UTILIZATION OF COMPUTER PLOTTING IN TRAFFIC ASSIGNMENT ANALYSIS

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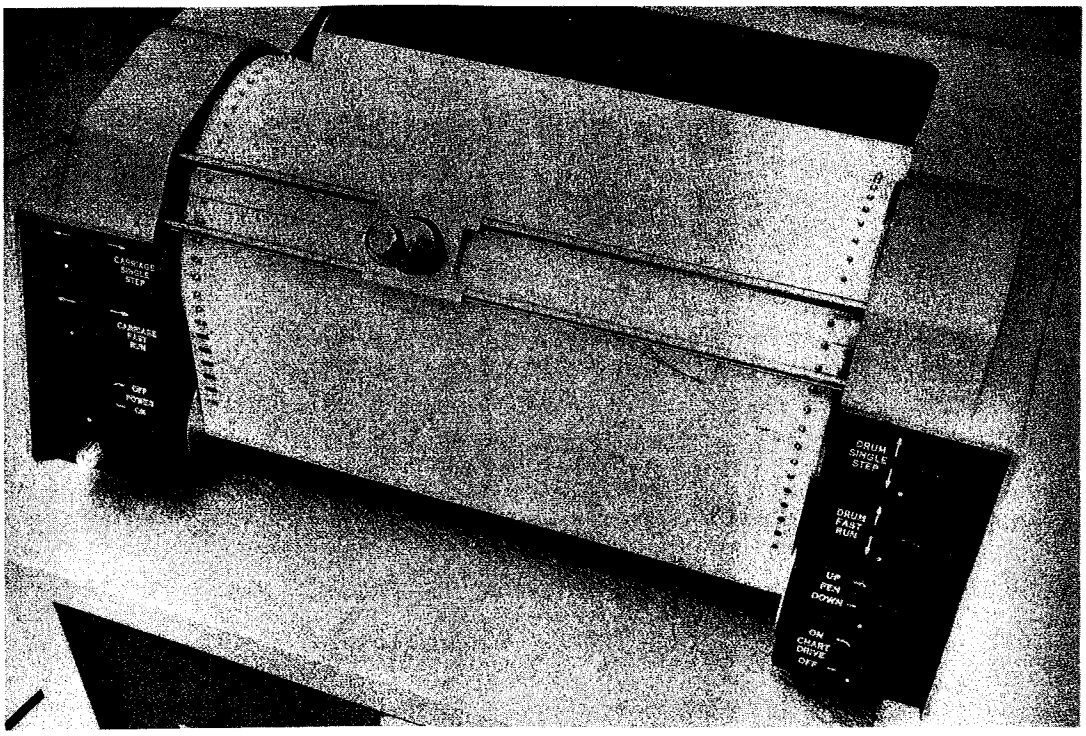
INTRODUCTION

Examination of the numerous pages of data produced by traffic assignment computer programs is a tedious and time-consuming task. As a result, the work incurs a high probability of error. Therefore, some type of summary and visual representation for traffic network analysis is highly justified. The best form of output would be a computer-drawn map of the network being studied. With such a map, on which volumes of traffic or changes to the existing network could be plotted, many preliminary analyses could be made rapidly and with a high degree of accuracy.

The development of computer-drawn maps is not a new idea, as such maps have been produced using printed characters to give a resemblance of the network. These, however, are difficult to examine. Furthermore, the accuracy of this type output is limited because of printer spacing. Therefore, the printing-plot method has not been widely accepted as a usable means of obtaining information. Because of their limitations, network maps of this type would be unsuitable for distribution to highway planners.

The Digital Incremental Plotter

A new development has been introduced to the computer devices industry. This device, termed a digital incremental plotter, is now being recognized as a powerful tool. An incremental plotter (Figure 1) operates in the following manner: an impulse, or signal is sent to the plotter



