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16. Abstract

The B-2 TRIDAQS (Travel Information Data Acquisition System) is a unit for recording travel time information in a floating vehicle. The unit is highly portable, with easy transfer from vehicle-to-vehicle, and virtually independent of any special equipment installations that would limit the use of the unit to a specific vehicle. The unit is easily operated by the driver, with the acquired data recorded on cassette tape. A playback arrangement within the unit permits recorded data to be transmitted directly to the computer for processing, utilizing an acoustic coupler and telephone hookup. This report is a revised users manual for the equipment.

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TRAVEL INFORMATION DATA ACQUISITION SYSTEM (TRIDAQS) REFERENCE MANUAL

by

Charles W. Blumentritt

Research Report 290-3
Research Study Number 2-18-81-290
Developing a Freeway Data Collection System

Sponsored by

Texas State Department of Highways and Public Transportation
In cooperation with the
U. S. Department of Transportation, Federal Highway Administration

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

December 1983

ABSTRACT

The B-2 TRIDAQS (Travel Information Data Acquisition System) is a unit for recording travel time information in a floating vehicle. The unit is highly portable, with easy transfer from vehicle-to-vehicle, and virtually independent of any special equipment installations that would limit the use of the unit to a specific vehicle. The unit is easily operated by the driver, with the acquired data recorded on cassette tape. A playback arrangement within the unit permits recorded data to be transmitted directly to the computer for processing, utilizing an acoustic coupler and telephone hookup. This report is a users manual for the equipment.

DISCLAIMER

SUMMARY

The TRIDAQS (Travel Information Data Acquisition System) is the result of Research Studies HPR 2-18-79-269 and 2-18-81-290 conducted by the Texas Transportation Institute for the Texas State Department of Highways and Public Transportation (SDHPT) in cooperation with the Federal Highway Administration. The target equipment of this research was a highly portable, low cost, easily operated device for recording floating vehicle travel time studies. The recording medium is a cassette tape.

The use of a separate playback unit was envisioned when the project was initiated; the playback unit was to be office based and utilized in interfacing with the portable unit for the purpose of accessing the recorded data and forwarding it to the SDHPT computer. This plan was revised by SDHPT, and a request was made to incorporate both the recording and playback functions in the playback unit. This change was made during the course of development of the portable unit.

The TRIDAQS is a microprocessor* based unit which utilizes a SD Sales Z80 Starter Kit housed in a Halliburton aluminum case, with associated circuitry. This choice of microcomputer was a good one, and it has proven to be a reliable unit, once early failures were corrected. A number of useful features are present to assist in check-out and programming, such as an internal operations monitor (ZBUG) and cassette tape interface. The RAM size is 2K bytes, with PROM sockets for 6K, of which 2K is usually reserved for ZBUG.

The original cassette tape recorder for the TRIDAQS was a National Multiplex Model CC-8, which is a standard audio cassette recorder with new electronics incorporated (replacing the audio circuitry) and thus implementing a digital data recorder. An RS-232 interface is provided,

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*A technical dictionary may be useful to clarify some of the computer terms used in this report. One such reference is "Standard Dictionary of Computers and Information Processing," by Martin H. Weik, Revised Second Edition, 1977, Hayden Book Company, Rochelle Park, New Jersey.

allowing the user a popular method of communicating data between the microcomputer and the recorder. This standard was, in fact, incorporated in this application. The choice of such a low cost recorder proved to be unfortunate, with many reliability problems encountered. Generally, the unit could not maintain a minimal level of data integrity, and much time and effort was expended in trying to overcome this deficiency.

Eventually, it became evident that such a low cost recorder would never perform satisfactorily in the field environment, and at the required data rates. A replacement of this recorder with a much higher quality cassette recorder was proposed, and this effort became a part of Research Study 2-18-81-290. At the same time, an auxiliary microprocessor system was acquired to assist the programming effort for the TRIDAQS microprocessor. The secondary effort to revise the equipment configuration was quite successful, and the TRIDAQS is now used on a daily basis for data acquisition in the Houston area.

This user's manual provides a detailed description of the operation of the TRIDAQS unit. Both the field recording and data transmission modes are described, as well as speed sensor installation. Some sections of this manual have not changed significantly from those included in TTI Research Report 269-1F, but have been included in this report so that the document is complete. A description of the programs for processing TRIDAQS data has been included.

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I. INTRODUCTION

This document is focused primarily toward the suitcase computer, designated TRIDAQS, that was originally developed under research study HPR 2-18-79-269. An earlier document, TTI Research Report 269-1F entitled "Travel Information Data Acquisition System (TRIDAQS) Users Manual" reported the status of work on the first B-1 prototype. The low cost modified audio cassette recorder used in the system was found to be unreliable, and a much higher quality recorder was installed and tested as an objective within a later research study HPR 2-18-81-290. The resulting revised prototype B-2 is described in this document, and some of the material covered in report 269-1F has been repeated in the interest of making the document complete.

An associated effort was the development of a battery of data processing programs to process the field data on a large host computer. These programs have undergone extensive modifications since their brief mention in Report 269-1F, and they are described more fully at this time. However, it is seen that the programs continue to be changed frequently with the benefit of operating experience, and it is anticipated that further documentation will have to be written for the program battery in the future. Another factor that will influence the program battery is the integration of this package within the operational philosophy of the proposed traffic database system. It is seen at this point that a substantial revision in the data structures must occur for the integration, but it is necessary to proceed with the present operating philosophy until such time as the traffic data base approaches reality.

Another factor in the future of TRIDAQS is the recent announcement of several lap computers. It is felt that these new units will essentially take the place of any custom units for mobile data acquisition. A further word on this and other aspects of the future of TRIDAQS is in Appendix H, Recommendations for Further Research.

The basic role of the TRIDAQS and associated data processing programs is to acquire and present information relating to travel time studies over designated links. Typically, a number of studies for a given link are combined to obtain the average link travel characteristics. As each study is processed in Austin, it becomes part of a master file. The data processing program has the capability of selecting a broad combination of studies for inspection.

Chapters II, III, IV and V are concerned primarily with the description and operation of the suitcase computer TRIDAQS. Chapter VI describes the computer programs for processing the data acquired by TRIDAQS.

II. DESCRIPTION

The B-2 TRIDAQS (Travel Information Data Acquisition System) is the result of Research Studies HPR 2-18-79-269 and 2-18-81-290 conducted by the Texas Transportation Institute for the Texas State Department of Highways and Public Transportation, in cooperation with the Federal Highway Administration. The study was an outgrowth of needs enumerated by Mr. Bill Ward, Engineer-Manager of the Houston Urban Office, to satisfy the fundamental requirements for monitoring traffic flows in Houston, Texas. This study provided some of the equipment to partially support the answer to the question: "What is the quality of traffic flow on specific segments of roadway?"

The basic requirement was for a unit that could, at a minimum, record travel time information in a floating vehicle. The unit needed to be highly portable, with easy transfer from vehicle-to-vehicle, and virtually independent of any special equipment installations that would limit the use of the unit to a specific vehicle(s). The unit was to be easily operated by the driver, and the data acquired with this portable unit were to be recorded on cassette tape, with a playback arrangement that would transmit the data directly to the computer for processing. Finally, the unit needed to be low in cost so that a number of the units could be utilized simultaneously. Briefly, these were the major requirements to be satisfied. Many other conditions and tradeoffs were encountered during the course of the research.

