Use of Parking Meter Revenues - During the past year, at the request of the Committee on Parking, the Committee investigated the use of parking meter revenues. A paper on this subject was presented at an open session of the Department of Traffic and Operations, Highway Research Board, at the 1949 annual meeting, sponsored by the Committee on Parking. It is being published in the 1949 proceedings of the Board.

The purpose of the investigation was to examine, objectively, the present significance of the parking meter in terms of the regulation it facilitates and the annual revenue it produces. Further, the study has sought to ascertain the legislative bases for the installation and use of the parking meter; and to review the judicial decisions involving such meters. Finally, based on these present legislative sanctions and judicial attitudes, certain economic aspects of the use of the parking meter have been investigated, particularly the potentialities of an extension of its present use at the curb.

INFORMATION INTERCHANGE

The Committee has issued 11 monthly memoranda during 1949, through the Correlation Service, covering current developments in the fields of its activity, including new laws and their significance, court decisions, State practices, and other items of timely interest as follows:

Memorandum No.	1949
22	January
23	February
24	April
25	May
26	June
27	July
28	August
29	September
30	October
31	November
32	December

Thus information not otherwise available for public distribution is furnished to highway administrators and technicians on the firing line as well. This service will be continued during the coming year.

ACCIDENT ANALYSIS - TELEGRAPH ROAD 1947-1948

J. Carl McMonagle, *Director, Planning and Traffic Division, Michigan State Highway Department*

This accident study was initiated in an attempt to measure the relationship or association that exists between accidents and highway design and roadside features.[1] The section of road selected for analysis is a 70-mi. strip including that part of US-24 which extends north from the Ohio state line to an intersection with M-58 at the southern city limits of Pontiac and the part of M-58 from its intersection with US-24 to its junction with US-10 just northwest of the city (See Fig. 1). This study section, known as Telegraph Road, contains a variety of roadside features and carries representative volumes and kinds of traffic. Ideally, for study purposes, it is improved with two-, three-, and four-lane pavements, and it traverses strictly rural areas, several industrial districts, and for a considerable distance the urban and suburban developments along the west city limits of Detroit. A heavy volume of traffic with a large commercial component is carried on the study section between

[1] This analysis was undertaken as an exploratory study for the purpose of developing statistical techniques to be employed in a more comprehensive analysis at a future date. The first progress report entitled HOW ROADSIDE FEATURES AFFECT TRAFFIC ACCIDENT EXPERIENCE, was presented by Mr. McMonagle, at the 1949 Annual Convention of The American Association of State Highway Officials, October 11, 1949, before the Committee on Traffic, at San Antonio, Texas

northern Ohio and several important industrial cities in southeastern and central Michigan. It is a convenient route for this traffic because it does not pass through the City of Detroit. However, due to its heavy traffic load and its proximity to metropolitan Detroit, extensive marginal development has taken place. Since most of the route is outside of incorporated areas, very little control of the development has been exercised.

A major stumbling block in previous accident studies has been the difficulty of locating accidents accurately in relation to design and roadside features. To overcome this difficulty, consecutively numbered station markers were positioned along the road every 1000 feet. Co-operation of the Michigan State Police and county sheriffs was secured in locating accidents in relation to the station markers. Accidents so located could then be plotted with accuracy on the strip map which was prepared for the study. (See Fig. 2).

The total number (2675) of fatal, personal injury and property damage accidents for the years 1947 and 1948 have been used in the study. For a listing of the roadside and design features considered, see Table 1.

The analysis of these data and the conclusions drawn therefrom are based on the philosophy, that irrespective of the quantity of data available, the precise causes of accidents cannot be positively determined. It is only possible to record and study a limited number of conditions under which an observed number of accidents have taken place. With this philosophy in mind the statistical analysis of the data proceeded by two methods.

TABLE 1

HIGHWAY DESIGN AND ROADSIDE FEATURES FOR ACCIDENT STUDY
TELEGRAPH ROAD - 1947-1948

Highway Design Features	Roadside Features	Advertising Signs
Curve	Tavern	(Large
Intersection	Gas Station	(Medium
Hillcrest	Garage	(Small
Transition in Width	Store	(Placard
Grade Sepr., Culvert, Gd. Rail	Restaurant	(Illuminated
Bridge	Park	(Neon & Flashing Neon
	Recreation Building	(Reflectorized
	Private Drive	(Animated
	Other Establishment[a]	(Miscellaneous

[a]In the event that two or more of the same type of establishments, such as two gas stations, were located within 950 ft. of an accident, the gas station nearest the accident was recorded as "Gas Station" and the other was recorded as "Other Establishment." Establishments other than those specifically mentioned above were also recorded as "Other Establishment."

