The Traffic Counting Program In Cincinnati

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The traffic counting program in Cincinnati is the result of an effort to develop a comprehensive program for obtaining information on traffic volumes on the city's street system.

This information is used for three purposes: 1. in the planning and design of traffic control and traffic operations on existing facilities; 2. in the planning and design of new highway facilities; and 3. in the study of traffic patterns and trends.

The basic element of this program is the use of portable 15-minute recording counters, which provide short time traffic volume information suitable for use in traffic control and operations work, and also provide an efficient method of obtaining traffic volumes for 24 hours and longer periods. The portable counters are supplemented by manual counts, made mostly during peak hours, and by six permanently located hourly recording counters, which are maintained by the Ohio State Highway Department.

In the field of traffic operations, traffic volume studies are used in determining warrants for and designing traffic signals; in determining warrants for parking restrictions, stop signs, and street markings; and in the planning and operation of reversible lanes and one-way streets.

The traffic counting program in Cincinnati also provides basic data for use in planning and designing highway improvements and new highway facilities.

The equipment and procedures used in this program and some of the studies which have been and are being made of traffic patterns and trends are described. These include studies of hourly variations at key stations; comparative studies of hourly, daily, and seasonal traffic patterns on a city street, a state highway with trucks prohibited, and a state highway with mixed traffic; and development of city-wide traffic flow maps and vehicle mileage figures.

● TRAFFIC COUNTS and volume studies have been an integral part of Cincinnati's traffic engineering program since 1949. Prior to that year, the counting was done manually, since it was not possible to develop a comprehensive counting program because the Division of Traffic Engineering was functioning without adequate manpower.

In 1949, 11 Streeter-Amet 15-minute recording counters were purchased and this number had been increased to seventeen by the end of 1955. These counters have formed the basis of the traffic counting program. By the end of 1956, a total of more than 7,000 individual counters had been placed at various locations in Cincinnati.

Supplementing the mechanical counts, many manual counts are made at various locations, primarily during peak hours. These studies obtain other information, such as turning movements, vehicle classification, and vehicular delays. Furthermore, the policy is to hire extra help during the summer season each year, and a considerable portion of this extra help has been used on special manual counts and volume studies.

An important additional source of traffic volume information became available in 1954 with the installation of 6 permanent hourly recording traffic counters at various locations in the city. These counters operate from the vehicle detectors at volume-density controlled traffic signals, and are providing valuable continuous volume information. The installations were made, in connection with city owned signals, by the Planning Survey Division, Ohio Department of Highways, with 50 percent participation of Federal funds.

Traffic volume information has three major areas of usage: operations, planning and classification, and studies of traffic volume patterns and characteristics. The uses of traffic volume information in operations work include:

1. Determination of warrants for, and planning and design of traffic control devices.
2. Determination of warrants for, and planning and design of channelization and localized street improvements.
3. Enforcement studies.
4. Planning of maintenance operations.
5. Speed zoning of thoroughfares.
6. Before and after studies of traffic improvements.

Traffic volumes are used for classification and planning work in many ways including:

1. Developing priorities and planning for major highway and expressway improvements.
2. Establishment of standards of construction on major highway and expressway improvements.
3. Street system classification and development of major through street plan.
4. In conjunction with major traffic surveys such as parking, origin-destination, speed-delay and economic studies, and mass transit studies.
5. Capacity-volume studies.
6. Utilization of data by commercial interests in connection with development of abutting lands.

Another area of usage of traffic volume studies is in study and analysis of traffic volume patterns, trends, variations and characteristics. One important phase of this work in Cincinnati has been the use of various volume study techniques and statistical methods in determining count-frequency levels sufficient to produce adequate results.

Much of the data used in these studies was obtained from the quarterly count program (started in January, 1952), in which traffic is counted four times per year, approximately three months apart, at key locations throughout the city. The program originally included 18 locations, but has been expanded to include 26 locations, with a total of 92 individual stations or street sections (Figure 1).

Because the analysis of traffic volume data on a research basis is relatively new in Cincinnati, these studies are not definitive, but are samples of the types of investigations and analyses which can be made, and which may warrant further study.

Studies of 24-Hour Sampling Procedures

Since the great majority of traffic volume counts in Cincinnati are 24-hour mechanical counts, studies would be desirable to determine the reliability of single, randomly selected, 24-hour mechanical counts, and to determine how such counts may differ from the Average Daily Traffic (ADT) volume, and from the average weekday volume.

As a preliminary, a brief study was made to compare traffic volumes obtained through two available methods simultaneously. In this study, the 24-hr volumes obtained from the quarterly counts, made with the portable 15-min recording counters, were compared with volumes for the identical periods obtained from the permanent hourly recording counters in 1955.

The results of this study did not show as close an agreement between the volumes obtained by the two methods as was desired, even considering the fact that it was not always possible to coordinate the counting periods closer than ½ hr. The differences between the two were converted to percentages and studied. It was found, using the permanent count volumes as a base, that the portable count volumes in the 14 comparable situations had an average deviation of 5.26 percent, and a standard deviation of 6.05 percent.