The result of the study is a portable microcomputer system based on an SD Sales Starter Kit, interfaced to a Memodyne cassette recorder, and housed in a Halliburton aluminum suitcase. The unit's single power source is 115 volts AC, intended to be derived from a 12 volt inverter in the vehicle. A keyboard, mounted in the unit, serves to accept both function commands and numeric data. Six numeric readouts are present for observing data parameters being entered or queried. A power on/off switch and reset button complete the switches on the operation panel, which is generally in the plane of the line of separation between the two suitcase halves. Figure 1 shows the layout of the operation panel. Finally, a coil-cord lead joins the unit to the speed sensor, which is installed in the speedometer drive line; a heavy duty power cord is utilized for the power connection.

In its data acquisition role, these are the functional components of the portable unit. It is intended to reside on the front seat in close proximity to the driver, who can reach the keyboard to control the unit. During operation, the driver need only press one button to start a study, and similarly press one button to stop the study. Under normal operating circumstances, once the unit has been initialized, the starting and stopping of studies is the major extent of interaction that the driver has with the unit.

In its data transmission role, the unit is assumed to be in an office environment. An acoustic coupler links the unit to a standard telephone for transmitting the field data to the large-scale processing computer. To transmit data, the operator merely dials the computer's number and places the telephone handset in the cradle of the acoustic coupler, and the transmission of data is automatic from that point forward.

A calibration procedure is provided to calibrate the TRIDAQS for each

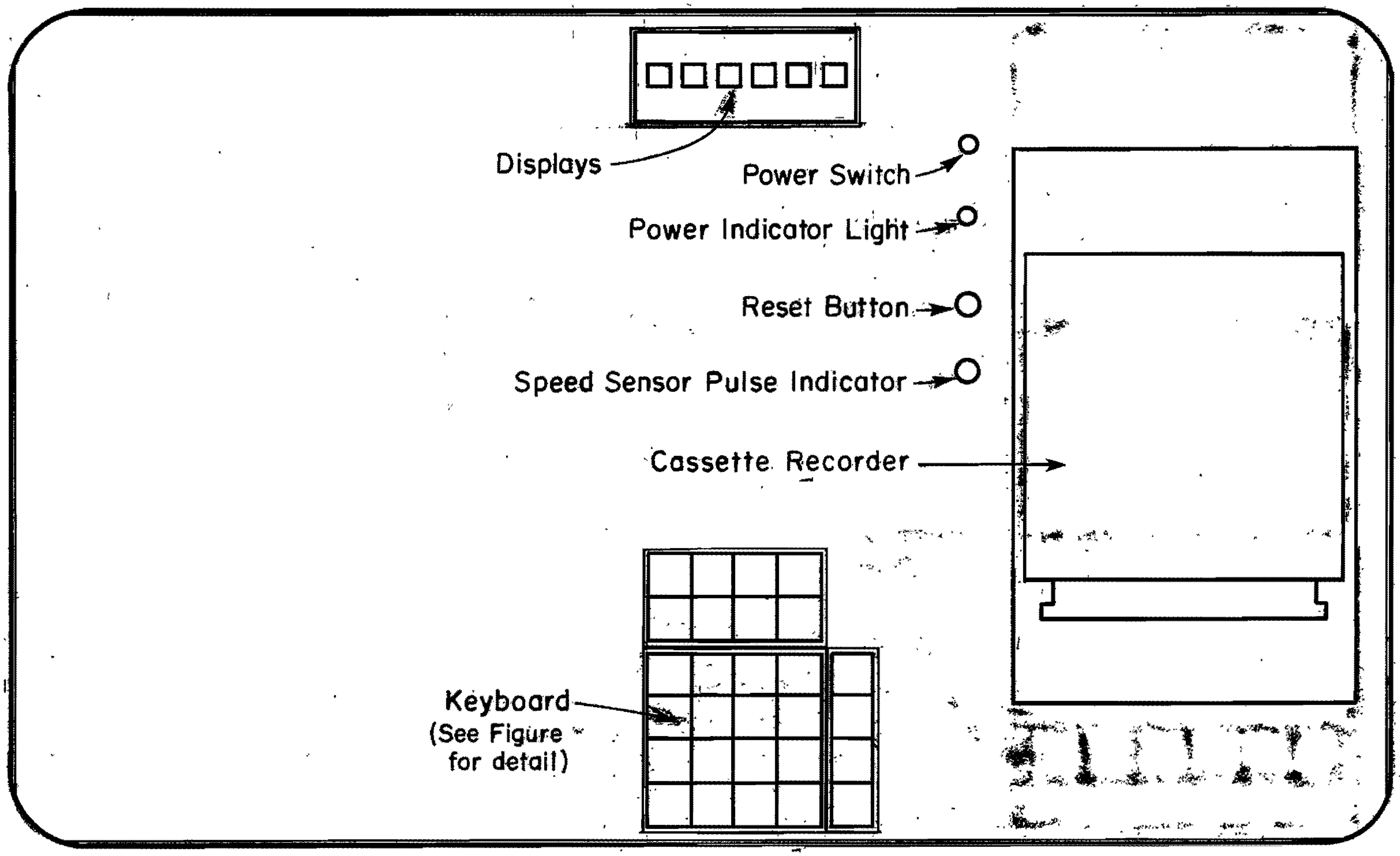

Figure 1. Front View of Operation Panel

vehicle. Upon being utilized in a new vehicle, the calibration procedure is initiated before the first study is made in that vehicle. This develops the necessary factors for the data processing programs to compute accurate travel distances.

During data acquisition, speed sensor pulses are accumulated for each one second period. At the end of each second, that data is transmitted to the cassette recorder, where it is buffered for 64 seconds and then recorded on cassette tape. This sequence is repeated during the cumulative time period that studies are in progress. The one second data is collected in an 8-bit byte format. Bit 7 (most significant) is the pushbutton event for that second. Bits 6-0 contain the count of speed sensor pulses for that second. To allow room for expansion (plus ease of processing by the battery of data processing programs), one-second data is processed in a 2-byte or 16 bit format. See Appendix H, Recommendations for Further Research, for suggested use of these additional bits.

This is an overview of the background and configuration of the B-2 TRIDAQS. The unit described is a revised prototype and undoubtedly will be modified as future needs warrant. Specific details of operation are given in Chapters IV and V of this report.

The terms "link" and "study" are used through this report. A link is a predefined roadway section delineated by landmarks, such as a one-mile section of freeway from overpass to overpass, a street section from intersection to intersection, etc. A study is a unique travel time run over a particular link.

III. SPEED SENSOR INSTALLATION

The only component of the B-2 TRIDAQS that is permanently installed (or at least semipermanently installed) is the MassTech speed sensor. This is a small, rubber encased unit that fits in the speedometer drive line. There are two versions of this sensor, depending on the point of installation. The TR8 version has standard transmission fittings (7/8-18 UNS threads) and would be installed directly on the transmission, and the speedometer drive cable would be connected to the TR8 in turn. The TR10 version differs only in the types of fittings, which have 5/8-18 UNF threads for mounting directly to the speedometer head. For example, the speedometer cable would be disconnected from the speedometer head, and the TR10 attached to the head in place of the cable. In turn, the speedometer cable would be attached to the TR10. Note that both the TR8 and TR10 are simply inline units that add approximately 2 1/4 inches of length to the speedometer drive line. Two pigtail leads emanate from the MassTech Sensor, and these should be attached to a longer, durable 2 conductor cable with the point of connection waterproofed. This cable extension must be long enough to reach a) through the floorboard, b) through the firewall, or c) from behind the dash, all to a point at the center of the front seat. A PHIL-UC-BB connector should be installed on the free end of the cable entering the passenger compartment, which will mate with the plug on the lead from the TRIDAQS.

