AN INVESTIGATION OF THE FEASIBILITY OF IMPROVING FREEWAY OPERATION BY STAGGERING WORKING HOURS

by

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CHAPTER I

INTRODUCTION

The Problem

One of the most severe problems associated with living and working in our cities has been and may continue to be traffic congestion. The cause of traffic congestion may be expressed in two ways depending on the viewpoint of the observer. The first explanation is that the traffic system is inadequate, while the second explanation is that the demand for service is excessive. Each viewpoint has advantages; however, neither by itself is absolutely correct. Further discussion of these two explanations will be continued later in this chapter.

Traffic congestion itself is unlike most other city problems primarily because it is usually not continuous. Normally traffic congestion occurs during only two relatively short periods of the day. These periods of congestion result from peak period traffic demand which occurs twice in a typical work day, the first being in the morning and the second occurring in the afternoon. The morning peak is caused primarily by people traveling from work or school and usually lasts less than two hours. The afternoon peak period is caused primarily by the return trip and usually lasts somewhat less than three hours. At other times during the day and at night the street system, under normal conditions, is completely capable of handling the demand.

Methods to Alleviate the Problem

In recent years several methods have been employed or suggested to reduce traffic congestion during periods of peak travel demand. Several of these methods are justified using the first explanation of traffic congestion as stated above. One method has been the use of regulations and controls to increase the capacity of the existing traffic facilities. Other methods include the construction of new, high speed, high volume facilities and the encouraging of motorists to use mass transportation systems.

All of the above methods have made contributions to improving the ability of the individual motorist to travel more safely, more economically and usually at a more rapid rate. The first two methods noted above, however, are quite expensive and the third method has at present, lost ground in most cities primarily because it is not the mode of transportation that the vast majority of citizens desire to use.

Looking at the problem from the alternative viewpoint has yielded other methods of reducing traffic congestion. One of the most promising of these methods is proper land use planning and control. While land use planning has several major objectives, one of the most important is the reduction of travel demand in congested areas. Although this method yields almost immediate benefits in new and rapidly developing areas, the benefits in older and more densely developed areas are necessarily slow and require, in many instances, 20 or more years.

Staggered Hours

Another method similar to land use planning and control (in that it views the problem as one of excess demand) is staggered working hours. The purpose or goal of staggering working hours is to distribute the period of peak travel demand over several hours and, thereby reduce the magnitude of the peak. This approach is based on the traffic characteristic that travel demand is not constant and is cyclical.

Staggering of working hours was first used in the United States over 20 years ago. During World War II approximately 60 United States cities used this idea to help alleviate the critical problem of mass transportation. In all cases some degree of success was achieved and in many cities peak period travel demand was reduced by as much as 30 per cent. After the war all major staggered hours plans were terminated.

There is a definite possibility that although staggering of working hours may reduce the expected peak period demand, new trips may be generated during these periods because of the reduction in traffic congestion. Similarly, the decline in transit usage may be accelerated as more transit riders become motorists.

Non Traffic Aspects

With the adoption of a major staggered hours program several other city services may be favorably affected. Such services as water, sewage, telephone, and other communications services, and electric power could have their peak requirements substantially reduced.

One of the major problems of instituting a staggered hours program is that human habits are hard to change. It should be expected that some criticism to any change will result. Probably the most effective method of handling this problem would be to precede any change with a massive public relations and public education program.

Previous Research

Betz and Supersad[1] reported a study that they had completed to develop a method of analysis for planning a staggered hours program for urban areas. For purposes of their study, two hypothetical cities were used and the staggered hours plan developed was based on obtaining a volume-capacity ratio equal to or less than unity for all travel links and intersections in the system. This idea of volume-capacity ratio control seems to be extremely promising; however, at present the method has not been used on an actual city.

Washington, D. C. conducted a study of the possible effects of staggered working hours on traffic congestion in 1958-59. Washington's study considered the afternoon peak period only, because it was the most critical of the two peaks. The maximum amount of shift in working schedules was held to one hour and in most cases each generator was staggered internally as well as externally. The existing afternoon peak periods of employee quitting times were 4:30 p.m. and 5:00 p.m. and consisted of 132,604 and 143,799 employees finishing work, respectively. The proposed staggered hours plan would have resulted in having the same quitting time peak periods, with 138,153 persons finishing work at 4:30 p.m. and 119,861 persons finishing work at 5:00 p.m.

By comparing the work quitting times of the proposed staggered hours plan to existing work quitting times it can be seen that although the 5:00 p. m. peak would be reduced, the 4:30 p.m. peak would actually be increased. Although enough information is not available to definitely conclude anything on expected peak traffic flow if the proposed staggered hours plan is instituted, it is suspected that such a plan would cause the traffic demand peak to occur earlier. This could possibly cause the period of traffic congestion to last longer. At present, Washington, D C. has not adopted this or any other staggered hours plan.

Objectives and Scope

This research was primarily designed for two purposes. The first objective was to investigate the feasibility of staggering working hours in Houston, Texas. The second objective was to evaluate the impact that staggered working hours of selected traffic generators would have on the morning peak period operation of the Gulf Freeway in Houston.

In order to investigate if it is feasible to stagger working hours in Houston three areas were selected for study as follows:

1. The reaction of management to working hours changes.
2. Magnitude of change required in Metropolitan Houston to evenly distribute traffic demand over a reasonable period.
3. Minimum size of organization that should be considered for work time change to achieve simplest staggered hours plan.

In evaluating the impact of such a change on the Gulf Freeway morning peak period operation the following effects were selected for study:

1. The effect of the University of Houston on the Gulf Freeway morning peak period operation.
2. The effect of other selected traffic generators on the freeway's morning peak period operation.
3. The effect on freeway operation of the combination of all traffic generators selected for study.

This research was not designed to formulate a complete staggered hours plan that could be immediately put into effect, but was designed to investigate the feasibility and benefits of such a plan.

CHAPTER II

FEASIBILITY STUDY

Expected Problems

One of the most important aspects of a staggered hours plan is the problem that may arise for an organization if a change in work times is effected. To gain an insight into some of these problems, interviews were held with managerial leaders of several organizations. The following is a list of the organizations contacted, the problem areas that the administrators interviewed felt should be considered, and their receptiveness to the idea of staggered working hours:

1. a. Organization—Senior High School

   b. Person Consulted—Assistant Superintendent of Schools, Secondary Education Department and High School Principal

   c. Problem Areas

      (1) In many instances parents must take students to school prior to their going to work; therefore, some synchronization in necessary.

      (2) School bus routes must be coordinated to provide required transportation.

      (3) All schools should have approximately the same schedules in order that intra-school meetings (meetings between superintendent school board members, principals, and faculties) can be held in the afternoons following classes.

(4) If schools have widely varied schedules, teachers with children could be adversely affected.

d. Receptiveness to Staggered Hours—Uncommitted

2. a. Organization—Telephone Company

b. Person Consulted—Assistant Manager District Toll Office

c. Problem Areas

(1) Personnel must be on duty during peak telephone traffic periods.

(2) Working hours must be overlapped to provide smooth, continuous operation.

d. Receptiveness to Staggered Hours—Receptive

3. a. Organization—Executive Offices of Major Oil Firm

b. Person Consulted—Assistant Personnel Relations Officer

c. Problem Areas

(1) A relatively few employees must be on the job by 7:30 a.m. in order to make field contact each morning.

(2) Any change would involve passage by Board of Directors in order to assure a smooth transition.

(3) No insurmountable obstacles can be foreseen.

d. Receptiveness to Staggered Hours—Highly Receptive

4. a. Organization—General Post Office

b. Person Consulted—Personnel Management Officer

c. Problem Areas

(1) No major obstacles to minor changes.

(2) It would not be beneficial to change working hours because shift changes occur during traffic off-peak times.

d. Receptiveness to Staggered Hours—Receptive

5. a. Organization—Wholesale Distributor

b. Person Consulted—Personnel Manager

c. Problem Areas

(1) This is a highly competitive organization that cannot allow itself to be put at an unfair disadvantage when dealing with customers.

(2) The working hours of this organization are dictated by the requirements of its customers.

d. Receptiveness to Staggered Hours—Not Receptive

Although the above list does not include all types of organizations, it does give an overall picture of some of the problems that may arise if a staggered hours program was instituted.

One major industrial group that was not consulted was retail trade organizations. The reasons these people were not consulted are twofold. First, most retail organizations open sometime after the morning peak period and close sometime after the evening peak period which would put them out of consideration. Second, retail trade is a highly competitive industrial group. Because of this retail trade organizations usually keep the same working hours so that they will not be put at an unfair disadvantage. It is felt that all retail trade administrators would resist any attempt to change individual organization working hours.

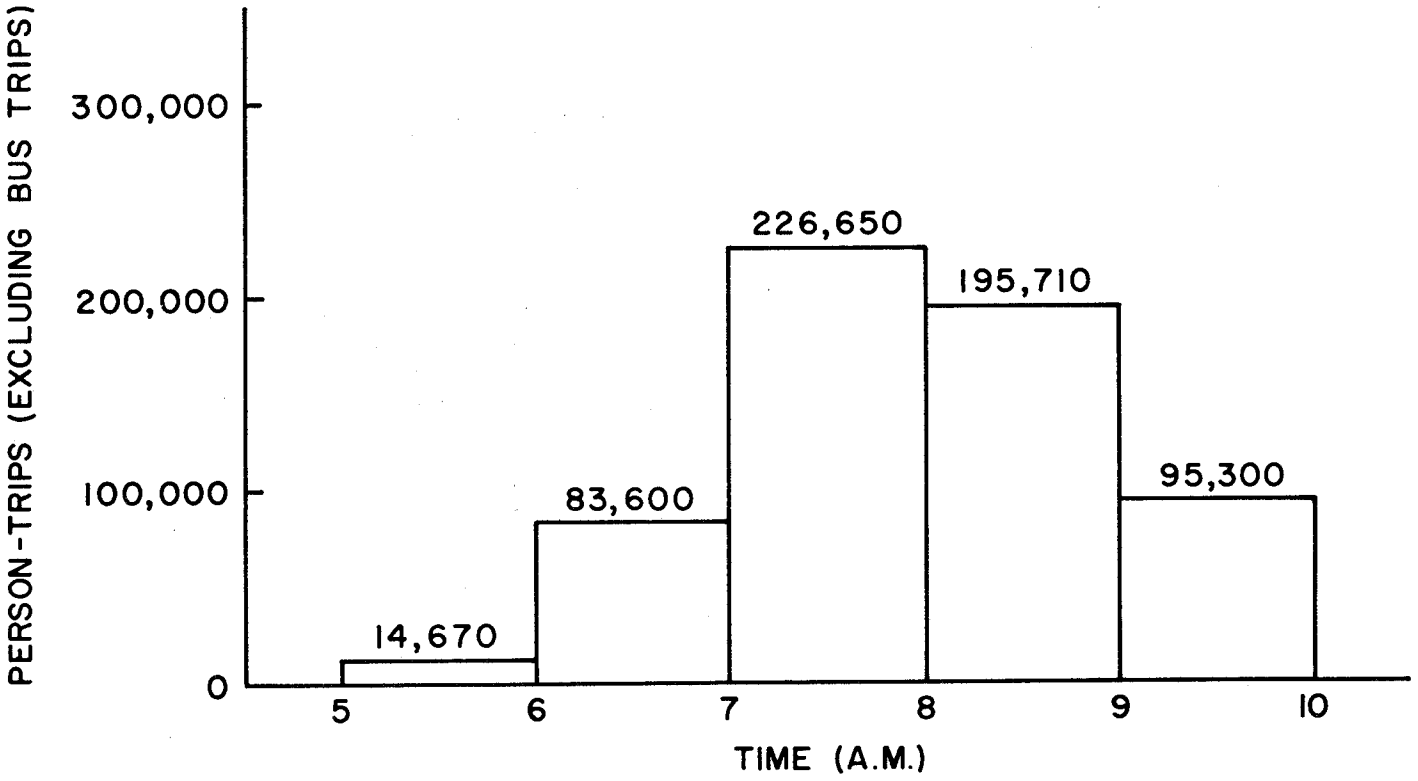
Magnitude of Change Required

In any study of peak period operation of an urban street network a basic knowledge of the hourly distribution of trips for that particular network is absolutely necessary. For this information the 1960 Origin-Destination Survey of the Houston Metropolitan Area was consulted. Although more complete and current information on hourly trip distribution was desirable, none was available. Also, due to the particular information needed in this study it was decided that extrapolation of past trends would be of no added benefit.

