METHOD FOR RECORDING LATERAL POSITION OF VEHICLES

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SYNOPSIS

With the trend in new construction toward multiple lanes and wider pavements, and with extensive programs of pavement widening already underway, additional information is needed on the lateral placement and speed of cars.

Widening existing pavements increases the hazards caused by existing narrow bridges. Data, including the rate of deceleration and multiple lateral placement readings to show the path of approaching vehicles, should be obtained, in order that proper use can be made of signs and other safety devices. By the use of an electrically-operated motion-picture camera mounted on the bridge, these data can be recorded simultaneously.

To obtain lateral placement data at locations other than bridges, the camera, mounted on and concealed back of an existing road sign, records the measurement at a single location along the pavement. Car and truck classification, number of axles on trucks, and other pertinent information is included with this record. The use of this new method has three distinct advantages: accuracy, ease of changing location, and the absence of visible equipment to distort normal driver reaction.

With slight modification of the procedure, night readings can also be taken with the same equipment, both for the multiple readings at narrow bridges, and the single readings on open highways.

Accurate measurements of the lateral position of moving vehicles are vitally needed in the proper design of highway facilities. With the current trend in new construction toward multiple lanes and wider pavements, and with extensive pavement-widening programs already underway, designs for these improvements are still in the development stage. Records of pavement usage, based upon definite measurements of lateral placement, can be of much use in this work.

There is a wide difference of opinion among highway engineers regarding the proper width of traffic lanes. Two-lane pavements have been gradually increased in width, and at the present time no maximum width has been established. The problem becomes even more complicated when extended to include multiple lane highways of various designs. It is recognized that there is a practical economic limit in the width to which traffic lanes should be constructed, and that lanes which are too wide may cause confusion and lead to accidents. The Public Roads Administration and cooperating States have carried on an extensive program of obtaining lateral placement and speed data at numerous locations.[1]

[1] T. Taragin, *Proceedings*, Highway Research Board, Vol. 24, p. 292 (1944).

When existing pavements are widened by the addition of widening strips, other problems arise. It has been observed that drivers do not use the widened pavement in the same manner that they would use a new pavement of the same width. There are many possible combinations in widths of the original pavement and of the widening strips, and very little is known regarding the use that traffic makes of these various combinations. Lateral placement studies can help in establishing the proper design for widening construction in these different situations.

Widening an existing pavement usually produces, in effect, an increased number of narrow bridges. Bridges on most principal highways are generally of adequate width at the time of construction. However, when these main routes are included in pavement widening programs, bridges which formerly were considered satisfactory may become serious hazards to traffic. It is usually impractical to rebuild existing bridges to newer standards, as a part of a current program of general improvement. It frequently becomes necessary, therefore, to decide whether to abandon plans to improve such highways, or to proceed with needed widening projects, planning at the same time to reduce the hazards as much as possible by the proper use of signs, guard rail funnels, and other devices. Careful analysis of the speeds and paths of the vehicles entering these narrow bridges is needed to help solve this problem.

NEW EQUIPMENT FOR OBTAINING LATERAL PLACEMENT DATA

In making a study of the behavior of drivers approaching a bridge, it became apparent that a set of multiple readings should be obtained, both for speed and for lateral position. The Joint Highway Research Project has been using the Photo-Valaxometer, which was constructed a few years ago[2] to measure the deceleration of cars as they approach a narrow bridge from a wider pavement. In using this equipment, seven consecutive "speed traps" consisting of rubber tubes and air switches are set up in the lane of approaching traffic, and the car speed for each of these intervals is automatically recorded. It was seen that, in a similar manner, it would be desirable to obtain several lateral placement recordings for each car, taken at different distances from the end of the bridge. From this information, the average paths of vehicles could be accurately plotted. This type of record seemed to require an entirely new method for obtaining the data.

Since this investigation involved reading of the lateral positions of a moving vehicle at several locations in rapid succession, the use of a motion picture camera was indicated. After some experimentation, the following equipment was developed, and is proving to be satisfactory.

The motion picture camera used is a regular army gun-sight camera (without overrun control), with a three-inch telescopic lens, driven by a 24 volt storage battery. The camera uses standard 50-ft magazine of 16 mm film, which can be loaded in daylight. It has a built-in automatically controlled heating unit, to keep the mechanism operating satisfactorily in cold weather. The camera is connected to the battery by means of a 100-ft length of three-conductor cable, and is controlled by a separately-connected, push-button switch located near the battery.

