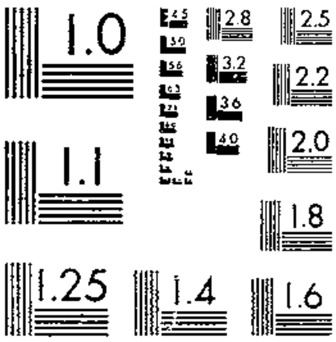

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NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL BULLETIN No. 243 August, 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

TRANSPORTING AND HANDLING MILK IN TANKS

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CONTENTS

RAPID INCREASE IN TANK HAULING

Adequate facilities for transporting milk are necessary in extending the area of a milk shed. Not only must the means of transportation be regular, but it must be quick and sanitary in order to deliver the product in the city with the least possible lowering in quality. No system yet devised has fulfilled the above requirements to the same extent as have the tank car and tank truck. The year 1910 saw the first tank car and 1914 the first tank on motor truck for use in the transportation of milk. Since then the use of tanks has increased rapidly until at present some cities receive 70 to 95 per cent of their fluid milk in tanks.

CAUSES OF CHANGES IN METHODS OF HAULING

To what may the increase in the use of tanks be attributed? The building of good roads has made it possible for motor vehicles to go into nearly every farming section in the country; and also, the motor vehicle itself has been greatly improved. Furthermore, in some cities, because of their rapid growth and their milk-ordinance requirements, dealers have been compelled to obtain part of their milk supplies from outlying territories; and in their endeavor to maintain quality, price, and ease of shipment they have turned to tank hauling. For example, in Chicago the city board of health passed a regulation requiring that all milk entering the city be from tuberculin-tested

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cows. There were not enough tuberculin-tested cows in the Chicago milk territory to supply the city with milk at the time the law went into force, for the following reasons: (1) A lack of funds for indemnifying owners for condemned tubercular cows, (2) the physical impossibility of testing the necessary number of cows within the time limit, and (3) the feeling on the part of some producers that the law would not be enforced. Dealers, therefore, were forced to go beyond the former limits of their milk territory. As a result, tank shipment of milk into Chicago increased 21 per cent from December, 1925, to May, 1926. For another example note Detroit. The rapid growth of this city has changed what were formerly good dairy-production sections into suburbs or market gardens, and milk dealers have been forced to go farther away from the city for their supplies.

OBJECT OF STUDY

The object of the study reported in this bulletin was to determine the methods of handling milk delivered to the plant in tanks, the labor and time requirements of tank delivery, the advantages and dis-

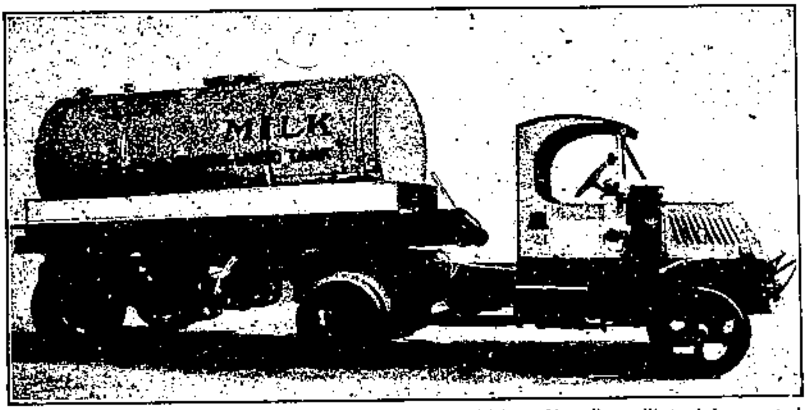

FIGURE 1.—A semitrailer, equipped with air brakes, on which a 2,000-gallon milk tank is mounted

advantages of such delivery, and the cost of handling milk in this way. Data on 300 tank trucks, 89 trailers, and 53 tank cars were collected by the bureau in 1927–1929; and observations were made on 82 tank trucks, 29 tank trailers, and 28 tank cars.

TANKS MOUNTED ON MOTOR TRUCKS

KINDS IN USE, CAPACITY, AND COSTS

Data collected on 438 tanks showed the following kinds of tanks in use, in the percentages given: Glass-lined steel, 84 per cent; tin-lined copper, 9 per cent; nickel, 6 per cent; and stainless steel, 1 per cent. The last-mentioned type is the latest to be put on the market. Of these tanks, 82 per cent were insulated. The insulating materials were cork, wood, felt, and canvas pads, given in order of frequency of use. In 87 per cent of the insulated tanks, cork approximately 2 inches thick was used, which was protected by heavy canvas, sheet aluminum, or sheet steel. Either aluminum or sheet steel is to be preferred, as they have a smoother surface, are easier to clean, and protect the cork better than the canvas.

The type of chassis upon which a tank is mounted depends upon the capacity of the tank and the road laws of the State in which the tank is used. Most tanks up to 1,250 gallons capacity are mounted on regular motor chassis. Where the load to be carried is larger than this, the tank usually is mounted on a semitrailer (fig.1); or in some cases two medium-sized tanks of 1,000 to 1,250 gallon capacity each are mounted on a 6-wheel chassis.

The capacity of 252 tanks studied ranged from 500 to 2,000 gallons. Seventy-two per cent were of 1,000 to 1,400 gallons capacity, approximately one-third being between 1,000 and 1,100 gallons. The 2,000-gallon tanks were used on semitrailer chassis. Tanks used on trailers did not vary in capacity so much as did those used on trucks, the capacity of the former ranging between 1,050 and 1,100 gallons.

The cost of 70 tanks mounted on motor trucks was obtained. Forty of these tank-trucks, or 57 per cent, cost $6,000 to $8,500 each; 17 or 24 per cent, cost $6,000 to $6,500 each. The average cost was $5,994, and the range was from $2,500 to $9,762, the lower costs being those of small outfits and used equipment. The average cost per gallon capacity was $5.17.

LENGTH OF ROUTES AND SPEED OF HAULING

The consensus of opinion of tank-truck owners and operators is that the economical limit of tank-truck hauling is from 120 to 150 miles per round trip, depending upon the type of roads and topography of the country. Table 1 divides 92 of the routes into 25-mile zones and shows the time en route and the miles per hour for each route within these zones. The length of 79 motor-tank routes out of 113 studied, or 70 per cent, was between 29 and 111 miles round trip.

The distance traveled per hour for the 0 to 25 mile zone was 15.8 miles per hour; for the 25 to 50 mile zone, 15.9 miles per hour; for the 50 to 75 mile zone, 17.2 miles per hour; for the 75 to 100 mile zone, 18.5 miles per hour; and for the 100 to 125 mile zone, 17.3 miles per hour. The decreased average in distance traveled per hour for hauls over 100 miles in length was caused by the fact that the drivers made more stops for gasoline and oil, passed through more towns, and required a lunch period.

Table 1.—*Effect of length of route on distance traveled per hour by tanks mounted on motor trucks*

0 TO 25 MILE ZONE

Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour
	H. m.	*Miles*		*H. m.*	*Miles*		*H. m.*	*Miles*
2	8	15	10	25	24	20	1 30	13
3	20	9	11	45	15	20	1 30	13
3	15	12	11	38	17	20	1 30	13
3	15	12	12	50	14	20	1 30	13
7	30	14	12	38	19	20	1 0	20
8	30	16	14	45	19	20	1 30	13
10	35	17	15	40	23	20	2 0	10
10	35	17	15	60	15	22	1 15	18
10	45	13	18	1 30	12	24	55	26
10	25	24	18	1 30	12			

25 TO 50 MILE ZONE

Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour
25	1 30	17	31	2 15	14	42	2 30	17
25	1 30	17	34	3 0	11	42	2 0	21
25	1 0	25	35	2 15	16	44	2 20	19
27	2 30	11	35	2 0	18	45	3 0	15
28	2 0	14	36	2 30	14	45	3 0	15
30	2 0	15	39	3 0	13	45	2 30	18
30	2 0	15	40	2 30	16			

