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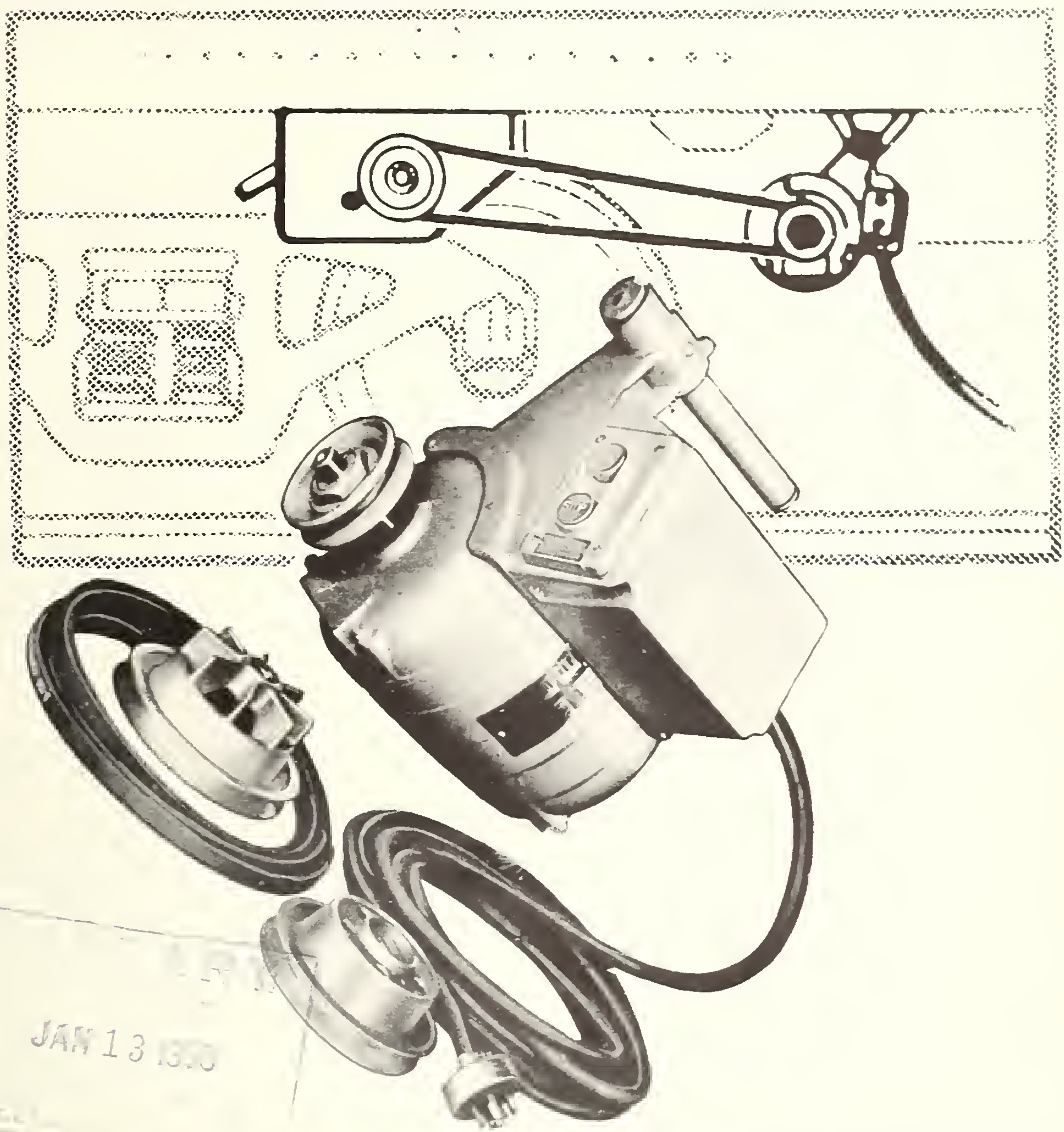
in Cars of Produce After Arrival at Terminal Markets



Marketing Research Report 206

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PREFACE

This project provides further information on means of protecting perishable fruits and vegetables during shipment. It is part of a broad program of research designed to reduce waste and spoilage of perishable farm products and so help reduce the costs of marketing. Reduction of losses in shipment of perishables in the short run benefits the shipper. In the long run it is reflected in benefits to the farmer or consumer, or both.

