

Vehicle Operating Characteristics on the West Virginia Turnpike and Alternate Routes

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● THIS REPORT is concerned essentially with the results of studies to measure some of the factors that affect the economics of vehicle operation over the West Virginia Turnpike, or toll road, and the parallel free highways normally used to travel between the same termini served by the turnpike.

The West Virginia Turnpike is the only 2-lane toll road in existence and represents the ultimate in a 2-lane fully controlled-access and grade separated facility in mountainous terrain.

The parallel free routes are characterized by bad alignment, steep grades, inadequate sight distance, and roadside development.

The construction of the turnpike presented an opportunity to study the performance characteristics on these routes before and after opening of the turnpike.

The before studies were confined to the operation of a 1951 passenger car over the parallel routes. Three round trips, by the average test method, were run over each section of the study routes. The data collected were fuel consumption, speed and braking, by speed groups and travel time.

The after studies were made over the same study routes and the turnpike, using the same passenger car; and, at the request of the West Virginia Turnpike Commission, were extended to include a truck study. The truck study was made with a typical truck-tractor using diesel fuel.

Three round trips, with the passenger car, were run over the turnpike at each of the attempted speeds of 40, 50 and 60 mph. One round-trip average test method was run on Study Routes A and B before discontinuance due to instrument failure. The data collected were the same as in the before study.

In the truck study three round trips were run on all study routes by the average test method. The data collected were fuel consumption, number of gear changes, time spent in each gear, and total travel time.

The data were obtained from the performance of one 1951 passenger car and one tractor-truck combination operated by the respective drivers throughout the tests.

While the data presented are limited to the comparison of one 2-lane controlled-access toll route and its parallel free alternates, and to one passenger car and truck, it is hoped that the data presented will add something to the information previously collected.

TERMINOLOGY

Terms frequently used are the same as used in Highway Research Board Bulletin 107.

Study routes. The total length of the route from common point to common point. (The West Virginia Turnpike, or turnpike study route, includes 2.51 miles of travel on US 21 from the north end of the Kanawha City Bridge to the Charleston Interchange.)

Over-all travel time. The time of travel, including stops and delays except those off the traveled way.

Over-all travel speed. The speed over a specified section of highway, being the distance divided by over-all travel time. The average for all traffic, or component thereof, is the summation of distances divided by the summation of over-all travel times.

Composite performance. The performance in given terms for a round trip over a specified section of highway. (Composite gasoline consumption in gal-

lons per mile is the total number of gallons of gasoline required by a vehicle to travel in both directions on a section of highway, divided by twice the length of the section in miles.)

Directional performance. The performance in given terms in a single direction over a specified section of highway.

Road user benefits. The advantages or savings that accrue to drivers or owners through the use of one highway facility as compared with the use of another. Benefits are measured in terms of the decrease in road user costs and the increase in road user services.

Total rise and fall. The arithmetic sum of the vertical rise and fall in feet for any section of highway. (If a section of highway progressively rises 100 ft, falls 500 ft, rises 30 ft, and falls 10 ft, the total rise and fall will be 640 ft. The total rise and fall is the same regardless of the direction of travel.)

Rate of rise and fall. The total rise and fall for any section of highway divided by the length of section in hundreds of feet. (It is not to be confused with the percent of grade. It is equivalent to the average percent of grade only when either the rise or fall is 100 percent of the total rise and fall.)

Average test method. The driver travels at a speed which, in his opinion, is representative of the speed of all traffic at the time, without trying to keep a balance in the number of passings.

"Attempted Speed" test method. The driver attempts to maintain a specified speed over a section of highway, passing all vehicles that interfere with maintaining the specified speed, and exceeding the specified speed only during the passings.

STUDY ROUTES

The routes for the passenger car and truck study were chosen in 1952 for the purpose of making a before and after passenger car study on the principal routes from which traffic would be diverted by the proposed West Virginia Turnpike.

Control points were selected on each

route at possible points of choice for use of the turnpike and to eliminate unnecessary duplication of common travel. The same control points were used in the after study with special runs to adjust to the final location of the turnpike. The study routes and adjusted control points are shown in Figures 1-5. Figures 4 and 5 also show the profile of the respective routes. The profiles were plotted from elevations measured with an altimeter.

The routes all begin at a common point (Control Point 1) at the north end of the Kanawha City Bridge at the junction of US 21 and US 119 in Charleston, and end at a common point on US 119 at the junction of the turnpike west of Princeton (Control Point 6A-Figure 1). Also, the before study routes are over a common route (US 21) from the junction of W. Va. 3 and US 21 south of Beckley (Control Point 5) to common Control Point 6A.

For brevity, the routes are referred to in the report and tables as described in the following.

Study Route A

Study Route A begins at the Common Point 1 at the Kanawha City Bridge in Charleston; thence southerly on US 119 via Marmet to Racine; thence on W. Va. 3 via Whitesville to the junction of US 21 south of Beckley; thence on US 21 to Princeton; thence on US 219 to the Common Point 6A — total length 89.51 mi.

Study Route B

Study Route B begins at the Common Point 1 in Charleston; thence on US 21 southerly via Gauley Bridge, Oak Hill and Beckley to Princeton; thence via US 219 to Common Point 6A — total length 119.30 mi.

Study Route C

Study Route C begins at the Common Point 1 in Charleston; thence on US 119 to Marmet; thence on W. Va. 61 via Montgomery to Oak Hill; thence on US

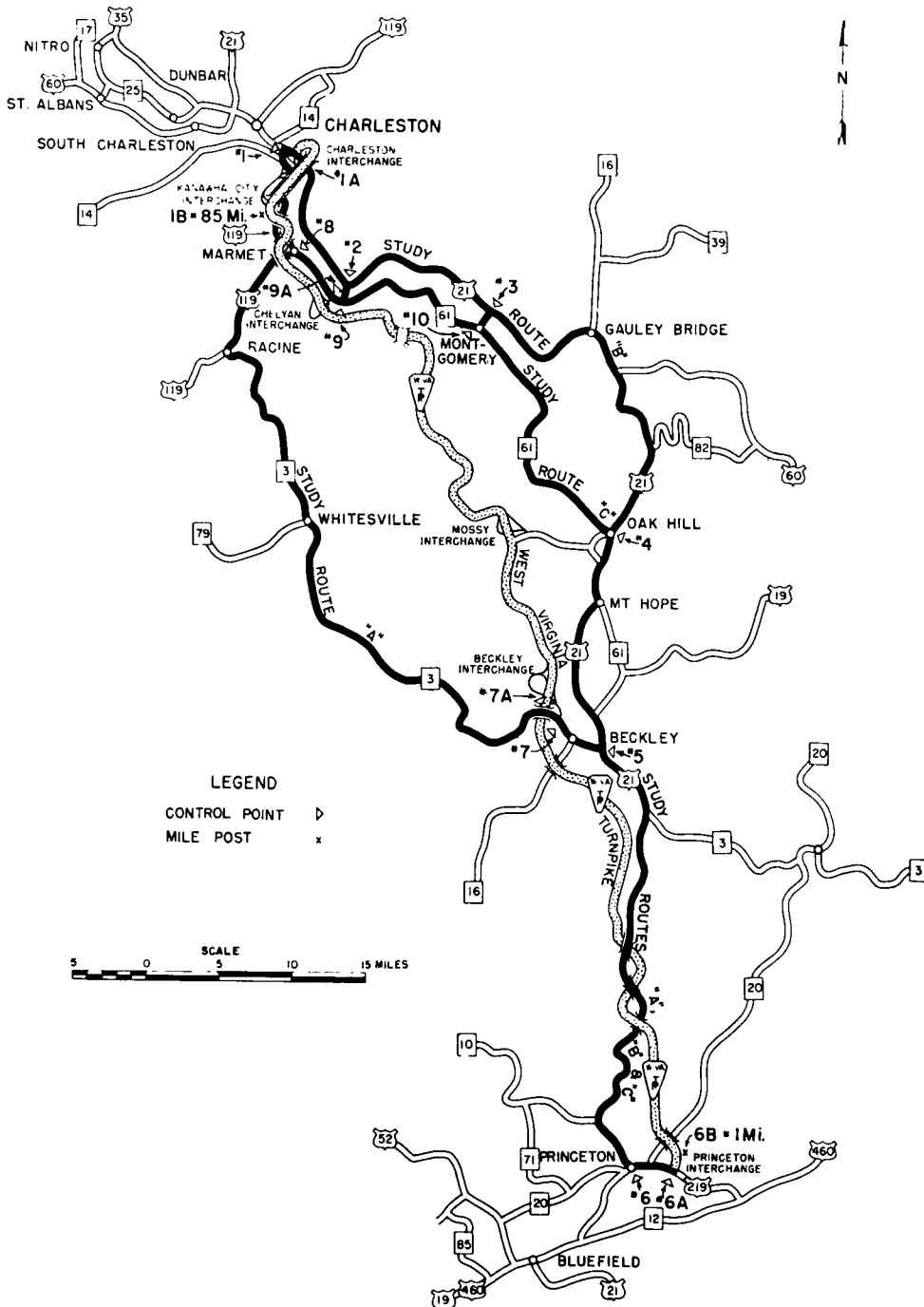


Figure 1. Study routes and control points.