The camera mounting consists of an adjustable clamp which will fit any ordinary steel bridge member, and will allow the camera to be adjusted to any angle. Another type of mounting was developed to hold the camera in position on the shoulder of the road, or in other locations where a steel truss member is not available.

Target boards, to be used as measuring scales, are 8 in. wide and 6 ft long. They are painted white, and have a saw-tooth pattern in black, for the full width of the board, with the points spaced at 1-ft intervals. Eight of these boards were constructed, together with suitable brackets for holding them erect when they are placed on edge upon the pavement.

PROCEDURE AT NARROW BRIDGES

To record the position of traffic approaching a through-truss bridge, the camera is fastened to a convenient truss member by means of the clamp, approximately 40 ft from the end of the bridge, 10 ft above the floor, and just inside the line of the truss. The camera is aimed by means of a regular optical aiming mechanism which temporarily replaces the film magazine within the camera. The field of view should include the pavement at the end of the bridge, and also the entire length of the pavement on the approach to the bridge, which is to be included in the study. The conductor cable is connected to the camera with the battery and operating switch placed in an inconspicuous position at the side of the road, opposite a point near the center of the portion of highway to be studied.

After the camera is in place, the traffic lane under observation is divided into eight or more stations, which are spaced at convenient intervals. A target board is placed on edge at each of these stations, with the end marked "zero" at the edge of the pavement, and the board extending towards the center, at right angles to the edge. Traffic must be flagged around the boards for the short time that they are in place.

When the target boards have been set up, the camera is started and a few frames of film are exposed with the boards in place. The boards are then removed, and nothing is left on or near the pavement to distract the driver, or to interfere with the normal traffic pattern.

[2] A. K. Branham, "An Automatic Traffic Speed Recorder," *Proceedings*, Highway Research Board, Vol. 21, p. 348 (1941).

R. E. Frost, "Indiana Wartime Traffic Speeds," *Proceedings*, Highway Research Board, Vol. 23, p. 388 (1943).

Cars to be observed are photographed by the camera, which is started and stopped by the observer, who is located at the operating switch. When one magazine of film has been exposed, another can be inserted, without disturbing the position of the camera. An average of approximately 3 sec of exposure is used for each car; 40 cars can be recorded on each 50-ft strip of film.

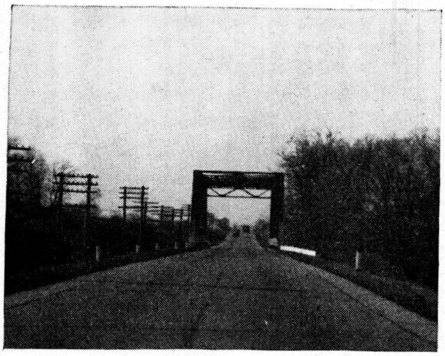

Figure 1. Approach to a Narrow Bridge

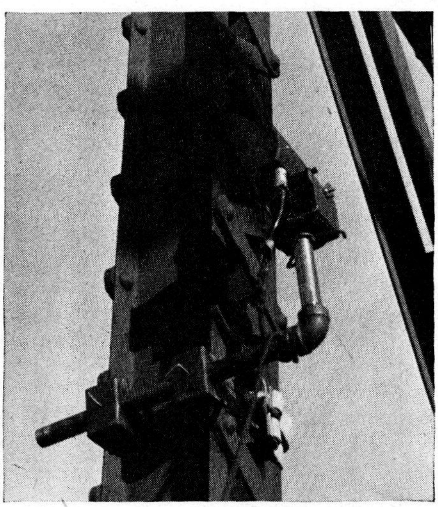

Figure 2. Closeup of Camera in Place

After the film is processed, one of the first few frames, which contains the picture of the target boards in place, is projected on a screen. The remainder of the film, taken at the same camera position, is projected simultaneously on the same screen with a second projector, and the two images are made to coincide. The projectors which are used are hand-operated and can be operated very slowly and stopped at will. When the second projector is started and a car comes into view, the wheels appear to run across each of the target boards. As each board appears to be crossed by the front wheels of the car or truck, a direct reading can be made, giving the distance from the edge of the pavement (zero on the board) to the outside edge of the right front