One was to tabulate frequency distributions of accidents by distance of occurence from each specific feature. From these distributions accumulative percentages within various distances and rate curves were computed.

The other approach was to calculate correlation coefficients between the number of accidents and the number of various roadside and design features.

Following is a detailed analysis and presentation of conclusions obtained from the two statistical techniques employed.

ACCIDENT ANALYSIS STUDY ROAD
US-24 AND M-58

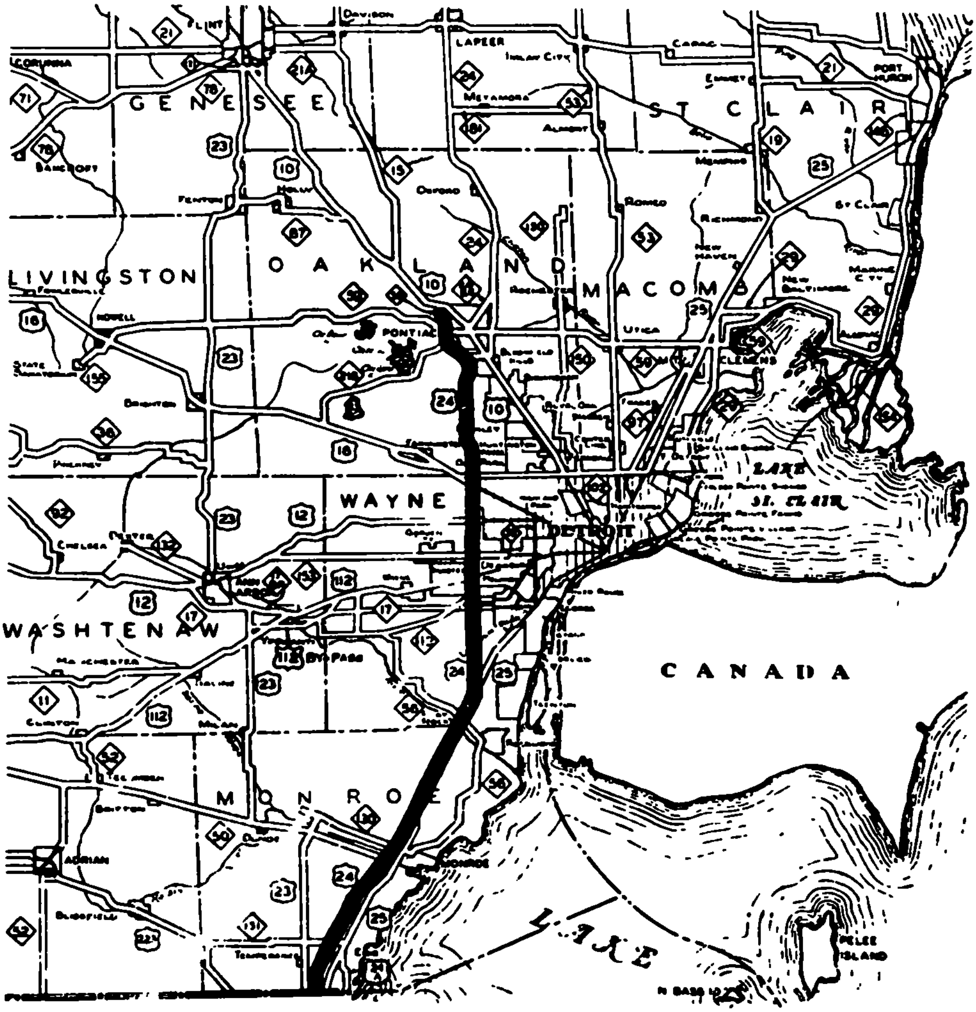

Figure 1. This map of Southeastern Michigan shows the importance of the study road both as an interstate highway between Toledo and industrial Michigan and as a route around the west side of Detroit. Telegraph Road was built as a by-pass route, but suburban developments immediately along its roadside have seriously impaired its usefulness for through traffic.

I. Analysis of frequency distributions of distances of accidents from individual features.

These frequency distributions were tabulated in order to ascertain accident patterns by distance. In the event that a large percentage of the accidents occured within a relatively short distance of the feature, that feature could be considered hazardous. A study of the accumulative percentage table reveals three distinct groupings of features, according to their accumulation pattern.