50 TO 75 MILE ZONE

Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour
50	4 0	13	52	3 0	17	66	4 0	17
50	3 30	14	53	3 0	18	67	4 0	[illegible]
50	3 20	15	54	3 30	15	70	5 0	14
50	3 0	17	55	3 0	18	70	2 45	25
50	2 0	25	58	2 45	21	72	4 0	18
50	3 0	17	60	4 0	15	72	6 30	11
50	2 40	19	65	4 0	16	73	6 30	13
51	2 15	23	65	4 0	16			
52	3 0	17	65	3 0	22			

75 TO 100 MILE ZONE

Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour
75	4 0	19	80	4 0	20	90	6 0	15
80	4 0	20	85	6 0	14	90	6 0	15
80	4 30	18	85	5 30	16	94	4 0	24
80	4 0	20	88	3 45	23			

100 TO 125 MILE ZONE

Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour	Length of route (miles)	Time on route	Distance traveled per hour
100	7 0	14	110	10 0	11	125	7 0	18
100	6 30	15	110	6 30	17			
100	4 15	23	120	5 0	24			

Plants operating large numbers of tank trucks should have some method of obtaining information concerning the length of routes, time en route, attention given to trucks, their performance, loads carried, etc. This is all the more important if the daily supply of milk depends entirely upon this means of transportation. The usual method of obtaining information is by a driver's report card, one form of which is shown here:

Driver's Daily Report Card

Date ______________________________, 193___

Truck No. ____________ Station ______________________________

Trailer No. ____________ Station ______________________________

Daily mileage______________________________

Gallons gasoline received______________________________

Engine oil received______________________________

Truck lubricated______________________________ Yes ________ No ________

Time leaving station______________________________

Idle time on road ______________________________

Cause ______________________________

Time arriving______________________________

Unloading hours______________________________

Time leaving______________________________

Idle time on road______________________________

Time arriving at station______________________________

Weight of milk on truck______________________________

Weight of milk on trailer______________________________

Weight of milk on trailer______________________________

Is truck running OK?______________________________

If not, what is wrong?______________________________

____

____

Weather: Fair______________ Rain______________ Snow______________

Roads: Good______________ Rough______________ Muddy______________

Signed______________________________

Driver.

This card is solely a route report. Some cards combine with this a station report giving quantity of milk of various grades received, time of receiving last shipment, quantity of milk carried over, and other facts which the main plant must know.

NEED FOR SUPPLEMENTAL TANKS

The frequency with which tank trucks need repair and overhauling depends on the length of routes, contour of the roads, type of driver, and size of load. A partial load puts an extra strain on the chassis and motors because of the surge of the liquid contents. Therefore, extra tanks should be kept not only to replace the regular equipment when it is broken down or the motor overhauled but also to haul surplus milk and to meet the requirements of road laws.

For example, during March, April, and May of each year one State requires that the maximum axle load carried on concrete pavements or pavements with concrete base, for trucks with spacing of axles of 9 feet or over, shall not exceed 13,500 pounds, that the maximum load on any wheel shall not exceed 450 pounds per inch of width of tire if axle spacing is under 9 feet, and that the maximum load for any wheel shall not exceed 525 pounds per inch of width of tire; for all other types of road, the maximum axle load with spacing of 9 feet between axles shall not exceed 10,000 pounds, and the maximum wheel load at any axle spacing shall not exceed 450 pounds per inch of width of tire.

Another State has a law applying to weights and speeds in times of thaws and excessive moisture. This law permits the director of highways to prescribe a reduction in carrying weight of not more than 25 per cent on State highways, and of not more than 50 per cent on other highways.

Laws of this nature limit the load of motor trucks to within 15 to 50 per cent of capacity, depending upon size of truck, type and size of tires, and kind of roads, and the difference between what the truck could haul and what it is permitted to haul, must be carried with extra equipment.

Most plants operating only one or two trucks usually would find it uneconomical to have extra equipment to take care of emergencies. What is considered the economical point at which such equipment is feasible? Most of the tank owners and operators interviewed agreed that a milk plant should have at least four regular routes, depending somewhat upon the length of the routes. However, it is not necessary to have all the extra tanks motorized; most of them may be mounted on trailers.

TEMPERATURE CHANGES OF MILK IN MOTOR TANKS

Table 2 shows the effect of time en route upon variation in temperature of milk hauled in insulated full tanks, as reported by tank owners and operators throughout the country. This table shows a great uniformity in temperature changes of the milk, for within the air-temperature range of 40° to 100° F., 63 per cent reported a rise of only 2° to 3°. Much of the rise in temperature, however, may have been due to the temperature of the tank when the milk was put into it. The temperature of a tank will be about that of the atmosphere unless means are provided for precooling the tank.

TABLE 2.—*Effect of air temperature and time en route upon change in temperature of milk hauled in 43 insulated tanks*

Air temperature and time en route	Change in temperature	Air temperature and time en route	Change in temperature	Air temperature and time en route	Change in temperature
0° to 39.9° F.		70° to 100° F.		70° to 100° F.	
H. m.	*°F.*	*H. m.*	*°F.*	*H. m.*	*°F.*
3 0	0	0 20	0	2 30	+2.0
3 0	−3	0 45	+1.0	3 0	+5.0
4 0	0	1 0	+1.0	3 0	+2.0
4 0	0	1 0	+1.0	3 20	+2.0
6 0	0	1 0	+0.5	4 0	+1.0
		1 30	+2.0	4 0	+2.0
40° to 69.9° F.		1 30	+2.0	4 0	+1.5
		1 30	+1.5	4 0	+3.0
		1 35	+2.0	5 0	+2.0
1 0	−1.0	2 0	+2.5	5 30	+3.0
1 30	+2.0	2 0	+2.0	6 0	+3.0
2 45	+2.0	2 0	+0.5	6 0	+2.0
3 0	+2.0	2 0	+1.0	7 0	+4.0
3 30	+2.0	2 0	0	8 30	+2.0
4 0	+1.5	2 15	+4.0	10 0	+4.0
6 30	+2.0	2 30	+1.0		

At one plant observations were made on two occasions of the temperature of milk hauled in a 2-inch cork-insulated tank and in an uninsulated tank of the same size, loaded at the same country plant with milk of the same temperature. The length of the haul was 55 miles, the trip was made in approximately 4 hours, and the air temperature ranged between 73° and 83°F. During the trip the milk in the uninsulated tank rose 12.6° in temperature more than the milk in the insulated tank. This illustrates the importance of insulating the tanks.

HANDLING MILK FROM MOTOR TANKS AT CITY PLANTS

In handling milk delivered by tank trucks at city plants, three steps are involved: (1) Preparation for unloading, which includes getting the truck in position for unloading, stirring the milk, connecting pipes, taking samples, and opening valves; (2) unloading and weighing the milk; and (3) washing the tank, which also includes disconnecting pipes and closing all openings, and treating it to kill bacteria. Table 3 shows the number of man-minutes required per 1,000 gallons of milk and the percentage of the total time used for each of these operations at 15 plants.

TABLE 3.—*Labor required for each step in handling milk from motor tanks at 15 city plants*

Plant No.	Preparation for unloading		Unloading and weighing		Washing tank and treating to kill bacteria	
	Man-minutes per 1,000 gallons	Per cent of total labor	Man-minutes per 1,000 gallons	Per cent of total labor	Man-minutes per 1,000 gallons	Per cent of total labor
1	5.0	13.8	16.8	45.9	14.7	40.3
2	12.4	31.7	17.8	45.7	8.8	22.6
3	6.0	11.3	25.6	48.0	21.7	40.7
4	7.8	11.6	40.3	59.9	19.3	28.5
5	10.8	20.7	31.8	55.8	[illegible]	23.5
6	5.1	17.2	18.1	60.2	5.8	22.6
7	2.5	3.8	25.0	38.1	38.1	58.1
8	2.7	4.5	30.6	50.0	27.2	45.5
9	4.4	8.5	28.2	53.9	19.6	37.6
10	2.7	6.1	33.2	74.5	8.6	19.4
11	8.5	15.0	29.3	51.9	18.7	33.1
12	5.5	10.2	35.1	64.9	13.5	24.9
13	7.1	12.6	39.1	69.4	10.1	18.0
14	10.9	14.1	44.9	57.7	21.8	28.2
15	5.0	13.3	30.2	67.9	8.4	18.8
Average	6.5		29.7		16.6	

In only four plants was the labor of unloading and weighing less than 50 per cent of the total labor. Plants 7 and 8 were the only ones using steam for treating to kill bateria. Of the 38.1 and 27.2 man-minutes per 1,000 gallons used for washing and treating in these two plants, 12.5 and 10.6 man-minutes were used for steaming.