An alternate point of installation can be considered. If the vehicle is equipped with a cruise control, there will be a cruise control junction box under the hood, which has the speedometer cable entering from the transmission and exiting to the speedometer head. For this configuration, it is a simple matter to install the TR10 between the cable coming from the transmission and the junction box. Similarly, the 2-conductor extension cable would be channeled through a cable entry point in the firewall to reach the passenger compartment. A diagram of the speed sensor wiring is shown in Figure 2.

Finally, it should be noted that the U.S. industry standard for speedometer drive cables is 1000 revolutions per mile. The MassTech speed sensor consists of a multiple magnet which rotates past a reed switch, producing contact closures. The sensors are available with 2, 4, 6, or 8 pole magnets. For each contact closure, a vehicle will travel the distances noted below:

# Poles	Distances (feet)
2	2.64
4	1.32
6	.88
8	.66

This gives some indication of the resolution in feet that can be expected with each of the options. It is suggested that a minimum of 4 poles be utilized with the B-2 TRIDAQS.

Also note that the polarity of the wiring connections to the speed sensor is immaterial, since all that is being measured is contact closure. The switch closures merely provide a ground completion circuit.

The microcomputer is programmed for a 6 pole speed sensor. The B-2 will still work with a 4 or 8 pole speed sensor, but the speed- and distance- related information that is displayed on the readouts in the

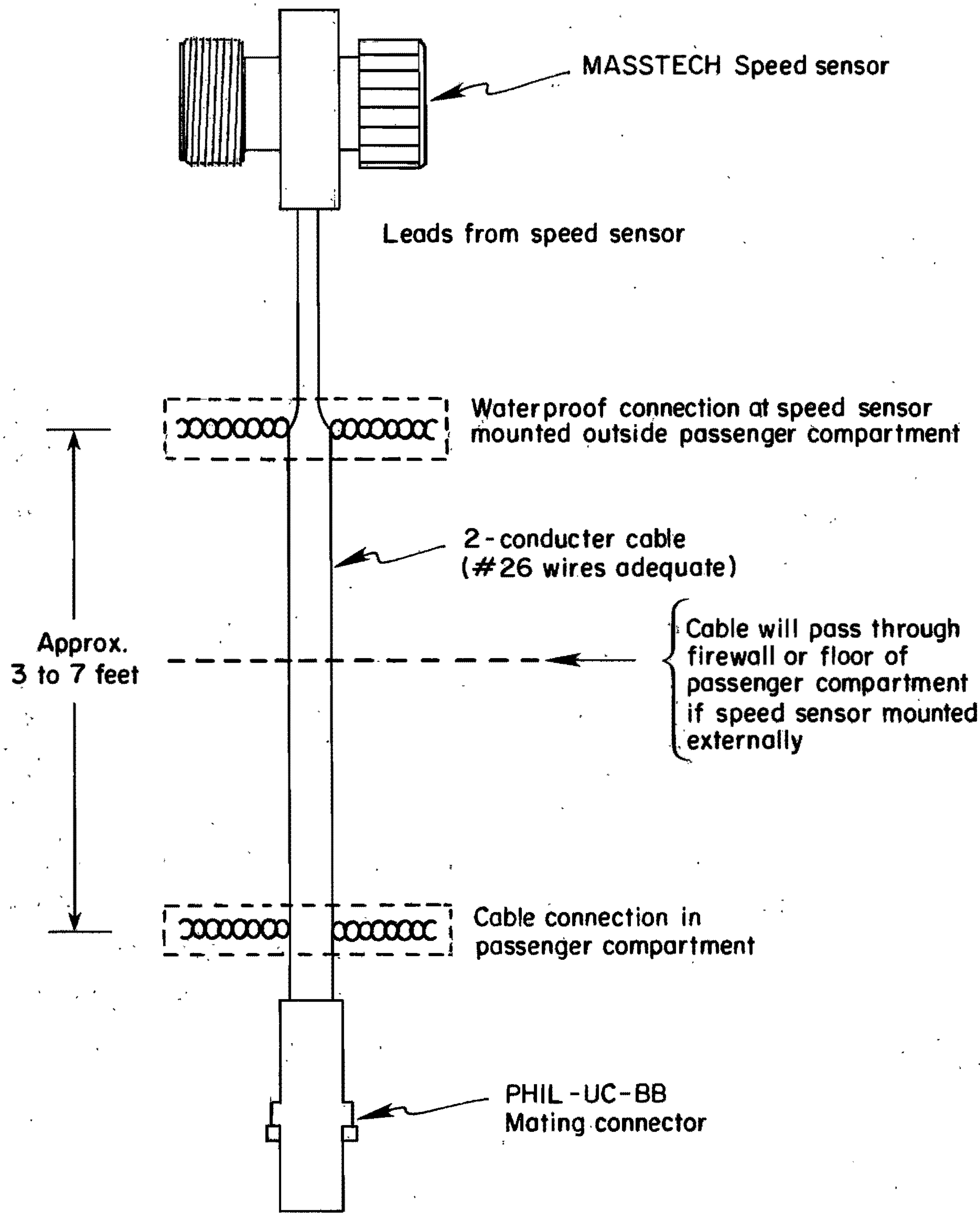

Figure 2. Detail of Wiring to Speed Sensor

vehicle will be incorrect. The computer printout associated with the final data reduction, however, will be accurate. This is achieved by the initial calibration sequence in the vehicle which results in a factor that reflects the distance traveled per distance pulse.

A brochure describing the MassTech speed sensor is shown in Appendix A - Speed Sensor Datasheet. These sensors are available through Robertson Fleet Service in Dallas or Trend Instruments in Houston. Delivery time of 6 months is normal.

IV. DATA ACQUISITION OPERATION

A. Initial Setup

The initial setup is concerned with preparing the unit for physical operation within the vehicle. This setup operation is presumed to be taking place in the vehicle, but it can be practiced in an office environment. The steps for setting up the unit are:

a. Remove the top cover of the case by releasing each of the four suitcase latches. Put the cover aside, since it is used as a protective shield only when the unit is not in operation.

b. Plug the heavy black cable (the AC power cable) in the connector on the end of the case that is opposite the tape recorder.

c. Plug the speed sensor cable (black coil-cord) into the corresponding receptacle at the same end.

d. Plug the speed sensor cable into the matching cable that is connected to the speed sensor. Details concerning the latter cable were described in Chapter III, Speed Sensor Installation.

e. Plug the AC power cable into the portable inverter, which in turn is plugged into a 12 volt source in the vehicle. The initial setup of the unit is now complete.

B. Procedure for Initializing the Computer

The following procedures are concerned with the entering of parameters to the computer after power is applied to the unit. This procedure must be followed each time the unit is powered up, if it is to perform the data acquisition function. (A different procedure is followed when the unit is utilized as a data transmission device.) When power is removed from the unit, all internal data used by the computer is lost.

The session for entering these parameters is characterized by a series of prompts which appear in the displays, each followed by a response from the operator. This response will be in the form of numeric data entered in the keyboard, which, when the first key is pressed, replaces the prompt in the displays. This allows the data to be viewed prior to entering it in the computer. If an error is noted, press the "CANCEL" key and re-enter the data. When the data is correct, press the "ENTER" key. If the computer rejects the data (Such as would occur with the specification of an illogical date), the prompt for the same data will reappear in the displays. If, on the other hand, the data is accepted by the computer, the next prompt in sequence will be displayed as a request for the next item of data. A summary of the commands and procedures for the data acquisition mode are given in Appendix B. This can be referred to after the operator becomes familiar with the procedures described in detail in the remainder of this section.

The data parameters requested by the computer are as follows:

TAPE ERASURE
FILE NUMBER
DATE
DRIVER NUMBER
VEHICLE NUMBER
WEATHER CODE
PAVEMENT CODE
STARTING LINK
FEET/DISTANCE PULSE
TIME.

