COMPUTERIZED TRAFFIC DATA ANALYSIS SYSTEM

by

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Research Engineers

(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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ABSTRACT

The techniques of collecting detailed traffic data for a given site are well known. A popular method uses chart recorders in combination with various vehicle sensing devices, such as tape switches, to provide an accurate pictoral display of the traffic flow. The human effort required to decipher these "pictures" is typically equal to or greater than the time required to gather the data. When considering the case where multiple lanes and multiple sites are to be monitored simultaneously, it becomes clear that the human effort to evaluate the data is disproportionately high.

This paper discusses a specially designed data acquisition system that includes both the hardware to reliably collect traffic data from up to forty sensors, and the software (computer programs) to provide results analyzed in a comprehensive yet concise form. The hardware consists of a main control unit that utilizes computer compatible magnetic tape for data storage and four remote terminals each with ten possible inputs. There are two programs in the software package; a general purpose program that reads the magnetic tape and generates a data file, and a special purpose program that can be modified to analyze the data in accordance with the needs of the researcher.

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INTRODUCTION

Highway research often includes the gathering of data concerning the flow characteristics of vehicles on the highway. Parameters of general interest include speed, vehicle position relative to the highway and other vehicles, and vehicle following characteristics (headways, queuing, etc.). Obtaining traffic flow data from one location and the subsequent reduction of these data is a relatively simple procedure. However, as the number of data points increase, the task of data collection and reduction becomes quite difficult in terms of time and manpower, as well as accuracy. Since all of the above mentioned parameters are binary events (share the characteristic that the event either occurs or does not occur), and since the times of occurrence of these events are available, digital data gathering techniques may be used to both reduce the time necessary for analysis and to increase the accuracy of the result.

Due to the need for a data acquisition system capable of gathering simultaneous data from a number of points in a format which is appropriate for efficient computer analysis, the system as described in this report was designed and built. Although the system was designed for use in a specific project,(1) it has a wide range of utility and can be modified for use in any research dealing with such variables as speed, lateral placement and headway.

PURPOSE AND SCOPE

It is the intent of this report to provide insight into the design goals (as well as some details of the actual design) of the data acquisition system. In addition, the operating instructions for this system are detailed for the benefit of anyone desiring to use it.

The system developed has a broad range of utility in the highway research field. Thus, the secondary purpose of this research is to illustrate various appropriate applications of the system.

DESIGN SPECIFICATIONS

Because of the extreme demands of monitoring the traffic flow characteristics within a section of highway or intersection, specifications for application had to be decided. Upon consideration of present and future applications the design was based on the need to simultaneously monitor up to 40 signals.

An example of the data acquisition system's general application may be given by assuming a need to simultaneously monitor five traffic sites as detailed in Figure 1. The sensing device to be used was the simple Tapeswitch Corporation of America tapeswitch which has been used successfully in the past for data collection. Although the switch does have limitations when used during adverse weather conditions or prolonged periods of time, it can be considered reliable for temporary use. Although the system was designed to utilize a tapeswitch sensing device, other sensor types such as magnetic and optical detectors may be used with minor alterations to the system.

There are several general specifications that are applicable for all field data acquisition systems. The equipment should be neatly packaged in keeping with the need for portability. It should be compact enough to be hauled in and operated from a station wagon size vehicle. The operating procedures should be straight forward enough to allow rapid familiarization by a technician. The portable power source should allow data to be gathered for periods as long as 12 hours.

The following information is collected by the system specific to the situation illustrated in Figure 1:

(1) Total traffic volume is to be established for a monitoring period of up to 12 hours. This information is to be broken down by traffic lane and vehicle class for each of five sites — four classes of vehicles are to be considered (i.e., passenger cars, trucks, tractor trailers, and all other types).

(2) The lateral placement of vehicles is to be monitored for one of the lanes in four of the five sites, (specifically sites 1, 2, 4, and 5). Four placement zones are to be defined from the edge of the pavement as follows: <u>Zone #1</u>, less than three feet; <u>Zone #2</u>, from three to six feet; <u>Zone #3</u>, from six to nine feet; and <u>Zone #4</u>, greater than nine feet.

(3) The speed of each vehicle is to be recorded to provide data for the calculation of the mean, standard deviation, and the 85th percentile of the speed distributions. These are to be calculated for each vehicle class within each traffic lane.

(4) The time distance between vehicles (headway) is to be monitored to allow average headway, 85th percentile, and standard deviation of the headway distribution to be calculated for each site and lane. Headway can be optionally definable as either the time it takes to cover the distance between the first axle of the leading vehicle and the first axle of the trailing vehicle, or between the last axle of the first vehicle and the first axle of the trailing vehicle.

(5) Vehicle queue information is to be calculated from the speed and headway data. A queue, or platoon, is defined as two or more vehicles in a given lane such that the time between pairs of vehicles is less than an optionally specified time, referred to as the queue cutoff time. The speed of the queue is defined as an average of the speeds of the individual members of the queue. The standard deviations of the queue speeds as well as average and standard deviation of queue length are to be established. In addition, the average and standard deviation of the distance between vehicles in the queues are to be calculated. These values are to be determined for each site by lane.

Bar graphs are to be prepared indicating the distribution of vehicles by type for each of the first five positions in the queues.

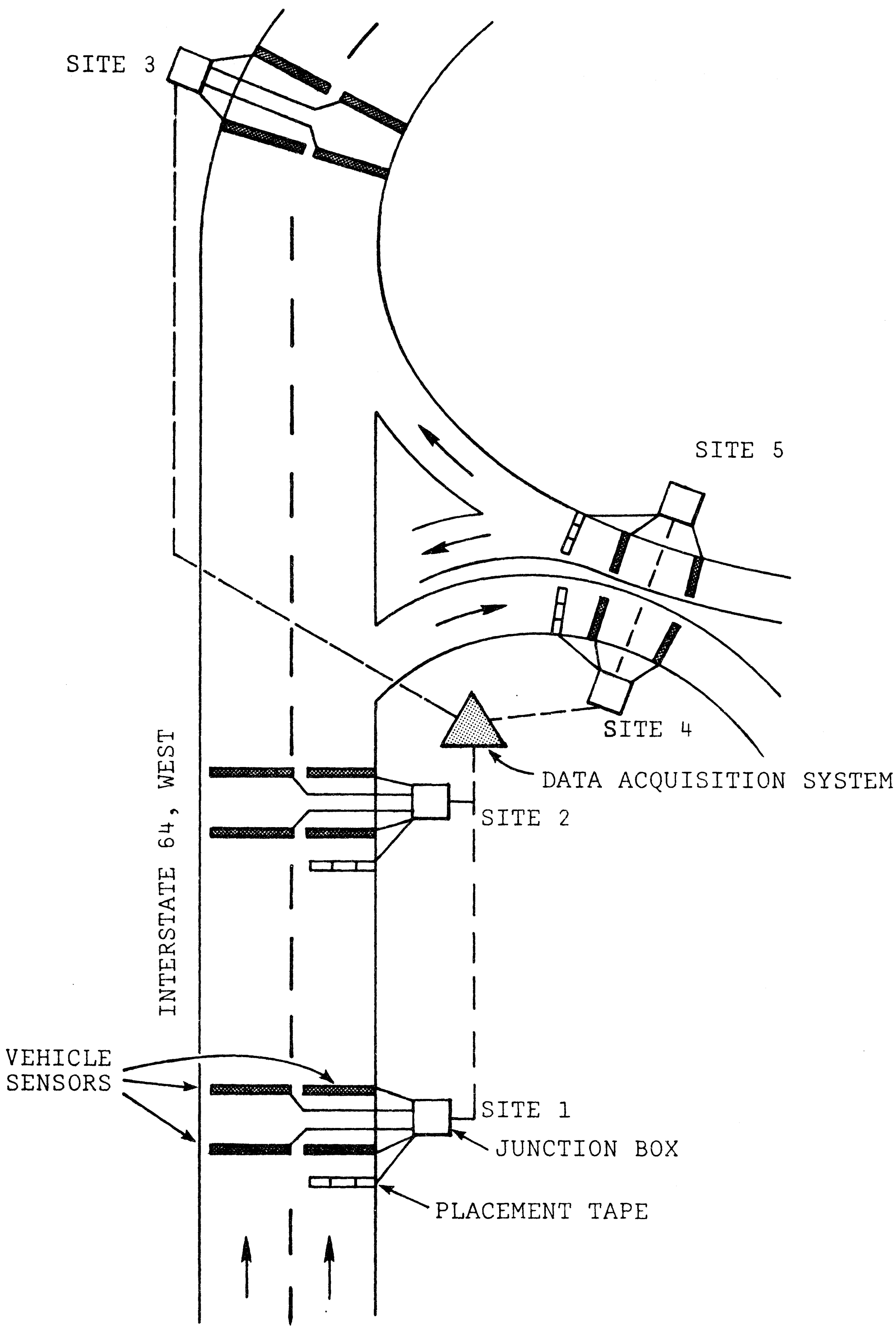


Figure 1. Installation configuration with 5 sites and a total of 28 switches.

