

# A Study of Factors Influencing Traffic Speeds

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The over-all objectives of the research project were (a) to evaluate the effectiveness of speed limits established by present practices and (b) to develop new or more substantial criteria for the establishment of speed zones. The results of the first phase of the research were reported previously. This report covers the second phase of the research and deals specifically with an evaluation of factors influencing the drivers' selection of speed

The first part deals with a study of factors that influence traffic speeds in areas of transition from rural to urban conditions. Two study techniques were used to measure speeds in transition areas: (a) measurement of the average speed of each vehicle through each of several sectors of the transition zone, and (b) continuous measurement of the speed of a test car through the transition zone. The studies pointed up several roadway and development characteristics that influenced traffic speeds, including horizontal and vertical curves, sight distance, changes in roadway cross-section, commercial development, and appearance of residential development.

Several studies involving 12- and 24-hr speed observations were conducted to determine the influence of changing traffic conditions on traffic speeds. These studies showed that speeds were subject to only minor variations during the hours of normal traffic operation

Other studies were concerned with the influence of radar enforcement operations on traffic speeds. These studies showed that enforcement operations caused appreciable speed reductions, but the influence did not extend beyond four miles on either side of the enforcement unit.

• IN 1958 THE TEXAS Transportation Institute initiated a research project aimed at providing data for the development of new or more substantial criteria for the establishment of speed zones. The project, which was sponsored by the Texas Highway Department, was conducted in two phases. The first phase consisted of an evaluation of the effectiveness of speed limits established on the basis of 85-percentile speeds. The results of the first phase have been reported previously (1)

In the first phase of the research project, comparative before-and-after studies were conducted in 186 spot speed study locations to determine the effect of speed limit signs on traffic speeds. This large number of studies permitted an analysis of data for conditions when the speed limits were changed from 60 down to 30 mph, and from 30 up to 55 mph in increments of 5 mph. The results of this study indicated that speed limit signs actually had very little influence on the drivers' choice of speed. Figure 1 shows results typical of the study. The only notable influence on traffic speeds was a slight decrease in the over-all dispersion of traffic speeds. A summary of the results is given in Table 1.

These findings should not be construed to mean that speed zoning serves no worthwhile purpose. Speed zoning is necessary to provide the needed flexibility in the

general speed laws, so that traffic speeds can legally conform to the desirable operational characteristics of the roadway.

This report covers the second phase of the research which dealt with an evaluation of factors influencing the drivers' selection of speed.

The speed of an individual vehicle is subject to considerable variation throughout a given section of roadway. This is particularly true if the section of roadway is in an area of transition from rural to urban conditions. The factors causing the variation in speed are innumerable. They may be physical or psychological; tangible or intangible. However, it is presupposed that variations or changes in the speed of a vehicle are functions of the driver's evaluation of the existing conditions ahead.

Most of the tangible or measurable factors can be categorized into three basic groups: (a) roadway geometrics, (b) characteristics of development, and (c) traffic conditions. In transition from rural to urban conditions these factors rarely occur independently, but rather in complex combinations. Also, successive occurrences of the various factors involved cause speed changes to occur almost continuously throughout the transition area.

In the second phase of the research, studies were conducted to evaluate the specific factors influencing individual speeds in transition areas (rural to urban). In the studies, primary consideration was given to geometric and roadside development characteristics. The influence of traffic conditions was reduced as much as possible by selecting free-flow vehicles for the main consideration in the analysis.

The influence of traffic conditions was given greater consideration in additional studies conducted to determine the variations in traffic speeds throughout the day. These studies consisted of evaluation of all speeds during 12- and 24-hr speed observations on three different types of roadways.

Studies were also conducted to evaluate the influence of radar enforcement practices on traffic speeds. These studies were made to determine the effects of enforcement on

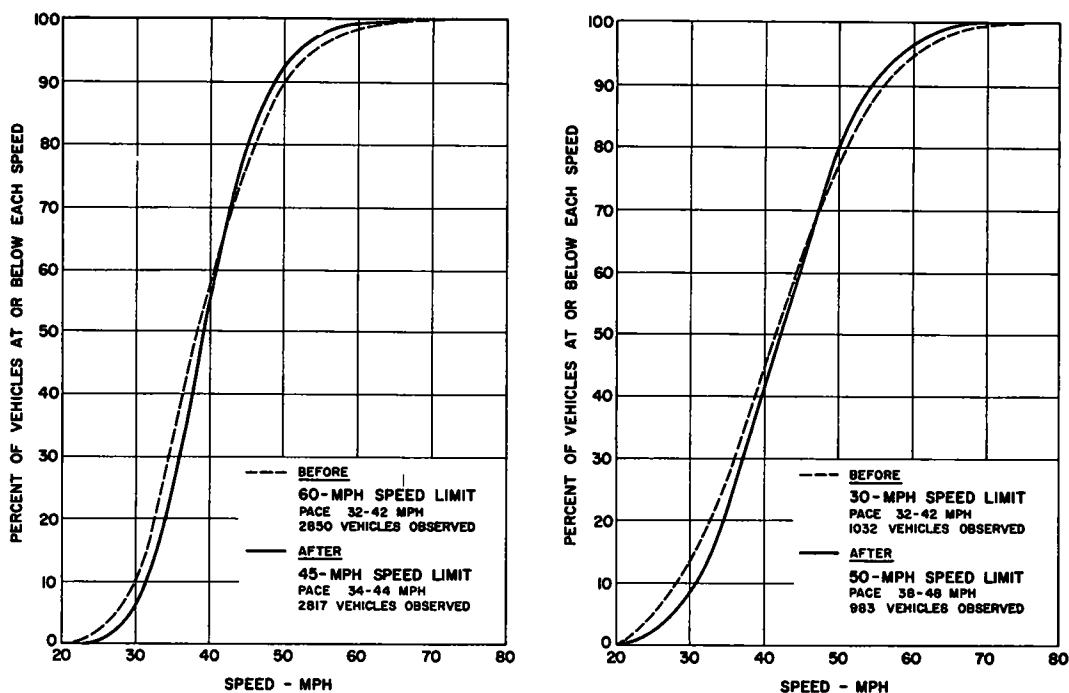


Figure 1. Typical speed distribution curves for before-and-after conditions of speed zoning.

traffic speed in the immediate vicinity of the radar unit and the distance along the roadway to which the influence extended.

### FACTORS IN TRANSITION AREAS

In an effort to identify various influencing factors and evaluate their effects, studies were conducted in several transition areas where significant speed changes occurred. Two study techniques were used:

1. Individual vehicle speed study method.—Measurement of the average speed of each individual vehicle through each of several control sections or sectors of the transition zone.

2. Test car method.—Continuous measurement of the speed of selected drivers in a test car for several trips through the transition zone.

### Study Locations

The major problems of speed zoning in Texas have been encountered in the transition sections to small towns on two-lane highways. For this reason, five study locations were selected to provide a good representation of the various conditions normally encountered. Table 2 summarizes very briefly the general characteristics of each of the five study locations. The study sections were approximately one mile in length.

TABLE 1  
RESULTS OF BEFORE-AND-AFTER STUDIES TO DETERMINE EFFECT OF POSTED SPEED LIMITS ON TRAFFIC SPEEDS

District	Speed Limit (mph)		No of Vehicles	Speed (mph)				Pace (mph)	Std Dev (mph)	
	Before	After		85-Percent	15-Percent	Differential	Average			
12 (Houston)	60	-	1,518	59.4	42.0	17.4	51.68	48-58	8.61	
	-	60	1,564	58.7	41.7	17.0	51.33	48-58	8.62	
	60	-	2,783	55.5	37.5	18.0	47.33	40-50	8.77	
	-	55	3,099	55.0	38.3	16.7	47.62	42-52	8.06	
	60	-	2,930	53.7	35.5	18.2	45.64	38-48	8.80	
	-	50	2,976	52.0	35.1	16.9	44.54	38-48	7.92	
	60	-	2,850	47.3	31.2	16.1	40.27	32-42	8.00	
	-	45	2,817	46.4	32.6	13.8	40.59	34-44	6.93	
	60	-	524	41.5	28.3	13.2	35.74	28-38	6.21	
	-	40	481	39.9	28.5	11.4	35.41	30-40	5.56	
	60	-	1,807	40.2	25.6	14.6	33.70	26-36	7.30	
	-	35	2,052	38.9	24.3	14.6	32.77	26-36	7.27	
	60	-	531	31.2	21.3	9.9	27.53	22-32	4.98	
	-	30	571	33.2	23.3	9.9	29.23	22-32	4.83	
	1 (Paris)	60	-	5,452	57.0	33.8	23.2	46.22	40-50	10.90
		-	60	4,902	56.6	35.0	21.6	46.85	40-50	10.09
60		-	407	55.2	35.1	20.1	45.55	38-48	9.09	
-		55	614	51.2	33.5	17.7	43.86	40-50	8.62	
60		-	2,611	51.5	29.3	22.2	41.74	32-42	10.45	
-		50	2,010	50.9	30.7	20.2	42.06	38-48	10.09	
60		-	954	47.6	23.4	24.2	36.72	24-34	11.41	
-		45	658	43.9	26.3	17.6	36.07	28-38	8.21	
60		-	431	40.4	22.8	17.6	33.17	28-38	8.57	
-		40	338	38.6	24.7	13.9	32.98	28-38	6.64	
30		-	4,584	53.2	30.7	22.5	26.83	38-48	7.10	
-		55	3,596	50.5	33.5	17.0	27.99	38-48	6.96	
30		-	1,103	52.6	30.4	22.2	30.18	32-42	7.19	
-		50	832	51.3	32.5	18.8	31.41	38-48	7.51	
30		-	4,742	45.4	28.1	17.3	33.68	30-40	7.97	
-		45	4,156	45.2	28.8	16.4	34.61	32-42	8.12	
30		-	2,678	40.3	24.4	15.9	37.50	28-38	8.25	
-		40	2,165	42.0	25.2	16.8	37.89	28-38	7.91	
30		-	1,032	36.8	21.4	15.4	42.64	24-34	10.61	
-		35	983	38.4	23.0	15.4	42.97	24-34	9.06	
30		-	322	33.5	18.3	15.2	43.33	20-30	10.77	
-		30	400	34.1	19.5	14.6	43.22	22-32	7.96	

TABLE 2  
GENERAL DESCRIPTION OF STUDY LOCATIONS

Study No.	Location (town)	Hwy. No.	Road Class.	Predom. Develop.	Study Section Length (ft)	No. of Sectors	ADT <sup>a</sup>	Pop. <sup>b</sup>
I	Waller	US 290	Primary <sup>c</sup>	Commer.	4,958	6	5,940	1,000
II	Madisonville	Texas 21	Secondary	Resid.	6,585	7	1,330	3,000
III	Cameron	US 77	Primary	Mixed	5,898	5	2,200	5,052
IV	Bremond	Texas 6	Primary	Mixed	5,492	9	1,980	1,141
V	Oakwood	US 79	Primary	Commer. and Resid. (segregated)	5,978	8	1,600	759

<sup>a</sup>Rural, within 4 mi of city limits.

<sup>b</sup>1960 census.

<sup>c</sup>Truck route.

The ADT values on these roadways ranged from 1,330 to 5,940 vehicles per day. Development in the study sections ranged from predominantly residential to predominantly commercial. The geographic location of the study sites is shown in Figure 2.

A number of variables were eliminated or controlled through careful selection of study sites. Care was exercised to avoid roadway sections that contained the following:

1. Traffic signals or control devices other than flashing amber beacons.
2. Horizontal and vertical curves that severely limited traffic speeds.
3. Major intersections presenting complex traffic problems.
4. Serious pavement surface irregularities.

In general, an attempt was made to select study sections in which the factors affecting vehicle speeds could be categorized into roadway geometrics, development characteristics, and traffic conditions.

### Study Methods

**Individual Vehicle Speed Study Method.**—A comprehensive survey was used to collect traffic data in each of the study locations. The survey consisted of four components: (a) measurement of individual vehicle speeds throughout various sectors of the study section, (b) concurrent measurement of individual vehicle speeds in an adjacent rural section, (c) observation of all passing, turning, or crossing traffic, and (d) a study of the development and roadway geometrics in the study section.

To develop a profile of individual vehicle speeds through the transition zone, the section of roadway selected for study was divided into control sections, referred to as sectors. The limits of these sectors were determined by changes in development and by physical changes in the roadway geometry. The average speed of each vehicle was measured through each of the designated sectors.

An event recorder was used in the measurement of individual vehicle speeds in the urban areas. This recorder (a 20-pen ink-type recorder) was used with a series of road tubes and air switches to measure the time required for a vehicle to travel the length of each of the sectors. To measure the time increments, the road tubes and air switches were placed at the limits of each of the sectors, as shown in Figure 3. By means of field telephone cable each air switch was connected to a pre-selected pen in the 20-pen recorder. As a vehicle passed through the study section, a "blip" was recorded by each corresponding pen as the vehicle crossed each of the road tubes. Because the chart in the recorder moved at a constant, predetermined speed, the distance between successive "blips" was proportional to the time required for the vehicle to travel between the road tubes. An example of the chart record is also shown in Figure 3.

To identify the direction in which the vehicles were traveling, two different road tube arrangements were used. The arrangement most commonly used resembled the

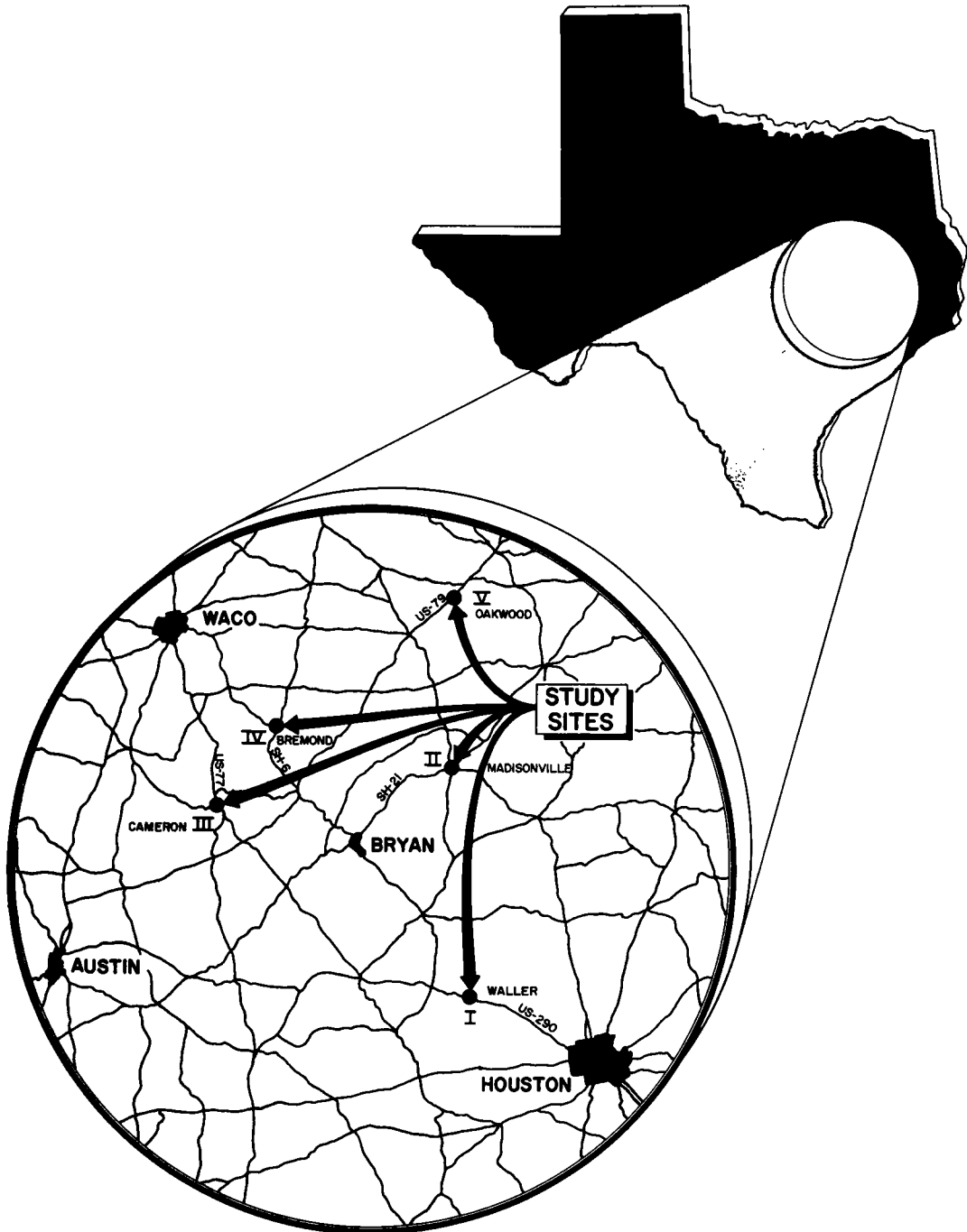


Figure 2. Location of study sites.

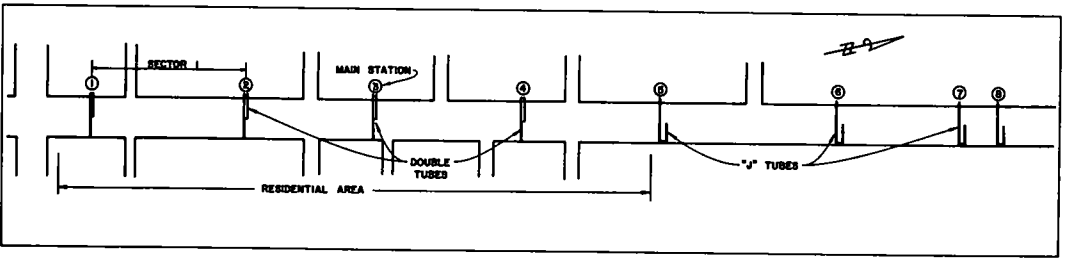
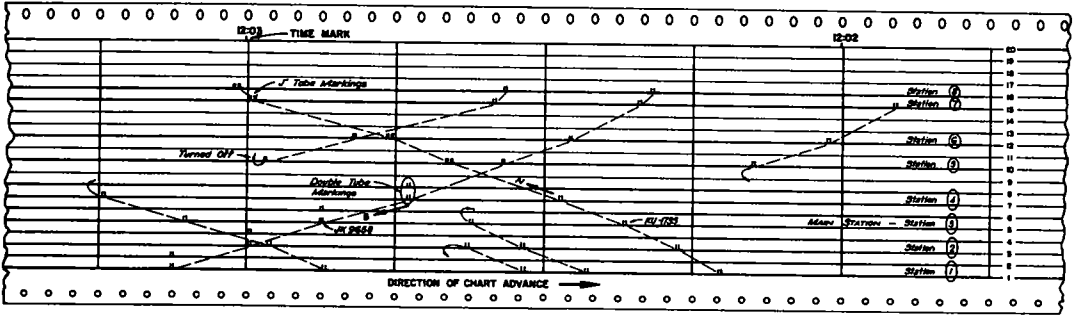


Figure 3. Example of 20-pen recorder chart resulting from road tubes located as shown at study site.

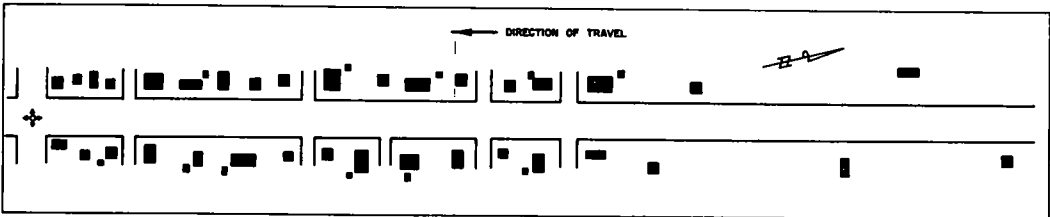
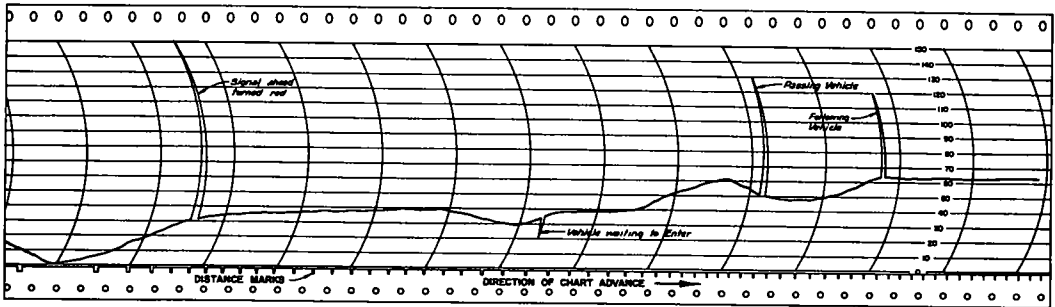


Figure 4. Example of recording speedometer chart and study site comparison.

letter "J" as shown in Figure 3. To form this arrangement, the road tube was extended from the centerline to one edge of the pavement, then along the pavement edge for approximately 15 ft (about  $1\frac{1}{2}$  times the normal wheelbase of a passenger car), and then across both lanes to the air switch. This arrangement provided two "blips" on the chart for 2-axle vehicles in one direction and four "blips" for 2-axle vehicles traveling in the other direction.

