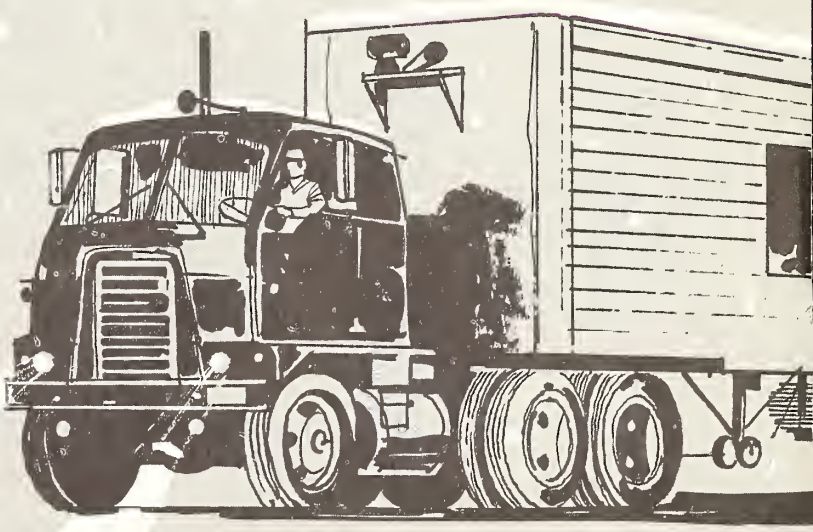
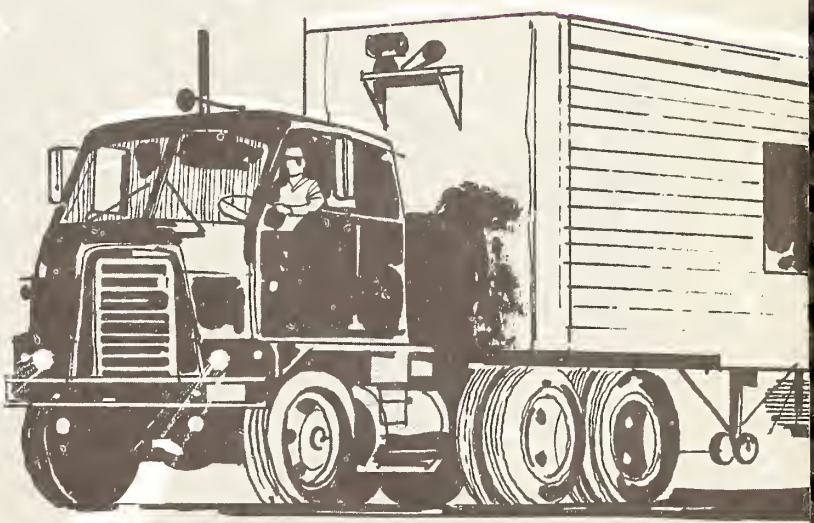
Protection of CHIPPING POTATOES from Low Temperatures during Transportation by Truck



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

Marketing Research Report No. 431

Protection of CHIPPING POTATOES from Low Temperatures during Transportation by Truck



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

Marketing Research Report No. 431

CONTENTS

ACKNOWLEDGMENTS

These tests were made possible through the cooperation of:

Howard Haave, Mark Henderlie, and Paul Sirak, representing Red Dot Foods, Inc., Grand Forks, N. Dak., and George Bushee & Son, Inc., East Grand Forks, Minn., who supervised the loading of test loads and teletyped departure and estimated arrival information to receivers; Elmer Forsberg, Thor Hansen, William Zarda, Charles Harrington, and James Lund, who cared for loads and instruments and supplied data; Donald Colee and Elmer Delougherty, who coordinated driver activity and scheduled test loads; Donald Babcock, Fern Davis, George Newton, F. J. Stevenson, and W. W. Weber, representing Red Dot Foods, Inc., Madison, Wis., and Ottumwa, Iowa, and personnel of National Food Stores, Hopkins, Minn., who supervised unloading of test loads and recovery and return of test instruments; R. E. Nylund, of the University of Minnesota, who received instruments; and A. C. Fortey, of Preco, Inc., Los Angeles, Calif., who supplied alcohol heaters.

This study is part of a national program of research by the Agricultural Marketing Service to improve efficiency and hold down costs in marketing farm products.

Washington, D. C.

Issued September 1960
Approved for reprinting February 1968

SUMMARY

During the 5 shipping seasons 1954-55 to 1958-59, inclusive, 81 semitrailers and their loads of potatoes were studied in observations and tests to improve transit conditions for potatoes for making potato chips.

Conventional equipment often fails to protect loads. Floor racks, insulation, and vapor barriers are often either inadequate or lacking. Blower fans for forced air circulation are rare. Load patterns often depend more on ease of loading and heavier payload than on protection of chipping potatoes from low temperatures.

Without forced air circulation, inside L. P. (liquid petroleum gas) heaters maintained proper temperatures only in top-layer bags of potatoes. An underslung L. P. heater which distributed heat under the floor gave somewhat better floor-layer potato temperature than inside L. P. heaters with about the same B. t. u. per hour output.

Placement of two thermostatically controlled alcohol heaters in the trailer, one in the front and one in the rear, gave more uniform potato temperatures in both top and bottom layers than locating both heaters in either front or rear.

Oxygen and carbon-dioxide exchange between the inside of the trailers and the outside atmosphere was adequate for potato respiration and alcohol heater combustion.

Either a windproof canvas loading tunnel or operation of a fan in the heated trailer was effective in preventing dangerously low bottom air temperatures when loading outside the storage house. A fan and the loading tunnel, combined, were more effective than either one used alone. Without such protection, a floor air temperature of 7° F. was reached in one 1958-59 test.

Forced air circulation within the heated trailer maintained potato temperatures in transit fairly close to their loading temperature at levels satisfactory to maintain chipping quality in all loads. Floor racks increased blower fan effectiveness. Without fans, floor racks were little better than straw placed on the floor.

Effective July 1, 1964, the responsibility for this research was transferred from the Agricultural Marketing Service to the Agricultural Research Service.

PROTECTION OF CHIPPING POTATOES FROM LOW TEMPERATURES DURING TRANSPORTATION BY TRUCK

By H. W. Hruschka, J. C. Hansen,[1] and H. Findlen
Market Quality Research Division, Agricultural
Marketing Service

BACKGROUND

About one-third of all potatoes transported from the Red River Valley of Minnesota and North Dakota are hauled in truck trailers. This is over 3 million hundredweight annually. About 1/2 million hundredweight of these are processed into chips. Potatoes for chipping require special care in storage and transit. Temperatures much below 50° F. may cause accumulation of reducing sugars in potatoes and result in undesirably dark-colored chips. Potato chip manufacturers want potatoes, delivered at the plant, that can be made into light chips without costly and often uncertain reconditioning.

Because of the diversity of ownership, control, and personnel in the trucking industry, little uniformity of trailers and protective services exists for hauling such commodities as potatoes. Some loads are well protected while others are seriously damaged in transit.

Tests therefore were made to find ways of improving the transit temperature conditions for chipping potatoes hauled in truck trailers in winter.

TEMPERATURE RECORDING

During the 1954-55 season, recording thermometers were used in six trailerloads to determine the effect of conventional methods and equipment on the transit temperatures of potatoes. In 1955-56, a survey was made of 26 loaded trailers. During 1956-57, 1957-58, and 1958-59, respectively, 9, 16, and 24 commercial trailerloads of chipping potatoes were studied to determine the effects of blower fans, heater use and placement, floor racks and floor straw, a loading tunnel, and initial potato temperatures on transit temperatures of chipping potatoes.

Potato Temperatures. --Thirty-day recording thermometers (Ryan thermometers) were placed in bags in bottom-layer positions to record minimum potato temperatures during transit, and in top-layer positions to record maximums (fig. 1).

Outside Air Temperatures. --Circular chart recording thermometers were secured to the truck underframe to get outside air temperature records.

Inside Air Temperatures. --Ten-hour recording thermometers were used in some of the trailers to get air temperature records at the floor position during loading.

[1] Resigned from AMS in 1959.

Figure 1.--Instruments for recording temperature data: 1, 10-hour recording thermometer for floor-level air temperature; 2, 30-day recording thermometer for inside-bag potato temperature; 3, 7-day recording thermometer for outside air transit temperature.

RESULTS AND DISCUSSION

General Trailer Condition and Handling Practices

Preliminary observations in 1954-55 and 1955-56 showed great variation in trailer construction and in handling and load protection practices.