DATA ACQUISITION SYSTEM HARDWARE

1. Description

The system consists of four remote stations, each capable of time-multiplexing signals from up to ten tape switches, and a central processor (CP) which performs three functions: (a) sends clock pulses to the remote stations to synchronize their operation, (b) receives event (data) pulses from the remote stations and time-multiplexes these, and (c) issues commands and presents data to the digital magnetic tape unit (MTU) (see figure 2).

The CP communicates with the remote stations and vice-versa by means of differential line signaling over shielded twisted-pair cables not exceeding one-half mile in length. Each remote station uses one cable for receiving from the CP, and another cable for transmitting data to the CP.

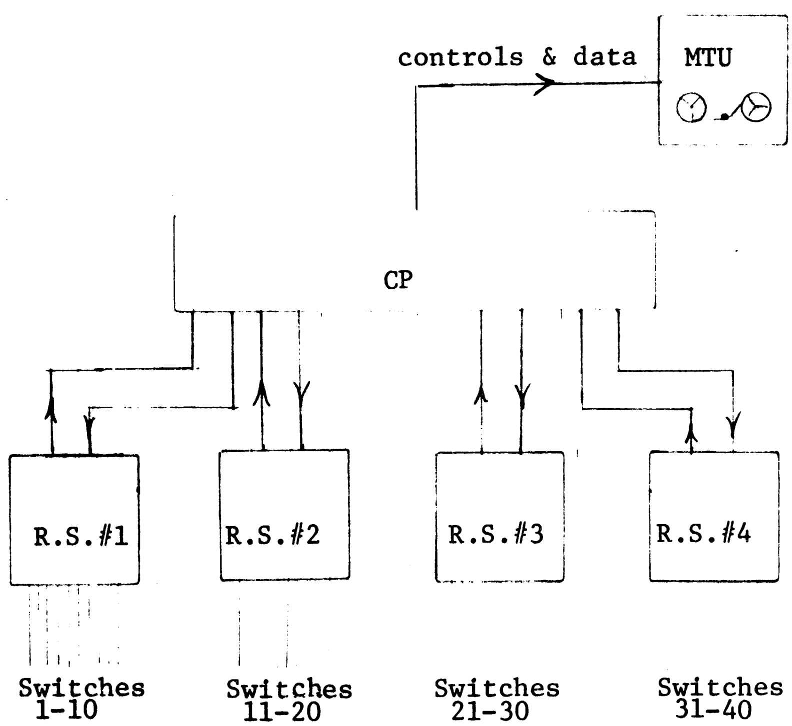


Figure 2. Overall functional diagram.

2. Operation

A. Synchronization of Remote Stations

The CP sends a pulse train with a 400 μsec pulse repetition time (PRT) and a 2/5 duty cycle, as depicted in Figure 3.

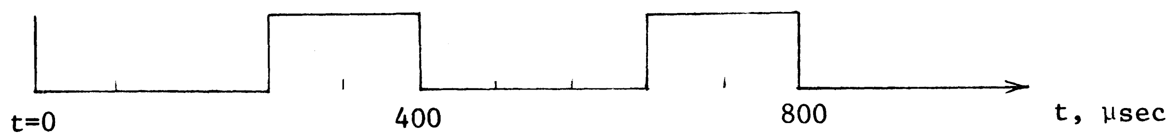


Figure 3. Central processor control signal (normal signal).

Every tenth pulse is modified, however, to be 3/5 duty cycle, as depicted in Figure 4. In fact, this modification is made on the first pulse sent from the CP and then on every succeeding tenth pulse. The exceptional "sync pulse" is detected and used to force the decade counters of the remote stations to a zero count. Each such counter points in turn to each of the 10 tape switches serviced by the remote station. These would ordinarily rezero themselves at the proper time by counting on the clock pulses, but momentary noise in the system or in the transmission line might cause an extra or missed count. Without the sync pulse detection and rezeroing mechanism, an offset between the remote station and CP decade counters would continue over time and utterly invalidate the data recorded. With this mechanism, momentary noise can lead at worst to a few invalid events recorded on tape.

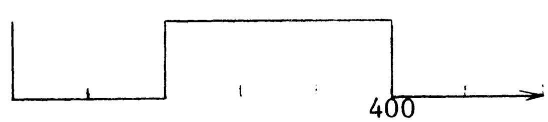


Figure 4. Central processor control signal (tenth pulse).

B. Treatment of Tape Switch Signals

It is desirable to poll every switch for a possible tripping every 4 msec, and yet a vehicle tire is capable of holding a switch closed for as long as 20 msec or more. Detecting only switch closers every 4 msec would in general lead to multiple data pulses being sent out for a single tripping. Instead the system uses a flip-flop (FF) circuit wired so as to produce a "1" output upon receiving the input sequence "switch open, switch closed". The flip-flop is sampled, and if "1" it is reset. The input from the tape switch may, of course, still be low (meaning "switch closed"), but as the FF remains at a zero level until its input indicates the tape switch has been open and then closed.

Events, closures of the tape switches by vehicle tires occur randomly in time and could occur at the moment the associated FF is being examined and result in a missing event or a double event. These potential errors are eliminated by connecting a second FF to the output of the first. This second FF is activated only when both the first FF has been set and an end of a clock pulse is detected. It is the second FF that is examined to determine if an event has occurred.

A logic diagram of this dual FF configuration for the processing of each tape switch input by a remote station is presented in Figure 5.

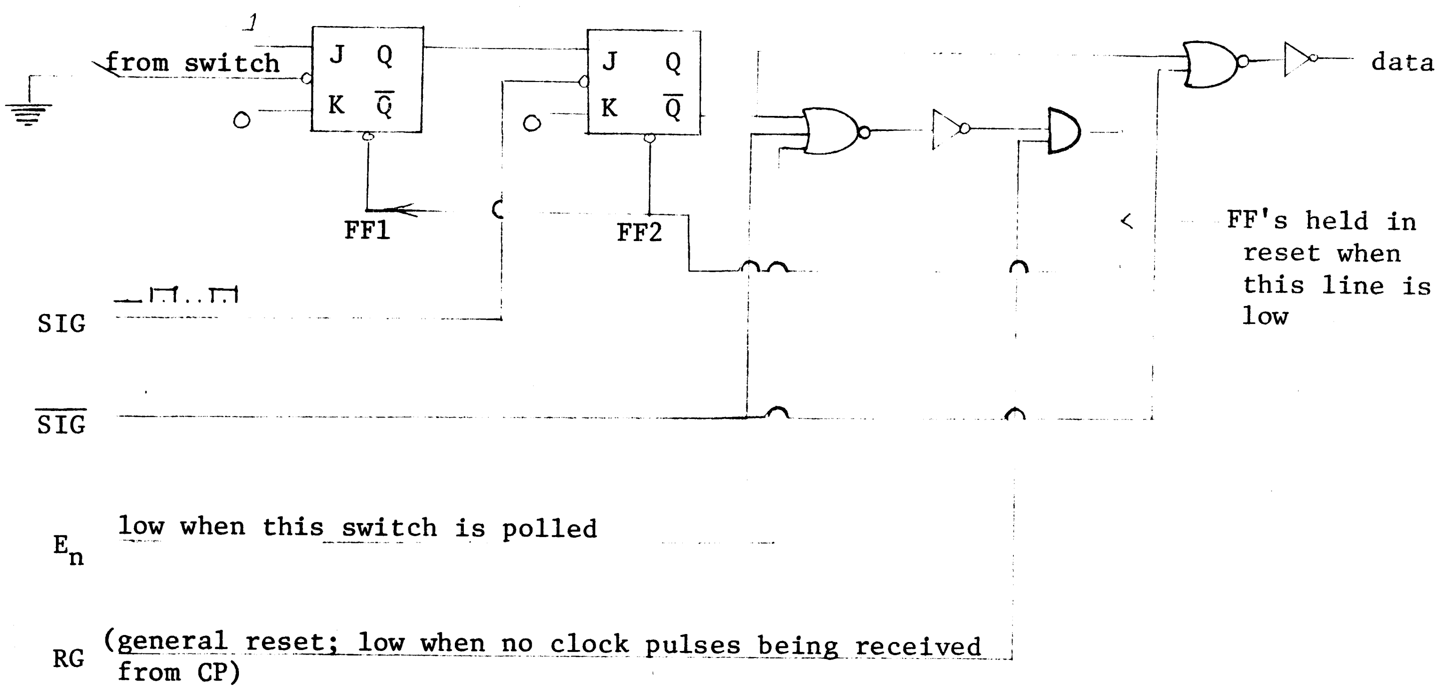


Figure 5. Control logit for tape switches (remote station).