A more positive means of simultaneously indicating direction of travel and identifying vehicles with three or more axles was provided by the double road tube arrangement, also shown in Figure 3. In this system, two road tubes were placed side by side and connected to two separate air switches. One of the tubes extended only to the centerline of the roadway. Vehicles traveling in one direction crossed the long road tube and actuated one pen in the recorder, whereas vehicles traveling in the opposite direction crossed both road tubes and simultaneously actuated two pens in the recorder. With this arrangement, the number of "blips" in a group on the chart always represented the actual number of axles of the vehicles.

At a station near the center of the study area each vehicle was identified by its license number and the direction of travel as it crossed one of the double road tube arrangements. The information was recorded on a portable voice recorder in chronological order. In addition, frequent time indications were recorded on the voice

TABLE 3  
COMPARISON OF COMMERCIAL WITH ALL FREE-FLOW VEHICLE SPEEDS

Study	Sector	Northbound-Outbound				Southbound-Inbound			
		Commercial		Free-Flow		Commercial		Free-Flow	
		No of Veh	Avg Speed (mph)	No of Veh.	Avg Speed (mph)	No of Veh	Avg. Speed (mph)	No of Veh	Avg Speed (mph)
I	1	15	47 0	51	39.4	6	42 3	27	46 2
	2	15	39 5	51	37 6	6	37 3	27	40 2
	3	15	35 7	51	33 4	6	33.2	27	38 4
	4	15	34 3	51	34 6	6	32.7	27	37 6
	5	15	37 8	51	38 7	6	34 9	27	41.0
	6	15	38 6	51	47 0	6	38 4	27	44 9
II	1	19	27 0	159	32 6	12	34.5	143	35 6
	2	19	33 1	159	37 7	12	38 3	143	38 5
	3	19	33 5	159	38 2	12	39 6	143	41.5
	4	19	34 3	159	40 2	12	41 0	143	43.0
	5	19	36.4	159	40 6	12	40 6	143	42 6
	6	19	39.6	159	45.5	12	42 3	143	44.4
	7	19	38.9	159	45.1	12	45 8	143	46.5
III	1	8	28.9	140	30.9	12	30 6	140	32 6
	2	8	29 3	140	31 4	12	30.4	140	32 2
	3	8	31 5	140	33.5	12	35.7	140	35 1
	4	8	33.4	140	37 3	12	39.7	140	40.4
	5	8	36 7	140	42.6	12	40.8	140	42 9
IV	1	14	25.3	100	32 7	24	30 9	112	33.8
	2	14	31 7	100	37 1	24	35 7	112	37.2
	3	14	35 0	100	39 2	24	39.0	112	39.2
	4	14	38.9	100	43 9	24	46.1	112	45.8
	5	14	39.4	100	43 9	24	44.4	112	45 7
	6	14	44.6	100	47 6	24	49.8	112	51 0
	7	14	44.0	100	48 0	24	50 0	112	53.5
	8	14	43.3	100	48.8	24	53.5	112	55.4
	9	14	43.2	100	49.9	24	51.6	112	55.1
V	1	17	45.7	127	51 5	19	37 2	171	43 6
	2	17	42.6	127	47.4	19	38 5	171	44.5
	3	17	37 2	127	40 1	19	35.2	171	38.2
	4	17	33 0	127	33 8	19	32.0	171	32.8
	5	17	36.5	127	38 7	19	36 8	171	39.2
	6	17	39.4	127	44.8	19	43 0	171	47.1
	7	17	41.6	127	48 1	19	45.7	171	54 0
	8	17	42 4	127	49 5	19	47 5	171	56.1

TABLE 4  
SPEED CHARACTERISTICS OF SECTORS IN STUDY SECTION I

Sector	Characteristic	Northbound			Southbound		
		All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
1	No. veh	205	129	51	111	81	27
	Speed (mph):						
	Avg.	39.9	40.1	39.4	43.8	45.0	46.2
	85-percent.	47.5	48.0	47.0	48.5	52.5	56.5
	15-percent.	31.0	32.5	31.5	34.5	36.0	35.5
	Diff.	16.5	15.5	15.5	14.0	16.5	21.0
	Pace (mph)	33-43	33-43	33-43	39-49	39-49	35-45
Std. dev. (mph)	8.86	8.07	8.30	7.15	7.56	8.98	
2	No. veh.	236	129	51	129	81	27
	Speed (mph):						
	Avg.	35.6	37.4	37.6	38.5	37.9	40.2
	85-percent.	41.0	42.0	44.0	43.5	44.5	52.0
	15-percent.	28.0	31.0	30.0	31.0	29.0	31.0
	Diff.	13.0	11.0	14.0	12.5	15.5	21.0
	Pace (mph)	29-39	33-43	33-43	31-41	33-43	31-41
Std. dev. (mph)	6.45	5.90	6.69	7.14	7.82	8.75	
3	No. veh.	220	129	51	116	81	27
	Speed (mph):						
	Avg.	31.6	33.0	33.4	34.4	35.1	38.4
	85-percent.	36.0	37.0	38.5	39.5	40.0	46.5
	15-percent.	25.0	27.0	27.0	26.5	28.5	28.0
	Diff.	11.0	10.0	11.5	13.0	11.5	18.0
	Pace (mph)	27-37	27-37	27-37	29-39	29-39	29-39
Std. dev. (mph)	6.14	5.91	6.30	7.01	7.97	11.11	
4	No. veh	210	129	51	120	81	27
	Speed (mph):						
	Avg.	32.3	32.7	34.6	33.3	35.9	37.6
	85-percent.	37.5	37.5	39.0	38.0	40.5	42.0
	15-percent.	25.5	26.0	28.0	27.0	28.0	28.5
	Diff.	12.0	11.5	11.0	11.0	12.5	13.5
	Pace (mph)	25-35	27-37	31-41	27-37	31-41	31-41
Std. dev. (mph)	6.40	6.10	6.59	6.60	6.49	7.78	
5	No. veh	225	129	51	120	81	27
	Speed (mph):						
	Avg.	36.8	37.9	38.7	36.9	39.9	41.0
	85-percent.	42.0	43.5	44.0	42.5	43.5	46.5
	15-percent.	29.0	29.5	31.0	29.0	32.5	31.5
	Diff.	13.0	14.0	13.0	13.5	11.0	15.0
	Pace (mph)	31-41	35-45	35-45	33-43	33-43	35-45
Std. dev. (mph)	7.06	6.76	6.66	7.42	7.04	9.06	
6	No. veh.	230	129	51	137	81	27
	Speed (mph):						
	Avg.	45.9	47.2	47.0	43.3	43.9	44.9
	85-percent.	51.5	52.0	52.5	50.0	49.5	53.5
	15-percent.	38.0	39.0	38.5	34.5	35.6	35.6
	Diff.	13.5	13.0	14.0	15.5	13.9	17.9
	Pace (mph)	41-51	41-51	41-51	37-47	39-49	39-49
Std. dev. (mph)	7.04	6.74	6.80	7.69	7.06	8.77	



TABLE 5  
SPEED CHARACTERISTICS OF SECTORS IN STUDY SECTION II

Sector	Characteristic	Outbound			Inbound		
		All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
1	No. veh.	422	237	159	374	219	143
	Speed (mph)						
	Avg.	33.0	32.6	32.6	34.8	35.0	35.6
	85-percent.	39.0	39.0	38.5	40.0	40.0	41.0
	15-percent.	24.5	24.0	24.0	27.0	27.5	28.0
	Diff.	14.5	15.0	14.5	13.0	12.5	13.0
	Pace (mph)	27-37	27-37	27-37	31-41	29-39	29-39
	Std. dev. (mph)	7.62	7.41	7.25	7.40	7.61	7.75
2	No. veh.	347	237	159	323	219	143
	Speed (mph)						
	Avg.	37.0	37.4	37.7	38.0	38.8	38.5
	85-percent.	44.5	45.0	43.0	44.0	44.0	45.0
	15-percent.	28.0	28.0	29.0	30.0	31.0	30.5
	Diff.	16.5	17.0	14.0	14.0	13.0	14.5
	Pace (mph)	31-41	31-41	31-41	31-41	33-43	33-43
	Std. dev. (mph)	8.22	8.11	7.62	7.47	6.67	6.77
3	No. veh.	355	237	159	315	219	143
	Speed (mph)						
	Avg.	38.1	38.0	38.2	40.0	41.4	41.5
	85-percent.	47.0	47.0	46.0	47.5	49.0	49.5
	15-percent.	27.5	28.5	29.5	30.0	31.5	31.0
	Diff.	19.5	18.5	16.5	17.5	17.5	18.5
	Pace (mph)	31-41	33-43	31-41	35-45	35-45	35-45
	Std. dev. (mph)	9.32	9.22	8.30	8.91	8.30	8.54
4	No. veh.	377	237	159	303	219	143
	Speed (mph)						
	Avg.	39.5	39.8	40.2	41.8	43.0	43.0
	85-percent.	47.5	48.0	47.5	49.0	50.0	50.0
	15-percent.	30.0	30.0	31.0	32.5	34.5	34.0
	Diff.	17.5	18.0	16.5	16.5	15.5	16.0
	Pace (mph)	33-43	35-45	35-45	37-47	37-47	37-47
	Std. dev. (mph)	8.96	9.12	8.58	8.41	7.75	7.60
5	No. veh.	274	237	159	262	219	143
	Speed (mph)						
	Avg.	39.8	40.2	40.6	41.3	42.1	42.6
	85-percent.	47.5	48.0	48.5	49.0	49.5	50.0
	15-percent.	30.0	30.5	31.0	31.5	32.0	33.0
	Diff.	17.5	17.5	17.5	17.5	17.5	17.0
	Pace (mph)	35-45	35-45	35-45	35-45	35-45	35-45
	Std. dev. (mph)	9.26	8.81	8.85	8.98	8.32	8.15
6	No. veh.	280	237	159	261	219	143
	Speed (mph)						
	Avg.	43.8	45.1	45.5	43.5	44.7	44.4
	85-percent.	53.5	54.0	54.5	53.5	53.5	54.0
	15-percent.	32.0	34.0	34.5	32.5	34.0	34.5
	Diff.	21.5	20.0	20.0	21.0	19.5	19.5
	Pace (mph)	39-49	39-49	41-51	41-51	41-51	37-47
	Std. dev. (mph)	10.83	10.52	10.64	10.26	9.37	9.10
7	No. veh.	271	237	159	248	219	143
	Speed (mph)						
	Avg.	43.8	44.5	45.1	46.0	46.8	46.5
	85-percent.	52.0	52.5	53.0	54.5	55.0	55.5
	15-percent.	33.0	34.0	35.0	35.5	36.5	36.0
	Diff.	19.0	18.5	18.0	19.0	18.5	19.5
	Pace (mph)	41-51	41-51	41-51	43-53	43-53	43-53
	Std. dev. (mph)	9.79	9.78	9.25	9.72	9.30	9.76

recorder and the event recorder simultaneously to facilitate later identification of vehicles.

To record turning, crossing, and passing movements in each sector, a sufficient number of observers were stationed at vantage points throughout the study section. All entrance, exit, and passing maneuvers were recorded as to the exact time of occurrence to facilitate later interpretation of the 20-pen recorder charts.

A development or land-use survey was conducted at each study location. From the survey, strip maps were prepared showing roadway dimensions, driveway and building locations, the size and use of the buildings, and the type and extent of access to the main roadway.

This method of measuring vehicle speeds was subject to certain limitations. The study method could only be used satisfactorily on two-lane roadways. The increased freedom to maneuver on multi-lane facilities would make it almost impossible to trace

TABLE 6  
SPEED CHARACTERISTICS OF SECTORS IN STUDY SECTION III

Sector	Characteristic	Outbound			Inbound		
		All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
1	No. veh.	469	208	140	344	200	140
	Speed (mph):						
	Avg.	30.4	30.9	30.9	31.2	32.2	32.6
	85-percent.	35.5	35.0	35.0	35.5	36.0	37.0
	15-percent.	24.5	25.0	25.5	25.5	26.5	27.0
	Diff.	11.0	10.0	9.5	10.0	9.5	10.0
	Pace (mph)	25-35	27-37	27-37	25-35	25-35	27-37
Std. dev. (mph)	5.57	5.72	5.03	5.34	5.14	5.11	
2	No. veh.	422	208	140	321	200	140
	Speed (mph):						
	Avg.	31.2	31.1	31.4	31.2	31.6	32.2
	85-percent.	35.5	35.0	35.5	35.0	36.0	36.5
	15-percent.	24.0	24.5	25.0	25.0	25.0	25.5
	Diff.	11.5	10.5	10.5	10.0	11.0	11.0
	Pace (mph)	25-35	29-39	27-37	25-35	25-35	25-35
Std. dev. (mph)	6.41	5.96	5.97	5.65	5.92	5.41	
3	No. veh.	350	208	140	269	200	140
	Speed (mph):						
	Avg.	32.8	32.7	33.5	34.3	35.0	35.1
	85-percent.	37.5	37.5	38.5	39.5	39.5	39.0
	15-percent.	26.5	26.5	27.0	27.5	28.0	29.0
	Diff.	11.0	11.0	11.5	12.0	11.5	10.0
	Pace (mph)	27-37	27-37	27-37	29-39	29-39	29-39
Std. dev. (mph)	7.02	6.35	5.39	7.04	6.06	5.79	
4	No. veh.	360	208	140	281	200	140
	Speed (mph):						
	Avg.	36.3	36.5	37.3	39.3	40.1	40.4
	85-percent.	42.0	42.0	43.0	46.5	46.0	46.0
	15-percent.	29.0	28.5	29.5	30.5	33.0	33.5
	Diff.	13.0	13.5	13.5	16.0	13.0	12.5
	Pace (mph)	29-39	33-43	33-43	35-45	35-45	35-45
Std. dev. (mph)	6.66	6.86	7.00	7.61	6.81	6.48	
5	No. veh.	268	208	140	250	200	140
	Speed (mph):						
	Avg.	41.0	41.2	42.6	44.0	43.3	42.9
	85-percent.	49.0	49.0	50.5	51.0	49.5	49.5
	15-percent.	33.0	33.0	34.0	34.5	35.0	34.5
	Diff.	16.0	16.0	16.5	16.5	14.5	15.0
	Pace (mph)	33-43	33-43	37-47	39-49	39-49	37-47
Std. dev. (mph)	7.92	8.22	7.93	9.10	7.57	7.59	

TABLE 7  
SPEED CHARACTERISTICS OF SECTORS IN STUDY SECTION IV

Sector	Characteristic	Outbound			Inbound		
		All Veh	Through Vehicles	Free-Flow Vehicles	All Veh	Through Vehicles	Free-Flow Vehicles
1	No veh	204	128	100	237	161	112
	Speed (mph)						
	Avg	30.6	32.1	32.7	32.2	33.2	33.8
	85-percent	37.5	38.5	39.0	36.5	38.0	38.5
	15-percent	22.0	23.5	24.0	25.5	26.5	27.0
	Diff	15.5	15.0	15.0	11.0	11.5	11.5
	Pace (mph)	25-35	27-37	31-41	27-37	27-37	27-37
	Std dev (mph)	7.61	7.10	7.16	6.84	6.07	5.74
2	No veh	237	128	100	246	161	112
	Speed (mph)						
	Avg	34.6	36.9	37.1	35.0	36.7	37.2
	85-percent	41.5	43.0	43.0	40.5	42.0	42.5
	15-percent	26.0	29.0	29.0	27.5	29.0	29.5
	Diff	15.5	14.0	14.0	13.0	13.0	13.0
	Pace (mph)	29-39	31-41	31-41	29-39	29-39	33-43
	Std dev (mph)	7.86	8.01	7.92	6.80	6.43	6.36
3	No veh	246	128	100	273	161	112
	Speed (mph)						
	Avg	35.4	38.9	39.2	36.0	38.8	39.2
	85-percent	43.0	44.5	45.0	42.5	44.0	44.0
	15-percent	26.5	30.5	30.5	28.5	31.0	31.5
	Diff	16.5	14.0	14.5	14.0	13.0	12.5
	Pace (mph)	29-39	37-47	37-47	29-39	33-43	33-43
	Std dev (mph)	8.02	7.01	6.95	7.14	6.33	6.34
4	No veh	208	128	100	243	161	112
	Speed (mph)						
	Avg	41.6	43.5	43.9	42.1	44.3	45.8
	85-percent	49.0	50.5	50.5	50.0	50.5	51.5
	15-percent	31.5	33.5	33.5	32.5	35.5	37.0
	Diff	17.5	17.0	17.0	17.5	15.0	14.5
	Pace (mph)	37-47	39-49	37-47	37-47	39-49	43-53
	Std dev (mph)	8.56	8.12	8.29	8.61	7.94	7.53
5	No veh	174	128	100	209	161	122
	Speed (mph)						
	Avg	42.3	43.2	43.9	43.5	44.2	45.7
	85-percent	49.0	49.0	49.5	49.5	49.0	50.0
	15-percent	34.5	34.5	35.0	35.5	36.0	37.0
	Diff	14.5	14.5	14.5	14.0	13.0	13.0
	Pace (mph)	39-49	41-51	41-51	41-51	41-51	41-51
	Std dev (mph)	7.66	7.55	7.71	8.90	8.61	7.78
6	No veh	179	128	100	225	161	112
	Speed (mph)						
	Avg	48.0	47.4	47.6	48.5	50.3	51.0
	85-percent	54.5	54.5	55.0	55.5	57.0	57.5
	15-percent	36.0	38.5	38.5	39.5	41.0	41.5
	Diff	18.5	16.0	16.5	16.0	16.0	16.0
	Pace (mph)	43-53	43-53	43-53	41-51	45-55	45-55
	Std dev (mph)	8.99	8.20	8.57	8.35	7.77	8.09
7	No veh	177	128	100	215	161	112
	Speed (mph)						
	Avg	46.9	48.3	48.0	51.3	53.0	53.5
	85-percent	55.5	55.0	54.0	60.0	61.0	61.5
	15-percent	37.0	38.5	38.0	42.0	44.0	43.5
	Diff	18.5	16.5	16.0	18.0	17.0	18.0
	Pace (mph)	45-55	45-55	45-55	45-55	45-55	47-57
	Std dev (mph)	9.34	8.53	8.34	8.29	8.19	8.84
8	No veh	176	128	100	215	161	112
	Speed (mph)						
	Avg	48.1	47.6	48.8	52.8	54.2	55.4
	85-percent	56.5	55.5	57.0	61.0	62.5	63.0
	15-percent	37.0	36.5	37.5	43.5	44.0	44.0
	Diff	19.5	19.0	19.5	17.5	18.5	19.0
	Pace (mph)	45-55	43-53	45-55	47-57	47-57	49-59
	Std dev (mph)	9.70	9.58	9.28	8.61	8.44	9.06
9	No veh	172	128	100	214	161	112
	Speed (mph)						
	Avg	49.3	49.8	49.9	53.2	54.3	55.1
	85-percent	58.0	58.0	58.0	62.0	64.0	64.0
	15-percent	38.0	37.5	37.5	43.5	44.5	44.5
	Diff	20.0	20.5	20.5	18.5	19.5	19.5
	Pace (mph)	47-57	47-57	49-59	45-55	45-55	49-59
	Std dev (mph)	10.02	9.84	9.90	8.61	9.00	9.65

a vehicle through the study section, and the greater density which is usually present on this type of facility would further complicate the procedure.