Data on the trailers surveyed in 1955-56 are given in the appendix, table 1. Trailers ranged in age from new to 10 years old, with a few of indeterminate age. Most had rock-wool or fiberglass insulation in walls and roof. One had no insulation. None of the trailers had insulation in the floor. Most had wood floor racks with either 1 or 2 inches of space under the top rack slats. When racks were absent, straw was sometimes spread on the trailer floor to protect loads. Only 1 of the 26 trailers had sidewall racks. Five trailers had blower fans, but only three were used under winter conditions. Liquid petroleum gas (L.P.) heaters or charcoal heaters were most generally used to keep potatoes warm in transit. One trailer was heated with a gasoline heater and another with alcohol heaters.

Most inside air temperatures were within the range of 30° to 49° F. immediately before departure. Extremes of 5° in one trailer and 55° in another were noted. Outside air temperature during loading ranged from about -20° to +20°.

The preliminary tests (in February 1955) with well-insulated nonfan trailers equipped with 1 inch floor racks showed that the L.P. gas heater, when used with no forced air circulation, mainly affected top-layer potato temperatures, causing a rise of about 5 degrees F. (appendix, table 2, trailers 28 and 29).

Five load patterns were observed. Bump loads (3 stacks loaded sidewise wall to wall), bridged-aisle loads, and lengthwise wall-to-wall loads generally have little or no space between the load and the trailer walls, especially at the bottom layers. Thus, no channel for air circulation in this critical zone is provided. The possibility of heat loss by conduction also exists. The pyramid load and a blocky, solid load with wall space provide for air circulation around the load. The bridged-aisle load (fig. 2) was used in the 1956-57 and 1957-58 tests, and the solid load (figs. 3 and 4) was used in the 1958-59 tests.

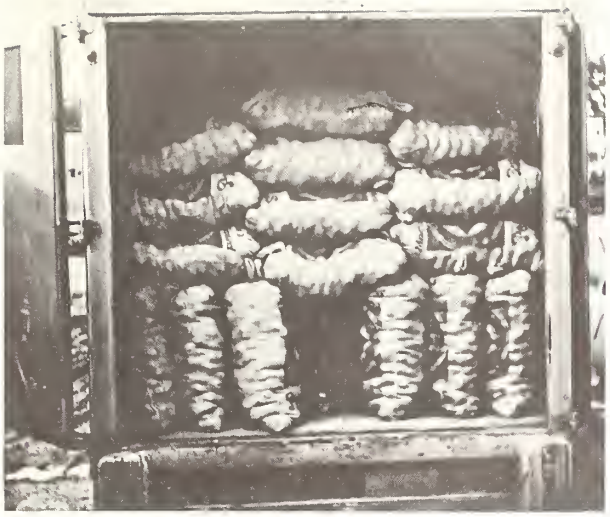


Figure 2.--Bridged-aisle load pattern for bagged pototoes in semitrailers. This type of lood does not provide for oir circulotion between the pototoes ond the walls.

Figure 3.--Solid-load pattern with woll spoce, for bagged pototoes in semitroilers. Note outlet, ot ceiling level, for oir delivery from blower-fan.

Heaters and Heater Placement

Inside and Underslung L. P. Gas Heaters.--In the 1956-57 tests[2] built-in L.P. gas heaters were used. These were either underslung or inside the trailer. The L.P. gas heaters used inside the trailers ranged in rated heat output from 10,000 to 20,000 British thermal units per hour (B.t.u./hr.) when burning at full force, and were manually controlled. The underslung L. P. gas heater with thermostat set at 65° F. had a rated heat output of 25,000 B.t.u./hr. when full burning.

Nine trailer truckloads of chipping potatoes, reconditioned by warming to and holding at 70° to 75° F. for about 2 weeks, were hauled during December and January to destinations 500 miles or more from the Red River Valley of North Dakota and Minnesota. The insulated trailers were in fair condition. Trailer floors were covered either with wood floor racks with 1 or 2 inches of air space beneath the upper slats, or with 3 inches of straw. A bridged-aisle load pattern of 300 to 400 one-hundred-pound burlap bags of potatoes was used (fig. 2). This load pattern provided no space between the load and walls. No forced air circulation was used. The trailers were preheated with a hot-blast heater and loaded within a warm building.

On arrival at destination, 24 hours after loading, the difference in temperatures between the top-layer and bottom-layer potatoes ranged from 10° F. to 30°. In some tests, bottom-layer temperatures were low enough to adversely affect chipping quality, while in others, top-layer temperatures were high enough to favor blackheart development. This indicated inadequate air circulation within the trailers, which could possibly be improved by higher floor racks, provision for space between the potatoes and the walls, and the use of forced air circulation.

In one test (fig. 5) with an underslung L. P. heater (25,000 B.t.u./hr.), with heated liquid circulating through pipes under a false floor, fairly uniform warm temperatures

[2] Findlen, H., and Hansen, J. C. Transportation of Late-Crop Potatoes for Chipping. Proceedings of Production and Technical Division Meetings, National Potato Chip Institute. Illus. January 1958. Pp. 3-6.

LOAD DIAGRAMS

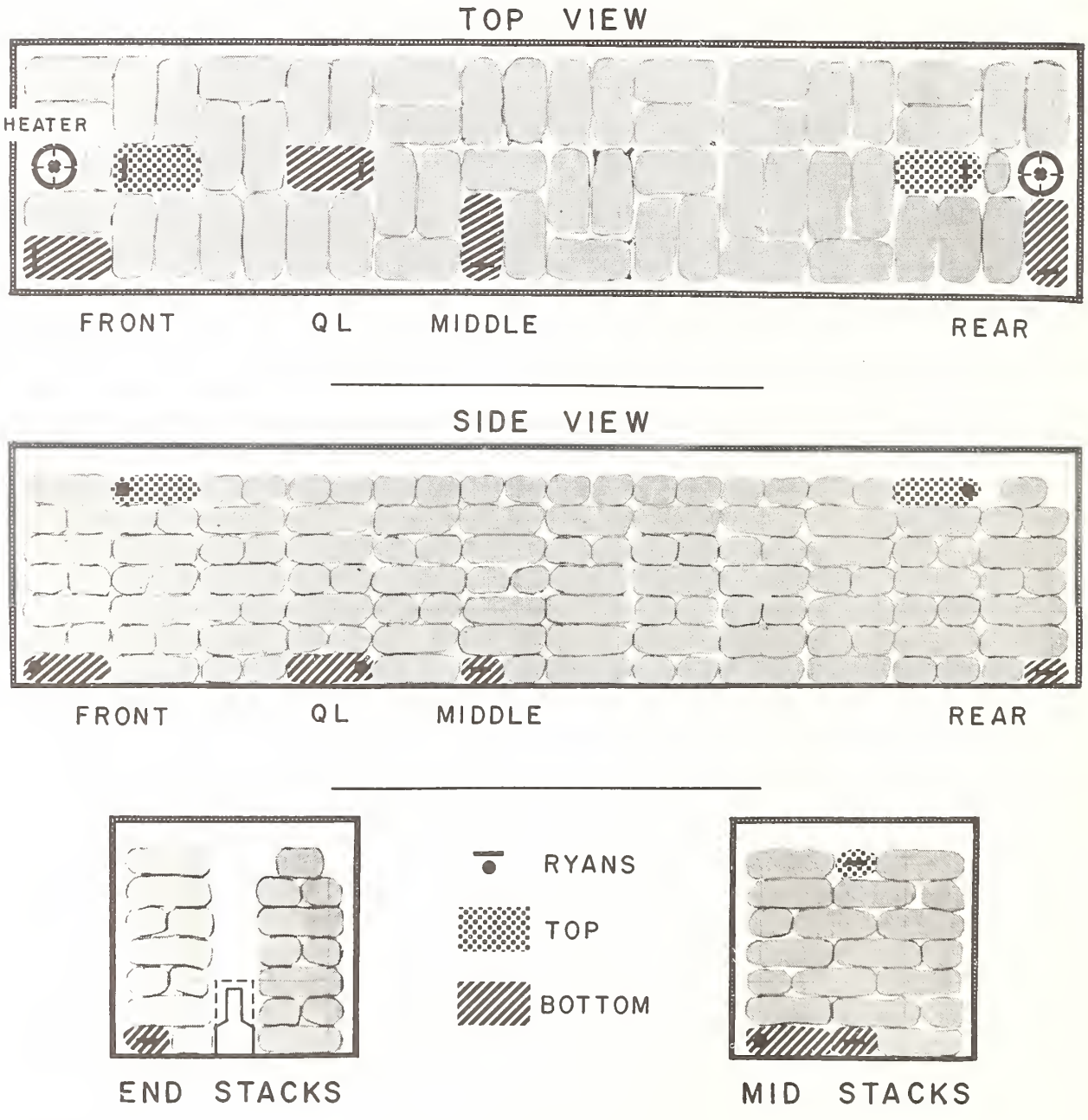


Figure 4.--Diagrams of solid-load pattern as used for potatoes in semitrailers in 1958-9 tests. Wall space, heater placement test packages, and Ryan recording thermometers within packages are shown.