Each of these items will now be generally discussed to provide background information for the parameter entry sequence to be described in Section C of this chapter, Summary of Initialization Procedure.

TAPE ERASURE

This is a request as to whether or not the cassette tape is to be erased. Ordinarily, a tape should be erased if it has been used before. Particularly, if multiple files of data are being recorded, the tape should be erased. This is most critical if the unit is being powered down between recording of data files.

Tape erasure is initiated if any nonzero quantity is entered. A zero or non-entry will inhibit tape erasure.

FILE NUMBER

This is a request for the file number on which recording of the current group of studies is to be made. Either a zero, one, or non-entry will cause data to be recorded on the first file.

DATE

The date requested is the current day's date. The accuracy of the date is vitally important, since it combines with the time and link number to form a unique identifier for each study. The computer cannot ascertain the date, since it does not have an electronic calendar. It does, however, make some simple tests to verify the reasonableness of a given date. These tests are (1) month designation must be 1 through 12, inclusive, (2) day designation must be 1 through 31, inclusive, and (3) year designation must be 80 through 89, inclusive. Any date values outside these ranges will be rejected, and the result will be the re-display of the date prompt. Note that the date checking feature is very unsophisticated, and for this prototype version an accounting for (1) the number of days per month, and (2) leap year calculations, are <u>not</u> made. Again, the accuracy of the date entered is very important, since the computer would accept a designation for February 31, for example.

DRIVER NUMBER

The driver number is a unique code assigned to the operator of the vehicle. This same number must be used by the operator each time he or she is making studies. When the study data is analyzed, the driver number is a factor in determining statistical bias, that is, the effect of particular driving habits on vehicle travel times. Driver numbers in the range of 1 through 999999 inclusive, are acceptable. A driver number of 0 will not be accepted by the computer.

VEHICLE NUMBER

The vehicle number is the unique code assigned to the vehicle in which the travel time data is being collected. The use of the six-digit Texas exempt license plate number is recommended, but any non-zero numeric identifier of up to 6 digits may be used.

WEATHER CODE

The weather code is a one-digit number that is used to describe the current weather condition. The weather code is entered during the computer initialization sequence, but may be updated at any time during data acquisition. Valid weather codes are:

1 Clear

2 Partly Cloudy

3 Cloudy

4 Rain

5 Sleet

6 Fog

7 Dust

8 Snow

PAVEMENT CODE

The pavement code is a one-digit number that is used to describe the current pavement condition. Like the weather code, the pavement code is entered during the computer initialization sequence, but may be updated at any time during data acquisition. Valid pavement codes are:

1 Dry

2 Damp

3 Wet

4 Ice

5 Snow

STARTING LINK

The starting link number relates to the overall plan that is being followed in conducting the studies. That is, it is assumed that the driver does not randomly select the links over which data will be acquired. Rather, the travel route will be over a predetermined path and will follow a numerically increasing sequence of link numbers. Here, a link is any roadway segment with a known distance. A link is further characterized by landmarks at the beginning and ending points, and which are easily recognizable by the drivers. The landmark (e.g., intersection, interchange, bridge, overpass, etc.) should be prominent to the extent that it can be recognized from any lane of a congested multilane roadway. This is necessary because the driver is required to press a button signifying the location of the landmark, preferably accurate to within 100 feet.

The driver is supplied with a "driving plan" which clearly marks the route he or she is to drive. Generally, this will be one (or more) closed loop(s) that is (are) repeated as many times as practical over a given time period. Each of the closed loops will contain a number of links which are not necessarily contiguous, but which will have links that are numbered in a continuous, ascending sequence. For example, links 1001, 1002, 1003, 1004, 1005, and 1006 may be a sequence of links that are traveled during the AM peak period. The driver would begin with link 1001, drive over successive links 1002, 1003, 1004, and 1005, and then end the circuit with link 1006. After that, the driver would return to the beginning of link number 1001 and repeat the sequence. The starting link for this sequence is 1001. This is the starting link number that the driver would enter in the computer prior to driving the 1001-1006 link sequence. Note that the starting number is the only link parameter that must be entered in connection with a link sequence, as long as an ascending numerical sequence of link numbers is being driven. The computer will automatically increment the link number after each study in concluded. Thus, for the example sequence of links 1001-1006 given above, the first study would be associated with link number 1001, the second study with link 1002, and so on. To implement the circuitous nature of travel time studies, the TRIDAQS is equipped with a reset feature to return the internal link number to the value of the starting link that was entered through the keyboard. Further note that, during the day, the starting link would be updated as different link sequences are driven. For example, the daily driving plan might be:

Time	Link Sequence
0600-0900	1234-1246
0900-1530	46-59
1530-1900	64835-64848

During the course of the (long!) day, three starting links would be entered. The first, during the computer initialization sequence, would be starting link number 1234. Sometime, after 9 a.m., a new starting link number of 46 would be entered in the computer, and sometime after 3:30 p.m., another new starting number of 64835 would be entered.

FEET/DISTANCE PULSE

The complete title for this subsection is "Number of Feet per Distance Pulse." A request for this parameter is solicited during the computer initialization sequence, and the normal response is a zero to signify that the computer's internal feet/distance pulse parameter is to be utilized. As noted in Chapter III, the computer is programmed for a speed sensor which produces 6 pulses per revolution of the speedometer cable. Since the U.S. Standard for speedometer drives is 1000 revolutions per mile, the computer will detect 6000 pulses per travel mile, or 5280/6000 = 0.88 feet per pulse. This is the basic distance resolution for the TRIDAQS when using a 6 pulse per revolution speed sensor. The TRIDAQS can display several distance and time-distance relationships such as:

a) distance traveled in feet

b) distance traveled in miles

c) speed in miles per hour

d) speed in feet per second

The time standard that the computer uses for calculations c) and d) above is rather accurate, so it would not be considered a source of error. If the user was utilizing a speed sensor with a different number of pulses per revolution (2, 4, and 8 are also available), the above calculations a), b), and c) and d) would have a substantial error. Beyond that, a small margin of error might be experienced even with a 6 pulse speed sensor. Should the user desire to utilize the TRIDAQS as a very accurate distance measurement device, it would be useful to be able to enter the number of feet per distance pulse in the computer, to within two decimal places.

The feet/distance pulse prompt during the computer initialization sequence affords the user the opportunity to enter a parameter which is possibly more accurate than the existing default parameter (in the case of a 6 pulse speed sensor). Certainly, if a 2, 4, or 8 pulse speed sensor were being utilized, a feet/distance pulse parameter should be entered if any of the distance and time-distance relationships are going to be displayed. The standard parameters for the various speed sensor options are given below:

Speed Sensor Pulses Per Revolution	Feet Per Pulse	Number to Enter	Resolution of Change
2	2.64	264	0.4%
4	1.32	132	0.8%
6	0.88	Exists by default	1.1%
8	0.66	66	1.5%

While the resolutions and accuracies above seem impressive, closer analysis reveals that the ability to compensate for distance errors is quite limited. In fact, this ability varies inversely with the number of pulses per revolution provided by the speed sensor. Referring to the "Resolution of Change" column in the table above, it can be seen that a distance error of at least 1.5% would have to exist before a change to the 0.88 default parameter would be meaningful. This means a distance error greater than ±60 feet per mile would have to be experienced before a change from 0.88 to 0.89 or 0.87 would be meaningful. This figure is much better for a 2 pulse speed sensor, where distance errors exceeding ±10 feet can be corrected.