PREPARATION FOR UNLOADING

In getting the truck into position for unloading, it is driven or backed to the unloading place and the front raised to such an angle as to make certain that all milk will pass through the outlet. The general practice is to drive the front wheels onto wedge-shaped pieces of timber from 6 to 8 inches thick. Few plants back their trucks to the unloading position, as it takes extra time and requires more area for maneuvering the trucks, especially semitrailers. Where facilities are available for unloading more than one tank at the same time (Fig. 2), backing saves extra lengths of pipe. The unloading space illustrated in Figure 2 is fully protected from the weather by being inclosed within the plant.

Forty-seven per cent of the plants observed used some means of stirring the milk, either the electric stirrer, a stirrer propelled by chassis motor, a hand stirrer, or compressed air. The electric stirrer is either separate or attached permanently to the tank. If it is separate, the manhole must be opened completely and the stirrer either be fastened to the edge of the opening or be held by hand. This thoroughly agitates the milk. However, it is likely to injure the glass lining around the neck of the tank; to add bacteria from the stirrer itself because of carelessness in handling; and it leaves the milk exposed to atmospheric contamination.

Stirrers permanently connected to the tank and run by either separate electric motor or special attachments from the motor of the truck, are very satisfactory. Care must be taken to see that the packing box of the shaft is kept tight and clean.

Hand stirrers are subject to the same criticism as the separate electric stirrers. In addition, there is danger that stirring will not be continued long enough to agitate the contents of the tank thoroughly.

Compressed air was used the least. The general criticisms of this means are that the air must be filtered thoroughly and that the

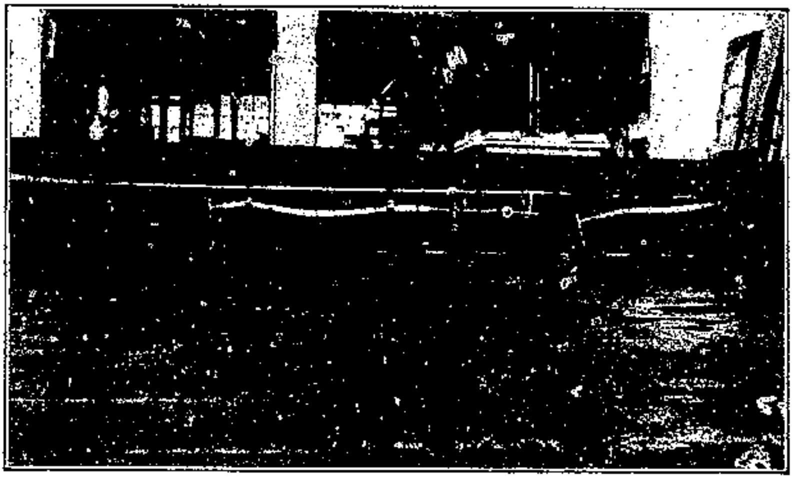

FIGURE 2.—Battery system for unloading tank trucks. Entire floor space is protected by building

small-sized pipe which is placed in the milk is hard to clean and therefore often neglected. However, in using compressed air there is very little chance of atmospheric contamination, as only a small opening into the tank is necessary. Furthermore, the stirrer does not injure the neck of the tank.

The opening to the outlet valve should be flushed with pure water before the pipe for emptying the milk from the tank is attached, as this opening, when not protected by a cap, collects mud and road dust. Even if the opening is protected by a cap, milk may leak through the valve and accumulate in the cap. This milk will be warmed to atmospheric temperature, bacteria will multiply rapidly, and if the milk is not rinsed out it may be a source of contamination. The valve is sometimes placed in a position hard to reach. (Fig. 3.) A valve so placed that the operator must crawl under the chassis is seldom taken apart for washing. It is very important that the valve be placed where it is easily accessible for attaching the pipe and for taking it apart to clean. (Fig. 4.)

Connections from the tank to the plant are made by straight sanitary pipe, flexible copper pipe, or rubber hose. Of these three, the rubber hose is in most general use, as it is flexible enough to be easily attached and it wears well. It is usually of the best material obtainable, white in color, and may or may not be reenforced between the layers with heavy wire. Care must be exercised to keep it clean and sanitary. The straight sanitary pipe is the easiest to keep clean and

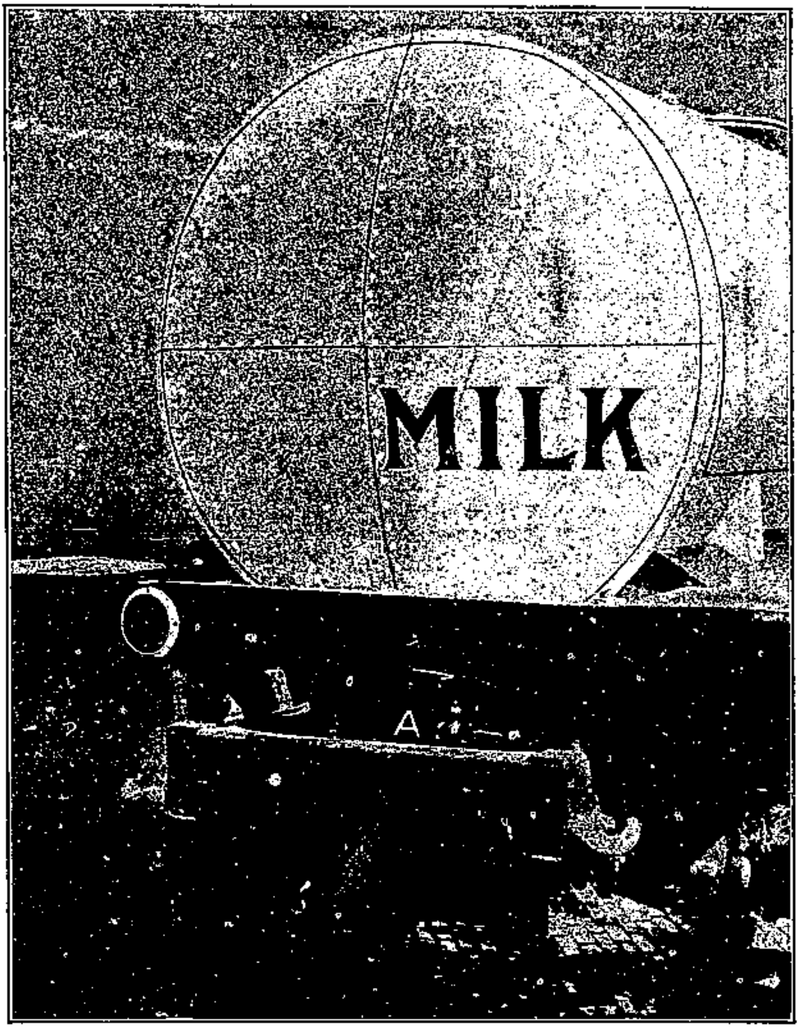

FIGURE 3.—The valve (A) on this milk-tank truck is difficult to reach for cleaning and unloading

comparatively free from bacteria, but it has the disadvantage that unless the truck is placed in a certain position the pipe is difficult to attach and the joints are hard to tighten so as to prevent leakage. From 6 to 10 feet of flexible copper tubing and rubber hose are used to connect the tank with the sanitary piping. The flexible metal tubing is easy to clean and treat to kill bacteria, but it jams easily; even a slight jam causes it to leak.

It is customary to take samples for butterfat tests and bacterial counts directly from the tank. This is one reason why thorough stirring is necessary. In taking both samples the bottles are let down into the milk through the manhole, a sterile container being used for the bacteria sample. At some plants when the milk is unloaded into a single container the butterfat sample is taken from it after the milk has been thoroughly agitated. However, at all plants bacterial samples should be taken directly from the tank.

