come. The pictures should be worth what they cost in time, effort, and money, for they would furnish a complete and accurate record of all that happens within the area studied. It is felt that several hours of such observations will reveal more than days of less complete data. From this standpoint it could well be that aerial photographs will prove comparatively cheap.

Past experience leads to the conclusion that analyzing the data will be even more difficult than obtaining them. The data will be complete and therefore entirely non-selective. The investigator must select those phases of traffic that are significant and then prove them so. There is the compensatory factor that if a wrong selection is made, complete data are at hand from which to make a new selection for a new start. Past experience, while making one aware of the difficulties to be expected, has revealed that traffic performs in definite patterns and that these patterns may be analyzed by established statistical methods. It is our opinion that only through basic research may we reduce traffic engineering to a more exact science comparable to that of civil or mechanical engineering. In view of the fact that research pays a bigger return in the long run than almost any form of human endeavor, we feel justified in proposing the expense and difficulty of aerial photographs to supplement the more common field surveys of traffic movements and to further traffic research.

SIMPLIFIED METHODS FOR TRAVEL STUDIES IN SMALLER CITIES

DANIEL O'FLAHERTY
Public Roads Administration

SYNOPSIS

Techniques have been developed in recent years for comprehensive surveys in larger cities. Less costly and time-consuming studies are needed to obtain less extensive information in smaller cities. There were 1,843 cities between 5,000 and 50,000 population in 1940.

A new procedure has been developed which utilizes an external origin and destination study and a modified parking survey in combination. Such studies are appropriate in cities where mass transportation is not an important factor and where all but a minor portion of the places of business and recreation are concentrated in the downtown area.

Information is obtained for external trips crossing a cordon at or near the city limits, and for internal trips that end in parking in the central business district.

The analysis procedures for this type of survey were developed in the Alexandria, Louisiana study where acceptable information was obtained by the new technique.

It is possible to make statistical checks to determine the accuracy of the new procedure. These checks have proven satisfactory.

Another method of conducting origin and destination surveys in smaller cities with characteristics favorable for such procedures, involves street-side interviews similar to those made at external stations. In a study of this kind, origin and destination information for vehicles crossing a cordon around the downtown area was obtained recently in Hagerstown, Maryland, a city of approximately 35,000 population.

Time to conduct the field work for these types of surveys ranges from 10 days to six weeks. If properly organized, the whole job can be completed in from one to four months depending on the size of the city and the ability of the organization handling the work.

Urban surveys are necessary to plan properly highways in cities to serve through and local traffic to the best advantage. Travel has increased more than sixfold since 1920 and something must be done to relieve congestion particularly in the cities.

There has long been great need for traffic relief in urban areas. Many rural highways have been improved to the extent that traffic is now able to approach cities with little inconvenience. Traffic is discharged into the cities where funds have not been available to construct sufficient facilities to provide safe, economical, and expeditious transportation service. A typical example is illustrated in Figure 1 in which the top picture shows the easy flow of traffic as it approaches the northern limits of Charleston, South Carolina, on U. S. Highway 17, while the lower picture shows the congested condition created when the traffic is emptied into narrow King Street. Correction of these conditions requires a

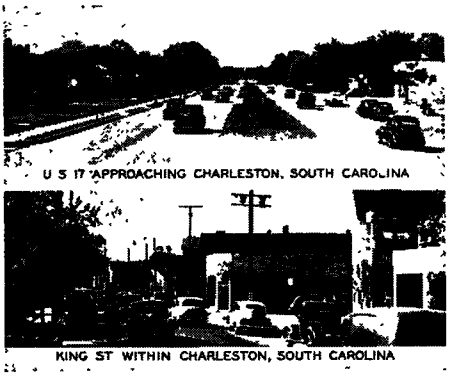

Figure 1. Modern Rural Highways now Discharge Free Flowing Traffic onto Congested City Streets

comprehensive, accurate knowledge of the travel requirements.

The Public Roads Administration realized that factual traffic data must be obtained in cities to aid in locating new highway facilities, and therefore did a large amount of work in reviewing and evaluating the sampling procedures used in previous traffic survey work and in other fields. The best features of these methods were incorporated in an entirely new procedure for determining the movement of persons and goods by all means of transportation through, into, and within cities. This method has been applied in some 60 of the larger urban areas. After thorough review, the Highway Research Board Committee on Origin and Destination Survey Techniques endorsed the procedure and will publish a manual on the subject. Proved methods are therefore available for making the comprehensive surveys necessary for understanding the transportation problem of the larger urban areas. Our principal need for the future in this field is the establishment of sound methods, simple of application, for smaller cities.

It is believed that much of the information required for the larger urban areas is not needed for the smaller cities. The time and cost required to make complete surveys could seriously delay the collection of data needed in the many small cities throughout the country. It is important that information to aid in the selection of urban highway locations in all cities be obtained quickly if the States and cities are to receive full benefit from the $125,000,000 a year authorized by the Congress to be expended within urban areas.

The Public Roads Administration desires that the Federal-aid urban systems give adequate service to urban places and has indicated that in those places of 5,000 or more population a study should be made to determine the pattern and the extent of an ultimate system of principal arterial routes. The principal lines of travel should be determined as promptly as possible by adequate traffic studies. The task of designating these lines will be greatly facilitated by traffic origin and destination surveys.

Some of the things that must be determined are: What are the city traffic problems? Will a bypass remove sufficient traffic from the downtown area to relieve the congestion there? Does a parking problem exist? When the answers to these and other significant questions are available, then the authorities will be better able to build highways which will best serve their communities.

Table 1 shows the number of cities in the several population classes in 1940.

There were 2,042 places with 5,000 or more population in 1940. Because of the impossibility of collecting the needed traffic information by means of comprehensive surveys within a reasonable period, and because it was believed that such complete data for the smaller cities were not required, a procedure has been developed which is less time-consuming and yet sufficiently complete to give the answers to the most important traffic problems in all but the more populous areas. These new surveys are discussed in this paper.

Origin and destination traffic surveys in which drivers are stopped at the edge of the city and interviewed regarding their trips, have been made for many years. These are called external surveys. A trip may be defined as the one-way travel between an origin and a destination. The parking survey is a newer development that is now becoming standardized. Under present procedures, the origin and destination of all driver trips ending in parking in the central business district during the hours of survey operation are obtained as well as the usual parking information. A combination of the external and parking studies produces information concerning the most important traffic movements in the smaller cities.