This is the status of the current implementation of the distance pulse parameter. Clearly, to achieve the accurate measurements that were originally intended, the feet/distance pulse factor needs to be handled internally by the computer to an accuracy of 4 places rather than 2, e.g. 0.66 would be requested as 0.6600. Thus, 0.6601 would compensate for a relative error of 1 part in 6600 rather than 1 part in 66. The result would be the ability to measure to the nearest foot in a distance of 1 mile, which was the original objective. This change will be made in the next version of the computer program that is generated for the TRIDAQS.

Finally, a word about accuracy. There is considerable discussion about the accuracy of distance measurements in the context of acquisition of travel time data. Too much is made of the arguments in favor of magnets on the front wheel or the use of a fifth wheel. Indeed, these are accurate ways to measure distance. The manner in which these distances are used is quite another matter, however. For travel time studies, the starting and stopping points are quite variable. When making studies on a six lane freeway, the starting and ending points of a link are subject to interpretation by the driver. The floating vehicle passes these imaginary points at freeway speeds and short headways. The starting and stopping points registered by the driver have an accuracy far less than the distance measurement equipment. The link length that is scaled from the plans is not as accurate as the distance measured by the TRIDAQS. Finally, the multiple studies for a link are heavily averaged to obtain consistency and representation of aggregate flow. Thus, while the accuracy of a study's distance measurement is degraded by the driver's dynamic assessment of link boundaries, the averaging inherent in conducting studies tends to remove this error. Technically, this yields results consistent with the relative accuracy of the distance measurement instrument.

TIME

The time of day is entered as a six digit number in the military, or 24 hour format. This is entered to the nearest second. For example, fifteen seconds past 9:00 a.m. would be entered as 090015, and nine seconds before 4:15 p.m. would be 161451.

Once entered, the computer automatically increments the internal clock at one second intervals. The current time of day may be displayed and the beginning time of a study becomes a part of the identification data relating to that study. Note that the internal time clock is correctly incremented at midnight, i.e., the time at the second after 235959 is 000000. However, the day of the month will not increment. Therefore, any study that begins before midnight and ends after midnight would signal the need to end the current tape and reinitialize the computer.

This concludes the discussion of the individual data parameters that must be entered during the computer initialization sequences. The following section describes the individual steps of the initialization procedure.

C. Summary of Initialization Procedure

The following steps are required to initialize the computer prior to making the first study. The prompt message is in the left column, and the operator response is in the right column. For a more detailed description of the meaning of the particular parameter that is being requested, see the preceding Section B, Procedure for Initializing the Computer. An abbreviated description of this procedure is given in Appendix B. Seven-segment display representations of alpha-numeric characters are given in Appendix C.

Prompt	Response
none	Press the red "RESET" button.
none	Put a cassette in the recorder.
none	Press any button in the first column (from the left) of the buttons of the Keyboard. These are "PAVET COND", "WEATH COND", "7", "4", "1", or "0".

Beyond this point, the operator will press the "ENTER" key after each response, signaling the computer that an action has been taken. The computer will verify the reasonableness of the data quantity entered, using a test that is appropriate for the data item. Simply pressing "ENTER" in response to the prompt is equivalent to entering a zero quantity.

Prompt	Response
rdYCAS	This prompt will flash until a cassette is readied in the recorder. Normally, this prompt will not occur.
ErASE?	This queries whether or not the tape is to be erased. Enter any nonzero quantity to cause the tape to be erased. Simply press "ENTER" as a default to bypass the erasing procedure.

Prompt	Response
FiLE?	Enter the file number on which data recording is to begin. Simply press "ENTER" as a default to begin recording on file 1.
dATE?	Enter today's date via the keyboard as MMDDYY, where MM is the number of the month (1-12), DD is the day of the month (1-31), and YY is the last 2 digits of the year (e.g., 83 implies 1983). Each numeric key that is depressed will cause the corresponding value to appear in the rightmost digit of the display. This value is shifted left one digit each time a new digit is entered. When the display contains the desired date, press "ENTER." If an error is made, press "CANCEL" and re-enter the date. If the date that is entered is not in the range of MM=1-12, DD=1-31, or YY=80-89, the date prompt will reappear and the correct date should be entered.
drivr?	Enter a 1 to 6 digit nonzero driver identification number via the keyboard and press "ENTER."
vEHCL? (Vehicle)	Enter a 1 to 6 digit nonzero vehicle identification number via the keyboard. For Texas state vehicles, this is generally the exempt license plate number. Press "ENTER".
WEATH? (Weather)	Enter a one digit weather code via the keyboard. Weather codes are 1 Clear, 2 Partly Cloudy, 3 Cloudy, 4 Rain, 5 Sleet, 6 Fog, 7 Dust, and 8 Snow. Press "ENTER." If more than one digit is entered, only the rightmost two digits are processed.
PAvET? (Pavement)	Enter a one digit pavement code via the keyboard. Pavement codes are 1 Dry, 2 Damp, 3 Wet, 4 Ice, and 5 Snow. Press "ENTER." If more than one digit is entered, only the rightmost two digits are processed.
STLin? (Starting Link)	Enter a nonzero starting link number that represents the first link on the next circuit to be driven according to the daily "driving plan." Press "ENTER."

FTdiS? (Feet/Distance Pulse)	Enter a factor XXXXXX which represents the XX.XXXX number of feet traveled per distance pulse. Note the position of the imaginary decimal point is between the 2nd and 3rd display digit from the left. See Section B, Procedure for Initializing the Computer, for a detailed explanation of this factor. Normally, the operator would make no numeric keyboard entry and merely press "ENTER" to satisfy the prompt, which is equivalent to entering a zero.
CLoC? (Clock Time)	Enter the time of day as HHMMSS military time, where HH is the hour (00-23), MM is the minute (00-59), and SS is the second (00-59). Press "ENTER."
	After the time of day is entered, the displays will blank, signaling the end of the computer initialization session. The TRIDAQS is now ready to begin a study or calibration run.

D. <u>Keyboard Function Buttons</u>

The function buttons of the keyboard, as distinguished from the numeric buttons, are the green keys. The four function keys across the top of the keyboard are:

PAVMT COND	BEGIN CALIB	END CALIB	END TAPE

Just under this row is another row of four green function buttons. They are:

WEATH COND	ENTER	CANCEL	RESET LINK

Finally, down the right hand side of the keyboard is a column of 4 green function buttons. They are:

EVENT

START
STUDY

STOP
STUDY

STOP/
START
STUDY

Figure 3 shows the configuration of the keyboard. At this time each of these function buttons will be discussed in their groups of logical affinity.

(a) Pavement and and Weather Condition

The PAVMT COND key denotes pavement condition, and the WEATH COND key denotes weather condition. Recall that both the pavement and weather conditions are routinely entered during the computer initialization sequence, independent of the use of these special purpose keys. The function of these keys is to provide an easy means for updating the pavement and weather conditions, without going to the trouble of performing the computer initialization sequence each time. Since both these conditions are subject to change during the course of a day, it is desirable to have a means for quickly updating these parameters. Thus, the pavement and weather conditions may be updated at any time, such as before, during, or after any study. In fact, the only time that the pavement and weather conditions cannot be updated is during a calibration sequence. (The calibration sequence will be explained in a following section).