WEIGHING AND UNLOADING

As tank trucks carry comparatively large loads of milk in bulk, they require a different system for checking weights at the receiving end than do other methods of hauling. The larger the percentage of total milk received in tanks, the greater is the necessity for checking the weights. If only 5 per cent of the total milk is hauled in tanks, errors in estimating this quantity make very little difference when spread over the whole, but if 90 per cent is received in tanks the error in estimating would be of considerable importance to the plant. Sixty per cent of the plants observed used some system of weighing. Three methods of weighing were used: The platform, 2-hopper scales, and 1-hopper scales.

FIGURE 4.—The valve on this milk-tank truck is in an accessible position. Dust cap has been removed

Platform scales have some disadvantages. The possibility of error is large, and they are hard to keep in adjustment. Then, too, there is a tendency to neglect weighing the tare every day. This in itself makes for large errors, as the weight of the truck varies with the moisture in the air, the amount of dust and mud on the truck, the amount of gas and oil in it, and the extraneous material which may be carried.

The 2-hopper scales are in general use. Errors in weight are likely to occur, as most hoppers hold only 1,000 pounds each, and 10 to 12 weighings of each tank must be made. At times the operator may forget to set down one weighing. Then, too, the scales are hard to balance when each hopper is emptied. Some plants overcome this difficulty by installing a weigh scale for each hopper.

The 1-hopper scales are used in few plants, on account of the expense and extra room required for installation. However, as the hopper is large enough to accommodate the contents of any tank, accurate weights can be made if the scales are sensitive and care is used to keep them in adjustment. Accurate samples for butterfat testing can be taken without the necessity of opening, stirring, and exposing the milk to the outside atmosphere.

Weighing the milk and unloading it from tank trucks require nearly as many man-minutes of labor as do all the other operations. In the 15 plants represented in Table 3 these two operations averaged 56.2 per cent of the total labor. (See p. 7.)

Milk is unloaded from tanks by gravity, pump, or compressed air. Of 80 plants for which reports were received and observations made, 48.7 per cent unloaded by pump, 38.8 per cent by gravity, and 12.5 per cent by compressed air. The air pressure used varied between 10 and 16 pounds, most plants using 10 to 12 pounds. When gravity is used, some means must be provided for elevating the milk to the upper floors of the plant. Observations at 17 plants showed the average number of gallons unloaded per man-minute by the different systems to be as follows: Gravity, 19.12; pump, 20.54; and compressed air, 25.91. Disregarding the number of men, the number of gallons unloaded per minute was as follows: Gravity, 46.4; pump, 65.2; and compressed air, 89.5. Rates for the above systems may vary from those indicated, depending upon size of pipe, size and capacity of pump, and air pressure used. For example, at one plant equipped with compressed air, all tanks but two were unloaded at the rate of 101 gallons a minute through a 3-inch pipe line with an air pressure of 10 to 12 pounds. The other two tanks, which had a 2-inch opening, were unloaded at the rate of 80.5 gallons a minute. If the plant is so arranged that a gravity system can be used, a small number of tanks can be unloaded satisfactorily. However, if the plant uses a large number of tank trucks, the rapidity of receiving is an important factor, and if the arrangement is unsatisfactory for gravity one of the other systems of unloading is preferable.

WASHING AND TREATING TO KILL BACTERIA

Washing the tanks and treating them to kill bacteria are of prime importance. The tanks not only must be clean, but they must also be comparatively free from odors and bacteria. On an average, milk tanks are more carelessly cleansed than the other equipment of the plant. Tanks were inspected for cleanliness by plant men at 52 per cent of the plants studied. Of these, 16 per cent inspected the tanks each day immediately after washing, 28 per cent inspected them twice weekly, and 8 per cent asked for inspection at country plants. At 56 per cent of the plants observed the tanks were washed without being moved from the unloading place; at 28 per cent they were washed in the garage, which was usually some distance from the plant; and at 16 per cent they were moved short distances.

The following form shows a report on tank washing at the city plant, tank inspection and filling at the country station, and condition of the milk upon arrival at the city plant, which the manager of one city plant required to be filled out with every shipment.

Tank Wash Report

Truck tank No. ------------------ Trailer tank No. --------------------

Washed by --

Date ------------------------------ Time ------------------- {A. M. / P. M.

Tank Inspection, Trip, Grade, and Stock Report

Station ------------------------- Date ----------------------------

☐ Tank clean.	☐ Tank not clean.
☐ Tank sweet.	☐ Tank odorous.
☐ Valve clean.	☐ Valve not clean.

Remarks: --

Driver's name --

Station arrival -- {A. M. / P. M.

Station departure -- {A. M. / P. M.

Grade ☐ ☐ Temp. ---------- ° F.

Approximate milk on hand after this shipment, including to-day's receipts:

---------- cans. ---------- cans.

Signed ----------------------------

Station Manager.

Arrival------------------------ {A. M. / P. M.

Temp. ---------- ° F. Quality:

Table 4 gives data on washing tanks and treating them for bacteria at 17 plants. When the driver of a tank was on hand his time was included, as he assisted in turning on water, taking apart and assembling valves, and taking care of tools used in washing. The capacity of the tank had no direct bearing upon the amount of labor required to wash it, as the labor varied from 6.8 to 27.7 man-minutes per 1,000 gallons. The man-minutes per tank ranged from 7.4 to 36, a variation of 386 per cent, with an average of 17.6 man-minutes.

There was no uniformity in the temperature of the wash water used at different plants. A difference of 65° F. was found between plants and of 57° at different times in the same plant. At no plant was a thermometer used to gage the temperature of the water. Twenty-nine per cent of the plants changed the temperature of the water for rinsing. Eleven plants used some form of cleansing powder, and two used vegetable-oil soap. There was no uniformity in the amount of powder used; the amount varied from ½ to 5¼ pounds per tank. There is no reason why tanks on trucks should require any more cleansing powder per 1,000 gallons capacity than other milk equipment within the plant.

TABLE 4.—*Time and materials employed in washing tanks mounted on trucks and treating them to kill bacteria at 17 plants*

Plant No.	Average time per tank		Range in time per tank	Average time per 1,000 gallons of milk	Average percentage of total man-minutes used for washing and treating	Average temperature of—		Range of temperature of wash water	Washing powder used	Chlorine used per tank for each washing
						Wash water	Rinse water			
	Man-minutes	*Minutes*	*Man-minutes*	*Man-minutes*	*Per cent*	*°F.*	*°F.*	*°F.*	*Pounds*	*Pints*
1	9.4	8.0	6–20	6.8	22.6	67		63–70	1.15	
2	8.2	8.2	7–10	8.4	16.8	92	163	90–95	5.25	
3	7.7	4.5	4–14	8.5	19.4	125		120–129		
4	15.7	15.4	3–32	8.8	22.6	107		81–131	[1] 0.50	
5	7.4	6.3	5–10	10.2	18.0	82		77–86	(2)	1
6	15.5	7.9	9–28	12.2	23.5	132		90–147		4
7	8.7	10.0	10–22	12.6	24.4	104		99–115	0.62	3
8	10.4	7.0	5–16	13.5	24.9	114		77–122	2.56	1
9	28.1	16.3	13–40	14.7	40.3	129		109–149	1.50	4
10	19.1	9.6	10–34	18.7	33.1	106		77–131	0.62	(4)
11	24.7	12.3	18–34	19.3	[3] 28.5	84	190	185–194	0.87	1
12	19.2	11.1	8–34	21.4	28.2	77		68–90		
13	28.2	14.5	20–38	21.7	40.7	101		93–109	0.85	1
14	20.3	20.3	27–34	24.6	[5] 47.3	107	164	104–109	4.25	
15	22.5	22.5	15–30	27.7	[6] 45.0	78	147	131–185		
16	30.0	18.0	30–42			(7)			(8)	
17						104	162		(9)	
Average	17.6	12.1		15.3		100.6	165		1.82	2.14

1 Twice weekly.
2 Saturated solution of washing powder brushed over tanks twice weekly.
3 Steam turned into each tank for 1 minute.
4 Chlorine mixed with washing powder at the rate of 1.5 pounds of chlorine to 5 pounds of powder.
5 15.5 per cent of total man-minutes used for steaming.
6 17.5 per cent of total man-minutes used for steaming.
7 Air gun used to force water.
8 Vegetable-oil soap used; 8 pounds to 50 gallons of water; 1½ gallons of mixture used per tank.
9 1 pound of vegetable-oil soap mixed with 2 gallons of water; entire amount used for each tank.