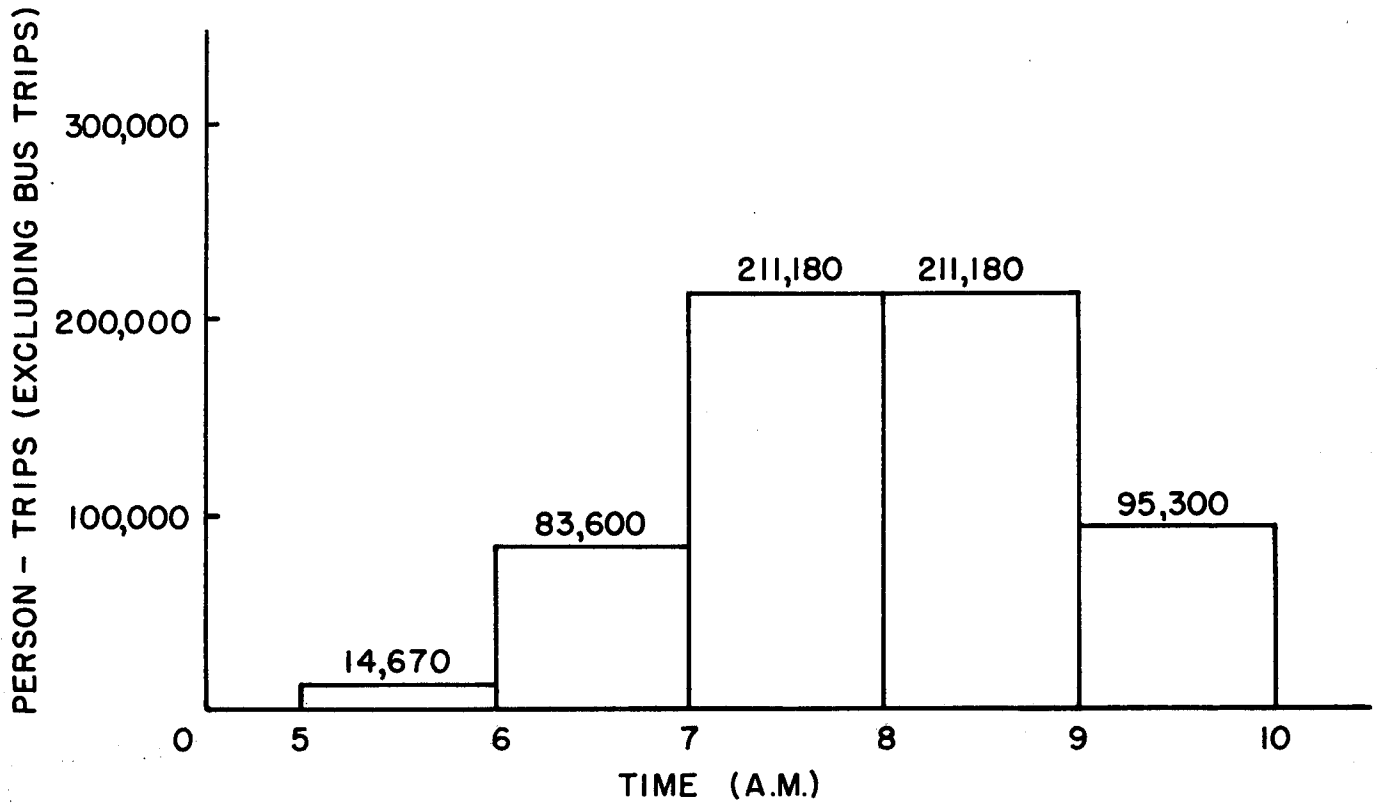
Since this study was concerned with individual workers it was decided to convert the origin-destination information to person-trips. Since bus trips contribute a negligible number of vehicle trips, person trips on buses were excluded from these calculations. Figure II-1 is a histogram of the above information.

It was then decided that in order to effect a staggered hours plan only reasonable work starting times could be used. Since there was no precedent to follow, two ranges of work starting times were investigated. The first was from 7:30 a.m. until 9:00 a.m. and the second was from 7:00 a.m. until 9:00 a.m. To reduce the possibility of confusion the 7:30 a.m. until 9:00 a.m. starting time range and the 7:00 a.m. until 9:00 a.m. starting time range will be referred to as Time Range "A" and Time Range "B", respectively, throughout the remainder of this paper.

It was then estimated that organizations with work starting times during Time Range "A" would generate traffic between 7:00 a.m. and 9:00 a.m. and the



CITY OF HOUSTON
1960 ORIGIN-DESTINATION SURVEY
PERSON-TRIP DISTRIBUTION BY TIME
FIGURE II-1



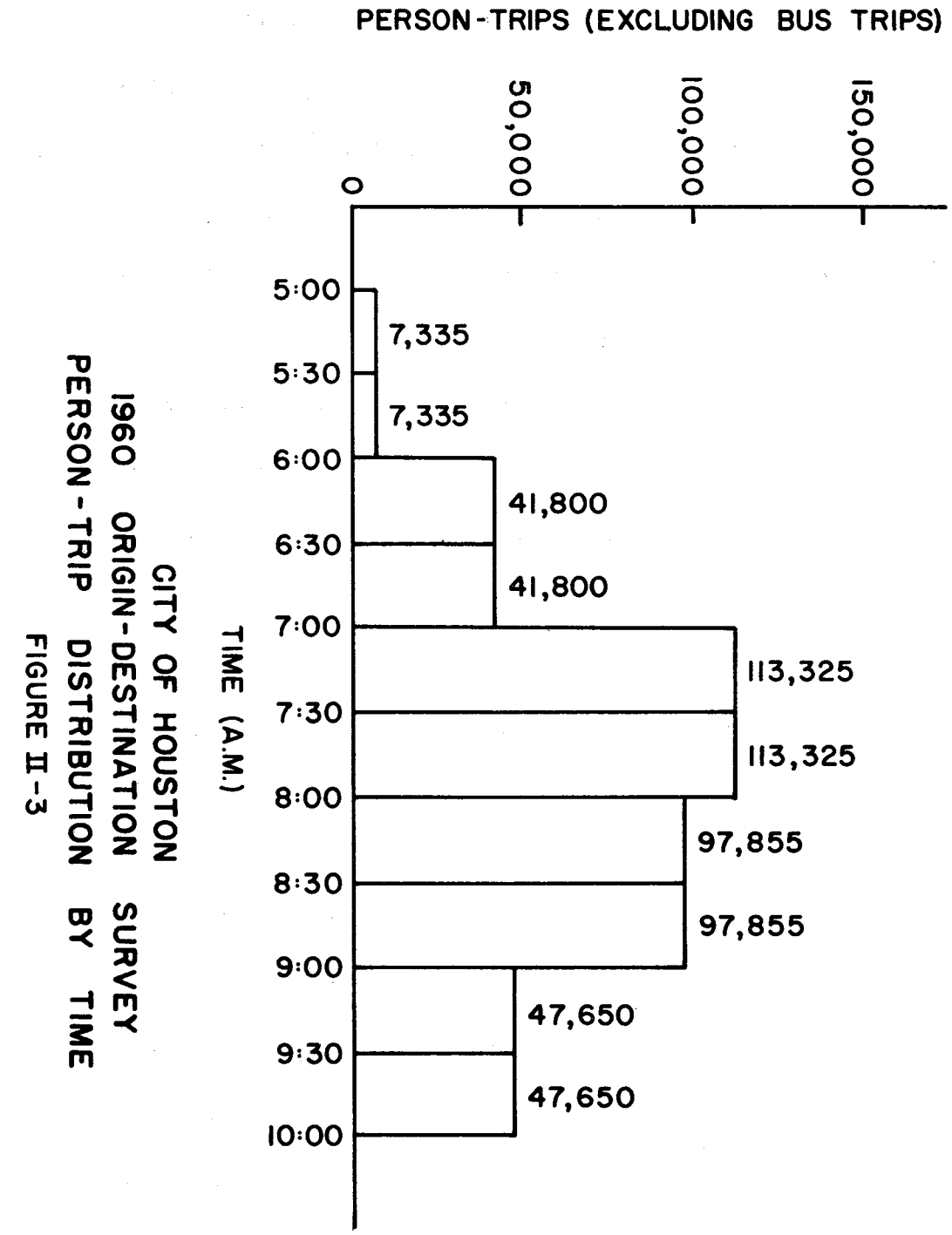
CITY OF HOUSTON
OPTIMUM PERSON - TRIP STAGGERING
TIME RANGE "A"
FIGURE II - 2

organizations with work starting times during Time Range "B" would generate traffic between 6:30 a.m. and 9:00 a.m.

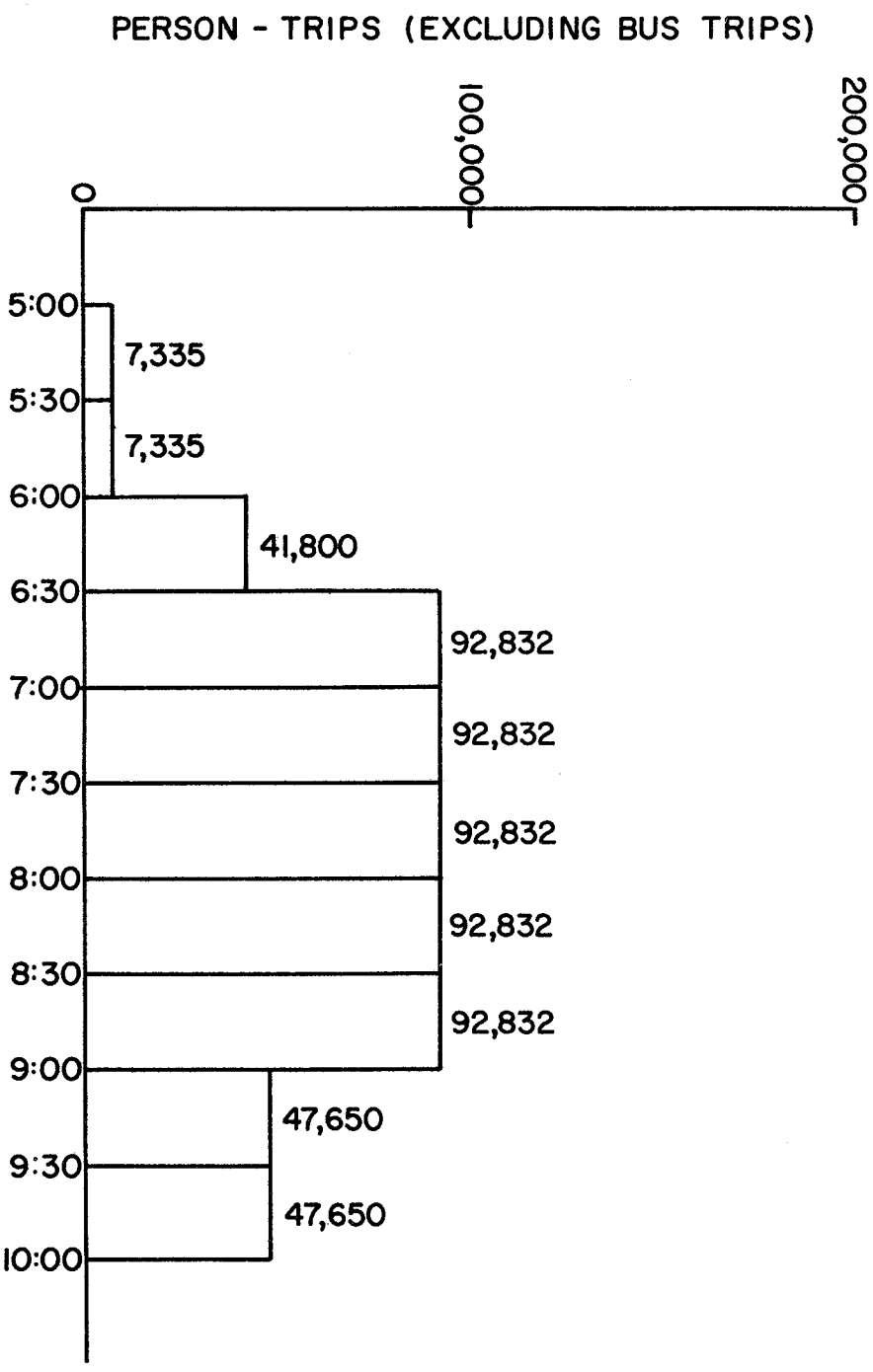
It should be readily apparent that an optimum staggered hours plan would be achieved when all trips are equally distributed throughout the time period under consideration. Using Time Range "A" and the information shown in Figure II-1 it can be seen that, by properly staggering selected traffic generators, excess trips occurring between 7:00 a.m. and 8:00 a.m. can be made to occur between 8:00 a.m. and 9:00 a.m. Figure II-2 shows the optimum trip staggering that can be obtained using Time Range "A". The reduction during the peak hour would be approximately 15,470 person-trips or almost seven per cent.