TABLE 1
THE NUMBER OF CITIES IN THE SEVERAL POPULATION CLASSES IN 1940

Population	Total	Cumulative Total
1,000,000 or more	4	5
500,000 to 1,000,000	9	14
250,000 to 500,000	23	37
100,000 to 250,000	55	92
50,000 to 100 000	107	199
25,000 to 50,000	213	412
10,000 to 25,000	665	1,077
5,000 to 10 000	965	2,042
2,500 to 5,000	1,422	3,464

Among these cities in which origin-destination and parking surveys have been conducted are Portsmouth, New Hampshire; Walla Walla, Washington; Alexandria and Monroe, Louisiana; Corpus Christi, Texas; and Anderson, South Carolina. The Alexandria study is one of those in which a deliberate effort was made to combine the two types of surveys. It was in this survey that the analysis procedure described in this report was developed.

External surveys are usually conducted for a period of 16 hours from 6:00 a.m. to 10:00 p.m. However, stations on minor routes with about 500 vehicles per day may be operated for only eight hours, while stations on thoroughfares having 5,000 or more vehicles per day are often occupied for the full 24 hours. The data collected are expanded by hours and by type of vehicle to represent an average day. In some instances the surveys are made purposely during the peak season of the year and in others in seasons of more nearly average traffic.

Parking surveys normally are conducted during daylight hours, usually from 8:00 a.m. to 6:00 p.m. or 10:00 a.m. to 6:00 p.m. The former period which covers both morning and afternoon traffic peaks as well as the parking peaks is preferable. During the parking survey vehicles are counted and classified by type at a cordon around the central business district, usually referred to as the inner cordon, by half-hour periods separately for inbound and outbound traffic. The traffic on each street crossing that cordon is counted and classified in this manner for one day during the hours of survey operation. Additional classification counts are made at typical locations for the full 24 hours so that the number of vehicles may be expanded to the full day. Mechanical counts for several 24-hour periods are made at crossings on the inner cordon in order to establish definitely the average daily traffic on this line.

The internal trips to and from the central business district are expanded to 24 hours on the basis of the information obtained during the parking survey period. That is, the trips to the central business district during the whole day are assumed to be in the same proportion to the total day's count at the inner cordon as the trips to the central business district during the parking survey are to total counts at the inner cordon for that period. It is probable that this assumption is not true for the larger cities, but is believed to be reasonable for the smaller cities where there is usually a very definite central business district with few or no neighborhood centers. In the central business districts of the smaller cities are concentrated both the places of business, work and shopping that attract traffic during the day, and the places of recreation such as bowling alleys and theaters that attract traffic during the evening. The results are similar patterns of travel throughout the twenty-four hours from the several zones to the central area even though the purposes of the evening trips are different from those during the day.

The term "smaller cities" as used here means, in general, urban places approximating 50,000 population or less. However, a more useful differentiation, both for planning and for traffic survey purposes, can be made on the basis of travel habits and suburban development rather than on population alone.

Some cities with 75,000 or greater population may be more suitable for surveys of this type than other cities with less than 50,000 population. Since mass transit trip information is not obtained in the abbreviated surveys, cities in which public transportation is a major factor require the more comprehensive metropolitan area type of survey. Similarly, cities in which there are several neighborhood business and recreational centers that create important traffic movements which do not enter the central business district also require the more comprehensive survey. Conversely, cities in which mass transportation plays a minor part and in which practically all of the business as well as the recreational facilities are concentrated in a central downtown area can be grouped with the smaller cities and the abbreviated type of survey may be considered satisfactory.

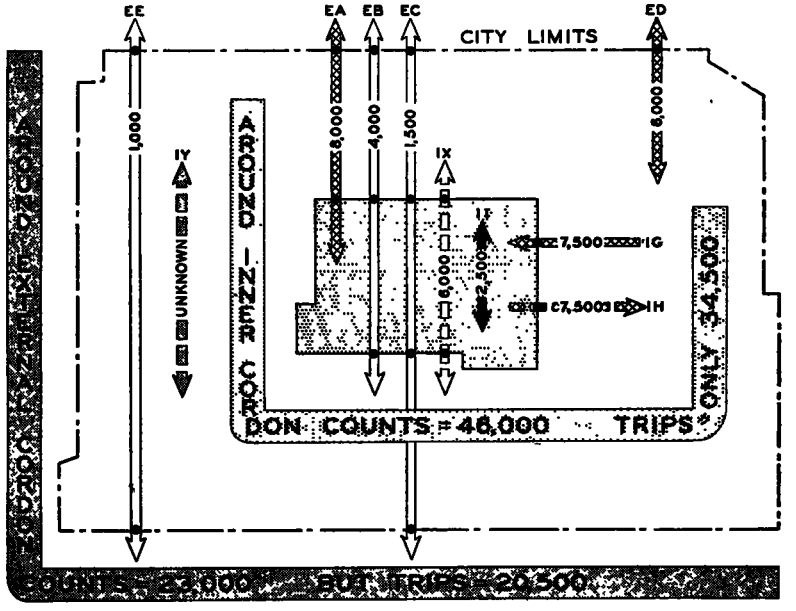

Figure 2. Types of Trips Within, To, From, and Through a Metropolitan Area

Figure 2 shows the type of trips involved in a city study, and the number of the several types of known trips in a typical city of 35,000 population. To simplify the illustration and avoid confusion by showing too many lines on the chart, each letter designation includes trips in both directions except in two instances, "IG" and "IH" trips.

Trips to and from the external area, passing through the cordon of stations at the edge of the metropolitan area are labeled with the prefix "E." The "EA" trips have an origin outside the city and a destination in the downtown area. The inbound "EB" trips have their origins in the external area and destinations in the city but outside the downtown area, and pass through that area without stopping. The "EC" trips have both origins and destinations outside the city but pass through the downtown area. The "EE" trips are similar to the "EC" except that they do not pass through the downtown area. The "ED" trips have origins outside and their destinations inside the city but do not enter the downtown area. Information concerning all of the trips with an "E" prefix is obtained in the external origin and destination survey.

The internal trips, those having both origins and destinations within the city have a prefix "I." The origins and destinations of the "IG" and "II" trips are recorded in the parking survey. The "IH" designation represents the reverse of the "IG" trips. Urban studies of the comprehensive type in many cities have shown that there is a balance between the trips from a zone to the down-

town area and from the downtown area to that zone. The "II" trips are confined within the central business area and do not extend beyond the inner cordon.