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OPERATING FANS IN CARS OF PRODUCE AFTER ARRIVAL AT TERMINAL MARKETS

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SUMMARY AND CONCLUSIONS

Tests were conducted in 1954, 1956, and 1957 to determine the effectiveness of operating permanently installed fans in cars in order to maintain desirable temperatures in perishable fruits and vegetables while the cars stand on track at terminal markets. Operating such fans helps avoid excessively high temperatures in the top or dangerously low temperatures at the bottom of the load. The tests were made both on iced and heated cars. Continuing operation of the fans by use of auxiliary motors after the cars arrived at destination improved commodity temperatures under both these classes of service.

In iced refrigerator cars containing highly perishable items such as lettuce, strawberries, sweet cherries, and peaches, the lower temperatures achieved in the top layer by operating the fans would be of distinct value, even when cars are held on the track for only 1 day. If they are held for a longer time, use of the fans would be even more beneficial.

In tests with heated cars in cold weather, slightly higher average temperatures were obtained in the bottom layer of the load, and considerably lower temperatures in the top layer, by operating the fans while the cars were standing. Use of fans could prevent freezing injury in the bottom layer when the temperature is at the critical point. Temperatures in the top layer were generally more than 10 degrees lower, and in some cases nearly 20 degrees lower, in cars with fans operating, than in comparable cars with fans off.

The higher bottom layer temperatures obtained by the use of fans could be of value in preventing chilling injury in commodities such as mature green tomatoes or sweetpotatoes.

Tests were made to determine the effect of fan operation at only one end of the car. The cars were fully loaded, with nearly all of the floor space occupied. Temperatures were satisfactory except in those cars containing bananas; these loads being so open that the air by-passed much of the product. In partly unloaded cars, with some of the floor rack area uncovered, the results would probably be the same. In such cases, the bare floor racks should be covered with paper or with packages of produce, so that the fan operating at only one end of the car will force air through the load remaining in the car.

Gasoline engines and also electric motors were used to operate the car fans in this study. Electric motors are more convenient if proper electrical connections are available.

BACKGROUND

One of the weak links in the movement of fruits and vegetables from the producer to the consumer has been the general failure to operate refrigerator car fans after arrival of the cars at terminal markets. During transit the fans are operated by rotation of the car wheels. However, cars (either full or partly unloaded) are frequently held on track for periods up to several days because of holidays, weekends, insufficient demand or other market conditions. This results in a commodity temperature rise in the top layers of iced cars during warm weather, and may result in chilling or freezing in the bottom layers during cold weather or excessively high temperatures in top layers, in cars under heater service.

Tests were conducted in 1954 by the United Fruit Company in cooperation with the U. S. Department of Agriculture which showed that narrow spreads between top and bottom temperatures could be maintained in cars of bananas while they are standing by operating the car fans with "hold" or auxiliary motors. As a result of these tests, the Company issued instructions to its inspectors of perishable freight in August 1955, recommending use of "hold" motors to operate fans in banana shipments while cars are at diversion points or destination markets. It further recommended either a 1/2 hp. motor using a standard 3 3/4-inch (outside diameter) drive pulley or a 3/4 hp. motor using a 5-inch drive pulley, for electric fan cars.

For cars equipped with mechanically driven floor fans (which have a drive assembly at each end of the car), satisfactory results were obtained by operating the fan continuously, at only one end of a car under normal icing service. However, when very heavy re-icing was necessary, operation of a car fan at only one end of the car did not produce satisfactory temperatures in the end opposite the operating fan. It was necessary to switch the motor from one end of the car to the other every 8 to 12 hours.

Studies reported in this publication were conducted to determine the practicability of operating fans in iced and/or heated cars loaded with fruits and vegetables, while on track at terminal markets.

TESTS ON REFRIGERATED LOADS

Procedure:

The studies on refrigerated loads were made in New York City during August, September, and October, 1954. The cars were loaded with pears packed in standard Northwestern pear boxes or with lettuce packed in cartons. A description of the loads and the refrigeration given them before the tests is given in table 1. The pear boxes were loaded on end, three layers high. The lettuce cartons were placed flat, 6 layers high. Bunker ice only was used during the transit and holdover period. The ice bunkers were filled shortly before the tests were started, if they were less than seven-eighths full.

It is not known exactly when the cars arrived in New York, although they probably were there 24 hours before the beginning of the test. Car D had been on track at destination at least 2 days and car E at least 1 day.