Referring to Figure 5, the FF reset line will go low when three conditions occur (assuming the RG line is high):

(a) $\overline{Q}$ of FF2 is low, i.e., an event has been registered and synchronized,

(b) $\overline{SIG}$ is low, i.e., SIG is high

(c) This switch is being polled, i.e., E_n is low.

Note that (a) will occur only after falling edges of SIG, and (b) will then not be satisfied until at least 2/5 of a SIG period later (since a "sync pulse" is down for only 2/5 period). Thus $\overline{Q}$ remains low at least 2/5 · 400 μsec = 160 μsec and this is the minimum duration of the data pulses sent back to the CP (most are 3/5 · 400 μsec = 240 μsec). The data line is normally high; pulses are low periods.

The logic shown above is performed for either four or two tape switch inputs by the circuit boards designated "REMOTE FLIP-FLOP" boards.

C. Other Remote Station Functions

As has already been indicated, the lines E1 - E10 "polling" the various switches must be enabled (i.e., made low) in turn for 400 msec periods. This is done by a decade counter which counts on falling edges of SIG, and a "4-to-10 decoder" which makes one of ten lines low according to the binary count on the decade counter outputs. The advisability of using special "sync pulses" to re-zero the decade counters has been discussed in Section A. The circuitry utilized in detecting the sync pulses is illustrated in Figure 6.

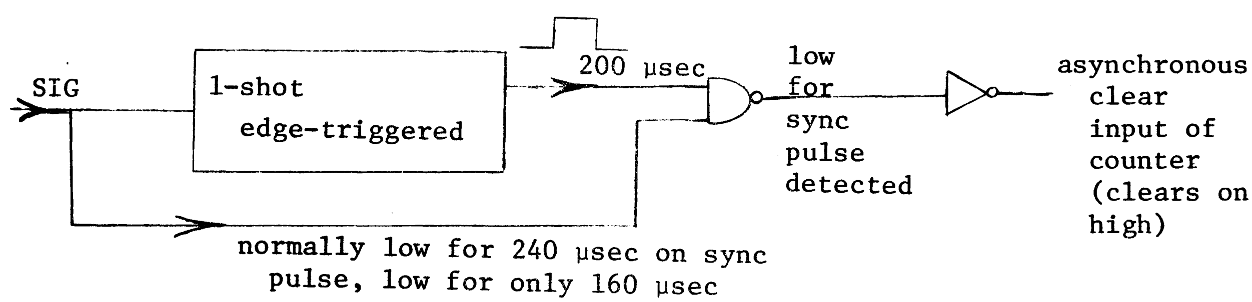


Figure 6. SYNC pulse detector.

It is desirable to hold the switch input FF's in the reset mode while no signals are being received from the CP; otherwise all of these would be tripped by the time the CP was started, with the result that a burst of spurious data would be recorded. The line RG is used for this purpose; it is simply the output of a retriggerable 1-shot having the SIG line for input. RG remains high so long as SIG does not remain low for more than 5 normal SIG periods 2 msec. If RG should go low, however, the FF's and the decade counter are held in the reset mode and zero count, respectively.

The functions described above are performed by the circuit board designated "MAIN REMOTE BOARD".

D. Central Processor: Internal Timing

The internal clock of the CP generates a square wave clock signal (CLK) of period 20 μsec, which is subdivided into CLK/2 and CLK/4 signals of period 40 and 80 μsec, respectively. The signal CLK/4 is used to generate the signals shown in Figure 7, but only after the CP has been activated by the START pushbutton:

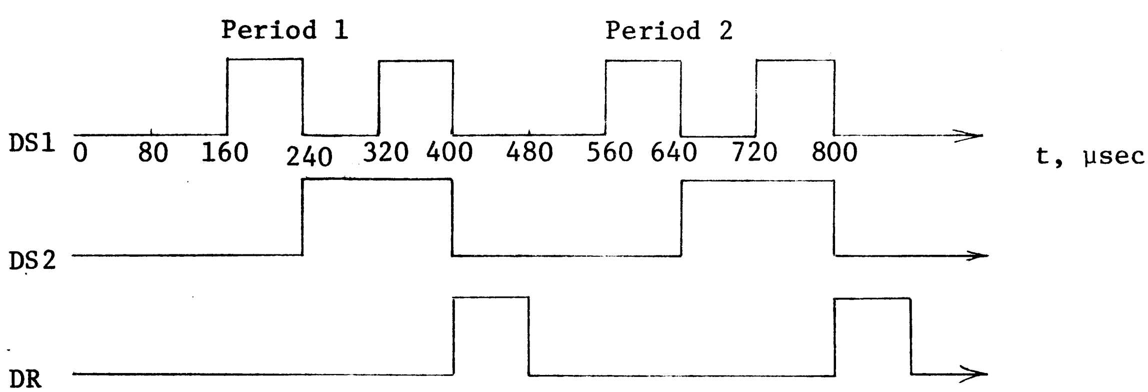


Figure 7. Typical pulse train to select remote data lines.

During any interval of 400 μsec, the variables DS2, DS1 take on 4 pairs of values and are used to select one of the four data lines from the remote stations for a period of 80 μsec each. Recall that the data pulses last for only 16 μsec and are sent only when SIG is low, i.e., during the first 160 or 240 μsec of every 400 μsec period. It would thus be impossible to see a data pulse on lines 3 and 4, which would be selected by Ds2, Ds1 during the interval 240-400 μsec. To overcome this, flip-flops are used as temporary memory devices to hold data pulses for 400 μsec after the period begins; these are cleared by the signal DR during the first 80 μsec of the next period. Note that the signal SIG sent to the remote stations is logically DS2 + Φ DSI, where Φ is logical 1 only when the CP's main decade counter reads zero.

The 20 μsec oscillator, frequency dividers, and logic circuitry associated with the development of DS1, DS2, DR, and SIG are to be found on the circuit board designated "CLOCK + SIG GEN." The main decade counter referred to above, the data receivers and associated flip-flops, and the remote station selector are located on the board designated "RECEIVER."

E. CP: Data Compilation and Transfer

The system is designed to record to within 4 msec accuracy the time of passage of vehicle axles over any of forty switches. This time is taken to be an 18-bit binary integer variable which increments every 4 msec and overflows back to zero roughly every 15 minutes. A switch closer event will be recorded by indicating the switch number using the first 6 bits, plus the 18-bit time value for a total of 24 bits. The magnetic tape unit stores 6 bits in parallel (one frame on tape), therefore, it is necessary for the CPU to present 4 groups of 6 bits each successively on the 6 data lines to the MTU.

The 6 bits specifying the switch number are organized as follows: the most significant bit (MSB) and second MSB are usually (exception: after EOF pushbutton has been depressed) the signals DS2 and DS1. As these are used to select the remote stations in turn, as described in Section D, they encode the station to which any switch belongs. The third through sixth MSB's are the outputs of the main decade counter: their codings change every 400 μsec and indicate a particular switch of the remote station selected by DS2, DS1. The switch-designator bits point to the switches in the order: SW1, SW11, SW 21, SW 31, SW 2, SW 12, SW 22, SW 32, etc., changing every 80 μsec. When an event is detected at a remote station during a 4 msec cycle, the CP input FF for that station will be set during the 400 μsec interval (within the 5 msec cycle) corresponding to the switch number (1 through 10) at the remote station. The lines DS2, DS1, and the 4 main decade counter outputs of the CP will specify the switch as described above, during an 80 μsec subinterval of the 400 μsec interval. Thus all of the data specifying the event must be stored in the buffer of the MTU within 80 μsec. Since there are four 6-bit words used for each event to store, 6 selector devices capable of choosing one of four inputs are used, and the select code is switched every 20 μsec. (The select code is given by the lines S2 (MSB) and S1, which are identical to CLK/4 and CLK/2, respectively). This is done continuously, whether or not an event was detected; the 6 selector outputs are the data lines to the MTU buffer. Event detection results in sending four 20 μsec pulses along the record command line (REC) to the MTU; the data line values are buffered in, according to the MTU specifications, when the REC line goes high and remains so for at least 8 μsec. Since square pulses are used (the system CLK is simply gated into REC), REC stays high for 10 μsec, and the data lines remain fixed as well.