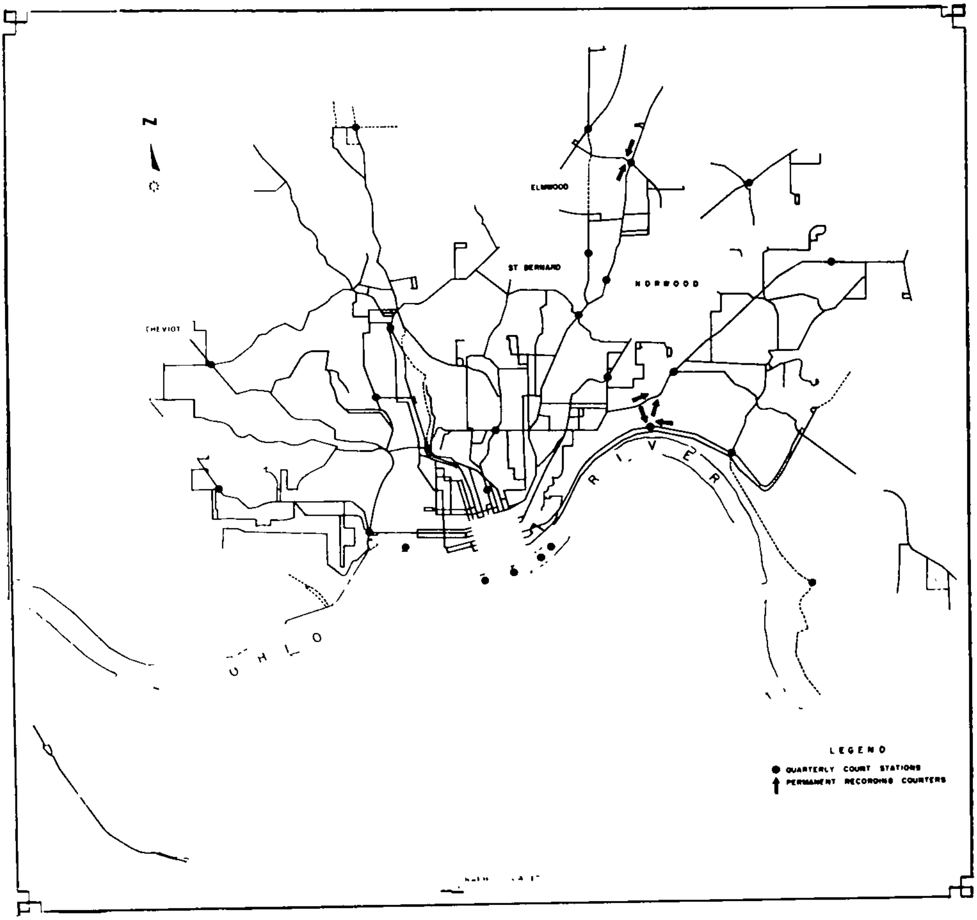

Figure 1. Counting stations, Cincinnati.

The maximum deviation was 9.75 percent.

Although such a range of deviations is sufficiently small to be satisfactory for traffic operations and traffic control work, it was disappointing when found in counts taken of the same traffic at the same time and location. This apparently indicates the need for much closer checking of count records, counter maintenance, and counter placement and tabulating procedures, in an effort to reduce these deviations. In spite of the problem, it was felt that both the portable and permanent counts could be used profitably in making further studies and analyses.

Since the ADT volume is the "common denominator" for traffic volume studies, ADT volumes and average weekday traffic volumes were figured by various methods using the data from both the permanent and the quarterly counts obtained in 1956.

Table 1 shows that ADT volume obtained by averaging all of the good days from each of the permanent count stations (first column). Since some days were missed due to mechanical or electrical defects in the counters and such missed days were not necessarily evenly distributed through the week, the figures in the second column were computed using a weighted average, based on the yearly average volume for each day in the week. This figure is the most accu-

TABLE 1
AVERAGE TRAFFIC VOLUME
TABULATION AND COMPARISON OF VARIOUS METHODS

Location	Permanent Station			Quarterly Station			Quarterly Station
	Average All Good Days	Weighted Average	Weighted Weekday Average	Four-Season Average Volume	Deviation from Weighted Av.* (%)	Average Deviation from Wkday Weighted Av.† (%)	Three-Season Average
SB Reading, n. of Seymour	13,296	13,305	13,443	13,178	−0.95	−1.97	13,751
NB Reading, s. of Seymour	11,399	11,482	11,388	10,502	−8.55	−7.79	10,808
WB Columbia, e. of Torrence	11,926	11,933	12,234	12,307	+3.13	+0.59	12,692
SB Torrence, n. of Columbia	5,766	5,758	6,226	6,566	+14.0	+5.46	6,749
NB Torrence, s. of Madison	4,818	4,825	5,151	—	—	—	—
EB Madison, w. of Torrence	10,274	10,282	10,706	—	—	—	—

* AD = 6.64%. † AD = 3.95%.

rate available for the true ADT volume.

For operational purposes in an urban area, the average weekday traffic volume may actually be a more satisfactory figure than the true ADT volume for two reasons: (a) where the Sunday and holiday volumes are greatly different from the weekday volumes, the ADT may be substantially different from the volumes occurring more than 300 days out of the year; and (b) since weekend and holiday counts are more difficult to obtain because of personnel and equipment limitations and are usually of little value in themselves for operational purposes, an urban counting program will usually be based on weekday counts. The average weekday volumes are shown in the third column of Table 1. The fourth column shows the average of the four quarterly seasonal counts at each of the comparable locations, and the fifth and sixth columns show the deviations from the true ADT and from the true average weekday volumes, respectively. Since the quarterly counts are actually weekday samples, it is not surprising that the deviations from the average weekday volumes are much smaller (average deviation 3.95 percent) than the deviations from the true ADT (average deviation 6.64 percent). The difference between the two deviations will depend on the characteristics of the roadway with respect to traffic volumes on Sundays and holidays.

Although this study involves too few samples to be statistically significant, it indicates that the average of the four seasonal counts does give an accurate estimate of the average weekday traffic volume.

The last column shows the figure which would be obtained if the winter count at each location were omitted and the three other seasonal counts averaged. This figure, in general, may be expected to be higher than the true annual average weekday volumes, since the winter volumes are generally the lowest of the year. This figure would be primarily useful in reducing the number of counts needed to measure yearly trends. It does not appear satisfactory as a method of estimating the average weekday traffic volume.

Using data obtained from the permanent count records, a study was made of the variations in traffic volumes on different days of the week. Figure 2 shows the results of this study, with the daily volume at each station converted to a percentage of the ADT volume.