Car C loaded with pears, and Car A loaded with lettuce served as "check" cars and were tested with the fans not in operation.

Fans in two cars of pears and one car of lettuce were operated by a gasoline engine. One car of pears (car D) and one of lettuce (car B) were equipped with two floor fans, one at each end of the car, but only one fan was operated to determine whether this was sufficient to maintain satisfactory temperatures. Car E, loaded with pears, was equipped with electric overhead fans. In this type of car the fans at both ends of the car are operated simultaneously, as there is only one drive assembly operating the alternator (generator) which is electrically connected to three motor-driven fans at each end of the car.

The gasoline engine used in these tests was rated at 1.70 hp. at 1,800 revolutions per minute (r.p.m.) and 3.35 hp. at 3,600 r.p.m. On car E, the engine operated at 3,000 r.p.m., at which speed it had a rated hp. of 2.95. The engine was operated at a considerably slower speed on cars B and D, probably about 2,000 r.p.m. The engine, equipped with a 2-gallon capacity fuel tank, ran approximately 8 hours per gallon of gasoline at the slow speed and about 4 hours per gallon at the high speed.

TABLE 1.--Description of refrigerated loads used in New York City tests--August, September and October 1954

Car	Commodity	Number and type of packages	Shipping point and date	Refrigeration	Date of inspection by receiver; temperature recorded	Height of load (inches)	Space above load (inches)	Date test started
A	Lettuce	640 cartons	Salinas, Calif. Sept. 11	Pre-iced 2 percent salt standard refrigeration. Re-iced 2 percent salt each icing station.	Sept. 20 - Top doorway pulp temperature, 40° F.	63	24	Sept. 20
B	Lettuce	640 cartons	Salinas, Calif.	Pre-iced 2 percent salt standard refrigeration. Aug. 30 - 3,100 pounds ice and 93 pounds salt added.	--	66	21	Aug. 30
C	Pears	742 boxes	Placerville, Calif. Aug. 21	Pre-iced and replenished. 2 re-icings in transit. Iced to capacity in New York, Aug. 30 with 6,300 pounds.	Aug. 30 - Pulp temperature 48° F.	58	29	Aug. 30
D	Pears	744 boxes	Placerville, Calif. Aug. 16	Pre-iced but not replenished. Two re-icings in transit	Aug. 25 - Pulp temperature, 46° F.	58	29	Aug. 27
E	Pears	768 boxes	Medford, Oreg. Sept. 27	Half-stage standard refrigeration with 2 percent salt at each icing station.	Oct. 7 - Pulp temperature, 40° F.	58	31	Oct. 8

The pitch diameter of the motor sheave (pulley) was 4.35 inches (4-3/4-inch outside diameter). The pitch diameter of the floor fan sheave (cars B and D) was 5.6 inches (6-1/4-inch outside diameter) and of the overhead electric fan drive sheave (car E) 6.5 inches (7-1/4-inch outside diameter). The speed of the floor fan sheave (cars B and D) was approximately 1,500 r.p.m. and of the overhead electric fan drive sheave (car E) approximately 2,000 r.p.m.

Commodity and air temperatures were obtained at intervals by means of electric resistance thermometers connected with a master cable which extended outside the car. This cable was attached to a reading box, making it possible to read the temperatures outside the car without entering it. Six of the commodity temperatures were taken along the centerline in both ends of the car in the top layer packages at the bunker, quarter-length and doorway positions. A seventh was taken in the top layer package along the side wall at the doorway. Two additional commodity temperatures were taken in packages in the layer next to the top layer of the load, in each end of the car at the quarter-length position. Emphasis was placed on temperatures in top layer packages because these are the ones that are usually the warmest when fans are not operated. Bottom layer temperatures are generally sufficiently low in an iced car, regardless of whether the fans are operating. Two air temperature readings were taken approximately 1 inch above the load at the quarter-length centerline position, one in each end of car.

Percentage of salt in the drip water from the ice bunkers was determined with a salt hydrometer.