The functions described above are largely performed by the "18-bit counter and output selector" circuit board.

F. CP: System Clear, Start, Inter-record Gap and Pseudo-end-of-file

The system CLEAR and START pushbuttons may be thought of as inputs to a simple FF whose outputs are the system state lines R (is high when system is cleared and is low when active) and $S = \overline{R}$. Actually the situation is a little more complicated in that the CP is capable of clearing itself after the pseudo-EOF (PEOF) sequence has been executed. Thus, the logic has the form illustrated in Figure 8.

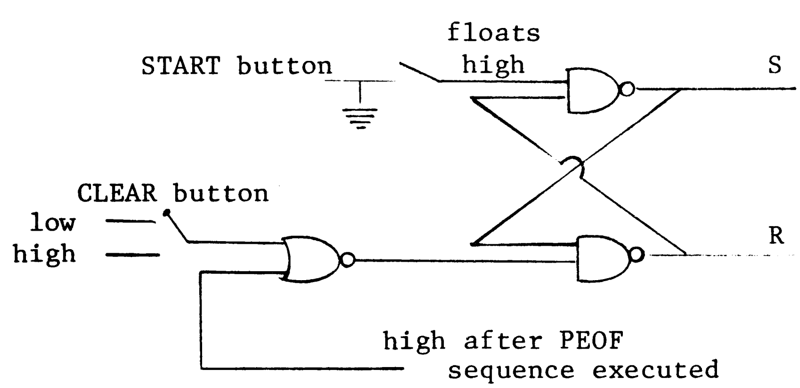


Figure 8. CLEAR and START logic.

The lines S and R are used to clear counters or free them, and to enable and disable signals to the remote stations and to the MTU.

The dual buffers of the MTU can store a maximum of 512 6-bit characters each. Issuance of an inter-record gap pulse (IRG) to the MTU causes subsequent data to be loaded into the other buffer while the first buffer is dumped to tape and a record gap made.

The CP uses a programmable counter to issue an IRG pulse simultaneously (to within the propagation delay of an 8-bit counter + 3 TTL gates) with the nth REC pulse after the last IRG is issued. The value of n here is wired to be any multiple of 16 up to 256 (the CP is being delivered with n wired to 256). The simultaneity of the IRG with a REC pulse is in conformity with the MTU spec's.

An IRG is issued when all outputs of an 8-bit counter become zero after counting on a REC pulse just initiated. The 8-bit counter consists of a low-order hex (4-bit) counter cascaded with a programmable hex counter. During system clear or after completion of an IRG pulse, the programmable counter displays its "programmed" (actually hardwired) initial count, which would be equal to κ ($o<\kappa<16$) to achieve a fixed record length n = 16 ($16-\kappa$). A 1-shot triggering off the falling edge of the IRG pulse is responsible for reloading the counter with the fixed initial count (see functional diagram of "TAPE INTERFACE" circuit board).

The CP separates various blocks of records of data on tape by writing a program-recognizable mark referred to as a "pseudo-EOF" (PEOF). Depression of the "EOF" pushbutton causes the line EOF to go high, but only after the current 80 used cycle so as not to interrupt any event data store operation already in progress. The high state of EOF produces high states on the 6 lines leading to the output selector, which specify the switch number. In the meantime the REC command line to the MTU is strobed until the current record is filled. The above-mentioned 1-shot delivers a short pulse following the end of the IRG pulse, which (only if the EOF line had been high) is gated into the system state FF and clears the system. The net result is that a series of events on "switch" #63 = 111111_2 (which is not an actual switch) are recorded to fill out the current tape record.

DATA ACQUISITION SYSTEM SOFTWARE

The software for the system is made up of two programs. The "VHCLFL" program reads the 7-level magnetic tape generated by the hardware and converts the encoded relative time (the timer on the equipment recycles approximately every 15 minutes) into a continuously increasing value and separates events by lane and site. In addition, classification of vehicle type and calculation of vehicle speed and headway are performed. "VHCLFL" builds a file of the decoded magnetic tape information using the magnetic tape format of 2-octal digit tapeswitch identification followed by a 6-octal digit time as input, and provides as output a disk file that includes time, speed, vehicle type, site, lane, headway, and placement, where applicable. The details of the output format are given in the Appendix.

The second program, "REPORT", reads the "VHCLFL" generated disk file and produces the tables and histograms described in the section entitled "Design Specifications." Further program details for both "VHCLFL" and "REPORT" are given in the Appendix.

APPLICATION EXAMPLES

Example 1

Monitoring of the relationship between adjacent vehicles is easily accomplished using this data acquisition system. A recent study(2) involved an evaluation of an overhead sign that warns approaching motorists who are "following too close." When an offending motorist triggers the "following too close" mechanism, the sign flashes the appropriate message and presumably the driver responds by slowing down and thus increasing the distance between his car and the one in front of him.

The parameters of interest in this case may be: the distance between vehicles at the location of the "following too close" mechanism and the speed of the vehicles at that location. The same items (speed and distance) would be of interest at the point where the motorist would first observe the sign, and again at a prescribed distance past the sign. This scheme can be viewed as the simple 3-site configuration illustrated in Figure 9.

Speeds and headways for each site are parameters that do not require additional programming effort to provide. If it were desirable to monitor a specific vehicle through the system, this could be accomplished by modifying the program.

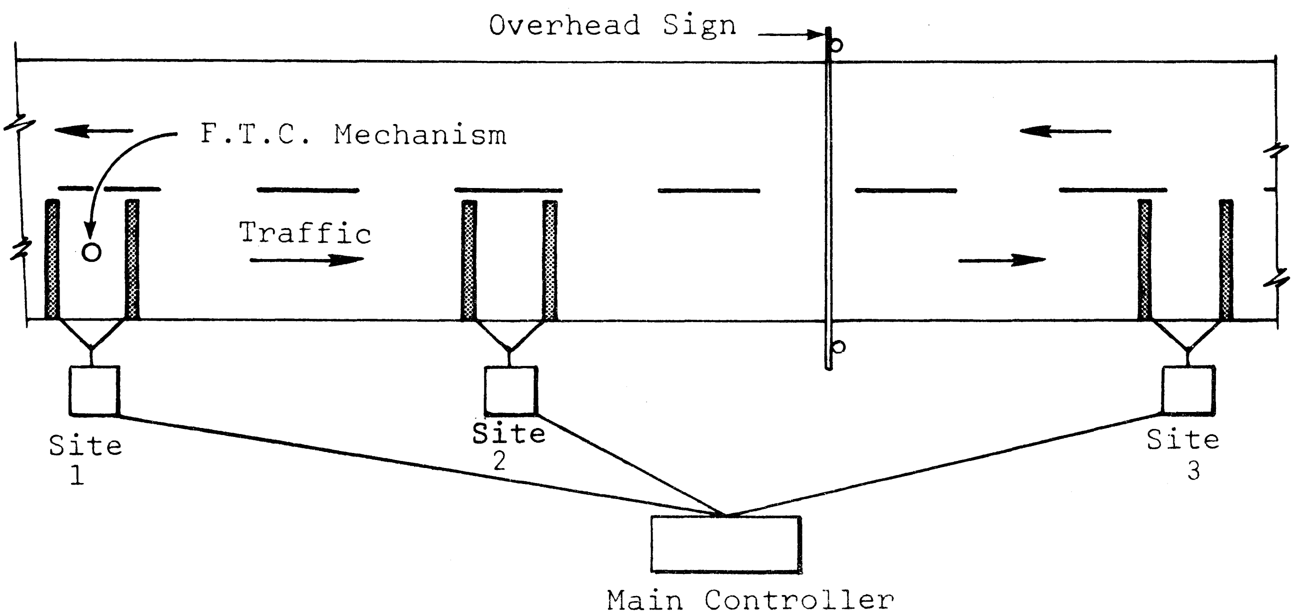


Figure 9. FTC proposed test configuration.