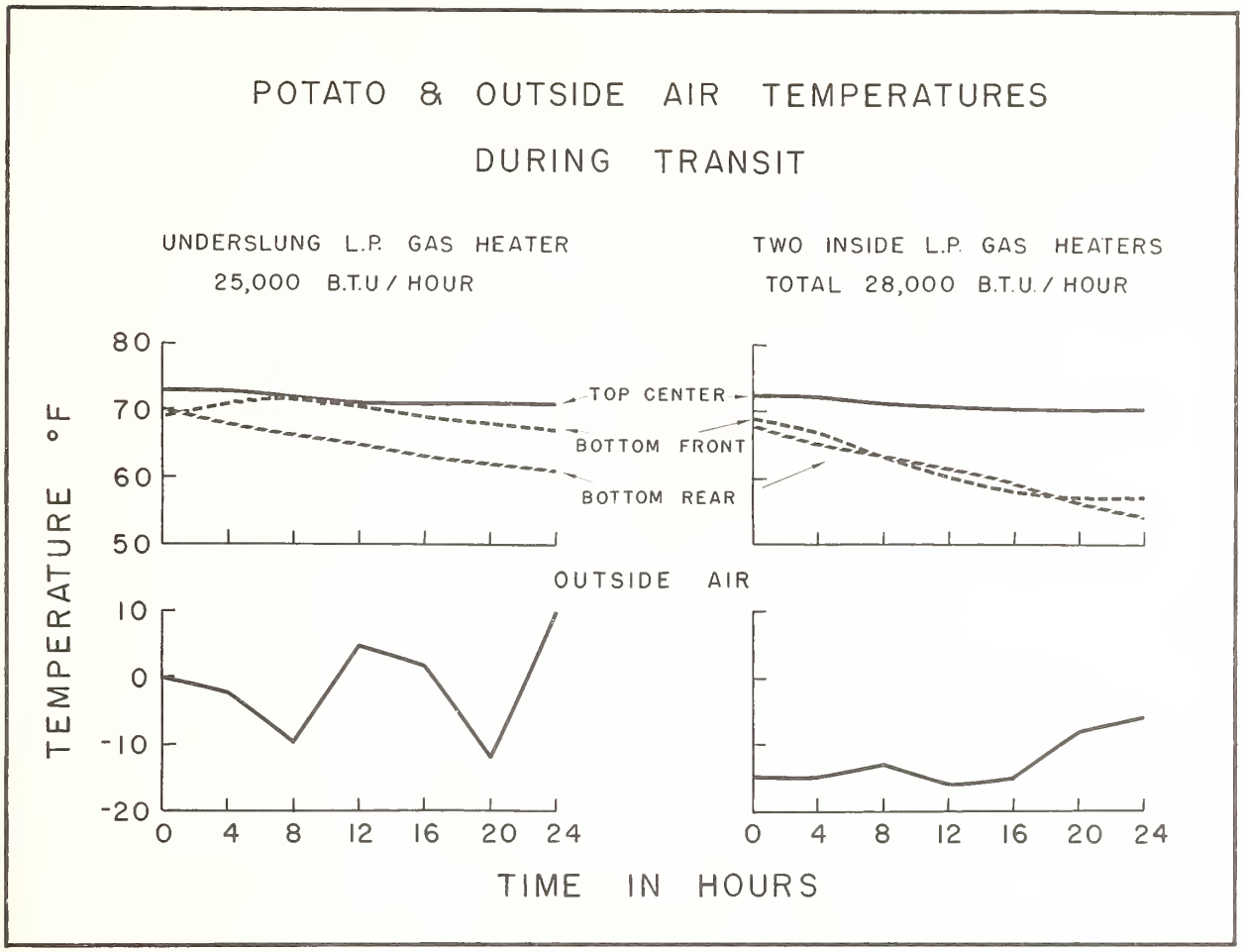


Figure 5.--Patata temperatures in twa semitrailers heated by underslung ar inside L. P. gas heaters (1956-57).

were maintained in transit. At destination, the lowest temperature of floor-layer potatoes was 61° F.

In another test (fig. 5) with L. P. heaters (14,000 B.t.u./hr. each), located one at the front and one at the rear inside the trailer, potatoes in the top layer, loaded at around 70° F., remained at 70° throughout transit. The bottom-layer potatoes, however, cooled fairly rapidly and reached 52° on arrival.

Location of Alcohol Heaters within Trailer.--In the 1957-58 tests,[3] Preco Model TH-11. alcohol (methanol) heaters were used. At full burning capacity, each heater had a rated heat output of 11,000 B.t.u./hr. Heater thermostats were set at 70° F. Heater placement was studied, comparing (1) two heaters placed in the front corners of the trailer, (2) two heaters placed in the rear corners of the trailer, and (3) one heater placed in the front centerline and one heater placed in the rear centerline of the trailer.

Sixteen trailer truckloads of chipping potatoes, reconditioned at 70° to 75° F. or taken directly from about 50° storage, were hauled during January and February 1958. All trailers were warmed to have a minimum floor temperature of 40° before the start

[3] Hansen, J. C. Winter Truck Transportation Tests with Chipping Potatoes from Red River Valley. Proceedings of Production and Technical Division Meetings, National Potato Chip Institute. January 1959. Illus. Pp. 9-11.

of loading inside a warm building. A bridged-aisle load pattern was used (fig. 2), with no forced air circulation. In these tests, no floor racks or straw was used. The floors were of the standard grooved type.

With both heaters placed either front or rear in the trailer, potato temperatures varied widely from front to rear (fig. 6). With heaters placed one in the front and one in the rear, front-to-rear temperatures were more nearly uniform and more desirable for maintaining chipping quality. With potatoes at 70° F. when loaded and both heaters in one