The character of the urban street and the type of traffic it carries has a very strong influence on the various traffic patterns. This is certainly the case in the daily variation pattern as shown in this illustration. The streets with commercial and/or state highway traffic show a much more stable daily pattern than do the streets with parkway and non-commercial traffic, on which the Saturday and Sunday volumes drop off very sharply. In this connection, the term "parkway" has a somewhat different meaning in Cincinnati than in some areas, referring merely to a roadway on which commercial traffic is prohibited. Thus, Columbia Parkway and Torrence Parkway form a part of the arterial street pattern, serving a large amount of commuter traffic, rather than being express facilities, or serving recreational traffic.

Generally speaking, if Sundays and holidays were disregarded entirely, the deviation of any one day from the average weekday volume becomes quite small. The maximum deviation of any weekday except Saturday shown at any of the six stations was 7.98 percent. From this, it appears that no serious error will be introduced into traffic volume studies due to the day of the week on which the counts are made.

The major part of the traffic counting in Cincinnati is based on the use of single mechanical counts, made on a ran-

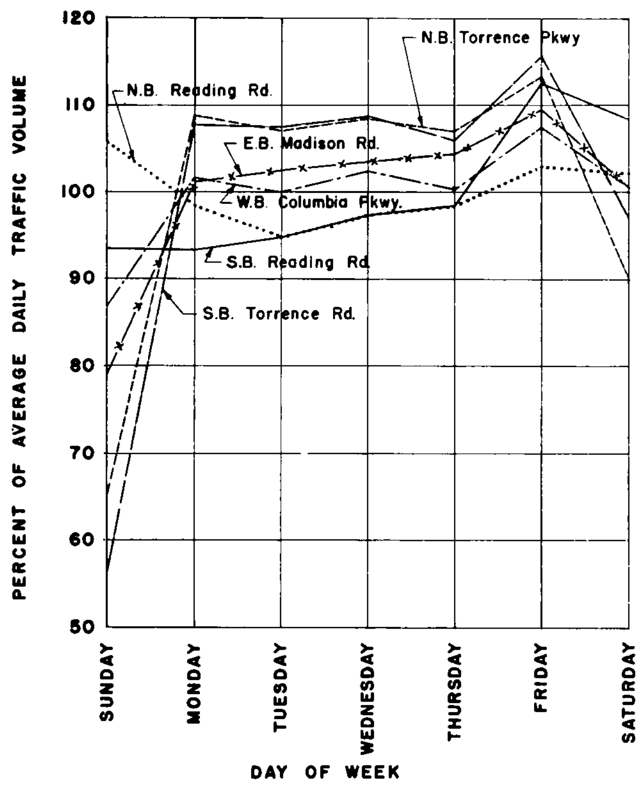

Figure 2. Average traffic volume by day of week, permanent count stations.

domly selected 24-hour weekday period. It was important, therefore, to determine the reliability of such counts; that is, the difference of single 24-hour weekday volumes from the annual average weekday volume. In analyzing these differences, a statistical method suggested by Boris B. Petroff, Secretary, HRB Committee on Urban Volume Characteristics, was used. Petroff also participated in the computational work of the analysis.

Except for the six permanent stations, there were no data available as to the true annual average weekday traffic volume. However, an approximation was possible, using the quarterly count data. At 26 key locations, comprising 92 street sections or stations, four 24-hour weekday counts were made each year, three months apart. At each of the 92 stations the average of the four counts during the year represents the estimate of the annual average weekday traffic volume. Petroff reported that this procedure has been found in other studies to give accurate estimates of the annual average weekday traffic volume, and these studies are in agreement with this principle. Comparisons could be made between the individual 24-hour counts and the corresponding estimates of average weekday traffic volumes based on four seasonally spaced 24-hour weekday counts.

Testing Procedure

1. For the first listed street section at each of the 24 quarterly count locations (these include four bridges) the estimate of annual average weekday traffic was obtained by adding the four seasonal counts and dividing by four.
2. The differences between each individual seasonal count were computed and expressed as percentages of the annual averages. These percentages are the errors of estimates.
3. The standard deviations of errors were computed, and comparisons were made between the theoretical normal distribution and the actual distribution of errors for one or two standard deviations. In accordance with the normal curve of distribution, 68 percent of all units in the sample should have errors equal to or smaller than plus or minus one standard deviation, and 95 percent of all units should have errors equal or smaller than plus or minus two standard deviations.

The comparisons showed standard deviations from the four-season average as follows: winter, 12.0 percent; spring, 7.7 percent; summer, 8.2 percent; autumn, 12.3 percent. The actual distribution of the deviations conformed closely to the theoretical normal distribution, indicating the reliability of the studies. These figures indicate that more than two-thirds of the individual 24-hour count volumes in each season deviated from the four-season average by less than the figure given.

These figures indicated that the 1955 spring and summer counts deviated considerably less and can be considered more dependable than the fall and winter counts. However, the counts from all seasons could be considered accurate enough for most practical purposes, therefore, the randomly selected individual 24-hour count does give a reasonably reliable representation of the annual average weekday traffic volume for most purposes.

Although the above conclusion is of importance, a higher level of accuracy from the counting program can be obtained (without expanding the program) by a closer control and check of the counter placement and tabulation to prevent the inclusion of counts which are abnormal, incorrect, or not representative — due to defects in the counter, its placement or tabulation, or due to unusual traffic conditions. This type of control is important because the acceptance of such unrepresentative counts may undermine the dependability of the entire counting program and may invalidate any statistical analysis of the data.

Traffic Flow Maps

An elementary but valuable and practical use of traffic volume data is in the preparation of flow maps. A graphical presentation has many uses including:

1. Simplified computations for vehicle-mileage and accident rate studies.
2. Development of through street system and classifications.
3. Planning of highway routing and off-street parking.
4. Planning and scheduling maintenance.
5. Planning selective traffic enforcement.
6. Planning traffic control devices, including development of priorities.

Figure 3 shows a block by block flow in the central business district, and Figure 4 shows the city-wide traffic flow, with volumes shown in each homogeneous segment on the major through street system. Homogeneous segments refer to segments through which the physical characteristics are more or less constant, and in which there are no major turning movements onto or off of the main street.