To study Time Range "B" one major assumption was made. This assumption was that the flow rate was constant throughout each hour. This was necessary in order that 30-minute flows could be studied. Using this assumption and Figure II-1 the histogram of 30-minute flows in Figure II-3 was drawn. Using Time Range "B" and the information shown in Figure II-3 it can be seen that, by altering the working hours of selected traffic generators, excess trips occurring between 7:00 a.m. and 9:00 a.m. can be made to occur between 6:30 a.m. and 7:00 a.m. Figure II-4 shows the optimum trip staggering that can be obtained using Time Range "B". The reduction during the peak hour would be approximately 41,000 person-trips or 18 per cent.

Since it affords a much greater reduction in person-trips it would seem that Time Range "B" would be the better of the two starting time ranges and it may be;



CITY OF HOUSTON
1960 ORIGIN-DESTINATION SURVEY
PERSON-TRIP DISTRIBUTION BY TIME
FIGURE II-3



CITY OF HOUSTON

OPTIMUM PERSON - TRIP STAGGERING

TIME RANGE "B"

FIGURE II-4

however, it does have several disadvantages as follows:

1. Over three times as many people would have to have their work times altered.
2. Some work times may have to be altered as much as two hours in order to achieve optimum trip staggering.
3. Many people with school aged children would be put in a difficult position because schools do not begin classes in Houston until 8:00 a.m. This problem could conceivably be overcome by coordination with school officials.

At this point no definite conclusions can be made as to which starting time range is the best; therefore, both time ranges will be considered throughout the remainder of this paper.

Minimum Size Organization to be Considered for Staggering Working Hours

After the magnitude of the required change has been determined the next logical step is to determine the size of organization to approach with the idea of staggered hours. After careful consideration of this aspect of the problem it was decided that two areas of information would be required. They were employment breakdown by industrial group and employment breakdown by size of organization. For this information the Houston Chamber of Commerce Research Department and the Houston Office of the Texas Employment Commission were consulted. Tables II-1 and II-2 list the information obtained from the above organizations.

From discussions with personnel managers, personnel relation officers; and other administrators of organizations in Houston it was decided that certain

TABLE II-1

LABOR FORCE AND EMPLOYMENT BY INDUSTRY GROUP*

CATEGORY	AS OF DEC, 1965
Total Labor Force	631,600
Unemployment	13,600
Employment	618,000
Agricultural	4,800
Non-Agricultural	613,200
Major Industry Groups:	
Total Nonagricultural	613,200
Total Manufacturing	108,400
Total Nonmanufacturing	504,800
Mining	22,500
Contract Construction	52,500
Communications	6,300
Utilities	9,800
Finance, Insurance, Real Estate	34,500
Business and Personnel Services	43,900
Medical and Professional Services	41,800
Government	56,400
Agricultural Services, Forestry, Fishing	1,400
Transportation and Allied Services	40,900
Wholesale Trade	48,100
Retail Trade	121,400
Private Household	25,300

*Compliments of Houston Chamber of Commerce.

TABLE II-2

EMPLOYMENT BY SIZE OF ORGANIZATION*

Size	Number	Cumulative Number	Employment	Cumulative Employment
5000-5500	2	2	11,500	11,500
4000-4999	2	4	9,000	20,500
3000-3999	6	10	21,000	41,500
2000-2999	3	13	7,500	49,000
1000-1999	24	37	36,000	85,000
900-999	2	39	1,900	86,900
800-899	8	47	6,800	93,700
700-799	13	60	9,750	103,450
600-699	19	79	9,750	113,200
500-599	17	96	9,350	122,550
400-499	34	130	15,300	137,850
300-399	61	191	21,350	159,200
200-299	110	301	27,500	186,700
100-199	402	703	60,300	247,000

*Compliments of Texas Employment Commission.

industrial groups could not, for numerous reasons, be expected to alter their working hours. These industrial groups include agricultural services, forestry, fishing, transportation, and allied services, wholesale trade, retail trade, and private households. Also, some organizations have work starting times outside of the periods under study and there will be some organizations that will refuse to alter their working hours.

From the above it was determined that the working hours of some employees in a metropolitan area cannot be changed. Because of this it became necessary to determine the number of employees that would have to be examined (employees under preliminary study, E_p) so that the number of employees that could have their working hours changed would equal the number of person-trips to be staggered to achieve optimum staggering (potential number of person-trips to be staggered, N_p). The factors effecting the number of employees under preliminary study are as follows:

1. The industrial group factor, f(IG), is the percentage of employees working in industrial groups that could conceivably alter their working hours divided by 100.
2. The work starting time factor, f(WT), is the percentage of employees that start work during the period that is to be staggered divided by 100.
3. The will stagger working hours factor, f(WS), is the percentage of employees that have employers that will agree to participate in a staggered hours program divided by 100.

Using the above factors, the number of employees under preliminary study would be as follows:

$$E_p = N_p \div [f(IG) \times f(WT) \times f(WS)]$$

Excluding the industrial groups listed above that could not be expected to alter their working hours, it was determined from Table II-1 that 61.4 per cent of the employees in Houston worked in industrial groups that could conceivably be included in a staggered hours plan. Thus, the Industrial Group Factor, f(IG), for Houston would be 0.614.

Sufficient information was not available to determine the values for the Work Starting Time Factor, f(WT), and the Will Stagger Working Hours Factor, f(WS); therefore, a range of values for these two factors was studied.

Using the equation above, the number of person-trips required to be staggered to achieve optimum staggering for both time ranges under consideration, f(IG) equal to 0.614, a range of values from 50 per cent to 100 per cent for f(WT) and a range of values from 10 per cent to 100 per cent for f(WS), Tables II-3 and II-4 were organized. As an example of the computations involved the following case is presented:

If N_p = 15,470 Person-Trips

$f(IG)$ = 0.614

$f(WT)$ = 70% or 0.70

$f(WS)$ = 80% or 0.70

Assuming Time Range "A" then

$$E_p = 15,470 \div (0.614 \times 0.70 \times 0.80)$$

E_p = 44,991 Employees Under Preliminary Study.

TABLE II-3

NUMBER EMPLOYEES UNDER PRELIMINARY STUDY

TIME RANGE "A"

f (WT) / f (WS)	50%	60%	70%	80%	90%	100%
10%	482,680	402,233	344,771	301,675	268,155	241,340
20%	241,340	201,116	172,385	150,838	134,078	120,670
30%	160,893	134,078	114,924	100,558	89,385	80,447
40%	120,670	100,558	86,193	75,419	67,039	60,345
50%	96,536	80,447	68,954	60,335	53,631	48,268
60%	80,447	67,039	57,462	50,279	44,693	40,223
70%	68,954	57,462	49,253	44,991	38,308	34,477
80%	60,335	50,279	44,991	37,709	33,519	30,168
90%	53,631	44,693	38,308	33,519	29,795	26,816
100%	48,268	40,223	34,477	30,168	26,816	24,134

TABLE II-4

NUMBER EMPLOYEES UNDER PRELIMINARY STUDY

TIME RANGE "B"

f(WT) / f(WS)	50%	60%	70%	80%	90%	100%
10%	1,592,262	1,326,885	1,137,330	995,164	884,589	796,131
20%	796,131	663,442	568,665	497,582	442,294	398,066
30%	530,754	442,295	379,110	331,721	294,863	265,377
40%	398,066	331,721	284,332	248,791	221,147	199,033
50%	318,452	265,377	277,466	199,033	176,918	159,226
60%	265,377	221,148	189,555	165,861	147,432	132,688
70%	227,466	189,555	162,476	143,061	126,370	113,733
80%	199,033	165,861	143,061	124,396	110,574	99,516
90%	176,918	147,432	126,370	110,574	98,288	88,459
100%	159,226	132,688	113,733	99,516	88,459	79,613

Once the number of employees under preliminary study has been determined, the minimum size of organization to be considered for staggered working hours can be determined from Table II-2. This would be accomplished by entering the cumulative employment column of Table II-2 where the value is equal to or greater than the calculated value of E_p. Using the value of E_p from the example above the minimum size organization to be considered for staggered working hours would be those organizations with 2,000 or more employees.

Unfortunately, even good estimates for the Work Starting Time Factor and the Will Stagger Hours Factor are not available; therefore, nothing definite can be concluded about the mimimum size organization that should be considered in a staggered hours program.

To clarify what has been previously stated it should now be pointed out that all organizations contacted need not be changed. Only enough organizations, contributing person-trips during the peak flow period, with employment sufficient to total the number of person-trips desired to be changed are necessary in order that optimum staggering would be the goal, a somewhat lower amount of staggering could be very beneficial.

CHAPTER III

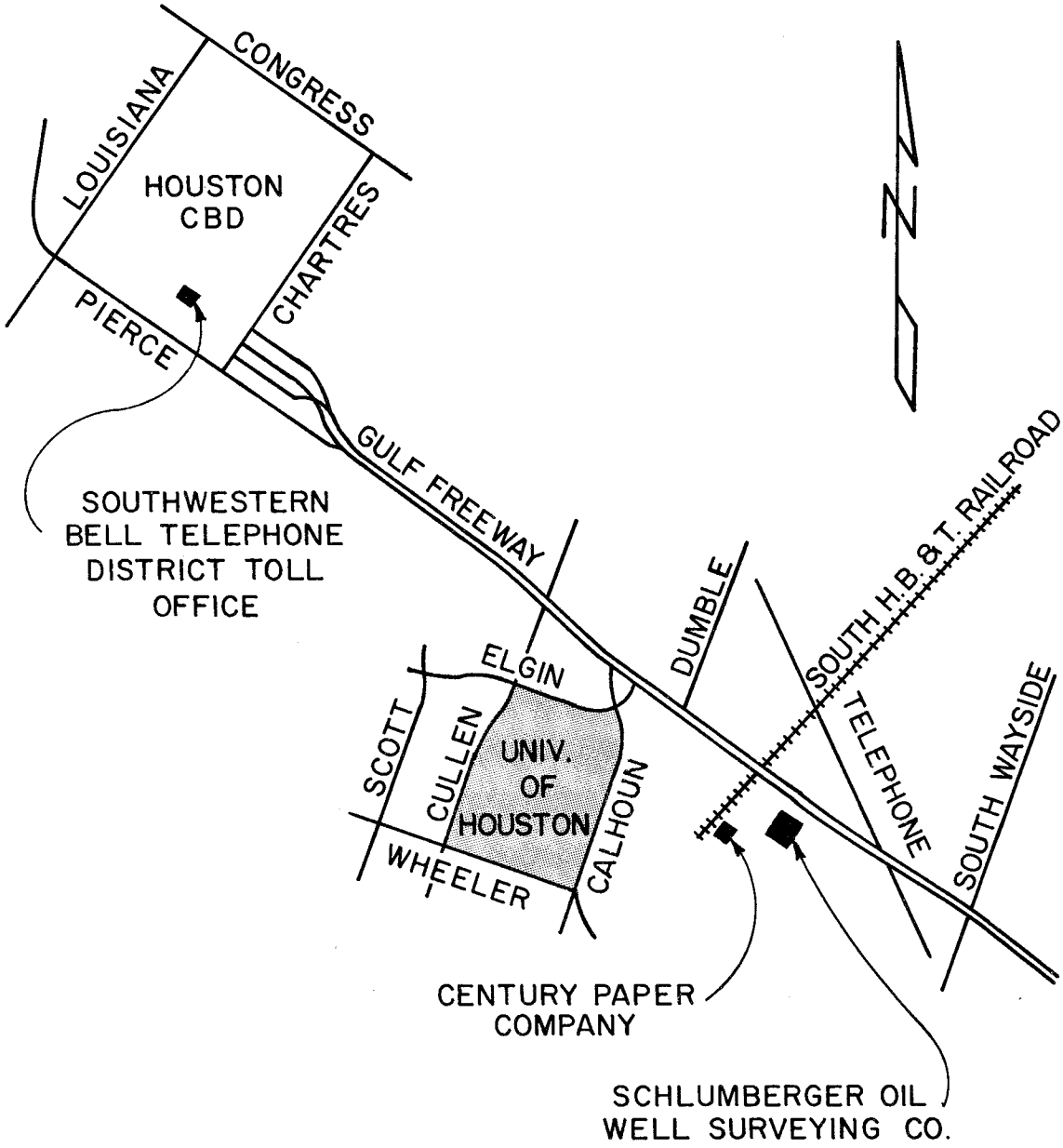
IMPACT STUDY

Introduction

Undoubtedly the most important aspect of a staggered hours plan is the results that the plan produces. Because of this, it was decided that the effects of certain selected generators on freeway operation should be studied. Since current information on traffic operation of the Gulf Freeway was available, it was selected as the traffic facility to be studied. The traffic generators studied were selected because they were located near the Gulf Freeway and it was suspected that they contributed heavily to the morning traffic peak.