PEN CARRIAGE AND DRUM OF CALCOMP PLOTTER

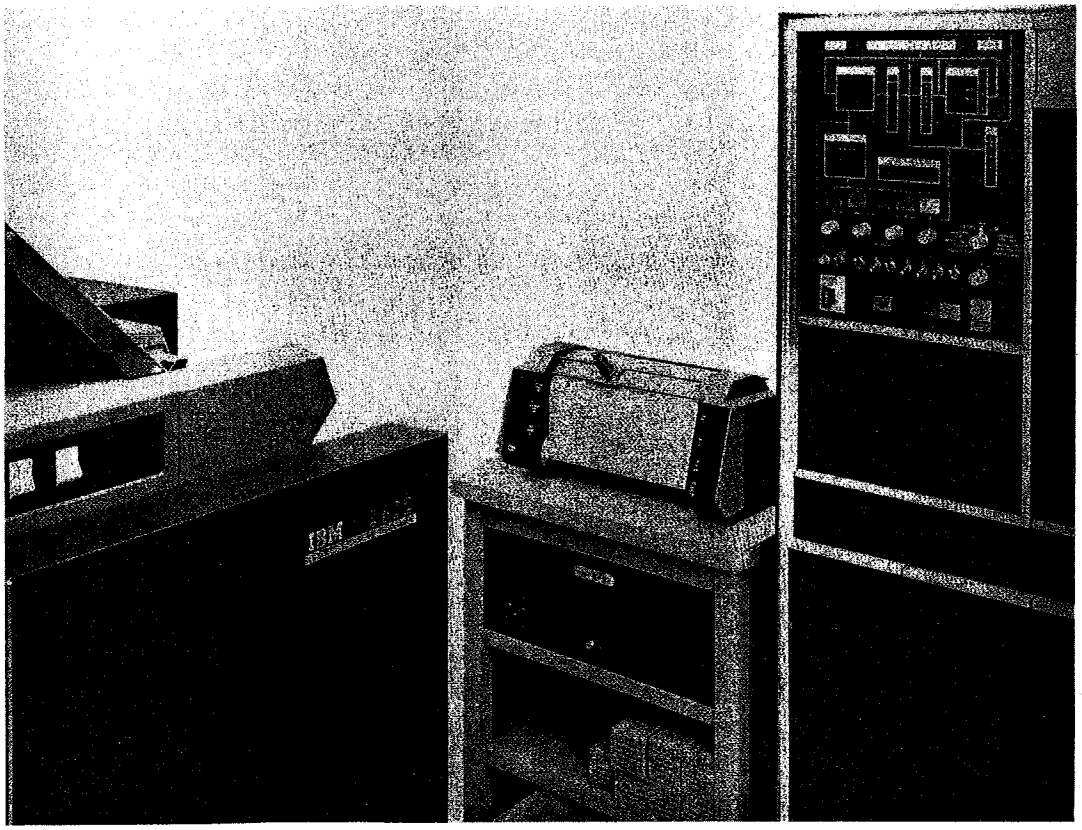


Figure 1. CALCOMP PLOTTER ATTACHED TO IBM 1401

directing the plotter pen to move in a particular direction and to lift or to lower itself. Straight lines may be drawn, then, for representation of data in graphical form.

Since the digital incremental plotter appeared to have significant potential as an aid to the analysis of data from traffic assignment programs, a research study was initiated by the Texas Transportation Institute to develop plotting programs. This study was a phase of a Traffic Assignment project which was sponsored by the Texas Highway Department in cooperation with the U. S. Bureau of Public Roads.

Work on the development of the plotting programs was initiated in September 1963 and completed in October 1964. This report will discuss the plotting capabilitites and requirements of the plot programs in order to acquaint those responsible for the analysis of traffic assignment data with their use and to permit an evaluation of the plot programs as an additional tool for data analysis.

PLOTTING CAPABILITIES

After consideration of the traffic analysis process, the following plotting capabilities were developed for use in traffic assignment analysis:

1. Plot Network Description.
2. Plot Loaded Networks.
3. Plot Trees.
4. Plot Central Business District.
5. Plot Loaded Network with Volume Option.

The above capabilities will be discussed in detail in the following sections.

General

Plot size (or map size) is specified by indicating on a control card, the number of "strips" or 11-inch widths of paper on which the map is to be drawn. The limits on the y coordinate for each strip are determined by the computer. All plot programs offer the option of selecting the number of strips to be utilized in producing the desired map; i.e. the size map desired.

Four colors are available for plotting: red, blue, green, and black. Street types and volume ranges are thereby easily recognized by utilization of the color distinction. Networks are coded with respect

to three classes of streets - local, arterial, or freeway. These street types are determined from information given on the traffic assignment parameter card.