Results:

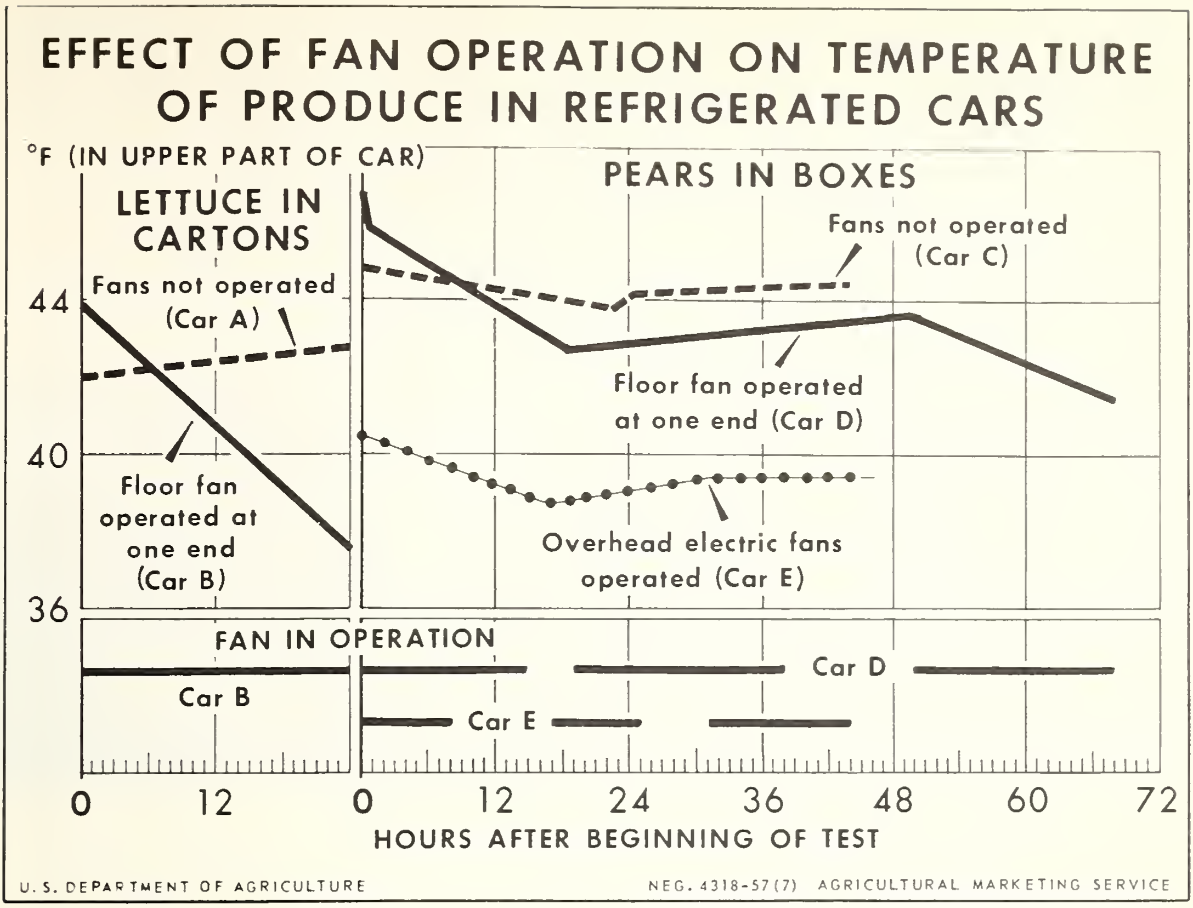
There was a slight rise in the lettuce temperature of car A in which the fans were not operated, while in car B in which the floor fan was operated at one end of the car only, the average lettuce temperature was lowered 6.3° F. (table 2 and figure 1). Lettuce temperatures were lowered appreciably in both ends of car B even though the fan was operated only in one end. Top air temperatures in car A in which the fans were not operated averaged 47.5° after one day, so if the test had been conducted longer even higher lettuce temperatures could have occurred in this car.

In the car of pears in which fans were not operated (car C) the average fruit temperature was 44.8° F. at the start of the test and it changed very little. In car D in which one floor fan was operated, the average temperature of the pears was lowered from 46.8° to 41.4° during the 68 hours of the test. Most temperature change occurred during the first 24 hours (fig. 1). Although the temperature drop was greatest in the end of the car in which the floor fan operated, the difference between the two ends was not great even though there was considerably more ice meltage in the end in which the fan operated (table 2). There was a temperature rise as a result of the 12-hour period in which the fan was not operated (fig. 1). After the motor was re-started, air temperatures dropped immediately and fruit temperatures started dropping shortly afterward. There was a slight general lowering of commodity temperatures during the test in car E, in which the electric fans were operated in both ends of the car.