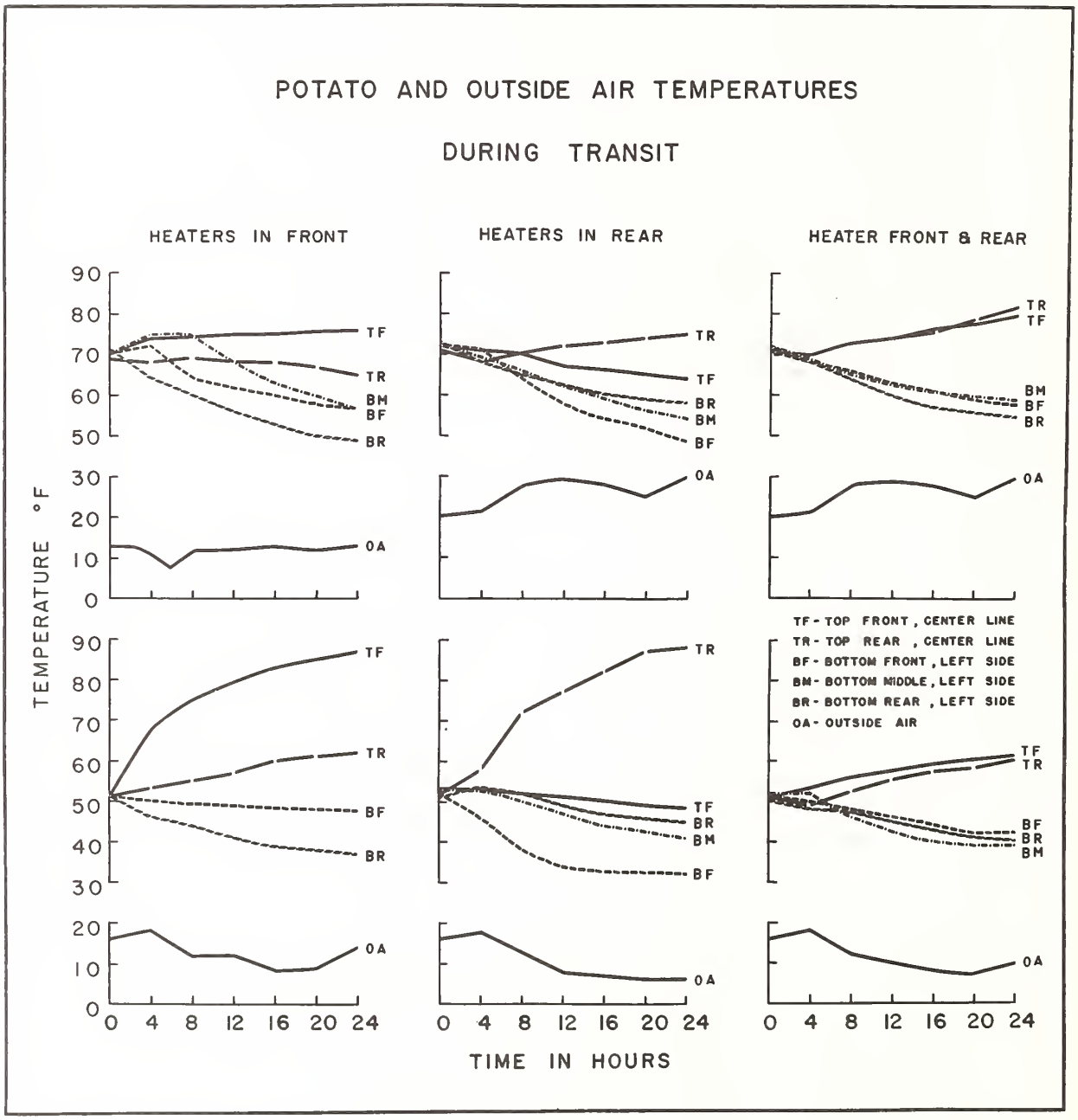


Figure 6.--Effect of heater location and initial potato temperature on potato temperatures in transit. (Six trailers, 1957-58). Upper--loaded with 70°F. potatoes. Lower--loaded with 50° potatoes.

end, temperatures at arrival varied 11 to 12 degrees in top layers and 8 to 9 degrees in bottom layers, while one heater in each end gave variations of 2 degrees in the top layer and 4 degrees in the bottom layer. With potatoes at 50° when loaded, arrival temperatures varied 25 to 40 degrees in top layers and 11 to 13 degrees in bottom layers when both heaters were in one end, and 1 degree in the top layer and 3 degrees in the bottom layer when a heater was placed in each end of the load.

Considerable spread between maximum and minimum potato temperatures within the load was noted in all three heater placement groups. The greatest spread (56° F.) was noted in potatoes at 50° when loaded, with heaters in the rear only. The least spread (22°) occurred in the trailers loaded with 50° potatoes and with a heater in front and rear.

In trailers with heaters in one end only, minimum temperatures below 40° F. were found in potatoes in the ends of the trailers away from the heaters. This is dangerously low. Somewhat better minimum temperatures of potatoes were achieved by placing heaters at both ends in the trailers.

Trailer Atmosphere

Analysis of air samples taken from seven trailers showed carbon dioxide ranging from 0.1 percent to 2.7 percent and oxygen ranging from 17.1 percent to 20.7 percent. In none of the trailers was the oxygen content low enough to affect heater burning rate or to favor blackheart in potatoes. Apparently there was a relatively free exchange of gases between the inside of the trailers and the outside atmosphere.

Blower Fan, Loading Tunnel, and Floor Rack Tests

Since surveys and tests conducted the previous 4 years indicated that better air circulation within the trailer was needed to equalize temperatures, additional tests were run to determine the effect on transit temperatures of (1) forced air circulation and (2) floor racks. Information was obtained also on the effect of a loading tunnel and initial potato temperatures.

Twenty-four test shipments of Irish cobbler chipping potatoes, in eight tests of three trailers each, were loaded at Grand Forks, N. Dak., and hauled about 600 miles to either Ottumwa, Iowa, or Madison, Wis., during January and February 1959.

The three modern 32-foot trailers used repeatedly in these eight tests were aluminum sheathed, had insulated walls and ceilings, and were in generally good condition. The flat floors of the trailers were made of 2-inch wood planking or had 1-inch celotex placed over extruded aluminum. The floors were covered either with floor racks (1- by 3-inch slats over 2- by 2-inch stringers) or with five bales of evenly spread straw. Each of the three trailers used floor racks for four tests and straw for four tests. One of the three trailers had a 1,000-c.f.m. blower-type fan (figs. 3 and 7). The fan was operated during preheating, loading, and transit.

All three trailers were loaded and dispatched within a 3-hour period and traveled under similar outside air temperature conditions except the fan-equipped truck in test 7, which was 1 day late. All trailers contained potatoes at 48° F. when loaded except in test 8, which was loaded with 75° F. potatoes. These potatoes had been stored at 48°, which is a close approximation of the recommended storage temperature of 50°.

A gas (L.P.) or portable charcoal heater in each trailer was used only during preheating and then extinguished.

Two 11,000-B.t.u./hr. alcohol heaters, placed one in each end of the trailer body, were used during both preheating and transit. The alcohol heater thermostats were set at 70° F.

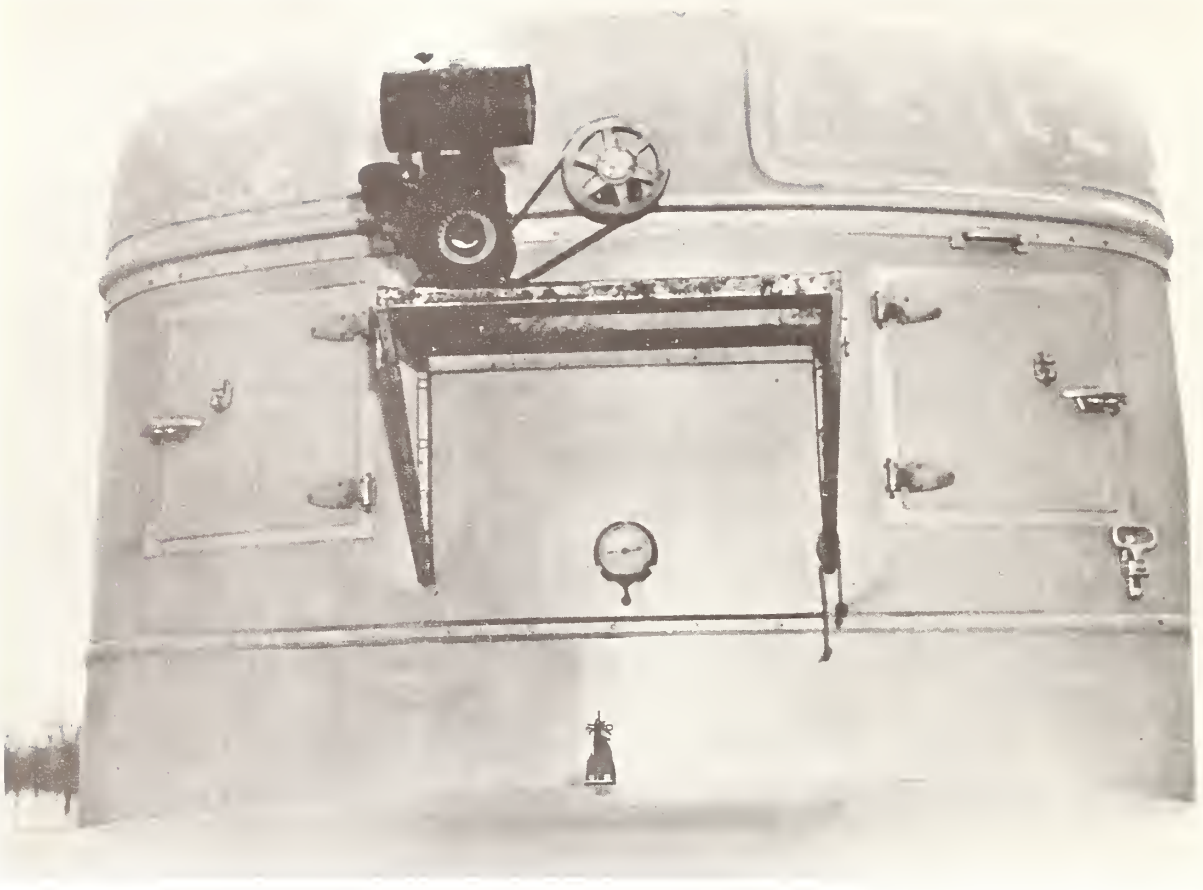


Figure 7.--Blower-fan circulates air within semitrailer at 1,000 c. f. m. For outlet within trailer, see figure 3.

Outside air temperatures during loading and transit were below freezing in all eight tests. Temperatures were below 0° F. during all or part of six tests. They averaged below 0° for three of the tests (-1.8°, -8.2, -13.3°), with minimums of -6°, -19°, and -20°.

The trailers were loaded outside the potato storage. A windproof loading tunnel was used except in tests 1, 2, and 3.

The loads consisted of 370 or 400 one-hundred-pound bags of potatoes in a solid load pattern (figs. 3 and 4). A divided tier of two double stacks was used in the front and rear of each trailer, with one double stack (two bags per layer) placed on each side of each alcohol heater. Air space between the load and the walls ranged from 4 to 8 inches and averaged 6 inches. There was a space of 10 to 12 inches between the seventh layer of the load and the ceiling. These spaces provided for air circulation around the load. The loaders tried to limit the loads to seven bags high. However, in the fan trailers, some bags were placed in an eighth layer. These settled in transit and left a 6-inch air space over the eighth layer at destination.