SAMPLE SECTION OF STUDY ROAD RECORD MAP

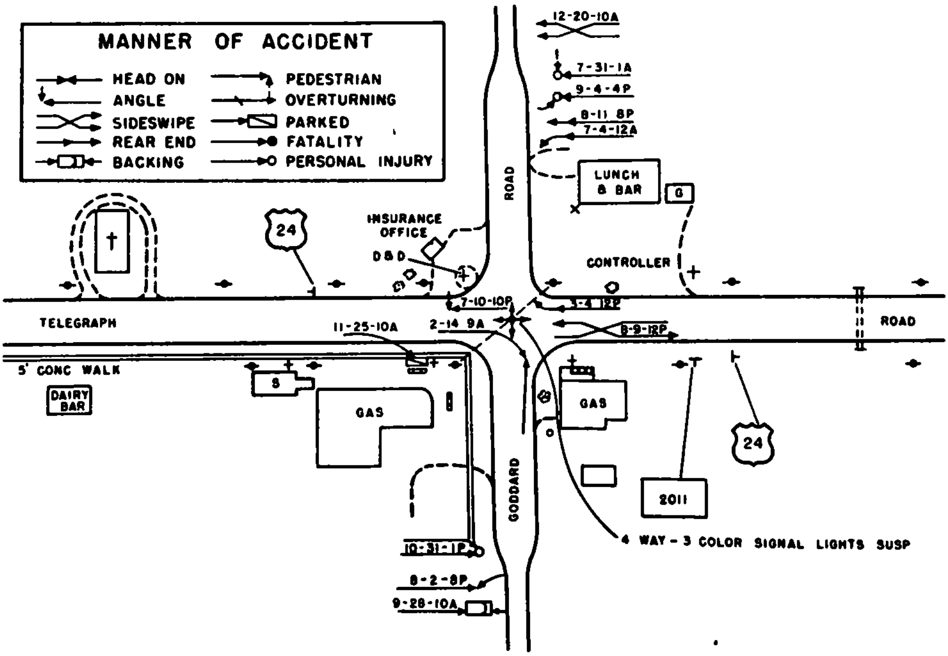

Figure 2. This is a section of the strip map which was drawn as an initial step in preparing accident data for analysis in relation to highway and roadside features. The features were inscribed on the map from the preliminary inventory of conditions. The data for each accident was then put on the map at the proper location in accordance with information contained in the police reports. Later all this data was punched into IBM cards for tabulation and machine computations and analysis.

(See Table 2.) Intersections lead all other features with 55 percent of the accidents occurring at the feature (zero distance) and by the criterion of accumulative percentage intersections are definitely the most hazardous feature in the study.[2] Gas stations are next with 38 percent of the accidents occurring at zero distance and the distribution pattern is very similar to that for intersections. The most significant comparisons of the data can be made by inspecting the percentages at zero and 250-ft. distances.

[2]Accumulative percentages are calculated with total number of accidents within 950 ft of the feature as a base.

The 250-ft. distance was chosen as a critical distance because a majority of the accumulative percentage curves exhibit a slope of 45 deg. or less beyond 250 ft. and also because of the flattening out of the rate curves beyond that distance. A study of the similarity of the accumulative percentage patterns for intersections and gas stations led to the belief that part of this similarity might be due to the fact that gas stations are located at intersections in many instances. To test this belief, a method was devised whereby the effect of gas stations on accidents could be considered separately from that of intersections. The procedure was to tabulate a frequency distribution

TABLE 2

ACCUMULATIVE PERCENTAGES OF ACCIDENTS OCCURRING WITHIN VARIOUS DISTANCES OF ROADSIDE AND DESIGN FEATURES

Group	Feature	Distances from Feature								
		0 ft.	50 ft.	150 ft.	250 ft.	350 ft.	450 ft.	550 ft.	750 ft.	950 ft.
I	Intersections	55	66	78	84	89	93	95	98	100
	Gas Stations	38	49	62	73	78	83	86	93	100
II	Curves	37	40	45	49	54	65	68	89	100
	Crest of Hill	25	27	33	45	54	61	70	92	100
	Other Establishments	24	33	53	67	79	87	91	96	100
	Transition in Width	18	26	47	64	74	81	85	94	100
	Taverns	8	15	34	61	65	75	82	93	100
	Stores	18	25	44	57	70	77	87	94	100
	Private Drives	8	15	33	53	66	79	84	93	100
	Restaurants	17	21	39	52	63	73	78	92	100
	Garages	9	11	28	45	53	62	67	86	100
	Advertising Signs	8	12	26	44	53	68	77	87	100
III	Recreation Buildings	2	7	40	43	45	56	66	80	100
	Parks	10	11	20	33	41	58	69	86	100
	Grade Sep'r. & Guard Rails	8	12	22	33	43	55	65	78	100
	Bridges	3	6	10	19	25	35	45	64	100
	Intersections[a]	35	46	62	67	75	82	87	94	100
	Garages	9	14	24	34	48	57	63	78	100
	Stores	7	11	22	31	37	49	63	83	100
	Restaurants	11	14	23	33	40	50	60	81	100
	Gas Stations	4	7	13	24	40	53	62	76	100