The "IX" trips cross the cordon around the downtown area but their origins and destinations are unknown. The total number of such trips, however, can be computed in the following manner: The counts from all other trips crossing the downtown cordon are known and can be subtracted from the total counts on that cordon to give the number of counts involved in the "IX" trips However, each of the "IX" trips crosses the central business district cordon twice and consequently is counted twice. Therefore, to determine the number of trips, it is necessary to divide the volume counts by two. The formula is as follows:

$$IX = \text{cordon count} - \frac{(EA + 2EB + 2EC + IG + IH)}{2}$$

The "IY" trips do not enter the central business district and nothing is known about them from the simplified study. In surveys of this type cities are subdivided into small areas called zones in order to study the movement of vehicles from place to place. There are many trips which never extend beyond the zone where the trip began, or the zone adjacent thereto. Almost half (48 percent) of the "IY" trips were of this type in Mason City, Iowa, which had a population of 28,000 in 1940. In fact, one-third of both the "IY" and "IX" trips fell into this category. Trips which do not extend beyond the zone of origin or that end in the adjacent zone will seldom use expressways or through routes passing through such zones because time and distance can be saved by using the more convenient local streets. Consequently the lack of information on the "IY" trips is not serious.

In a typical city of 35,000 population, there were 23,000 counts of vehicles at the external cordon which accounted for 20,500 trips. On the inner cordon there was a total of 46,000 counts which were the result of 34,500 trips crossing the cordon. How are these differences accounted for? There has been considerable confusion, even among those familar with surveys of this kind, in differentiating a traffic count from a trip. On a single cordon, some trips are counted once while other trips are counted twice.

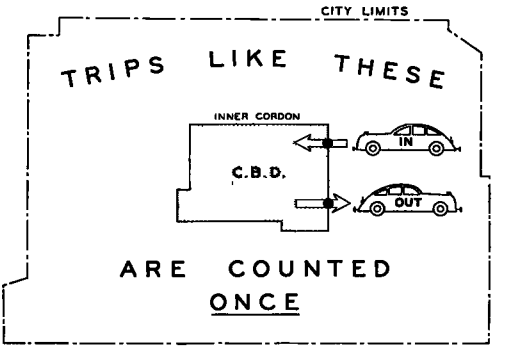

Figure 3

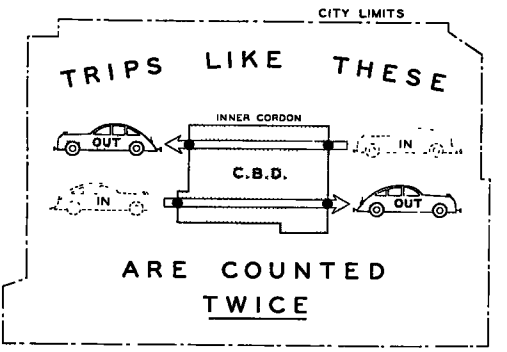

Figure 4

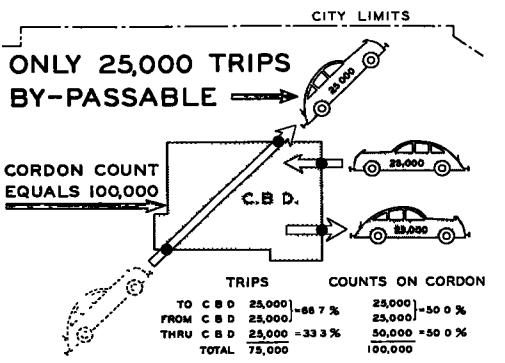

Figure 5. Trips Into and Through the Central Business District

The number of counts is illustrated in Figure 3 which shows that the top vehicle has an origin in the city and a destination in

the downtown area. It is counted only once as it crosses the inner cordon. Likewise, when this same vehicle leaves the downtown area, it is again counted as it crosses the cordon. Each of these counts represents a trip.

Figure 4 shows the type of trip that is counted twice on the inner cordon because the vehicle passes completely through the central business district without stopping. It is counted once as it enters the area and once as it leaves. In other words, such vehicles are