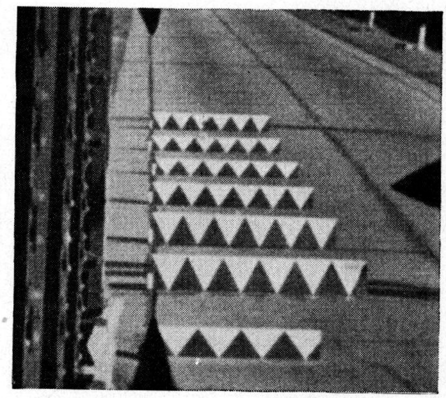

Figure 3. Target Boards in Place

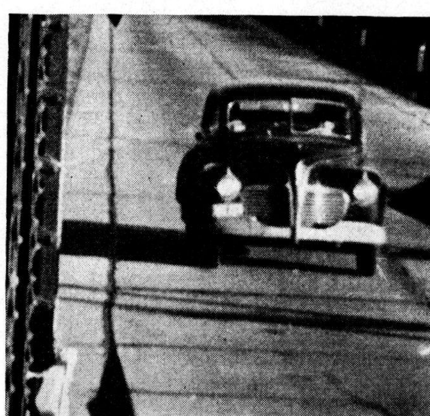

Figure 4. Car Approaching Bridge

tire. This reading can be made to the nearest 6 in. on the more distant stations, and to the nearest 3 in. on the nearer ones. From these data, the path followed by each car or truck can be plotted accurately.

Figure 6 is a diagram of a widened pavement approaching a narrow bridge, in a typical situation. The average paths of the front wheels of both cars and trucks are shown. It is also possible to obtain the path of the outside edge of dual-wheels on trucks and busses. This chart is based on a relatively small number of vehicles, but the average paths form smooth curves on the diagram.

Rates of deceleration of the observed cars were sometimes recorded simultaneously with their lateral positions. This was done by installing air tubes across the pavement at the locations used for the target boards for lateral placement. The Photo-Velaxometer was then used to record speeds for each of the seven intervals. It was found to be advisable, however, to obtain at least a part of the lateral placement data with no equipment or road switches visible to the drivers, in order to insure an accurate record of the normal traffic pattern.

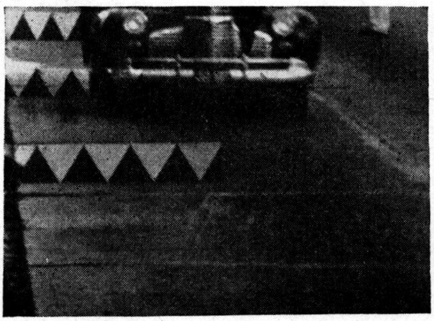

Figure 5. Car Crossing Boards, Superimposed

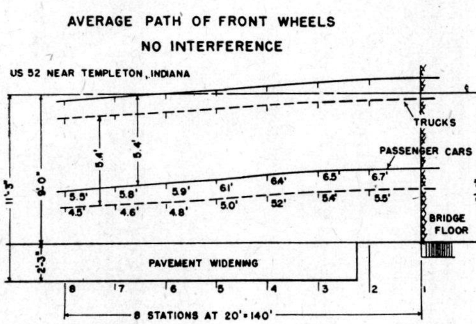

Figure 6. Average Path of Cars

In using motion picture film to measure lateral placement, it was also found possible to obtain speed data to a moderate degree of accuracy. By counting the number of exposed frames between the apparent crossing of the car wheels over consecutive target boards, and with the speed of the camera known, a fairly accurate determination of the speed for each 20-ft interval can be made. More work needs to be done, however, in correlating speeds determined by this method, with those recorded with the Photo-Velaxometer, which is accurate to a fraction of a mile per hour, before the accuracy of the new method can be definitely established.

Dr. Bruce D. Greenshields and his associates, working at the Bureau for Highway Traffic Research at Yale University, have been using timed-interval pictures to record the progress of vehicles through city street intersections.[3] Although his picture interval is more than ten times as long as that of motion pictures, the accuracy of both methods depends upon the constant speed of the timing devices. Dr. Greenshields used the progress of the car as the variable measurement to determine speed, while in the use of motion pictures, the distance is fixed, and the number of exposures are counted. Although the timed-interval pictures will give more accurate speed data at intersections, the use of motion pictures for obtaining multiple speed recordings appears to be satisfactory, when it is used in conjunction with lateral placement studies.

NIGHT READINGS AT NARROW BRIDGES

Bridges which are narrower than the adjacent pavement are dangerous in the daytime, but even more dangerous at night. The problem of correctly placing the proper signs and markings for maximum night effectiveness is difficult. Over-signing, especially with the use of modern reflectorized signs, may even induce accidents, by startling the driver and causing him to swerve into the opposing lane, or to slow down too suddenly.

