Congress Street Expressway Surveillance Project

A. D. May Jr.
Director
Expressway Surveillance Project
Illinois Division of Highways
Chicago, Illinois

This project is a cooperative research venture between the city of Chicago, Cook County, state of Illinois, and the U. S. Bureau of Public Roads. The project began in April 1961. A Project Advisory Committee was established at the beginning of the project and the committee consisted of two representatives of each of the four cooperating agencies. George Hagenauer is Chairman of this Advisory Committee. Cooperation has been received from many persons, but I would like particularly to recognize the contribution of Abe Taragin of the Bureau of Public Roads. During this first 15 months of study the Ramo-Wooldridge Co. provided project managership for the project.

This paper will be presented in four parts, with most of the time devoted to parts 1 and 3. The first part of the paper deals with the preliminary operational studies that were conducted during the initial phase of the project. Then mention will be made of some of the equipment evaluation that was conducted. The third part will describe the pilot system that was designed, and the fourth part deals with the initial studies that were conducted with the Pilot Detection System.

Part I. *Preliminary Operational Studies*

At the beginning of the project it was decided that the approach used would be to select a study section which would be utilized by the project staff as a laboratory. The objective of the project was to reduce congestion on the freeway; if successful in the study section, consideration would be given to extending the surveillance to other portions of the expressway system. Decisions had to be made in regard to selecting the study section. Should it be inbound or outbound? Should it be on the Congress Street Expressway or Northwest Expressway? How long should the section be?

It was decided first of all that the study section would be on the Congress Street Expressway because it has good design features and it was typical of the expressway system. Another criterion in selecting the study section was that the study section should be so selected that free flow should exist downstream so that if capacity could be increased in the study section, congestion would not be further aggravated at some location downstream. Consequently, the outbound Congress Street Expressway was selected as the site for the study section.

The next question then was how long a section should be selected. The general idea at the beginning was that the study section should be long enough to permit a good evaluation of surveillance techniques, but not too long so that energies would be spread over a long section. Consequently, a four to eight-mile section was thought of as a desirable length.

Now let us turn to some of the preliminary operational studies. The preliminary studies can be presented in four parts: volume counts, modified speed study, aerial density study, and ground photography. The first step was to obtain volume counts along the entire length of the Congress Street Expressway by making counts on each "off" and "on" ramp and at selected locations along the main line. This permitted the development of peak hours, as well as 24-hour traffic flow maps (Fig. 1). In order to identify the level of service on the Congress Street Expressway a modified speed study was conducted. Essentially a test vehicle each 15 minutes entered the traffic stream in the downtown area and moved out along the Congress Street Expressway for a distance of

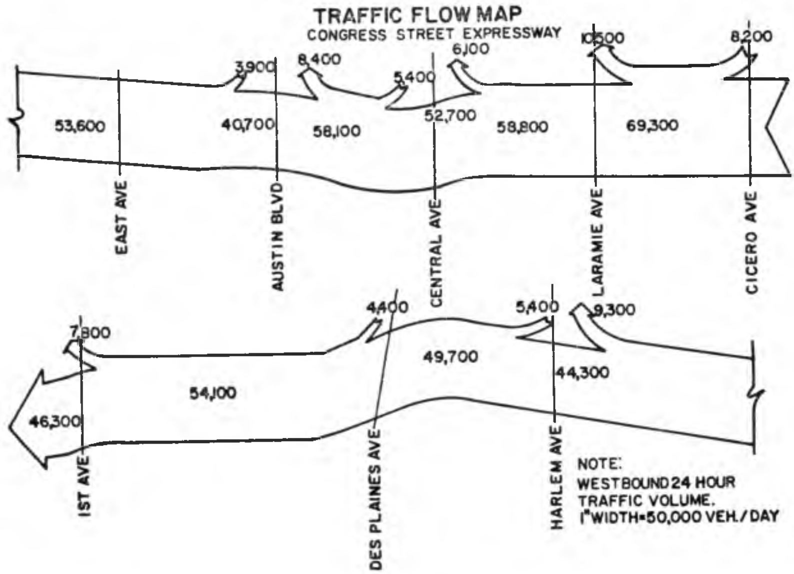


Fig. 1.

approximately 12 miles. At each interval distance of one-tenth to two-tenths mile length the speedometer was read. From the speed readings a contour map was developed (Fig. 2).