In order that a direct correlation could be made of individual vehicle speeds under rural and urban conditions, rural traffic speeds were observed concurrently with the urban study at a station located two to four miles from the urban study section. A radar speed meter with graphic recorder was used for the rural speed observations. The unit was concealed in a mailbox-type camouflage, and the recorder was removed to an inconspicuous position. The license number, type of vehicle, and the direction of travel for each vehicle were written directly on the speed recorder chart.

**Test Car Study Method.**—In addition to the studies involving the observation of individual vehicle speed, a "test car" method was devised and utilized in four of the five selected study locations. Selected drivers operating the test car made a series of runs through transition zones. The test car was equipped with a recording speedometer to

TABLE 8  
SPEED CHARACTERISTICS OF SECTORS IN STUDY SECTION V

Sector	Characteristic	Northbound			Southbound		
		All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
1	No. veh.	266	172	127	318	212	171
	Speed (mph):						
	Avg.	48.3	51.4	51.5	41.8	43.5	43.6
	85-percent.	57.0	58.5	59.0	50.0	51.0	51.0
	15-percent.	36.0	43.0	42.0	31.0	35.0	35.0
	Diff.	21.0	15.5	17.0	19.0	16.0	16.0
	Pace (mph)	47-57	47-57	49-59	37-47	41-51	41-51
Std. dev. (mph)	10.15	8.53	8.32	9.08	8.13	8.20	
2	No. veh.	286	172	127	318	212	171
	Speed (mph):						
	Avg.	45.1	47.3	47.4	42.5	44.4	44.5
	85-percent.	53.5	55.0	55.0	50.5	50.0	51.0
	15-percent.	35.0	38.5	38.0	31.5	35.0	35.0
	Diff.	18.5	16.5	17.0	19.0	15.0	16.0
	Pace (mph)	39-49	41-51	41-51	39-49	41-51	41-51
Std. dev. (mph)	9.22	7.85	7.57	9.14	7.97	8.03	
3	No. veh.	270	172	127	325	212	171
	Speed (mph):						
	Avg.	36.8	39.9	40.1	35.1	38.2	38.2
	85-percent.	53.5	55.0	55.0	50.5	50.5	51.0
	15-percent.	35.0	38.5	38.0	31.5	35.0	35.0
	Diff.	16.5	15.5	16.0	17.0	15.0	14.5
	Pace (mph)	31-41	31-41	33-43	27-37	31-41	31-41
Std. dev. (mph)	8.59	7.59	7.31	8.35	7.34	7.44	
4	No. veh.	217	172	127	278	212	171
	Speed (mph):						
	Avg.	33.5	33.7	33.8	31.7	32.8	32.8
	85-percent.	39.5	39.5	39.0	39.0	38.5	39.0
	15-percent.	25.0	26.5	26.0	23.0	25.0	25.0
	Diff.	14.5	13.0	13.0	16.0	13.5	14.0
	Pace (mph)	27-37	27-37	29-39	25-35	25-35	25-35
Std. dev. (mph)	9.40	6.76	6.30	8.08	6.72	6.61	
5	No. veh.	257	172	127	306	212	171
	Speed (mph):						
	Avg.	37.5	38.7	38.7	38.0	39.1	39.2
	85-percent.	45.0	44.5	45.0	45.5	45.5	45.5
	15-percent.	29.5	31.0	31.5	29.5	31.5	31.5
	Diff.	15.5	13.5	13.5	16.0	14.0	14.0
	Pace (mph)	31-41	31-41	31-41	31-41	31-41	31-41
Std. Dev. (mph)	8.04	7.05	7.09	7.73	7.03	7.14	

provide a continuous record of the vehicle speed. An example of the speed chart is shown in Figure 4. To record the traffic conditions confronting the driver, the vehicle was equipped with a sequence camera actuated by the distance marker on the speed recorder.

The test car method of study was developed to provide, under controlled conditions, an evaluation of the relationships between vehicle speeds and the factors influencing speeds. The method provided a continuous speed indication, whereas the previously described method was a point-to-point type of survey measuring average speeds within sectors. It was anticipated that this study method would indicate points of reaction that may not necessarily be reflected in the individual vehicle speed studies using the average sector speed approach.

The study method was used to conduct limited studies in three of the selected study locations, and a comprehensive study in a fourth location. This study method was not used in the fifth location because the roadway in the test section was reconstructed to a four-lane facility. In the limited studies at the three locations, two drivers were used to make four test car runs in each direction. The results of these studies were used merely to determine more specifically the true shape of the speed profile through the section.

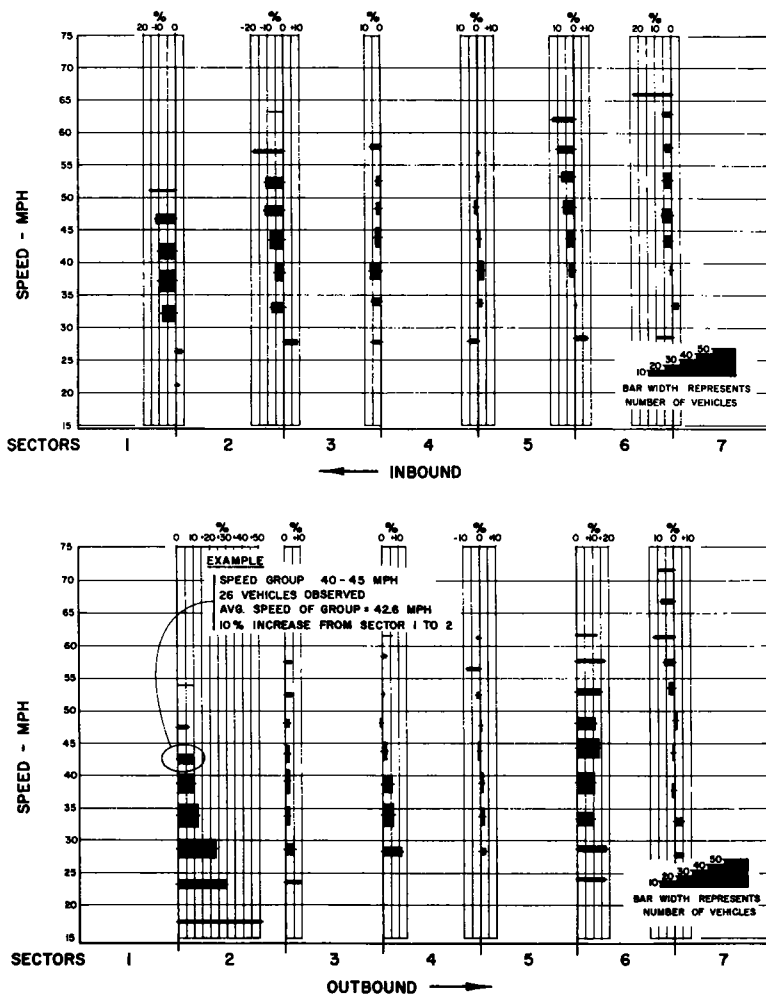


Figure 5. Study II, percent change in speed of 5-mph groups, Madisonville, Texas.

The comprehensive study, using the test car method, was conducted in one of the selected locations to provide data on specific reaction patterns of drivers. In this study, ten drivers made four test car runs in each direction. The experimental design and the results of the study are reported in a later section of the report.

#### Individual Vehicle Speed Studies

**Analysis of Data.**—Because of the large volume of data collected in the individual vehicle speed studies, electronic data-processing equipment was utilized to a great extent in the analysis. After interpreting the recorder charts, the linear time measurements for each vehicle and other supplemental data were transferred to IBM punch cards. The various computations involved were then made by electronic computer.



Figure 6. Site of individual speed study I.

The speed parameters used in the evaluations were average speeds, 85-percentile speed, 15-percentile speed, and the speed differential. These parameters were considered as most representative of the speed distributions observed. The pace was also used in the initial stages of the analysis but was later ruled out because of its apparent oversensitivity. An analysis showed that the pace could fluctuate greatly over the straight portion of the speed distribution curve when the speed differential was large. In other words, the pace was considered reliable only when it closely approximated the speed differential.

The traffic speeds observed in each of the studies were divided into three groups, depending on traffic flow conditions: all vehicles, through vehicles, and free-flow vehicles. In this report, "all vehicles" represents all the vehicles observed in each sector during the study period regardless of trip length or flow conditions; "through vehicles" indicates the vehicles that traveled throughout the entire length of the study section; and "free-flow vehicles" describes only the portion of "through vehicles" that was not influenced by slower-moving vehicles in the traffic stream. The condition of free flow was ascertained from interpretation of the recorder charts, where queuing and the rate of closure were readily discernible.

The speed parameter values for free-flow vehicles in each of the studies were plotted in relation to roadway geometry, development, and traffic movement, as shown in

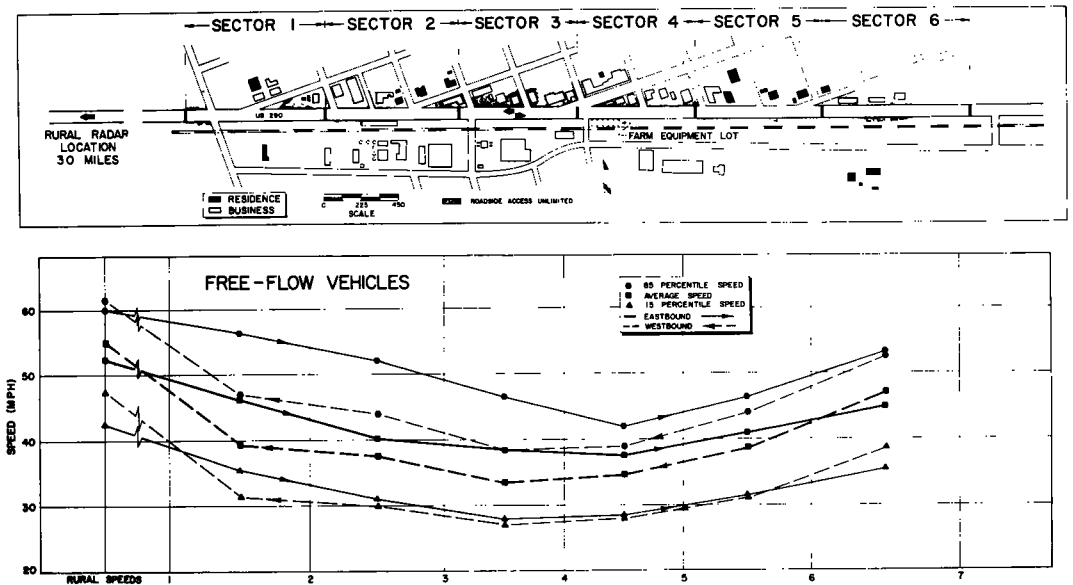


Figure 7. Individual vehicle speed study I, US 290, Waller, Texas.

TABLE 9  
DESCRIPTION OF STUDY SECTION I, WALLER

Sector No	Sector Length (ft)	Pavem Width (ft)	Shoulder Type	Horiz Curves (deg)	Flashing Amber Signal	Type of Develop	Resid Units (No )	Commer Units (No )	Driveways (No )	Percent with Unlimited Access	Intersecting Streets (No )	Sight Distance <sup>a</sup>	
												Northbound	Southbound
1	886	24	Gravel	-	-	Commer	1	5	0	75	2	No	No
2	842	24	Gravel	-	-	Commer	3	4	0	100	3	No	No
3	752	24	Paved one side	-	-	Commer	1	6	0	100	3	No	No
4	749	24	Paved one side	-	*	Commer	0	8	0	100	3	No	No
5	796	24	Gravel	-	-	Commer	4	1	0	100	3	No	No
6	933	24	Gravel	-	-	Commer	1	3	0	50 <sup>b</sup>	0	No	No

<sup>a</sup>Less than 1,000 ft at any point within sector  
<sup>b</sup>50 percent unlimited, 50 percent rural

subsequent figures. By using free-flow vehicle speeds, the influence of traffic conditions was reduced to the psychological effects of anticipated conflicts. The traffic volumes observed during the study are expressed in terms of average hourly volume and maximum hourly volume at each road tube station. Also, the average and maximum hourly turning movements are indicated within the sector in which they occurred. A detailed description of each study location is given in Tables 9 through 13.

The measurement of individual vehicle speeds through each of the sectors in a study made it possible to examine speed changes in relation to the speed in the previous sector. Figure 5, which typically represents these relationships, shows the percent change in speed between any two sectors for inbound and outbound traffic. These changes in speed can best be illustrated by example. The first graph in the lower half of the figure shows speed changes between Sectors 1 and 2 in the outbound direction. The third bar in this graph shows 26 vehicles (width of bar) were in the 40- to 45-mph group in Sector 1, and their average speed in that sector was 42.6 mph. The change

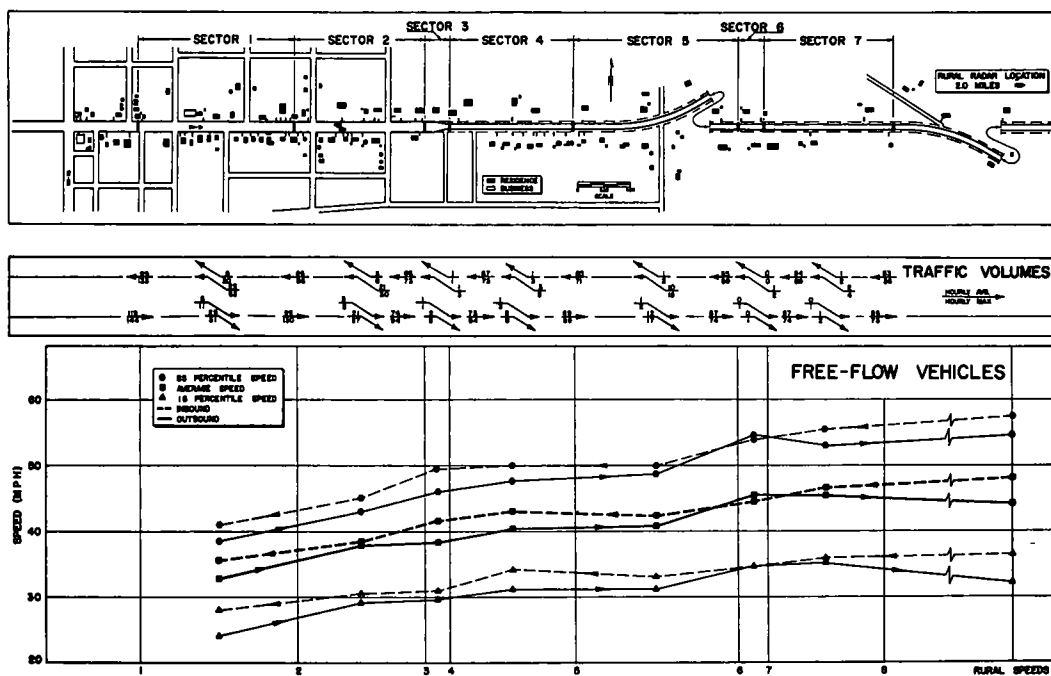


Figure 8. Individual vehicle speed study II, Texas 21, Madisonville.

TABLE 10  
DESCRIPTION OF STUDY SECTION II, MADISONVILLE

Sector No	Sector Length (ft)	Pavt Width (ft)	Shoulder Type	Horiz Curves (deg)	Type of Develop	Resid Units (No )	Driveways (No.)	Percent with Unlimited Access	Intersecting Streets (No )	Sight Distance <sup>a</sup>	
										Inbound	Outbound
1	1,353	40	Curb	-	Resid	19	17	0	4	Yes	Yes
2	1,140	40	Curb	-	Resid	15	17	0	2	Yes	Yes
3	211	40	.b	-	Resid	1	0	0	1	No	No
4	1,187	20	Grass	-	Resid	11	10	0	1	No	Yes
5	1,365	20	Grass	4	Resid	9	6	0	1	Yes	Yes
6	230	20	Grass	-	Resid.	2	2	0	0	Yes	No
7	1,099	20	Grass	-	Resid	7	3	0	0	Yes	Yes

<sup>a</sup>Less than 1,000 ft at any point within sector

<sup>b</sup>Transition



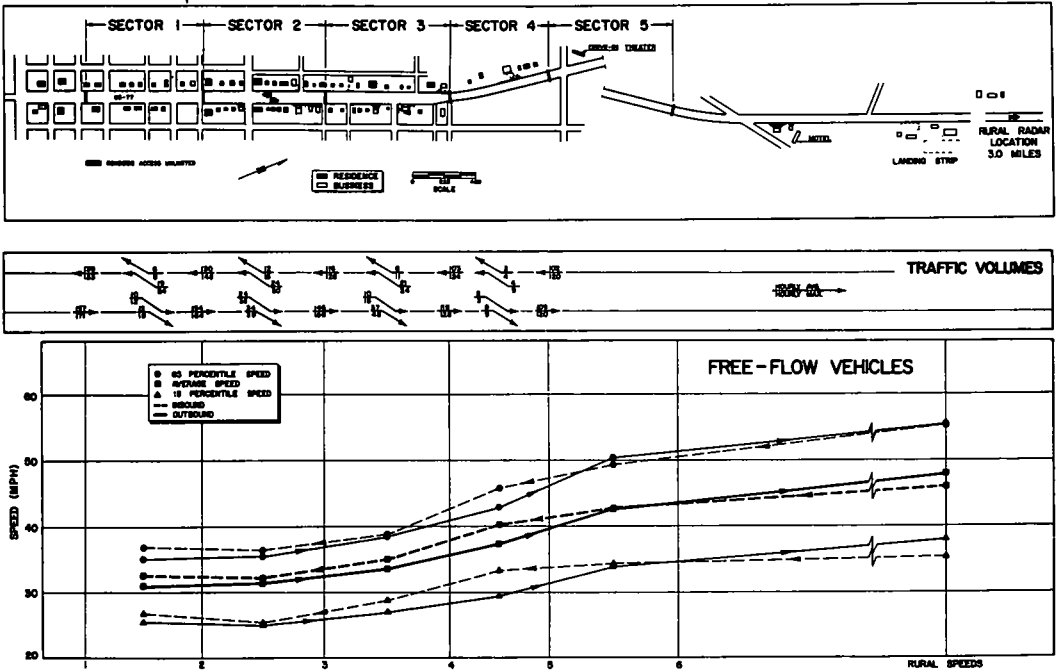


Figure 9. Individual vehicle speed study III, US 77, Cameron, Texas.

in speed of this group between Sector 1 and 2 was 10 percent of their average speed in Sector 1. The other bars in the first graph represent speed changes for the various 5-mph speed groups. The width of each bar (vertical dimension) represents the number of vehicles in the group, the center of the bar indicates the average speed of the group, and the bar length (horizontal dimension) indicates the percent change in speed between the two sectors for the same manner, the other graphs represent speed changes between the sectors indicated.

In the final analysis there was no distinction made between commercial and passenger vehicles because the number of commercial vehicles in each study was too small to be treated separately with any statistical reliability. The comparison of the average truck speeds with average speeds of the composite free-flow traffic stream is given in Table 3.

A complete listing of the results of the studies is given in Tables 4 through 8.

Discussion of Results. —The results of the individual vehicle speed studies repeatedly pointed up several factors of roadway geometrics and roadside development that directly affected traffic speeds. However, the sequence in which these factors occurred in the test section determined to a great extent their effect on speeds. In other words, the influence of certain factors was dependent on the conditions that the driver had expe-

TABLE 11  
DESCRIPTION OF STUDY SECTION III, CAMERON

Sector No	Sector Length (ft)	Pavt Width (ft)	Shoulder Type	Horiz Curves (deg)	Flashing Amber Signal	Type of Develop	Resid Units (No )	Commer Units (No )	Driveways (No )	Percent with Uncontrolled Access	Intersecting Streets (No )	Sight Distance <sup>a</sup>	
												Inbound	Outbound
1	1,187	40	Curb	-	-	Resid	13	1	4	0	4	No	No
2	1,207	40	Curb	-	*	Mixed	20	5	12	5	3	Yes	Yes
3	1,230	40	Curb	-	-	Mixed	15	6	13	10	5	Yes	Yes
4	1,012	40	Gravel	2 (approx )	-	Mixed	5	1	7	5	0	Yes	Yes
5	1,282	40	Gravel	-	-	Mixed	1	0	0	0	1	Yes	Yes

<sup>a</sup>Less than 1,000 ft at any point within sector

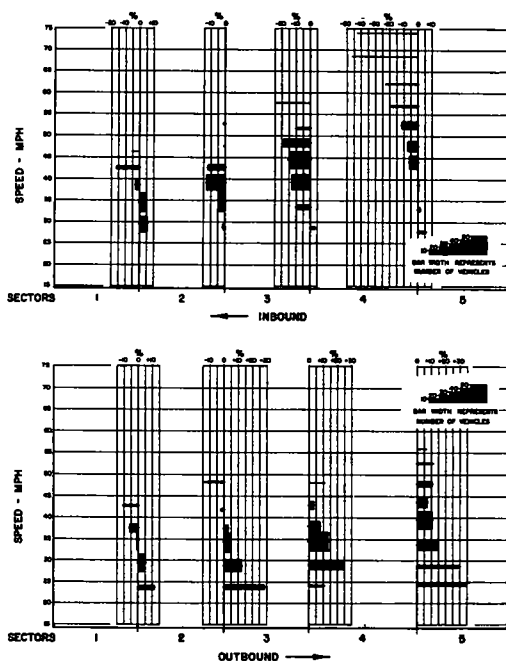


Figure 10. Study III, percent change in speed of 5-mph groups, Cameron, Texas.

rienced in previous portions of the test section. Each study is discussed individually so that previous influences will be accounted for in the evaluation of specific variables or combinations.