Example 2

A study is under way to determine the characteristics of vehicles decelerating at intersections and interstate exits. The data from the study may be used to develop guidelines for establishing minimum skid resistance standards for these critical roadway locations. The parameters of interest for this application include the speed of the vehicle before entering the exit lane, the speed of the vehicle at the beginning of the exit lane, and the speed at a location near the exit ramp. Special programming would have to be employed to provide the deceleration rate for a specific vehicle, but the equipment would not require any modification. A possible arrangement of the switches is shown in Figure 10.

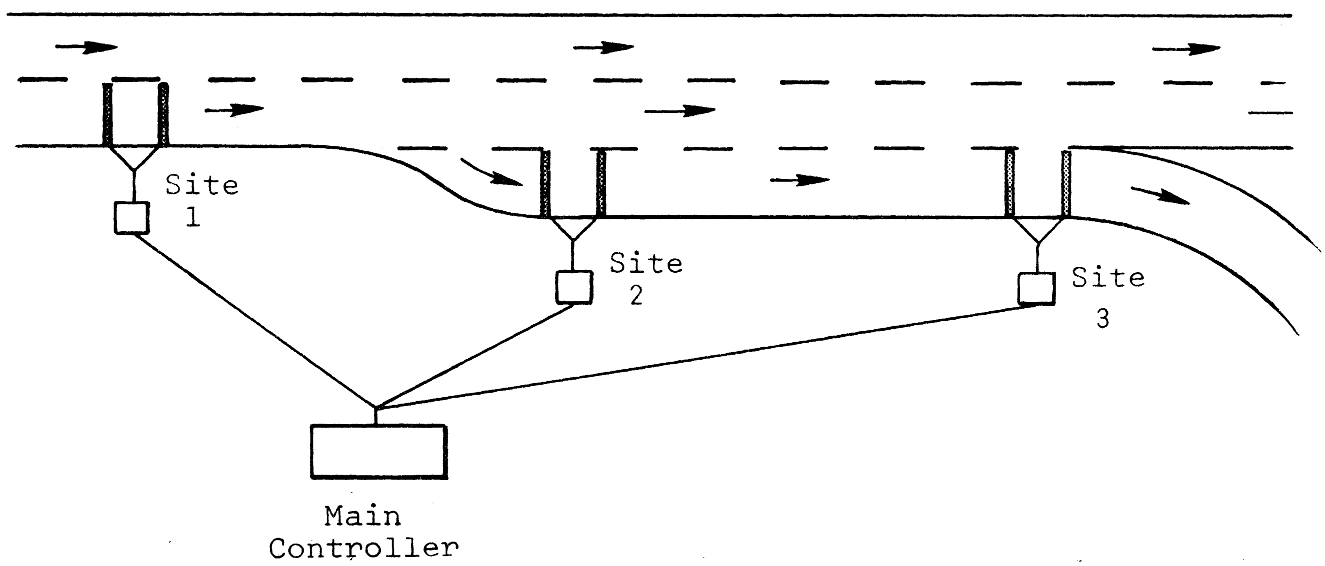


Figure 10. Proposed configuration for exit ramp deceleration tests.

REFERENCES

1. Shepard, F. D., "Traffic Flow Evaluation of Pavement Inset Lights for Use During Fog — Before Phase," Virginia Highway & Transportation Research Council, Charlottesville, Virginia, September 1975.

2. Parker, Martin R., Jr., "An Evaluation of the Following-Too-Closely Monitor System on Two-Lane Suburban Highways," an undergraduate thesis for the University of Virginia, Charlottesville, Virginia, February 1975.

APPENDIX A

INSTALLATION PROCEDURES FOR TRAFFIC DATA ACQUISITION SYSTEM HARDWARE

A. Preliminaries

1. The system requires two cables, a control cable and a data cable, from the central processor (CP) to each remote station (RS). These should be carefully distinguished at both ends. Each cable must be fitted at both ends with a 3-conductor jack. The jack conductors are designated as shown in Figure 11. Using 18 AWG 2-conductor shielded wire such as Belden #8760, connect the black lead to #3, connect the white lead to #2, and connect the shield to #1. After so connecting both ends of a cable, assure that there is continuity (< 20 ohms) between corresponding connector parts. Next assure that an open circuit (> 10 megaohms) exists between 1-2, 2-3, and 1-3. Improper connection will cause an equipment malfunction, and potentially result in damage.

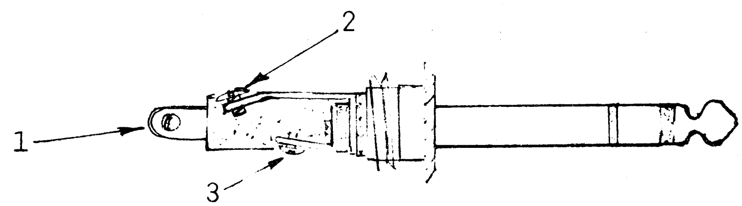


Figure 11. Control cable and data cable connector.

2. Install RS electronic boxes into wooden containers. With master switches off, wire the output terminal of the outer switch to the + (red) input of the RS box. Wire the negative battery terminal to the - (black) input of the RS box.

   It is most important to do this correctly, as the electronics are protected against reverse voltage.

B. On-Site Installation

1. Check that power switch of CP is "off".

2. For each remote station to be used: connect a pair of cables to the "in" and "out" ports of a channel of the CP. At the RS, insert the cable that is "in" at the CP to the port designated "out" at the RS and vice-versa. Only after both cables are fully inserted at both ends may power be applied to the RS. (Tapeswitch inputs may be inserted or removed at liberty whether or not RS is powered.) Using a voltmeter, check that battery voltage is greater than 5 volts with the power switch "ON". Note: It is a good practice to charge the batteries before each usage.

3. Make any final adjustments of tapeswitch input configurations. Note: Make diagrams of the tapeswitch configurations and the ports used at every RS site including the location of the attached switches. It will be helpful when analyzing the data.

4. Activate those CP channels connected to RS's by throwing the corresponding channel switches in the "up" position. Channel switches of unused channels should be "down".

5. After the RS's to be used have been readied as described in (2), position power switch of CP to "ON" and press the "CLEAR' button.

6. Turn power on at the battery box and ready the magnetic tape unit (MTU) to receive data by mounting a reel of magnetic tape. Set MTU in "record" mode.

7. To begin data acquisition, press "START" on CP.

8. To terminate acquisition, press "EOF" on CP. Acquisition may be re-initiated without loss of data already written by pressing "START". Alternatively, data may be overwritten by rewinding tape to load point before proceeding.

C. De-installation

1. Power down CP. Note: Do not remove CP cables until the respective RS has been powered down.

2. For each RS, power down and remove cables. Tapeswitches can be removed at any time.

As an aid to identifying the major components of the system, these items are illustrated in Figures 12 through 15.

Figure 12. Central processor and tape recorder.

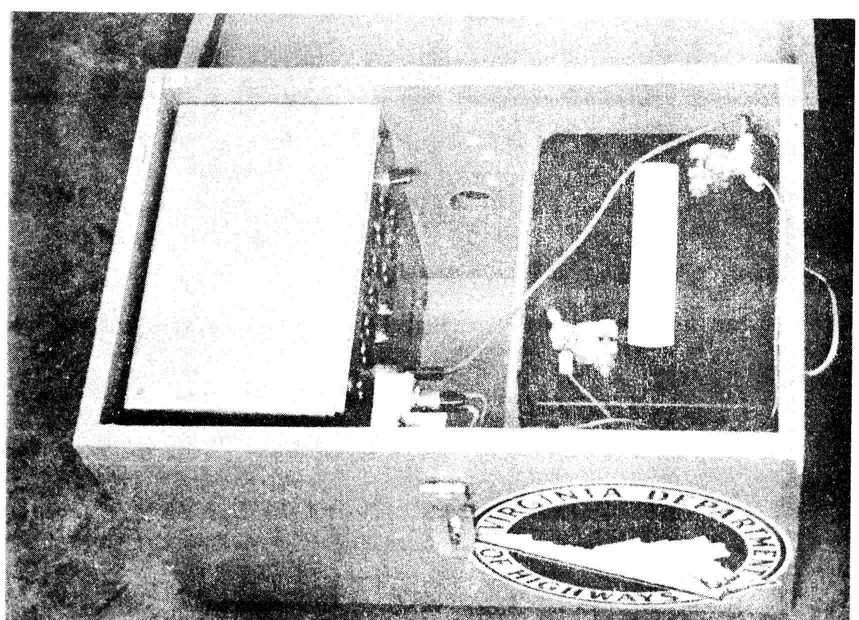


Figure 13. Typical remote station with power source.