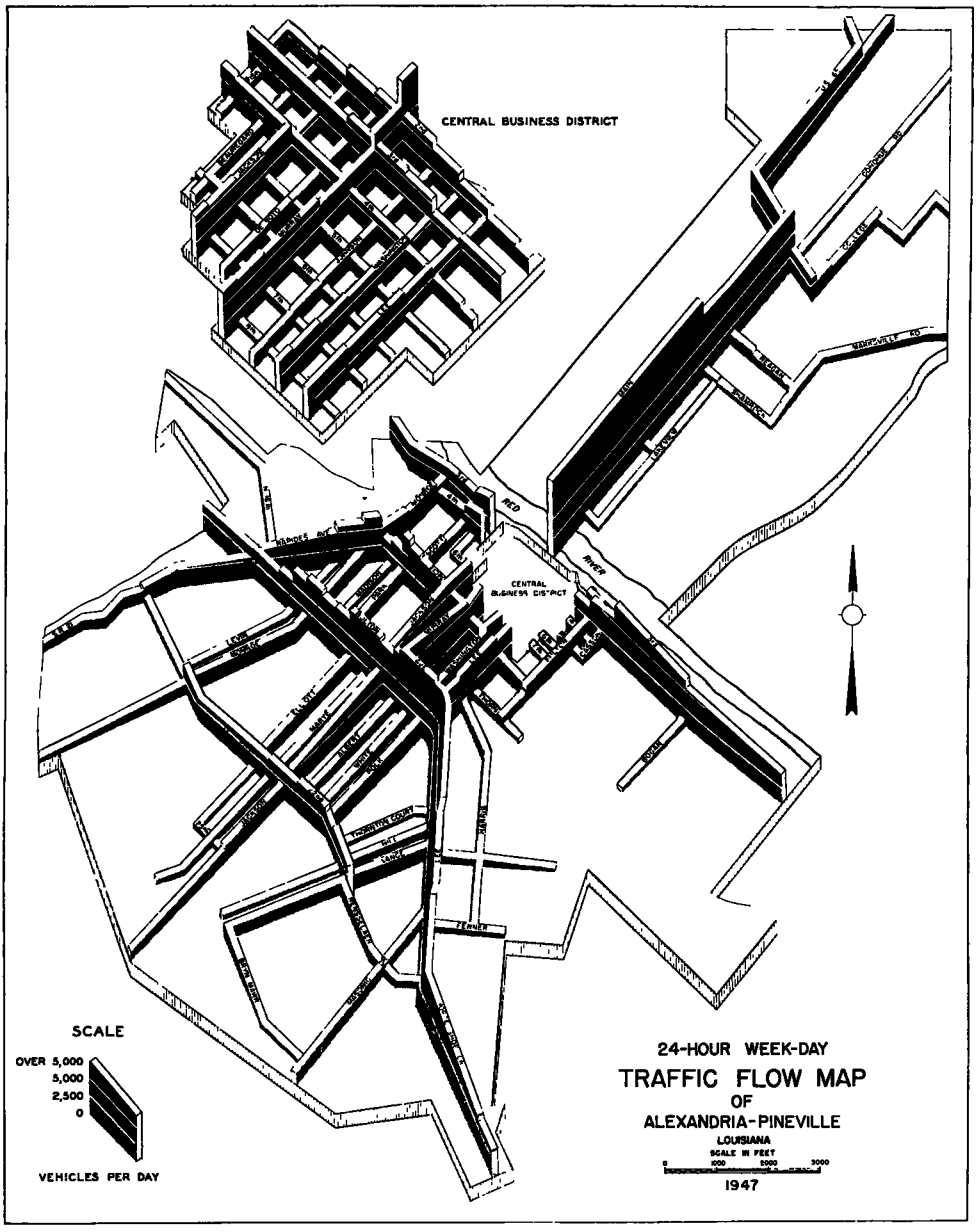

Figure 6

counted twice during the course of a single one-way trip from their point of origin to their point of destination.

It is very important that the difference between trips and traffic counts be understood, because trips, and not traffic counts, are assigned to routes The outstanding error resulting from the failure to distinguish between trips and counts is the presumption that the number of vehicles that could bypass a downtown area is equal to the difference between the number of counts resulting from trips that have an origin or destination in the downtown area, subtracted from the total counts on the cordon. Emphatically, this assumption is incorrect. The number of vehicles which might be kept out of the downtown area, if more convenient highways were available for their use, is equal to one-half that difference.

Figure 5 illustrates the condition where 25,000 trips enter the downtown area, 25,000 trips leave the downtown area, and 25,000 trips pass through this area. The total number of counts around the cordon indicates that half of the counts result from through trips. However, only one-third of the trips that enter and leave the downtown area pass through without stopping and might use a bypass of that area if time or distance could be saved, and a route to accommodate them were available.

The composition of traffic in urban areas is different at night from that in the daytime, the percentage of trucks in the total traffic being less at night than during daylight hours. The expansion of 8 or 10-hour traffic figures for parking surveys should not be made, therefore, on the basis of the distribution of traffic for that period but on the distribution by type of vehicle for the full 24 hours.

It should be realized, however, that the traffic flow during the period of a parking survey conducted from 8:00 a.m. to 6:00 p.m. includes almost three-fourths of the total traffic entering and leaving the downtown area during the 24 hours. Any assumptions made concerning the missed traffic will therefore not greatly affect the expanded figures. Further, the known data include those for the peak hours, which are the most important from a design viewpoint.

The report for the combination origin and destination parking survey in Alexandria, Louisiana, published by the Louisiana Department of Highways, has been distributed to the other State highway departments. This is the first report in which the type of analysis discussed here has been used. Several figures from that report are used in this paper to illustrate the results of a survey of the type under discussion.

The importance of properly presenting the analysis of the factual data after it has been collected cannot be overemphasized. The

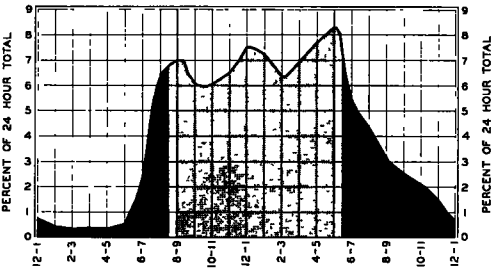

Figure 7. Vehicular Traffic—Variation of Flow by Hours of Average Week Day—Based on Composite of Continuous Counts at Six Stations, Feb. 18 to Mar. 21, 1947

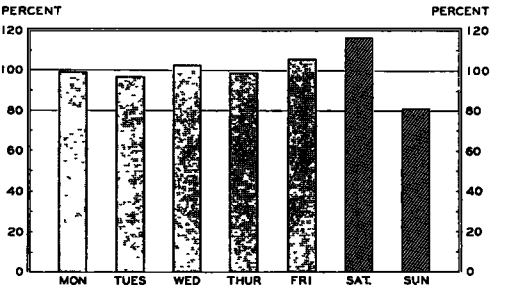

Figure 8. Traffic Variation by Days of the Week—Alexandria, La.—Percentage of Average Week Day

Public Roads Administration has encouraged the States to present information in urban reports in an attractive and colorful manner. Experience shows that reports are more widely read when so presented, than when presented in a drab, academic style. An appropriate presentation of the facts helps the highway administrators as well as the general public in understanding the problems

Figure 6 illustrates the isometric method of presenting traffic flow. This map was compiled from numerous 24-hour mechanical counts and many expanded short manual turning-movement counts. It is always well