If desired, volume of flow may be used as a plotting parameter. When considering a directional network, directional volumes are shown on each two-way link. If the plot is to be nondirectional, total link volumes are used. Traffic volumes may be written at the center of each link.

It is often desirable to analyze not only nondirectional, but directional networks. Outbound and inbound flow at an intersection may be represented by two parallel lines separated by .02 inches and drawn from origin to destination.

Example

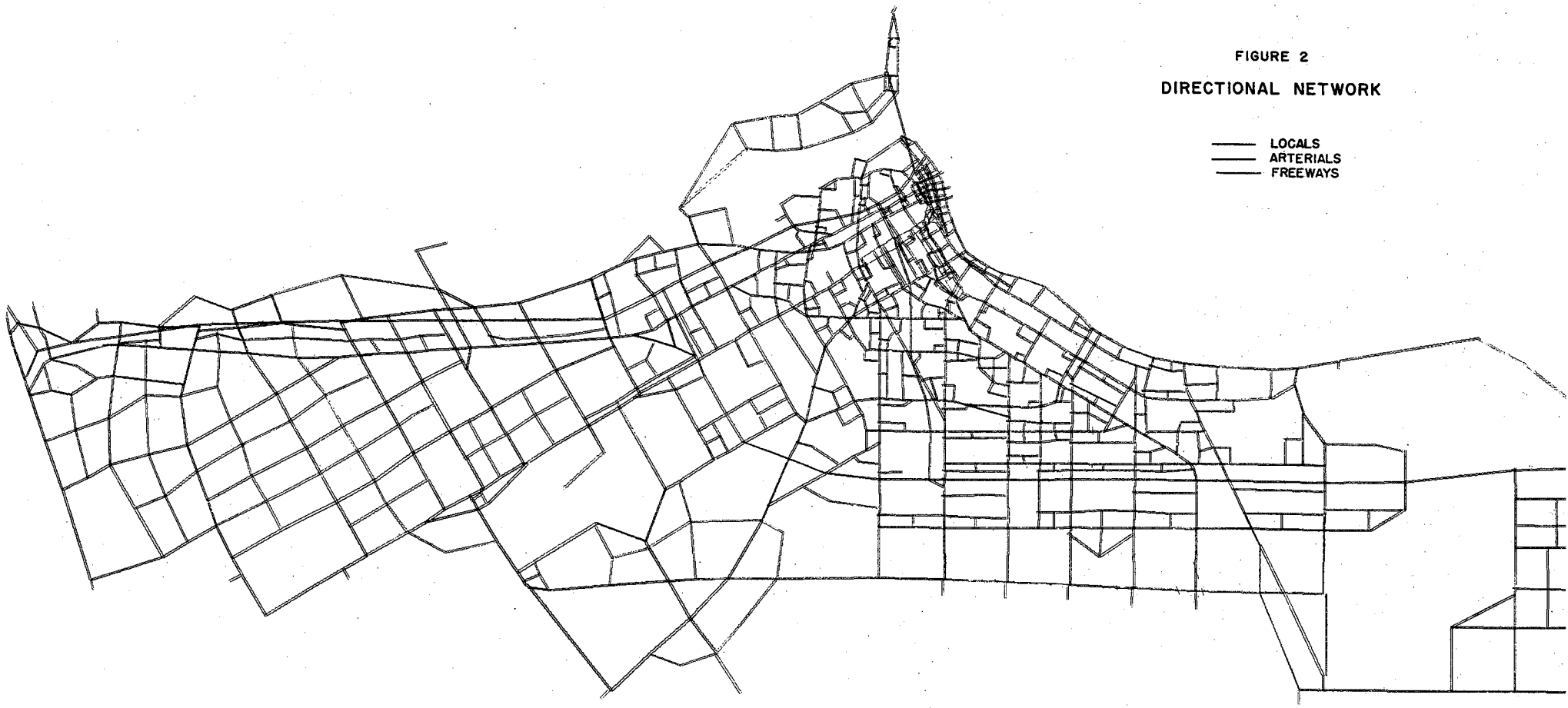
Scheme B-3 of the Corpus Christi network has been used in this report as an example for illustrating plotting capabilities. The Corpus Christi B-3 network has the following specifications:

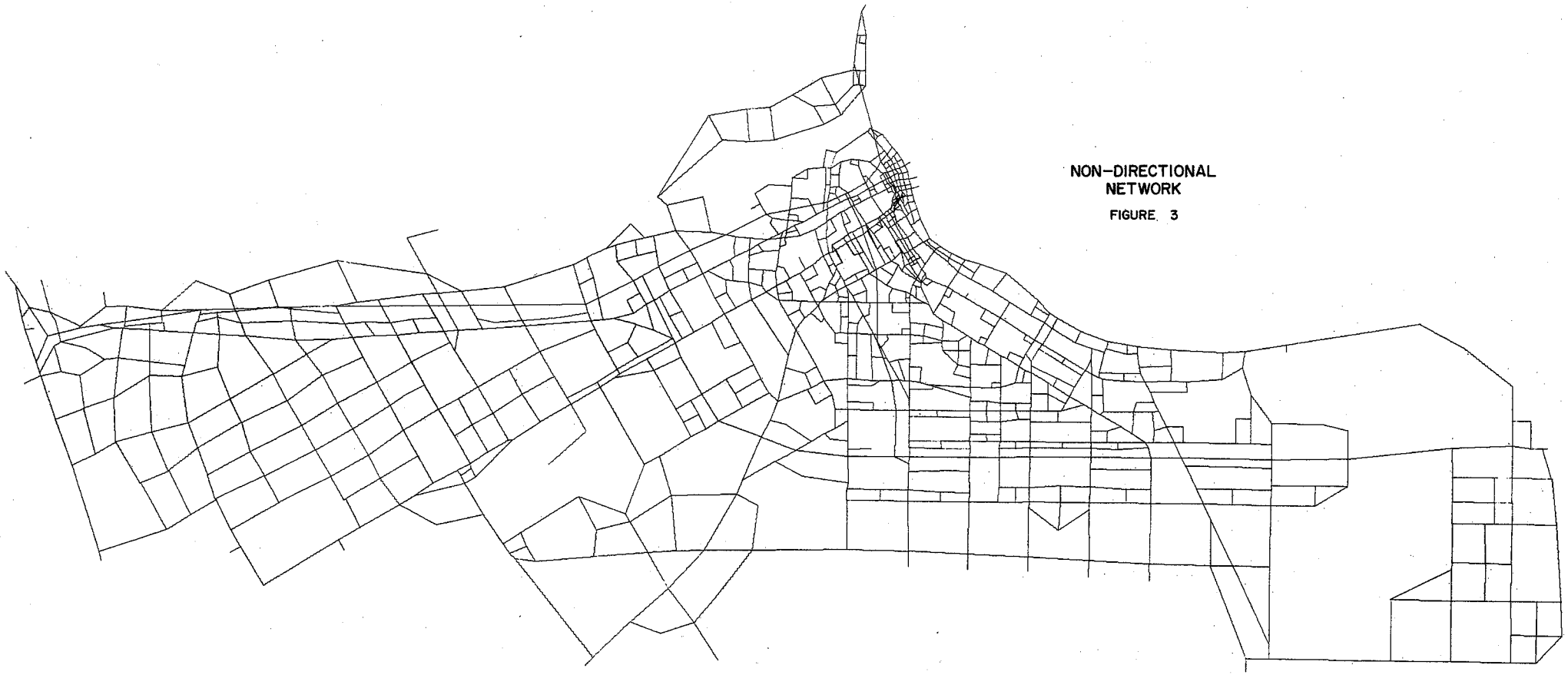
Centroids	223
Nodes	1,098
Nondirectional links	1,737
Directional links	3,474

Volumes of traffic used are 1/4 of the actual Corpus Christi B-3 forecasted peaks.

FIGURE 2

DIRECTIONAL NETWORK





NON-DIRECTIONAL
NETWORK

FIGURE 3

Network Descriptions

Program 23 in the traffic assignment package, Plot Network Description, draws a map of the network. Information in the network description record is that which was supplied by the link data cards. A network may be plotted in different colors depending on street type: local, arterial or freeway. If desired, any combination of the street types may be plotted.

Figure 2 illustrates a directional plot of a network. Local streets are plotted in green, arterial streets in black, and freeways in red. Computer time required for this plot was as follows:

Map Width	709	1401/565	Total Machine Time
11 inches	15 Min.	23 Min.	38 Min.
33 inches	11 Min.	45 Min.	56 Min.