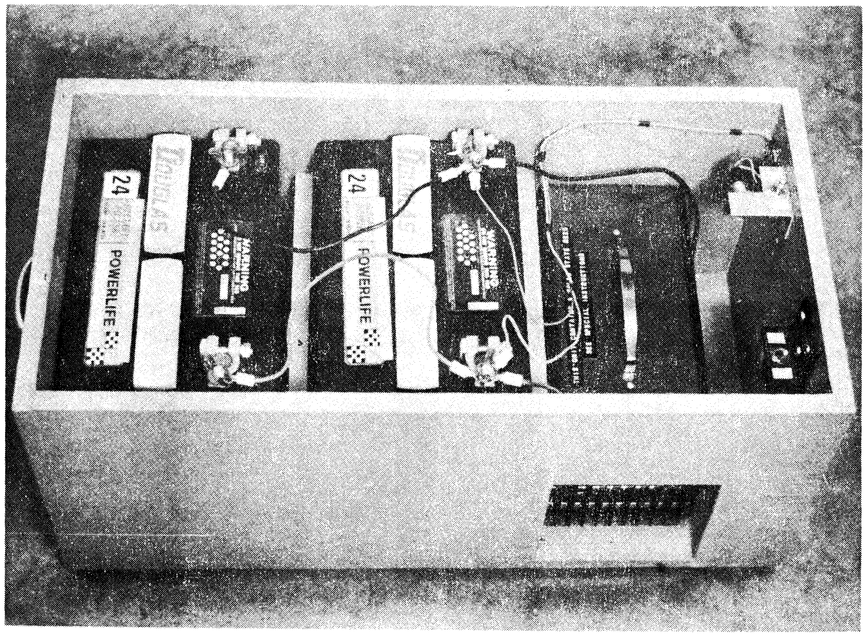


Figure 14. Power supply for tape recorder and central processor.

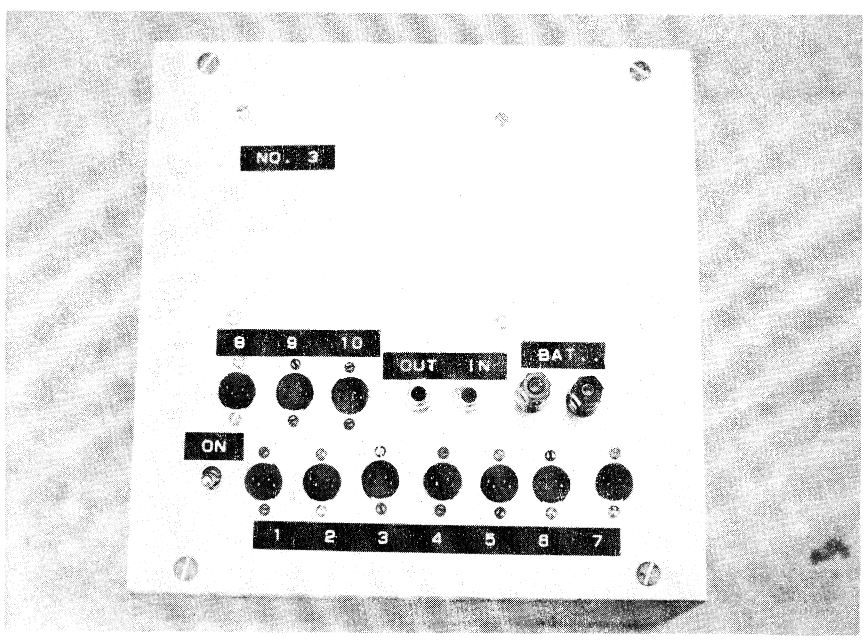


Figure 15. Typical remote station.

APPENDIX B

PROGRAM DESCRIPTION

A. VHCLFL

This program creates one file that contains the following information on each vehicle which travels through a data collection site.

HEDWAY	—	Real, F5.1, the headway this vehicle is giving to the one in front of it. If there is no such vehicle, HEDWAY = 0.0; if HEDWAY > 60.0, HEDWAY = 60.0.
PLACE	—	Integer I1, the lateral placement of the vehicle in the roadway. If PLACE equals one of these it means that this vehicle tripped the switch associated with this placement zone at this site. If the vehicle was in lane 2 or at site 3, both of which are assumed to have no placement switches, or if no placement switch was tripped when this vehicle was at this site, then PLACE = 4.
ENTRYT	—	Integer, I6, (e.g., 9:15 and 30 seconds PM would be 211530.)
VSPEED	—	Integer, I3, the speed of the vehicle in miles per hour.
VTYPE	—	Integer, I1, the type of vehicle, (passenger car, truck, tractor trailer, or other).
ISITE	—	Integer, I1, the site at which this vehicle was observed.
LANE	—	Integer, I1, the lane in which this vehicle was observed.

The program assumes that the input information is on magnetic tape and that the data recorded is the switch number that was tripped and the time at which it was tripped. The tape is known locally as TAPE73; the output tape is known as TAPE 74.

Program VHCLFL needs one temporary file for every switch. The program will call subroutine RDNSRT, which will sort the information from TAPE73 on the various temporary files so that PROCSS can look at the data in meaningful subgroups and determine the desired vehicle information for the vehicle at each site.

The data card needed for this program (Format (I1, 4x, I4)) tells the program how headways are to be computed (i.e., Head to Head or Tail to Head) and what time the recording began using the 24 hr. clock. The defaults are to Head to Head headways and a starting time of 0001.

The control cards necessary for compiling and running the program are outlined in Figure 16. When a compiled version of VHCLFL is available on disc, one need only attach and execute this copy of the program.