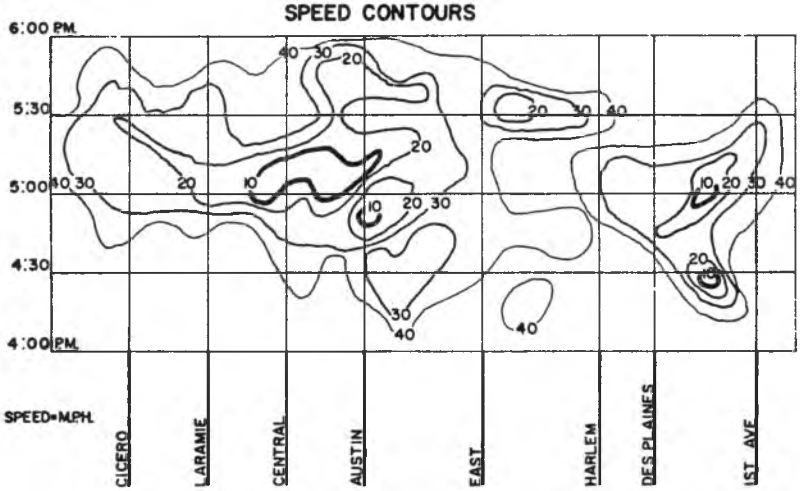


Fig. 2.

The third study was an aerial density study. The aerial density study consisted of a light aircraft flying over the expressway for periods of time before, during, and after congestion. The plane was equipped with a time lapse camera and photographs were taken. Photographs were analyzed, dividing the twelve-mile section of the freeway into quarter-mile to half-mile intervals. For each interval the number of vehicles was counted, and density was computed. Again a contour map was developed, this time based on aerial density measurements (Fig. 3).

The fourth preliminary operational study was a ground photography study where eight cameras were located on the section between First Avenue and Pulaski. The ground cameras were operated for two days for the two-hour period of 4 to 6 p.m. Each camera was run at the rate of one frame per second and a clock was exhibited in each frame. Measurements of speed, volume, and density were taken. Curves were constructed showing volume-speed, speed-density, and volume-density curves (Figs. 4, 5 and 6). The first graph's horizontal scale is total volume and the vertical scale is average speed. There were eight locations, two days at each location, for a total of 16 curves. The maximum volume rate which was in the vicinity of 100 vehicles per minute (hourly rate of 6,000 vehicles per hour) and occurred at speeds of about 30 to

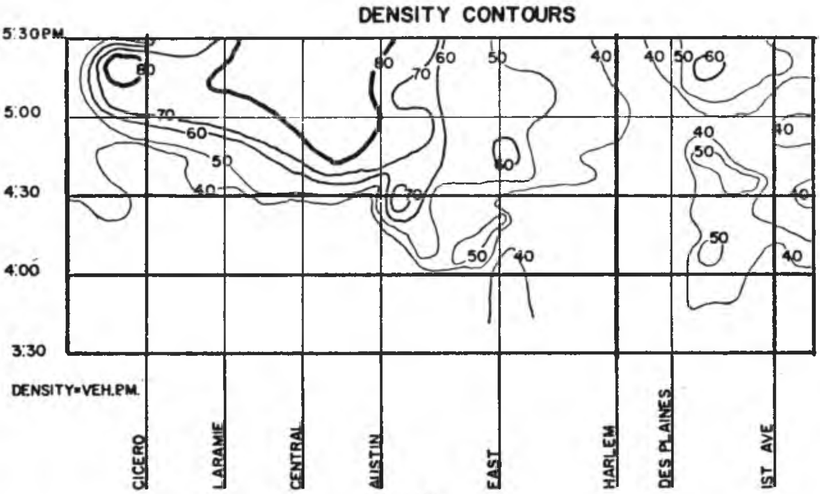

DENSITY CONTOURS
5:30PM
5:00
4:30
4:00
3:30
DENSITY=VEH.PM.
CICERO
LARAMIE
CENTRAL
AUSTIN
EAST
HARLEM
DES PLAINES
IST AVE
80
70
60
50
40

Fig. 3.