Effect of University of Houston on Gulf Freeway Operation

The University of Houston is located approximately two miles southeast of the Houston Central Business District (see Figure II-1). The major portion of the campus is bounded on the north by Elgin Street, on the west by Cullen Street, on the east by Calhoun Street, and on the south by Wheeler Street. The athletic fields and some parking lots are located west of Cullen Street. All entrances to parking areas at the University of Houston are within nine-tenths of a mile of the Gulf Freeway. The spring enrollment this year was in excess of 12,000 students which undoubtedly makes it the largest single traffic generator located near the Gulf Freeway within the Houston City Limits. Because of the above it was felt that this study of morning peak period traffic flow on the Gulf Freeway should include the University of Houston.



UNIVERSITY OF HOUSTON
AND OTHER SELECTED TRAFFIC GENERATORS

FIGURE III - 1

To determine if the University of Houston had starting times that would coincide with the morning peak period on the Gulf Freeway, a class schedule for the 1966 spring semester was obtained from that school's registrar's office. Using the class schedule, Table III-1 was organized to show the number of classes held at the University of Houston between 7:00 a.m. and 9:00 a.m. by day of week and time of class.

TABLE III-1

University of Houston Classes

Class Time / Day of Week	7:00 a.m.	8:00 a.m.	8:30 a.m.	9:00 a.m.
Monday	15	108	0	125
Tuesday	19	22	120	20
Wednesday	14	98	0	128
Thursday	20	21	120	19
Friday	12	100	0	119
Saturday	0	25	2	2

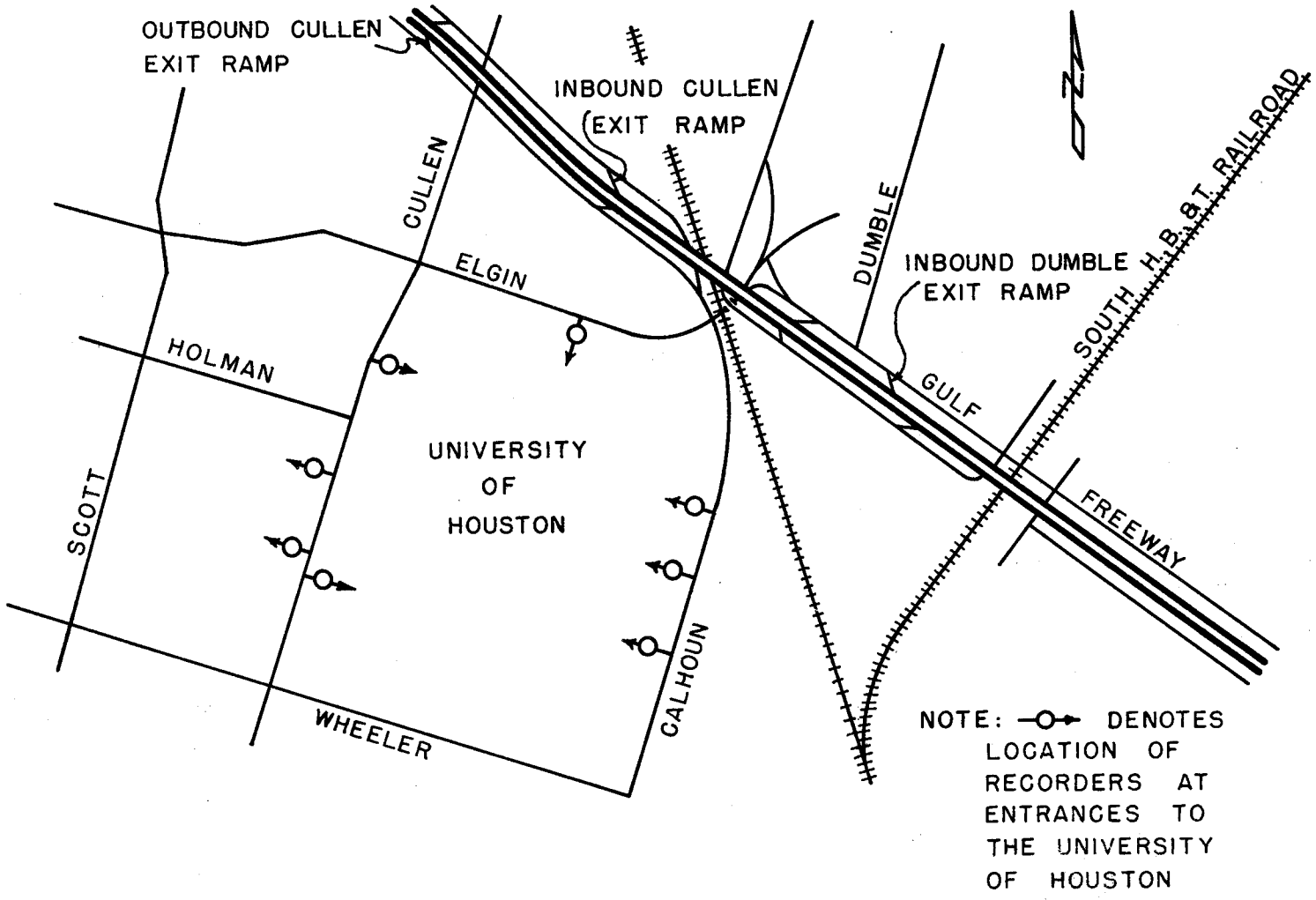
It can be readily seen that on Monday, Wednesday, and Friday 8:00 a.m. and 9:00 a.m. are peaks for class starting times while on Tuesday and Thursday the class peak is at 8:30 a.m.

Due to the large number of persons involved and the problems associated with distribution and collection of a questionnaire it was decided that the effect

of the University of Houston on the Gulf Freeway's morning peak period operation could be most conveniently determined by a license plate survey. This survey was conducted on Wednesday, March 2, 1966, between 6:30 a.m. and 8:15 a.m.

The license plate survey was designed to determine the number, time, and location of vehicles leaving the Gulf Freeway and entering the campus of the University of Houston. This was accomplished by selecting the two exit ramps on the inbound Gulf Freeway that would be expected to serve the University of Houston and recording the last four letters or digits of the license plate of each vehicle leaving the freeway at those three locations (see Figure III-2). The ramps selected for inbound freeway traffic were the Dumble exit ramp and the Cullen exit ramp. For outbound freeway traffic the Cullen exit ramp was selected. In order to determine the number of vehicles that exited the Gulf Freeway with a destination at the University of Houston all major and most minor entrances to the campus and parking areas had personnel recording the last four letters or digits of the license number of each vehicle that entered the campus. All recording was done in five-minute increments to afford a better comparison of vehicles exiting the freeway and entering the University of Houston Campus.

Data reduction was accomplished by transcribing the location of recording, time, and license number on data processing punch cards, sorting by license number and time, and then manually comparing license numbers from a printing of the above information. Table III-2 shows the number of University of Houston destined vehicles using the Gulf Freeway the morning of the study by time and exit ramp.



LICENSE PLATE SURVEY RECORDING LOCATIONS

FIGURE III - 2

The morning peak period flow on the Gulf Freeway is critical only on the inbound lanes. Because of this fact only inbound flow on the Gulf Freeway will be considered throughout the remainder of this paper.

Information on inbound Gulf Freeway flow was available for each work day for the previous six months. This information was screened to find a week that would meet certain criteria for inbound freeway flow. The criteria with which the ordinary week was selected was as follows:

1. No unusual occurrences should be happening during the week, i.e., schools out of session, parades, fairs, etc.
2. A minimum number of obstructions to traffic flow should occur during the period under study, i.e., traffic accidents, vehicles parked on shoulders, rain, ice, fog, etc.
3. Freeway volume at Griggs Road between 7:00 a.m. to 8:00 a.m. should be between 4,800 vehicles per hour and 5,600 vehicles per hour.

The week picked was the week of December 6, 1965 through December 10, 1965. Table III-3 was taken from the records of the Gulf Freeway Surveillance Office in Houston, Texas, and shows complete information on freeway flow during the week selected. It can be easily seen that this was not the perfect week; however, it conformed to the criteria the best of all weeks that had been studied.

For the selected week, information was available at three locations on the inbound Gulf Freeway. These locations were at the Griggs Road Overpass, the Telephone Road Overpass, and at the H. B. and T. Railroad Overpass South

TABLE III-2

GULF FREEWAY USERS DESTINED FOR THE UNIVERSITY OF HOUSTON

Ramp Exit Time (a.m.)	Inbound Gulf Freeway			Outbound Gulf Freeway	
	Dumble Exit	Cullen Exit	Total	Cullen Exit	Total
6:30-6:35	2	0	2	4	4
6:35-6:40	10	3	13	5	5
6:40-6:45	3	0	3	14	14
6:45-6:50	11	7	18	12	12
6:50-6:55	9	0	9	5	5
6:55-7:00	8	0	8	6	6
7:00-7:05	11	4	15	4	4
7:05-7:10	11	2	13	3	3
7:10-7:15	7	4	11	5	5
7:15-7:20	12	1	13	13	13
7:20-7:25	13	0	13	11	11
7:25-7:30	10	4	14	27	27
7:30-7:35	15	1	16	18	18
7:35-7:40	30	1	31	27	27
7:40-7:45	12	5	17	9	9
7:45-7:50	16	3	19	24	24
7:50-7:55	4	8	12	22	22
7:55-8:00	11	2	13	16	16
8:00-8:05	12	2	14	16	16
8:05-8:10	8	0	8	5	5
8:10-8:15	3	3	6	15	15
		Total Inbound	268	Total Outbound	261

Crossing (see Figure III-1). Figures III-3, III-4, and III-5 show the average ten-minute volumes of the week selected for the three locations listed above.

The question that now arises is "what would flow on the Gulf Freeway look like if the University of Houston did not exist?" or, more reasonably, "what would flow on the Gulf Freeway look like if class starting times at the University of Houston were altered so that all trips destined there were removed from the freeway during the peak period?" Assuming that every vehicle that exits the inbound Gulf Freeway at the Cullen exit ramp and the Dumble exit ramp that is destined for the University of Houston uses the Gulf Freeway at the South Crossing of the H. B. and T. Railroad, it is expected that the flows on the Gulf Freeway at that location would be as shown by the lower ten-minute volumes in Figure III-6 if those trips were removed. The upper figures in Figure III-6 show the existing average ten-minute volumes and the shaded portion represents the amount of reduction expected.

Although some reduction would occur the magnitude is not considered sufficient to greatly affect traffic flow.