[a]Percentages from a frequency distribution considering only those accidents 350 ft. or more from any gas station, garage, store, or restaurant. The percentages for garages, stores, restaurants and gas stations were computed from frequency distributions considering only those accidents 350 ft. or more from intersections.

of distances of accidents from gas stations which considered only those accidents 350 ft. or more from intersections. The same kind of tabulation was made for restaurants, garages and stores. Finally a frequency distribution of distances of accidents from intersections was made which considered only those accidents 350 ft. or more from any gas station, garage, store or restaurant. The accumulative percentage patterns for these distributions are shown in Table 2. In comparison with all other roadside and design features, intersections still have the greatest percentage of accidents within 250 ft. and therefore by the accumulative percentage criterion remain the most hazardous. Gas stations, garages, stores and restaurants, however, have distribution patterns similar to those of Group III. Therefore, the logical conclusion is that the situation where gas stations, stores, garages and restaurants are located away from intersections is less hazardous than the situation where intersections and the above features are found together.

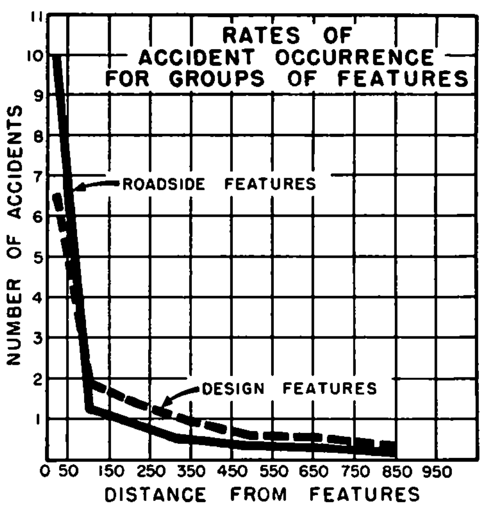

Figure 3. The two curves on this graph represent the rate of accident occurrence per hundred feet at various distances when the whole group of design features and the whole group of roadside features are considered. The roadside feature curve shows that the rate is more than 10 accidents per hundred feet close to such features, and that the rate falls to less than 2 at a distance of 100 ft. These rates are well above those for design features, which are about 6.5 close by, and fall to about 1.25 at a distance of 100 ft.

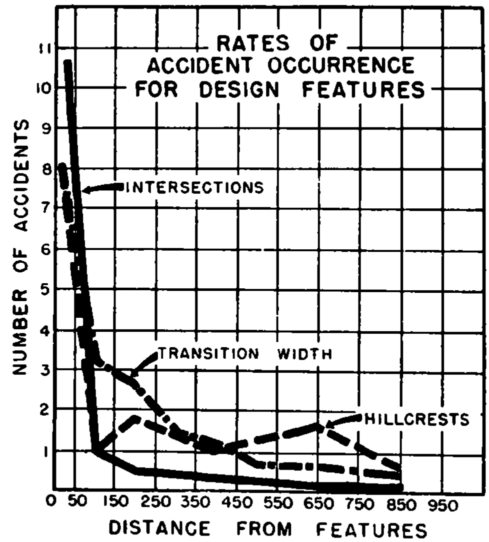

Figure 4. These curves represent the accident rates per 100 ft. for the three most significant types of design features. The intersection rate of more than 10 accidents within 50 ft. is the highest, though both changes in pavement width and crests of hills appear to be considerable factors. However, it should be noted how much more the influence of intersections is concentrated right at the feature.