Figure 3 illustrates a nondirectional network plot with no street type distinction. Plotting of this network required the following computer time:

Map Width	709	1401/565	Total Machine Time
11 inches	11 Min.	5 Min.	16 Min.
33 inches	9 Min.	15 Min.	24 Min.

Minimum Path Trees

In the analysis process, it may be desirable to study individual minimum path trees. The minimum path represents the minimum time route from a Centroid to all other nodes in the network. Minimum path routes (trees) may be plotted with Program 25. Plot size and pen color are the only options offered in this program. A network plot and a tree plot of the same size (number of strips) will match exactly.

Figure 4 illustrates a plot of the Corpus Christi minimum path tree number 1. Computer time used to generate the plot was:

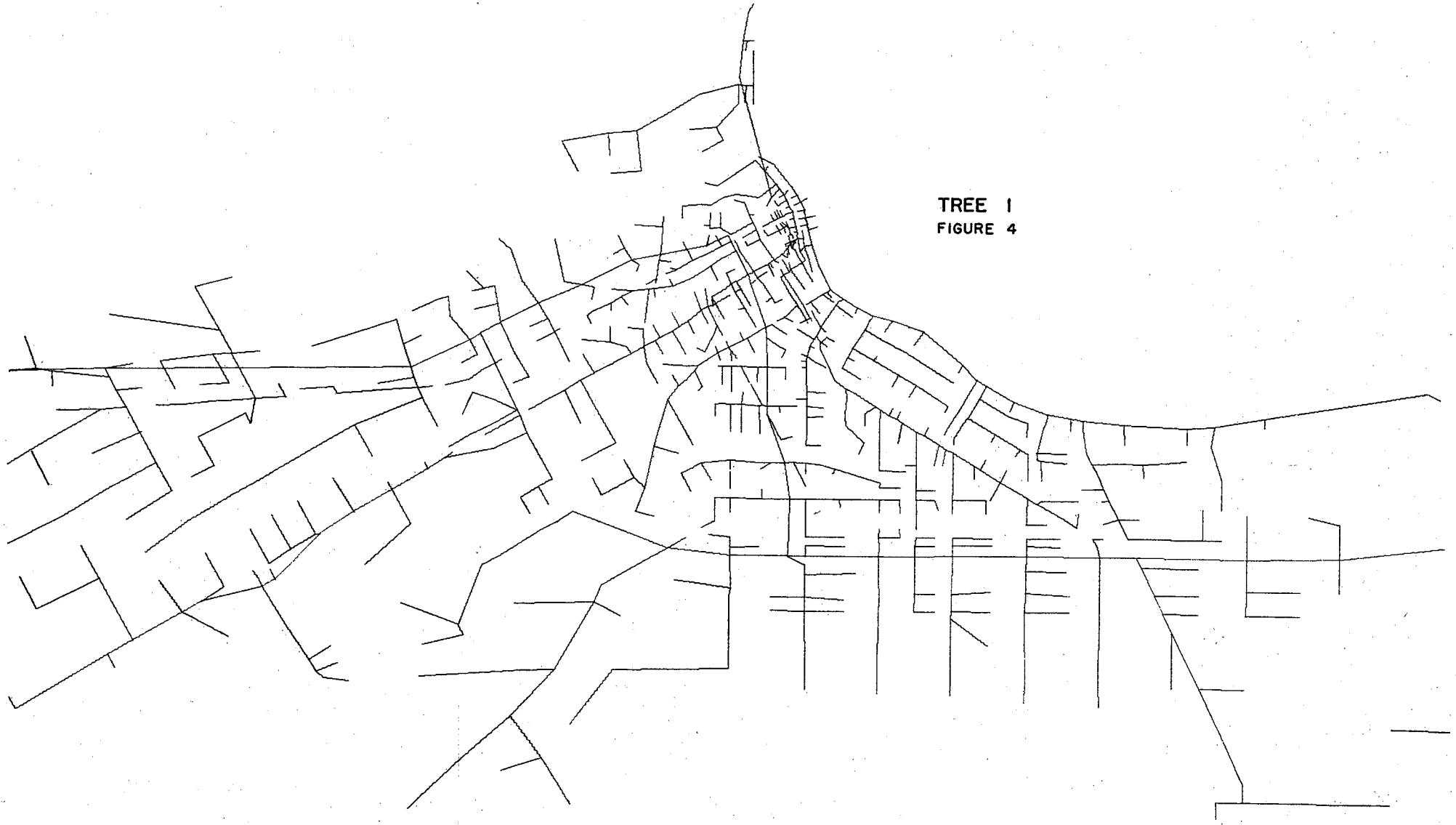
Map Width	709	1401/565	Total Machine Time
11 inches	20 Min.	4 Min.	24 Min.
33 inches	15 Min.	14 Min.	29 Min.