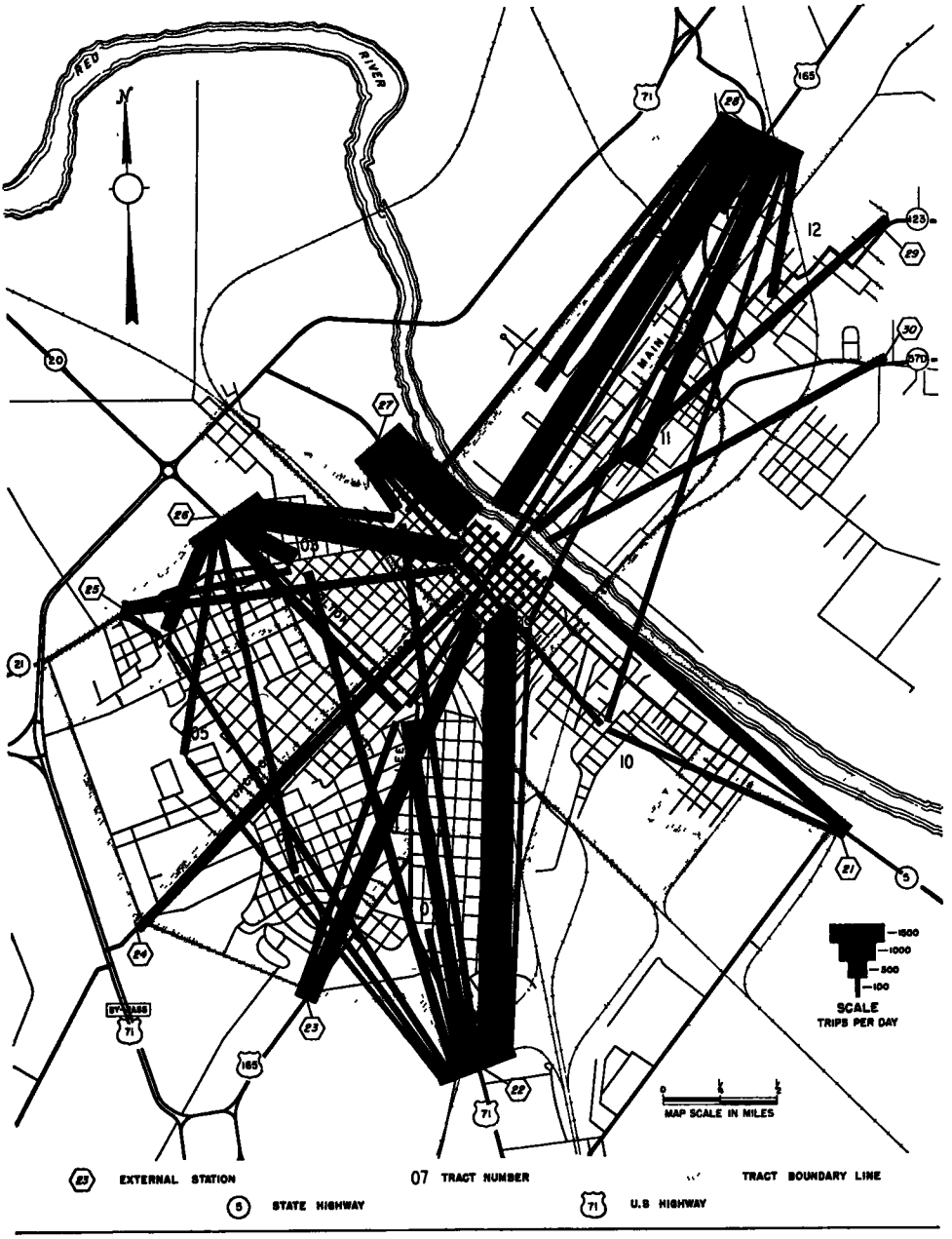

Fig. 9. External Automobile Trips, Volume Range of 100 or More in Alexandria, La.

to include a traffic flow map in the survey reports to show the traffic presently using the principal streets.

Figure 7 shows the hourly traffic pattern during a weekday in Alexandria, Louisiana. Seventy percent of the total traffic is included

during the 10 hours that the parking survey was conducted from 8:00 a.m. to 6:00 p.m.

Figure 8 was drawn to show the variation of traffic by days of the week. It shows little variation from Monday to Friday. As is usual, in urban areas, the traffic drops off considerably on Sunday. In Alexandria the small increase on Friday and the large increase on Saturday is offset by the decrease on Sunday. An average for the week, including all days, is almost identical with the average for the weekdays Monday to Friday, the former being 100.0 and the latter 100.4.

Figure 9 shows passenger-car trips from the external stations to the various zones, including the downtown area in Alexandria. The lines depict only those movements with volumes of 100 or more trips. It will be noted that there were no through movements of such volumes from any one external station to another. This is probably due to the fact that an excellent bypass is already available around Alexandria and Pineville. The location of this bypass can be distinguished to the left and top of Figure 9. The distribution of the trips in volumes of less than 100 (not shown) are so scattered that about the same number could use almost any through route proposed. A typical pattern of low-volume trip movements between zones is illustrated