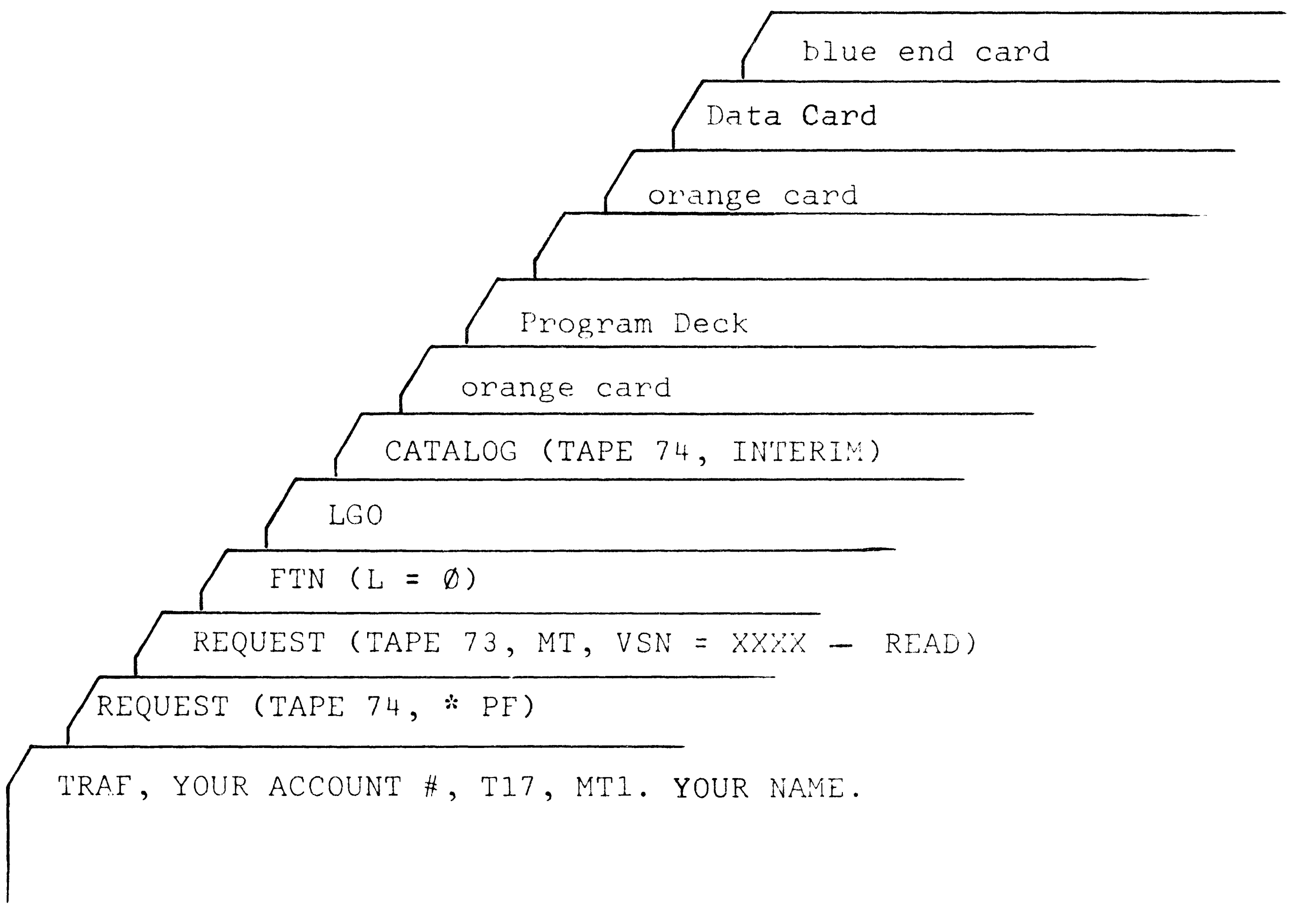


Figure 16. Control cards for "VHCLFL".

B. REPORT

The purpose of this program is to aggregate the information which VHCLFL writes on the file named Interim. The program produces the following outputs:

1. A volume table indicating volume by lane and site for each vehicle type and for all vehicles.

2. A table indicating the average speed, standard deviation, and 85th percentile for the speeds of each vehicle type by lane by site.

3. A table showing similar information by placement zone by site.

4. The average, standard deviation, and the median of the headway distribution of each lane at every site.

5. The percentages of each vehicle type in the different placement zones at each placement site.

6. A histogram of the headway distribution.

7. The number of queues encountered, the average and standard deviation of the number of vehicles in a queue, the average and standard deviation of the queue speed distribution and for the spacing of vehicles in each queue.

8. A bar graph showing the percentage of each vehicle type in the first five queue positions.

To run this program the following data cards are necessary. The first data card (Format (8A10)) contains any particular heading information for this set of output information the user wishes to specify; centering the Title on this card centers it on the output. The second data card (Format (A8, 6A9, I4, I4, 1X, F4.1, F4.1)) indicates the date this information was collected in the field, the weather condition prevailing in the field pertinent to this set of output information, the beginning and ending times for the data desired to be included in this set of output, the maximum headway time to be considered and the cut off time for queue determination.

Note that this program is written to generate the outputs for a data collection site as complex as the example included as Figure 1. Typical output from this program for the simple single site single lane situation is illustrated in Appendix C.

The control cards necessary for compiling and running the program are outlined in Figure 17.

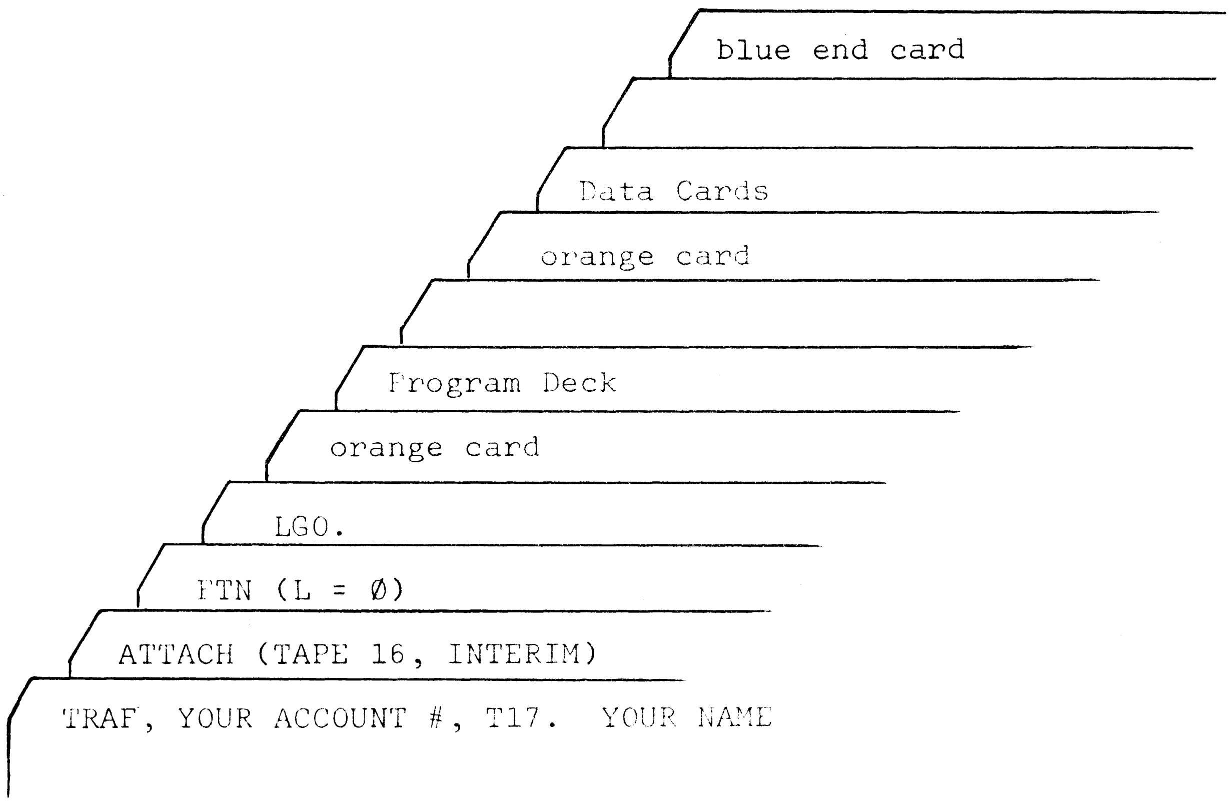


Figure 17. Control cards for "REPORT".

APPENDIX C

TYPICAL OUTPUT FROM THE REPORT PROGRAM

A F T O N   M O U N T A I N   F O G   S T U D Y   (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

T R A F F I C   V O L U M E

	LANE	CARS	TRUCKS	TRACTOR TRAILERS	OTHERS	ALL VEHICLES
SITE 2	1	76	7	10	0	93
	2	0	0	0	0	0

V E H I C L E   S P E E D

		CARS			TRUCKS			TRACTOR TRAILERS			OTHERS			ALL VEHICLES		
	LANE	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%
SITE 2	1	42.7	6.4	49.0	34.7	4.5	38.0	35.1	6.3	41.0	0.0	0.0	0.0	41.3	6.9	49.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SPEEDS IN PLACEMENT ZONES

		CARS			TRUCKS			TRACTOR TRAILERS			OTHERS			ALL VEHICLES		
	ZONE	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%	AVG.	S.D.	85%
SITE 2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	42.7	6.4	49.0	34.7	4.5	38.0	35.1	6.3	41.0	0.0	0.0	0.0	41.3	6.9	49.0

AFTON MOUNTAIN FOG STUDY (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

HEADWAY CUTOFF TIME 58.0 SECONDS

HEADWAYS

	SITE 1		SITE 2		SITE 3		SITE 4	SITE 5
LANE --	1	2	1	2	1	2	1	1
NUMBER OF VEHICLES			94					
AVERAGE	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0
STANDARD DEVIATION	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0
MEDIAN	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0

PLACEMENT
(IN PERCENT)

	CARS				TRUCKS				TRACTOR TRAILERS				OTHERS				ALL VEHICLES			
ZONE --	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
SITE 2	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

A F T O N   M O U N T A I N   F O G   S T U D Y   (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