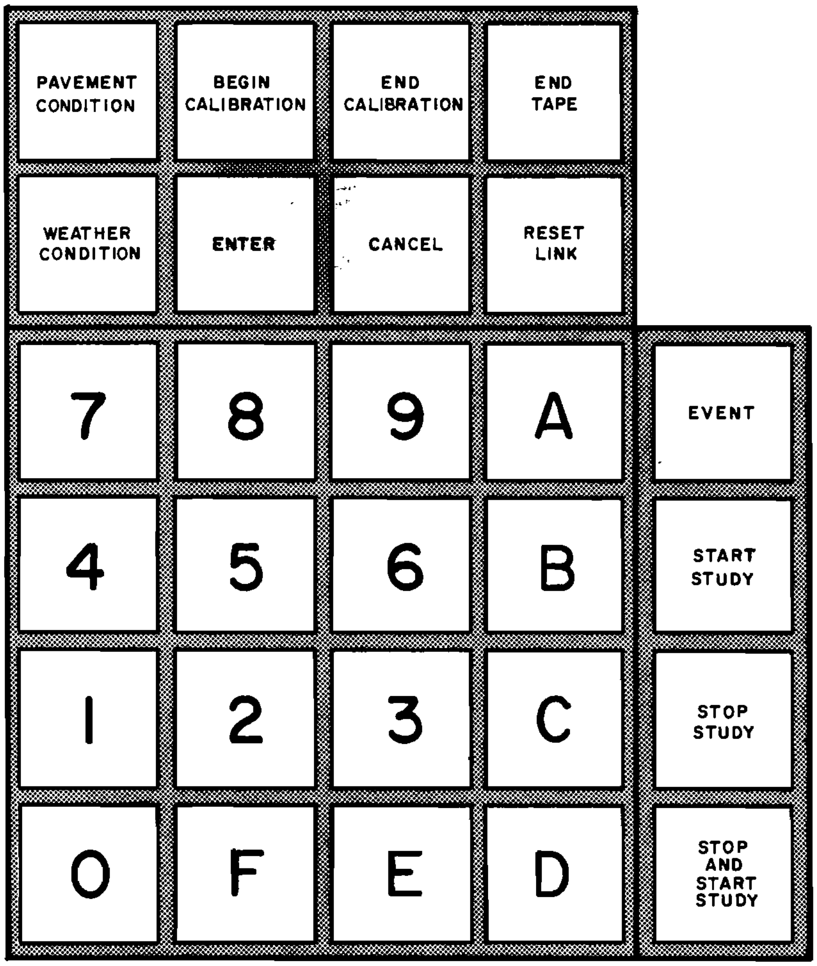

Figure 3. Keyboard Detail

The procedure for updating weather and pavement conditions is as follows:

Press PAVMT COND or WEATH COND as appropriate. The associated prompt PAvET? or WEATH? will appear in the displays. Enter the desired code and press "ENTER". The entry will be edited and if the quantity is zero or greater than a valid code, then "ERROR" will be displayed, and the previous code remains unchanged. In case of an error, the procedure must be started over, e.g., press PAVMT COND or WEATH COND to re-establish the data entry.

Pavement and weather codes, as well as other information, become a part of the study information that is recorded on cassette tape. These supporting data are noted by the computer at the beginning of each study. Thus, if a weather code of 7 (Dust) was entered during a study, that condition would not be recorded until the beginning of the next study.

(b) Entering and Deleting Keyboard Data

The "ENTER" key is used to signal the computer that the data now in the displays are ready for input to the computer. During the computer initialization sequence, the "ENTER" key is depressed after data have been entered via the keyboard in response to a prompt. If an error is made in keying the data prior to its being entered in the computer, the display can be "cleared" by entering a series of 6 zeros, followed by entering the desired numeric data. This feature is achieved by the fact that old digits are shifted to the left as new digits are entered, and as they are shifted out of the leftmost position, they are lost.

Additionally, the "ENTER" key is used to enter a query code to the computer. A query code can be entered at any time after the computer initialization sequence, while the displays are blank, except during the calibration sequence. If the displays are nonblank (indicating the presence of information displayed from a previous query), they can be blanked by pressing the "CANCEL" key. After a one- or two- digit query code is entered in the rightmost two digits of the displays, press "ENTER" to have the particular information displayed.

(c) Link Reset

The "RESET LINK" key may be pressed at any time, except during the calibration sequence. When the starting link number is entered during the computer initialization sequence, it is utilized in two ways. First, it serves as the base which is incremented just <u>after</u> each study is begun, so it always is one greater than the link number of the current study being conducted. Secondly, it serves as the initializing value for the link counter just described. Thus, the "RESET LINK" key is used to initialize the link counter to the base value of the starting link.

Note that the function of the link counter is still preserved in this action, that is, the link counter will still contain the value of the <u>next</u> link on which a study will be conducted. This elaborate discussion is intended to give insight as to when the "RESET LINK" key should be depressed. Simply stated, it can be used at any time after the study is begun on the last link of a circuit, and before the study is begun on the starting link of a circuit. It does not have to be utilized prior to beginning the first study after the computer initialization sequence, since the link counter is automatically initialized to the value of the starting link when it is entered. The same holds true when a new starting link number is designated by a query code as shown in Table 1 in Section E.

(d) End Tape

The use of the "END TAPE" key is vital in assuring that the requirements are met for properly ending the data transmission of the studies by telephone. As mentioned in the general discussion of the TRIDAQS, data are accumulated by the recorder for approximately 1 minute at which time these data are written to the cassette tape. This technique is called buffering. Whenever the last study of a given data acquisition period is made, there will always be at least one partial study still buffered.

The purpose of the "END TAPE" key is twofold. First, it serves to dump the buffered data to tape, thus ensuring that all data collected is now recorded. Second, a coded "termination" block of data is placed on the tape. The latter serves to signal the TRIDAQS computer, when it is reading back the data from tape to transmit to the data processing computer, that no further data are on the file. Otherwise, the TRIDAQS computer will continue to search the tape for nonexistent data.

After the "END TAPE" key is depressed, and it is observed that the computer is through writing to tape, (after approximately 20 seconds), the cassette should be removed from the recorder and placed in a protective carrying case at this point.

(e) Study Initiation and Termination

The column of four green function buttons to the right of the keyboard are concerned with controlling the beginning and ending of studies, as well as signalling intermediate events. The four keys are: "EVENT," "START STUDY," "STOP STUDY," and "STOP/START STUDY."

The "START STUDY" key is pressed to begin a study. If a study is already in progress, "ERROR" will be displayed and no other action will be taken, and the current study in progress will continue unaffected. If no study is in progress, the computer will "snapshot" a number of data parameters that become header data associated with the study. The header data will eventually be recorded on tape, immediately preceding the associated travel time data. The data in the header will be used by the data processing program to (1) properly identify the study and (2) annotate the printed output associated with the study. The data in the header include the following:

1. Month
2. Day
3. Year
4. Hour
5. Minute
6. Second
7. Link Number
8. Weather Code
9. Pavement Code
10. Driver Number
11. Vehicle Number
12. Calibration Counts
13. Calibration Distance

The header data become a permanent part of the travel time data and remain associated with the study data.

The "STOP STUDY" key is pressed to end a study. If no study is in progress, "ERROR" will be displayed and no other action will be taken. The "ERROR" message may be removed by pressing the "CANCL" key. Generally speaking, the ending of a study causes no observable actions to be taken. For example, the data for that study would not be written to tape upon its termination. The reason is that the tape is written only when the data buffer is filled, and pressing the "STOP STUDY" key will inhibit further collection of data in the buffer. Since data are accumulated in an increment of 1 second, and the buffer holds 64 increments, it is only coincidental that the buffer contents would be dumped to tape when the "STOP STUDY" key is pressed.

The "STOP/START STUDY" key simulates the action of pressing "STOP STUDY" and immediately pressing "START STUDY." Very frequently, link definitions are contiguous and the ending of one link is coincidental with the beginning of the next link. Under such circumstances, the driver merely presses the "STOP/START STUDY" key as the appropriate landmark is reached, and the computer separates the studies between distance pulses (between 0.88 feet intervals in the case of a 6 pulse speed sensor) without loss of data. At 60 mph, the driver would have to press the "START STUDY" key 0.007 second after the "STOP STUDY" key was pressed to emulate the action of a single depression of the "STOP/START STUDY" key.