Blower Fan and Loading Tunnel Effects on Floor Air Temperatures during Loading.--Floor air temperatures were higher during loading in the fan-equipped trailer than in the other two trailers (fig. 8). Floor air temperatures were higher also in tests in which a loading tunnel was used. When both were used, temperatures were best and ranged from 46°F to 51° in the first seven tests and reached 66° in test 8. Without either

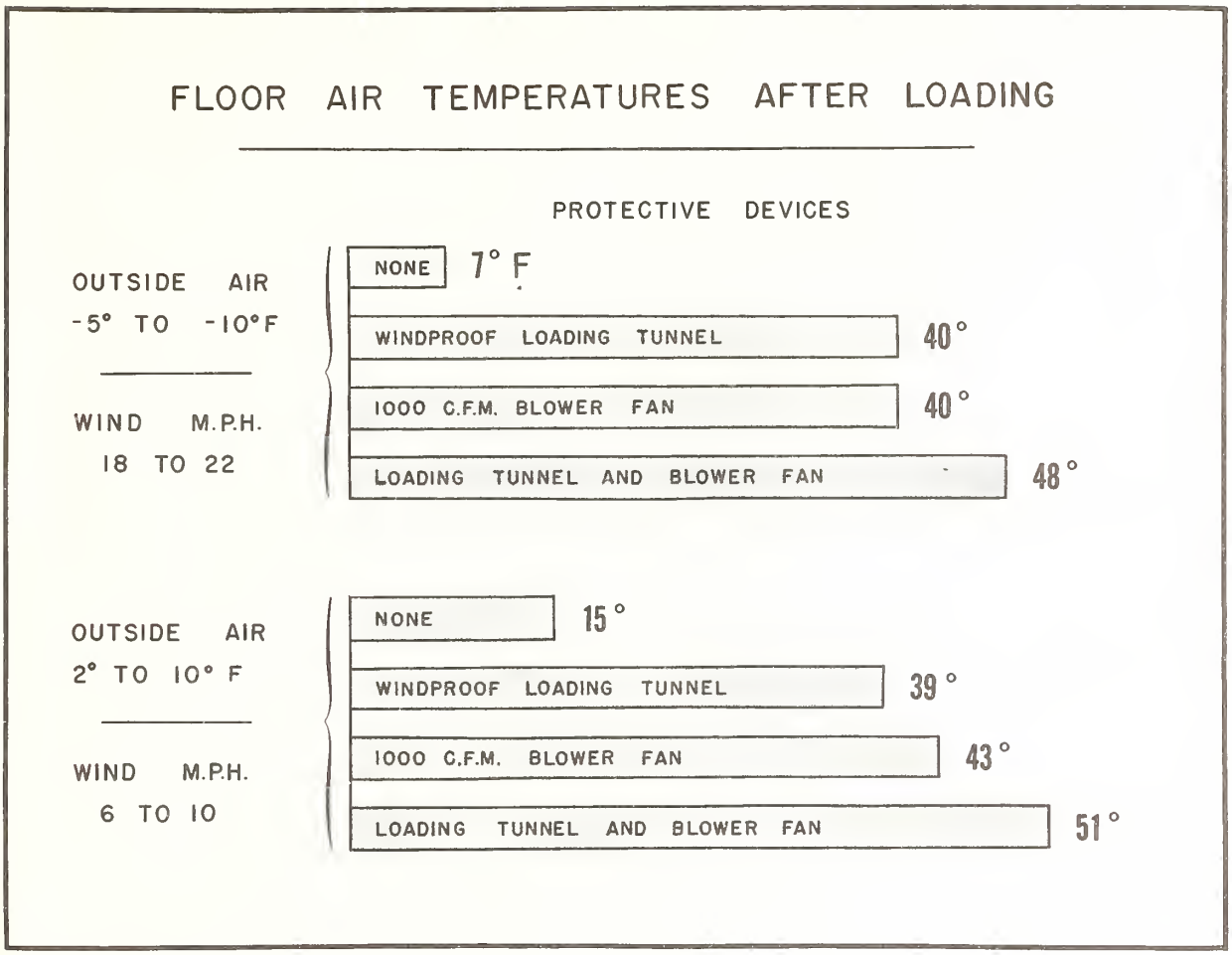


Figure 8.--Floor-level air temperatures in eight heated semitrailers as influenced by loading tunnel and blower fan (January and February 1959).

a blower-fan or loading tunnel, floor air temperatures during loading reached 7° to 29° F. The strikingly low temperature of 7° recorded in test 2 should warn shippers of the need for using a loading tunnel or, better still, for loading inside a heated shed during cold weather.

Blower Fan and Floor Rack Effects on Potato Temperatures during Transit.--With 48° F. potato loads, the fan-equipped trailer maintained potato temperatures closer to the starting levels than did nonfan trailers, and even raised some bottom-layer potato temperatures (fig. 9). Without fans, the use of racks improved potato temperatures very little over temperatures in trailers bedded with straw. Top-to-bottom temperature spreads in front positions were about 2 degrees F. for the fan-equipped trailer, 15 degrees for the rack-equipped nonfan trailer, and 18 degrees for the strawed nonfan trailer (fig. 9). Front, middle, and rear bottom-layer potato temperatures at destination (appendix, table 3) averaged 48° F. for the fan-equipped trailer and 41° for both the rack-equipped and strawed nonfan trailers.

In both rack-equipped and strawed nonfan trailers, the rear of the load was 1 to 2 degrees F. cooler than the front of the load in both top and bottom layers (fig. 10). The spread between top and bottom temperatures was very high in these nonfan trailers, however. In fan-equipped trailers, the rear of the trailer averaged 5 degrees higher than the front; the top-to-bottom temperature spread was about 2 degrees at the front and 10 degrees at the rear.

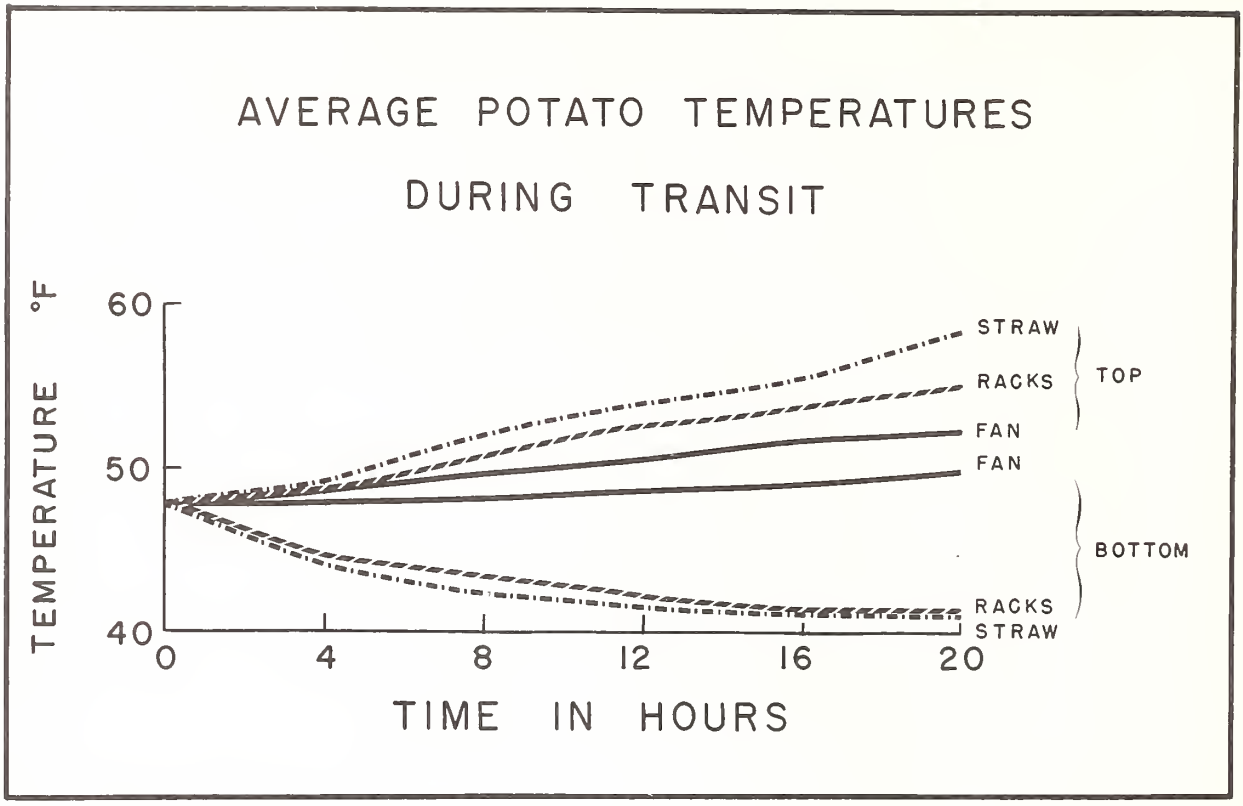


Figure 9.--Transit temperatures of potatoes (in front end of trailer) as influenced by fans, floor racks, and straw. Average of 6 trailers, tests 1 to 6 inclusive. Fan-equipped trailers are average of three with straw and three with floor racks. (January and February 1959)

There was a real advantage in using racks (rather than straw) when fans were used. When the fan was used with floor racks, there was a difference at destination of only 2 degrees F. between temperatures of the top and bottom layers of potatoes, but when the fan was used with straw the difference was 7 degrees (fig. 11).