Loaded Networks

The traffic assignment package loads the network with present or forecasted volumes of flow. Two plotting programs are available to provide visual data on the loaded networks. These are:

1. Program 24, Plot Loaded Network, and
2. Program 27, Plot Loaded Network with Volumes option.

Street types may be plotted in different colors, as in Program 23 (Plot Network Description). In addition, volume ranges, may be plotted in different colors. Both of the above options may be used in conjunction



TREE 1
FIGURE 4

with each other. For example, if freeways are selected for a street type, volume ranges may be used for a multi-color freeway plot. Using Program 27, the same plot may be made with volumes of flow written above the freeway links. All options offered by Program 24 are available in Program 27. However, the volumes option allows the plot of directional or nondirectional volumes of flow to be written above the links of arterial and/or freeway links. Volumes are written in hundreds of trips (example: 12 equals 1200).

Figure 5 illustrates a nondirectional plot of the loaded Corpus Christi network for 1983 forcasted peak PM traffic. Street types were not specified and the color code used was as follows:

Green	0-1,000 trips
Black	1001-2000 trips
Blue	2001-3000 trips
Red	more than 3000 trips

Computer time necessary to produce this map was as follows:

Map Width	709	1401/565	Total Machine Time
11 inches	12 Min.	10 Min.	22 Min.
33 inches	10 Min.	20 Min.	30 Min.

Volumes of traffic flow on freeways were plotted in Figure 6. In this case, only the directional freeway system was plotted using the following color code for volumes:

Green	0-500 trips
Black	501-2000 trips
Red	more than 2000 trips

Time spent on the computer was as follows:

Map Width	709	1401/565	Total Machine Time
11 inches	3 Min.	6 Min.	9 Min.
33 inches	4 Min.	14 Min.	18 Min.

Central Business Districts

As can be seen in the previous figures, it would be undesirable to write volumes of traffic on the links of the central business district. The Central Business District Plot program 26, as illustrated in Figure 7, was developed to plot only the CBD in nondirectional form.

Necessary computer time for this map was as follows:

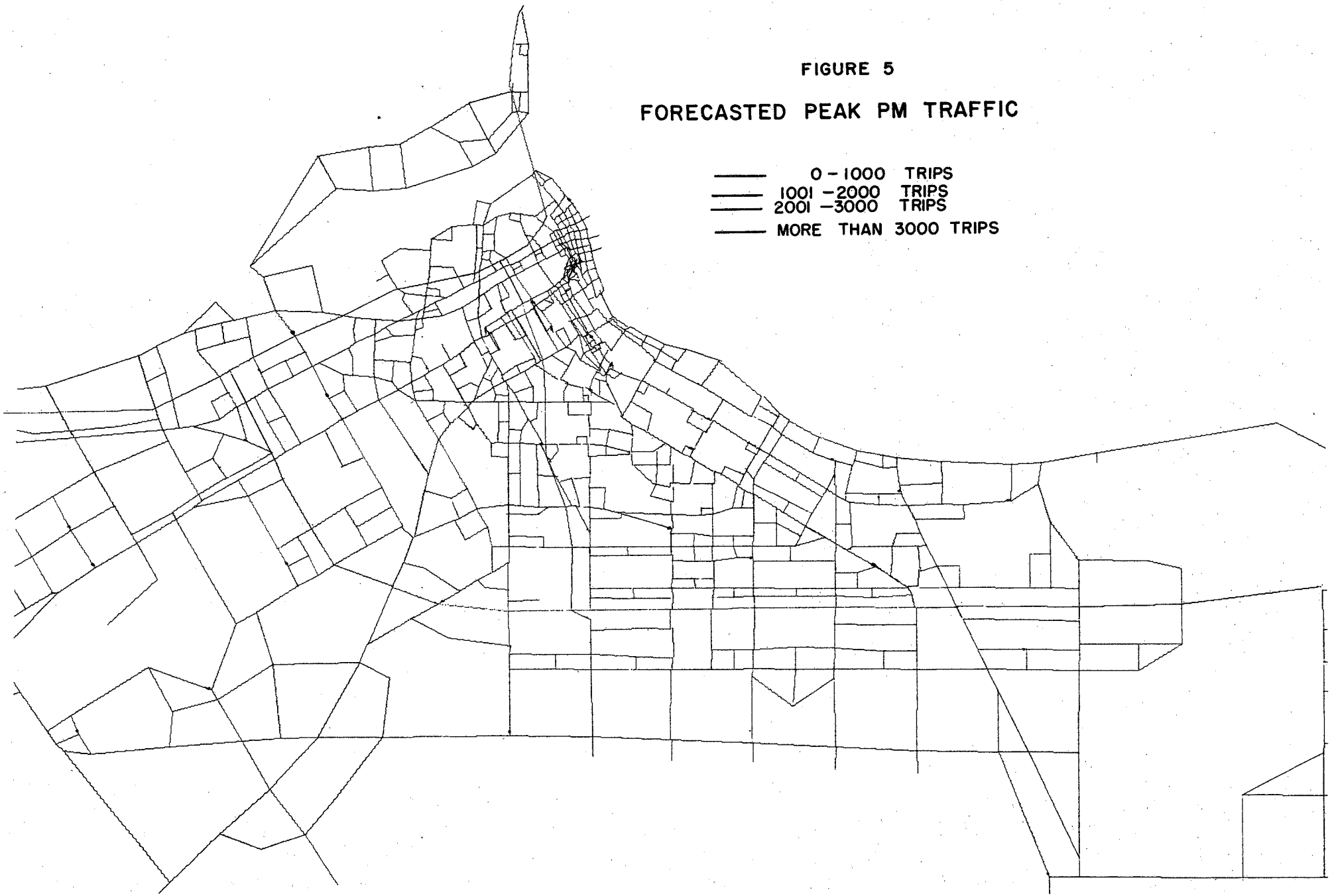
Map Width	709	1401/565	Total Machine Time
11 inches	4 Min.	5 Min.	9 Min.
44 inches	5 Min.	12 Min.	17 Min.

IBM 1401 Plotting Systems

An auxiliary plotting system has been designed for use with a 4,000 position memory IBM 1401. Plotting with the 1401 is necessarily more cumbersome and slower than with the 709 because of the differences