The "EVENT" key is used during the course of a study to signal the occurence of an external event. Its use is not necessary in signalling the passing of landmarks, since the accuracy of the distances can be measured once and applied to all studies over that link. This, indeed, is the method used for processing the data, and a landmark dictionary supplies the corresponding annotation. The event data are captured and become a part of the study data within which they occur. The event information is registered as a yes/no bit of data each second. Additionally, the beginning of the event is the only data item that is noted. The duration of time that the "EVENT" key is down is immaterial. Thus, an event is registered only during the second that the "EVENT" key transitions from an up to a down position. The succeeding event is registered after the key is released and pressed again, and so on.

(f) Calibration

The calibration function of the TRIDAQS is necessary to accurately establish the number of speed sensor pulses generated in a known distance for a given vehicle. Since minor discrepancies in travel distances can be expected from vehicle to vehicle (such as might be encountered if a vehicle had been fitted with nonstandard sized rear tires, for example), it is desirable to remove these discrepancies by a calibration procedure.

Prior to discussing the actual calibration procedure, it will be helpful to consider how the calibration data are related to the overall processing of data. When the main computer processes the travel time data for a given vehicle, it refers to a calibration dictionary for a factor which represents the distance traveled per speed sensor pulse. This pulse factor is very accurate, being represented as approximately 7.2 decimal digits. There are two entries in the calibration dictionary for each vehicle. The first is a number of calibration counts (speed sensor pulses) over a measured distance, and the second is the calibration distance in feet. The pulse factor is calculated by dividing a vehicle's second dictionary entry (feet) by its first dictionary entry (pulses). For example, if a calibration runs over a measured mile had produced 5,972 distance pulses, then the pulse factor used by the data processing computer in travel distance calculations would be: $\frac{5,280}{5,972} = .8841$ feet/pulse.

Each vehicle must have a calibration run made before the data it acquires will be accepted by the computer. Thus, the purpose of the calibration run is to enter the vehicle number in the calibration dictionary together with the two data items described above. All this is done automatically by performing a calibration run in the field. The results of the calibration run become a part of the first study made after that run, and when these data are processed by the main computer, the necessary dictionary entries are made and retained for subsequent processing of that vehicle's studies. Since the calibration parameters are a part of the header information for the next study, it will be necessary to perform at least one study before power is removed from the TRIDAQS. Of course, the normal "END TAPE" procedure would be followed before powering down the unit. Any number of runs may be made after the calibration run is made, just so there is at least one.

Prior to making a calibration run, check tire inflation for manufacturers recommended pressure. Drive the vehicle a sufficient distance to heat the tires to normal operating temperature.

The calibration procedure is quite simple. A calibration run may be made at any time that a study is not being conducted. Begin the calibration run at the beginning of a measured distance, preferably in a stopped condition. Press the "BEGIN CALIB" button, and CALibE will appear in the displays. Time is not a factor, so the run may begin at any time thereafter. Accelerate briskly, without wheelspin, to the average operating speed of the vehicle during travel time studies. Drive to the end of the measured distance, preferable stopping at that point. Press "END CALIB" at any time, to signal the TRIDAQS that the number of distance pulses accumulated since the beginning of the measured distance are to be used as the number of calibration counts. CALdS? will appear in the displays. This is the prompt for entry of the distance traveled, in feet, via the keyboard. Once entered, the calibration procedure is completed and no further action need be taken by the operator, except to insure that at least one study is made thereafter to force the recording of the calibration parameters on cassette tape.

A calibration distance of at least one mile is suggested. However, the uppermost consideration, regardless of distance, is that the measured distance be accurate. Using a 6 pulse speed sensor, a maximum calibration distance of 166 miles (999,999 distance pulses) is possible with the TRIDAQS.

Periodic calibration runs should be made to compensate for tire wear. Uniform tire pressure should be maintained for vehicles making travel time studies.

E. Information Queries

There are a number of information items that can be queried from the TRIDAQS. The general procedure for a query is, first of all, to blank or zero the displays. Next, enter a one or two digit code as described below. Finally, press "ENTER" to initiate the query. Each of the data items obtainable through this query mechanism is described in Table 1. Note that code 19 is used to enter, rather than to fetch data.

Table 1 - Query Codes and Descriptions

Code	Action
0	None
1	Display the date (MMDDYY)
2	Display time of day (HHMMSS; military format)
3	Display elapsed time (HHMMSS) since "START STUDY" OR "STOP/START STUDY" function button was pressed
4	Display distance traveled in hundreths of miles (MMMM.MM) since "START STUDY" or "STOP/START STUDY" function button was pressed
5	Display distance traveled in feet (FFFFFF) since "START STUDY" or "STOP/START STUDY" function button was pressed
6	Display current speed in miles per hour (0000MM)
7	Display current speed in feet per second (000FFF)
8	Display last weather code entered (00000X)
9	Display last pavement code entered (00000X)
10	Display driver number (XXXXXX)
11	Display vehicle number (XXXXXX)
12	Display link number for the next study
13	Display base or starting link, i.e., the link number that will become the next study's link number if "RESET LINK" function button is pressed
14	Display calibration counts. This number, if nonzero, indicates the number of speed sensor pulses that were accumulated during a calibration run made since the unit has been powered up.

Table 1 - Query Codes and Descriptions (Continued)

Code	Action
15	Display calibration distance. This number, if nonzero, indicates the calibration distance entered by the driver at the conclusion of a calibration run made since the unit has been powered up.
16	Display factor representing number of feet per distance pulse currently in use. May be a default value or may have been entered by driver during computer initialization sequence.
17	Display factor representing number of miles per distance pulse (.XXXXXX) currently in use. Internally derived from number of feet per distance pulse through multiplication by 0.6818.
18	Turn on audio indicator of distance pulse occurrence. Audio indication of distance pulse rate can be monitored. Note: The audio circuitry has been removed.
19	Enter new starting link number.

F. Terminating Operation

At the conclusion of a data acquisition session, a simple procedure is necessary to complete the operating sequence. The steps are as follows:

1. Press the "END TAPE" button. The tape will be seen to move twice in about 20 seconds.
2. Press the red "RESET" button to stop the computer.
3. Unplug the power cable from the inverter.
4. Disconnect the speed sensor cable.
5. Both the power and speed sensor cables may be disconnected from the aluminum cases if desired, and stored.
6. Place the protective cover on the TRIDAQS unit and fasten the latches.
7. Unplug the inverter from the automobile cigarette lighter socket. Note: Some difficulties were experienced in maintaining a long term power connection through the cigarette lighter socket. Recently, the inverter has been wired directly to a 12 volt source under the hood of the test vehicle.

V. DATA TRANSMISSION OPERATION

The procedure for transmission of recorded data to the Austin D-19 computer is considerably less involved than the field data acquisition of these data. It is recommended that cassette tapes be transmitted on a daily basis, and thereafter processed promptly to detect any non-obvious malfunction in the TRIDAQS.

The TRIDAQS unit transmits and receives data from the SDHPT Austin D-19 computer according to the 300 baud, auto answer protocol standard. This step transmits the field-recorded cassette data to a disk file which is accessible by the battery of data processing programs. A schematic of the total communication configuration is shown in Figure 4.