Very few plants used either steam or chemicals in treating their tanks to kill bacteria. Forty-seven per cent used some form of chlorine, but most of them used it only as a deodorizer. The usual method at the plants observed was to pour a pint or more of chlorine solution (the solutions used being of various strengths) into the tank and let it drain out, so that it came in contact with only the drain water along the bottom; some partly filled their tanks with water, poured the chlorine solution in, and let the treated water swash around until the return trip was nearly completed, when it was drained out; a few brushed the chlorine over the inner surface of the tanks. Chemicals, when used properly, are very satisfactory in killing bacteria, but should be applied with a sprayer so as to reach every part of the tank. Only three plants used steam; in two of these 18 to 19 per cent of the total time used for cleansing was used in applying the steam, which would be a considerable item in plants operating large numbers of trucks. Insulated tanks treated with steam cool slowly, a fact which adds another difficulty if they are to be used within a few hours.

Equipment used for washing and treating was found to consist of rubber hose, brushes, sponges, rags, and sprayers. Rubber hose, brushes (one type for the openings and one for the tank), and sprayers are essential. Sponges and rags should have no place in cleansing milk equipment. The rubber hose should be kept on an automatic reel so that it does not touch the ground, and its use should be restricted to cleaning the tank.

COSTS OF HAULING BY TANK TRUCK

The costs of tank-truck hauling can be grouped under the following heads: Depreciation; gasoline, oil, and tires; parts and repairs, including mechanic's wages; labor, including the proportional share of superintendence; interest, if the policy of the company includes interest in its cost account; and miscellaneous expenses, which may cover license, insurance, housing cost, claims for losses, road expense, or items not classified above. Table 5 shows the hauling cost per hundredweight mile and per 100 pounds at 15 plants. The total cost per hundredweight mile varied from $0.0017 to $0.0049, with an average of $0.00273 per plant. Nine of the plants used trailers. The average cost of hauling at these plants was $0.0028 per hundredweight mile, and at the other plants $0.0034.

TABLE 5.—*Cost per hundredweight mile and per 100 pounds for hauling with tank trucks at 15 plants*

Plant No.	Depreciation		Gasoline, oil, and tires		Repairs		Labor for operation	
	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total
1	$0.00071	26.2	$0.00061	22.4	$0.00024	9.1	$0.00091	33.6
2	.00065	10.4	.00096	26.3	.00083	23.5	.00100	31.4
3	.00063	33.4	.00064	33.9	.00010	5.5	.00032	16.7
4	.00120	25.0	.00180	36.4	.00043	8.6	.00150	30.0
5	.00047	15.8	.00090	30.4	.00043	14.6	.00086	29.2
6	.00077	27.9	.00075	27.6	.00012	4.3	.00073	26.7
7	.00042	15.7	.00118	43.9	.00016	5.8	.00080	29.8
8	.00030	18.4	.00060	36.3	.00013	8.0	.00042	25.1
9	.00050	18.5	.00100	37.0	.00008	3.1	.00006	38.9
10	.00027	12.6	.00069	32.8	.00051	24.4	.00049	23.5
11	.00066	21.9	.00096	32.0	.00014	4.4	.00096	31.9
12	.00034	12.3	.00110	39.8	.00007	2.4	.00101	36.9
13	.00087	25.9	.00119	35.2	.00018	5.5	.00100	29.8
14	.00025	13.2	.00043	22.8	.00041	21.6	.00066	34.6
15	.00030	15.5	.00041	21.1	.00050	25.5	.00055	28.1

Plant No.	Interest		Miscellaneous		Total		Distance hauled	Contour and type of roads
	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Per 100 pounds		
							Miles	
1			$0.00023	8.7	[2] $0.0027	$0.324	119	Slightly rolling; mostly concrete, with some gravel.
2	$0.00015	4.2	.00018	4.2	.0038	.289	77	Very hilly and bad curves; concrete and macadam.
3			.00020	10.5	[2] .0019	.179	94	Rolling; concrete and macadam.
4	([1])				.0049	.140	28	Some hills; gravel and concrete.
5	.00015	5.1	.00014	4.9	[2] .0029	.266	90	Slightly rolling; mostly concrete.
6	.00025	9.3	.00001	4.2	[2] .0026	.143	52	Level; cement.
7	.00008	2.9	.00005	1.9	[2] .0027	.268	100	Slightly rolling; part gravel; rema nder ecuerete.
8	.00010	5.0	.00011	6.6	[2] .0017	.179	108	Slightly rolling; gravel and concrete.
9	.00017	4.5			.0027	.065	24	Hilly; gravel.
10	.00006	2.7	.00008	4.0	[2] .0021	.075	36	Rolling; concrete and macadam.
11	.00014	4.4	.00016	5.4	.0030	.151	50	Level; concrete and macadam.
12	.00019	7.1	.00003	1.4	.0027	.131	48	Rolling; concrete.
13	.00013	3.7	.00002	.4	.0034	.068	20	Do
14	.00007	3.9	.00007	3.9	[2] .0019	.149	78	
15	.00006	3.0	.00014	6.8	[2] .0020	.173	88	

[1] Included in depreciation. [2] Trailers used.

The cost of gasoline, oil, tires, and labor ranged from 49.2 to 76.8 per cent of the total, the variation being due to type of roads, contour of roads, condition of motor, and the ability of the driver to handle the equipment. Depreciation varied according to the administrative policy of the company. The cost of repairs depended upon the newness and suitability of the equipment and the carefulness of the driver. Labor costs for operation varied with the section of the country.

Table 6 shows the cost of city hauling with tank trucks where they were used as supplemental equipment to unload tank cars spotted on sidings some distances from the main plant. As this hauling was for short distances within the city, the cost per hundredweight mile was high.

TABLE 6.—*Cost of city hauling with tank truck from tank cars at those plants*

Plant No.	Depreciation		Gasoline, oil, and tires		Repairs		Labor	
	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total
1	$0.00133	22.3	$0.00127	21.2	$0.00114	19.1	$0.00218	37.4
2	.00130	20.1	.00143	22.1	.00108	16.6	.00178	27.5
3	.00130	16.5	.00090	12.1	.00203	30.3	.00130	16.9

Plant No.	Interest		Miscellaneous		Total		Distance hauled
	Per hundredweight mile	Percentage of total	Per hundredweight mile	Percentage of total	Per hundredweight mile	Per 100 pounds	*Miles*
1					$0.00592	$0.0593	10
2	$0.00048	7.5	$0.00040	6.2	.00647	.0323	5
3	.00060	8.4	.00120	15.8	.00733	.0233	3

Motor tanks and labor may be made available to the plant in one of three ways: (1) The milk plant may own and man the entire equipment; (2) the plant may furnish the tank and keep it painted and in repair and the hauler furnish motor equipment and men; or (3) the hauler may furnish and man the entire equipment. When either of the last two arrangements exists, the hauling is done by the day, the mile, the load, or at railroad rates. Nearly every dealer arranges to have the name of his company appear conspicuously on the equipment. Table 7 shows the cost of hauling at 10 plants having one of the last two arrangements.

The average cost per 100 pounds hauled was $0.308 where the tank was furnished by the milk plant and $0.30 where all equipment and labor was furnished by the hauler; and the average costs per hundredweight mile were $0.00257 and $0.00309, respectively.

TABLE 7.—*Cost of hauling milk by tank truck with hired labor and equipment*

Plant No.	Cost per 100 pounds	Cost per hundred-weight mile	Distance hauled	Type and contour of roads
			Miles	
1 [1]	$0.35	$0.00343	102	Level; concrete and gravel.
4 [1]	.21	.00244	86	Rolling; concrete.
5 [1]	.26	.00200	132	Do.
10 [1]	.41	.00240	170	Very hilly; concrete and macadam.
2 [2]	.23	.00411	56	Level; concrete.
3 [2]	.21	.00262	80	Rolling; concrete and macadam.
6 [2]	.30	.00214	140	Rolling; concrete.
7 [2]	.25	.00357	70	Hilly; concrete.
8 [2]	.36	.00300	120	Hilly; concrete and macadam.
9 [2]	.45	.00313	144	Very hilly; concrete and macadam.