In order to determine the driver-reaction to different types and sizes of reflectorized signs, the average reaction to various experimental installations should be determined. This can be done by determining the average rate of deceleration, and the average path of the approaching cars and trucks after dark.

The method used to obtain these night readings is essentially the same as that used in the daytime. The camera is clamped into

[3] Bruce D. Greenshields, "Application of Statistical Sampling Methods to traffic performance," p. 377 this volume.

place on the bridge, and the target boards are photographed in their proper position, either by artificial illumination, or by exposing the film before nightfall. Since head lights are used in recording the positions of the vehicles at night, the boards are supported in position above the pavement by small trestles, at the approximate average height of automobile head lamps. The boards are removed, and the actual recording of traffic is begun after dark.

By the use of a suitable filter, the camera records the images of the two head lamps of approaching cars and trucks. When the film is developed, the picture of the target boards and that of the approaching cars are projected upon the screen, and made to coincide. As the two lamps appear to cross a target board, the location of each lamp is recorded, and the position of the car is determined. For direct comparisons with data obtained in daytime, the reading of the center of the car in relation to the edge of the pavement can be converted to the approximate front wheel clearance, by using the average distance from the center of a car to the outside edge of its front tire.

Although the night data are not quite so accurate as those obtained in daytime and the entire procedure is more difficult to carry out, nevertheless it is felt that the results are sufficiently accurate for practical use and that the need for information on night traffic justifies extensive studies. Only a relatively small amount of field work has been done to perfect the procedure used at night, but much more is planned for the immediate future.

LATERAL PLACEMENT ON OPEN HIGHWAYS

The method which has been described is used at locations where the vehicles are assumed to be following curved paths. In obtaining lateral placement recordings on the open highway, a different procedure has been developed, using the same type of camera.

At least two methods have previously been used successfully to measure the lateral positions of vehicles at a single location on a highway. The equipment used by the Public Roads Administration automatically records the position of two lanes of traffic, by the use of a detector strip containing switches located at one-foot intervals.

The joint Highway Research Project has constructed a machine that uses a set of eight small air tubes blocked off in increments of six inches from the edge of the pavement. Small lights on the panel of the machine indicate the position of the tire nearest the edge of the pavement.

In order to determine the reaction of the driver to the small road tubes on the pavement, it was decided to use the motion picture camera to obtain simultaneous readings of lateral position at the same location. In developing the procedures for using the camera for this work, it became apparent that the new method is superior to the one previously used. It is quickly set up, easy to operate, and there is practically nothing visible to distract the driver.

Since only one lateral position of the car is to be determined, and each car is assumed to be moving in a straight line down the highway, no target boards are needed. The camera is fastened to the back of an existing road sign, usually a confirmatory route marker, and is hidden from the view of approaching drivers by means of an auxiliary sign panel, reading "ROUTE NUMBER", made to standard dimensions, and temporarily mounted at the top of the permanent sign. This panel has a small rectangular hole cut in the lower edge, directly in front of the camera lens. If no sign is in place at the location to be studied, a permanent-type sign may be installed for the duration of the investigation. The camera is then aimed so that the cross-hairs intersect the edge of the pavement approximately 100 feet away, facing approaching traffic. The camera is operated by an observer who stands in an inconspicuous location, usually near the right-of-way line, opposite the target point on the pavement.

The developed film is projected upon a screen with a small hand-operated motion picture projector. A horizontal scale, which is divided into fifteen units, each representing one foot, is projected upon the same screen, by means of a slide projector. The "zero" point on the left end of the projected scale is made to coincide with the edge of the pavement, at some convenient point near the center of the picture. The center line of the pavement is then made to intersect the scale at the proper reading, representing the actual width of that portion of the pavement, as measured in the field. This is done by adjusting the distance between the screen and the slide projector to obtain the proper length of the projected scale. In a study of this kind, the longitudinal position of the car is not needed, and it is therefore not necessary to maintain an exact longitudinal location on the image of the pavement. The position of the vehicle can be read directly from the scale, using either the front wheels, or the dual rear wheels of a truck. Approximately 200 cars can be recorded on 50-foot length of film.

This method of obtaining lateral placement has several advantages. There is nothing visible, either on or near the pavement, to distract the driver, or to cause him to alter his normal position upon the pavement. The lateral position can be read accurately to the nearest three inches, using either the front or rear tires. It is also possible to make a separate study of trucks with dual tires.