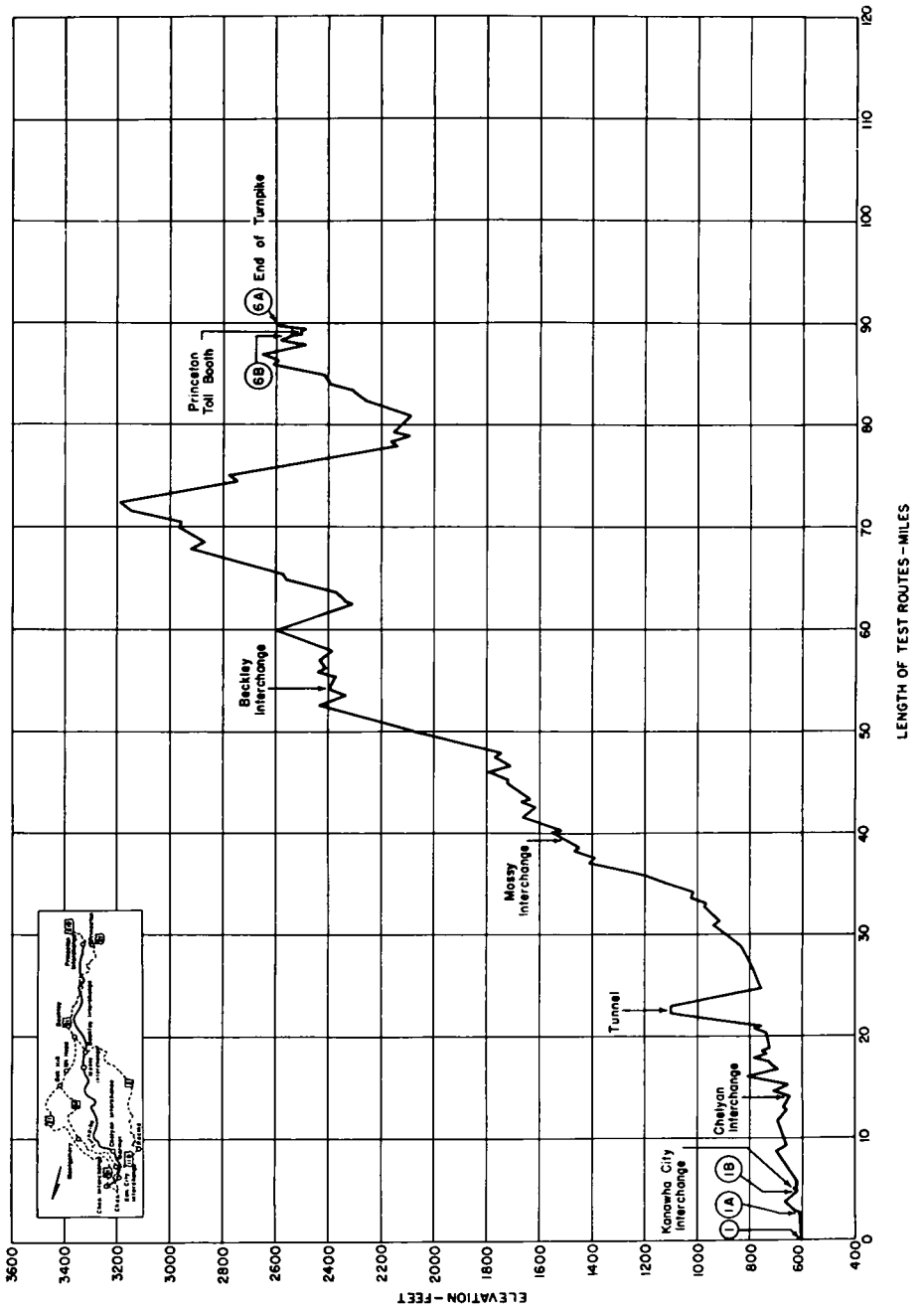


Figure 2. Profile and sketch of West Virginia Turnpike.

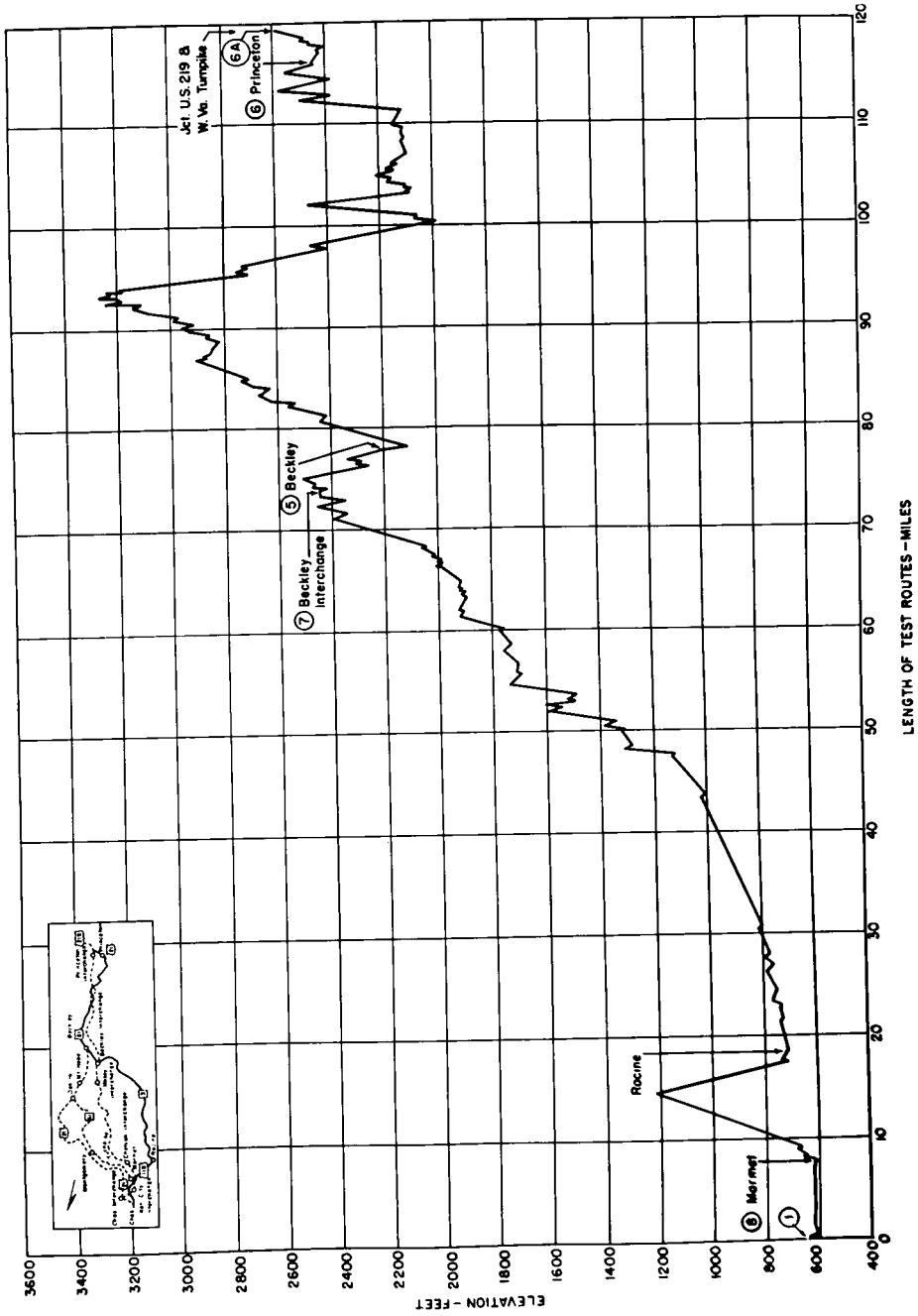


Figure 3. Profile and sketch of Study Route A.

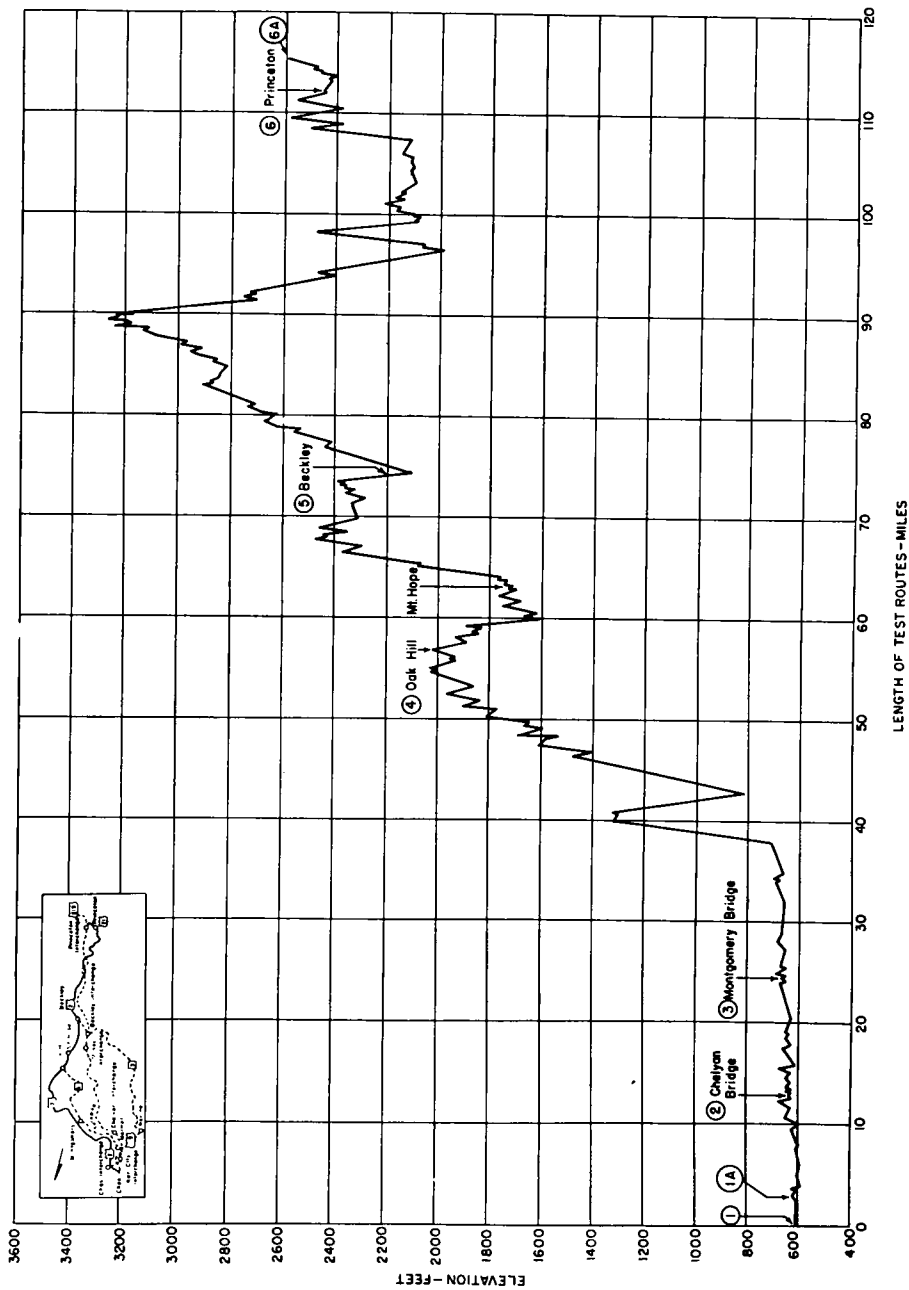


Figure 4. Profile and sketch of Study Route B.