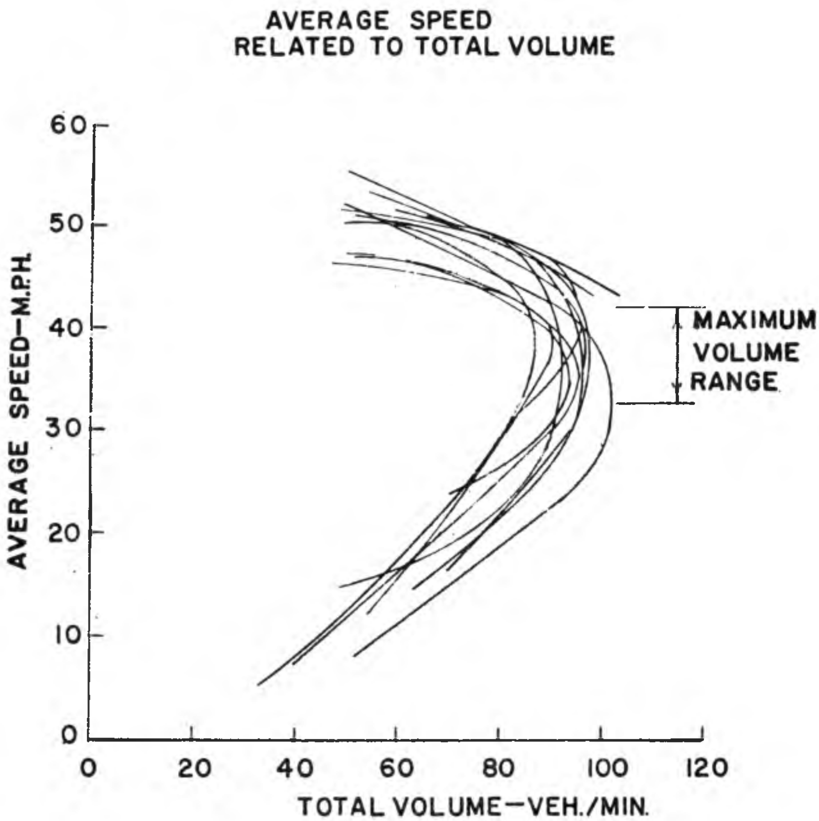

AVERAGE SPEED
RELATED TO TOTAL VOLUME
AVERAGE SPEED—M.P.H.
0
10
20
30
40
50
60
0
20
40
60
80
100
120
TOTAL VOLUME—VEH./MIN.
MAXIMUM
VOLUME
RANGE

Fig. 4.