Although the value of forced air circulation was demonstrated, the variations in temperature suggest the desirability of further improvement.

Effect of Initial Potato Temperatures on Transit and Arrival Temperatures

Top-layer temperatures of potatoes loaded into trailers from 48° F. storage generally rose, while the bottom-layer temperatures dropped or held steady, giving arrival temperatures averaging 41° in nonfan trailers and 48° in the fan trailers. When 75° potatoes were loaded, temperatures of both top and bottom layers dropped in nonfan trailers, while only bottom-layer temperatures dropped in the fan-equipped trailer. Front bottom temperatures on arrival were 70° for fan-equipped trailers, 54° for rack-equipped, and 58° for strawed trailers. With potatoes starting at 75°, bottom temperatures on arrival were 10° to 17° higher in nonfan trailers and 25° higher in fan-equipped trailers than for potatoes starting at 48° (fig. 12).

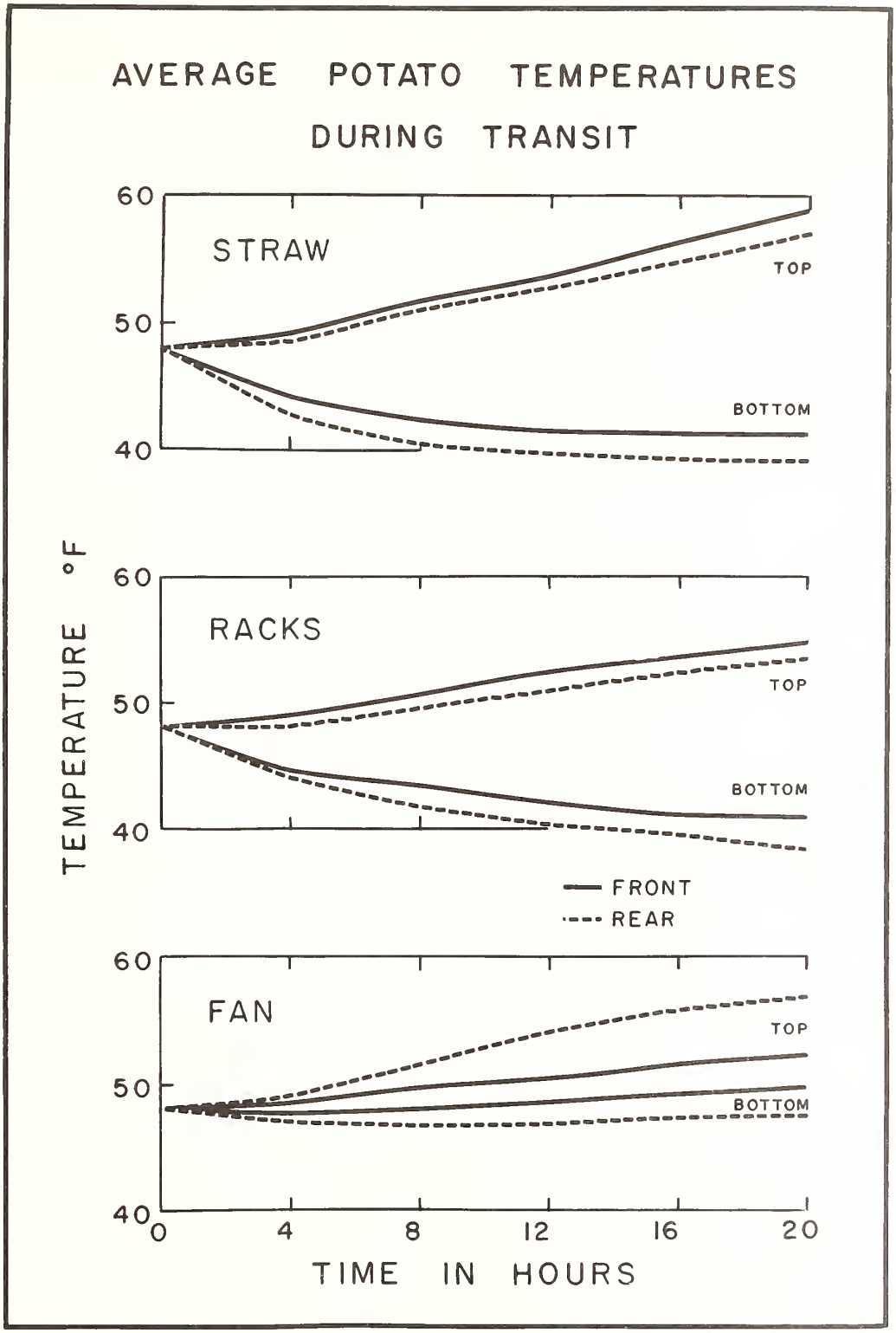


Figure 10.--Transit temperatures of potatoes as influenced by fans, floor racks, and straw. Average of six trailers, tests 1 to 6 inclusive. Fan-equipped trailers are average of three with straw and three with floor racks. (January and February 1959).

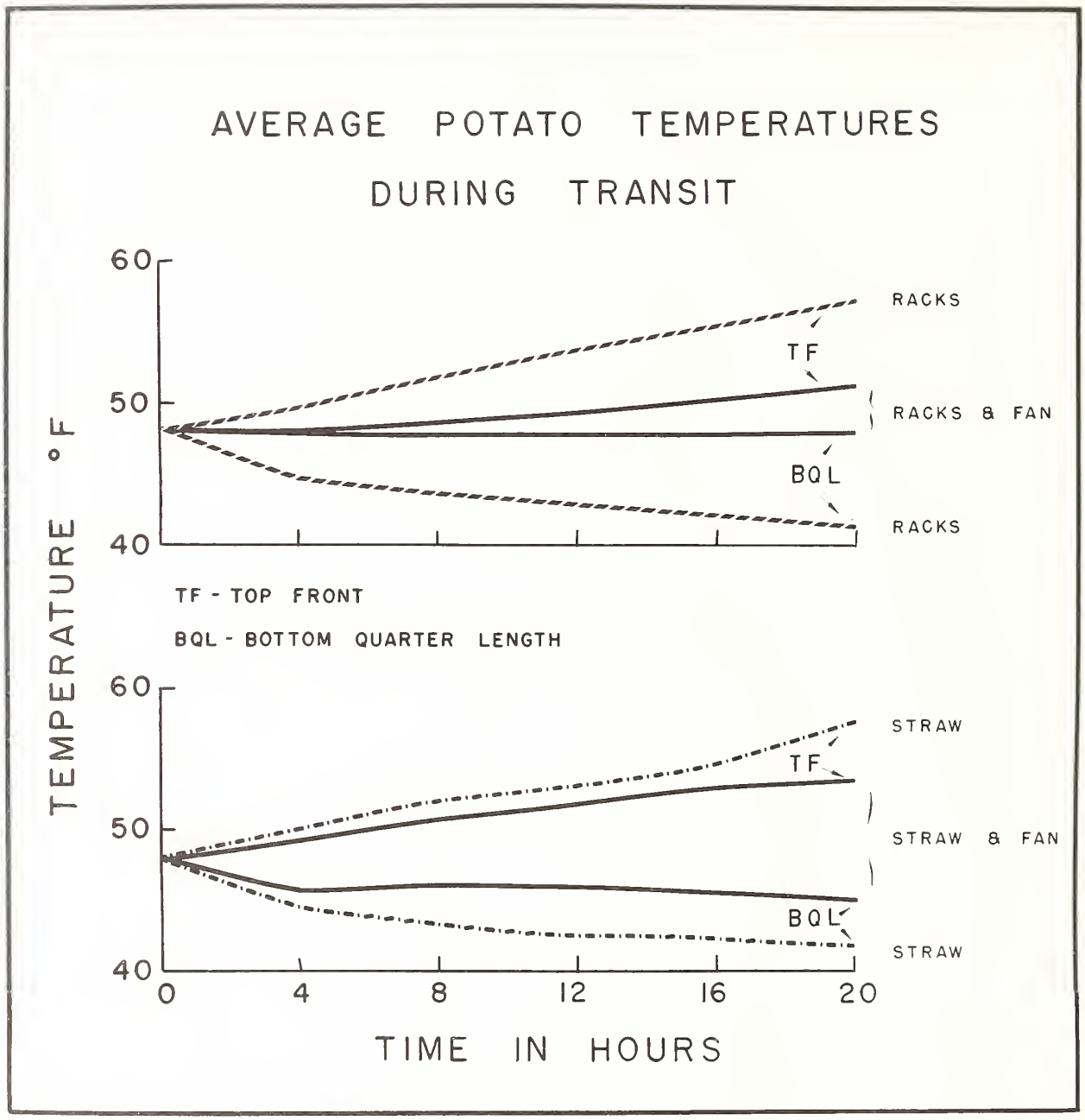


Figure 11.--Comparison of effects of floor racks and straw when used in conjunction with fans on potato transit temperatures (average of three trailers for each treatment, January and February 1959).