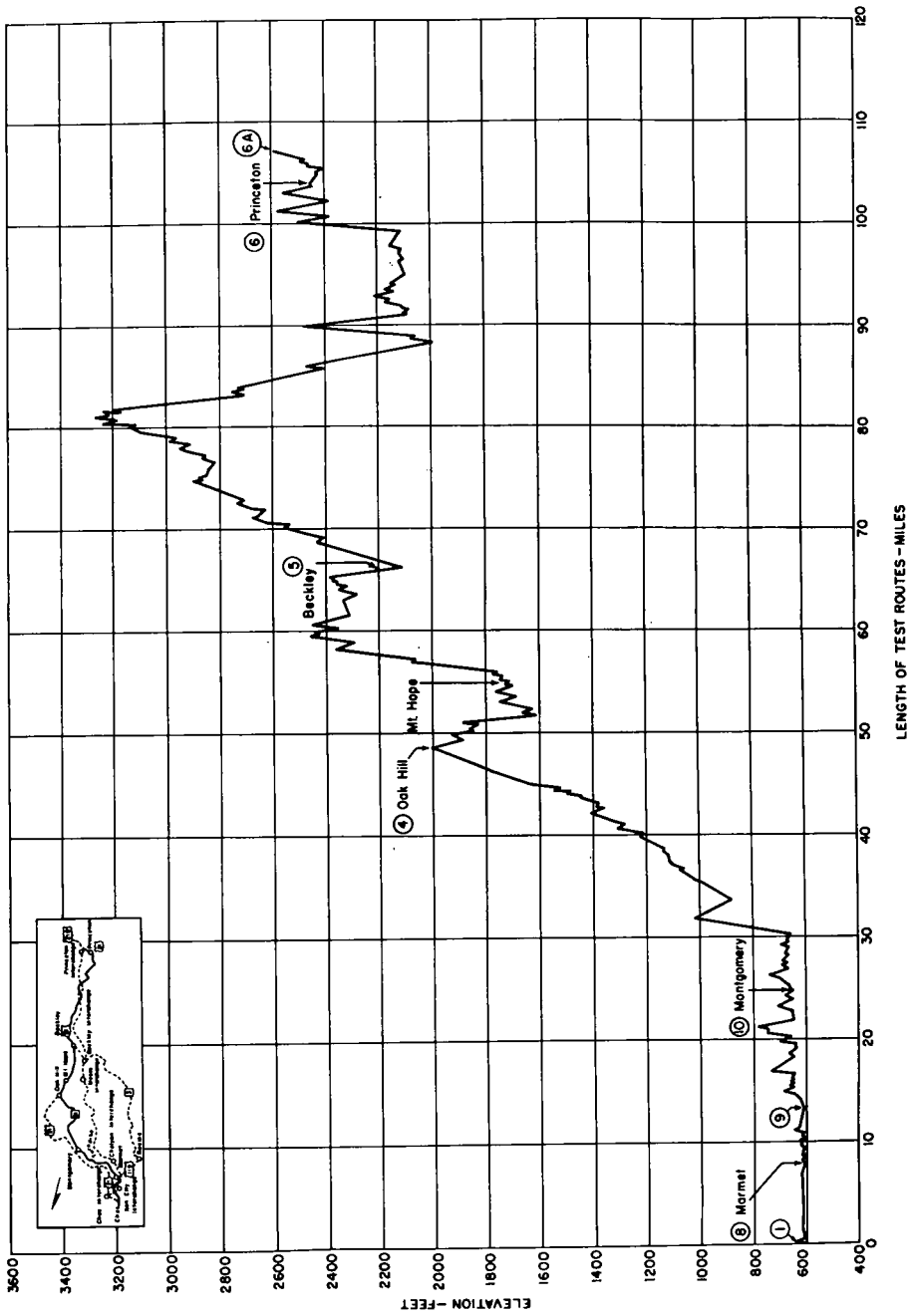


Figure 5. Profile and sketch of Study Route C.

21 following Study Route B to Beckley; thence over common Study Routes A and B to Common Point 6A — total length 106.91 mi.

West Virginia Turnpike

The turnpike begins at a point on US 60, 2.71 mi east of Common Point 1; thence southerly via Beckley, 86.8 mi to Common Point 6A west of Princeton.

The Turnpike represents the ultimate in a two-lane full controlled-access and grade separated facility in mountainous terrain.

Design Features

- 2 twelve-ft portland cement concrete traffic lanes throughout;
- 9-ft penetration macadam shoulders both sides;
- 25 miles of 12-ft creeper lanes;
- 6 miles of 4-lane dualization in present construction;
- 1 tunnel, ½ mile long;
- 60 mile per hour design speed;
- 5½ degree maximum curvature (1000 ft radius);
- 3 percent desirable maximum grade; and
- 5 percent actual maximum grade.

Interchanges

Princeton at mile	0.6
Beckley at mile	35.5
Mossy at mile	51.3
Chelyan at mile	75.5
Kanawha City at mile	85.2
Charleston at mile	86.5

The Turnpike follows generally the south side of the Kanawha River Valley to about Mile 15 and varies in rise and fall in ft per 100 ft from 0.52 to 2.27, average 1.77 (Table 3).

Study Routes A, B, and C are characterized by bad alignment, steep grades, inadequate sight distance, and roadside development.

Study Route B, between Control Points 1 and 5 (55.42 mi) follows the north side of the Kanawha River Valley to about Mile 37 and varies in rise and fall in ft

per 100 ft from 0.51 to 3.45, average 204 (Table 3).

Study Route A between Control Points 1 and 5 (77.94 mi) follows the south side of the Kanawha River Valley to about Mile 8 with an average rise and fall in ft per 100 ft of 1.34 (Table 3).

Study Route C, between Control Points 1 and 4 (48.4 mi) follows the south side of the Kanawha River Valley to about Mile 30 and varies in rise and fall in ft per 100 ft from 0.45 to 1.45, average 1.45 (Table 3).

The section between Control Points 5 and 6A (41.36 mi) is common to Study Routes A, B, and C, with an average rise and fall in ft per 100 ft of 3.11 (Table 3).

PASSENGER CAR STUDY

The before and after studies were made with a 1951 model passenger car equipped with recording instruments¹. The data collected were fuel consumption, speed and braking by speed groups and travel time.

Test Car Specifications

The pertinent specifications of the test car are listed:

Make and model	1951 Pontiac 6; 4-door sedan
Transmission	3-speed synchromesh
Weight: Front	1,920 lb
Rear	2,080 lb
Total	4,000 lb
Bore and stroke	3 9/16 x 4 in.
Piston displacement	239.2 cu in.
Compression ratio	6.5
Transmission ratios:	
1st	2.67 to 1
2nd	1.66 to 1
3rd	1 to 1
Rear axle ratio	4.10 to 1
Maximum gross horsepower	96 at 3,400 rpm

The following horsepower and torque data were taken from curves in the Manufacturer's Shop Manual:

Road Speed in 3rd Gear	Maximum Gross Horsepower	Maximum Gross Torque
mph		lb-ft
20	34	185
25	44	191
30	54	191
35	63	189
40	72	186
50	85	178
60	94	163
70	96	143
80	91	119