**Study I.**—This preliminary study was conducted primarily to evaluate study techniques and to determine if the data would reflect the extent of influence from the various factors. A site was selected for this preliminary study for which the general speed pattern was known, and which had few variations in conditions throughout the section. The traffic volume through this section was higher than desired, but this afforded a better check on the operation of the equipment and the study techniques being tested. This test was conducted just before the reconstruction of the study section to a four-lane facility. Therefore, additional studies could not be conducted.

As shown in Figures 6 and 7, the test section was composed almost entirely of commercial development. This development was limited to the north side of the roadway because of the proximity of the railroad tracks on the south side. Ingress and egress to the various businesses were provided by a continuous paved shoulder. The roadway

TABLE 12  
DESCRIPTION OF STUDY SECTION IV, BREMOND

Sector No	Sector Length (ft)	Pavt Width (ft)	Shoulder Type	Horiz Curves (deg)	Flashing Amber Signal	Type of Develop	Resid Units (No)	Commer Units (No)	Driveways (No)	Percent with Uncontrolled Access	Intersecting Streets (No)	Sight Distance <sup>a</sup>	
												Inbound	Outbound
1	432	20	b	-	-	Resid	7	0	2	0	1	No	No
2	687	20	b	-	-	Mixed	8	3	2	30	2	No	No
3	333	20	b	-	-	Resid	5	0	1	0	1	No	Yes
4	916	20	b	-	-	Resid	10	1	4	5	3	No	Yes
5	1,080	20	b	-	-	Commer	7	5	4	50	1	Yes	No
6	304	20	b	-	-	Rural	0	0	0	0	0	Yes	No
7	678	20	b	2	-	Rural	0	0	0	0	1	No	Yes
8	820	20	b	2	-	Rural	3	0	0	0	1	Yes	No
9	718	20	b	-	-	Rural	0	0	0	0	1	Yes	No

<sup>a</sup>Less than 1,000 ft at any point within sector

<sup>b</sup>Grass and/or gravel

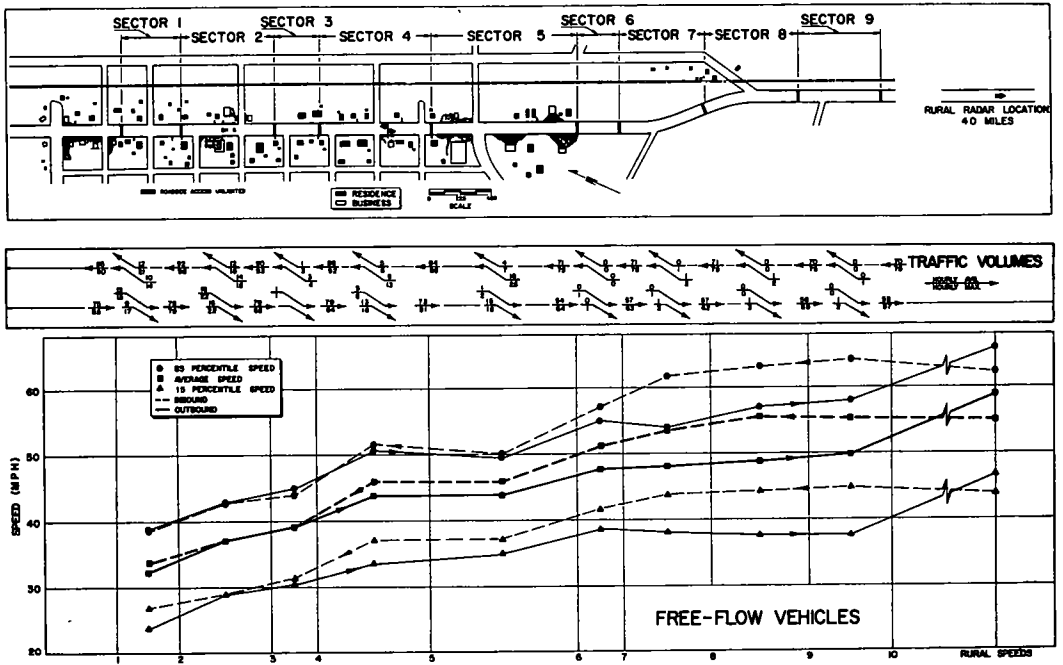


Figure 11. Individual vehicle speed study IV, Texas 6, Bremond.

was straight throughout the test section and adjacent areas, and the grades were negligible; therefore, no sight distance problems were encountered. The cross-section of the roadway was the same throughout the study area with the exception of the paved shoulder provided next to the development. A detailed description of the study section is given in Table 9.

The speed profiles in Figure 7 show that traffic speeds in the rural areas were essentially the same for both directions of travel. As the vehicles entered the developed area in the eastbound direction, their speeds reduced gradually, reaching a minimum in Sector 4. At this point the speeds began to increase gradually because the drivers could clearly see the end of the developed area. In the westbound direction speeds were reduced gradually as traffic entered the developed area, reaching a minimum in Sectors 4 and 3. Again, speeds gradually increased until the vehicles had passed through the developed area in Sector 1. The westbound traffic did not attain rural speeds within the test section.

The speeds on the developed side of the roadway were significantly lower than the speeds on the undeveloped side.

TABLE 13  
DESCRIPTION OF STUDY SECTION V, OAKWOOD

Sector No	Sector Length (ft)	Pavt Width (ft)	Shoulder Type	Horiz Curves (deg)	Flashing Amber Signal	Type of Develop	Resid Units (No)	Commer Units (No)	Driveways (No)	Percent with Uncontrolled Access	Intersecting Streets (No)	Sight Distance <sup>a</sup>	
												Northbound	Southbound
1	300	20	b	-	-	Resid	3	0	4	0	1	No	No
2	1,000	20	b	-	-	Resid	8	0	9	0	1	No	No
3	754	20	b	-	-	Resid	6	3	2	5	2	Yes	No
4	716	20	b	-	*	Commer	5	4	0	100	2	Yes	Yes
5	758	20	b	-	-	Commer	4	3	2	35	1	Yes	Yes
6	1,366	20	b	4	-	Resid	7	0	1	5	1	No	Yes
7	300	20	b	-	-	Rural	0	0	0	0	0	No	No
8	300	20	b	-	-	Rural	0	0	0	0	0	No	No

<sup>a</sup> Less than 1,000 ft at any point within sector  
<sup>b</sup> Grass and/or gravel

**Study II.** —The location for Study II was selected to afford an analysis of the influence of purely residential development. A strip map of the study section is shown in Figure 8, and a detailed description is given in Table 10. In the first two sectors, the roadway was a curbed street with parking permitted on both sides. In Sector 3, the cross-section changed to a two-lane rural type highway with grass shoulders. A 4-deg horizontal curve was located in Sector 5, and a second 4-deg curve was located just outside Sector 7. Sight distance was restricted in certain portions of the test section by the horizontal curves and by the slightly rolling profile through the test section.

The speed profiles for inbound traffic indicated a general deceleration pattern throughout the study section. Deviations from a constant deceleration pattern could be directly related to features of the roadway and the appearance of the development. The abrupt reduction in speed in Sector 5 was caused by the sight distance restrictions imposed on the driver by the horizontal curve in that sector. The speed change relationships between Sectors 6 and 5, shown in Figure 5, indicated that these conditions caused a proportionately greater reduction in the higher speed ranges.

A second abrupt reduction in the speed of the inbound traffic was observed as the roadway cross-section changed from a rural to a curbed urban section (Sector 3). This

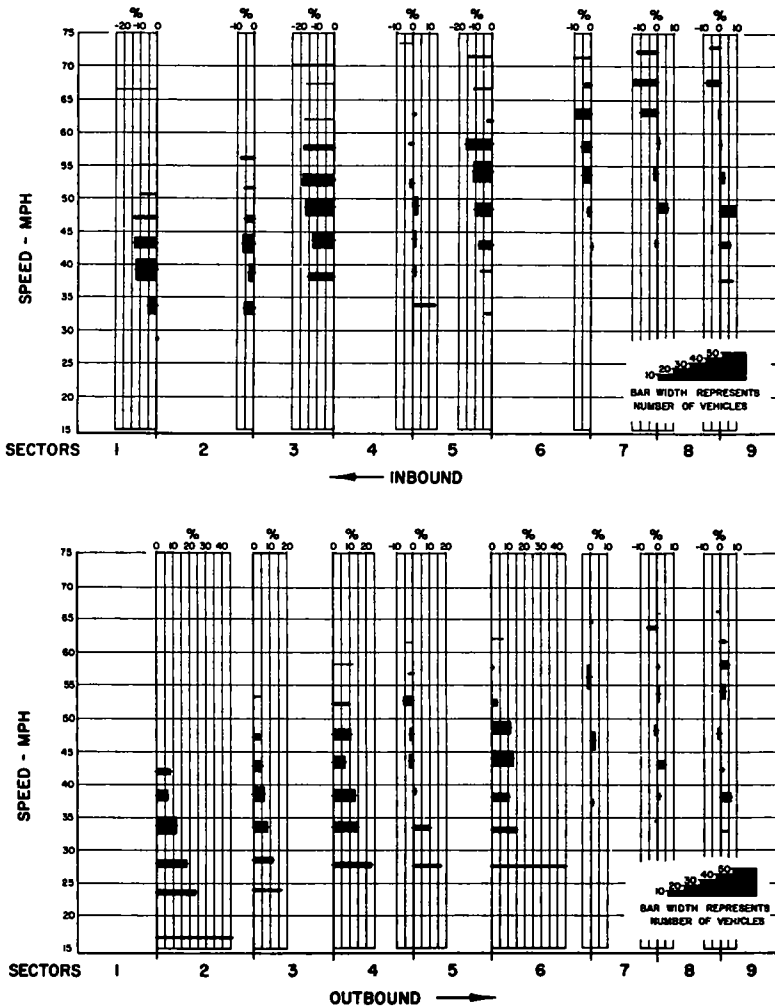


Figure 12. Study IV, percent change in speed of 5-mph groups, Bremond, Texas.

reduction was not altogether due to the change in cross-section. There was a significant change in the development in the general area of the speed change. The development in the urban section differed from that in the rural section by extensive planting of trees and shrubbery near the curbline. Again the speed change relationships in Figure 5 show the higher speed ranges to have been most severely affected between Sectors 3 and 2, where the change in development occurred.

The speeds of the outbound traffic indicated the same general tendency to follow a constant speed change pattern except where deviations were caused by horizontal curves and the sight distance restrictions imposed by the curves. This effect was observed in Sector 5 and again in Sector 7. Figure 5 shows a marked reduction in the higher speed ranges, whereas the lower speeds were affected to a lesser degree.

**Study III.**—The location for Study III was selected to permit an analysis of traffic speed patterns in relation to mixed development. The study site consisted of a transition section with intermittent commercial and residential development followed by a continuously developed city street of extended length as shown in Figure 9. In Sectors 1, 2, and 3, the roadway was a curbed street with parking permitted on both sides. A flashing amber beacon was located within Sector 2. Between Sectors 3 and 4 the roadway cross-section changed to a two-lane rural highway with grass shoulders.

The centerline profile through the study section was slightly rolling with crest vertical curves located in Sectors 2, 3, and 4. Also a sag type vertical curve was located within the horizontal curve in Sector 4. A detailed description of the study section is given in Table 11.

The speed profile in Figure 9 shows that the major speed changes of inbound traffic occurred between Sectors 3 and 5. It was noted that intermittent development outside the study section had caused a slight reduction in the speed of inbound traffic before it entered the study section. However, limited test car studies indicated that part of this reduction was due to sight distance restrictions imposed on the inbound traffic by a crest vertical curve located in the vicinity of Station 5.

The speed reduction observed between Sectors 5 and 4 was due to the re-introduction of development and critical sight distance restrictions imposed on the driver by the

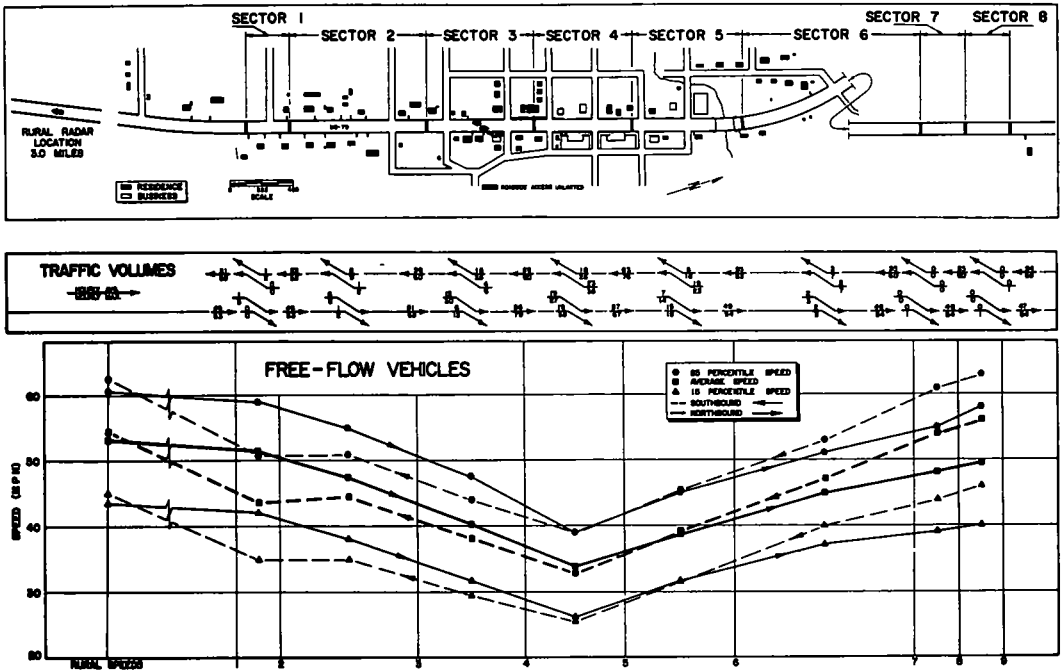


Figure 13. Individual vehicle speed study V, US 79, Oakwood, Texas.

combination of horizontal and vertical curvature, which occurred in Sector 4. Figure 10 shows the greatest reduction to have occurred in the higher speed ranges.

The greatest reduction in speeds of the inbound traffic was observed between Sectors 4 and 3. This reduction was the result of a combination of factors including the change in cross-section, an increase in the proportion of commercial development, and restrictive sight distance due to a crest vertical curve in Sector 3. The commercial development in the area generated frequent traffic conflicts.

Speeds were essentially constant through Sectors 1 and 2 where the drivers were confronted with a continuously developed city street section. However, the limited test car studies indicated an internal reaction in Sector 2 where there was an important intersection controlled by a flashing amber beacon. Also, sight distance was restricted by a crest vertical curve near the intersection. The reaction was a slight depression in the test car speed profile immediately preceding and within the intersection area. The reduction was only slightly reflected in the average sector speeds.

TABLE 14

## COMPARISON OF AVERAGE SPEEDS OF LOCAL AND NONLOCAL VEHICLE TRIPS

Study	Sector No.	Northbound-Inbound			Southbound-Outbound		
		Avg. Speed of Veh. (mph)		Speed Diff.	Avg. Speed of Veh. (mph)		Speed Diff.
		Nonlocal	Local		Nonlocal	Local	
I	1	40.1	38.8	-1.3	45.0	40.6	-4.4
	2	37.4	33.3	-4.1	37.9	36.0	-1.9
	3	33.0	29.6	-3.4	35.1	31.2	-3.9
	4	32.7	30.5	-2.2	35.9	30.6	-5.3
	5	37.9	35.2	-2.7	39.9	34.9	-5.0
	6	47.2	43.8	-3.4	43.9	40.8	-3.1
II	1	32.6	33.7	+1.1	35.0	34.5	-0.5
	2	37.4	36.9	-0.5	38.8	36.7	-2.1
	3	38.0	37.3	-0.7	41.4	39.0	-2.4
	4	39.8	39.1	-0.7	43.0	38.6	-4.4
	5	40.2	38.7	-1.5	42.1	37.5	-4.6
	6	45.1	37.9	-7.2	44.7	37.4	-7.3
	7	44.5	40.2	-4.3	46.8	41.9	-4.9
III	1	30.9	29.4	-1.5	32.2	29.8	-2.4
	2	31.1	31.1	0	31.6	30.6	-1.0
	3	32.7	33.0	+0.3	35.0	32.2	-2.8
	4	36.5	36.0	-0.5	40.1	36.5	-3.6
	5	41.2	40.8	-0.4	43.3	43.5	+0.2
IV	1	32.1	29.0	-3.1	33.2	29.9	-3.3
	2	36.9	31.5	-5.4	36.7	31.4	-5.3
	3	38.9	32.4	-6.5	38.8	32.1	-6.7
	4	43.5	39.5	-4.0	44.3	37.6	-6.7
	5	43.2	40.1	-3.1	44.2	41.6	-2.6
	6	47.4	42.5	-4.9	50.3	43.8	-6.5
	7	48.3	43.7	-4.6	53.0	47.6	-5.4
	8	47.6	42.0	-5.6	54.2	47.9	-6.3
	9	49.8	45.9	-3.9	54.3	49.2	-5.1
V	1	51.4	44.1	-7.3	43.5	38.5	-5.0
	2	47.3	42.3	-5.0	44.4	38.7	-5.7
	3	39.9	32.4	-7.5	38.2	30.7	-7.5
	4	33.7	29.8	-3.9	32.8	25.7	-7.1
	5	38.7	33.3	-5.4	39.1	35.4	-3.7
	6	45.0	40.1	-4.9	47.3	44.1	-3.2
	7	48.1	42.3	-5.8	53.9	48.6	-5.3
	8	49.7	43.8	-5.9	55.6	50.5	-5.1

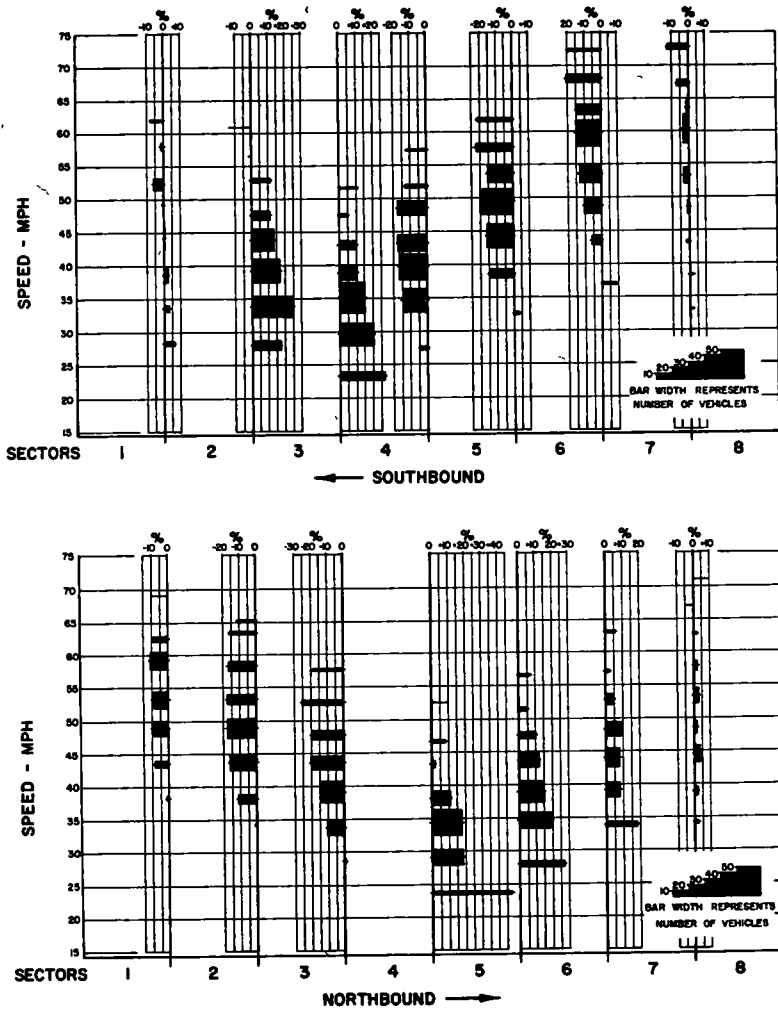


Figure 14. Study V, percent change in speed of 5-mph groups, Oakwood, Texas.