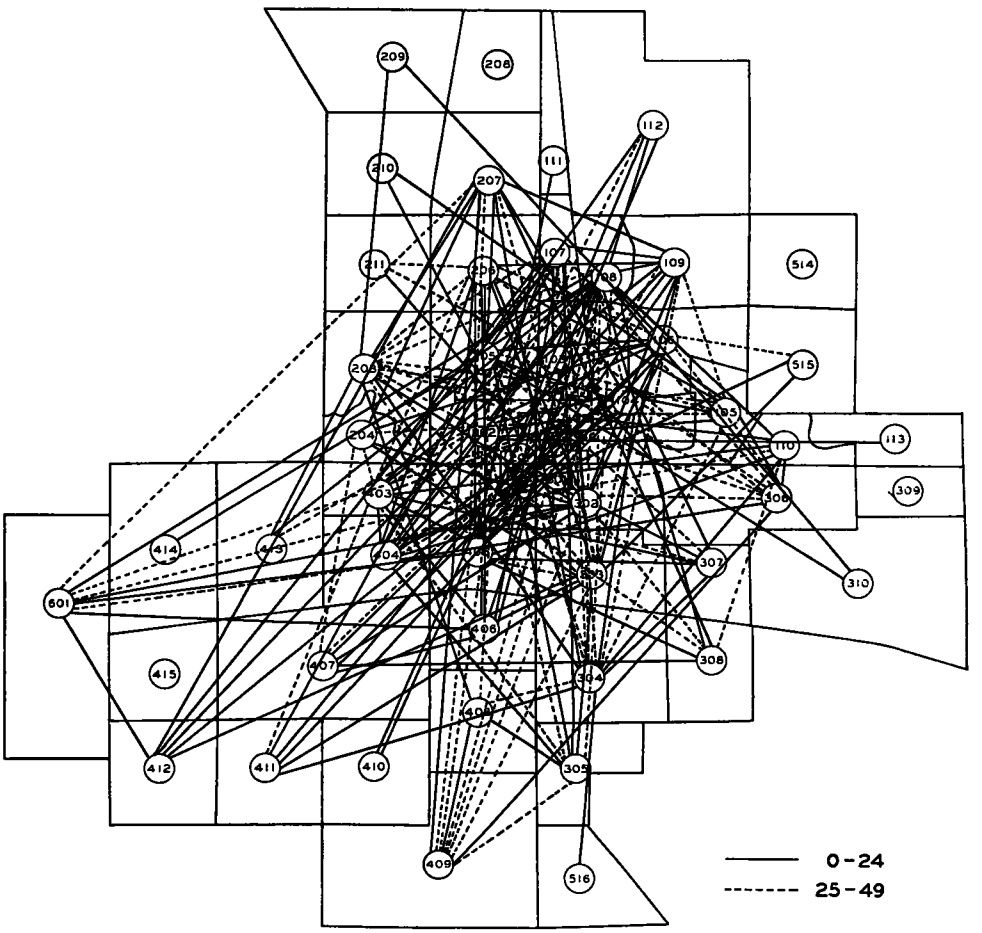

Figure 10. Distribution of Internal Trip Volumes of Less Than 50 Between Zones in Mason City, Iowa

in Figure 10 which shows the distribution of such movements in Mason City, Iowa.

internal area. This information was obtained from the parking survey. The general traffic

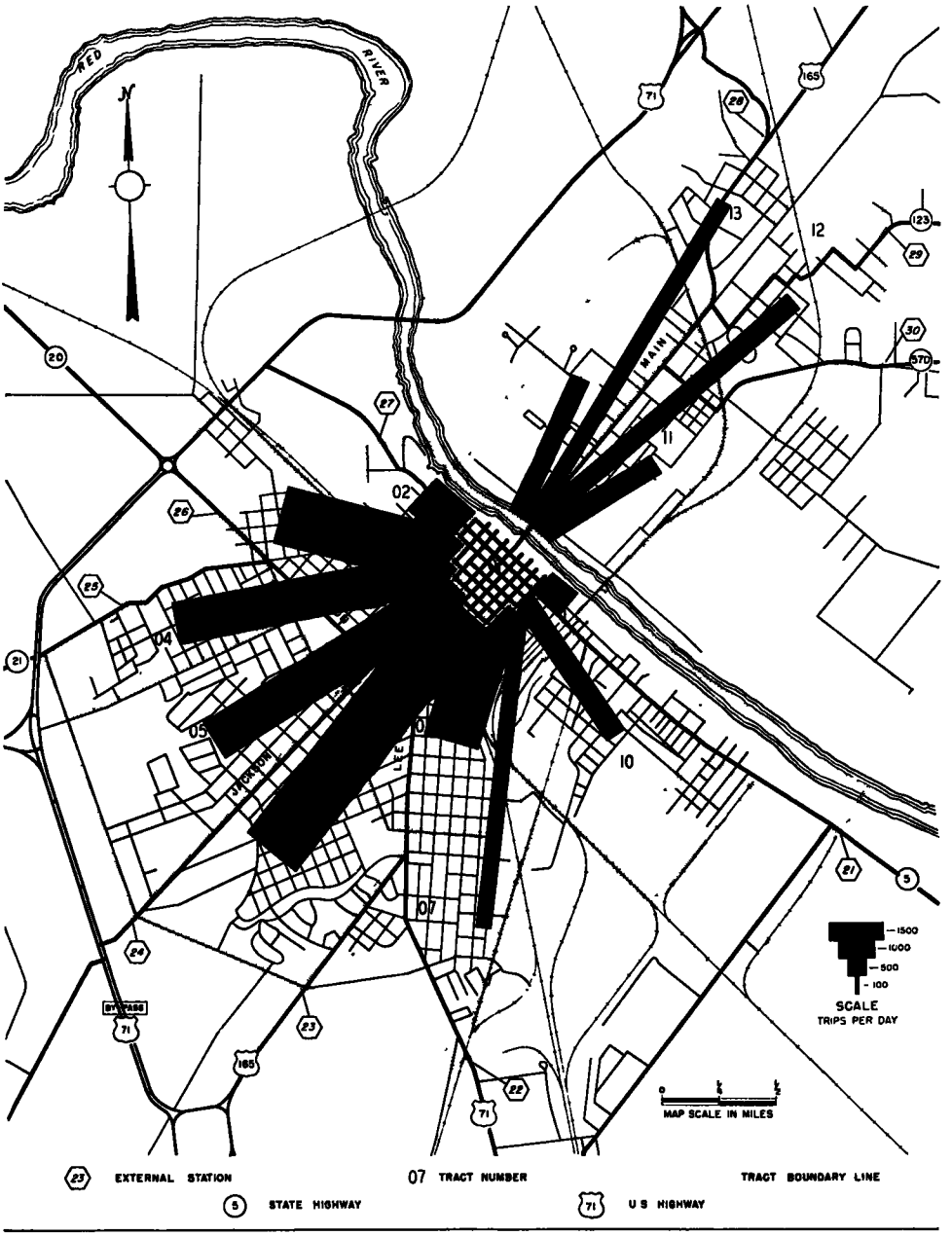

Figure 11. Internal Automobile Trips, All Volumes, in Alexandria, La.

Figure 11 shows the desire lines of the automobile trips to the downtown area in Alexandria from the several zones in the pattern for passenger cars and trucks combined, including both internal and external trips obtained in the survey, is shown in

Figure 12. This chart depicts volumes of 250 trips or more. Figure 13 is similar except that the volumes of trips range from 100 to 249. It will be noted that there is a considerable difference in the traffic pattern between these two charts.

Figure 12. Internal and External Automobile and Truck Trips Combined, Volume Range of 250 or More in Alexandria, La.