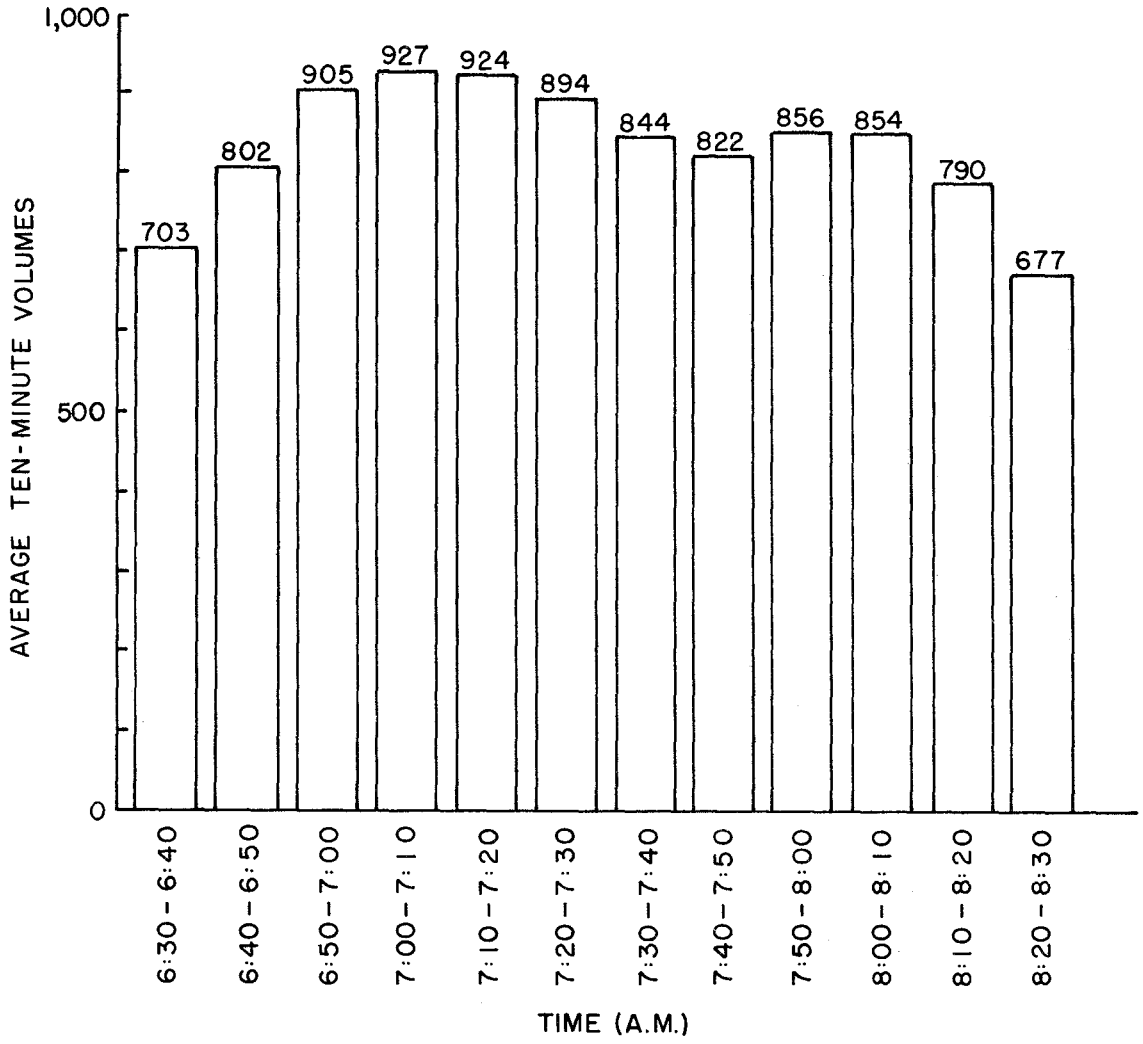
Other Selected Generators

Although the University of Houston does have an effect on Gulf Freeway peak period operation other generators located near the freeway also have certain amounts of effect on freeway operation. It was decided that the effects of some of these other generators should be studied. Three private industry organizations were selected for study. They were Schlumberger Oil Well Surveying Company, Century Paper Company, and Southwestern Bell Telephone

TABLE III-3

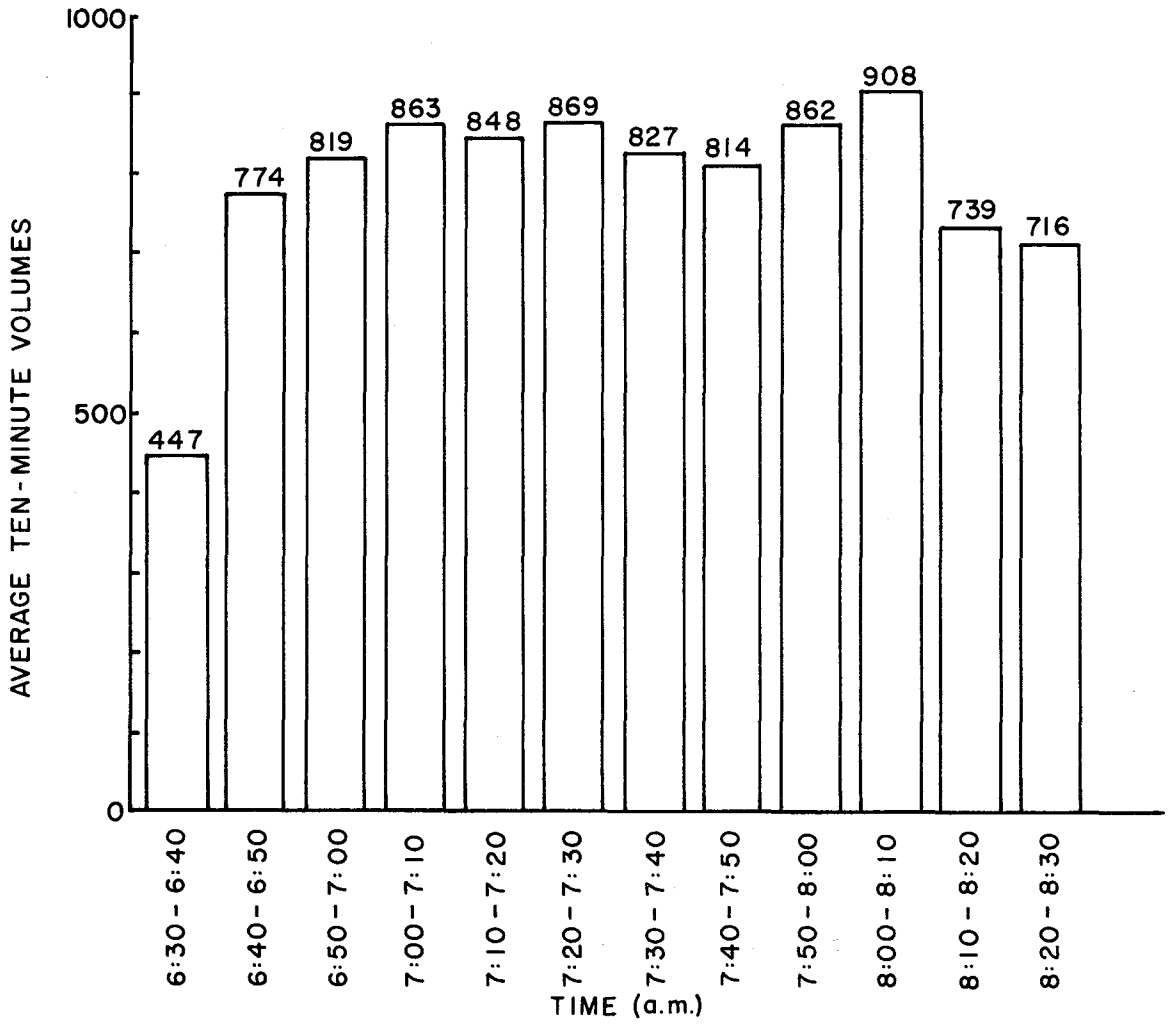
FREEWAY FLOW DURING THE WEEK SELECTED

Date	Dec. 6	Dec. 7	Dec. 8	Dec. 9	Dec. 10
Day of Week	Monday	Tuesday	Wednesday	Thursday	Friday
Weather	Clear	Clear	Cloudy	Cloudy	Cloudy
Pavement	Dry	Dry	Dry	Dry	Damp
Obstruction to Traffic Flow	None noted	None noted	Minor accident at S. H. 35 at 7:38 a.m.	Two accidents outbound, one accident inbound	Stall at S. H. 225, damp pavement
Description of Operation	Fair	Very good	Very good	Very bad	Fair
7:00-8:00a.m. Volume at Griggs Road	5,376	5,506	5,445	4,754	5,101
Travel Time from Broadway to Dowling	--	7:10-10 1/2 min. 7:30-12 min.	7:30-13 1/3 min.	--	--
Time Reveille Interchange Cleared	8:15	7:40	7:49	After 8:15	8:05
Remarks	Peak was late arriving	Peak was early arriving. Freeway slowed at Griggs 7:30-7:45.	Freeway stopped at 7:40 & 7:55. Stoppage came from Dumble area.	Accident outbound at 7:15 & 7:20. Accident inbound at 7:45 at Woodridge.	Early morning drizzle & pavement damp. Volume picked up as pavement dried.

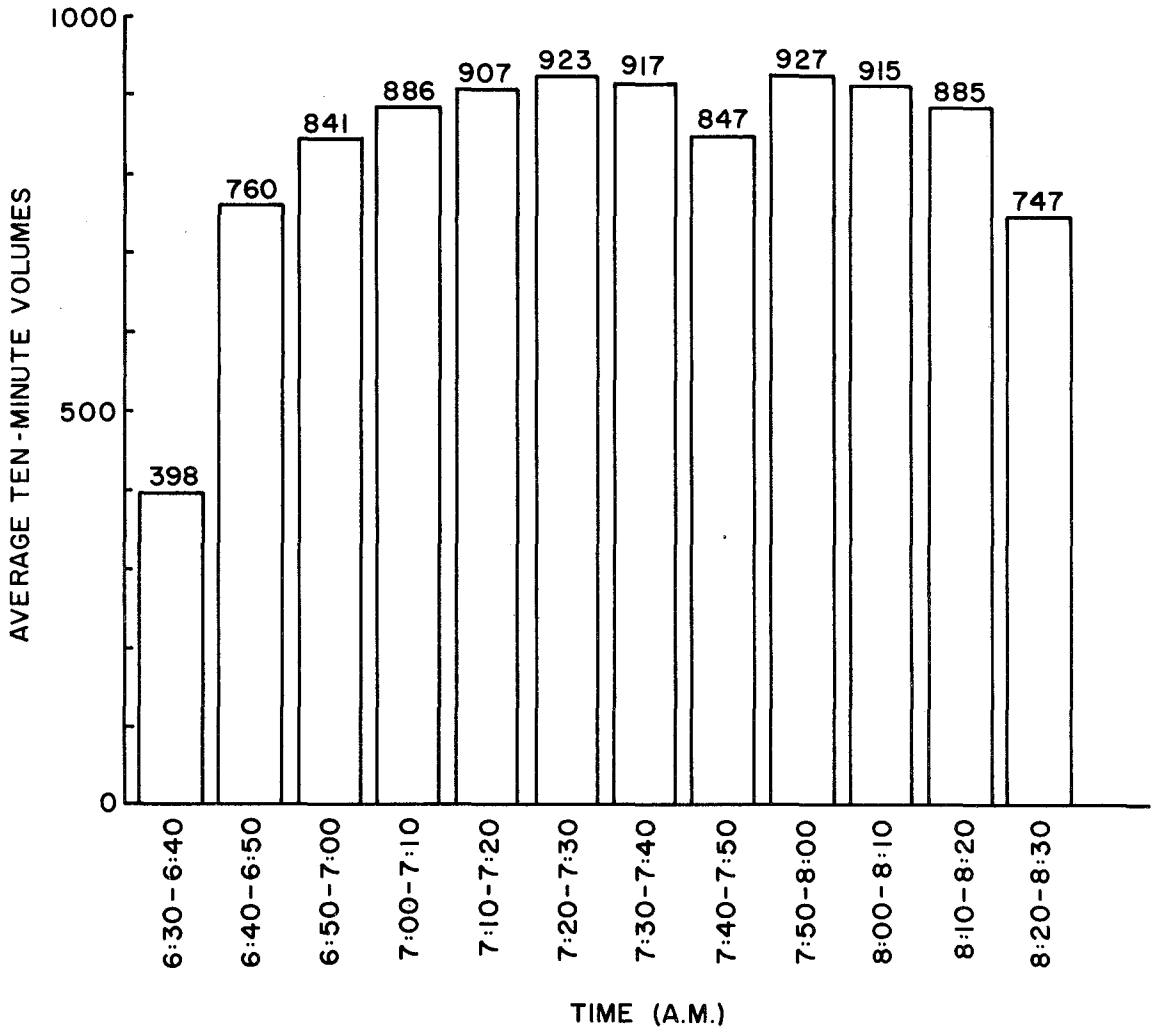


AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT GRIGGS ROAD
INBOUND LANES ONLY