TABLE 15  
COMPARISON OF TEST CAR SPEEDS WITH NORMAL TRAFFIC SPEEDS

Sector No.	Speed (mph)					
	Inbound			Outbound		
	Test Car <sup>a</sup>	Normal Traffic <sup>b</sup>	Diff.	Test Car <sup>a</sup>	Normal Traffic <sup>b</sup>	Diff.
1	50.0	41.0	9.0	46.2	38.5	7.7
2	55.9	45.0	10.9	52.4	43.0	9.4
3	60.3	49.5	10.8	54.9	46.0	8.9
4	61.3	50.0	11.3	57.3	47.5	9.8
5	61.1	50.0	11.1	57.7	48.5	9.2
6	63.6	54.0	9.6	61.4	54.5	6.9
7	65.5	55.5	10.0	64.0	53.0	11.0

<sup>a</sup> Average speed for 10 drivers.

<sup>b</sup> 85-percentile speed (from individual vehicle speed study II).

In the outbound direction, traffic speeds exhibited many of the same characteristics as previously pointed out for the inbound traffic. Speeds were fairly constant through Sectors 1 and 2, where the roadway did not portray the characteristics of a transition area. As in the inbound direction, the major transitional speed change occurred between Sectors 3 and 5.

**Study IV.** —The location for Study IV was selected to provide data for an analysis of the influence of mixed development on traffic speed patterns in a relatively short

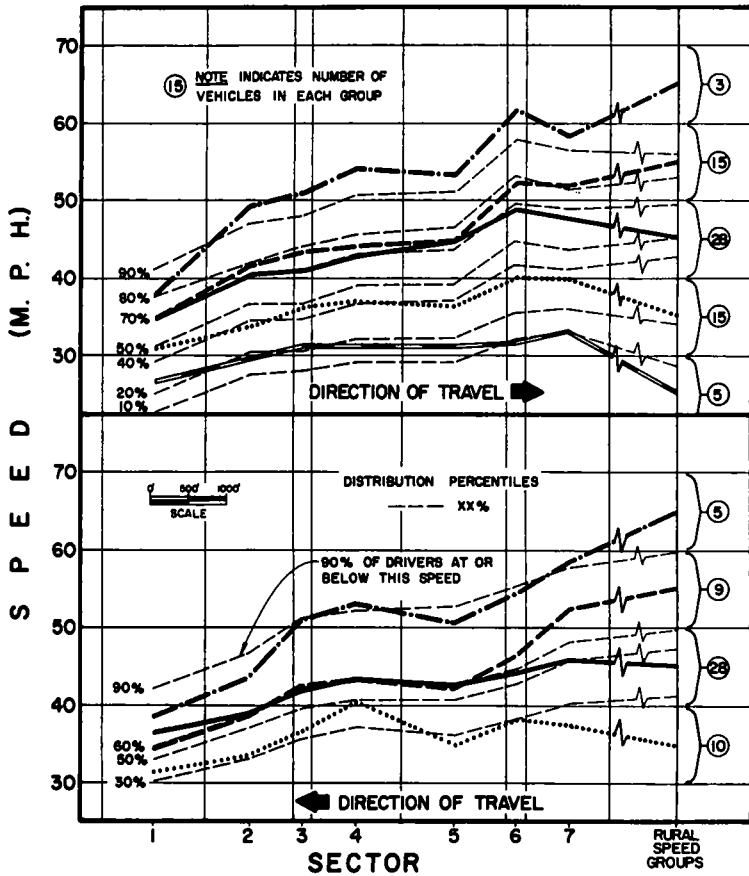


Figure 15. Average speeds through urban sectors compared to rural speeds, Study II.

TABLE 16  
COMPARISON OF TRAFFIC SPEEDS FOR CONDITIONS OF RADAR ENFORCEMENT AND NO ENFORCEMENT

Direction of Travel	Study Loc	Radar Enforcement						No Enforcement							
		Veh Obs (No)	Avg	85-Percent	15-Percent	Diff	Percent Exceeding 55 mph	Std Dev	Veh Obs (No)	Avg	85-Percent	15-Percent	Diff	Percent Exceeding 55 mph <sup>a</sup>	Std Dev
Enforced	1	239	50.3	56.5	41.6	14.9	24.7	8.95	471	52.2	58.1	44.3	13.8	35.0	6.80
	2	446	52.8	57.6	45.7	11.9	35.7	6.28	272	54.6	60.2	47.4	12.8	44.5	7.11
	3	176	50.7	57.0	42.2	14.8	29.5	7.40	404	51.0	56.9	43.3	13.6	27.0	6.38
	4	195	55.3	62.0	47.2	14.8	49.7	7.54	67	52.2	60.0	42.4	17.6	43.3	6.68
Opposing	1	282	45.3	49.6	38.4	11.2	4.6	5.55	402	50.3	56.0	42.7	13.3	21.6	6.48
	2	228	48.5	54.3	41.3	13.0	15.8	6.69	128	52.3	60.9	43.3	17.6	35.2	9.65
	3	202	45.0	49.7	37.3	12.4	2.4	5.87	259	51.2	56.7	43.3	13.4	29.7	6.30
	4	76	48.7	54.5	41.3	13.2	17.1	8.03	133	54.7	61.5	45.7	15.8	46.6	8.24

<sup>a</sup>Speed limit



transition area. A detailed description of the study section is given in Table 12. A rural-type two-lane highway cross-section with grass or gravel shoulders was continuous throughout the study section. Traffic volumes were low, and there were few intersecting streets of any significance.

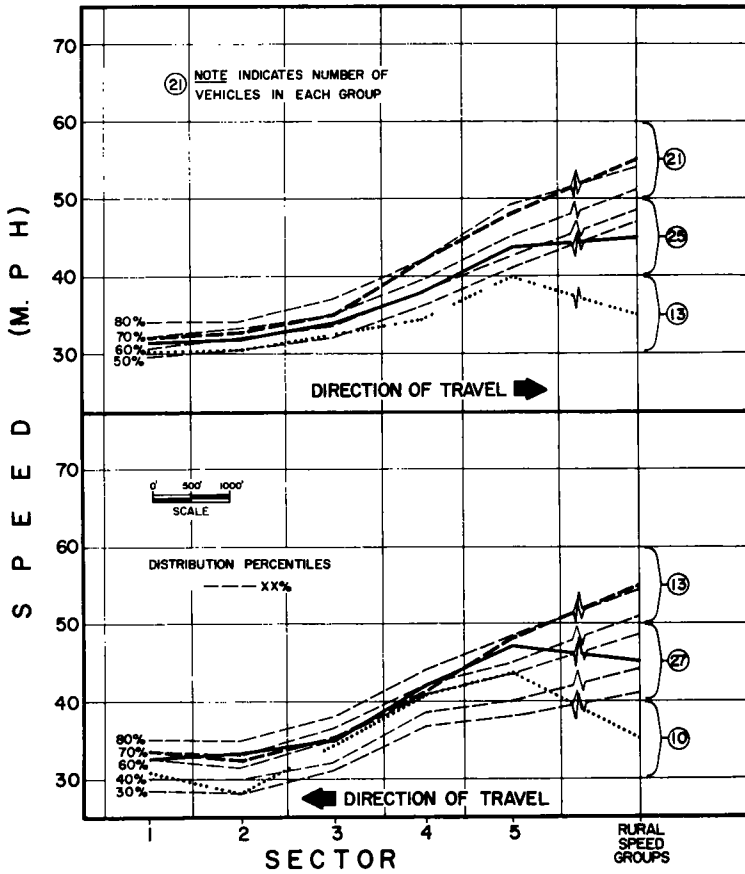


Figure 16. Average speeds through urban sectors compared to rural speeds, Study III.

TABLE 17  
COMPARISON OF TRUCK SPEEDS FOR DAYTIME, NIGHTTIME AND RADAR ENFORCEMENT CONDITIONS

Time Condition	Direc of Travel	Veh Obs (No )	Speed (mph)				Percent Exceeding		
			Avg	85-Percent	15-Percent	Diff	45 mph <sup>a</sup>	55 mph	Std Dev
Day Normal <sup>b</sup>	Combined	191	49 4	57	42	15	73 4	22 5	7 47
Night Normal <sup>c</sup>	Combined	146	49 9	54	44	10	82 2	15 8	5 82
Radar Enforcem <sup>d</sup>	Enforced	155	46 7	52	40	12	55 5	9 0	6 21
	Opposing	126	42 9	47	36	11	28 6	4 0	5 92

<sup>a</sup>Speed limit

<sup>b</sup>Observations by concealed research unit, 4 locations Waller, US 290 West, Oakwood US 79 West, Madisonville, Texas 21 East (2)

<sup>c</sup>Observations by concealed research unit, 4 locations Navasota, Texas 6 North, College Station, Texas 6 South, Bryan, Texas 6 North, Bryan Texas 21 East

<sup>d</sup>6 locations Navasota, Texas 6 North (2), College Station, Texas 6 South, Bryan, Texas 6 North, Bryan, Texas 21, East, Calvert, Texas 6 North

The transition section was preceded by two 2-deg horizontal curves as shown in Figure 11. With regard to horizontal alignment, this location was similar to Study II, where the transition section involved two 4-deg curves. However, no direct comparison could be made because the curves in Study IV did not impose the same sight distance restrictions and there was no associated development.

In evaluating the results of this study, the first reduction in speed of the inbound traffic was noted in Sector 6 (Fig. 11) and the deceleration was continued into Sector 5. This substantial reduction was due to a combination of circumstances which confronted the driver. The extent of the concentrated commercial development in Sector 5 (see strip map, Fig. 11) became apparent to the driver as he entered Sector 6, and his sight distance was restricted by a vertical curve in the approximate vicinity of Station 5. The speed-change relationships in Figure 12 show that the greatest speed reductions between Sectors 6 and 5 occurred in the higher ranges.

As the inbound traffic left the area of concentrated commercial development, there was a tendency toward a slight increase in speed. In the area where the increase occurred, there was also an increase in the sight distance afforded the driver, and the development had assumed a residential appearance. The sudden change in conditions acted as a vacuum and encouraged higher speeds. However, the recurrence of commercial development again caused a reduction in speed in Sector 3. The development causing the reduction was actually located in Sector 2, but it came into prominent view just before the vehicles entered Sector 3.

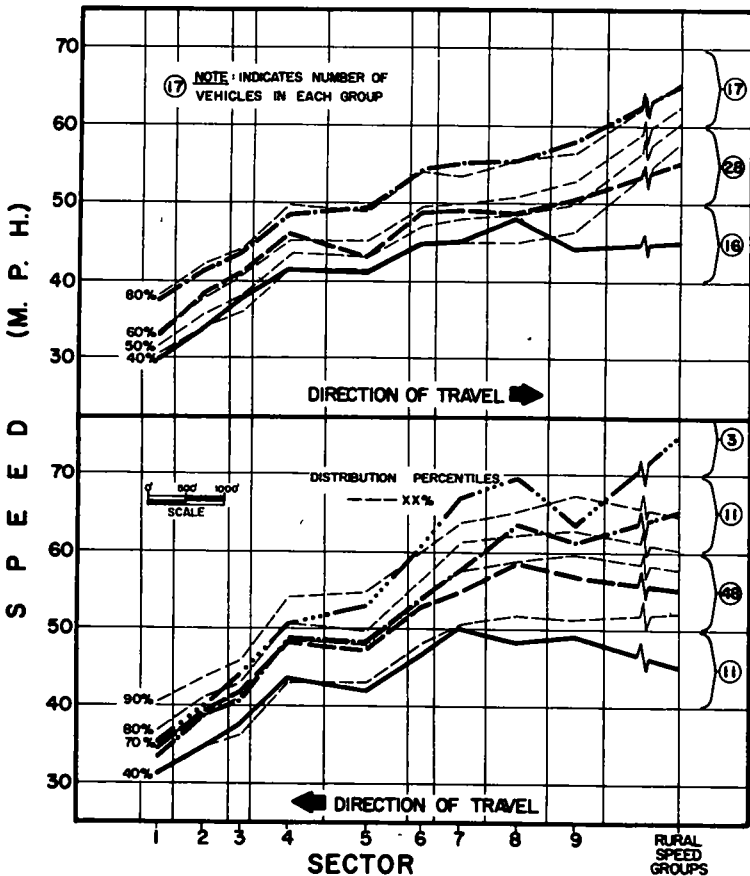


Figure 17. Average speeds through urban sectors compared to rural speeds, Study IV.

Traffic speeds in the outbound direction exhibited essentially the same characteristics as the inbound speeds. A general acceleration pattern was followed by the traffic throughout the study section except for deviations occurring in Sectors 4 and 5. A significant increase in speed occurred in Sector 4 as the traffic passed from a commercial area into an area which was predominantly residential. In Sector 5, a reduction in speed was due to the concentrated commercial development in that sector. Also, there was a slight reduction in speed noted in Sector 7. Figure 12 shows this reduction to have occurred only in the higher ranges of speeds. At this point the drivers were confronted by a horizontal curve superimposed on a sag vertical curve, a condition that presented a deceptive appearance.

**Study V.**—The location for Study V was selected to afford an analysis of traffic speed patterns in relation to segregated but adjacent areas of commercial and residential development. The developed area was composed of a concentrated business area surrounded by a tightly grouped zone of residential development, all of which was centered on a single main highway (Fig. 13). The roadway through the test section was a two-lane rural-type highway with grass or gravel shoulders. The gravel shoulders provided continuous access throughout the business area. A detailed description of the study section is given in Table 13.

In view of the general conditions just outlined, it was possible to include all of the developed area in the study section and thus obtain speed data on vehicles passing through the entire town. This condition is shown in Figure 13.

Two studies were conducted in this location because volumes were low during the

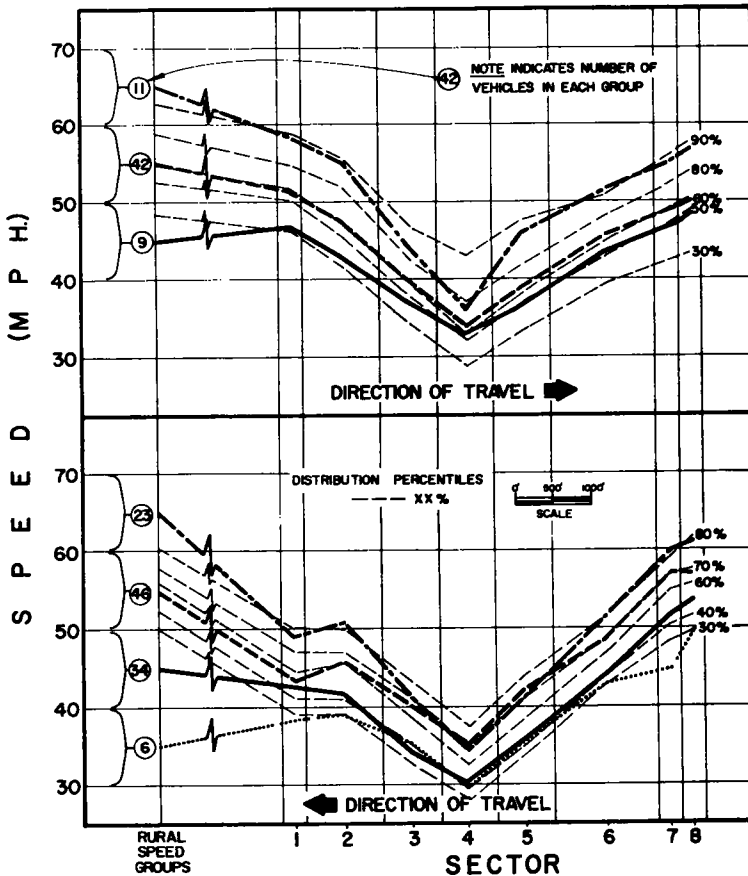


Figure 18. Average speeds through urban sectors compared to rural speeds, Study V.

periods of observation. The studies were first analyzed independently. Because the results of the two studies were very similar, they were combined to provide a more reliable sample.

In this study, the effects of horizontal and vertical alignment were very limited. There was a slight vertical curve which crested at Station 4 and had the business district

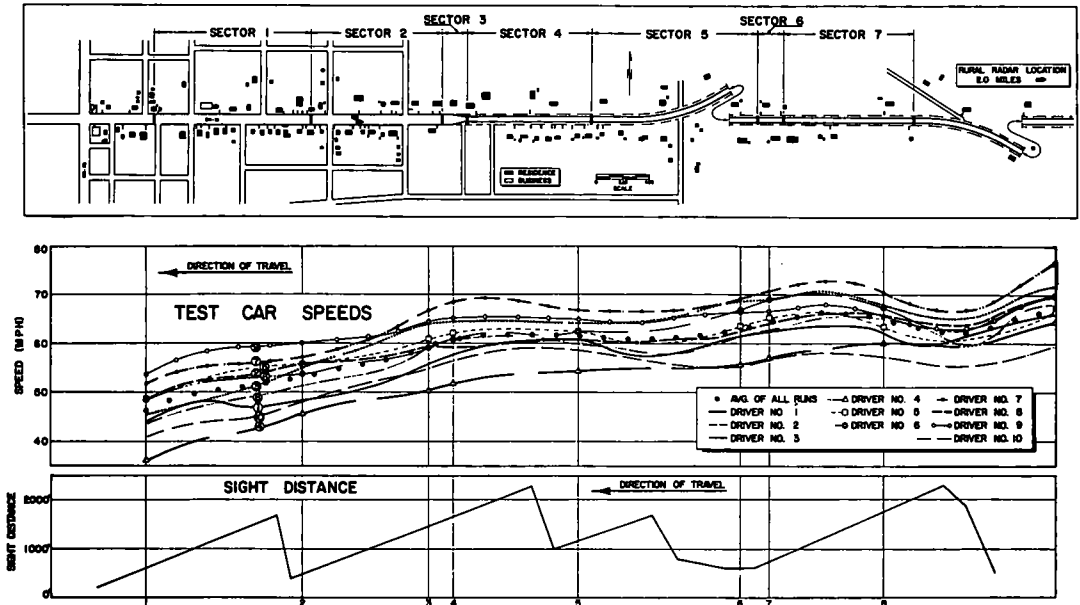


Figure 19. Inbound direction of travel, test car study, Texas 21, Madisonville.