Rate Curves - The rate curves (See Figures 3, 4, and 5) were obtained from the data furnished by the frequency distributions. The rate in this instance is defined as the number of accidents per feature per 100 ft. for each distance interval. The number of accidents per feature was determined by dividing the number of accidents in each distance interval of the frequency distribution by the total number of the particular feature under consideration. In determining the rate per 100 ft., adjustments of the number of accidents were necessary because of the variability of the distance intervals established for the frequency distributions. To compute the accident rate per 100 ft. for the first 50 ft., the number of accidents of the feature and those from one to forty-nine feet from the feature were added together and multiplied by two. To compute the accident rate per 100 ft. for the 200-ft. distances, the number of accidents within each of these intervals was divided by two.

A study of the rate curves shown in Table 3 reveals a grouping of roadside and design features similar to that for accumulative percentages. The groupings are as follows:

Group I contains those features which exhibit high accident rates, eight or more per 100 ft. for the initial 50-ft. distance, and then display relatively low accident rates which are fairly uniform for the remaining distances.

Group I

Curve
Gas Station
Intersection
Crest of Hill

Group II contains those features which exhibit accident rates, less than eight but greater than two for the initial 50-ft. distance, and then show marked fluctuations for the remaining distances.

Group II

Transition in Width
Tavern
Restaurant
Garage
Other Establishment
Store
Recreation Building

Group III contains those features which exhibit low accident rates, less than or equal to two per 100 ft. for the initial 50-ft. distance, and also show low rates for the remaining distances.

Group III

Park
Bridge
Grade Sepr. & Gd.Rail
Private Drive
Adv. Sign (Large)

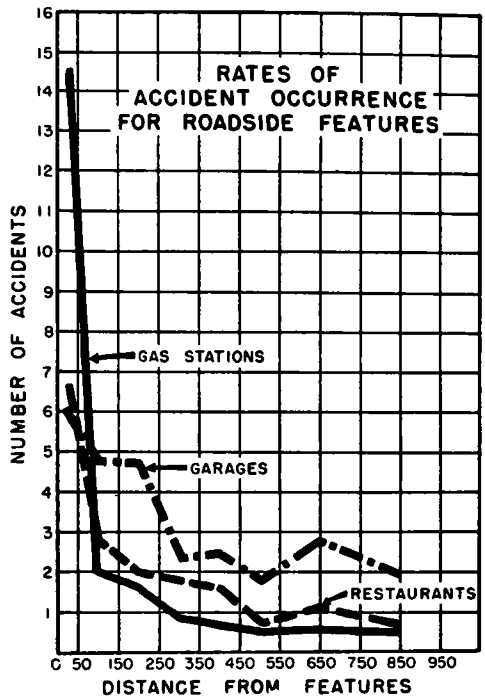

Figure 5. The clearly outstanding thing on this graph is the high accident rate at gas stations in comparison to the rates for restaurants and garages, the two roadside features of next importance. The gas station rate of over 14.5 within 50 ft. is by far the highest found for any other feature of any kind. But as I have pointed out, these stations are for the most part at or close to intersections, and it is suspected that this proximity influenced results obtained by our method of analyzing the data. The similarity in the curves for gas stations and intersections supports this view.

TABLE 3

RATE OF OCCURRENCE OF ACCIDENTS PER FEATURE PER 100 FEET

GROUP I

Distance	Curve	Gas Station	Intersection	Crest Of Hill
0-49	15.13	14 56	10.64	8.11
50-149	.90	1.98	.94	92
150-249	.90	1.62	48	1.81
250-349	.90	.82	.37	1.32
350-449	2.05	.69	.31	1.03
450-549	.63	.48	.19	1.32
550-749	2 00	.53	.10	1.62
750-949	1.03	.50	.08	.59

GROUP II

Distance	Trans. In Width	Tavern	Restaurant	Garage	Other Establm't.	Store	Recreation Building
0-49	8.07	6.98	6.65	6.11	4.72	4.46	2.33
50-149	3.20	4.27	2 74	4.79	1.43	1.71	5.17
150-249	2.62	6.18	1.98	4.74	.98	1.18	.50
250-349	1.44	1.00	1.76	2.34	.79	1 17	.33
350-449	1.13	2.20	1.60	2.47	.55	.68	1.67
450-549	.65	1.62	73	1.76	.30	.89	1.50
550-749	.65	1.24	1.12	2.76	19	30	1.17
750-949	.45	.78	61	1.92	.13	.27	1.66

GROUP III

Distance	Park	Bridge	Grade Sep'r. & Gd. Rail	Private Drive	Adv Sign (Large)
0-49	2.40	2.09	1.80	.84	.24
50-149	.93	65	.77	.53	.13
150-249	1.50	1.57	.82	.57	.17
250-349	.85	1.09	.76	.35	.08
350-449	1 80	1.87	.97	.38	.15
450-549	1.18	1.61	.71	.15	.08
550-749	.98	1.69	.52	13	.05
750-949	.75	3.17	.83	.18	.06