TESTS WITH LOADS UNDER HEATER SERVICE

Procedure:

Two tests with potatoes under heater service were conducted at East Grand Forks, Minn., one in February-March 1956 and the other in January 1957. Tests were conducted at this locality because of the availability of outside temperatures around 0° F. which would represent a fairly severe weather condition at a destination market.



Each load consisted of 360 (100-pound) burlap bags of potatoes loaded pyramid style with the bottom bags about 4 to 6 inches from the side walls.[1] The loads were about 64 inches high with about 24 to 31 inches of space above the load.

Two comparable cars were used for each test. The cars used in 1956 were equipped with overhead electric fans whereas cars in the 1957 test had mechanical floor fans. The fans of one car in each pair were operated with a 3/4 hp. electric motor; the fans in the other or "check" car were not operated. In the mechanical floor fan car, a fan was operated in one end of the car only. Figure 2 illustrates the method of mounting the motor on the special bracket provided for this purpose on fan cars.

A 5-inch sheave was used on the motor which operated at 1,680 to 1,780 r.p.m. A 7-1/4-inch sheave was used on the alternator of the electric fan car. Speed of the alternator was 890 r.p.m. indicating some belt slippage. According to data supplied by the manufacturer of this equipment, fan speed was calculated as 1,200 r.p.m. and free air flow at approximately 3,400 c.f.m. This is equivalent to the speed attained when the fans are operated by the car wheels at a car speed of 21 m.p.h. From velometer readings made of the air movement, actual free air flow was calculated at 2,616 c.f.m..

In the floor fan car with fan operation at one end of the car only, a 6-1/4-inch sheave was used on the fan shaft. The motor operated at an average speed of 1,760 r.p.m. and the fan shaft at 1,045, indicating some belt slippage. From velometer readings made at top bunker openings, free air delivery was calculated at 944 c.f.m.

1 Association of American Railroads. 1942. Recommended arrangement for loading 45,000 pounds of potatoes in 100-pound bags by the "Pyramid through load" method. Assn. of American R.R., Bul. 43.

TABLE 2.--Commodity temperatures and ice meltage records of refrigerated loads as influenced by fan operation in standing cars

Car	Commodity	Fans	Length of test (hours)	Average outside air temperature (°F.)	When record taken	Commodity Temperature Average (°F.) A End	B End	Entire car[1]	Ice in bunkers (pounds) A End	B End	Entire car	Salt in drip water (percent)
A	Lettuce	Not operated	23.5	66	Start	43.2	41.1	42.0	5000	5000	10,000	2.0
					End	43.5	41.2	42.7	4250	4250	8,500	1.0
					Change	+0.3	+0.1	+0.7	750	750	1,500	
B	Lettuce	Floor fan - A end of car	24.5	68	Start	42.4	44.0	43.9	5750	5750	11,500	4.5
					End	35.8	38.5	37.6	5000	5000	10,000	1.7
					Change	-6.6	-5.5	-6.3	750	750	1,500	
C	Pears	Not operated	43.5	67	Start	45.0	43.9	44.8	5000	5000	10,000	None
					End	44.5	44.0	44.4	3750	3750	7,500	
					Change	-0.5	+0.1	-0.4	1250	1250	2,500	
D	Pears	Floor fan - B end of car	68.0	69	Start	46.3	46.0	46.8	4900	4900	9,800	None
					End	42.3	39.8	41.4	3600	1450	5,050	
					Change	-4.0	-6.2	-5.4	1300	3450	4,750	
E	Pears	Electric fans operated--both ends of car	44.0	61	Start	40.6	39.6	40.4	5750	5750	11,500	2.0
					End	37.8	40.6	39.5	4900	4450	9,350	0.4
					Change	-2.8	+1.0	-0.9	850	1300	2,150	

[1] Includes side doorway.