The city-wide flow map illustrates vividly the essentially radial, but badly cut up pattern of Cincinnati's street system, and also some of the traffic trouble spots which result in a city which "just grew" — and grew within an area of rugged topography. Also shown is the lack of good continuous cross-town or circumferential routes and the resulting overloads placed on certain spots on the radial system by inadequacy of cross-town routes.

Vehicle Mileage Computations

Vehicle mileage figures for individual

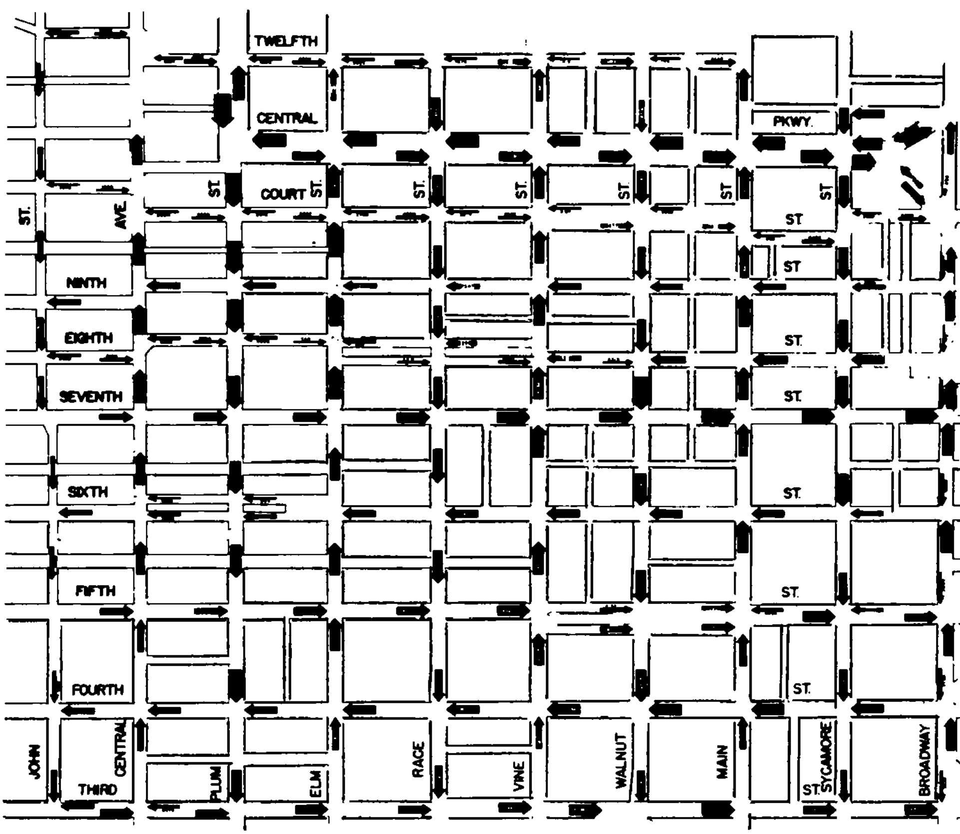

Figure 3. Traffic flow chart, central business district, 1956.

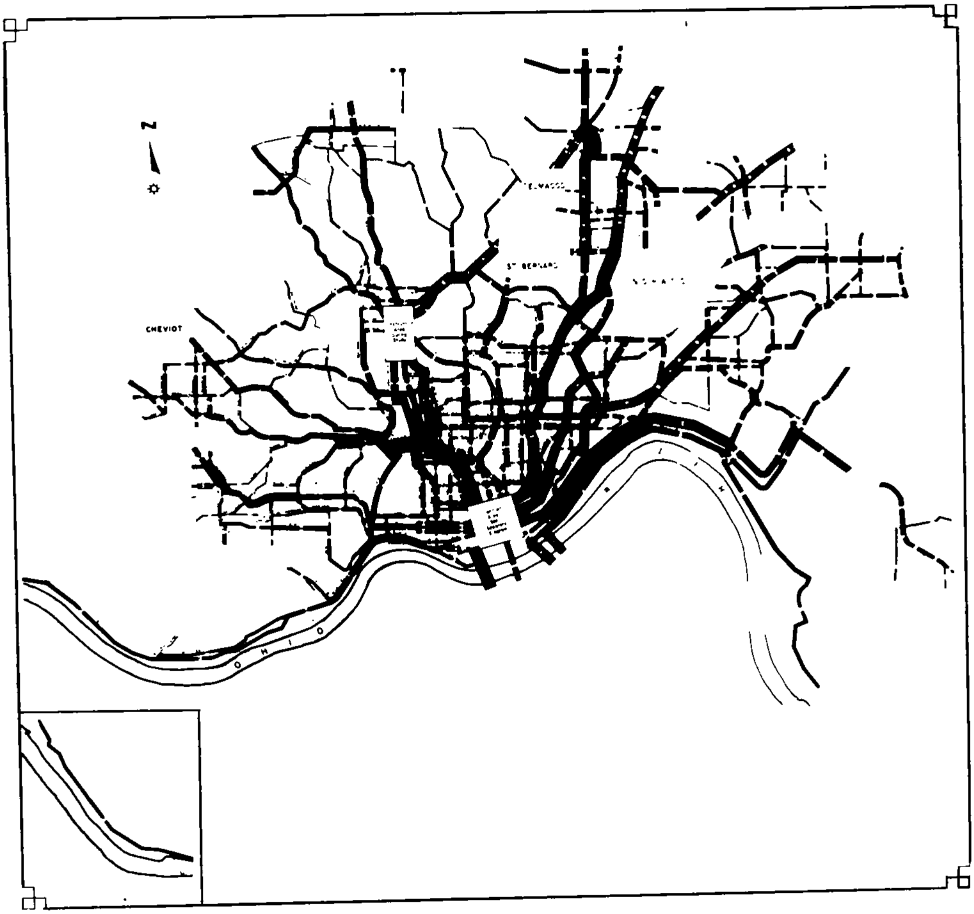

Figure 4. Traffic flow diagram, 1956.

streets or roadways are used in many ways, including:

1. Priorities for work programs or street improvements.
2. Priorities for snow and ice removal.
3. Computations of vehicle delay rates.
4. Computation of accident rates.