The effect of initial potato temperatures on destination temperatures is shown also in the 1957-58 tests (fig. 6). Potatoes initially at 70° F. to 75° arrived with bottom-layer temperatures from 49° to 58° in trailers with heaters in one end, and from 55° to 59° in trailers with heaters in both ends; while potatoes initially at 50° arrived with bottom-layer temperatures ranging from 32° to 48° in trailers with heaters in one end, and 39° to 42° in trailers with heaters in both ends.

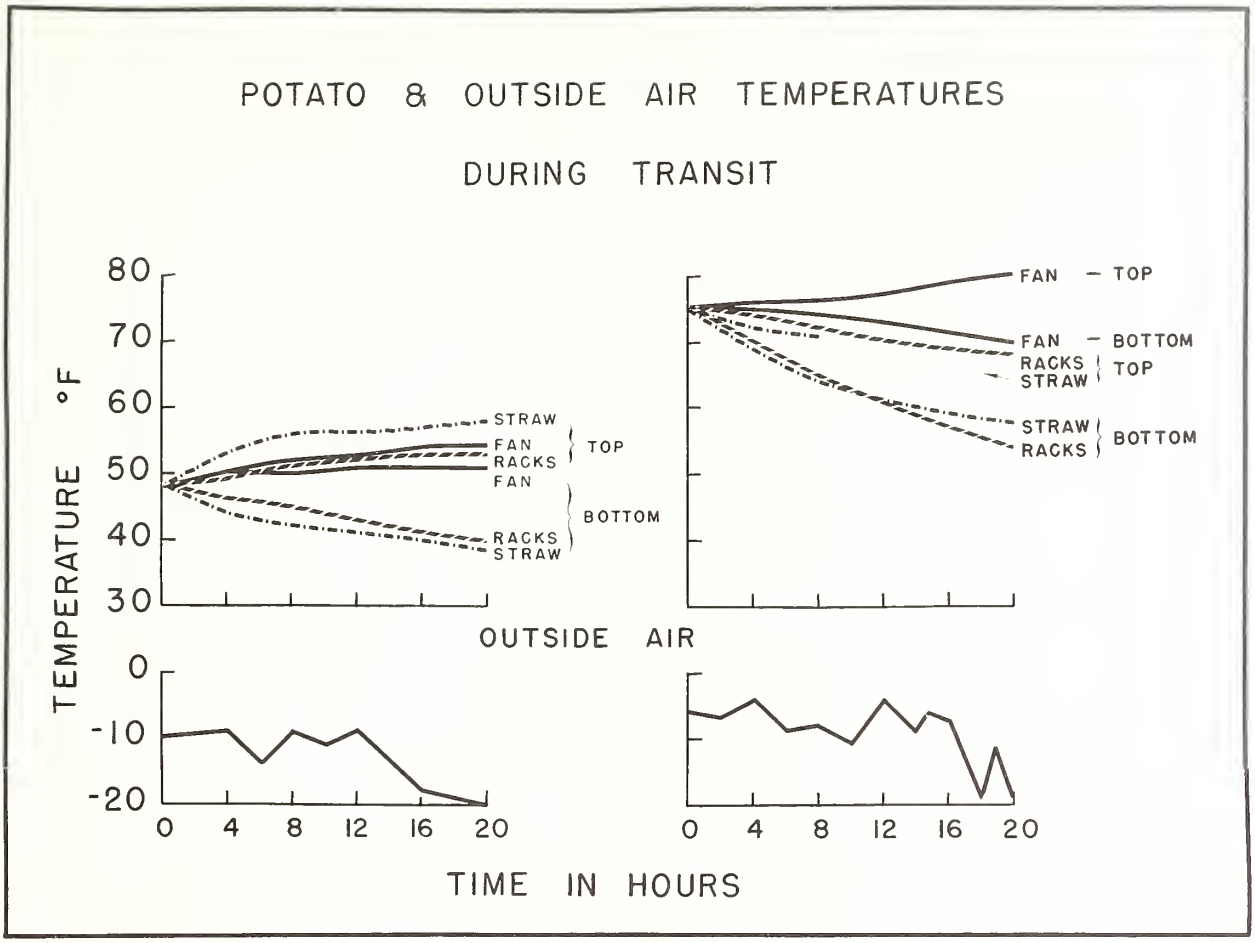


Figure 12.--Transit temperatures as influenced by initial patata temperature. Left, initial temperature, 48°F. right, initial temperature, 75°F. (three trailers laaded with 48°potatoes and three with 75°patataes, January and February 1959).

TABLE 1.--Trailer, load, and loading conditions for 26 semitrailers surveyed in 1955-6 shipping season

Trailer No.	Year built	General condition	Insulation thickness and type	Height of air space under floor racks	Built-in heaters	Portable charcoal heaters	Blower fan	Load type	Load size, 100-lb. bags	Temperature at loading			Transit time (estimated)
										Potatoes	Truck air	Outside air	
				Inches					*Number*	°F	°F	°F	*Hours*
1	1948	- (Plywood joints open)	3" rock wool	2		x		Pyramid	400	50	45	4	12
2	-	- (Light cracks around door)	2" rock wool	2	x			Pyramid	320	50	33	4	12
3	1954	- (Frost on Bolts)	- -	1	x			Pyramid	300	50	40	4	8
4	Old	Good	2" rock wool	1	x	x		Pyramid	300	65	45	4	12
5	1947	Good	2" rock wool	1	x			Pyramid	300	53	36	20	8
6	1952	- (Light cracks around door)	3" rock wool	1		x		Bump	275	54	27	26	12
7	Old	- (Loose hatch)	4" rock wool	2		x		Pyramid	300	57	52	15	12
8	1954	Very good	2" fiberglass	1		x		Pyramid	400	43	34	14	8
9	Old	Fair	- rock wool	[1] 2	x			Pyramid	340	50	43	20	8
10	1955	Good	1½" fiberglass	1		x		Pyramid	350	49	54	18	14
11	1955	Good(1st trip)	- -	None		x		Pyramid	320	44	18	5	12
12	1954	Good	4" alderlight	2	x		[5] x	Pyramid	300	37	50	5	12
13	1954	Good	- None	1		([3])	x	Pyramid	350	50	43	10	15
14	1945	- (Light cracks in floor and near center	2" rockwwool	2	x	x		Pyramid	300	64	55	8	10
15	1950	Fair	2" fiberglass	2		x		Pyramid	300	55	36	8	14
16	Old	Poor	4" rock wool	2	x			Pyramid	300	38	40	8	13
17	1955	Good	3" fiberglass	[2] 1	x			Pyramid	340	70	27	0	48
18	1950	Good	3" fiberglass	2	x			Length-	300	52	40	-5	7
19	1949	Fair	2" rock wool	2		x		wise wall	300	38	20	-5	16
20	1955	-	2" rock wool	2	x		x	to wall	340	57	5	-18	8
21	1948	- (4 holes in body)	2" fiberglass	2	x			Pyramid	300	74	30	-5	30
22	1948	Fair	2" fiberglass	2	x			Pyramid	300	53	40	-12	8
23	1952	Good	2" fiberglass	None		[4] x	[5] x	Bump	320	45	45	-12	30
24	1955	Good	2" fiberglass	1		x		Pyramid	340	53	48	-3	8
25	1953	-	2" rock wool	2	x			Pyramid	300	65	40	-3	8
26	1955	Good	2" fiberglass	[2] 1	x		x	Pyramid	340	53	30	-3	30

[1] Also equipped with sidewall flues.
[2] Ribbed floor with straw covering.
[3] Gasoline heaters only.
[4] Portable alcohol heaters also used.
[5] Not used for winter shipments.