FIGURE 5

FORECASTED PEAK PM TRAFFIC



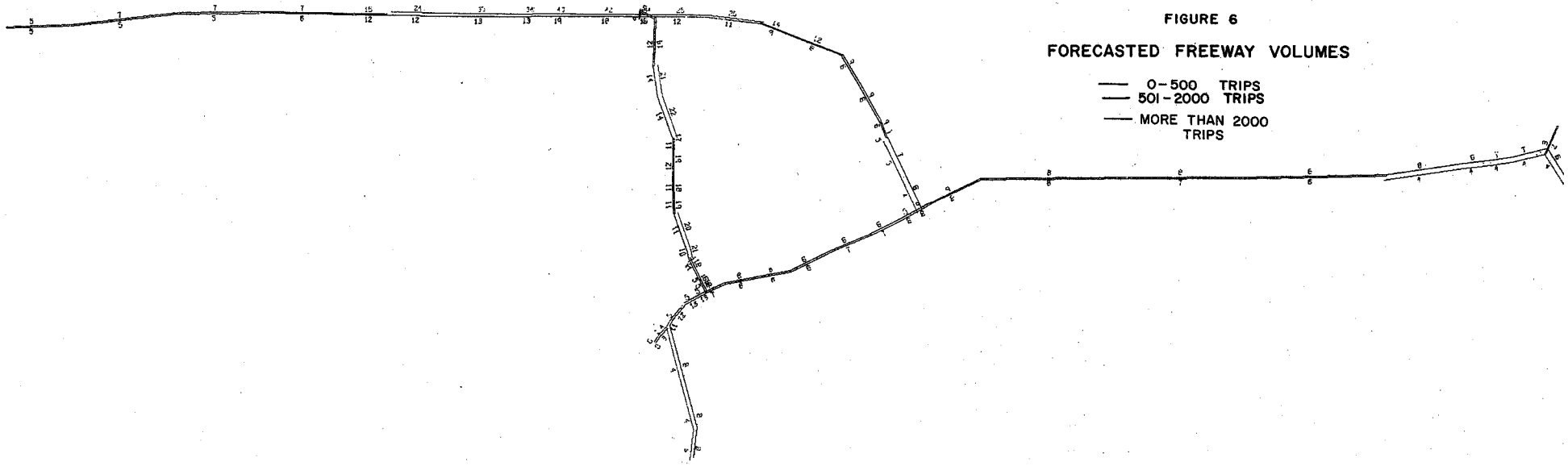


FIGURE 6

FORECASTED FREEWAY VOLUMES

0 - 500 TRIPS
501 - 2000 TRIPS
MORE THAN 2000 TRIPS

in computer speed and size. The 1401 plotting system does not have a directional capacity. Any desired color differences in street type and/or volume of flow must be made by a sorting of the link data cards.

An advantage of the system is that the IBM 709 traffic assignment programs need not be used for a network plot. The original link data cards used for network coding and the cards of node coordinate locations may be used as input data to produce the map. Three programs comprise the 1401 system, these are (1) Utility, (2) Phase 1, and (3) Phase 2. For additional network plots, only Phase 2 needs to be used. The Utility and Phase 1 programs are for preliminary data preparation.

Program time to produce a network map (Figure 3) which was 11 inches in width was as follows:

Utility	2 Min.
Phase 1	23 Min.
Phase 2	20 Min.
Total	45 Min.

In addition to the above total time, a card sort is required to reduce computer time in Phase 2.

CENTRAL BUSINESS DISTRICT
FREEWAY AND ARTERIAL VOLUMES

FIGURE 7

PLOTTING REQUIREMENTS

Equipment

Plotting programs developed by the Texas Transportation Institute for inclusion in the Traffic Assignment Package using the Texas A&M University Control System were developed for use with an IBM 709/ 90/94 digital computer. The plot programs can be run on an IBM 709/90/94 digital computer and the generated output tape plotted on an IBM 1401/ California Computer Products Model 565 digital imcremental plotter (Calcomp 565). The Calcomp 565 (Figure 1) has an incremental step size of .01 inch and plotter accuracy of $\pm$ .01 inch per 120 feet. Other plotter specifications are as follows:

Drum width	11 inches
Paper length	100 feet
Plotter weight	33 pounds

Since all imcremental plotters work on the same basic principle, the generated plot tapes may be altered for use with other plotters.

Data

Two input sources are necessary to plot a network or tree. These inputs are (1) the network information and (2) the location (in x, y co-ordinate form) of each node in the network. The network information necessary is produced by traffic assignment programs which are as follows:

Network Description	Pr. 5, Build Network
Loaded Network	Pr. 2, Load Minimum Paths
Minimum Path Trees	Pr. 1, Build Trees

Node location coordinates are punched on cards and read onto tape for the IBM 790/90/94 program input. The coordinate of each node is a two-number set (an x coordinate and a y coordinate). Coordinates are 5-digit numbers between 00001 and 32767. It has been found that if the ranges of x and y are of a different order, coordinate transposition errors may be found easily. For example, x could range from 01000 to 10000 and y could range from 15000 to 30000. The scale chosen for the range is arbitrary. However, for accurate plotting, each node should be distinctly located by an exact coordinate set. Since central business districts are drawn to a smaller scale (more detail), the scale chosen should accurately define that section so that plotting accuracy may be maintained. After deciding upon a scale for the central business district, the scale should be transformed for use with the network map. By convention, the x-axis should be the length of the network map, the y-axis, its width.

PUBLICATIONS

Project 2-8-63-60
Traffic Assignment

1. Research Report 60-1, "Texas A&M Traffic Assignment Link Data Editor for IBM 1401 Data Processing System" by Glenn N. Williams.

2. Research Report 60-2, "Texas A&M Traffic Assignment Edit Print Trip Volumes for IBM 1401 Data Processing System" by William F. Pry.

3. Research Report 60-3, "Traffic Assignment Plot Systems for IBM 1401 and IBM 709/90/94 Data Processing Systems" by William F. Pry.

4. Research Report 60-4, "Utilization of Computer Plotting in Traffic Assignment Analysis" by William F. Pry and Charles Pinnell.