[1] Tank furnished by milk plant.
[2] Tank furnished by hauler.

CONDITIONS UNDER WHICH TANK-TRUCK HAULING IS UNSATISFACTORY

Tank-truck hauling has proved satisfactory to most users; however, conditions such as the following make it uneconomical: small

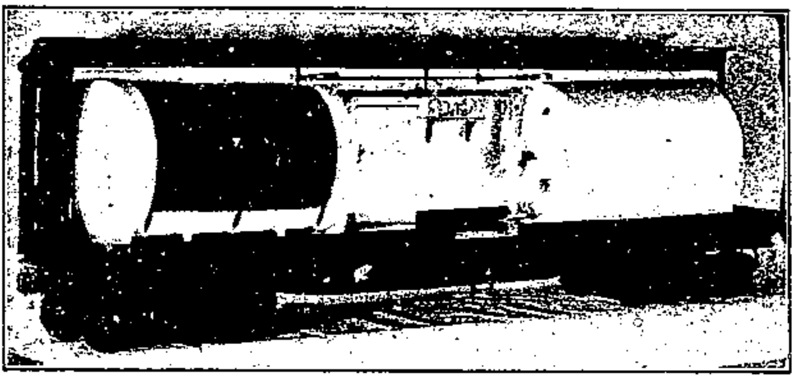

FIGURE 5.—Model showing general arrangement of modern milk tank car

plants, shippers situated a short distance from the plant, small supply of milk from one community, poor roads, and exceedingly long routes where climatic conditions are severe.

TANK CARS

EQUIPMENT

The railroad milk tank car is of the express-car type, and is equipped with 4-wheel trucks designed for high speeds. It is wired for electricity, has a thoroughly insulated body and an acid-resisting waterproof floor sloping to the center of the car and equipped with a drain. The car floor is 4 feet 2⅞ inches above the rails. A glass-lined steel tank is mounted at each end of the car. (Fig. 5.) The standard capacity of a tank is 3,000 gallons, although some recently made tanks hold 3,820 gallons. The tanks are pitched toward the center of the car and insulated with 2-inch cork board protected by a metal covering. They are equipped with a 4-inch inlet; a 20-inch manhole (the doors of some manholes swinging into the tank and others out); a direct motor-driven propeller-type agitator with 2-speed motor; a filter for compressed air; angle stem thermometer; two 5-inch glass openings in the front head near the top, one with electric light for illuminating the interior; and a 4-inch outlet equipped with a special valve. (Fig. 6.) Some tanks have sampling valves. Accessory equipment in the car may consist of a stationary milk pump or an air compressor; a water reservoir for use in washing the tanks; and a brine system for cooling, although this feature has not come into general use.

It is the usual practice to paint on the car the name of the plant and other advertising matter. Some thought is expended by milk plants on the colors to be used, in order that they be not only pleasing to the eye but also of such a shade that they do not show dust and coal smoke readily. For example, if the cars have to go through

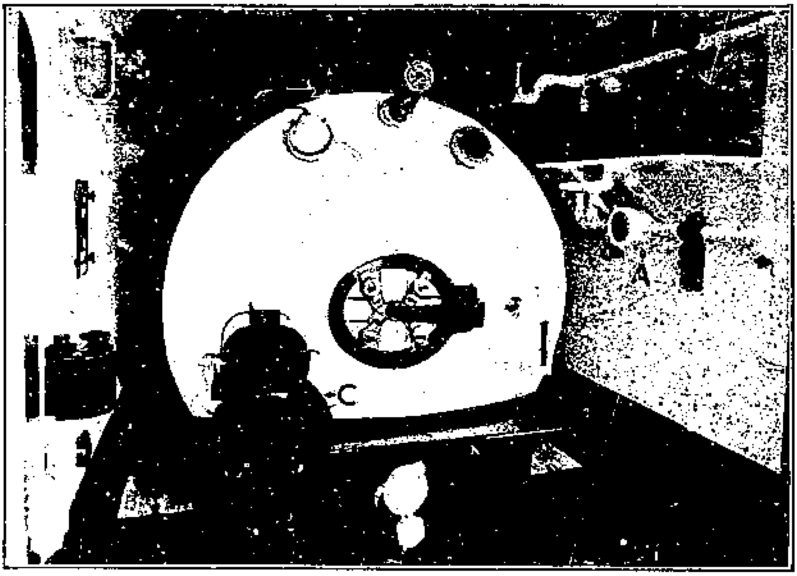

FIGURE 6.—Interior view of one end of a modern milk tank car showing air filter (A), air pump (B), agitator (C), electric wiring, and insulated tank with manhole opening inside

tunnels en route, dark-colored cars are preferable as they do not show the coal smoke as much as light-colored cars.

Milk plants get the use of tank cars in two ways: By purchase from the manufacturers or by daily rental. Repairs on cars are made by the railroad at its shops, and the cost is charged to the company owning or renting the cars. The cost of repairs on eight cars for which data were collected for six years averaged $0.0032 per mile.

LENGTH OF ROUTES AND NUMBER OF CARS REQUIRED

The average 1-way haul by tank cars on 36 routes throughout the country was 122 miles. Eleven per cent of the routes had a 1-way haul of under 50 miles; 22 per cent, between 50 and 100 miles; 42 per cent, between 100 and 150 miles; 14 per cent, between 150 and 200 miles; 5½ per cent, between 200 and 250 miles; and 5½ per cent, between 250 and 300 miles. Tables 8 show the length of 15 routes, time in transit, and the distance covered per hour. This table shows that time en route did not have a direct relation to the distance hauled.

TABLE 8.—*Time of tank cars in transit for routes of different lengths*

Length of haul	Time en route		Distance per hour	Length of haul	Time en route		Distance per hour
Miles	*H.*	*m.*	*Miles*	*Miles*	*H.*	*m.*	*Miles*
50	2	50	17.6	114	4	0	28.5
58	2	0	29.0	116	14	0	8.3
66	2	15	29.3	156	12	0	13.0
76	5	0	15.2	167	14	30	11.5
80	3	20	24.0	180	15	0	12.0
101	4	50	20.9	280	8	0	35.0
108	4	50	22.4	350	48	0	7.3
110	12	0	9.2				

The number of cars required for a route depends upon the railroad schedule, service on connecting lines, length of haul, and method of using the cars. Hauls of 100 to 400 miles usually require three cars. When shipment must be made by fast freight, which is somewhat slower than express or passenger service, an extra car may be required, even for relatively short hauls, in order to maintain the daily schedule. Some plants find it economical and advantageous to use the tank car for storage. Where cars are used for this purpose, enough cars must be provided so that the country stations will have their cars on time.

NEED FOR SUPPLEMENTAL TANKS

If a plant depends to a large extent upon tank cars for its daily supply of milk, it should have some reserve tanks in case of breakdowns, delays in schedule, or bad weather. At what point supplemental equipment should be purchased will depend upon size of the plant, length of routes, and the climatic conditions of the section in which the plant is located. In sections subject to severe snowstorms, extra equipment may be desirable so that the city plant may hold over at the city siding cars of milk for use when shipments are delayed by storms. Tank owners and operators state that a plant with 8 to 10 regular cars should have 1 or 2 cars in reserve.

HANDLING MILK FROM TANK CARS AT CITY PLANTS

In handling milk delivered to the plant by tank cars, three steps are involved: (1) Preparation for unloading, which consists of opening the car, starting the agitator, attaching pipes, taking samples, and opening valves; (2) weighing and unloading the milk; and (3) cleansing the car thoroughly, which includes treating to kill bacteria and closing the car.