TABLE 2.--Potato temperatures in 6 semitrailers during transit from East Grand Forks to Minneapolis, Minn., February 1955

Trailer No.	Date	Recorder position	Hours in transit						
			0	2	4	6	8	10	12
			°F	°F	°F	°F	°F	°F	°F
27	Feb. 3-4	Top center centerline.....	44	43	42	41	-	-	-
		Bottom bunker right side.....	44	43	41	40	39	38	36
		Bottom door left side.....	41	40	40	40	39	39	39
		Outside air.....	26	28	17	17	13	15	-
[1]28	Feb. 7-8	Top center centerline.....	38	38	39	40	40	41	42
		Bottom bunker right side.....	40	39	39	38	38	37	36
		Bottom door left side.....	39	38	37	36	35	34	33
		Outside air.....	18	23	27	20	15	23	14
[1]29	Feb. 10-11	Top center centerline.....	41	42	44	45	46	46	47
		Bottom bunker right side.....	36	35	34	34	33	33	32
		Bottom door left side.....	36	35	34	34	33	32	32
		Outside air.....	-16	-13	-18	-12	-11	-11	-12
30	Feb. 14-15	Top center centerline.....	43	43	43	43	43	43	43
		Bottom bunker right side.....	43	43	42	41	41	41	41
		Bottom door left side.....	44	44	44	44	43	43	43
		Outside air.....	38	37	30	24	20	16	14
31	Feb. 17-18	Top center centerline.....	47	46	46	45	45	44	44
		Bottom bunker right side.....	48	47	46	46	46	45	45
		Bottom door left side.....	47	47	46	46	45	45	44
		Outside air.....	37	35	40	39	38	36	32
32	Feb. 21-22	Top center centerline.....	45	45	45	45	45	44	44
		Bottom bunker right side.....	44	43	43	42	41	39	38
		Bottom door left side.....	43	43	42	42	42	42	41
		Outside air.....	19	14	10	8	6	7	7

[1] L. P. gas heaters (24,000 B. t. u./hr. capacity at full burning) used in trucks 28 and 29. Heaters not used in trucks 27, 30, 31, and 32.

TABLE 3.--Potato temperatures in 24 semitrailers during transit, January and February 1959.

Test No.	Recorder position	Floor racks: Hours in transit						Fan:[1] Hours in transit						Straw: Hours in transit					
		Start	4	8	12	16	20	Start	4	8	12	16	20	Start	4	8	12	16	20
		°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
1	Top front center	48	50	52	55	57	60	48	47	48	49	50	51	48	45	48	51	56	58
	Top rear center..	48	47	48	52	53	56	48	47	50	52	54	56	48	45	48	53	57	59
	Bottom front side	48	44	42	40	39	39	48	46	47	48	48	49	48	44	43	43	43	43
	Bottom mid. side	48	46	45	44	44	44	48	46	46	46	47	48	48	45	44	43	43	43
	Bottom rear side.	48	46	45	44	44	44	48	45	44	44	44	43	48	44	44	44	45	46
	Bottom q.l.center	48	47	46	45	44	43	48	47	48	48	49	49	48	45	44	43	43	43
	Outside air	+13	+15	+23	+22	+22	+28												
2	Top front center	48	47	48	49	51	52	48	51	52	53	54	54	48	48	49	50	53	56
	Top rear center	48	47	48	49	51	52	48	50	51	54	55	56	48	46	47	48	49	53
	Bottom front side	48	42	40	39	38	38	48	47	47	47	48	49	48	43	40	37	37	37
	Bottom mid. side	48	45	43	43	42	42	48	48	47	47	46	46	48	45	43	42	41	40
	Bottom rear side	48	42	38	37	36	35	48	47	45	44	43	43	48	43	41	39	39	39
	Bottom q.l.center	48	45	44	44	43	42	48	43	44	45	45	45	48	41	40	38	38	38
	Outside air	-4	-6	-1	-1	+1	0												
3	Top front center	48	-	-	-	-	-	48	49	50	51	52	53	48	49	51	55	56	58
	Top rear center	48	47	49	50	52	53	48	50	51	53	53	54	48	51	53	55	57	58
	Bottom front side	48	43	43	43	43	44	48	49	49	50	50	50	48	44	43	43	43	43
	Bottom mid. side	48	44	44	44	44	44	48	49	49	49	49	50	48	45	44	42	41	40
	Bottom rear center	48	42	42	42	42	42	48	49	50	51	52	52	48	43	40	39	39	38
	Bottom q.l.center	48	42	41	40	40	40	48	49	50	50	50	50	48	43	43	42	42	42
	Outside air	+3	+2	+6	+9	+1	+14												
4	Top front center	48	49	51	53	53	53	48	50	52	53	54	54	48	53	56	56	57	58
	Top rear center	48	49	52	52	53	53	48	49	50	52	52	53	48	50	54	55	57	57
	Bottom front side	48	46	45	43	41	40	48	50	50	51	51	51	48	44	42	41	40	39
	Bottom mid. side	48	46	44	43	41	40	48	49	49	49	49	49	48	47	45	44	44	43
	Bottom rear side	48	45	41	38	37	35	48	47	46	44	44	44	48	37	32	30	29	29
	Bottom q.l.center	48	46	44	42	41	40	48	48	48	48	47	46	48	47	46	45	45	44
	Outside air	-10	-14	-11	-9	-18	-20												
5	Top front center	48	49	51	52	53	54	48	48	48	48	49	49	48	53	55	58	61	66
	Top rear center	48	49	50	51	52	53	48	-	-	-	-	-	48	50	53	55	56	58
	Bottom front side	48	45	44	43	42	41	48	48	48	48	48	48	48	47	46	46	46	46
	Bottom mid. side	48	47	45	44	43	42	48	48	47	47	47	46	48	47	46	45	44	43
	Bottom rear side	48	44	42	39	37	35	48	48	49	51	51	51	48	45	44	44	43	43
	Bottom q.l.center	48	45	44	43	42	41	48	47	45	45	44	44	48	47	46	46	46	46
	Outside air	+10	-7	-4	+7	-7	+13												
6	Top front center	48	49	51	52	54	55	48	47	48	49	51	52	48	49	51	53	54	56
	Top rear center	48	51	53	-	-	-	48	48	49	52	54	56	48	49	51	52	54	56
	Bottom front side	48	45	45	44	43	43	48	47	48	49	50	51	48	42	39	38	38	39
	Bottom mid. side	48	45	44	44	43	43	48	47	47	48	50	52	48	45	44	43	43	42
	Bottom rear side	48	45	43	42	42	41	48	47	46	47	49	50	48	43	41	41	40	40
	Bottom q.l.center	48	46	45	45	44	44	48	46	46	45	44	44	48	45	44	44	44	43
	Outside air	-5	+1	+18	+12	+13	+13												
7	Top front center	48	52	55	57	58	59	48	47	47	47	47	47	48	52	56	58	60	62
	Top rear center	48	52	55	58	59	61	48	-	-	-	-	-	48	49	53	56	58	59
	Bottom front side	48	47	47	46	45	45	48	44	44	44	44	44	48	47	46	45	45	45
	Bottom mid. side	48	48	47	47	46	45	48	48	48	48	48	48	48	48	47	47	46	46
	Bottom rear side	48	47	46	45	44	43	48	47	47	47	47	47	48	47	46	46	46	45
	Bottom q.l.center	48	46	46	45	45	45	48	43	42	41	41	41	48	48	47	46	46	45
	Outside air	+8	+22	+32	+27	+25	+25	0	+2	+2	+6	-1	+13	+8	+22	+32	+27	+25	+25
8	Top front center	75	74	72	70	69	68	75	76	76	77	79	80	75	73	71	-	-	-
	Top rear center	75	72	69	68	67	65	75	76	78	81	83	85	75	72	73	73	75	76
	Bottom front side	75	70	65	61	57	54	75	75	74	73	71	70	75	69	64	61	59	58
	Bottom mid. side	75	69	64	60	57	54	75	74	74	73	71	70	75	69	66	63	61	59
	Bottom rear side	75	68	59	55	51	47	75	71	71	71	71	69	75	65	63	59	57	55
	Bottom q.l.center	75	68	62	56	53	50	75	73	72	69	68	67	75	72	69	66	64	62
	Outside air	-6	-4	-9	-4	-7	-19												

[1] Tests 1, 3, 5, 7, fan with floor racks; tests 2, 4, 6, 8, fan with straw.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1968 O - 291-159