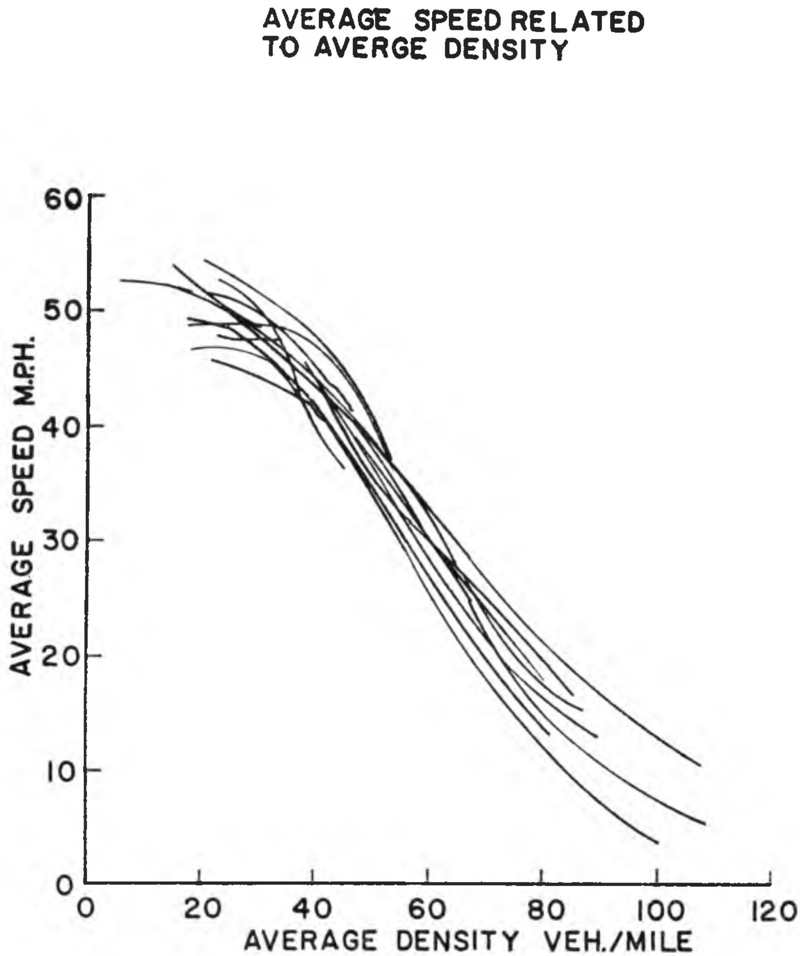


Fig. 5.

40 miles an hour. It was also possible to develop curves between speed and density and again we have 16 curves shown—eight locations—two days for each location.

A third type of graph (volume density) was prepared from the same data and resulted in a series of 16 curves showing that the maximum volume rate was 100 vehicles per minute and occurs at densities around 45 to 60 vehicles per mile.

From these graphs a generalized curve combining volume, speed and density was developed (Fig. 7).

The purpose of this graph was to show our interpretation of four zones of operation. Zone one may be considered as a constant speed of