Area-wide or city-wide vehicle-mileage information is used in several ways including:

1. Computation of area-wide or city-wide accident rates; and development of standards for such rates.
2. Administrative purposes, such as allotment of funds by states to cities, or assignment of police manpower to districts or area.
3. Study of traffic trends, since overall vehicle mileage is certainly the ultimate measure of traffic changes and trends.

Obtaining a reasonably accurate vehicle mileage figure for an individual street or highway is not difficult, because a relatively small number of counts will give an adequate picture of the traffic volumes on all sections of the street, and the distance is known. However, extending such coverage to obtain information over an entire city of one-half million residents, serving a population of nearly a million, becomes a much greater problem because of limitations of manpower and equipment.

The computation of accident rates was an important part of a city-wide speed zoning program launched in Cincinnati in 1954. This also required a city-wide accident rate to use as a standard, which in turn required some sort of a city-wide vehicle-mileage figure. The figure which was used of necessity was little more than an informed guess. Surprisingly, the figure of 3,125,000 vehicle-miles per average weekday gave satisfactory results and reasonable answers from an operational standpoint in the accident-rate computation. It was found that accident rates in excess of 20 accidents per million vehicle-miles, or below 15 accidents per million vehicle-miles were worthy of special attention in the speed zoning work.

With the completion of the city-wide and downtown flow maps, a method was available for a much more accurate vehicle-mileage estimate. The downtown flow map showed a traffic volume in each block. In the outlying areas the flow map was based on the through street system which is subdivided into five classifications as follows:

Class AAA, Expressways and limited access roads;
Class AA, Arterial State and Federal Routes;
Class A, Arterial Through Streets;
Class B, Thoroughfares; and
Class C, Local Service Streets.

In preparing the flow map, volumes were obtained on each major segment of all streets of Class B or higher classification. A major segment was defined as a section of road between two successive intersections of other streets of Class B or higher classification.

To obtain a vehicle-mileage figure for all of the through streets of Class B or higher, the volume in each major segment was multiplied by the length of that segment. This did not account for approximately 90 miles of Class C through streets, and approximately 630 miles of non-through streets.

Class C through streets generally fall into one of three groups: (a) a collector or feeder street, which is an integral part of the through street pattern in feeding local traffic to a more important street from a residential business, or industrial area, or connecting two more important routes; (b) streets which are legally so classified because of existing (and frequently obsolete) stop sign control; (c) streets which are legally so classified by Ohio law because of the presence of a scheduled bus route. This classification thus includes a wide variety of streets with a wide variation in traffic volumes. However, on the basis of many traffic counts which have been made on such streets, the average volume estimate of 3,600 vehicles per day is a reasonable one.

Residential and other strictly local non-through streets are even more of an unknown quantity. In an effort to obtain volumes on them, a program of obtaining 24-hour volumes on a systematically selected sample of block segments has been started. Although this study is far from complete, indications are that the average volumes on such streets are approximately 570 vehicles per day. It is possible that this figure may be somewhat lower than that which would be obtained in a similar study in other cities, because the topography of many parts of Cincinnati creates many isolated residential streets, and many streets which are actually dead-end or no-outlet.

Table 2 is a summary of the computations used to develop the current estimated vehicle-mileage in Cincinnati. The final total was 3,752,000 vehicle-miles per average weekday.

Seasonal and Yearly Traffic Trends

It is difficult to develop a limited system of counting stations which gives a perfect representation of city-wide traffic volume trends. Therefore, the studies based on these locations are studies of apparent trends; however, these locations were selected as being representative of all sections in the city.

The use of such a system of representa-

TABLE 2
1956 VEHICLE-MILEAGE COMPUTATION, CITY OF CINCINNATI

Street Classification	Miles of Street	Average Volume, Vehicles per day	Vehicle-Mileage
Downtown grid	14.4	11,600	167,000
Class AAA	0.25	24,000	6,000
Class AA	85.4	16,200	1,380,000
Class A	90.7	10,900	989,000
Class B	81.5	6,450	525,000
Class C	90.0	3,606	325,000
Unclassified	630.0	570	360,000
Total	992.0	3,780	3,752,000*

* Vehicle-miles per average weekday.

tive counting stations at various locations is subject to one serious limitation — when the possible capacity of one or more approaches to any of the intersections is reached, the volumes at that intersection (at least for the periods in which the capacity is reached) no longer reflect the true traffic volume increase in the area. This defect can be overcome to a degree by the use of a "screen-line" system of counting stations, in which all traffic passing an arbitrary line would be counted, regardless of the street being used. However, to have done this in Cincinnati would have required a large increase in the number of quarterly counts, at the expense of the remainder of the counting program. This was not justifiable, inasmuch as none of the intersections operate at maximum capacity continuously or for extended periods of time, although certain approaches to many of the intersections reach this point almost daily.