FIGURE III-3



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT TELEPHONE ROAD
INBOUND LANES ONLY
FIGURE III - 4



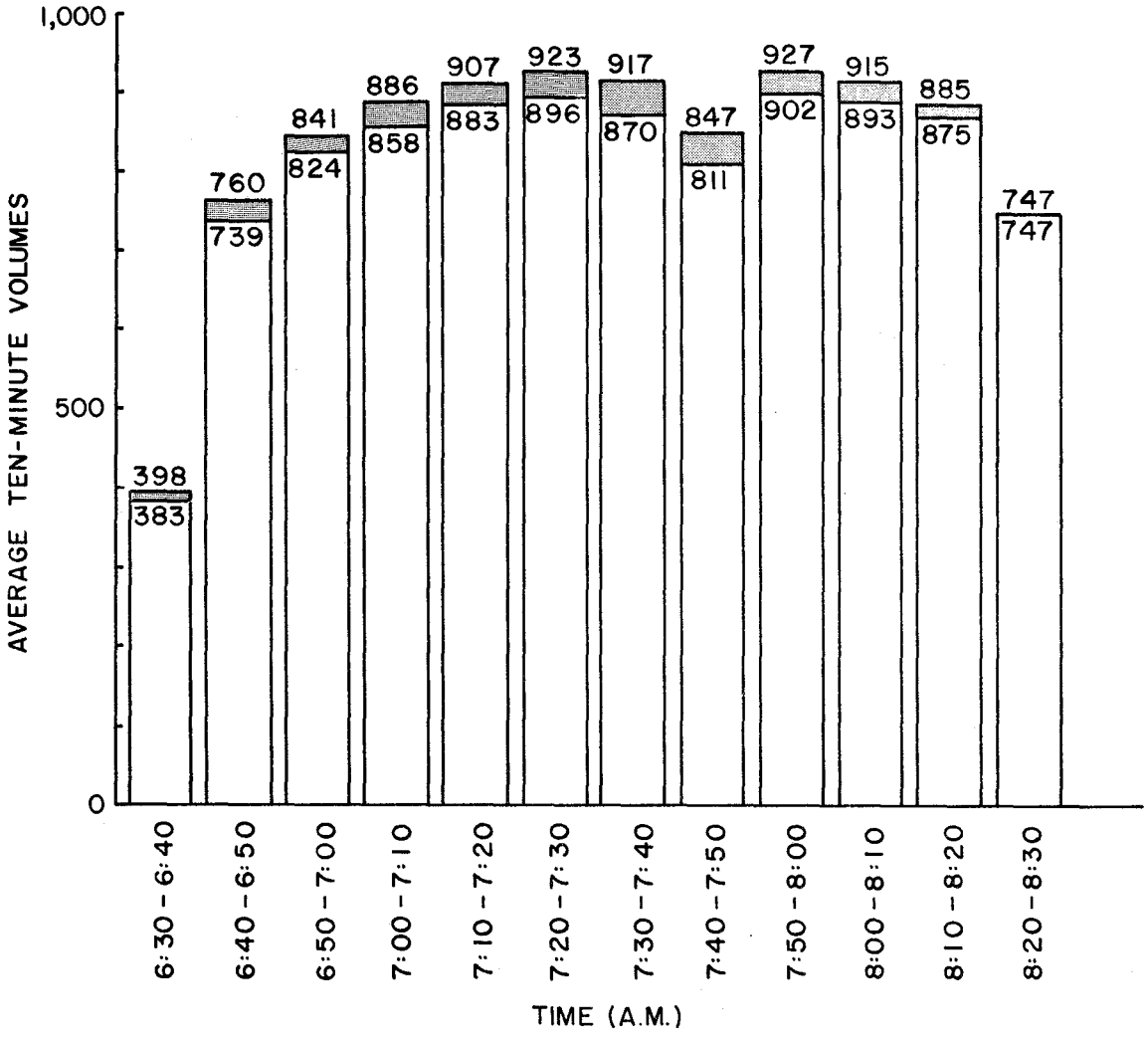
AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT SOUTH H.B. AND T. RAILROAD
INBOUND LANE ONLY

FIGURE III - 5

Company District Toll Office (see Figure III-1). The first two organizations listed above are located on the southwest side of the Gulf Freeway approximately two and one half miles from the Houston Central Business District and the third organization listed above is located in the central business district approximately nine city blocks from the Gulf Freeway terminus.

In order to determine the effects of these organizations on the Gulf Freeway morning peak period operation, questionnaires of the type shown in Figure III-7 were distributed to all employees through each organization's personnel office. The return of questionnaires was extremely good at Schlumberger and Century Paper with 72 per cent and 83 per cent return, respectively; however, Southwestern Bell Telephone's return rate was only 29 per cent. Although one organization did not have real good response to the questionnaire, it is felt that enough information was gained to establish flow rate patterns of all these organizations on the Gulf Freeway.

To determine the arrival times at selected locations of vehicles destined for these organizations a computer program was written that, using distance traveled, time in travel, arrival time at organization, time required to be at organization, and entrance ramp used, would perform a straight line interpolation and print as output the arrival time of individual employees at selected locations on the Gulf Freeway. These arrivals were then grouped in ten-minute intervals by individual work starting times and were expanded to 100 per cent by dividing 100 by the per cent of questionnaires returned per organization and then multiplying by the number of arrivals per ten-minute interval. Vehicle arrivals at selected



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT SOUTH H.B. & T. RAILROAD
INBOUND LANES ONLY
UNIVERSITY OF HOUSTON TRIPS SHADED

FIGURE III - 6

freeway locations with required destination arrival times during Time Range "A" are shown in Table III-4 and vehicle arrivals at selected freeway locations with required destination arrival times during Time Range "B" are shown in Table III-5.

Using Figure III-3 and Table III-4 the expected ten-minute freeway volumes at Griggs Road were calculated and are shown in Figure III-8 by the lower ten-minute volumes. These would be the flows expected on the Gulf Freeway if vehicles destined for Schlumberger Company, Century Paper Company, and Southwestern Bell Telephone District Toll Office with arrival times during Time Range "A" were removed from the selected week's flow pattern. Likewise, the lower ten-minute volumes in Figure III-9 show the expected ten-minute volumes for Time Range "B". Although not shown, other freeway locations on the Gulf Freeway show similar results when the above conditions are applied.

From Figure III-9 it can be seen that between 7:40 a.m. and 7:50 a.m. the result of Time Range "B" staggering would be to reduce the ten-minute volume by 38 vehicles. Although this would be a substantial reduction, it occurs after the peak period has passed. The reduction during the peak period between 7:10 a.m. and 7:20 a.m. would be only 24 vehicles; therefore, no major reduction in peak period flow could be expected.

Combined Effects of All Generators Studied

It was shown above that no major reduction in morning peak period freeway flow could be expected if the working hours of the University of Houston and the other selected generators were staggered separately. However, it was felt that by combining the effects of all of the generators studied, the freeway morning

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

The following questions concern the trip you made to work this morning.

1. Where did the trip begin?

_____
STREET Address City Time of Day

2. When did you arrive at work? _____
Time of Day

3. What time were you due at work? _____
Time of Day

4. How often do you make this trip between 6:30 and 8:30 a.m.? (check one)

___ Seldom ___ Twice per week ___ Four times per week ___ Five or more times per week

___ Once per week ___ Three times per week

5. How did you travel to work? (check one)

___ Bus ___ Taxi ___ Car driven by yourself ___ Car Pool

___ Other (Please Specify) _____

6. Did you use any part of the Northbound Gulf Freeway for this trip? (check one)

___ Yes ___ No

If the answer to Number 6 was "Yes" please continue.

7. What Entrance Ramp did you use? (check one)

____ Scott Street ____ Griggs ____ Cullen ____ Mossrose

____ Dumble ____ Woodridge ____ Telephone ____ Wayside

____ Other (Please Specify) _____

8. What Exit Ramp did you use? (check one)

____ Downtown ____ Sampson ____ Scott ____ Cullen ____ Griggs

____ Dumble ____ Tellepsin ____ Telephone ____ Wayside ____ Mossrose

____ Woodridge ____ Other (Please Specify) _____

EXAMPLE OF QUESTIONAIRE
FIGURE III-7

TABLE III-4

VEHICLE ARRIVALS

Time Range "A"

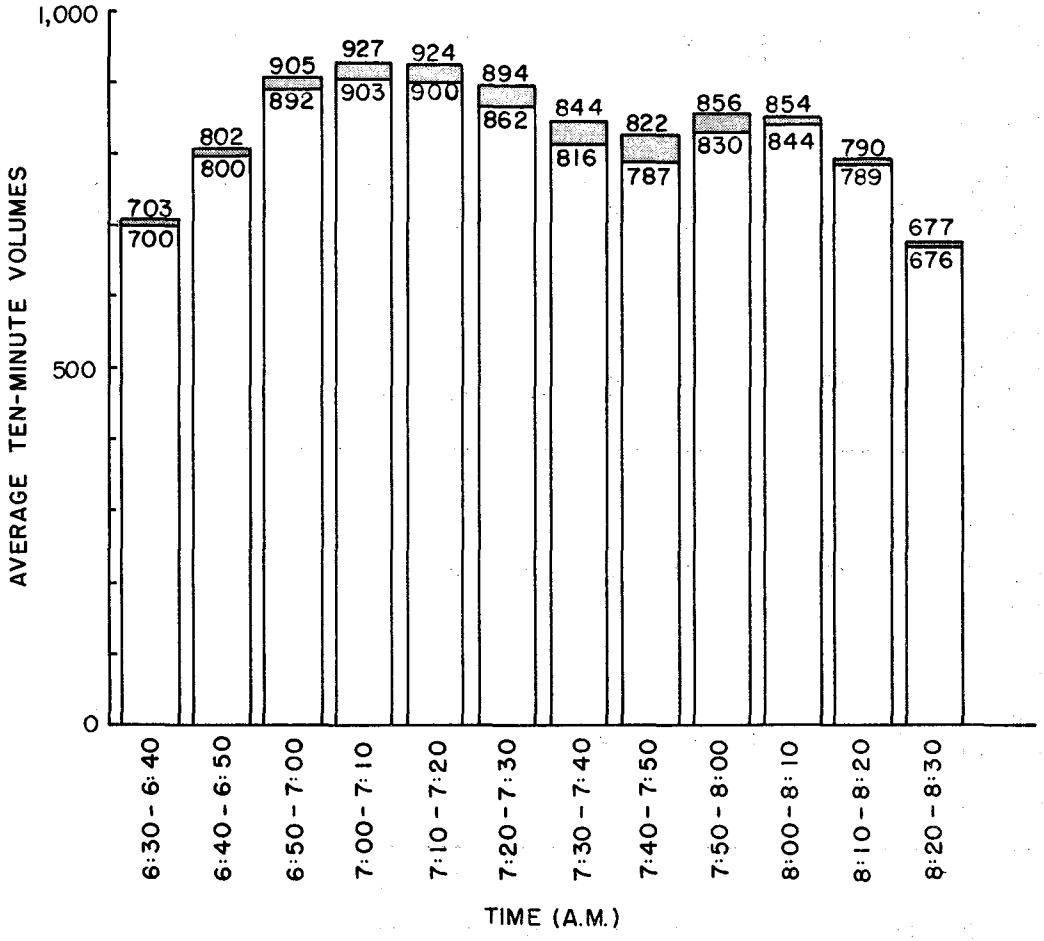
Time Period (a.m.)	Schlumberger		Century Paper		Southwestern Bell Telephone		
	Telephone Road	Griggs Road	Telephone Road	Griggs Road	H.B. & T. Railroad	Telephone Road	Griggs Road
6:30-6:40	0	0	0	0	0	0	3
6:40-6:50	1	2	0	0	3	3	0
6:50-7:00	4	3	0	0	6	6	10
7:00-7:10	2	4	0	0	13	14	20
7:10-7:20	7	7	0	0	17	27	17
7:20-7:30	17	16	2	2	21	10	14
7:30-7:40	8	19	0	6	17	17	3
7:40-7:50	27	30	7	5	3	6	0
7:50-8:00	38	22	4	4	3	0	0
8:00-8:10	15	10	2	0	0	0	0
8:10-8:20	5	1	0	0	0	0	0
8:20-8:30	0	0	1	1	0	0	0

TABLE III-5

VEHICLE ARRIVALS

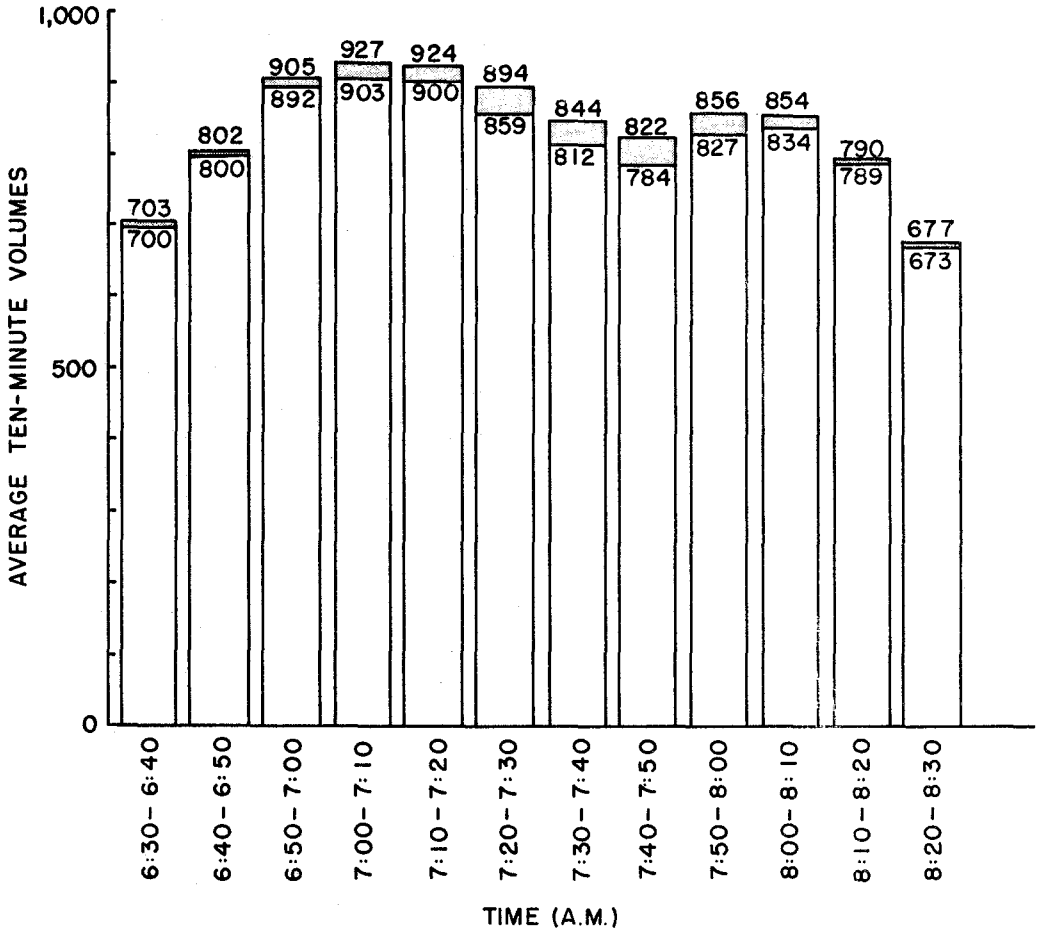
Time Range "B"