Figure 14 shows the major flow of traffic to, from, and through the central area of Alex-

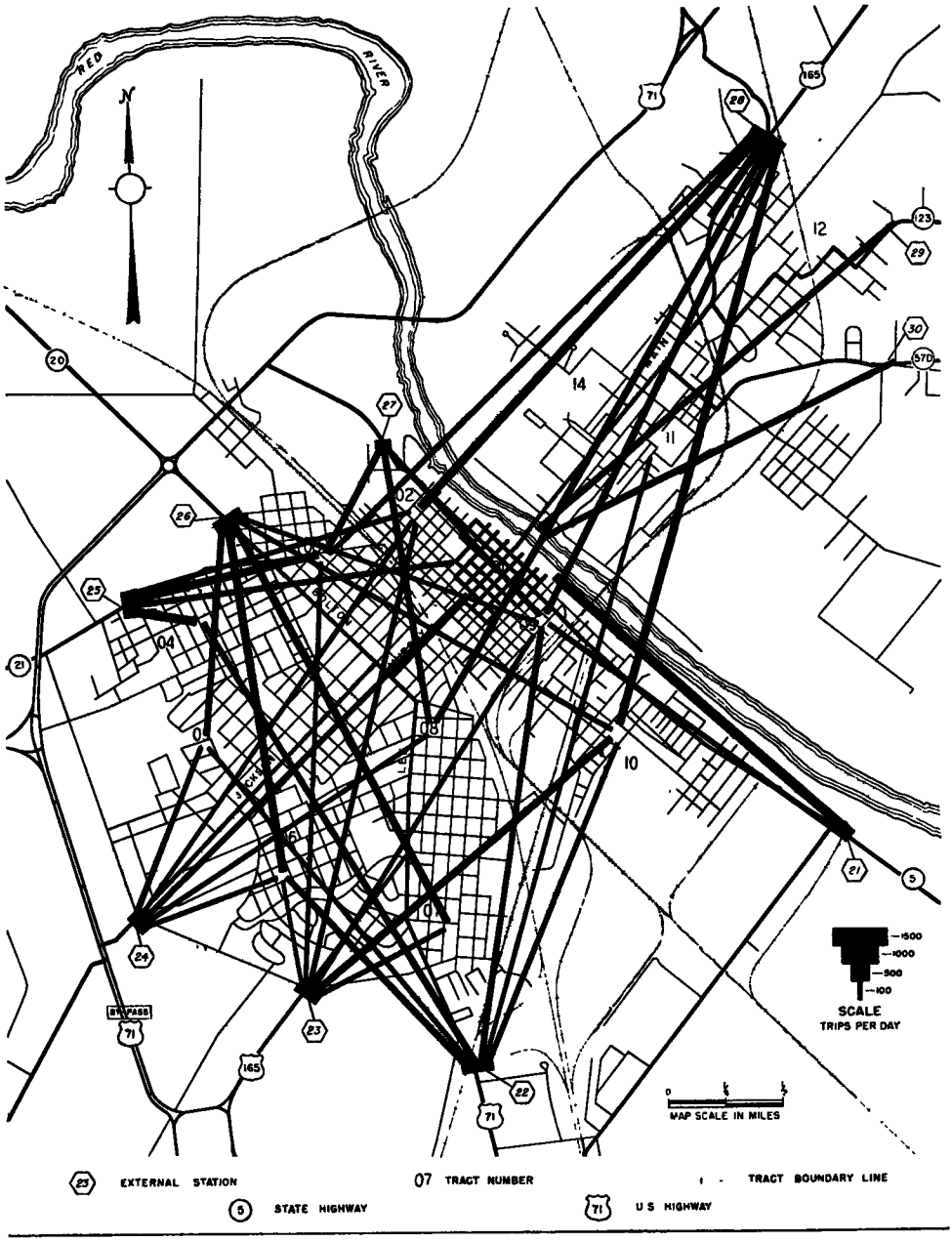

Figure 13. Internal and External Automobile Trips Combined, Volume Range of 100 to 249 in Alexandria, La.

andria on the basis of the origin and destination information obtained in the survey. This chart gives some idea of the route locations which would best serve traffic. Both passenger car and commercial vehicle trips are included.

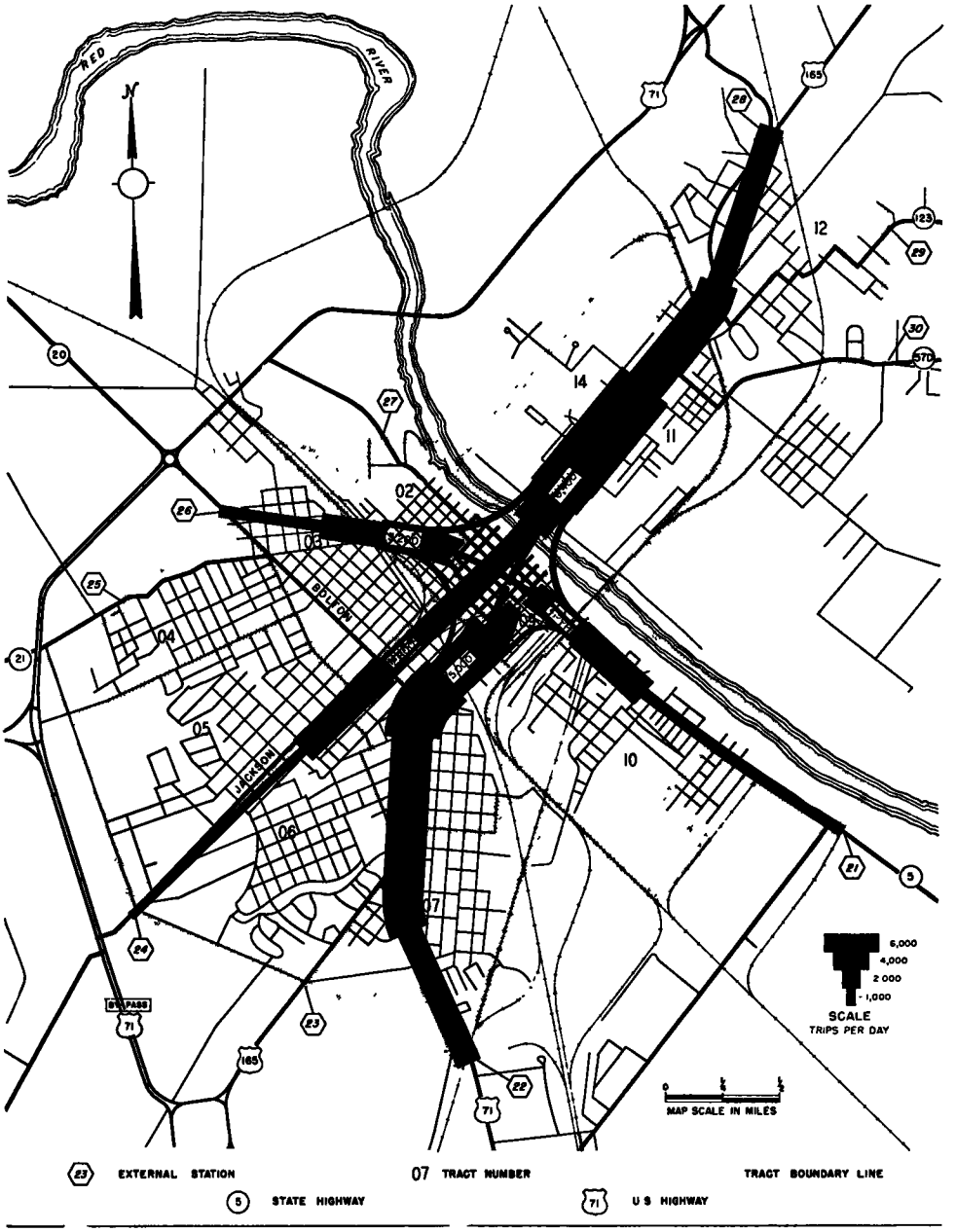

Figure 14. Origin and Destination Traffic Flows in Alexandria, La.