Studies were made of the change in the total volumes at the 26 locations which include 92 count stations to obtain information as to the seasonal and yearly trends in city-wide traffic volume trends. The quarterly count data have been available since 1952, and Figure 5 is a chart showing the results of this study. It is apparent that the general traffic volume trend has been up. The yearly averages have shown an increase of 24.6 percent between 1952 and 1956, an annual increase of 6.15 percent per year, assuming a straight line increase. The shape of the curve indicates that the increase is at an increasing rate. Assuming that the increase is occurring at a fixed rate compounded, the rate of increase has been 5.66 percent per year compounded. To the traffic control engi-

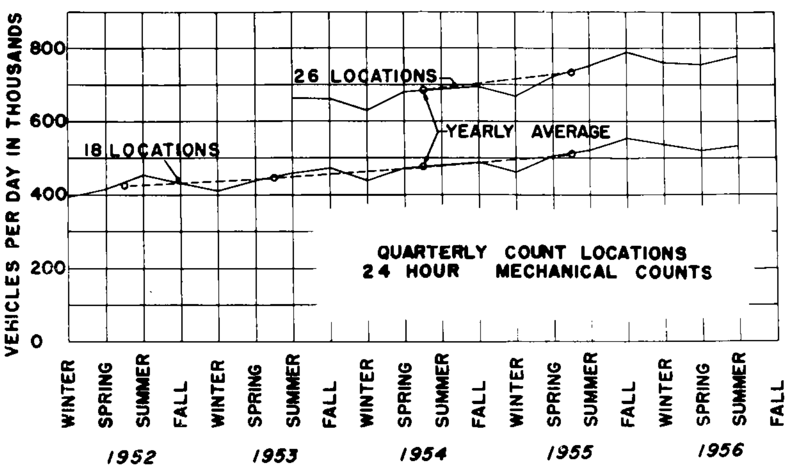

Figure 5. Traffic volumes by seasons.

neer and to the highway designer the trend indicated here is significant, as it indicates a need for generous application of expansion factors in predicting future traffic volumes. Figure 5 also indicates a seasonal pattern: the winter season generally has been the low point of the curve each year, and the summer and fall have generally been the high points. Figure 6 shows the daily, weekly and monthly variations in volumes recorded at the six permanent stations.

Hourly Variations in Traffic Volumes

The hourly variations in traffic volumes over a considerable area are of interest in many ways, because studies of these variations provide valuable information concerning the driving habits of the public, and the traffic characteristics they create. The hourly variation pattern at any one location is too sensitive to traffic generators in the immediate vicinity to be representative of the city as a

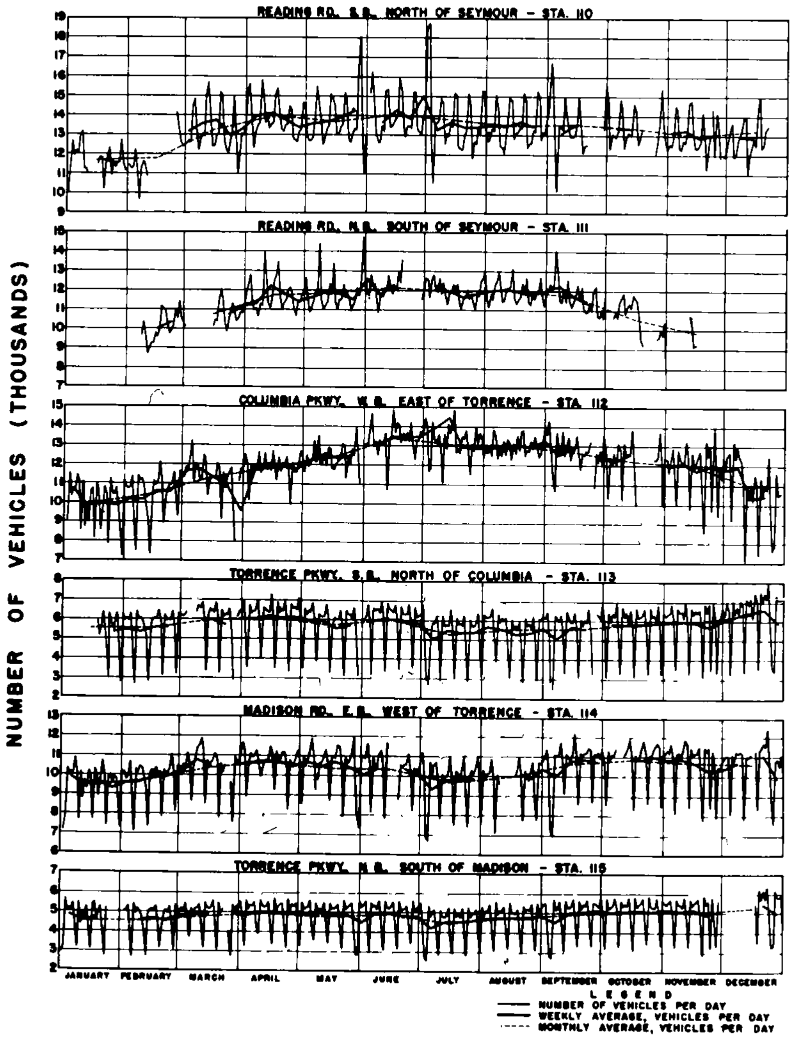

Figure 6. Permanent automatic counter records.

whole. Therefore, the hourly volumes from each of the 92 count stations were totaled for each of the four seasons, and the hourly totals plotted for each season (Figure 7). The chart shows the daily peak hours of traffic activity. The fall season showed the highest total volume during 1955, and this is reflected by the generally highest curve through the daylight hours. The winter season showed the lowest total volume during 1955, and the curve is generally the lowest.

The hourly volumes were converted to percentages of the 24-hour volume (Figure 8). With the exceptions of the early evening hours, these percentage curves follow each other more closely than do the actual volume curves. One noticeable characteristic shown on this graph is the lower morning peak percentages, and the higher early evening and night hour (8:00 p.m.-1:00 a.m.) volume percentages shown on the curve for the summer season. A possible explanation for the lower morning peak might be the absence of school traffic during the summer season, and the higher evening curve may represent an increase in recreational driving during the summer and hot weather.

Both charts indicate the increasing importance of the hour from 3:00 p.m. to 4:00 p.m. as a peak traffic hour. On two of the curves this hour shows a higher total volume than the hour from 8:00 to 9:00 a.m. In traffic control work in Cincinnati this pattern has been found on many streets, where the conventional 7:00 a.m. to 9:00 a.m., and 4:00 p.m. to 6:00 p.m. restrictions and control are no longer adequate. Special controls such as peak hour parking restrictions, restrictions on turning movements, and peak hour signal timing are needed starting at 3:00 p.m. at many locations.