II. Correlation Analysis - The statement has previously been made in the report that it is only possible to record and study a limited number of conditions under which an observed number of accidents have taken place. By considering several conditions which can be measured and by correlating their numerical values with numbers of accidents, one can express numerically the degree of consistency with which each condition accompanies accidents. When this correlation coefficient, as it is called, is sufficiently high, a case of cause and effect can be implied and the assumption made that the condition under consideration made some contribution to the occurrence of accidents.

In computing a simple correlation coefficient it is necessary to have a number of pairs of measurements for the two items being correlated. These pairs of measurements were secured by dividing the entire road into sections of uniform length and then enumerating, within each section, the number of accidents and, for example, the number of intersections (if accidents and intersections are the two items being correlated). (See Figures 6 and 7) Before proceeding with this enumeration, it was necessary to decide on the length of section to be used. Some preliminary tabulations were made for sections 1000 ft., 3000 ft. and 5000 ft. long. It was discovered that sections 1000 ft. long, 369 in number, were too short to be representative of the road as a whole because many of the roadside and design features were not included in the individual sections. Sections 3000 and 5000 ft. long, totaling 123 and 74 in number, were found to give much better representation. The decision to use sections 3000 ft. long was due principally to their larger number which is of importance in gauging the reliability of the correlation coefficients. For sake of comparison, however, correlation coefficients were computed using all three section lengths. The resulting coefficients are shown in Table 4.

The table bears out the foregoing analysis in that the values of the coefficients for the 1000-ft. sections are considerably lower than those for 3000-ft. and 5000-ft. sections. Apparently the 3000-ft. section is sufficiently representative since the values of the coeffi-

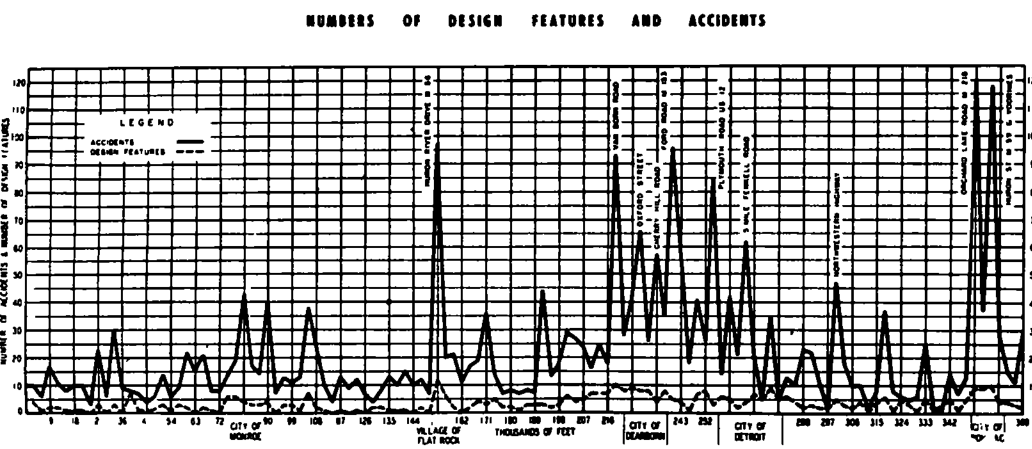

Figure 6. This is a strip graph covering the whole length of the study road. The curves represent the numbers of accidents and the numbers of design features occurring in each of the 3000-ft. sections into which the road was divided for analysis purposes. It will be noted that, while there are certain points where there appears to be some degree of parallelism in the direction of the curves, the correlation is by no means consistent.