¹ Highway Research Board Bulletin 107

TABLE 1
SUMMARY OF AVERAGE COMPOSITE PERFORMANCE OF TEST PASSENGER CAR ON EACH SECTION OF THE TEST ROUTES

Study Route	Between Check Points	Length (mi)	Rise and Fall (total)	Rise and Fall (ft/100 ft)	Fuel Consumption (gal.)		Fuel Consumption (mpg)		Trip Time (sec.)		Composite Speed (mph)		
					1962	1955	1962	1955	1962	1955	1962	1955	
Turnpike	1-A	2.71			0.166		15.1		255			35.4	
	1A-1B	1.80			0.141		11.3		192			30.0 ^a	
	1B-7A	49.00	4,070	1.44	3.194		15.3		3,104			56.9 ^b	
	7A-6B	35.00	4,260	2.24	2.341		15.0		2,195			57.4 ^b	
	6B-6A	1.00			0.082		12.2		120			30.0 ^a	
	1B-6B	84.00	Attempted Speed 50 mph			4.967		16.9		6,016			50.3
	1B-6B		Attempted Speed 40 mph		4.645		18.1		7,348			41.1	
	Section Total	89.51	8,330	1.76	5.924		15.1		5,866			55.0	
A					5.356		16.7		6,583			49.0	
					5.034		17.8		7,915			40.7	
	1-8	7.73	105	0.26	0.447		17.3		847			32.9	
	8-7	65.89	4,750	1.38	3.753		17.5		6,199			38.3	
	7-5	4.32	640	2.81	0.310		13.9		674			23.1	
	5-6	38.19	6,500	3.23	2.286		15.4		3,921			24.5	
	6-6A	3.17	295	1.76	2.487		15.4		3,604			35.1	
						0.209		15.2		477			23.9
						7.216		16.5		11,692			35.4
	Section Total	119.30	12,290	1.95	6.958		16.5		12,118			35.4	
B	1-1A	2.51			0.166		15.1		255			35.4	
	1A-2	10.17	345	0.51	0.524		19.4		956			37.7	
	2-3	11.70	505	0.82	0.666		18.1		970			38.3	
	3-4	31.04	3,965	2.42	1.863		16.7		3,377			43.4	
	4-5	17.15	3,120	3.45	1.019		16.5		3,245			33.1	
	5-6A	41.36	6,795	3.11	2.495		15.3		1,772			34.8	
						2.696		16.6		4,398			33.9
						7.047		16.2		11,715			35.0
						0.480		18.0		847			32.9
	Section Total	113.93	14,730	2.45	6.733		16.2		11,406			35.0	
C	1-8	7.73	105	0.26	0.480		18.0		847			32.9	
	8-9A	5.03	195	0.68	0.286		17.6		556			32.6	
	9A-9	0.36			0.021		17.1		40			32.4	
	9-10	11.68	1,035	1.68	0.646		18.1		1,271			33.1	
	10-4	23.60	2,360	1.89	1.406		16.8		2,406			35.3	
	4-6A	58.51	9,915	3.21	3.514		16.7		6,157			34.2	
						6.303		17.0		11,277			34.1
	Section Total	106.91	13,610	2.41	6.303		17.0		11,277			34.1	

^a Includes delay at toll booth.
^b Attempted speed -- 60 mph.

TABLE 2
SUMMARY OF AVERAGE COMPOSITE PERFORMANCE OF TEST PASSENGER CAR ON EACH TEST ROUTE

Study Route	Length, miles	Rise and Fall, ft/100 ft	Fuel Consumption, gal.		Travel Time, hr.		Average Speed, mph.	
			1952	1955	1952	1955	1952	1955
Turnpike A B C	89.51	1.76	6.958	5.924	3:22	1:38	35.4	55.0*
	119.30	1.95	6.733	7.216	3:15	3:15	32.0	36.7
	113.93	2.45	6.303	7.047	3:08	3:10	34.1	36.0
	106.91	2.41		Not Run				

* Attempted speed 60 mph.

Test Procedures

Before Studies — (a) The same driver operated the test car throughout the studies. The field runs were made by Persun of the Bureau of Public Roads, using a Bureau car equipped with recording instrument.

(b) Three round trips were made over each section of Study Routes A, B, and C (Figure 1).

(c) Travel speed average test method. Trips were scheduled to provide as nearly similar operating conditions as to time and weather as practical, including one night trip over each section.

(d) An observer rode with the driver to record the instrument totals at each control point.

After Studies — (a) The same driver operated the test car throughout the studies. The field runs were made by Persun of the Bureau of Public Roads, using a Bureau car equipped with recording instrument.

(b) Three round trips were made on the turnpike by the attempted speed method at 60, 50, and 40 mph. One round trip was made over each section of Study Routes A and B. Due to instrument failure the runs were discontinued before Study Route C was re-run. However, it had already been determined that there was no significant change from the before studies.

STUDY RESULTS

The pertinent results from the studies are as follows:

Passenger Car

1. There was no significant change in the fuel consumption or total trip time on the two parallel free routes in the before and after studies. While the vehicle volume on the common southern section decreased from 3600 in the before study to 1900 in the after study, commercial vehicles (dual tired or larger) decreased from 654 to 238.

2. Fuel consumption in miles per gallon varied from 17.1 in 1952 to 16.5 in 1953, or 0.6 mpg on Study Route A; and from 16.9 in 1952 to 16.2 in 1955, or 0.6

TABLE 3
VEHICLE OPERATION CHARACTERISTICS STUDY
RISE AND FALL BY SECTIONS

Route	From	To	Length, mi	Rise, ft	Fall, ft	Total Rise and Fall, ft	Rise and Fall	
							ft per mi	ft per 100 ft
Turnpike	N end Kanawha City Br. Chelyan Interchange Beckley Interchange	Chelyan Interchange Beckley Interchange Jct. US 219	13.63	210	165	375	27.5	0.52
			40.40	2,640	1,055	3,695	91.5	1.73
			35.48	2,305	1,955	4,260	120.1	2.27
US 21	N end Kanawha City Br. Chelyan Bridge Jct. 6L, Oak Hill	Total Chelyan Bridge Jct. 6L, Oak Hill Jct. 3, Beckley	89.51	5,155	3,175	8,330	83.5	1.77
			12.68	200	145	345	27.2	0.51
			42.74	2,910	1,560	4,470	104.6	1.98
			17.15	1,660	1,460	3,120	181.9	3.45
US 21-219	Jct. 3, Beckley Jct. 219-21, Princeton	Total Jct. 219-21, Princeton Turnpike Signal	72.57	4,770	3,165	7,935	107.6	2.04
			38.19	3,865	3,135	6,500	170.2	3.23
			3.17	220	75	295	93.0	1.76
WVA 61	N end Kanawha City Br. Chelyan Turnpike Entr.	Total Chelyan Turnpike Entr. Jct. 21, Oak Hill	41.36	3,585	3,210	6,795	164.3	3.11
			12.76	155	145	300	23.5	0.45
			35.64	2,395	1,000	3,395	95.3	1.80
WVA 3	N end Kanawha City Br.	Total Jct. 21, Beckley (South)	48.40	2,550	1,145	3,695	76.4	1.45
			77.94	3,650	1,945	5,495	70.6	1.34

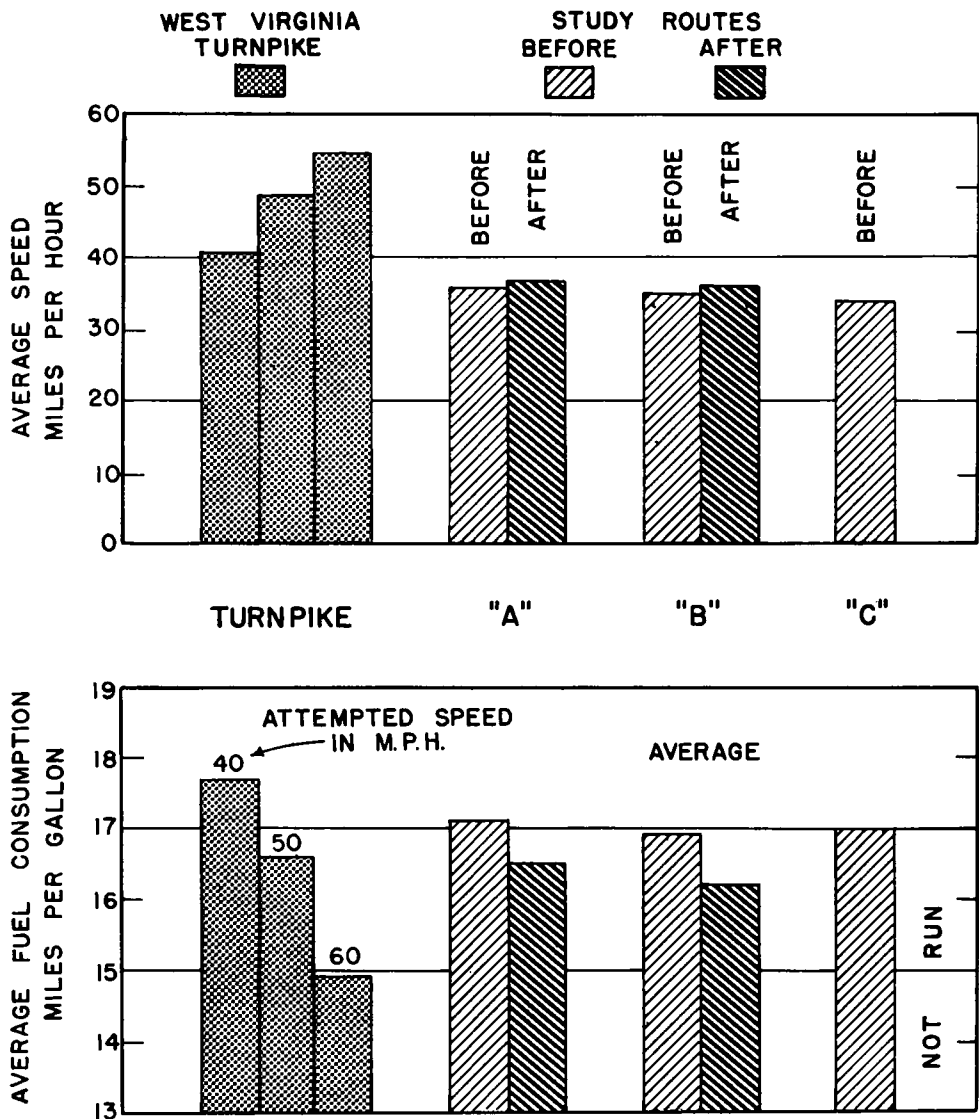


Figure 6. Fuel consumption and speed of 1951 Pontiac six sedan on the West Virginia Turnpike compared with that on Study Routes A, B, and C before and after opening of the turnpike.

mpg on Study Route B. The fuel consumption on Study Route C was 17.0 mpg in 1952 (Table 1, Figure 6).

3. The composite speed variation was within a range of 2.7 mph (34.1-36.7) for all study routes in both the before and after study.

4. Total fuel consumption in gallons in 1952 was 6.958 for Route A; 6.733 for Route B, and 6.303 for Route C; and

7.216 for Route A, and 7.047 for Route B in 1955 (Tables 1 and 2).