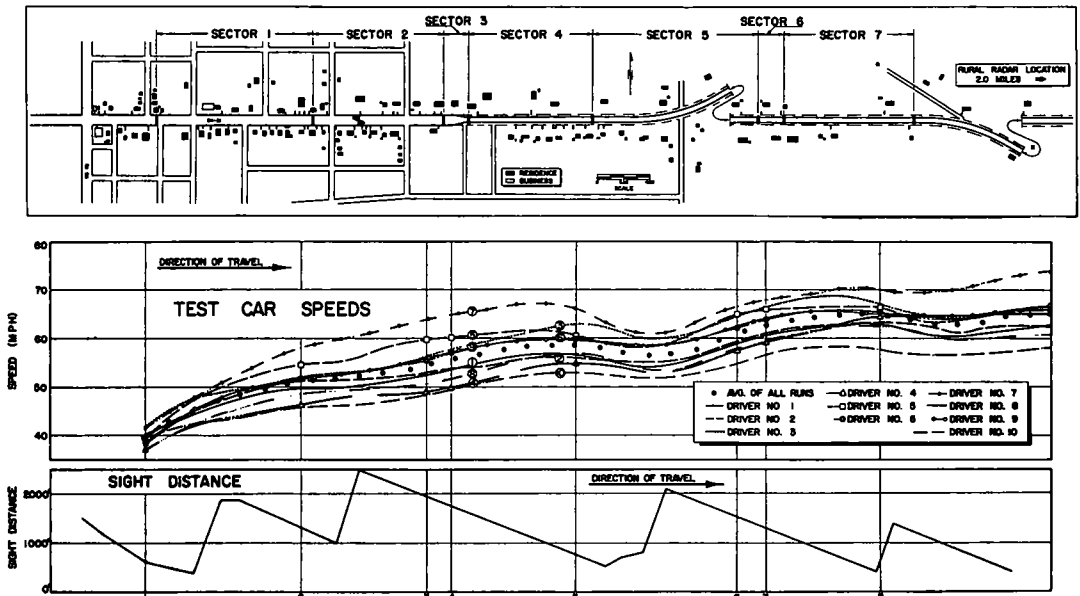
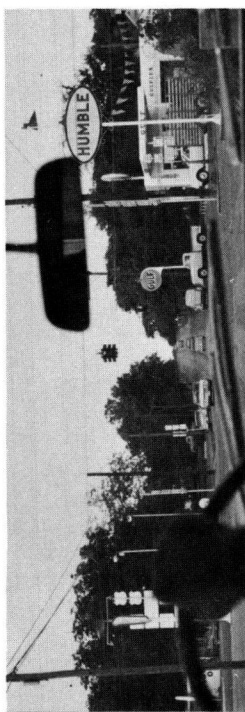


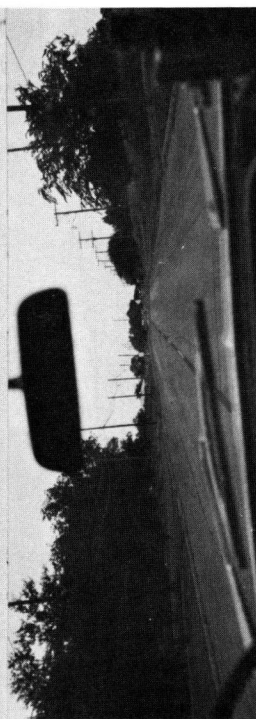
Figure 20. Outbound direction of travel, test car study, Texas 21, Madisonville.



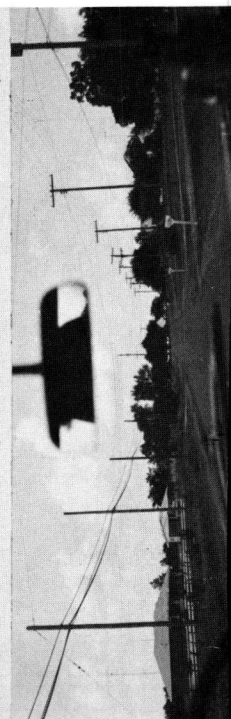
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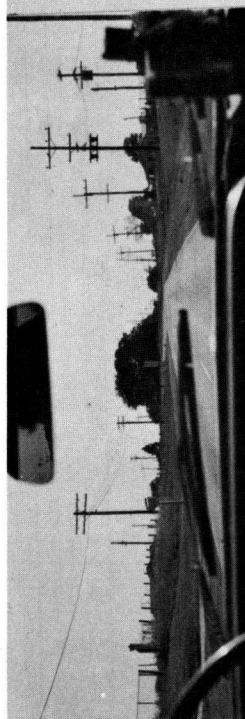
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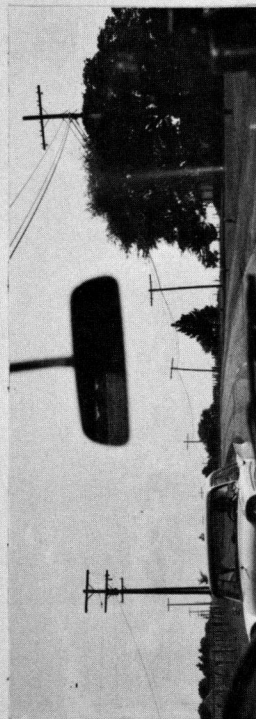
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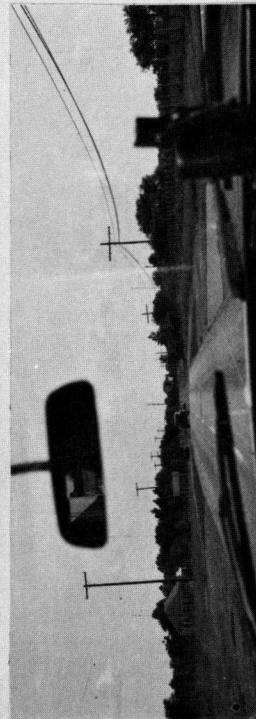
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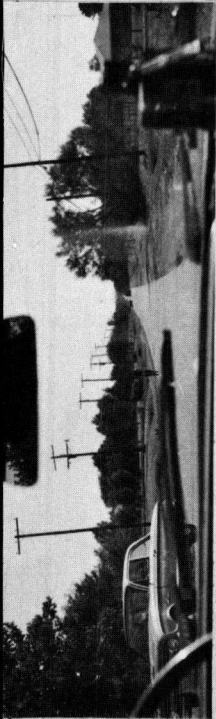


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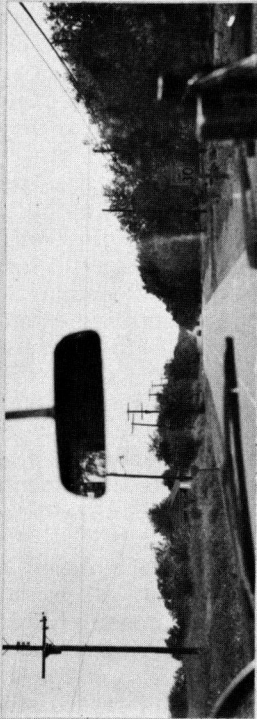


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Figure 21.



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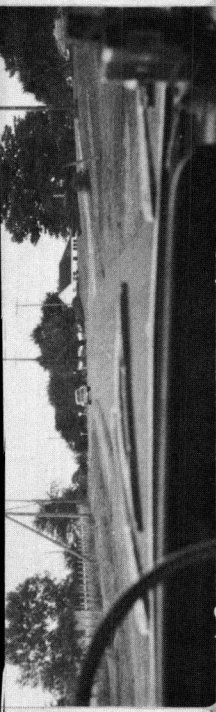


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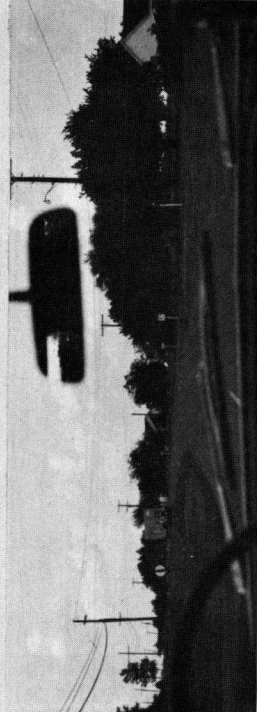


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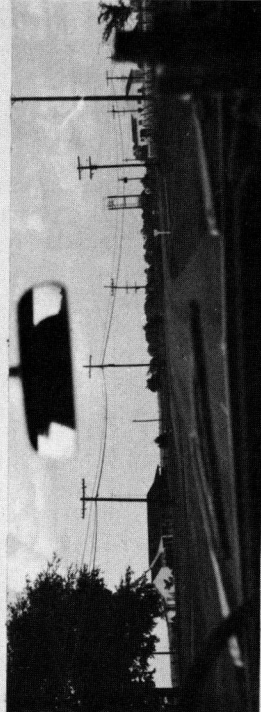
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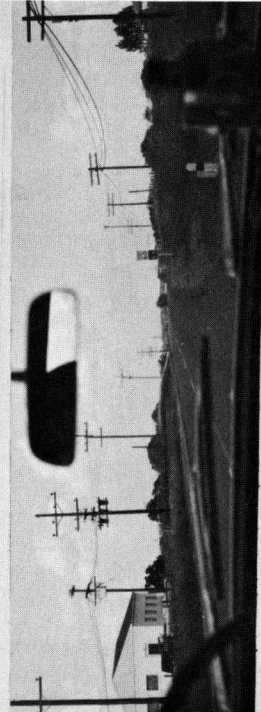
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15



16

OUTBOUND

from traffic approaching in the northbound direction. There was a 4-deg horizontal curve contained in Sector 6 which restricted the approaching southbound driver's view of the business district until he reached the approximate center of the curve. Although the immediate effect of these elements was not readily discernible in average sector speeds, the limited test car study indicated very definite driver reactions. At these points the drivers assumed a more rapid deceleration rate which continued into the business area.

The speed profiles in Figure 13 show that the traffic entering and leaving the developed area followed a linear speed-change pattern. This pattern occurred in short, compact transition sections which were virtually free from isolated influences of commercial development and critical geometric elements. However, southbound traffic speeds did not completely conform to this general pattern in Sector 1. Furthermore, there was no obvious explanation for the deviation. It occurred on the fringe of development and there were no sight restrictions, although there was a 1-deg curve ahead. Although this deviation did not occur in the limited test car studies, it was evident in both of the individual vehicle speed studies.

As in other studies, a general divergence was noted between inbound and outbound speeds. However, the magnitude of divergence in this study was greater than that observed in the other studies and was attributed primarily to the short, compact characteristics of the transition sections.

Summary of Findings.—The results of each of the individual vehicle speed studies repeatedly pointed up several factors of roadway and development characteristics that influenced traffic speeds. The most significant were as follows:

1. Roadway Geometry and Sight Distance.—The two most common elements of roadway geometry that were found to influence speeds were horizontal and vertical curves. These elements not only imposed physical limitations on vehicle operation but generally imposed limitations on sight distance, or the distance ahead at which the roadway and related development were visible. The visibility relationship appeared to be of most significance when traffic speeds were below the design speed of the geometric elements. However, restricted sight distance did not materially influence speeds unless associated with development. Apparently its effect on speed was the result of the driver's anticipation of traffic conflicts beyond the limits of his vision.

2. Cross-Section.—In the two studies where there were changes in cross-section, there were corresponding changes in speed. Although these factors could not be isolated for evaluation because of other factors, it was apparent that they contributed to an urbanized appearance.

3. Commercial Development.—In several of the studies, concentrated commercial development appeared to have a substantial influence on speed. Its full impact was demonstrated in Study IV by the increase in speeds observed as the traffic passed from the commercial area into a predominantly residential area of equal or greater density. However, it is recognized that restricted sight distance in the commercial area was also a contributing factor. The second occurrence of concentrated commercial development in the study also caused a marked reduction in speeds. In this case there were no additional factors involved.

4. Residential Development.—Residential development did not indicate the same level of importance as did commercial development. This may be due to its lower traffic generation characteristics. The appearance of residential development determined to a great extent its level of influence on traffic speeds. Residential areas having good lateral clearances had far less influence on speeds than those where shrubbery and trees were planted near the curbline.

5. Density of Development.—The density of residential development expressed as a percent of occupancy did not appear to correlate with speeds, except in its extreme ranges. Areas of residential development having the same density had entirely different appearances to the driver, and as pointed out previously, the appearance of development seemed to have a great influence on the driver's selection of speed.

6. Deceleration Pattern.—In some of the individual vehicle speed studies, traffic speeds followed a generally constant deceleration pattern in transition from rural to

urban conditions. In other studies, deviations from a constant deceleration line were directly related to certain characteristics of the roadway and development.

7. Divergence of Speeds. —In the studies involving short transition sections (Studies I and IV) the inbound and outbound speed patterns were significantly different. A general divergence between the speed profiles of the two directions was noted. This characteristic was observed in the other studies where transition sections were longer, but the divergence was much smaller.

### Rural vs Urban Speed Relationships

The individual vehicle speed data were analyzed to evaluate the consistency of drivers to travel at approximately the same percentile speed throughout the rural and urban areas. The free-flow vehicles that traveled throughout the urban and rural test section were selected for this analysis. Their speeds at the rural observation stations were grouped in 10-mph increments, and the average speed of each of these groups was computed for each of the sectors in the urban sections. These values were plotted for comparison as shown in Figures 15 to 18. Also, percentile bands were plotted to show the relationship of these speed groups to the distribution of free-flow vehicles traveling throughout the urban section. However, the percentile bands plotted at the rural stations represent the entire traffic stream because free-flow vehicles were not separated at that point.

Figures 15 to 18 show there was a general tendency for the speed groups to maintain their same relative position in the over-all distribution throughout the rural and urban areas. In other words, the faster drivers in rural areas were generally the faster drivers throughout the transition areas. However, the speed groups merged under city street traffic conditions as indicated in Sectors 1, 2, and 3 of Study III. Also, there was more consistency in the distribution of the speed groups in the outbound direction than in the inbound direction.

### Local vs Nonlocal Speed Characteristics

The individual vehicle speed study data were used to evaluate the differences in

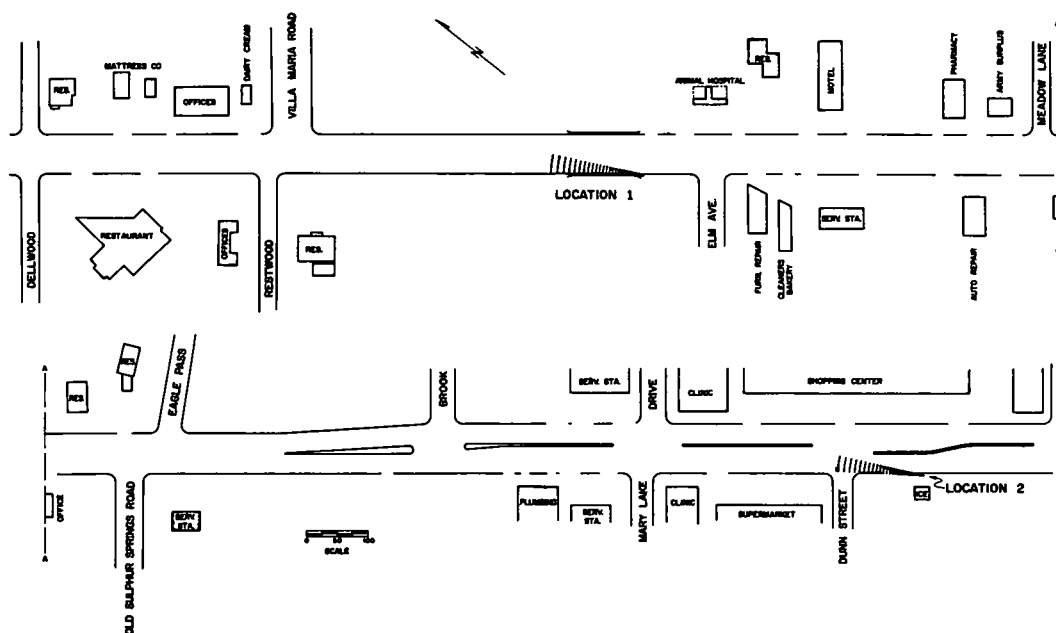


Figure 22. 24-hr speed study locations.



speeds of local and nonlocal vehicle trips. The speeds of the vehicles that traveled the entire length of the urban study section were separated from the total sample and designated as nonlocal vehicle speeds. The remaining portion of the sample, those that traveled through only part of the study section, were designated as local trips. The average speeds of each of these two groups of vehicles were computed for each of the sectors in the study sections. The results are given in Table 14.

A comparison of the two groups shows that the average speeds of nonlocal vehicles were higher than those of local vehicles, almost without exception.

**Test Car Study**

The test car study method was used to conduct a comprehensive study at one of the previously selected study locations. This location, which was the same as for Study II of the individual speed studies, was selected because of the several geometric influences it presented, and because of the singularity in the type of development (purely residential) in the area. In general, the study site provided a number of influential factors that could be separated for intensive study.

In planning the study, ten drivers were selected to operate the test car on a prescribed route which included the test section selected. The total length of the route was approximately 5 miles, including about 3 miles of rural highway outside the study section. Each of the ten drivers was required to drive the prescribed route in an alternating inbound-outbound pattern until he had completed four acceptable runs in each direction.

The ten drivers selected were students at Texas A & M College, between the ages of 21 and 28. Although they were part-time employees of the Texas Transportation Institute on other projects, they were not familiar with the objectives or survey techniques of this study. Before beginning the test runs, each driver was instructed to drive the prescribed route repetitively. Each driver continued to drive the route until the observer

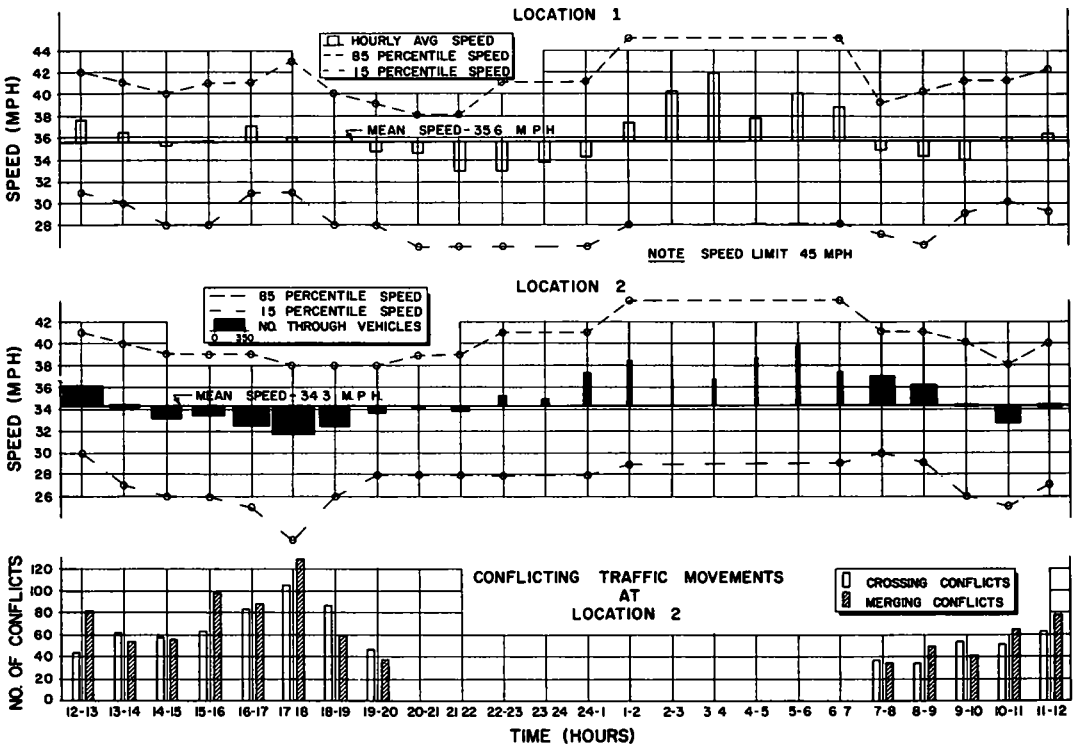


Figure 23. Hourly variations in traffic speeds.

had determined that he had made four runs in each direction without interference from other vehicles.

During the study, the existing speed limit signs were completely covered with paper to eliminate any possible influence on the driver. Also all test equipment except the sequence camera was placed in the rear of the station wagon to simulate as nearly as possible normal driving conditions.

It is probable that the test driver was more alert and more attentive to his driving than a normal driver. The fact that he was employed for the specific purpose of driving the test car is fairly substantial justification for this assumption. However, if most reactions to factors influencing speeds are of a subconscious nature, the test driver should react in much the same manner as the normal driver. This was fairly well substantiated by a comparison of the test car speeds with 85-percentile speeds from the individual vehicle speed study (Table 15). The test car speeds were 9 to 11 mph higher except in Sectors 1 and 6. These differences may have resulted from vehicle performance characteristics. The two sectors in which they occurred were acceleration areas; and the test vehicle, a 1961 six-cylinder station wagon with automatic transmission, had less-than-average acceleration characteristics.

Test car runs were plotted so that the individual runs of each driver could be compared. Because this comparison showed that each driver's runs were very similar in reaction pattern, an average run was plotted for each driver. The average runs for all the drivers are compared in subsequent figures.