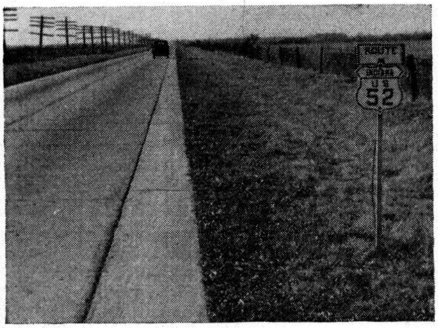

Figure 7. Drivers' View of Sign and Camera

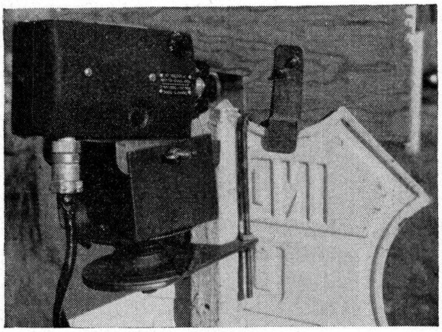

Figure 8. Camera in Place on Road Sign

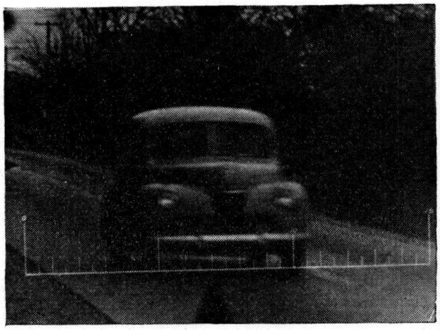

Figure 9. Scale Superimposed on Roadway, not in Alignment

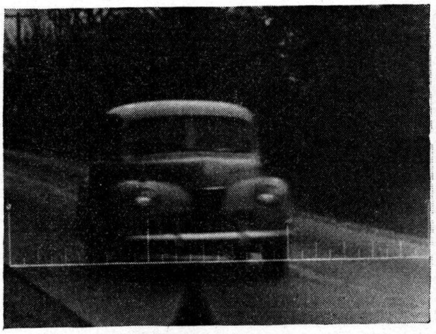

Figure 10. Scale Aligned and with Car Approaching

Other information is recorded on the film, including the classification of cars and trucks, the number of axles on trucks, and other data which might be of value for some special investigation.

The entire apparatus can be quickly set up, and easily moved. This feature is especially important in the study of the use of widened pavements, where there are many different situations to be studied. Statistical analysis of data has shown that for a given location a relatively small number of readings are needed to establish average placement for different types of vehicles, if the driving conditions remain constant. For this reason, the ease with which the recording equipment can be moved makes it practicable to obtain data at many locations for relatively short periods of time, and to return for additional observations when driving conditions become changed.

By modifying the procedure slightly, it is possible to obtain readings at night. By using a different projected scale, and recording the positions of the headlights, readings can be obtained that are almost as accurate as those taken in the daytime. A target light, contained in a long metal tube, placed at the edge of the pavement at the target point, is aimed directly at the camera. This light is operated simultaneously with the camera, and is not visible to the driver. A second light is temporarily placed on the center line of the pavement at the target point, and a few exposures are made of both lights, before any cars are recorded. These two lights are used in adjusting the relative position of the two projectors in relation to the screen, to obtain the proper length for the projected scale. The image of the single light at the edge of the pavement is then used to maintain the proper position of the scale for each reading of the headlights. This procedure has been tested by applying the method to films taken during daylight hours, and comparing the results with those obtained by using the regular procedure for daytime recordings, on the same film. It was found that the individual discrepancies were small, and that the difference in average placement was negligible.

The use of motion pictures for obtaining lateral placement data has been tested at a number of locations, and has proved to be satisfactory. It is planned to use this equipment to make an extensive study of pavement usage in Indiana, with special attention to be given to pavements which have been widened.

SUMMARY

Both lateral placement and speed data are needed for designing new pavements and for planning improvement on existing highways. Narrow bridges, particularly on widened pavements, are serious hazards. The data needed at these locations include both the lateral placement at various pre-determined points, from which the actual path of each approaching car can be plotted, and the rates of deceleration. Data are also needed on the lateral positions of cars and trucks on the open highway, especially at locations where the pavement has been widened. Because of the need for this type of information, the following methods have been developed.