5. Route lengths: Route A — 119.30 mi, Route B — 113.93 mi, and Route C — 106.91 mi.

Comparative Results

1. There is an unusually large savings in mileage by use of the turnpike. There

is a savings of 29.7 mi over Study Route A; 24.4 mi over Study Route B, and 16.4 mi over Study Route C. The savings in mileage is principally on the valley terrain on the northern end.

2. The rate of fuel consumption per mile was greater on the turnpike at the 60 mph attempted speed than on any of the parallel routes. However, the fuel consumption per mile on the turnpike was slightly less at the 50 mph attempted speed than on the other two routes studied in 1955. The fuel consumption per mile was less on the turnpike at the 40 mph attempted speed than on any of the parallel routes in either 1952 or 1955.

3. The saving in mileage by use of the turnpike results in a composite trip saving in fuel consumption in gallons, at 60 mph attempted speed, of 1.29 gal. over Study Route A, and 1.12 gal. over Study Route B in the after study.

4. There was approximately a 50 percent saving in time by using the turnpike at an attempted speed of 60 mph, in the after study, including delay at the toll booth.

5. Comparative results of an analysis by speed groups of a 30.0-mi section of the turnpike between Control Points 7A and 6B, and a 38.19-mi section of US 21 between Control Points 5 and 6 (common to Study Routes A, B, and C) are shown in Figures 7 and 8.

6. The results of similar tests² with the same passenger car operated over five pairs of test routes are reported in "Operating Characteristics of a Passenger Car on Selected Routes," contained in Highway Research Board Bulletin 107. The composite fuel consumption for several attempted speeds was related to the rate of rise and fall in Figure 30 of that report. It is significant that the rate of fuel consumption in miles per gallon read from Figure 30 for the rate of rise and fall of the West Virginia Turnpike (1.76) closely approximates the actual composite consumption. The actual was 17.8, 16.7 and 15.1 mpg for attempted speeds of 40, 50, and 60 mph, respectively.

Comparable values read from Figure 30 are 18.5, 16.8, and 15.0 mpg.

On the parallel major highways the actual consumption was 17.1 mpg on Route A, 16.9 mpg on Route B, and 17.0 mpg on Route C. Since an appreciable portion of the travel time on these routes was spent in the 47 to 56 mph group, and less than one percent of the time in a higher speed group, due to the design speed of the highway, an attempted speed of at least 50 mph is assumed. Using the 50 mph curve in Figure 30, the respective rates of fuel consumption for Routes A, B, and C would be 16.7, 16.3, and 16.4 mpg, which compare closely with the actual rates. The comparisons just described tend to substantiate the validity of the West Virginia study.

TRUCK STUDY

The purpose of the truck study was to measure some factors that affect the economics of truck operation over the West Virginia Turnpike and the parallel free highways.

The data collected were fuel consumption, number of gear changes, time spent in each gear, and total travel time.

Test Vehicle Specifications

- (a) GVW — 52,000 lb (cinder blocks)
- (b) Make and model truck tractor — Mack B-61T
- (c) Type of fuel — diesel (No. 2 fuel)
- (d) Displacement 672 cu in.
- (e) Gross HP — 170 @ 2100 rpm
- (f) Net HP — 159 @ 200 rpm
- (g) Tire size — 10.00x22 (12 ply)
- (h) Semi-trailer — 33 ft., tandem axle, Freuhauf Van
- (i) Rear axle gear ratio — 5.74
- (j) Weight-horsepower ratio 327
- (k) Transmission

<i>High Range</i>	<i>Low Range</i>
5th-0.79	1.09
4th-1.00	1.39
3rd-1.92	2.67
2nd-3.64	5.06
1st-6.74	9.37

² Comments by Carl C. Saal, Chief, Vehicle Operation Branch, B.P.R.

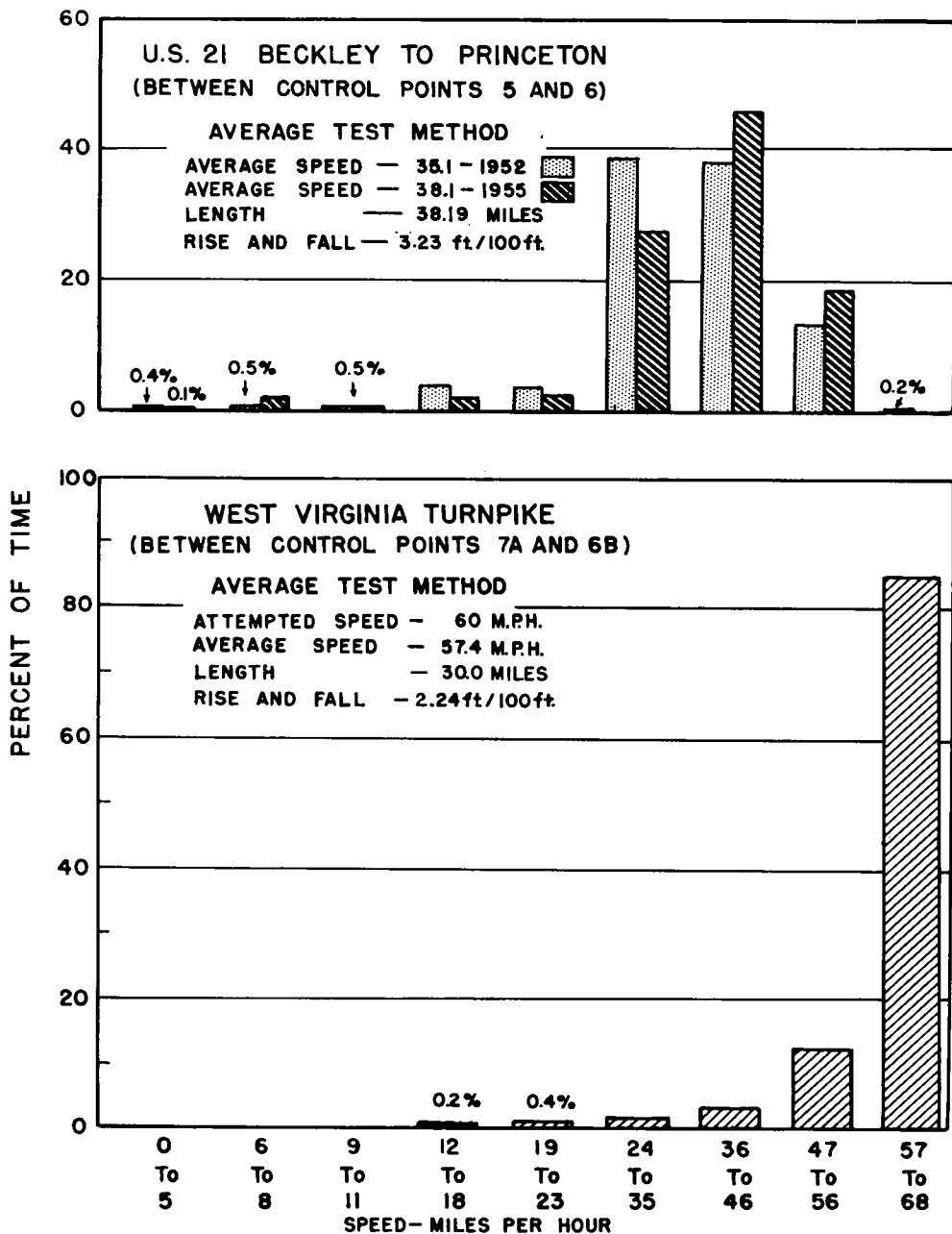


Figure 7. Time distribution by speed groups southern section of West Virginia Turnpike and US. 21.

FUEL CONSUMPTION

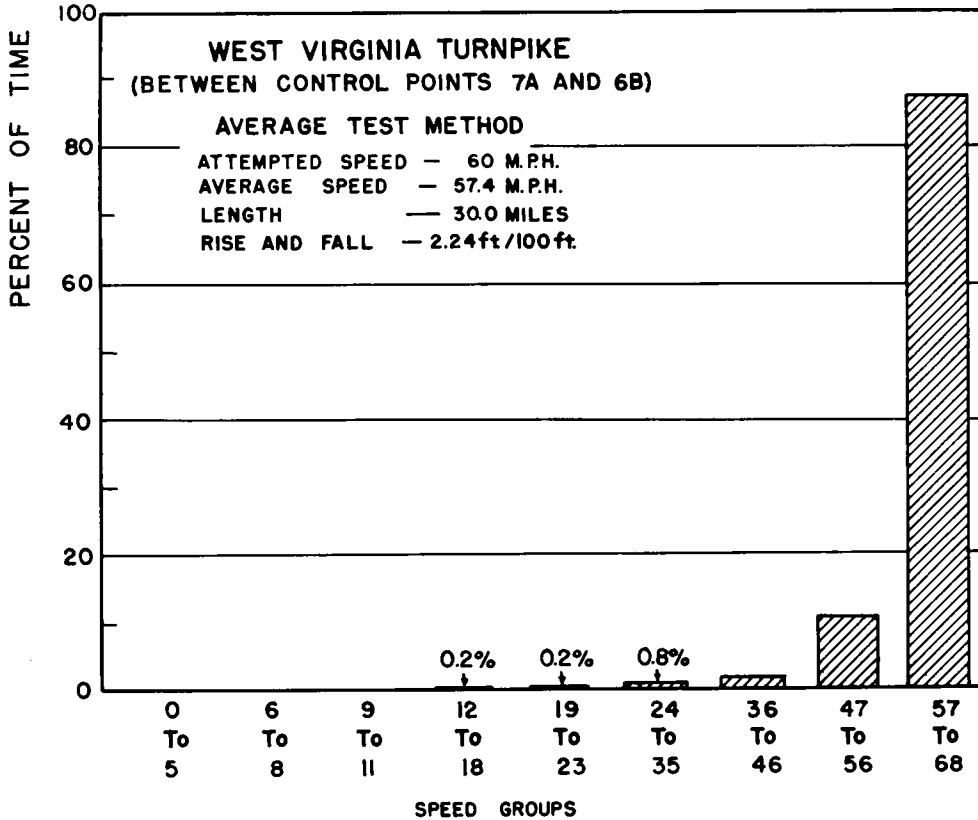
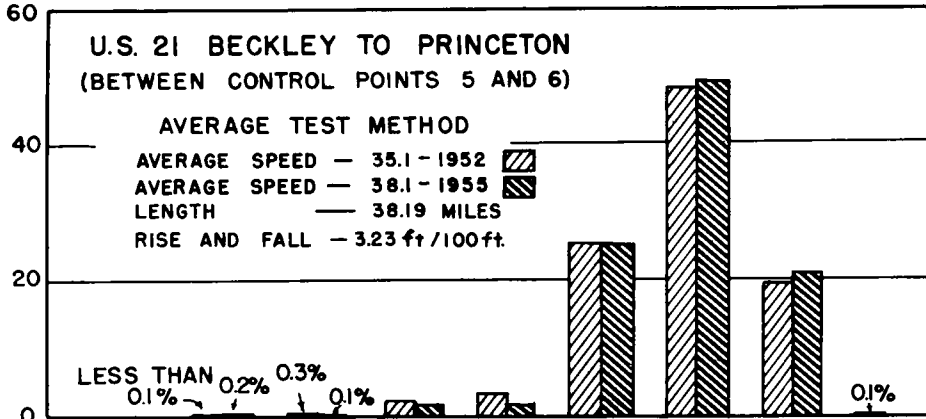