Time Period (a.m.)	Schlumberger		Century Paper		Southwestern Bell Telephone		
	Telephone Road	Griggs Road	Telephone Road	Griggs Road	H.B. & T. Railroad	Telephone Road	Griggs Road
6:30-6:40	0	0	0	0	0	0	3
6:40-6:50	1	2	0	0	3	3	0
6:50-7:00	4	3	0	0	6	6	10
7:00-7:10	2	4	0	0	13	14	20
7:10-7:20	7	7	0	0	17	27	17
7:20-7:30	17	16	2	2	21	13	17
7:30-7:40	8	19	0	6	21	17	7
7:40-7:50	27	30	7	5	10	14	3
7:50-8:00	38	22	4	4	3	0	3
8:00-8:10	15	10	2	0	10	13	10
8:10-8:20	5	1	0	0	14	10	0
8:20-8:30	0	0	1	1	0	0	3



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT GRIGGS ROAD
INBOUND LANES ONLY
SCHLUMBERGER, CENTURY PAPER, SOUTHWESTERN BELL TELEPHONE TRIPS SHADED
TIME RANGE "A"

FIGURE III- 8



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT GRIGGS ROAD
INBOUND LANES ONLY
SCHLUMBERGER, CENTURY PAPER, SOUTHWESTERN BELL TELEPHONE TRIPS SHADED
TIME RANGE "B"

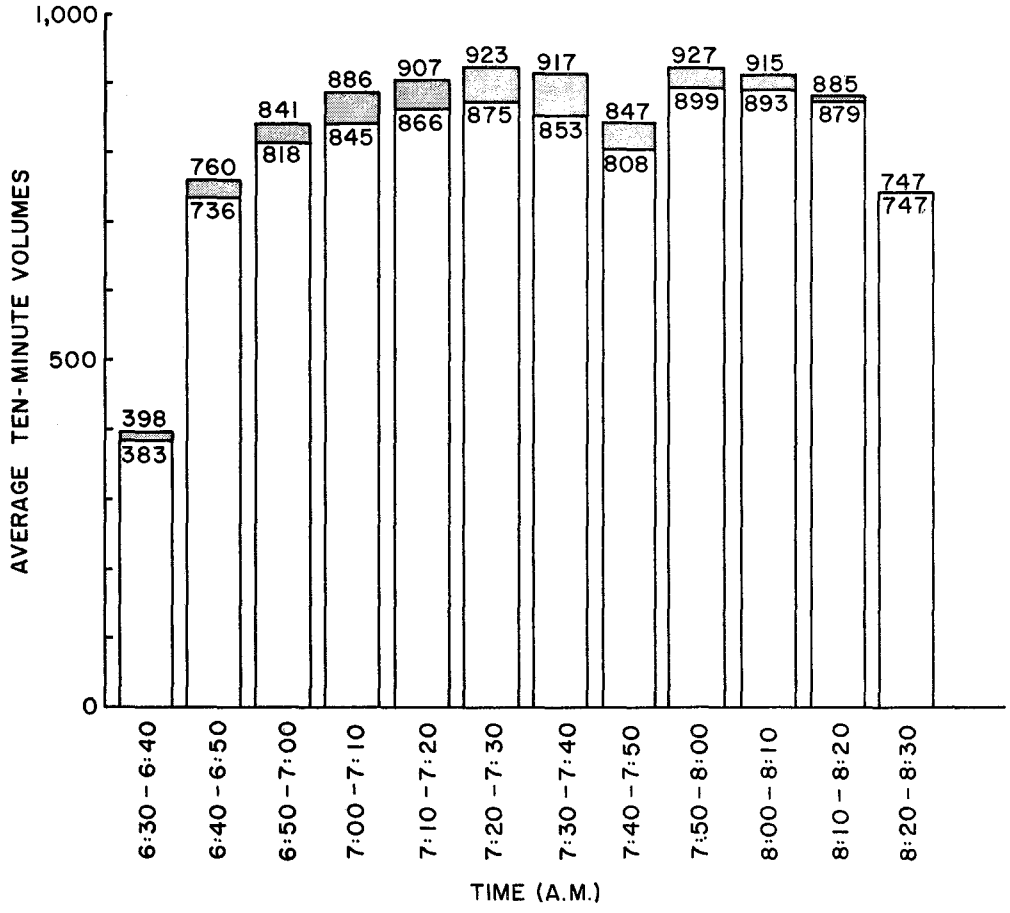
FIGURE III-9

peak period flow might be sufficiently reduced to justify a staggered hours plan.

Assuming that by altering working hours at the University of Houston and the Southwestern Bell Telephone District Toll Office all trips destined to these organizations could be removed from the morning peak traffic period, the flow on the Gulf Freeway at the south crossing of the H. B. & T. Railroad could be expected to occur as shown in Figure III-10 and III-11. It should be noted that the inbound traffic destined for the Schlumberger Company and the Century Paper Company exits the freeway prior to the south crossing of the H. B. & T. Railroad. Figure III-10 was drawn using Time Range "A" and Figure III-11 was drawn using Time Range "B". The shaded portions in both figures represent the amount of reduction of each ten-minute period.

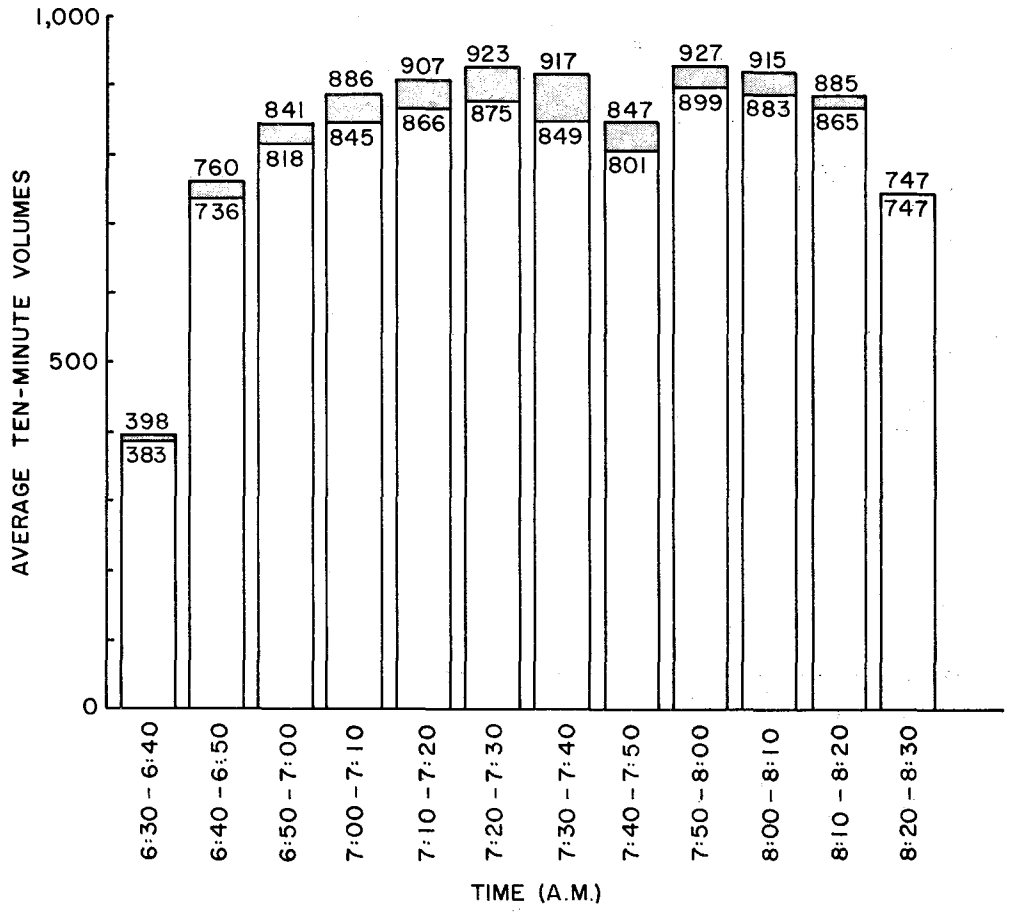
It can be seen that by altering the working hours at the University of Houston and at the Southwestern Bell Telephone District Toll Office the flow rate on the inbound freeway lanes could be expected to be reduced by approximately 136 vehicles per hour per lane between 7:30 a.m. and 7:40 a.m. if Time Range "B" staggering is employed. This should be more than sufficient to justify staggering working hours.

Although not shown, expected ten-minute volumes at the other two locations on the Gulf Freeway that were mentioned above were quite similar to the flows at the H. B. & T. Railroad provided that at least 75 per cent of the inbound freeway flow that is destined for the University of Houston is on the freeway at those locations.



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT SOUTH H.B. & T. RAILROAD
INBOUND LANES ONLY
UNIVERSITY OF HOUSTON AND SOUTHWESTERN BELL TELEPHONE TRIPS SHADED
TIME RANGE "A"

FIGURE III - 10



AVERAGE TEN-MINUTE VOLUMES
GULF FREEWAY AT SOUTH H.B. & T. RAILROAD
INBOUND LANES ONLY
UNIVERSITY OF HOUSTON AND SOUTHWESTERN BELL TELEPHONE TRIPS SHADED
TIME RANGE "B"

FIGURE III-11

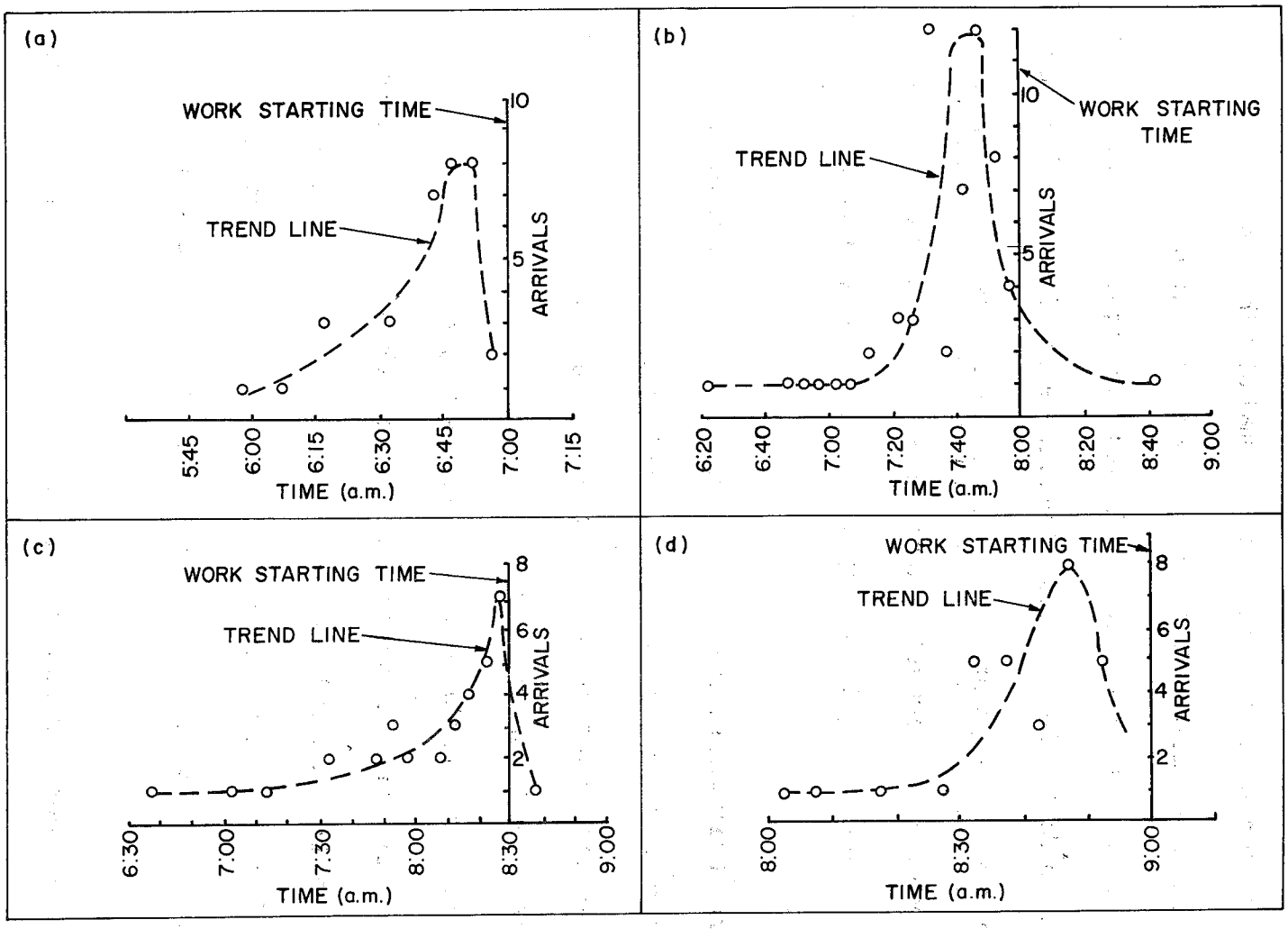
Arrival Time—Work Starting Time Relationship