In addition to the origin and destination information, data for solving the parking problems are, of course, obtained in this type of study. All of the information that is gathered in a parking survey is available in the combination studies. Parking surveys

have been discussed in other papers presented at the Highway Research Board. It might be of interest, however, to state that 68 percent of the drivers with destination in the Alexandria central business district parked less than one hour, and that 86 percent walked less than 400 feet from where they parked to their destination.

An important item in a comprehensive metropolitan area survey is that the results can be checked against actual vehicle counts on the streets. Similarly, there is also a check that can be made on the results obtained in the survey under discussion. Trips with an origin outside the city which end in parking in the downtown area are recorded both at external stations and in the parking survey. Checks of the comparable data from the two independent sources show that the trips obtained in the parking survey were approximately 90 percent of trips of that type in the external survey. Furthermore, certain trips with destination in the downtown area do not end in parking. For example, a driver may drop a passenger and return to his point of origin without parking. Thus, a check well over 90 percent is indicated.

INNER CORDON TYPE OF SURVEY

Another method of conducting origin and destination surveys in smaller cities with characteristics favorable for such procedures involves street-side interviews similar to those conducted at external stations. A complete study of vehicles crossing a cordon around the downtown area and those crossing a cordon at or near the city limits was recently completed in Hagerstown, Maryland. Ordinarily in a city the size of Hagerstown, approximately 35,000 population, interviews at the inner cordon should be sufficient.

Outbound traffic at the inner cordon was interviewed on the city streets from 6:00 a.m. to 10:00 p.m. with little inconvenience to the vehicle drivers. Generally, it has not been believed possible, even in the smaller cities, to stop traffic for interviewing at the edge of the downtown area without greatly inconveniencing the motorist and causing congestion. Also, with parallel streets, the bypassing of stations has been a problem. This was overcome in Hagerstown by operating simultaneously all stations on one entire side of the central business district. The interviewers in this city were young, active high school graduates and college students who were able to complete an interview in approximately 30 seconds. Seldom was a motorist delayed as much as two minutes even during the peak hour.

Figure 15. Interviewing Outbound Drivers on Potomac Street During Peak Hour in Hagerstown, Md.

Figure 16. Heavy Movement of Traffic in Both Directions on Prospect Street Between 4 and 5 PM in Hagerstown, Md.

Inspection of the work here, and experience elsewhere, indicates that under favorable conditions origin and destination information can be obtained on city streets by the interview method if traffic is properly segregated and an adequate number of interviewers utilized. Few, if any, motorists avoided the stations in Hagerstown, since a driver could go through the station quicker than he could bypass it.

Figure 15 shows the operation of an interview station in Hagerstown during the evening peak period. Only outbound motorists are

being interviewed. This picture was taken on Potomac Street where the interviewers were kept busy but still were able to handle the traffic without difficulty. Figure 16 is a picture made on Prospect Street and shows the heavy movement of traffic in both directions. During this particular period from 4:00 p.m. to 5:00 p.m., contrary to expectation, more traffic was moving toward the downtown area than in the opposite direction This was due to the fact that employees adjacent to this station were departing from work

The length of time required to conduct the field work by the types of surveys illustrated above, ranges from 10 days to six weeks. If properly organized and sufficient office personnel is available, trips can be coded even while the field work is in progress. Punching can be started as soon as the data are coded. If the charts are prepared concurrently, the whole job can be completed in from one to four months.

The biggest problem in the city is to adapt the ancient street pattern to a type of traffic that did not exist when the grid system of streets was laid out. The number of motor vehicles has tripled since 1920 while the miles per vehicle have doubled. This means that today, motor travel is some six times that of 1920. New and improved facilities must be built to accommodate this travel if the present city is to survive. The only way in which we can be sure that these new facilities will adequately accommodate the present and future traffic requirement is by a proper understanding of travel desires developed through carefully organized, statistically sound surveys.

THE PHOENIX-TUCSON ROUTE STUDY

KARL MOSKOWITZ, *U. S. Public Roads Administration, Phoenix, Arizona*

SYNOPSIS

Choosing one of several alternate routes between two cities over 100 miles apart is discussed.

There are 14 zones of traffic origin or destination involved in the two cities and intermediate points. Determination of the number of daily trips between each zone and each other zone by means of a few strategically placed interview stations on the several existing highways is explained.

The annual cost of vehicle operation for all inter-zone trips is added to the annual cost of owning the network of roads required, including the proposed route, for each alternate. The route offering the least sum is held to be the logical choice. This criterion is compared with the benefit quotient and with the Oregon (McCullough) Composite Quotient.

The unit costs used were 2½ cents per mile plus 57 cents per hour for passenger cars, 12 cents per mile for light trucks, and 30 cents per mile for heavy trucks. The sources of these figures are given.

The study involves the movement of 21,614 daily trips using portions of 286 miles of existing roads, at a current yearly vehicle operation cost of about $15,000,000 (1947). The conclusion is that the shortest route is the best route, although one segment of it will carry less traffic than the existing equivalent segment of existing road already carries.

Phoenix and Tucson are the two principal cities in Arizona. Phoenix is the capital and center of the major agricultural area of the State, has a metropolitan population of 161,000, and is surrounded by several satellite communities. About 200,000 people live within 20 miles. Tucson has a metropolitan population of about 70,000. The relation of these two cities to the Interstate Highway System is shown in Figure 1. The airline distance between the cities is 107 miles and the shortest existing road, 122 miles. Los Angeles