Figure 8. Fuel distribution by speed groups southern section of West Virginia Turnpike and US 21.

AVERAGE TEST METHOD

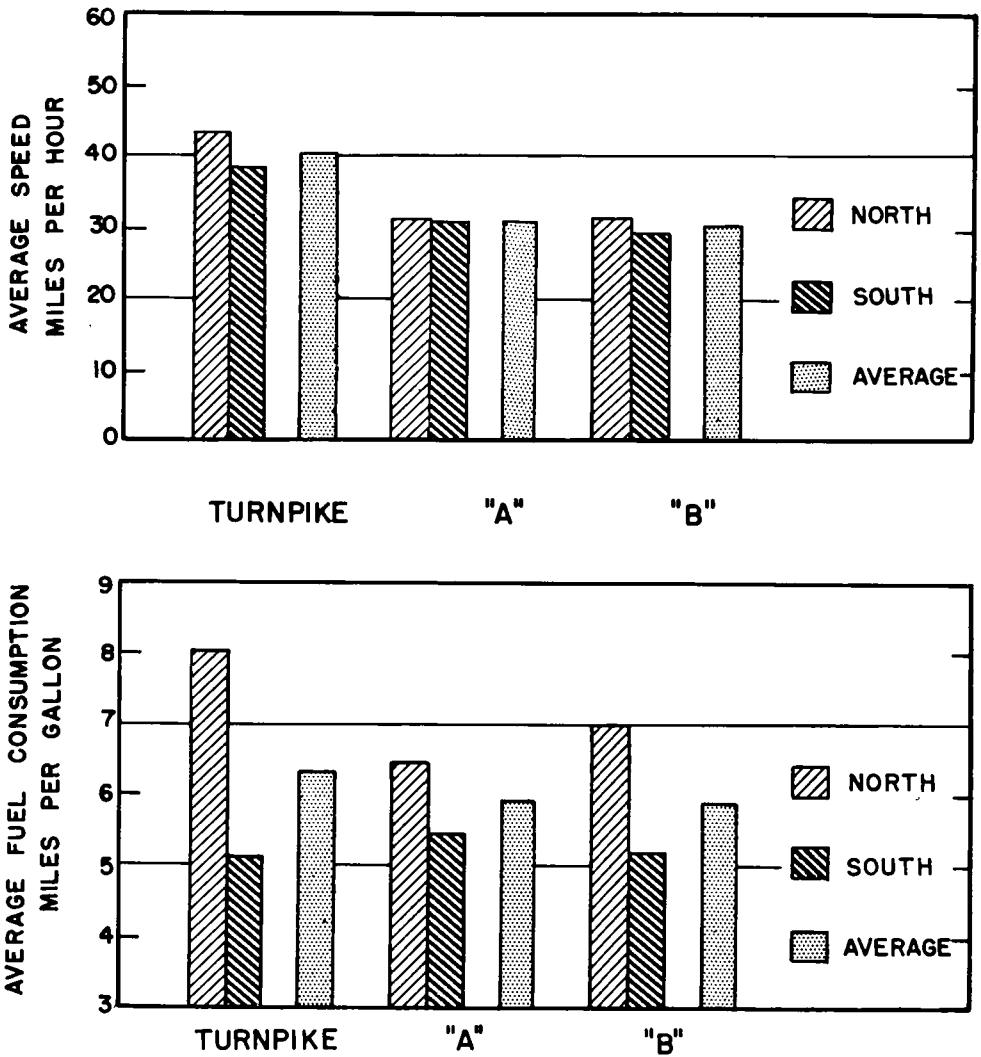


Figure 9. Directional and average fuel consumption and speed of truck on West Virginia Turnpike compared with Routes A and B.

Study Procedures

(a) The same driver operated the test vehicle throughout the study. He was a regular driver of Bell Lines, Inc., thoroughly familiar with the routes, and was instructed to drive in his normal manner in keeping with the speed limits

in effect on the study routes and under safe control on down grades.

(b) A minimum of three round trips were made over each study route. An extra round trip was made over the first route operated (turnpike) after the completion of the tests to measure any possible change in the performance of the

TABLE 4
1955 TRUCK STUDY ON W. VA. TURNPIKE AND ALTERNATE ROUTES: PERFORMANCE OF TEST TRUCK ON EACH TEST ROUTE

Study Route	Tape No.	Route	Direction	Starting Time	Miles Traveled	Fuel Consumption (gal.)	Mi/Gal.	Travel Time (min)
TPKE.	1	Tpke.	South	12:55 P	(179.0	27.9	6.4	143
	2		North	3:29 P	(127
	11		South	8:30 A	(179.0	27.9	6.4	141
	12		North	12:05 P	(123
	17*		South	8:10 P	(179.0	28.3	6.3	137
	18*		North	11:00 P	(123
	25		South	8:42 A	89.5	17.6	5.1	141
	26		North	12:05 P	89.5	11.2	8.0	124
A	9	US 119- W VA 3- US 21 & 219	South	8:53 A	(238.6	40.5	5.9	230
	10		North	1:37 P	(231	
	15		South	8:19 A	119.3	22.0	5.4	231
	16		North	12:27 P	119.3	18.6	6.4	233
	21*		South	8:20 P	238.6	40.4	5.9	228
	22*		North	12:30 A				218
B	3	US 21 & 219	South	8:45 A	(227.8	39.3	5.8	238
	4		North	1:50 P	(221	
	19*		South	8:11 P	(227.8	38.6	5.9	223
	20*		North	12:22 A	(200
	23		South	8:09 A	(113.9	21.7	5.2	240
24	North	12:55 P	(113.9	17.0	7.0	223		
C†	5	US 119- W VA 61- US 21 & 219	South	8:43 A	(96.8	16.3	5.9	103
	6		North	11:00 A	(97	
	7		South	1:55 P	(96.8	16.1	6.0	109
	8		North	3:53 P	(93
	13*		South	2:25 A	(96.8	15.5	6.2	93
	14*		North	3:58 A	(82
	27		South	8:45 A	48.4	9.4	5.1	104
28	North	11:10 A	48.4	6.1	7.9	95		

* Night Runs.
† Kanawha City Bridge to Oak Hill.

vehicle during the period of the study and to compare the performance by direction. An extra run was also made over W. Va. 61 for comparison of fuel consumption by direction.

(c) Trips were scheduled to provide as nearly similar operating conditions as to time and weather as practical, including one night trip over each route.

(d) An observer rode in the cab of the truck-tractor to do the recording and operate the speed and delay timer.

(e) The observer obtained the time spent in each gear ratio by use of speed and delay timer. The keys were coded as follows:

- Key No. 1 — HR 5th
- Key No. 2 — HR 4th
- Key No. 3 — HR 3rd
- Key No. 4 — HR 2nd
- Key No. 5 — HR 1st
- Key No. 6 — LR 5th
- Key No. 7 — LR 4th
- Key No. 8 — LR 3rd
- Key No. 9 — LR 2nd

- Key No. 10 — LR 1st
- Key No. 11 — Control Points
- Key No. 12 — Delay Enroute

The timer printed on a standard adding machine tape in .01 of a minute the total elapsed time between printings and printed on identifying key number. The keys could be selected or changed until the print key was pressed. Thus, by printing the identifying gear key and accumulated time for successive gear changes the total elapsed time was computed. The timer lost about .03 of a minute during the print cycle and the results were adjusted accordingly.

(f) Fuel point was always at same pump and spot location. The truck was refueled after each round trip and the amount of fuel recorded on the data sheet.

(g) A profile of each route was obtained by altimeter and rise and fall computed for each control section.