Peak Hourly Characteristics and Design Hour Volumes

There has been considerable discussion in recent years over the characteristics and relative merits of the various ranked hourly volumes as a design factor. Accordingly, an investigation was made of characteristics of peak hourly flows and their relationship to the ADT volume, using the data obtained from the six permanent recording counters.

The six stations cover four different

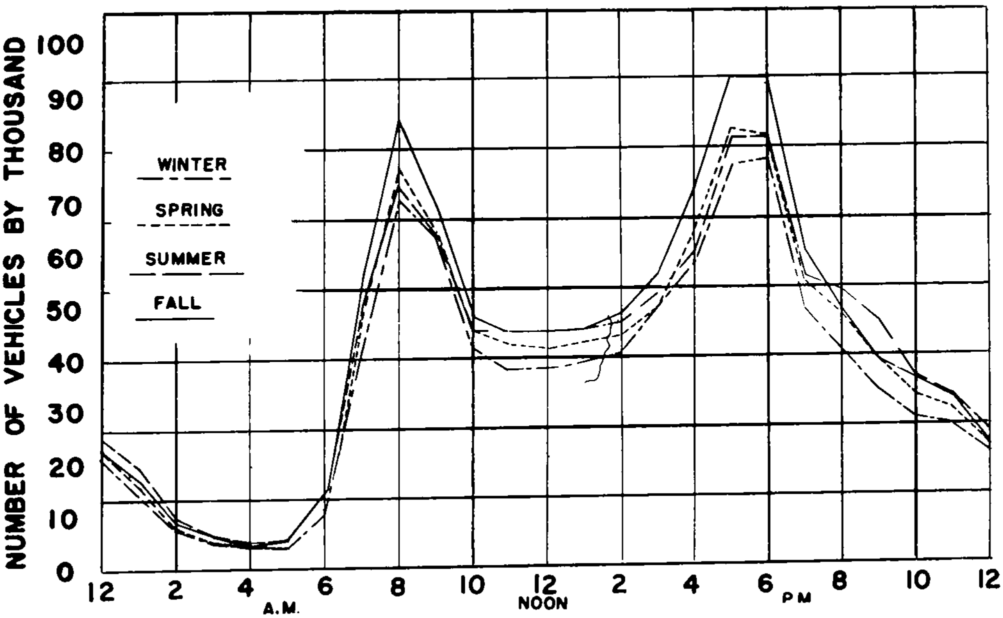

Figure 7. Hourly variation in traffic volumes at 25 quarterly traffic count locations.

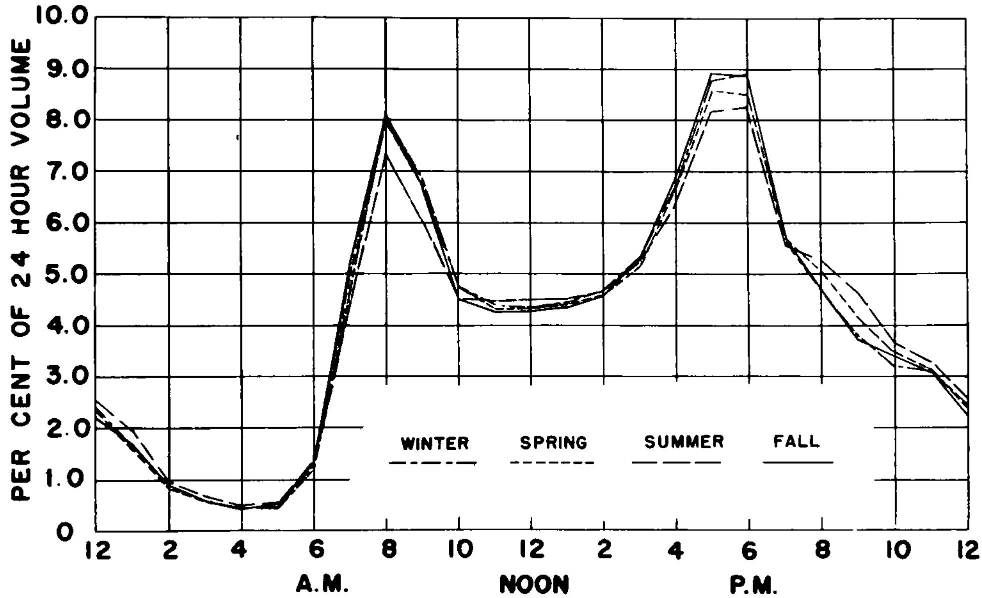

Figure 8. Hourly variation in traffic volumes at 25 quarterly traffic count locations.

roadways, each with somewhat different traffic characteristics. Torrence Parkway is a city street, forming a section of a radial arterial route, but with commercial traffic prohibited. Columbia Parkway is one of the radial arteries from downtown Cincinnati, and also carries passenger traffic on US 50. Madison Road is a radial artery, with no state routes, but carrying heavy volumes of mixed traffic. Reading Road (US 25 and US 42) is a major radial artery serving a large industrial area and carries heavy volumes of mixed traffic. The percentages of the ADT volume represented by the 200 highest hourly volumes during 1955 at each of these stations were plotted (Figure 9).

With the exception of Torrence Parkway, continuous counts were available in only one direction on the roadways under discussion (the two Reading Road counts were on opposite approaches to an intersection where heavy turning movements take place). Since most design hour volumes (except on expressways) are figured on the basis of two-directional traffic, the one-directional volume curves may not be entirely applicable for this purpose. Although these studies are not available in sufficient quantity to draw definite conclusions, a number of interesting characteristics of the curves can be noted.

Visual inspection of the curves in general shows the conventional patterns of a few very high hours leveling off into a more or less straight line curve. The leveling off point, however, occurs at somewhat different points, depending on the characteristics of the roadway. On relatively stable Reading Road, this takes place at the 5th highest hour, but on the highly peaked Torrence Parkway flow, the leveling did not occur until the 60th highest hour.