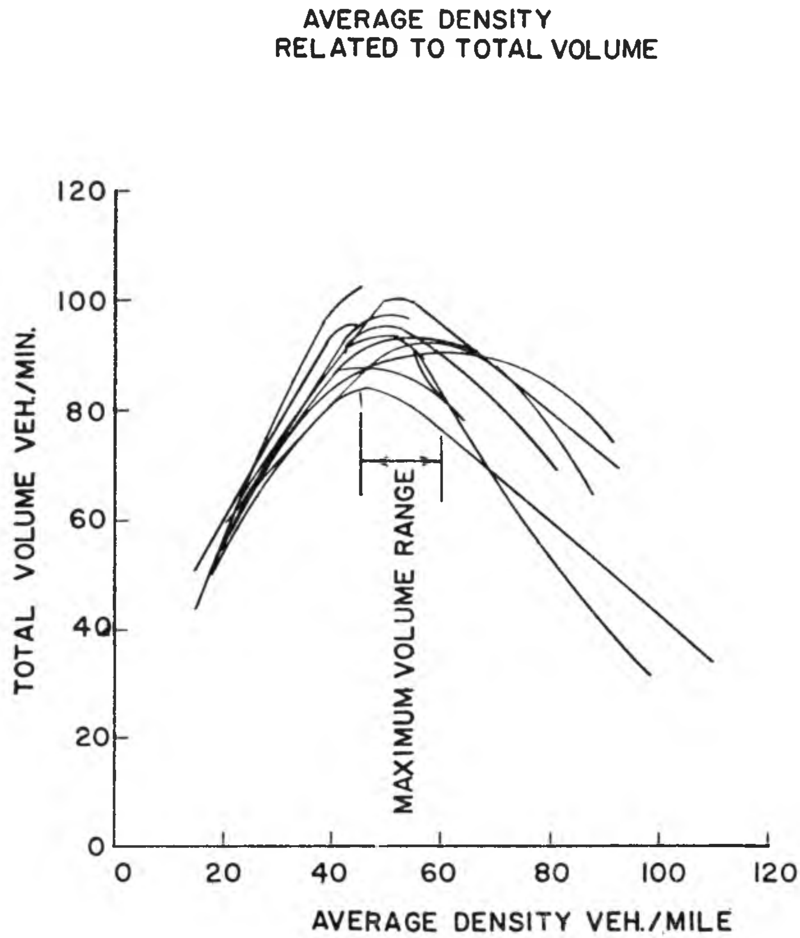
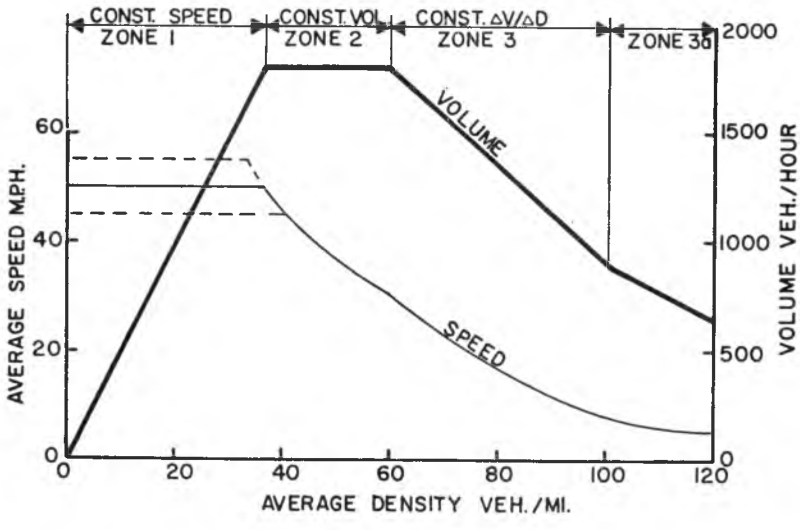


Fig. 6.

45 to 55 miles per hour, with all the traffic that wants to use the facility being carried. If traffic becomes heavier zone 2 occurs with maximum volume, densities of 40 to 60 cars per mile, and speeds of 35 to 40 miles per hour.

As congestion sets in concentration (density) increases. There is a reduction in how many vehicles can pass and the speed at which they pass; this is indicated by zone three. The last zone occurs when special conditions exist such as an accident or disabled vehicle. Operations therefore on the expressway are divided into four parts; green zone, yellow zone, red zone and flashing red zone.



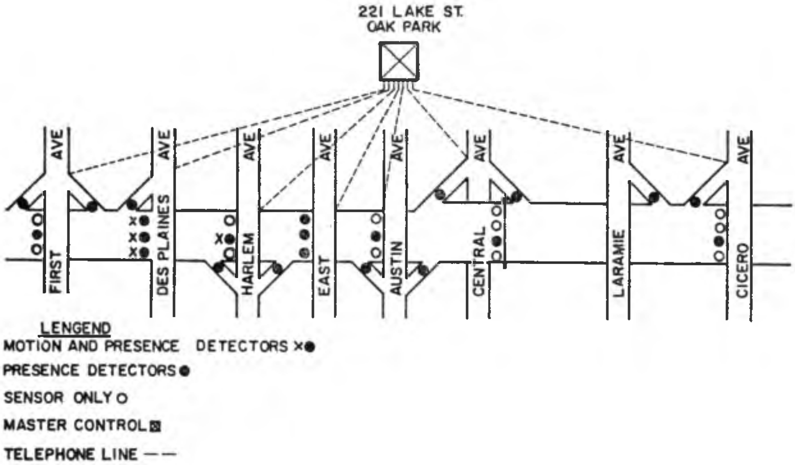
GENERALIZED TRAFFIC OPERATIONS
Fig. 7.