Fuel consumption was originally to be obtained by use of a fuel meter. Due to

1956 TRUCK STUDY ON W. VA. TURNPIKE AND ALTERNATE ROUTES

Study Route	Tape No.	Route	Direction	Actual Time Spent in Gear Shown									
				1	2	3	4	5*	1	2	3	4	5
TPKE.	1	Tpke.	South	—	1.04	Low Range	20.04	—	—	1.09	High Range	34.43	55.64
	2		North	—	0.25	15.06	7.59	—	—	0.35	8.58	17.64	75.18
	11		South	—	0.13	16.71	21.00	—	—	0.96	16.89	35.76	49.77
	12		North	—	0.34	15.98	6.63	—	—	0.21	8.38	13.97	77.39
	17†		South	—	—	11.30	20.15	—	—	0.72	16.73	35.33	52.82
	18†		North	—	0.18	14.54	8.19	—	—	0.19	8.52	17.02	74.16
A	9	US 119 W VA 3 US 21 & 219	South	—	5.34	17.57	46.87	—	0.11	21.90	21.67	89.28	27.02
	10		North	—	7.33	10.22	39.59	—	1.32	23.12	16.95	96.26	35.79
	15		South	—	5.69	17.24	46.00	—	0.11	17.43	20.61	101.80	21.63
	16		North	—	8.02	10.34	39.47	—	0.11	23.50	16.97	87.73	46.90
	21†		South	—	2.82	16.97	45.84	—	0.11	17.70	22.50	100.06	21.87
	22†		North	—	7.60	11.48	31.80	—	0.46	21.63	11.42	76.22	57.70
B	3	US 21 & 219	South	—	9.33	22.32	39.88	—	0.10	27.79	29.37	89.40	19.37
	4		North	—	5.10	12.86	34.99	—	—	22.89	21.43	92.84	31.16
	19†		South	—	2.19	18.78	41.43	—	—	23.53	31.23	78.40	27.27
	20†		North	—	6.42	10.20	29.32	—	—	17.95	18.03	70.33	48.17
	23		South	—	2.37	20.90	50.69	—	—	32.30	31.60	90.37	12.13
	24		North	—	7.59	12.81	37.62	—	—	22.30	23.50	86.89	31.91
C	5	US 119- W VA 61- US 21 & 219	South	—	9.27	21.35	65.22	—	0.11	20.12	32.35	68.32	16.62
	6		North	—	7.19	16.36	49.98	—	0.11	18.43	26.76	79.15	21.22
	7		South	—	5.86	23.67	72.35	—	0.11	24.41	36.22	61.15	15.18
	8		North	—	8.34	13.81	51.64	—	0.11	19.50	23.64	70.31	33.22
	13†		South	—	3.42	19.06	52.65	—	0.11	13.57	29.41	66.43	25.22
	14†		North	—	8.13	10.13	37.17	—	0.11	15.18	21.92	68.64	40.35

* Note: Plate on truck to the effect that 5th gear low range is not to be used.

† Night runs.

the fact that a fuel meter could not be used on the diesel powered truck, the survey was modified to show the over-all round trip fuel consumption rather than at selected check points, as was done in the passenger car study. The truck was loaded with fuel at the Bell Lines pumps, and pumps tested, so as to provide approximately 5 to 10 gal. more fuel than was required for a particular trip. The tank was drained and measured at the end of the trip. The measuring was done in standard measures furnished by the State Department of Labor, Weights and Measures Department.

STUDY RESULTS

The pertinent results from the Truck Studies are as follows:

1. Fuel consumption was less on the turnpike than the other study routes. Average fuel consumption miles per gallon was turnpike, 6.3; Route A, 5.9; Route B, 5.9, and Route C (part), 6.1. The corresponding total round trip gallons were turnpike, 28.2; Route A, 40.5; and Route B, 38.9 (Figure 6, Table 4).

Fuel consumption by direction was taken for one trip on each route. The consumption was greater in the southbound direction for all study routes. This is in line with a total over-all rise of about 2,000 ft in the southbound direction.

2. Travel time was less on the turnpike than the other study routes. Directional travel time was not appreciably affected by the over-all rise in the southbound direction.

Directional and average speeds were greater on the turnpike than the other study routes. Average speeds in miles per hour were turnpike, 40.6; Route A, 31.3; and Route B, 30.6 (Figure 9, Table 4).

3. The data from the gear change study is shown in Table 5 and Figures 10, 11, and 12. The turnpike shows the greater percent of time in 5th gear high with about 67 percent of the total travel time in 5th and 4th gear high range. The total gear changes on the turnpike were less than half the total of the other study routes. The total gear changes in the

LE 5
TRAVEL TIME AND GEAR CHANGE FOR TEST TRUCK

Percent of Trip Time Spent in Gear										Total Travel Time	Number of Gear Changes	
1	2	3	4	5	1	2	3	4	5			
		Low Range					High Range					
—	0.7	10.6	14.1	—	—	0.8	10.7	24.1	39.0	142.62	161	
—	0.2	13.9	6.0	—	—	0.3	6.7	13.9	59.0	127.19	95	
—	0.1	11.8	14.9	—	—	0.7	12.0	25.3	35.2	141.24	149	
—	0.3	13.0	5.4	—	—	0.2	6.8	11.4	62.9	122.90	81	
—	—	8.2	14.7	—	—	0.5	12.2	25.8	38.6	137.05	139	
—	0.1	11.8	6.7	—	—	0.2	6.9	13.9	60.4	122.74	84	
—	2.3	7.6	20.4	—	0.1	9.5	9.4	38.9	11.8	229.76	348	
—	3.2	4.4	17.2	—	0.6	10.0	7.4	41.7	15.5	230.58	255	
—	2.5	7.5	20.0	—	0.5	7.6	8.9	44.2	9.4	230.51	275	
—	3.4	4.4	16.9	—	0.5	10.1	7.3	37.6	20.1	233.04	265	
—	1.2	7.4	20.1	—	0.5	7.8	9.9	43.9	9.6	227.81	278	
—	3.5	5.3	14.6	—	0.2	9.9	5.2	34.9	26.5	218.37	212	
—	3.9	9.4	16.8	—	—	11.7	12.4	37.6	8.2	237.56	394	
—	2.3	5.8	15.8	—	—	10.3	9.7	42.0	14.1	221.27	260	
—	1.0	8.4	18.6	—	—	10.5	14.0	35.2	12.3	223.03	300	
—	3.2	5.1	14.6	—	—	9.0	9.0	35.1	24.0	200.42	212	
—	1.0	8.7	21.0	—	—	13.4	13.1	37.7	5.1	240.36	327	
—	3.4	5.8	16.9	—	—	10.0	10.6	39.0	14.3	222.62	267	
—	4.0	9.1	27.9	—	0.1	8.6	13.9	29.3	7.1	233.36	391	
—	3.3	7.4	22.8	—	0.1	8.4	12.2	36.1	9.7	219.20	297	
—	2.5	9.9	30.2	—	0.1	10.2	15.2	25.6	6.3	238.92	382	
—	3.8	6.3	23.4	—	0.1	8.8	10.7	31.9	15.0	220.57	284	
—	1.6	9.1	25.1	—	0.1	6.5	14.0	31.6	12.0	209.87	307	
—	4.0	5.0	18.4	—	0.1	7.5	10.9	34.1	20.0	201.67	229	

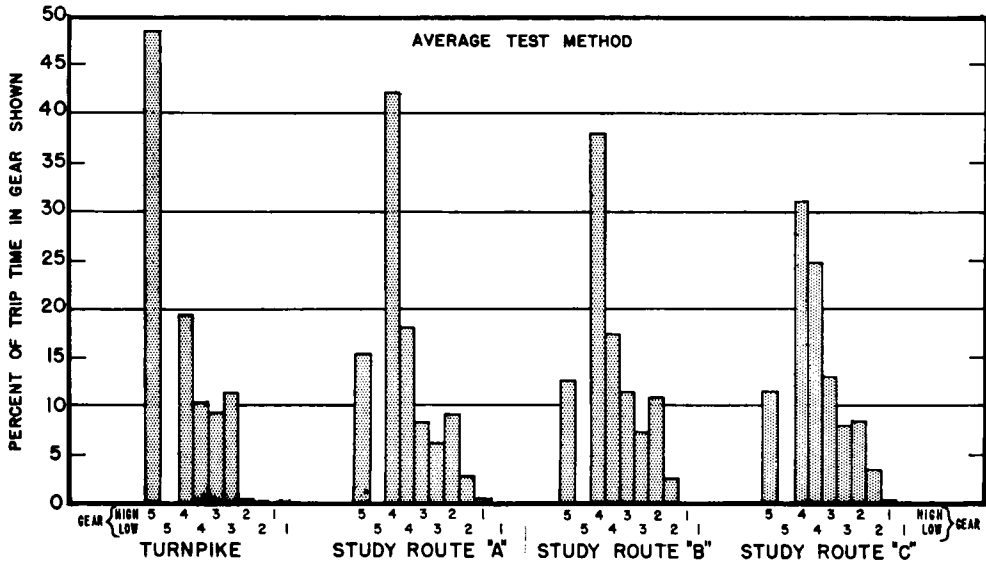


Figure 10. Time distribution by truck gears for all Study Routes.