1. Lateral placement and the approximate speeds of cars approaching a bridge can be recorded simultaneously at a number of predetermined points, by the use of motion pictures. By a slight modification of procedure, these readings can also be made at night.
   (a) By placing the camera in an inconspicuous location, a normal reaction pattern can be recorded.
   (b) Several lateral placement readings can be recorded for each car, and intervals can be selected to fit any situation.
   (c) Rates of speed and deceleration patterns can be obtained simultaneously with lateral placement recording, either by use of road tubes, or by counting the number of frames on the exposed film.

2. At locations where only one lateral placement reading is needed an electrically-driven motion picture camera, operated from an inconspicuous position near the edge of the pavement, can accurately record the positions of approaching cars. This method has the following advantages:
   (a) The camera is concealed behind an existing road sign by an auxiliary panel, and no equipment is visible to distract the driver.
   (b) The lateral positions of vehicles can be read accurately to the nearest three inches.
   (c) Special investigations, including a study of trucks with dual tires, can be made from the same records.
   (d) The recording apparatus is easily moved to new locations, increasing the total number of situations that can be studied.
   (e) Night readings can be made, with a slight modification of the procedure.

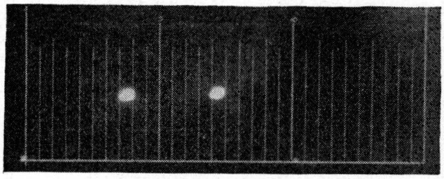

Figure 11. Scale, Aligned with Target Lights, and with Car Approaching

The use of automatic motion picture

cameras has provided an accurate and efficient method for obtaining information on driver-reaction and traffic movements. It has made possible the recording of sufficient data to define the actual paths of vehicles, even at locations where they are made to swerve to avoid apparent traffic hazards. It is hoped that the procedures which have been described can be used to add to the information already available, for use by design engineers and traffic engineers, in the advancement of highway safety.

Acknowledgments

The writer wishes to thank Mr. Warren S. Quimby and Mr. Walter B. Wilson, members of the Joint Highway Research Staff, for their help in developing these methods for obtaining traffic data. Some of the equipment was designed and constructed by Mr. Quimby, and Mr. Wilson helped to establish the accuracy of the data by developing direct comparisons with data obtained by other methods. Mr. R. E. Peterson, staff photographer aided in the photographic work, and is responsible for the illustrations using superimposed negatives.

PURPOSE, ANALYSIS AND APPLICATION, ORIGIN AND DESTINATION SURVEY, MILWAUKEE METROPOLITAN AREA

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SYNOPSIS

Costly traffic delays, congestion, and hazards exist in Milwaukee as in other urban areas. The installation of traffic signals has paralleled motor vehicle registration. Few of these installations help traffic flow but rather retard it in the interest of safety. New routes are being constructed with center parkways, streets are being widened, etc., but the accident rate does not decline and there is still serious congestion.

Speeds on existing arterial streets and expressways were studied. Downtown speeds averaged 10 mph in a zone with a 25 mph speed limit while expressway speeds averaged 31.5 mph in a 30 mph zone. A check on specific sections of downtown arterial streets and a section of expressway carrying similar traffic but with no cross traffic, showed the expressway to have the very significant advantages of a 2½ to 1 speed ratio, a 1 to 20 accident ratio, and a 1 to 30 injury ratio.

The cost of operation of motor vehicles in traffic was studied. A check disclosed that the average Milwaukee driver makes approximately four stops and loses 56 sec. in each mile of downtown artery travel. At 25 mph a vehicle making no stops gets 6 mi per gal more mileage than one making four stops.

The Milwaukee origin and destination survey was undertaken to determine if expressways would be economically justifiable by the volumes of traffic expected. For computing comparative data between expressways and improved existing streets a speed ratio of 2 to 1 (35 to 17.5 mph) was chosen and a minimum volume to justify expressway construction was established as 30,000 vehicles per day.

Several alternate north-south routes were studied in detail and three were determined to be adequate for the needs of traffic. Other considerations such as right of way cost, the existence of an adequate bridge etc. led to the selection of one route (over Sixteenth St.) for the principal north-south artery. The east-west route was chosen (over Highland Ave.) in the same manner. A belt route around the downtown business area and radiating feeders to interregional highways etc. are also recommended.

Milwaukee, as most other cities, owes its location to the fact that it was a logical transportation center for water-borne traffic. The city's three rivers provided a natural harbor where passengers and cargoes could be transferred from ship to land transport. Rail-