Most of the time required in preparing for unloading is used in attaching the pipes. If a sampling valve is present, samples for both bacteria and butterfat are taken from it; where there is no valve, bacterial samples are taken through the manhole of the tank. In the latter case the operator must wait until the milk level is below the bottom of the manhole. If compressed air is used for unloading and there is no sampling valve, samples can be taken from the outlet opening before attaching the pipes. This method is unsatisfactory for obtaining bacterial samples for the following reasons: (1) A small quantity of milk is hard to obtain through the large valve without spilling milk on the floor of the car; (2) this milk flows over considerable area, which may unduly contaminate a small quantity; and (3) the milk collected is that which has stood in the valve.

Weighing the milk from the tank cars is not practiced so much as weighing from tank trucks, because the cars carry the entire receipts of the country plant, whose daily report attached to the tank gives the amount contained, and because the power used for unloading forces the milk directly into the storage tank.

If weighing of the milk is practiced, the 2-hopper scales are generally used; however, the platform scales may be used at plants located away from the siding and where tank trucks are used in transporting the milk from the car to the plant, although they are open to the criticism discussed under tank-truck hauling.

Table 9 shows the results of observations at five city plants where tank cars were spotted on the siding at the plant. This table shows that most of the labor was used in weighing and unloading; in only one plant the number of man-minutes per 1,000 gallons of milk

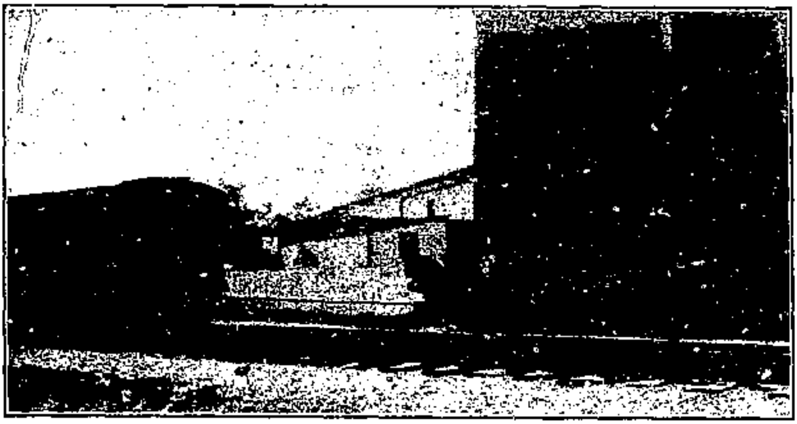

FIGURE 7.—Spotting a milk tank car by using a motor truck for power

handled was greater for washing and treating than for weighing and unloading.

TABLE 9.—*Methods used and time required in unloading milk from tank cars at five city milk plants having railroad sidings at the plants*

Method of unloading	Preparation		Weighing and unloading		Washing and treating to kill bacteria	
	Per 1,000 gallons	Percentage of total time	Per 1,000 gallons	Percentage of total time	Per 1,000 gallons	Percentage of total time
	Man-minutes		*Man-minutes*		*Man-minutes*	
Air	1.9	6.3	25.1	81.0	3.9	12.7
Do	6.0	13.8	24.8	56.9	[1] 12.8	29.3
Do	4.2	10.8	20.0	51.3	[2] 14.8	37.9
Pump	5.1	14.1	12.6	35.4	18.5	50.5
Do	6.4	22.4	11.6	40.8	10.5	36.8

[1] 7.5 man-minutes used for steaming. [2] 5 man-minutes used for steaming.

At most city plants situated on a siding, cars are spotted by the railroad engine. In some places the curve of the track may be too great for the engine, and other means must be employed. (Fig. 7.) When cars are unloaded at city plants located on a spur, a long pipe is usually needed. This is especially true when a large number of cars are spotted at nearly the same time. As this pipe is not mounted with the same care as the piping in the plant, it may have air pockets and therefore should be taken apart every day and washed and treated to kill bacteria.

UNLOADING

Plants located at some distance from the railroad siding use the tank truck to haul milk from the car. Unloading at the car is usually done by compressed air or pump. Gravity may be used, but it was not used at the plants studied. The compressed air either is purchased from the railroad companies, or the milk plant furnishes a portable compressor with electric motor (fig. 8) and pays for its power either through the railroad or direct to the electric-power company. All compressed air should be thoroughly filtered and the filtering material changed often enough to maintain its efficiency. Where

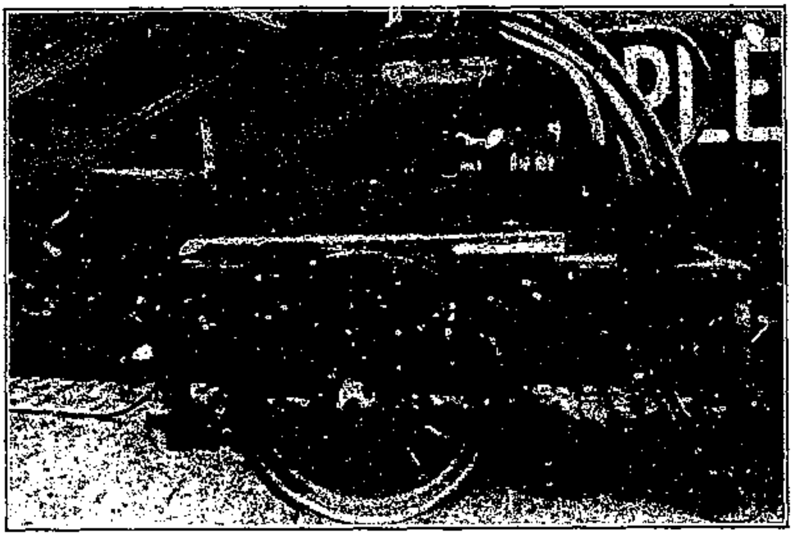

FIGURE 8.—Portable air compressor, fitted with a silencer, for unloading tank cars

pumps are used for emptying the tanks, some heating arrangement should be supplied in cold weather to prevent the milk from freezing in the pump.

How many tank trucks and trailers should a plant have for unloading tank cars where the siding is not located at the plant? The opinion of the operators and owners interviewed was that enough tank trucks should be supplied to unload a car within two or three hours from the time the seal is broken, or a truck and trailer equipment should be able to make at least one trip an hour.

WASHING AND TREATING TO KILL BACTERIA

For tank cars unloaded at the plant, the method of washing and treating to kill bacteria is about the same as the method of washing and treating truck tanks. However, more care must be used in taking apart the valves and piping which are in contact with the milk. The line used for compressed air should be washed and treated to kill bacteria, as moisture may accumulate at some point and if it is not removed it may add bacteria to the milk.

Table 10 gives complete data on washing tank cars and treating them to kill bacteria at five plants. The average number of man-minutes per tank ranged from 8 to 32. There were considerable differences in the man-minutes required in the same plant, one plant having a range of 22 to 49 man-minutes per tank. The capacity of the tank had no bearing upon the labor used in washing, as is shown by the column "Average time per 1,000 gallons tank capacity, man-minutes." Various kinds and amounts of cleansing powders or soap mixtures were used. These were brushed over the inside of the tanks and thoroughly rinsed off by the force of the water. Some of the powders made the tanks so slippery as to endanger the workmen. Steaming the tanks required much more time than spraying them with a chlorine solution.

TABLE 10.—*Time and materials employed in washing tank cars and treating them to kill bacteria for five plants*

Plant No.	Average time per tank		Range in time per tank	Average time		Average percentage of the total man-minutes used for washing and treating	Average temperature of wash water	Range of temperature of wash water	Washing powder per tank	Method of treating to kill bacteria
	Man-minutes	Minutes		Per 1,000 gallons of milk	Per 1,000 gallons of tank capacity					
			Man-minutes	*Man-minutes*	*Man-minutes*	*Per cent*	*°F.*	*°F.*	*Pounds*	
1	8.0	8.0	7–9	3.9	3.5	12.7	127	120–129	0	None.
2	15.2	20.2	12–18	[1] 15.3	8.1	32.5	179	172–190	0.76	Steam [2]
3	25.2	25.2	22–49	[3] 14.8	11.8	38.1	160	142–171	0	Do. [4]
4	29.9	29.0	22–47	18.5	9.9	50.5	114	90–126	0.93	Chlorine solution. [5]
5	32.0	32.0	19–45	10.5	10.7	30.8	127	120–135	([6])	Do. [7]

[1] 7.5 man-minutes used for steaming.
[2] To 170° F.
[3] 4.3 man-minutes used for steaming.
[4] To 210° F.
[5] 2.4 quarts.
[6] Soap mixture used.
[7] 2 quarts.