One of the phenomena noted when the data were analyzed was that work arrival patterns seem to follow a somewhat normal distribution. To better visualize this, Figures III-12, III-13, and III-14 were plotted with number of work arrivals versus time of arrival for different starting times. The trend line was inserted as a dashed line because it was not a fitted curve. The purpose of the trend line was only to point out the general trend of work arrivals. As can be seen, the peak of work arrivals occurs a few minutes prior to the time that the employee is due on the job and employees that arrive very early or late are in the minority.

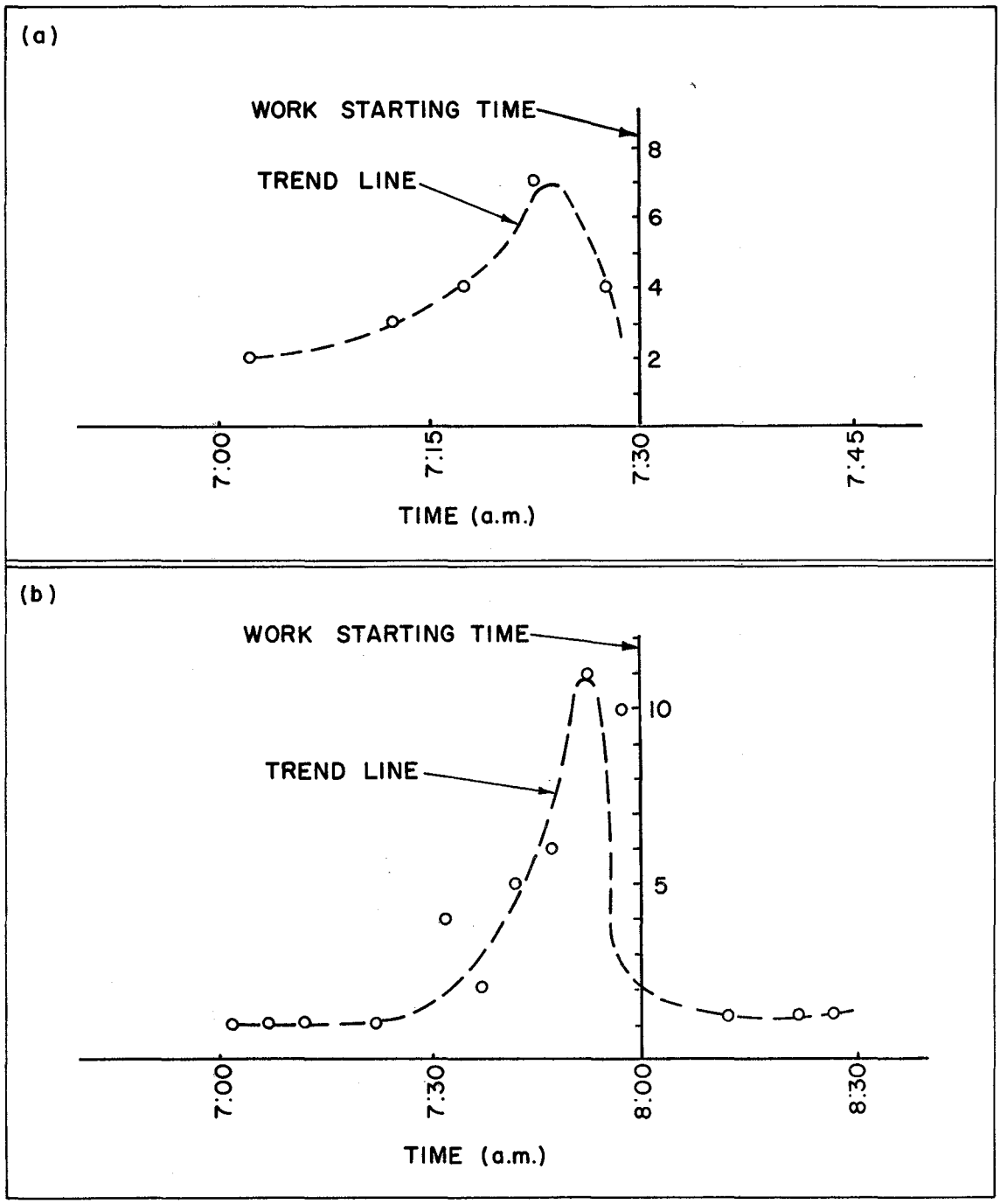
In the arrival patterns studied, it was observed that usually the peak period was sharply defined and short. It is expected that in cases where the peak is not well-defined and relatively long that traffic congestion is occurring on the traffic facilities used by the employees.

More complete information is needed on this subject because it seems reasonable to assume that employees that arrive at work very early or arrive at work late will not be affected by work hour staggering. The remaining majority of employees that arrive at or just prior to work starting times would be the ones that will cause any substantial effect on traffic facilities if a staggered hours plan is instituted.

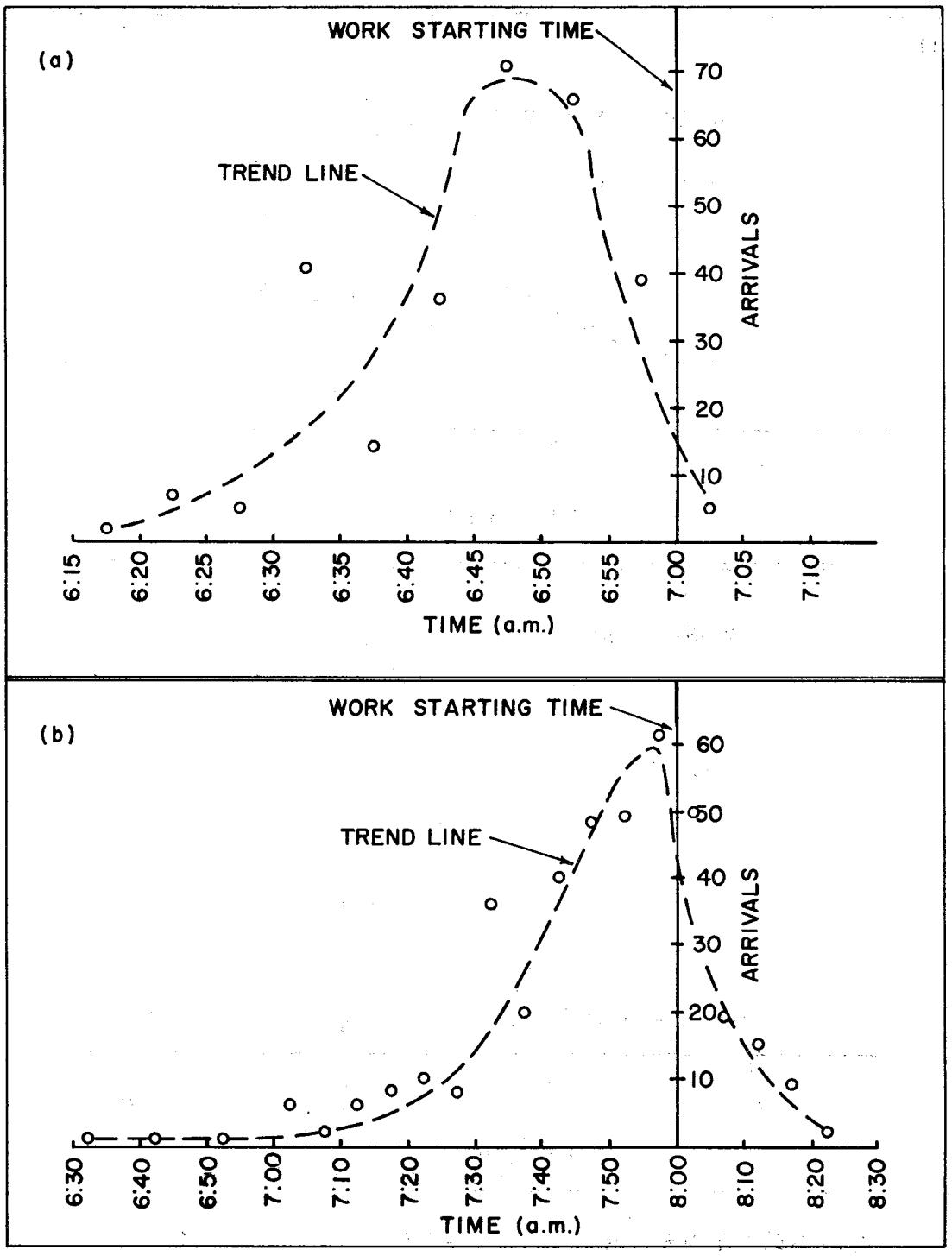
It would have been desirable to study the arrival patterns at the University of Houston; however, the method with which the data were collected did not include sufficient information.



ARRIVAL TIME-WORK STARTING TIME RELATIONSHIP
SOUTHWESTERN BELL TELEPHONE DISTRICT TOLL OFFICE
FIGURE III-12



ARRIVAL TIME - WORK STARTING TIME RELATIONSHIP
CENTURY PAPER COMPANY
FIGURE III-13



ARRIVAL TIME - WORK STARTING TIME RELATIONSHIP
SCHLUMBEGER OIL WELL SURVEYING COMPANY
FIGURE III-14

CHAPTER IV

SUMMARY OF FINDINGS

On the basis of this study of the feasibility and possible effects of staggered working hours the following observations can be made:

1. Although some problems will result in any altering of working hours these problems can be dealt with by restricting any change to a reasonable period and by close coordination with all organizations that decide to comply.
2. Organizational leaders contacted seem receptive to the idea of staggered working hours.
3. The magnitude of change required to achieve an optimum staggered hours plan to alleviate morning peak period traffic congestion is not excessive.
4. The effect of any one organization on the Gulf Freeway morning peak period operation does not seem sufficient to greatly affect that operation.
5. A combination of the effects of several organizations does seem capable of drastically affecting Gulf Freeway morning peak period operation.
6. Work arrival times follow some definite distribution. This distribution is probably normal.
7. There seems to be definite evidence that a staggered hours program is feasible and the results could be highly beneficial.

CHAPTER V

RECOMMENDATIONS

Although the morning peak period has been studied in this research, nothing has been said about the afternoon peak period which is also critical. Also, although the effect on the Gulf Freeway if certain trips were removed from the peak period has been discussed, nothing was said about when these trips would be made. With this in mind, my recommendations for future research would be as follows:

1. The effect of altering working hours on the afternoon peak period operation of Houston traffic system.
2. The effect on off-peak traffic operation in Houston caused by the introduction of displaced work trips.

The arrival times of personnel at their job sites seemed to follow a normal distribution. Although nothing can be definitely concluded about the arrival pattern from the limited observations made, this would be a very definite factor in determining a staggered hours plan; therefore, I recommend that a more extensive study of this subject be made prior to determining any staggered hours plan.

It is also recommended that a more exact method of determining arrival times at selected locations along the trip route be determined. The method used in this study was sufficient for its purpose because relative large increments of time (ten minutes) were used; however, five-minute or possibly even one-minute time intervals may be desired. The interpolation method used in this study is not refined enough to determine arrival times that accurately.

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