Part II. *Equipment Evaluation*

While the operational studies were being conducted a group of the project staff was evaluating surveillance equipment. A number of detectors, analog computer systems and data recording devices were evaluated in field tests conducted on the Congress Street Expressway. The results of these evaluations and the operational studies provided us the data necessary for designing the pilot system.

Part III. *Pilot System Design*

The study section was selected from Cicero to First Avenue. Figure 8 shows the study section and the location of our office approximately a mile north of the midpoint. In the field there are 38 traffic detectors and one pavement condition detector. Note that at each off and on-ramp a detector is located. (There are 11). At the seven mainline stations there is a detector located in each lane. Notice further that the detectors shown by the solid dot are connected to the field office. It is possible from the office to switch the computer to be connected to the different detectors. At East Avenue a detector is located over each of the three lanes and with the measurement at East Avenue and with measurements at the off and on-ramps, traffic volumes on an hourly and daily basis can be determined for any portion of this section. All the detectors shown in



PROPOSED PILOT DETECTION SYSTEM

Fig. 8.

a circular symbol indicate locations of detectors that measure volume and occupancy. In addition, at Harlem and Des Plaines four motion detectors which measure volume and speed have been installed. Also, at Des Plaines there is a detector which measures whether the pavement is wet or dry and whether the temperature is above or below freezing. This information is brought into the central office through Bell telephone lines. Special tone equipment is used at Des Plaines for experimental purposes. A voice phone system is available from each of the seven stations so that oral communications are possible between stations as well as between stations and the central office.

As mentioned earlier we have 38 traffic detectors and one pavement condition detector fed into computers in the central office. On each computer, meters and counters are located so that observations of these volumes, occupancies and speeds are possible. Computers are connected to a level monitor, X-Y plotter, printer-counter and a tape punch. The level monitors are used to control the map display. X-Y plotter is used to plot on-line various curves such as volume-speed, speed-occupancy or any one variable vs. time. The printer-counter is used to print out the three traffic characteristics, plus time. The tape punch is the backbone of our output which can scan through all the measurements of the system (84 measurements) in about 17 seconds and punch the data on paper tape. The paper tape can readily be put into a digital computer for further analysis or can be punched out on a flexowriter off-line.

Part IV. *Initial Studies*

The last part of the presentation deals with studies that have been initiated since the installation of the Pilot Protection System. The Pilot Detection System was officially turned on in September of 1962 and was calibrated and placed on line, ready for operation the first week in October. During October a comprehensive study was undertaken during a 21-day period in which 84 measurements per minute were punched on punch tape. This data is being used for two purposes; one for further studies of traffic flow characteristics and the other for operational inventory prior to any operational changes.

An illustration of an on-line speed occupancy continuous diagram which is plotted in the office is shown in Fig. 9.

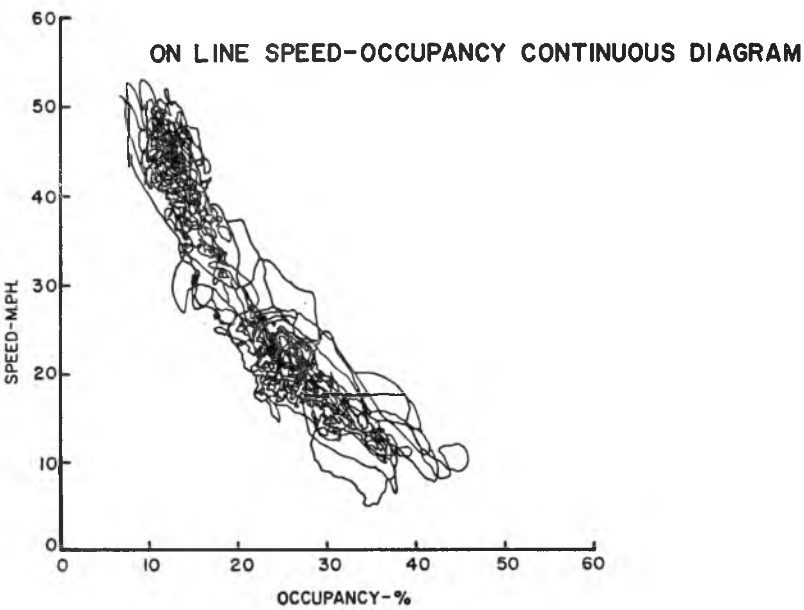


Fig. 9.