Table 11 shows the temperatures reached by steaming tank cars for the length of time indicated. The time necessary to reach a given temperature depends upon length and size of pipe, insulation, and steam pressure. Probably in but few cases was a satisfactory temperature (200° F for five minutes) maintained. Owners and operators stated that when tank cars are steamed to high temperatures, 15 to 18 hours, depending upon the outside temperatures, are required for their temperature to become as low as that of the atmosphere. Some plants hasten this lowering of temperature by putting ice in the tank cars and shipping it to the country station, there to be used for cooling the incoming milk.

If chlorine solution is used for treating the inside of the tanks to kill bacteria, it should be applied with a sprayer capable of thorough atomization, as this will insure reaching all parts with a minimum quantity of the chemical.

TABLE 11.—*Temperatures of tank cars reached in steaming for different lengths of time*

Tank car No.	Temperature at start	Temperature reached after steaming for number of minutes stated														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	100	112	113	113	120	126	132	136	141	146	150	155				(1)
2	90	116	120	123	124	128	132	136	140	144	149	153	154	158	164	[2] 168
3	104	106	106	110	113	116	120	126	131	136	140	144	149	154	158	160
4									200							
5										200						
6											210					
7									200							
8										208						
9											210					(3)
10													210			
11														211		
12														212		
13										208						(4)
14												206				
15															208	

[1] 118° at end of 20 minutes.
[2] 120° at end of 40 minutes.
[3] 170° at end of 75 minutes.
[4] 196° at end of 32 minutes.

If the tank car is unloaded at the siding some distance from the city plant, it is the usual practice to rinse the car thoroughly with water from a near-by hydrant or from a supply in special tanks in the tank car. The openings are then left open until the tank reaches the country station, where it is thoroughly washed and treated to kill bacteria. The tank should not be steamed if it is to be used the same day, as it will not cool sufficiently in so short a time.

FIGURE 9.—Interior of country milk-receiving station equipped for tank-car hauling

CONDITIONS UNDER WHICH TANK CAR HAULING IS UNSATISFACTORY

Tank-car hauling was considered by the plant owners and operators to be practical and economical, except in certain instances: City plants handling small quantities of milk; plants whose source of supply is within a radius of 30 to 50 miles; small country stations which have less than car-lot shipments for the greater part of the year, unless the railroad allows pick-up privileges and two neighboring stations can furnish a minimum carload at all times; and country stations receiving two grades of milk, neither in sufficient quantity to fill a tank. Some milk-plant operators consider that the protection afforded high-grade or special milks will overbalance the extra cost of shipping small quantities in tanks, although milk in a partly filled tank does not stay at such low temperatures as does milk in a full tank. Where pick-up service is permitted, country stations must be equipped with large storage tanks and facilities for loading quickly. (Fig. 9.)

ADVANTAGES OF HAULING MILK IN TANKS AS COMPARED WITH HAULING MILK IN CANS

The advantages of tank-truck and tank-car hauling over the hauling of milk in cans are as follows: Better temperature control of product, greater sanitation, smaller investment in cans, less loss of milk, less labor at country plants, the handling of more milk in the same-area by the city plant, saving in washing powder and in man-hours required for washing, the affording of an advertising medium for firm name and slogans, and reduction in floor space required in country plants.

Insulated tanks protect the milk from both heat and cold, the main problem being to get the milk into the tanks at a low temperature.

Tanks rarely rust with scale formations, which harbor bacteria, and the amount of contact surface per gallon of milk hauled in tanks is much smaller than in cans. For example, a 10-gallon can has a surface of approximately 1,108 square inches, or 110.8 square inches per gallon capacity, whereas a 1,200 or 1,250 gallon tank has a surface of only about 28.9 square inches per gallon capacity.

Owners and operators of trucks who are interviewed were unanimous in saying that tanks save can investment. One man said that each truck saved $1,200 a year in cans; another said that by changing from cans to tanks 7,200 fewer cans were purchased per year; and the records of another showed a saving of $15,000 per year. This refers only to can investment and does not furnish a comparison of this item with the tank itself. In either method of hauling the truck would be necessary.

In whatever way milk is handled there is likely to be some loss. Milk may be lost from tanks through leaky valves, leaky pipe lines, or poor connections. When cars are used the siding may not be level and some milk may be left in the tank. However, these losses are very small as compared with the losses resulting from the use of cans. They are due to milk spilling while the cans are being handled, especially while they are being filled; to milk adhering to the cans after they are dumped; to hurried and incomplete dumping; to leaky cans; and to milk souring because of improper temperature control while the cans are en route, at the terminal station, or at the plant, and because of delays caused by breakdowns.

Less labor is required at country milk-receiving plants, because the milk is transferred from point to point by mechanical means with little supervision, whereas labor must be used in filling, capping, and transferring cans and in unloading, washing, and stacking the empty cans for city shipment.

A comparison was made of the labor required for handling milk in cans at 13 plants, and in tanks, either car or truck, at 21 plants. Comparable operations were taken into consideration. The average number of gallons in cans handled per man-minute was 4.6, and in tanks, 23.5. Delivery in cans varied from 3.0 to 7.1 gallons per man-minute, and in tanks from 12.8 to 35.3 gallons. Nine of the plants used both systems, a comparison of which is shown in Table 12.

The amount of floor space required at the plant to receive the milk in cans depends upon the amount of milk received. Sometimes a point is reached where no more space can be spared for this purpose, yet the plant could put out more milk if the receiving department could handle more in the time allotted. If the plant is already operating under a country-station system, a change to tank hauling will help to remedy this difficulty. The truck owners and operators stated that they could handle from 40 to 70 per cent more milk in a given space than when the milk was delivered in cans.

TABLE 12.—*Comparison of efficiency of milk delivery by cans and by tanks*

Plant No.	Delivery by cans		Delivery by tanks	
	Per man-minute	Men employed	Per man-minute	Men employed
	Gallons	*Number*	*Gallons*	*Number*
1	3.7	6	27.38	2
2	4.8	6	25.55	2
3	7.1	6	18.69	3
4	5.6	6	19.10	2
5	3.3	9	12.80	3
6	3.7	7	22.50	2
7	4.6	8	33.60	2
8	3.0	5	22.50	1
9	4.5	5	25.60	2

Under certain conditions tank-truck transportation has advantages over tank-car transportation. Where roads are good the country stations can be located at points convenient to their milk supply and independent of railroad sidings. This will usually allow cheaper land to be used for a building site. Another advantage is the saving in cartage from the railroad terminal to the milk plant. Tank-truck transportation is the most flexible type, as the product can be diverted between substations with little labor and at short notice. If a driver on one of the farmer routes is late in reaching the country station, the truck can wait a short time before leaving in order to avoid storing small quantities of milk until the next day, as is often the case when milk is shipped by rail in cans or by tank car.

Tank-car transportation has a number of advantages over delivery by tank trucks which benefit the railroad as well as the plant. As the cars are either rented from the manufacturers or owned outright by the milk plants, the railroad needs to make no investment in them. They eliminate the necessity of platforms at the terminals and do away with the terminal service of unloading the shipments of milk and loading the return empties. The railroad has no expense for ice and no claims for spilled milk. The latter alone amounts to large sums of money when cans are used.

Tank cars reach the city more regularly than the trucks, as trains must be run on schedule. Less storage space at country stations is required, and consequently the cost of refrigeration is less. At some places early schedules of milk trains necessitate the employment of extra help in order to load the cans on time. With tank cars this is not needed, as loading is done by mechanical means. In places where no express milk trains are scheduled, fast freight can be used without undue rises in milk temperature. By providing extra cars, storage tanks at country stations can be saved and extra storage tanks in the city plant eliminated. At present the tank car is the only practical means of extending the milk shed beyond the 330 to 500 mile zone and, at the same time, maintaining the quality of the milk without extra expense en route.

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