TABLE 4

VALUES OF CORRELATION COEFFICIENTS FOR 1000, 3000 and 5000-FOOT SECTIONS

Feature Correlated with Accidents	Total Number	1000 ft.	3000 ft.	5000 ft.	Adjusted[a] 3000 ft.
Design Features					
Intersections	296	.41	.64	.72	.53
Crest of Hill	37	.20	.38	.23	-.04
Transition in Width	55	.20	.17	.20	.32
Curves	39	-.02	-.05	.08	-.05
Grade Separation & Guard Rails	181	-.05	-.29	-.36	-.28
Total of Selected Design Features[b]	427		.61		.61
Roadside Features					
Other Establishments	295	.38	.70	.74	.49
Gas Stations	124	.63	.68	.67	.58
Stores	168	.41	.63	.59	.38
Restaurants	95	.43	.61	.57	.48
Taverns	45	.41	.59	.49	.14
Garages	38	.22	.37	.45	.32
Parks	40	.02	-.09	-.16	-.09
Private Drives	836	.00	.03	.17	.02
Total of Selected Roadside Features[c]	765		.79		.64
Advertising Signs					
Small	623	.34	.46	.44	.33
Medium	426	.30	.33	.30	.30
Large	232	.12	.11	.13	.04
Illuminated	189	.42	.52	.48	.39
Neon and Flashing Neon	232	.46	.56	.52	.42
Reflectorized	79	-.01	-.08	-.11	-.09
Miscellaneous	793	.09	.11	.13	.14
Total Advertising Signs	1307	.36	.41	.37	.30

[a]Correlations computed after removal of ten high accident rate sections
[b]Intersection, Curve, Transition in Width, Crest of Hill
[c]Other Establishment, Gas Station, Store, Restaurant, Garage

Note - Correlation coefficients were not computed for bridges and recreation buildings because of their low frequency of occurrence along the road.

cients for that length section are very similar to those for the 5000-ft. section.

Before looking at the individual correlations, it is best to explain the meaning of a correlation coefficient and some of its properties. A correlation coefficient is simply a measure of the degree of association that exists between two variables. Graphically, it is a measure of how closely two variables tend to lie along a straight line when plotted on a Cartesian coordinate system. Perfect correlation is denoted by a value of one and complete absence of correlation by zero. Perfect negative correlation is signified by negative one. The relationship is such that the greater the association between two variables the higher the value of the correlation coefficient.

Returning to the table, we find a correlation of 0.70 between accidents and other establishments, of 0.64 between accidents and intersections, of 0.68 between accidents and gas stations, etc. These values are sufficiently high to indicate a definite relationship between the occurrence of accidents and the above named features. On the other hand we find a correlation of 0.17 between accidents and transition in width, and of 0.11 between accidents and large advertising signs. These values are so low that only a very slight association is indicated. There is also the negative correlation of -0.29 between accidents and grade separations and guard rails which gives some indication that these features might help prevent accidents.

When the study was initiated it was hoped that it might be possible to establish relative hazard values for some of the roadside and design features on the basis of the numerical size of the correlation coefficient. An analysis of the correlations between the features themselves precludes such a development however. In several instances the correlations between various roadside features are almost as high as the correlations between features and accidents. For example the correlation between accidents and gas stations is 0.68; between accidents and stores is 0.63. The correlation between gas stations and stores is 0.65.

NUMBERS OF ROADSIDE FEATURES AND ACCIDENTS

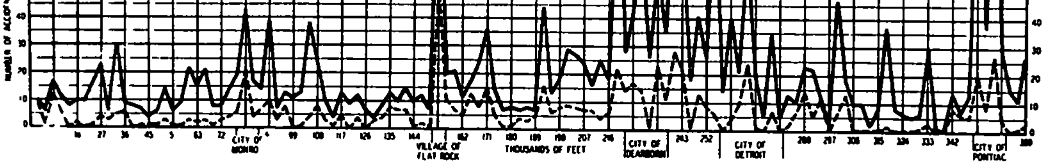

Figure 7. This is also a strip graph of the study road, but in this case numbers of accidents are plotted in relation to the numbers of roadside features in each 3000-ft. section. Contrasting with the preceding graph, the accident curve line in this case not only follows the direction of the curve representing roadside features, but tends to duplicate the amount of its movement. It should be pointed out that sections with many features usually have a larger proportionate number of accidents than do those sections with fewer features.

Items Correlated	Corr. Coeff.
Accidents and gas stations	.68
Accidents and stores	.63
Gas stations and stores	65

The conclusion to be drawn from this analysis is that no distinction can be made between the contributions of these two features to the occurrence of accidents because of their frequent proximity to each other.

It is possible to distinguish between roadside features, design features and advertising signs as groups. Certain roadside and design features were selected on the basis of their relatively high association with accidents and their totals were used in computing correlation coefficients. A complete total of advertising signs was used in establishing a correlation. The correlations resulting from this procedure definitely indicate that a grouping of roadside features contributes more to the occurrence of accidents than a grouping of design features and both in turn contribute more than advertising signs.