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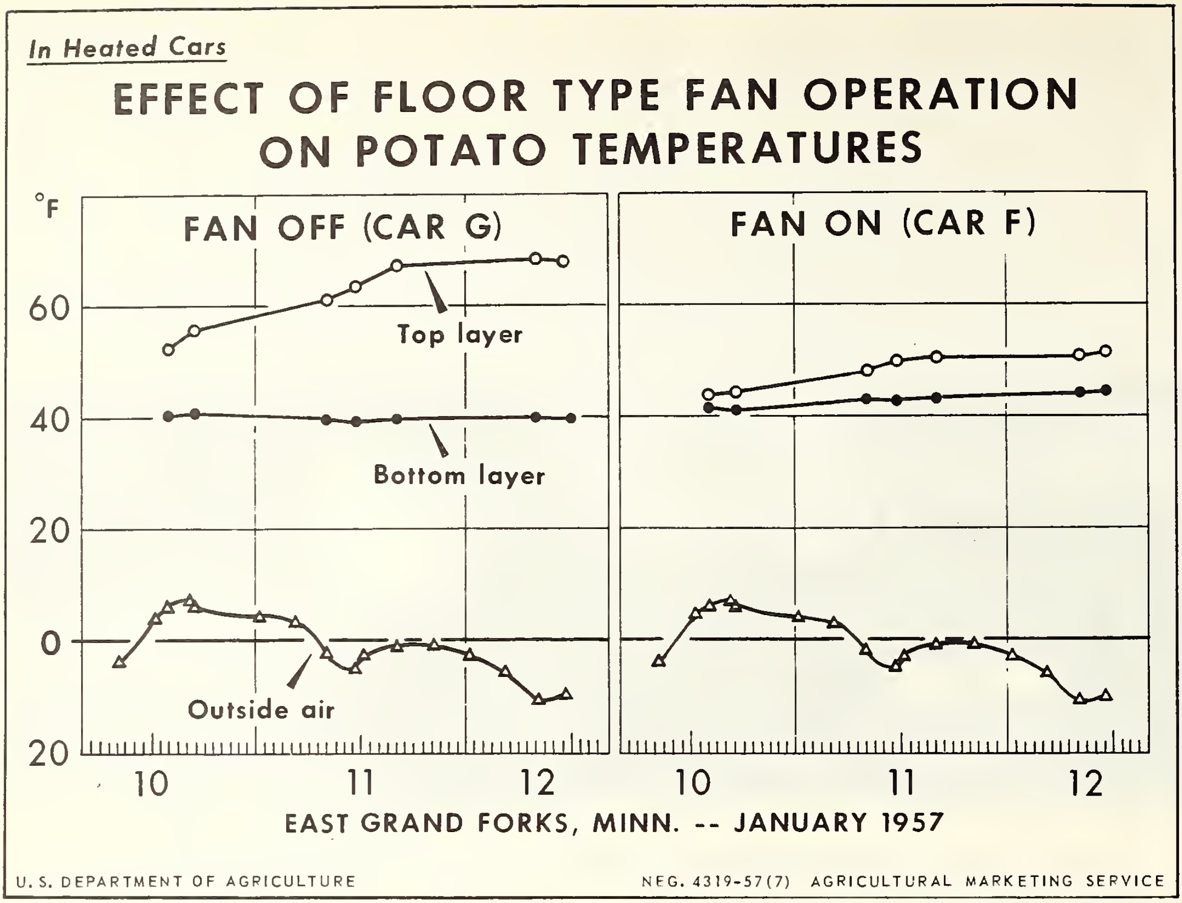
Figure 2.--Method of mounting electric motor to operote cor fons while fans ore standing on track.

Three 16-inch diameter charcoal bunker heaters were used in each car during the tests, two in one bunker and one in the other. During the test with the electric fan cars in 1956, one heater in each end of each car was extinguished Feb. 29, 1956 at noon when the outside temperature reached 17° F. During tests with the mechanical floor fan cars in 1957, the 3 heaters burned continuously. Fuel consumption was not measured in 1956. Total fuel consumption in the 3 heaters throughout the 1957 test was 72 pounds in the car with a fan operating and 81 pounds in the car with both fans off.

Eight potato and two air temperatures were taken with thermocouples in each test car at intervals during the tests. Five potato temperatures were in the bottom layer along the side wall. One of these was at the doorway, 2 at the quarter-length position (1 in each end of the car), and one at each bunker. Potato temperatures in the top layer were taken along the car centerline at the quarter-length position in each end and in the doorway area. Air temperatures were obtained at the top and bottom of the load at the doorway centerline position. Emphasis was placed on bottom layer temperatures in the heater tests as freezing damage is most likely to occur here.