Fig. 10 shows the light indications of our map display during a typical afternoon peak period. The clear area indicates when speeds are over 40 miles per hour and traffic flow satisfactory. Note that First Avenue is clear (green) throughout this particular day (October 10, 1962).

The cross hatched area indicates impending congestion and maximum flow. The black area indicates congestion. Note that congestion began at Austin around 4:20 and very soon afterwards congestion began at Cicero. The same thing happens at Des Plaines and by 5:20 congestion exists along the complete length of the study section and continues till 6:15 or so. This clearly indicates our two operational problems—one in the vicinity of Des Plaines and one in the vicinity of Austin. Upon completion of the analyses of the comprehensive study, plans are being formulated to consider experimentation with control in order to improve operations on the Congress Street Expressway.

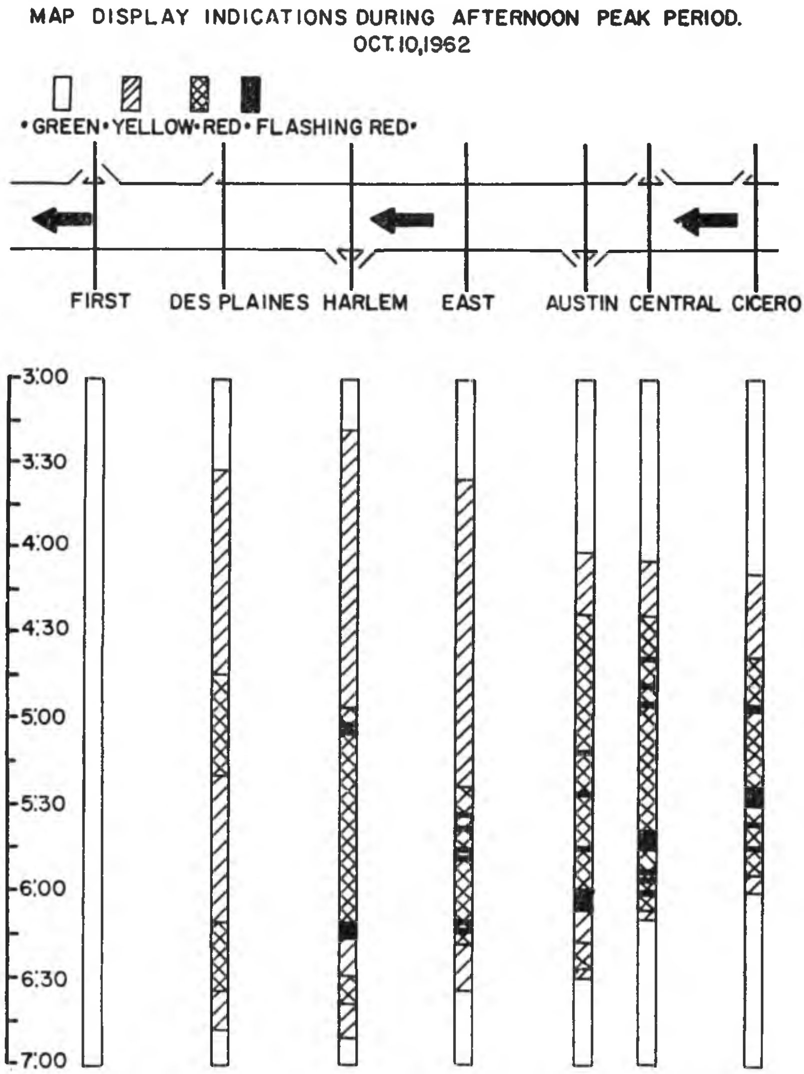


Fig. 10.