Items Correlated	Corr. Coeff.
Accidents and Total of	
Selected Roadside Features	.79
Selected Design Features	.61
Accidents and Total Advertising Signs	.41

It is now evident, that although it is extremely difficult to single out the contributions of individual features to the occurrence of accidents, it is possible to distinguish between groups of features and their contributions. The high correlation between accidents and other establishments gives support to the theory that accidents came about because of the effect upon drivers of an accumulation of features in a group. Various features taken singly are not nearly as hazardous as a group of those features.

To investigate this grouping effect more thoroughly some multiple correlation coefficients were computed. All previous correlation analysis has dealt with associations between two variables only. However, situations frequently arise in research studies which call for consideration of three or more variables bearing simultaneously on a problem. There are interrelations existing between three or more variables which must be investigated. By applying multiple correlation theory to this study it is possible to discover that group of intermixed design and roadside features which apparently contributes most to the occurrence of accidents. The results of the calculations are presented in Table 5.

TABLE 5

MULTIPLE CORRELATIONS BETWEEN ACCIDENTS AND VARIOUS ROADSIDE AND DESIGN FEATURES

Items Correlated	Corr. Coeff.
Accidents with Intersections, Gas Stations and Other Establm'ts.	.83
Accidents with Intersections, Gas Stations and Stores	.78
Accidents with Intersections, Gas Stations and Total Adv. Signs	.77
Accidents with Intersections, Gas Stations, Stores and Other Establm'ts.	.89

The table indicates a high degree of association between accidents and the group of features that includes intersections, gas stations, stores and other establishments. It is readily admitted that some of the intersections with considerable roadside development may also experience high traffic volumes and that such volumes may enter prominently into the occurrence of accidents. However, such a circumstance does not destroy the validity of the association that has been shown to exist between features and accidents. Traffic is variable which will be taken into consideration when further analysis is undertaken in connection with this study.

TABLE 6

FREQUENCY DISTRIBUTION OF NO. OF ACCIDENTS BY NO. OF SECTIONS

Accidents	3000 Ft. Sections	
0-9	37	
10-19	43	$M_v = 23.1$
20-29	18	
30-39	8	
40-49	7	$v = 25.0$
. . . . . .	. . . . . .	
50-59	1	
60-69	3	
70-79	0	
80-89	1	
90-99	3	
100-109	0	
110-119	2	
Total	123	

The frequency distribution shown in Table 6, appears to portray two different situations. The ten sections below the dotted line exhibit accident rates which are considerably higher than the sections above the line. Simple computations reveal that:

1. 855 or 32 percent of the total number of accidents in the study occurred within 8 percent of the total road distance.

2. 57 or 20 percent of the total number of intersections are within the ten 3000-ft. sections.

A detailed analysis of each of the ten sections, made by reference to the strip map, revealed that in *every instance* the accidents were concentrated at intersections characterized by extensive roadside development.

In view of the abnormal number of accidents characterizing these ten 3000-ft. sections, the decision was made to separate these sections from the other 113 and to make a correlation analysis of the data after these sections had been removed.

It was believed that these ten sections might be responsible for a large part of the correlations previously computed. This was done and although some of the individual correlations dropped in value (See Table 4), the coefficients for the total number of selected roadside features, design features and total advertising signs remained substantially the same.

III. Miscellaneous Studies

A. Manner of Accidents - Frequency distributions by manner of accident revealed that angle accidents occur predominantly at intersections.

B. Period Analysis - Frequency distributions of distance of accidents from Large Advertising Signs were tabulated for the 4-6-month periods of 1947-48. It was discovered that the accident patterns by distance were approximately the same.

C. Daylight and Darkness Study - This study was undertaken in order to determine if there was a variation in the correlation coefficients between accidents and selected signs for daylight and darkness. See Table 7 for results.

TABLE 7

CORRELATIONS BETWEEN ACCIDENTS AND SELECTED SIGNS DURING DAYLIGHT AND DARKNESS

Items Correlated	Corr. Daylight	Coeff. Darkness
Accidents and		
Illuminated Signs	.51	.49
Neon and Flashing		
Neon Signs	.55	.55
Reflectorized Signs	-.10	-.06

The conclusion is that the effect of Illuminated, Neon and Flashing Neon and Reflectorized Advertising Signs is the same in daylight as after dark.

D. Intersectional Study by Counties - Accidents at or within 50 ft. of intersections comprised 68 percent of the total in Wayne County, 67 percent of the total in Oakland County, and only 32 percent of the total in Monroe County. This seems to indicate that the intersectional problem is greater in the densely populated areas than in the sparsely populated areas.