Results:

With outside temperatures around 0° F. and with three charcoal heaters burning in the bunkers, the average bottom layer potato temperatures in the floor fan car with fans off (fig. 3, car G) was maintained at around 40° but the average top commodity temperature reached 68.5°. Minimum commodity temperatures were about 1 or 2 degrees lower than the bottom layer average and maximum commodity temperatures about 3 to 4 degrees higher than the top layer average. The minimum commodity temperature reached during the test was 37.2°; the maximum 72.6°.

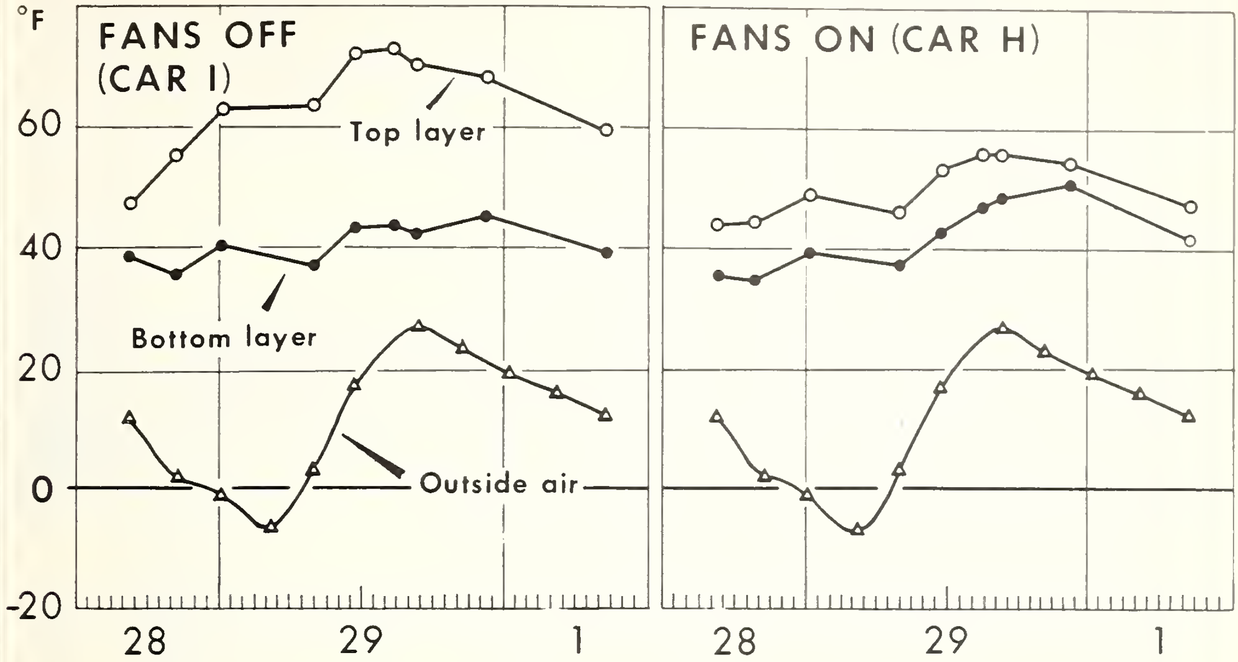


With the floor type fan operated at only one end of the car (car F), the average bottom commodity temperature was 40° F. or above throughout the test; the average top commodity temperature near 50°. The average bottom layer temperature was about 3 degrees higher than in the comparable car with the fans not operating, even though fuel consumption was slightly more in the car with fans off. Minimum commodity temperatures in car F were a degree or two below the bottom layer average, and maximum commodity temperatures about one degree above the top layer average. The minimum commodity temperature reached was 38.8° and the maximum 52.2°. In conducting this test, the single fan operation in car F was in the end of the car which had two heaters. However, bottom layer temperatures in both ends of the car were not greatly different. Those at the bottom bunker position where the fans were operated average only a little more than one degree higher than at the opposite bunker position.

In the studies with electric fan cars, average bottom layer temperatures during the first part of the test period were about the same in the car that had its fans operating (car H) as in the comparable car (car I) with the fans off (fig. 4). However, during the latter part of the test, bottom layer temperatures were somewhat higher in the car with fans operating. Top layer temperatures were substantially higher in the car with the fans off. Minimum commodity temperatures were about a degree lower than the bottom layer average in both cars. Maximum commodity temperatures were about 4 degrees higher than the top layer average in the car with the fans off, and about 3 degrees higher than the top layer average in the car with fans on.

In Heated Cars

EFFECT OF ELECTRIC TYPE FAN OPERATION ON POTATO TEMPERATURES



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