The fact that on three of the six one-directional curves, the 30th highest hour is still on the steeper part of the curve, might at first impression be taken as an indication that using the 50th highest hour as a design criterion could lead to underdesign of a highway facility. Actually, however, the maximum difference between the 30th and the 50th highest hours on any of the count stations was 0.35 percent of the ADT and the greatest percentage "underestimate" of the

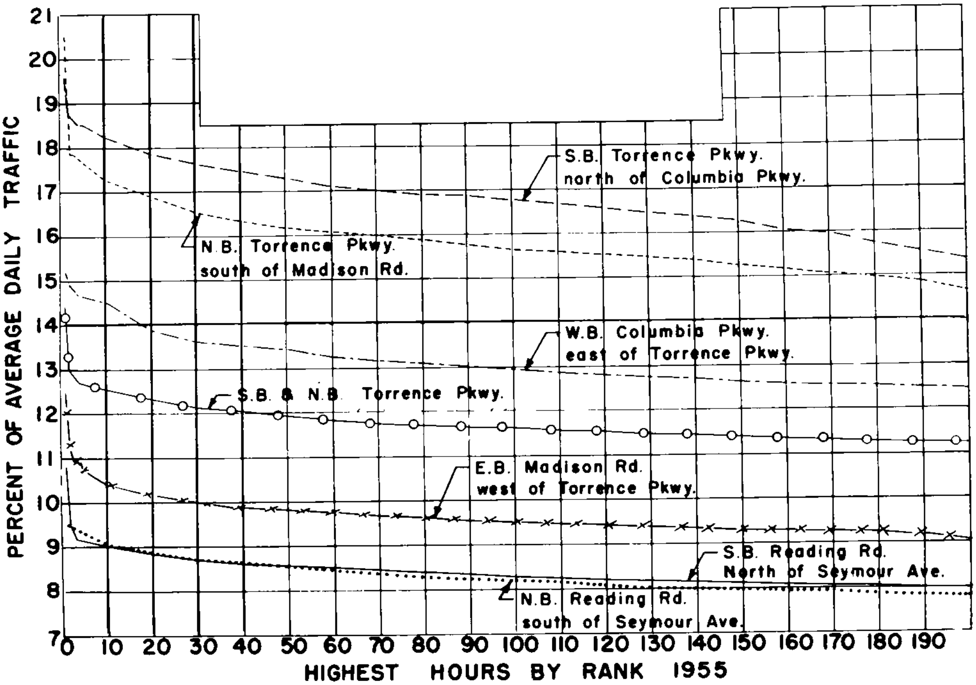

Figure 9. Peak hourly flows vs average daily traffic volume.

design hour volume by using the 50th highest hour instead of the 30th would be 2.17 percent. Even if it occurred on a roadway with an ADT of 20,000 vehicles in one direction the 0.35 percent would amount to only 70 vehicles during the peak hour. It is doubtful if any design engineer, in predicting future traffic on a roadway, would expect his estimate to be accurate to within 2.17 percent, or would design a roadway to such close tolerance that an error of this magnitude would be critical. This is not to be construed as a recommendation or suggestion that the 50th highest hourly volume should be used as a design criterion; it is merely a statement that on the particular roadways studied, choosing either the 30th or the 50th highest hour would have made little practical difference.

By far the highest peak hour volume percentages in one direction occurred on Torrence Parkway; which has high commuter volumes, but no commercial or state highway traffic to sustain the volumes during off-peak hours, hence the high peak hour volume percentages. Assuming, for the sake of comparison, that the curves are in the form of a straight line from the 30th highest hour to the 200th, the curves for Torrence also show the steepest diminishing slopes, and, in general, the greatest decrease between the 10th and 30th highest hour.

Conversely, the lowest peak hour percentages occurred on Reading Road, where heavy commercial traffic and state highway traffic maintain high volume rates throughout the day and most of the night. These two curves also show in general the flattest decreasing slopes from the 30th to the 200th highest hour, the smallest decrease from the 10th to the 30th highest hour, and the smallest percentage for the highest hour. An additional factor which probably tends to reduce the volume differentials and flatten these two curves is the fact that both movements are apparently working close to their possible capacity.

It was not possible to calculate intersectional capacities for any of the six movements studies at the three intersections, since all three intersections are equipped with volume-density controlled traffic signals, in which the timing for any movement varies, and is controlled not only by traffic on that movement, but also by traffic volumes on all other movements at the intersection.

Lying in between the high and low curves are the curves for Columbia Parkway, which carries intercity passenger car traffic from the state highway, but no commercial traffic, and Madison Road, which carries commercial but no state highway traffic. The lower placement of the Madison Road curve and its slope characteristics seem to indicate, at least in this instance, the greater influence of the mixed and commercial traffic as compared with intercity passenger traffic in creating a more evenly distributed traffic pattern.

The curve for the two-directional flow on Torrence Parkway (the only street section for which two-directional flow was available) is placed considerably lower and has a considerably flatter slope than do the one-directional curves for the same street section. However, the curve is still placed higher than the one-directional curves for Madison Road or Reading Road. The two-directional curve also showed fewer extremely high peaks than the comparable one-directional curves, and seemed to level off sooner.

CONCLUSIONS

There are several general conclusions which may be drawn from the data and studies which have been described in this paper.

It is apparent that there is still much to be learned about urban traffic volumes and urban volume characteristics, and that these studies have only scratched the surface of the field. This is particularly true with respect to the relationships between volume characteristics and the type of roadway, type of area served, type of community, and the various chronological relationships.

The studies indicate that urban traffic volumes are still increasing, and increasing rapidly. This implies the need for adequate expansion factors in predicting future traffic volumes, and also the need for continuing studies and research in the field of long time traffic volume trends.

It can be concluded that for operational purposes in urban traffic control a carefully controlled program of single 24-hour mechanical counts on weekdays will give satisfactory results.

The studies indicate that statistical methods, particularly with respect to the analyses of errors and deviations, can be of great value in measuring the reliability of traffic counts and traffic counting programs.

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