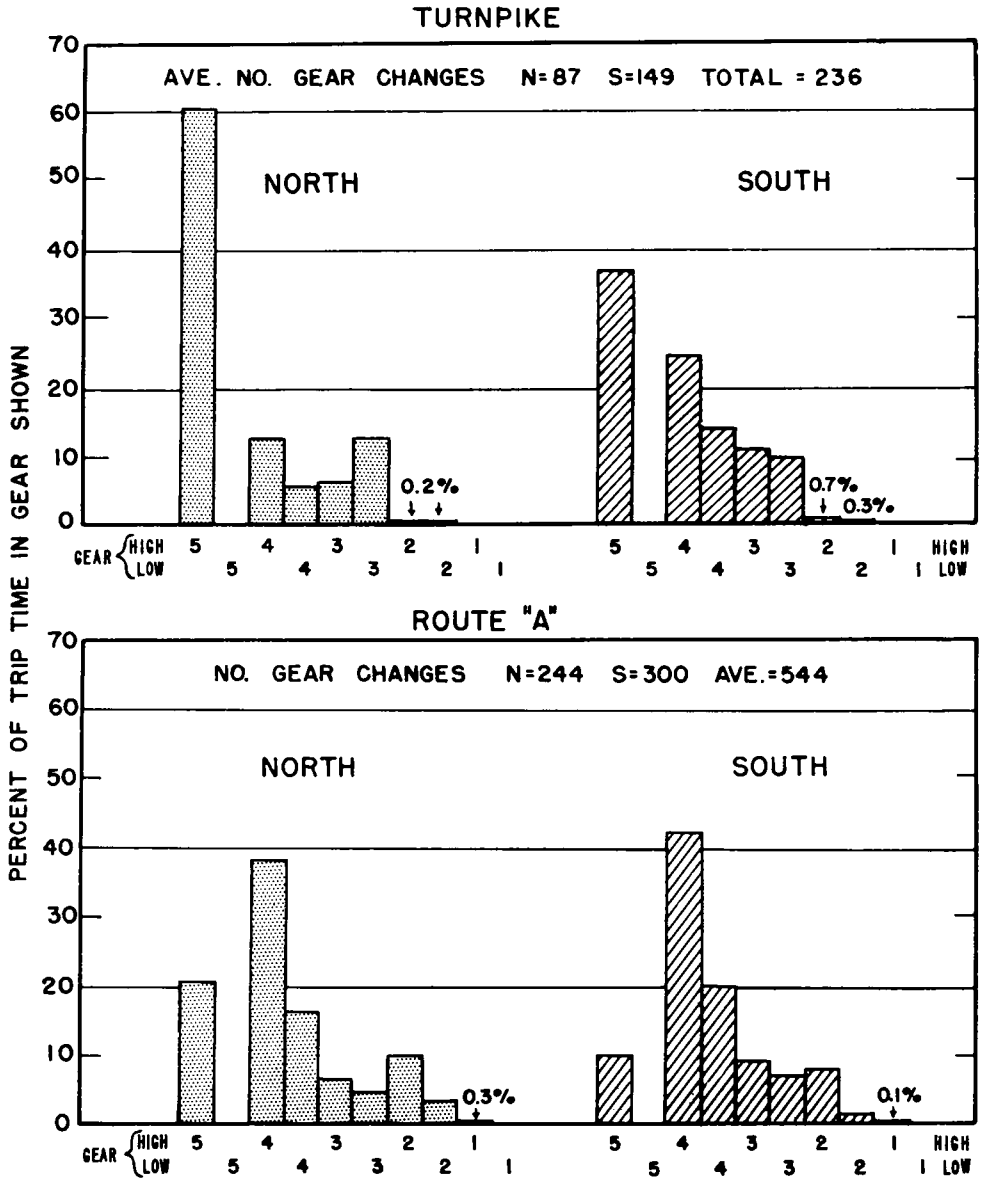


Figure 11. Directional time distribution by truck gears on West Virginia Turnpike and Route A.

southbound direction were greater on all the study routes.

4. In HRB Research Report 9-A there was established a rather definite relationship between gasoline consumption and the rate of rise and fall for a given gross vehicle weight and between travel time and the rate of rise and fall for a

given weight-horsepower ratio³. Although results were obtained in this study for only one vehicle, one weight, and one driver, it is interesting to note in Table 6 that the diesel consumption and travel time did tend to increase with the rate

³ Comments by Carl C. Saal, Chief, Vehicle Operations Branch, Bureau of Public Roads.

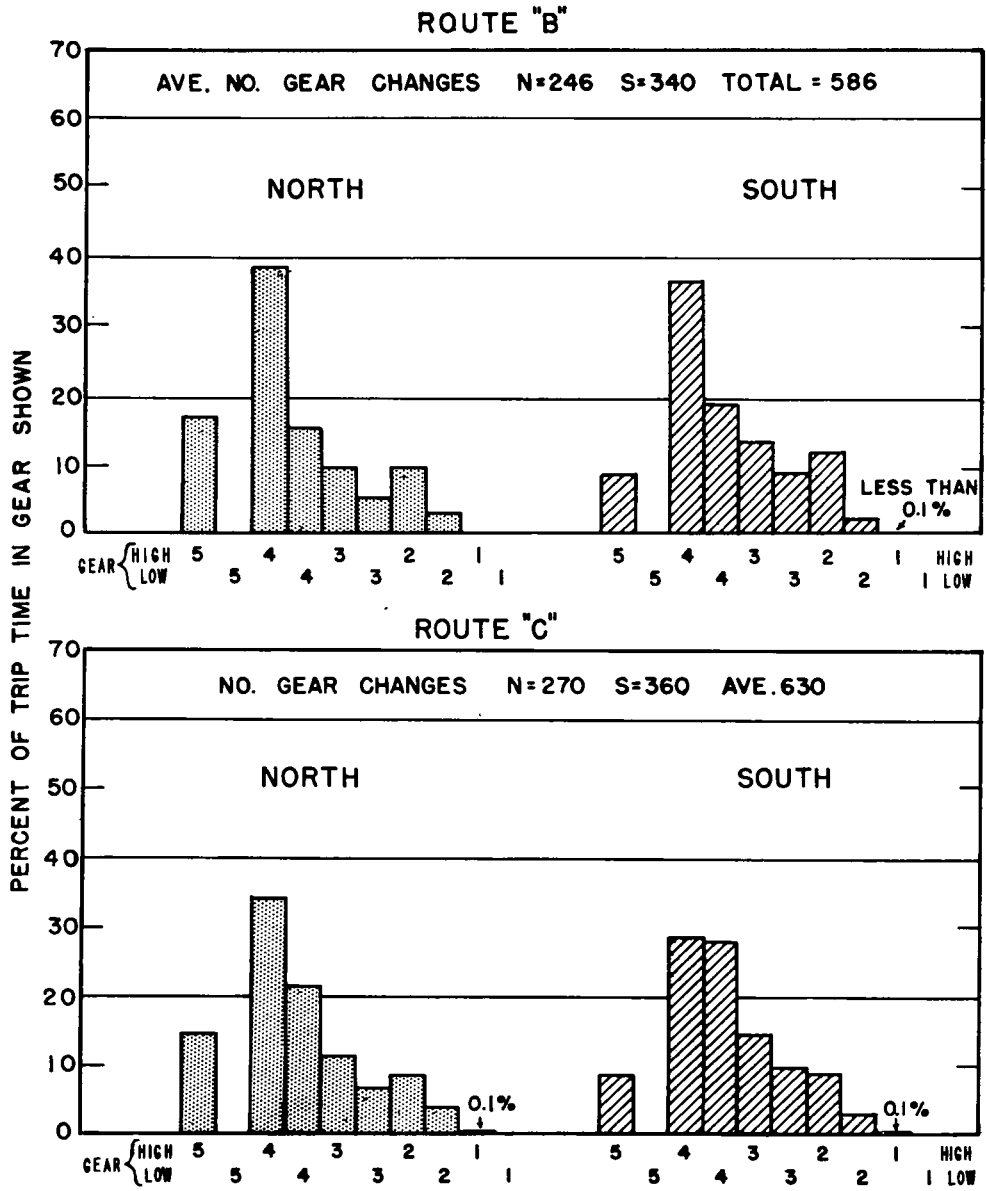


Figure 12. Directional time distribution by truck gears on Routes B and C.

of rise and fall. Since the variation is slight, if any, between Routes A and B, it may be argued that the difference between the turnpike and the alternate routes is due to difference in design factors, particularly that of curvature. In any case the difference could not be ex-

pected to be great in view of the small variation in rise and fall between the three routes.

It is significant in the case of fuel consumption that the percentage of the fuel for a round trip used southbound compared closely with the percentage of

TABLE 6
 VARIATION OF DIESEL CONSUMPTION AND TRAVEL TIME WITH RISE AND FALL

Route	Rise and Fall		Diesel Consumption		Travel Time	
	Rate (ft/100 ft)	Rate South- bound, percent	Composite, gpm	Percent South- bound	Composite, mpm	Percent South- bound
TP	1.76	62	0.157	61	1.48	53
A	1.95	58	0.170	54	1.91	50
B	2.45	57	0.171	56	1.97	52

TABLE 7
 DIESEL CONSUMPTION AND TRAVEL TIME COMPARED WITH ESTIMATED GASOLINE
 CONSUMPTION AND TRAVEL TIME

Route	Rise & Fall Rate (ft/100 ft)	Fuel Consumption			Travel Time		
		Diesel, gpm	Gasoline ^a , gpm	Ratio ^b , percent	Diesel, mpm	Gasoline ^c , mpm	Ratio ^c
TP	1.76	0.16	0.26	62	1.5	1.6	94
A	1.95	0.17	0.27	63	1.9	1.7	112
B	2.45	0.17	0.29	59	2.0	1.9	105

^a From Figure 8, HRB Research Report 9A, 1950 for gross weight of 52,000 pounds.

^b Ratio of diesel to gasoline.

^c From Figure 23, HRB Research Report 9A, 1950 for a weight-horsepower ratio of 327.

the total rise and fall that was rise in that direction. The fact that the rise was greater southbound did not appreciably affect the directional travel time.

In the absence of reliable data for diesel consumption, it has been rather common practice to estimate the gasoline rate of consumption for the given weight and multiply that rate by a factor of about 0.60 to obtain the diesel consumption. The actual diesel consumption rates and the estimated gasoline rates, both in gallons per mile, are compared in Table 7. It is seen that the diesel and gasoline consumption closely approximates the planning factor of 0.60.

Also included in Table 7 is the estimated travel time in minutes per mile which was determined by interpolating

the results shown in Figure 23 of HRB Research Report No. 9-A. Theoretically, there should not be much difference in the performance of a diesel or gasoline engine if the same relation between weight and power is maintained. Considering the many uncontrollable factors that affect travel time, particularly driver behavior, the difference between the actual and the estimated is most reasonable.

The results in Table 7 tend to prove the basic relations established in Research Report 9-A. They also lend some credence to the use of that report for estimating diesel consumption. However, more data are required before the correct relation between diesel and gasoline consumption can be established.