HEADWAY CUTOFF TIME 58.0 SECONDS

```
                                   DISTRIBUTION OF HEADWAYS BY TIME INTERVALS
TIME INTERVAL         PERCENTAGE OF HEADWAYS LESS THAN THE HEADWAY CUTOFF TIME IN THIS TIME INTERVAL
(IN SECONDS)      0    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80   85   90   95   100
 FROM    TO       +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
                  I                                                                                                         I
   0  -   1       +                                                                                                         I
                  I                                                                                                         I
   1  -   2       +=======                                                                                                  I
                  I                                                                                                         I
   2  -   3       +======================                                                                                   I
                  I                                                                                                         I
   3  -   4       +===                                                                                                      I
                  I                                                                                                         I
   4  -   5       +========                                                                                                 I
                  I                                                                                                         I
   5  -   6       +====                                                                                                     I
                  I                                                                                                         I
   6  -   7       +========                                                                                                 I
                  I                                                                                                         I
   7  -   8       +===                                                                                                      I
                  I                                                                                                         I
   8  -   9       +===                                                                                                      I
                  I                                                                                                         I
   9  -  10       +===                                                                                                      I
                  I                                                                                                         I
  10  -  20       +===============                                                                                          I
                  I                                                                                                         I
  20  -  30       +===========                                                                                              I
                  I                                                                                                         I
  30  -  40       +======                                                                                                   I
                  I                                                                                                         I
  40  -  50       +=                                                                                                        I
                  I                                                                                                         I
  50  -  60       +=                                                                                                        I
                  +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
                  0    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80   85   90   95   100
```

A F T O N   M O U N T A I N   F O G   S T U D Y   (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

QUEUE CUTOFF TIME 5.0 SECONDS

AT THIS QUEUE CUTOFF TIME 25 QUEUES WERE OBSERVED WITH AN AVERAGE NUMBER OF 2.6 VEHICLES (S.D.= .90) IN EACH QUEUE.

THE AVERAGE QUEUE SPEED WAS 41.3 MPH (S.D.= 6.12).

THE AVERAGE SPACING IN EACH QUEUE WAS 161.0 FEET (S.D.= 59.1).

PERCENTAGE OF VEHICLES IN THIS POSITION (0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100)

POSITION		NO.
1	CARS	19
	TRUCKS	2
	TRAC. TRLS.	4
	OTHERS	
2	CARS	23
	TRUCKS	
	TRAC. TRLS.	2
	OTHERS	
3	CARS	10
	TRUCKS	
	TRAC. TRLS.	
	OTHERS	
4	CARS	2
	TRUCKS	
	TRAC. TRLS.	
	OTHERS	
5	CARS	1
	TRUCKS	
	TRAC. TRLS.	
	OTHERS	

AFTON MOUNTAIN FOG STUDY (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

TRAFFIC VOLUME

	LANE	CARS	TRUCKS	TRACTOR TRAILERS	OTHERS	ALL VEHICLES
SITE 2	1	0	0	0	0	0
	2	32	0	0	0	32

VEHICLE SPEED

	LANE	CARS AVG.	CARS S.D.	CARS 85%	TRUCKS AVG.	TRUCKS S.D.	TRUCKS 85%	TRACTOR TRAILERS AVG.	TRACTOR TRAILERS S.D.	TRACTOR TRAILERS 85%	OTHERS AVG.	OTHERS S.D.	OTHERS 85%	ALL VEHICLES AVG.	ALL VEHICLES S.D.	ALL VEHICLES 85%
SITE 2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	44.3	4.2	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3	4.2	48.0

HEADWAY CUTOFF TIME 58.0 SECONDS

HEADWAYS

LANE --	SITE 1 1	SITE 1 2	SITE 2 1	SITE 2 2	SITE 3 1	SITE 3 2	SITE 4 1	SITE 5 1
NUMBER OF VEHICLES				28				
AVERAGE	0.0	0.0	0.0	21.1	0.0	0.0	0.0	0.0
STANDARD DEVIATION	0.0	0.0	0.0	17.7	0.0	0.0	0.0	0.0
MEDIAN	0.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0

A F T O N   M O U N T A I N   F O G   S T U D Y   (BEFORE LIGHTS)

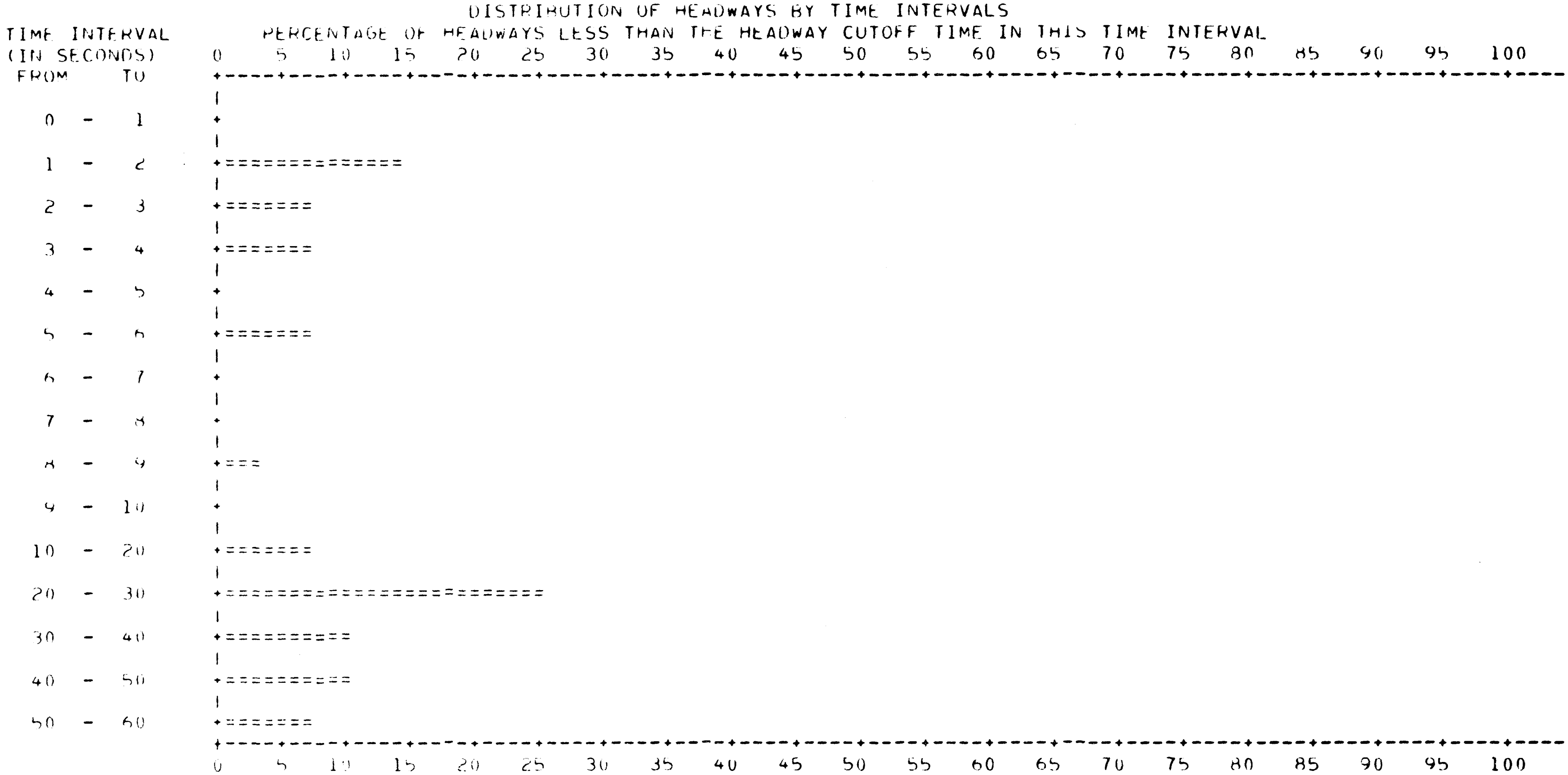
DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

HEADWAY CUTOFF TIME 58.0 SECONDS

DISTRIBUTION OF HEADWAYS BY TIME INTERVALS



AFTON MOUNTAIN FOG STUDY (BEFORE LIGHTS)

DATE - WINTER 1974-75

PERIOD ANALYZED - 1600 TO 1800

WEATHER CONDITION - FOG 90-110 FT. VISIBILITY - P. M. PEAK

QUEUE CUTOFF TIME 5.0 SECONDS

AT THIS QUEUE CUTOFF TIME 7 QUEUES WERE OBSERVED WITH AN AVERAGE NUMBER OF 2.3 VEHICLES (S.D.= .45) IN EACH QUEUE.

THE AVERAGE QUEUE SPEED WAS 43.6 MPH (S.D.= 3.56).

THE AVERAGE SPACING IN EACH QUEUE WAS 159.5 FEET (S.D.= 73.4).