The comparison of individual test car runs for each of the drivers indicated a slight increase in speeds in the order in which the runs were made. This trend probably resulted from increased familiarity with the roadway.

To facilitate a comparison of the test car speeds with roadway and development conditions, a strip map of the study section and a plot of sight distance are provided in proper proportion with the speed plots (Figs. 19 and 20). A detailed description of the study section is given in Table 10.

In Figure 21, a series of photographs taken from the test car shows the general characteristics of the roadway as viewed by the driver. These photographs were selected from a more complete series of snapshots taken during one of the travel runs. They provide an acceptable representation of the conditions confronting the drivers during the test runs.

In the evaluation of the results, primary consideration was given to a visual comparison of the speed profile with the existent conditions of roadway geometrics and development characteristics. This comparison pointed up several influencing factors and indicated the point and extent of reaction to these factors.

**Results.** —Evaluation of the test runs in the inbound direction showed the drivers were decelerating when they entered the test section (Fig. 19). This deceleration continued until a point was reached within the first 4-deg curve. Because these speeds were in excess of the design value of the curve, most of the reduction in speed was attributed to the drivers' evaluation of the physical limitations of the curve. However, due consideration should be given to the fact that sight distance was rapidly decreasing in the presence of limited development as the drivers were nearing the curve, and increased suddenly to more than 2,000 ft at the point where speeds began to increase. (The term "sight distance" describes the distance ahead in which the driver could see the roadway and related development.)

On leaving the first curve, the drivers continued to accelerate until reaching a point where sight distance was reduced to approximately 1,100 ft. From this point, they followed a constant deceleration pattern into the second 4-deg curve. The general appearance of the area in which the deceleration occurred is shown in photo 3 in Figure 21.

Test car speeds were more or less constant in the second curve, but increased slightly on leaving it, even though the density of development was greater than that preceding the curve. However, the sight distance had increased, and as shown in sequence photo 5, the development in the area confronting the driver did not impose any undue lateral sight restrictions. Also, access to the individual residential units was provided by culverts, and very little shrubbery was planted near the roadway.

The next significant change in test car speed was observed when the transition from rural to urban cross-section came into view. At this point, the drivers entered a distinct deceleration pattern that continued to a point approximately 400 ft beyond the transition section. The rapid change in speed was attributed to the change in cross-section accompanied by a significant change in development characteristics. Although the density of the residential units was essentially the same as the drivers had previously experienced in the test section, the appearance was completely different, as shown in sequence photo 7. The change in appearance was caused by extensive planting of trees and shrubbery up to the property line, giving the driver a feeling of lateral restriction. The change in appearance of the development and the change in cross-section combined to give the drivers a feeling of urban conditions, and resulted in a significant speed change.

A less pronounced rate of deceleration was observed following the influence of the transition to urban conditions. The rate of deceleration was comparable to that observed in the approach to the second curve. Sight distance conditions in the two sections were also comparable. In both cases, the drivers were subjected to sight distances less than 1,000 to 1,100 ft.

As the drivers continued in the inbound direction, their speeds became constant when sight distance was again restored. However, they assumed another similar deceleration pattern at approximately 1,000 ft from the intersection of US 75. This intersection was 600 ft outside the test section. The deceleration patterns outside the test section were highly variable depending on the signal at the major highway intersection.

The test car runs in the outbound direction were very similar in many respects to the inbound runs. However, several differences were considered worthy of discussion. Figure 20 shows that the drivers were still accelerating quite rapidly as they entered the test section, 600 ft beyond the signalized intersection. The rate of acceleration decreased slowly as the drivers slowly approached a speed commensurate with the existing conditions. As indicated by the sight distance plot, the drivers were confronted with a crest vertical curve just inside the test section. However, the restricted sight distance imposed by the vertical curve did not appear to influence the speeds because the drivers were still in the process of accelerating to what they considered a normal speed for the existing conditions.

Once the drivers had negotiated the first vertical curve, they were immediately confronted by a second vertical curve completely within the urban section. When sight distance was reduced to approximately 1,200 ft, some of the drivers altered their rate of acceleration. Once sight distance was restored, their speeds increased uniformly. Actually the major change in the speed profile occurred approximately 200 ft from the transition to urban cross-section. Sequence photo 11 shows the roadway ahead of the driver at the point of change.

The next major change in speed occurred in the approach to the first horizontal curve in the outbound direction. The drivers assumed a deceleration pattern when sight distance was reduced to 1,000 ft, and continued to decelerate into the curve until adequate sight distance was restored.

When sight distance was restored, the roadway and surrounding area had assumed an appearance of rural conditions. As a result, the drivers accelerated rapidly, approaching their normal rural speeds. As the drivers approached the second curve in the outbound direction, their sight distance was once more reduced below 1,000 ft, and a slight reduction in speed was observed. This reduction was considered primarily a reaction to the curve, because speeds returned to normal as the drivers passed from the curve into a completely rural section, as shown in sequence photo 16.

Although the sight distance was less than 1,000 ft at the end of the curve, the speed profile indicated a slight increase in speeds. Apparently the drivers did not consider sight distance as important outside the developed areas.

**Summary of Findings.** --The average test car speeds in each of the sectors were consistently 9 to 11 mph higher than corresponding 85-percentile speeds of the normal drivers. This over-all difference was attributed to the characteristics of the age group of the test car drivers, 21 to 28 years, and their knowledge of being tested.

Through the use of the test car technique it was possible to isolate certain variables

for specific evaluation. Because of the continuous speed record, the point of reaction related to a certain variable could often be detected.

The test car study served to substantiate further many of the findings of the individual vehicle speed studies. Of most significance was the influence of sight distance on speeds. In practically every situation where horizontal or vertical curves limited

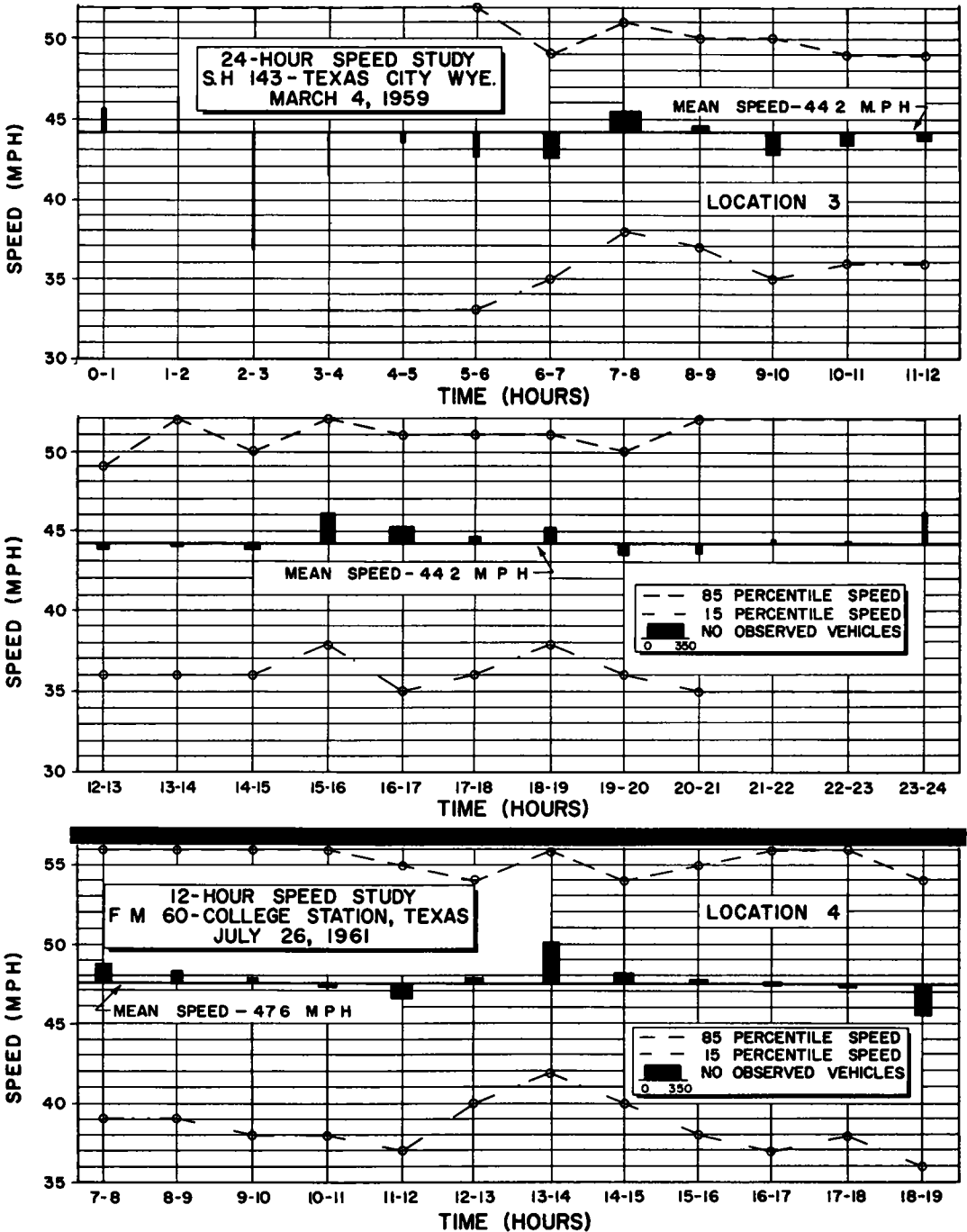


Figure 24. Hourly variations in traffic speeds.

sight distances to less than 1,000 to 1,200 ft, there was a distinct reduction in speeds. The drivers began to decelerate or to decelerate more rapidly each time sight distance became restrictive.

Although the influence of restrictive sight distance was demonstrated in the developed areas, it was apparently of little or no significance in the rural or undeveloped areas.

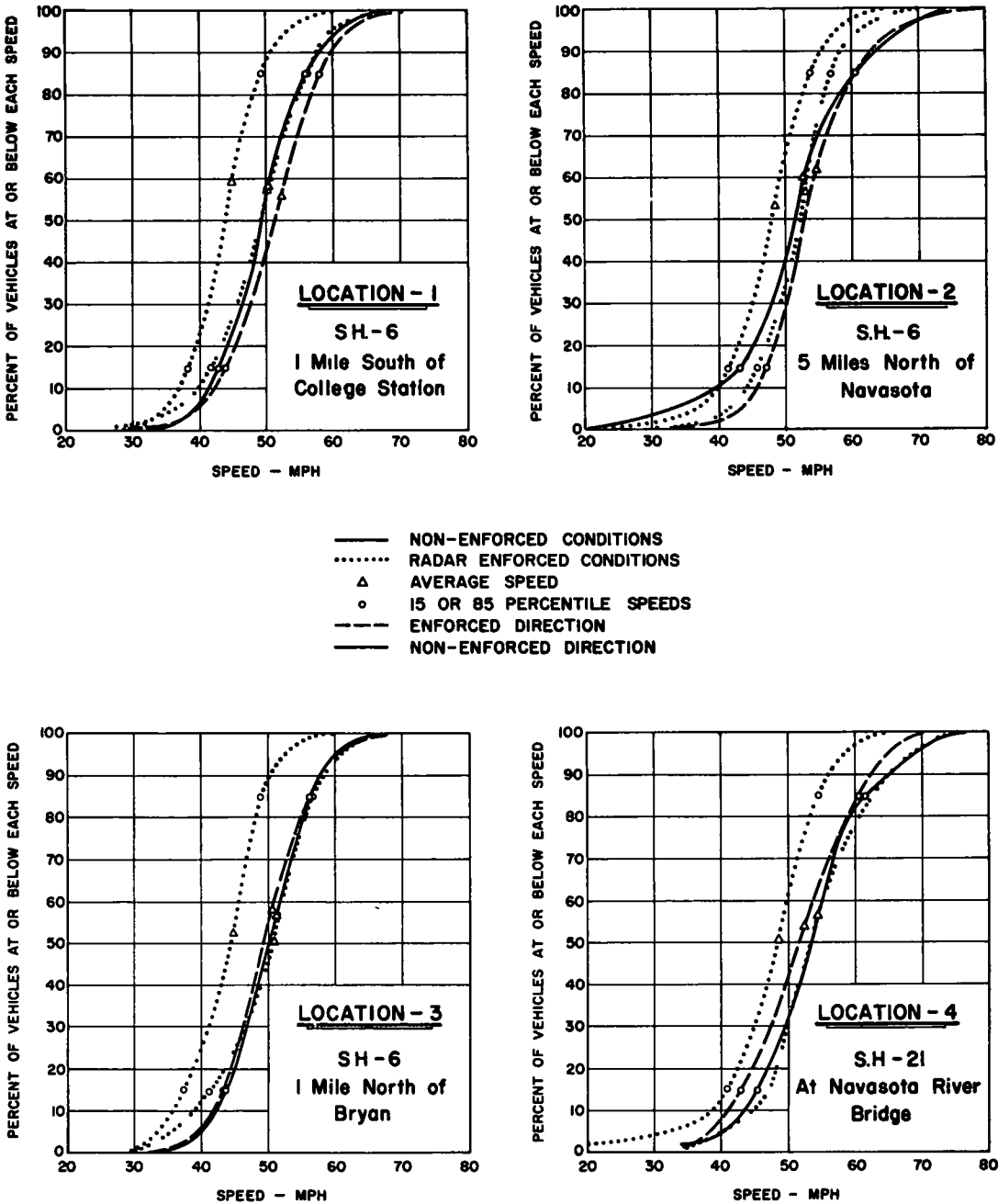


Figure 25. Distribution of traffic speeds operating under non-enforced conditions vs routine radar enforcement.

The influence of the appearance of development and roadway cross-section was also demonstrated in the test car study. The drivers decelerated rapidly over a section extending 400 ft on each side of the transition from rural to urban cross-section. In this same area there was also a significant change in the appearance of the development, caused by extensive shrubbery and trees near the roadway. This combination of factors caused a sudden change from rural to urban appearance.

### HOURLY VARIATIONS

Previous research has established that variations in traffic speeds generally exist over a 24-hr period (2). For this reason, it was felt that studies should be conducted to establish a possible relationship between traffic speeds and variations in traffic conditions.

The studies were conducted at four sites to provide data on the variations of speeds throughout the day. Speeds were observed for all vehicles during a 24-hr period at three locations and for a 12-hr period at the fourth location. Concealed radar units equipped with graphic recorders were used to measure speeds.

### Study Locations

The studies were conducted at four locations on three different types of roadways:

Location 1.—A midblock location on a four-lane undivided major street that also served as a primary highway route.

Location 2.—An intersection location in a shopping center area on a four-lane, channelized major street (same facility as Location 1) (Fig. 22).

Location 3.—A rural section of a four-lane divided State highway serving an industrial area.

Location 4.—A two-lane secondary highway carrying a rather high volume of traffic for this type of roadway.

Location 1 was a midblock section virtually free from turning movements, whereas Location 2 was at an intersection in a shopping center complex. The studies at these

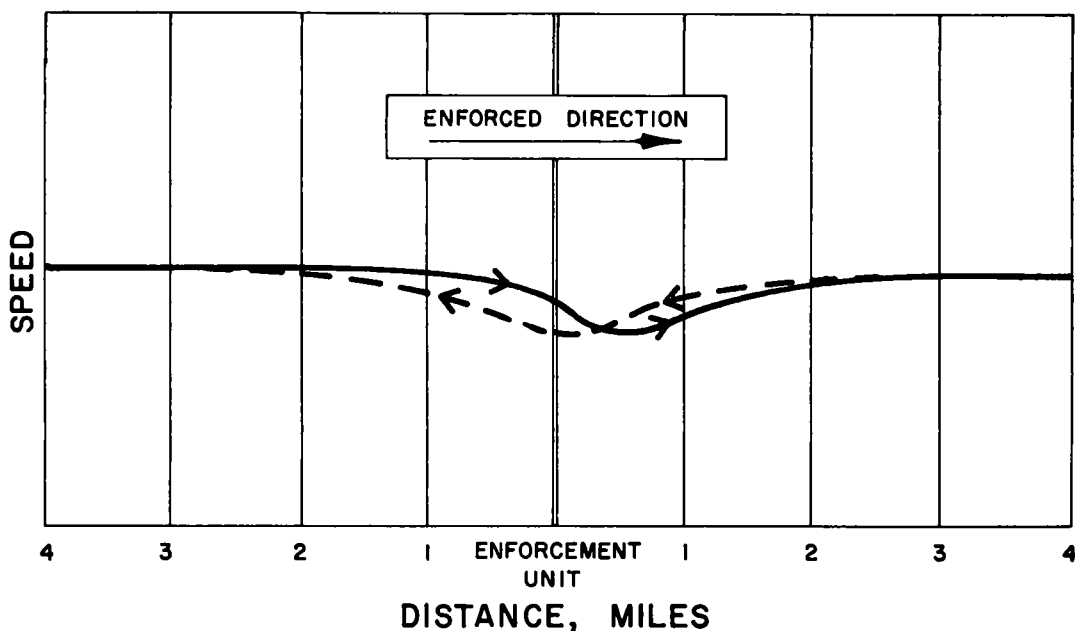


Figure 26. Speed profiles in area of enforcement.

locations were conducted concurrently to provide a comparative evaluation of the effects of turning movements on traffic speeds. At Location 2, observers recorded all turning movements in the intersection area and counted the number of through vehicles in the southbound direction during the business hours. Because of the excessive width of the street and high traffic volumes, speeds were observed in the southbound direction only.

At Location 3, speeds were observed in only one direction of travel, because the facility was a four-lane divided highway.

At Location 4, the study was conducted over a 12-hr period during the daylight hours. Speeds were observed in both directions of travel, and because a graphic recorder was used unattended, the speeds could not be separated according to direction.

### Analysis of Data

In each of the studies, the hourly average speed was compared to the mean speed for the entire study, as shown in Figures 23 and 24. The 85- and 15-percentile speeds for those hours having sufficient volume were plotted as an envelope about the mean speed. In the night and early morning hours when volumes were low, hourly speed observations were combined to yield statistically reliable percentile values for the group. This appears as a horizontal line joining two far-removed data points.

On the chart in Figure 23 the number of "through" vehicles for each hour is indicated by the width of the bar. These values, as well as the conflicting movements shown in the lower chart, were determined by manual counting. Because the volumes at Location 1 and 2 were essentially the same, no attempt was made to obtain an actual count at Location 1.

The volumes indicated on the charts for Locations 3 and 4 were determined through interpretation of the speed recorder charts and are therefore subject to a small amount of error due to the normal difficulties involved in measuring speeds of two lanes of traffic simultaneously.

### Results

The studies at Locations 1 and 2 provided data for the evaluation of variations in speeds on a typical major street where moderately high volumes and heavy traffic conflicts are experienced. Under these conditions, the maximum deviation from the mean of any hourly average speed was approximately 3 mph, as shown in Figure 23. Larger deviations were noted only in the early morning hours when traffic conflicts were essentially nonexistent. Except for the early morning hours, the 85-percentile speeds varied over a 5-mph range at Location 1 and a 3-mph range at Location 2.

With the exception of the early morning hours, the maximum deviations in average speed occurred during the peak hours. These deviations were not always below the mean as might be expected. At Location 2, the average speeds during the morning and noon peaks ranged from 2 to 3 mph above the mean, even in the presence of moderate conflicts at the intersection. These higher speeds can be explained by considering that the majority of the drivers were under the compulsion of a tight schedule. The concept of the influence of compulsion on the part of the driver is further substantiated by noting the low average speeds at both locations during the off-peak hours (10 to 11 and 14 to 15 hr). At these times the traffic stream was composed largely of shoppers and others who were not influenced by rigid schedules.

The effect of large numbers of conflicts can be realized through a comparison of average speeds at Locations 1 and 2 during the afternoon peaks (17 to 18 hr). The average speed at Location 1 was slightly above the mean, whereas the average speed at Location 2, where the large number of conflicts occurred, was approximately 2.5 mph below the mean (Fig. 23).

There was an apparent difference in the average speeds at Locations 1 and 2 during the morning peaks. This difference was the result of a large number of vehicles entering Texas Avenue from Villa Maria Road (Fig. 22) during this period and had not yet attained normal operating speeds before entering the range of the radar unit at Location 1. Similar differences were observed during the late evening hours (21 to 01). These differences were caused by traffic entering Texas Avenue from a drive-in theater

on Villa Maria Road and from a restaurant and drive-in cafe in the general area (Fig. 22). Again, this traffic had not yet attained full operating speeds before entering the range of the radar unit.

The study at Location 3 provided data for the evaluation of the variations in speeds on a high-type facility that primarily served industrial commuter traffic. This service was provided under comparatively low volume conditions and essentially no traffic conflicts.

The peak periods observed in the study reflected the shift changes at refineries and chemical plants in the general area. These shift changes normally occurred in two cycles: 7:00 AM-3:00 PM-11:00 PM; and 8:00 AM-4:00 PM-midnight. The study shows (Fig. 24) that average speeds observed during the shift changes were generally above the mean of the entire study. This further substantiates the previous ideas regarding the relationship between speeds and the pressure of a rigid schedule.

The study at Location 4 was conducted to provide data on variations in speeds on a two-lane secondary type roadway. In addition to serving the rural area, it also provided access to a small commercial airport and to limited facilities for some agricultural research and extension services.

The speeds were observed at a point approximately  $\frac{1}{2}$  mile outside the College Station city limit. Although the area was primarily rural, there were widely scattered residences in the general area.

Evaluation of the results showed the maximum deviation in hourly average speeds was approximately 3 mph (Fig. 24). However, deviations were less than 1 mph during 8 of the 12 hours of observation. The greatest variation in the 85-percentile speeds was 2 mph.

### Summary of Findings

In each of the four studies, hourly average speeds did not differ greatly throughout the daylight and evening hours. Even smaller variations were noted in the 85-percentile speeds during these periods.

The higher traffic speeds were observed during (a) extremely low volume conditions in the late evening and early morning hours, and (b) rush-hour periods when the driver was operating on a tight schedule. A large number of traffic conflicts resulted in a reduction in traffic speeds.

The result of these studies indicates that traffic speeds varied little throughout daylight hours. The 85-percentile, mean, and 15-percentile speeds during any hour were representative of the speeds during the remainder of the daylight hours. During the peak "rush" hours, increased intersection conflicts caused a reduction in speeds in the vicinity of the intersection. At none of the sites studied was the volume sufficiently close to the capacity of the roadway to cause a significant reduction in speed from the volume of traffic alone.

These studies indicated that for a spot speed study to be representative of a certain section of roadway, the selection of the specific site for the study is an important consideration.

### **EFFECT OF RADAR ENFORCEMENT**

The first phase of the project on effect of radar enforcement on traffic speeds showed that without rigid enforcement drivers generally disregard speed limit signs and select driving speeds according to their judgment of prevailing roadway and traffic conditions. However, little is known of the driver's reaction to efforts aimed at the enforcement of speed limits. From observation, it is evident that the presence of enforcement officials and equipment will reduce traffic speeds, but the extent of the effect in the enforced area and in adjacent sections is not fully known.

A study was undertaken in cooperation with the local highway patrol unit of the Texas Department of Public Safety to determine the effects of routine radar enforcement practices on traffic speeds. The study was designed to indicate changes in speed characteristics in the immediate area of the radar unit and to determine the distance from the radar unit that speeds were affected.



**TABLE 18**  
**COMPARISON OF AVERAGE SPEEDS AND PERCENTAGES OF TRAFFIC EXCEEDING**  
**SPEED LIMIT**

Direction of Travel  
 Enforced Direction

Study		4 miles	3 miles	2 miles	1 mile	Enforce- ment Unit	1.25 miles	2 miles	3 miles	4 miles
Area One	Average Speed, MPH Percent Exceeding Speed Limit	54.1 40*				51.6 30	49.8 12			
Area Two	Average Speed, MPH Percent Exceeding Speed Limit			54.3 43		52.9 32			50.3 19	
Area Three	Average Speed, MPH Percent Exceeding Speed Limit				** 51.8 26	53.4 34		50.0 15		
Area Four	Average Speed, MPH Percent Exceeding Speed Limit					50.8 25		50.2 14		52.1 31
* Speed Limit - 55 MPH										
** Slight Effect of Grade										

Direction of Travel  
 Non-Enforced Direction

Study		4 miles	3 miles	2 miles	1 mile	Enforce- ment Unit	1.25 miles	2 miles	3 miles	4 miles
Area One	Average Speed, MPH Percent Exceeding Speed Limit	53.8 40				46.6 6	49.7 18			
Area Two	Average Speed, MPH Percent Exceeding Speed Limit			51.6 22		47.8 7				
Area Three	Average Speed, MPH Percent Exceeding Speed Limit				51.6 26	44.6 2		52.0 32		
Area Four	Average Speed, MPH Percent Exceeding Speed Limit					48.4 10		51.7 21		53.3 38

## Enforcement Procedure

In routine enforcement operations, the patrol unit used a radar speed meter mounted on a tripod at the shoulder of the roadway. There was no attempt to conceal the unit; however, during the hours of darkness, the radar unit was not readily discernible by the driver until he had entered its range of operation.

During the operation, a patrolman observed speeds from an official vehicle parked 150 to 200 ft beyond the radar unit. He identified speeding vehicles and relayed the information to awaiting patrolmen at the pick-up station normally  $\frac{1}{4}$  to  $\frac{1}{2}$  mi beyond the radar unit. Whenever possible, the pick-up station was located within the view of the patrolman observing speeds so that violators could be more positively identified and apprehended. This method of operation limited the apprehension of violators to only one direction of traffic, commonly referred to as the enforced direction.

## Study Procedure

Studies to evaluate the effects of enforcement were conducted in two phases. The first phase consisted of studies conducted at isolated locations (a) to record traffic speeds in each direction of travel at the enforcement radar unit during enforcement operations and (b) to observe traffic speeds with a concealed radar unit at the same locations without the presence of enforcement officials. In the second phase, studies were conducted to determine how far the effect of enforcement extended along the roadway on each side of the enforcement unit. To accomplish this aim, concealed radar units were used to observe traffic speeds during enforcement operations in an "area" which extended 4 mi on either side of the enforcement unit.

## Study Locations

The locations selected for all studies were in general conformance with the convenience and best interests of the enforcement officials. They were normally situated in sections of roadway where speeds were not governed by geometrics. The locations for speed studies in the first phase, the point survey, were as follows:

- Location 1. —Texas 6, 1 mi south of College Station.
- Location 2. —Texas 6, 5 mi north of Navasota.
- Location 3. —Texas 6, 1 mi north of Bryan.
- Location 4. —Texas 21, Navasota River Bridge.

In the second phase which consisted of the "area" enforcement studies, an exact number of study locations could not be predetermined. With the two radar units available for research purposes, it was necessary to conduct studies on four different occasions to obtain sufficient data for the analysis. These four studies were not conducted at the same location because it was thought that repeat drivers would have begun to anticipate radar operations. The locations at which the area studies were conducted are as follows:

- Area 1. —Texas 6, south of College Station. Research radar units located 4 mi in advance and 1.25 mi beyond enforcement unit.
- Area 2. —Texas 6, south of College Station. Research radar units located 2 mi in advance and 3 mi beyond enforcement unit.
- Area 3. —Texas 36, north of Caldwell. Research radar units located 1 mi in advance and 2 mi beyond enforcement unit.
- Area 4. —Texas 6, south of College Station. Research radar units located 2 mi in advance and 4 mi beyond enforcement unit.

## Analysis of Data

The analysis of data from the enforcement studies was aimed at evaluating by comparison any differences in traffic speeds or their distribution resulting from radar enforcement operations. To facilitate this comparison, the speed characteristics given in Tables 16 to 18 were calculated, and the speed distribution curves were plotted.

**TABLE 19**  
**SUMMARY OF RESULTS, AREA ENFORCEMENT STUDY**

**AREA ONE**

State Highway 6 - 4 Miles South of College Station

E - Enforced Direction O - Opposing Direction	Location A Research Unit		Enforcement Unit Enforced Direction		Location D Research Unit	
	E	O	E	O	E	O
Total No. of Vehicles	303	186	283	158	308	160
Average Speed, MPH	54.1	53.8	51.6	46.6	49.8	49.7
85-Percentile Speed, MPH	59	60	57	51	54	56
15-Percentile Speed, MPH	48	46	44	39	44	42
Speed Differential, MPH	11	14	13	12	10	14
Percent Exceeding 55 MPH	39.6	40.0	30.0	6.3	12.3	18.1
Percent Exceeding 60 MPH	13.5	14.5	7.8	1.8	2.0	3.5
Standard Deviation, S	6.75	7.15	6.90	6.32	4.83	6.89

**AREA THREE**

State Highway 36 - 7 Miles North of Caldwell

E - Enforced Direction O - Opposing Direction	Location C Research Unit		Enforcement Unit Enforced Direction		Location E Research Unit	
	E	O	E	O	E	O
Total No. of Vehicles	179	89	160	79	182	84
Average Speed, MPH	51.8	51.6	53.4	44.6	50.0	52.0
85-Percentile Speed, MPH	58	56	61	48	54	59
15-Percentile Speed, MPH	45	45	45	39	43	43
Speed Differential, MPH	13	11	16	9	11	16
Percent Exceeding 55 MPH	26.3	25.9	34.3	2.5	15.4	32.2
Percent Exceeding 60 MPH	7.8	3.4	16.8	1.3	0	9.5
Standard Deviation, S	6.50	5.84	7.46	5.41	4.88	7.39

**AREA TWO**

State Highway 6 - 11 Miles South of College Station

E - Enforced Direction O - Opposing Direction	Location B Research Unit		Enforcement Unit Enforced Direction		Location G Research Unit	
	E	O	E	O	E	O
Total No. of Vehicles	204	191	207	164	220	
Average Speed, MPH	54.3	51.6	52.9	47.8	50.3	
85-Percentile Speed, MPH	60	56	58	52	55	
15-Percentile Speed, MPH	48	45	46	41	45	
Speed Differential, MPH	12	11	12	11	10	
Percent Exceeding 55 MPH	43.1	22.5	31.9	6.7	18.6	
Percent Exceeding 60 MPH	14.2	4.7	8.7	1.8	0.9	
Standard Deviation, S	6.07	6.23	6.20	5.41	5.50	

**AREA FOUR**

State Highway 6 - 9 Miles South of College Station

E - Enforced Direction O - Opposing Direction	Enforcement Unit Enforced Direction		Location F Research Unit		Location H Research Unit	
	E	O	E	O	E	O
Total No. of Vehicles	215	117	263	158	280	169
Average Speed, MPH	50.8	48.4	50.2	51.7	52.1	53.3
85-Percentile Speed, MPH	57	53	54	56	57	59
15-Percentile Speed, MPH	44	41	44	45	45	46
Speed Differential, MPH	13	12	10	11	12	13
Percent Exceeding 55 MPH	25.1	10.3	13.7	20.9	31.4	37.9
Percent Exceeding 60 MPH	5.6	0.9	1.2	7.0	5.0	13.0
Standard Deviation, S	6.70	5.64	5.00	5.82	6.15	7.38

In the analysis, the speeds of trucks and buses were separated from passenger car speeds and given special consideration.

## Results

**Phase I, Studies With and Without Enforcement.** —Evaluation of the results of studies conducted at the four locations with and without enforcement activity showed enforcement caused a reduction of traffic speeds in the direction opposite to the enforced direction (Fig. 25). This reduction was attributable to enforcement activity because there was no significant difference in speeds by direction of travel when observed under conditions of no enforcement. The difference observed under enforced conditions was largely attributable to the presence of the pick-up unit, which the drivers in the opposing direction had observed shortly before arriving at the radar unit.

Comparison of the average speeds given in Table 16 shows the magnitude of the speed differences resulting from enforcement ranged from 5.0 to 6.6 mph. Comparison of other speed characteristics indicates similar differences.

Although the 4-hr periods of speed observation at each study location provided good sampling of passenger cars, no one study provided a reliable sample of truck speeds. For this reason, truck speeds of all studies conducted with the enforcement unit were combined with respect to their direction of travel. In the studies with no enforcement, truck speeds for all locations were combined to form one large sample. This was considered permissible because an analysis showed no appreciable difference in speeds by direction of travel in the studies with no enforcement.

For further comparison, truck speeds from spot speed studies made during daylight hours in the four locations given in Table 17 were combined to form a sample. These studies were conducted on weekday afternoons using the concealed research radar unit.

Table 17 shows the various combinations of data made it possible to compare truck speeds under four different conditions:

1. Normal operation during daylight hours.
2. Normal operation during night hours.
3. During enforcement at night in the enforced direction.
4. During enforcement at night in the opposing direction.

The results indicated that truck speeds were essentially the same for day and night conditions in the absence of enforcement operations. Although the speed limit for trucks was 45 mph, the average speeds under each of the two conditions were 49.4 and 49.9 mph, respectively. It is notable that approximately three-fourths of the trucks were exceeding the speed limit.

The comparison of truck speeds at night under conditions of enforcement and no enforcement shows a decrease in the average speed from 49.9 to 46.7 mph in the enforced direction. This decrease was probably the result of "passing the word" among the truck drivers, a practice which seemed to be much more prevalent with truck drivers than with passenger car drivers.

The most significant reduction in truck speeds was observed in the opposing direction of travel, where the vehicles passed the pick-up unit before arriving at the enforcement radar unit.

**Phase II, Area Studies.** —The results of the "area" enforcement studies indicate that the influence of enforcement operations loses significance within approximately 4 mi on either side of the enforcement unit. However, these studies do not show and were not intended to show the far-reaching effects of the over-all enforcement program. To provide this evaluation it would be necessary to study the speed characteristics of a roadway before the initiation of an enforcement program in comparison with the speed characteristics of the roadway after the enforcement program was established.

The extent to which enforcement affects speeds in areas adjacent to the enforcement unit can be ascertained through a careful study of the speed characteristics of the "area" studies given in Table 19. To permit an easier evaluation of the results of the studies, the average speeds and percent of vehicles exceeding the speed limit have been extracted and are given in Table 18. This summary of results shows that speeds in both directions were essentially the same and were apparently unaffected by enforcement at a point 4 mi

in front of the enforcement unit. However, in this same study a significant reduction in the average speed of traffic in the enforced direction had occurred when the traffic arrived at the enforcement unit. A further reduction was observed at a point 1.25 mi beyond the unit. Very substantial reductions were observed in the percent of vehicles exceeding the speed limit.

In the area 2 study, traffic speeds in the enforced direction at a point 2 mi in front of the enforcement unit apparently were not yet affected by the enforcement activity. When the traffic arrived at the enforcement unit, the average speed and the percent of traffic exceeding the speed limit had decreased. Further reductions were observed 3 mi beyond the unit.

In the area 3 study, the radar unit placed 1 mi in front of the enforcement unit was located on an upgrade to the traffic in the enforced direction. Although the grade was not recognized as a speed deterrent at the time of the study, the results showed that speeds at this point were lower than at the enforcement unit. Also, low volume conditions on the roadway reduced the effect of "passing the word" by drivers that had observed the enforcement activity.

A comparison of the speeds in the enforced direction at the enforcement unit and at a point 2 mi beyond, showed a substantial reduction in average speed and the percent of traffic exceeding the speed limit.

In area 4 the research units were located 2 mi beyond the enforcement unit. This study indicated only a slight reduction in average speeds between the enforcement unit and a point 2 mi beyond. However, the traffic exceeding the speed limit had decreased significantly.

At a point 4 mi beyond the enforcement unit, traffic speeds had not completely returned to normal when compared with speeds in the opposing direction. However, the differences in speed at that point were minor.

A general comparison of speeds within the area of enforcement operations has shown that traffic in the enforced direction began to reduce speed at some point within 2 mi in front of the enforcement unit. This reduction was apparent at the enforcement unit, but possessed greater significance at points 1 to 3 mi beyond the unit. The traffic speeds had, for all practical purposes, returned to normal at a distance of 4 mi beyond the enforcement unit.

A similar comparison of speeds in the opposing or nonenforced direction showed that traffic had begun to reduce speed at a distance of 2 mi from the enforcement unit. Again this influence was attributed to "passing the word." From the point at 2 mi, speeds in the nonenforced direction continued to decrease, reaching a minimum at the enforcement unit. The significant reduction in speed at the enforcement unit was the result of drivers' having just passed the pick-up unit. From observation, it appeared that drivers inherently reacted to the presence of a patrol officer regardless of the speed at which they were traveling.

Traffic speeds in the opposing direction did not completely return to normal immediately after passing the enforcement unit. The influence was still evident 2 mi from the enforcement unit but had dissipated at 4 mi.

In comparing speeds by the direction of travel at the enforcement unit, the studies in areas 1, 2, and 3 show differences in average speed of 5.0 to 6.8 mph, whereas area 4 shows a difference of only 2.4 mph. In the latter study, the pick-up unit was located approximately  $\frac{1}{2}$  mi from the enforcement unit as compared with approximately  $\frac{1}{4}$  mi in the other three studies. This comparison suggests that the pick-up unit was the primary cause of the speed reductions.

Figure 26 shows the general influence of radar enforcement on traffic speeds. The speed profiles show the minimum speed to be in the vicinity of the pick-up unit. Although speeds were not measured at the pick-up unit for practical reasons, field observation showed that the maximum speed reduction occurred in that general area.

## CONCLUSIONS

The following conclusions have been drawn from the results of this research:

1. Substantial speed reductions occurred when sight distance was below 1,000 to

- 1, 200 ft. This sight distance, defined as the distance ahead in which the driver could see the roadway and related development, appeared to alter the driver's choice of speed only in developed areas where there were potential traffic conflicts.
2. The introduction of a curbed urban street cross-section had an effect on the speed pattern.
3. Continuous residential development caused a reduction in traffic speeds. The extent of this reduction was more dependent on the lateral restrictions it imposed than on the relative density of development. Extensive planting of trees and shrubbery near the roadway contributed greatly to this result.
4. Concentrated commercial development in transition areas caused substantial reductions in traffic speeds.
5. The faster drivers in the rural areas were generally the faster drivers throughout the transition areas. Generally, the speed groups remained in the same relative position in the over-all distribution throughout the rural and urban areas.
6. The speeds of vehicles making trips entirely within the developed area were consistently slower than vehicles traveling through the developed area.
7. The test car technique is a reliable means of predicting normal driver reactions to factors influencing traffic speeds.
8. In the 24-hr speed studies, there were no substantial differences in hourly average speeds within the hours of normal traffic operation. Even smaller variations were observed in the 85-percentile speeds.
9. Traffic speeds were reduced in the immediate vicinity of radar enforcement activity. The localized influence of enforcement had essentially dissipated at 4 mi on either side of the radar unit.

### RECOMMENDATIONS

The results of this research have shown that traffic responds to changing conditions on the roadway and surrounding area in a manner that is definitely in the interests of safety. Therefore, it is logical that speed limits be established using as a basis the characteristics of traffic speeds observed on the roadway. Any method or procedure of speed zoning that truly represents the speed characteristics of the traffic is acceptable.

It is reasonable that the speed characteristic chosen as a basis for speed zoning be representative of the majority of the traffic on the roadway. This majority is best defined by a speed value on a cumulative speed distribution curve above which the higher speed values are associated with rapidly decreasing percentages of vehicles; i. e., the breakpoint of the curve. Numerous observations have shown that this breakpoint is closely approximated by the 85-percentile speed.

It is recognized that traffic volumes on many secondary roadways are often too low to provide adequate samples of spot speed data within a reasonable length of time. Under such conditions it appears reasonable that methods of predicting traffic speed characteristics based on prevailing conditions would be much more economical and equally or more reliable than the small speed samples obtainable. However, based on this research, numerical values cannot be assigned to factors influencing speeds because each of the factors most frequently occurs in combination with other factors. These factors are believed to impose variable influences, depending on the specific combination, and on their sequence of occurrence within the developed area.

It is possible that a straight line relationship could be used to predict with reasonable accuracy speed characteristics in short, compact transition sections in small towns. However, fixing the end points of the line would depend on good engineering judgment. Generally, the rural speed limit could be used at the beginning of concentrated development. The urban end could be fixed by a reliable spot speed study at the inbound end of the transition section.

In longer transition sections where the straight line relationship does not necessarily apply, the test car method could be used in conjunction with a very limited number of reliable spot speed studies to predict the traffic speed characteristics continuously throughout the transition area.

This research has shown that traffic operation on a facility is directly related to its

geometric design and the character of development along the roadway. Therefore, if proper consideration is given to the influence of geometric elements and future development, it is possible to predict the level of service afforded throughout the design life of the facility.

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