A. Initial Setup

The initial setup is concerned with preparing the unit for data transmission in an office environment. This setup requires the TRIDAQS unit, an acoustic coupler (Operator's Manual is in Appendix D), and a standard telephone. These four items should be in close proximity on a desk or tabletop, with an AC power source within 4 feet. The steps for setting up the unit are:

a. Remove the top cover of the TRIDAQS case by releasing each of the four suitcase latches. Put the cover aside, since it is used as a protective shield only when the unit is not in operation.

b. A gray multiconductor cable is supplied with the unit. It is actually 2 cables, both joined at one end with an Amphenol connector, and with DB-25 connectors terminating the other

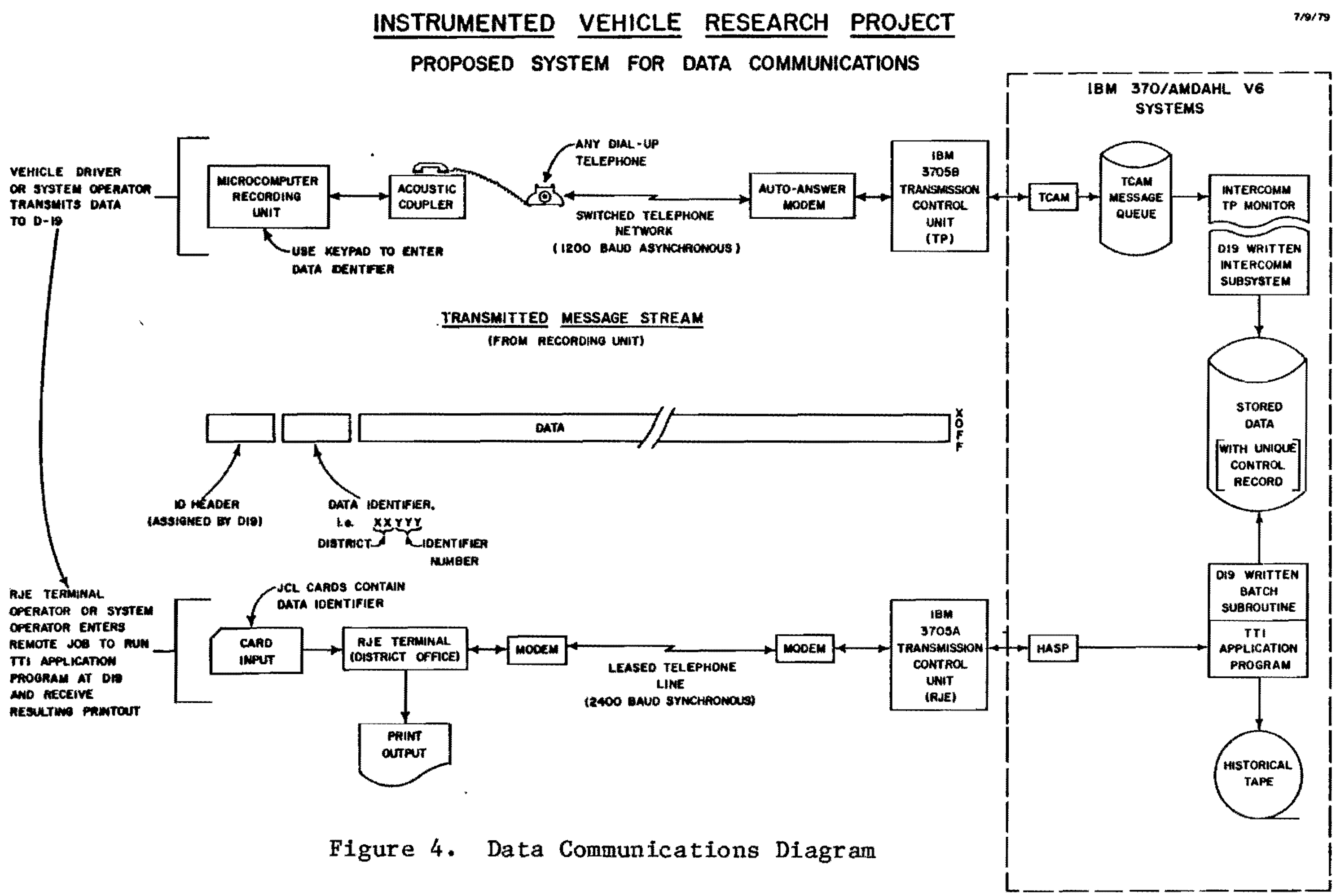

Figure 4. Data Communications Diagram

Source: Texas State Department of Highways and Public Transportation two ends. The TRIDAQS in the data transmission configuration will utilize one leg of this cable. Plug the amphenol connector in the receptacle on the end of the case that is opposite the tape recorder. Plug the DB-25 connector into the rear of the acoustic coupler. (The plugs are polarized, so only the proper plug with match the connector in the acoustic coupler).

c. Plug the main power cord of the acoustic coupler into the AC receptacle. There are three control switches on the acoustic coupler. They should be set as follows:

   1. Turn the OFF/ON rocker switch ON. The power indicator lamp to the left of the switch should light.

   2. The line terminator pushbutton switch should be out with a black visual indicator in the center of the pushbutton. If set improperly, a green visual indicator would be showing in the center of the pushbutton.

   3. The DUPLEX rocker switch indicator should be at FULL.

d. Plug the main power cord of the TRIDAQS into an AC receptacle.

B. Procedure for Initializing the Computer

The computer is now ready to be initialized for the data transmission mode. The following steps are required to initialize the computer prior to transmitting a data tape. In the left column is the prompt message, and the right column is the operator response.

Prompt	Response
none	Place the data tape to be transmitted in the cassette unit.
none	Press the red "RESET" button.
none	Press any button in the third column of buttons (from the left) of buttons of the keyboard. These are "END CALIB", "CANCEL", "9", "6", "3" or "E". The tape will rewind, and then move forward to load point.
FILE?	Enter the file number for data to be transmitted, and press "ENTER". The tape will be seen to move as the first data block is read.

The computer is now initialized and awaiting a short handshaking dialogue with the Austin computer prior to transmitting the data on the cassette.

C. Transmitting the Data

The following steps are required to complete the procedure:

a. Dial the number for the Austin computer. As the last digit is dialed (before the number starts to ring) place the handset into the acoustic muffs of the acoustic coupler, recognizing the cord end.

b. If the Austin computer acknowledges the call, the CARRIER indicator lamp to the right of the "OFF/ON" switch on the acoustic coupler should light. If carrier is not observed, restart with the reset procedure described in Section B above.

c. At this point, the conversation between the computers is entirely automatic. The gist of this conversation follows the sequence below:

(1) D-19 computer transmits its identification.

(2) TRIDAQS responds with its identification and awaits permission to send data.

(3) D-19 computer transmits acknowledgement and prepares to receive data.

(4) TRIDAQS reads a block of data from the cassette, and transmits these data. The TRIDAQS displays reflect this activity.

(5) The TRIDAQS pauses to await acknowledgement from the D-19 computer that the data transmitted was not subject to any obvious data transmission errors. During this interlude, this first 5 digits of the display will be blank, and the last (right-most) digit will be "0".

(6) If errors were encountered, the D-19 computer notifies the TRIDAQS, and the TRIDAQS retransmits the same block of data. This can account for an extraordinarily long pause between cassette tape movements. If a data block is not successfully transmitted within 10 attempts, the TRIDAQS will abort the session. The displays become static, and operator should hang up the telephone.

(7) If no errors were encountered, steps (4), (5), and (6) above are repeated as necessary.

(8) When the last data block is read from tape and transmitted, the TRIDAQS will signal to the D-19 computer that no further data are forthcoming. The D-19 computer will hang up and this can be observed by the carrier pilot indicator on the front of the acoustic coupler being unlit. At this point the

operator should hang up the telephone.

(9) When finished, the TRIDAQS displays 6 digits of information regarding the success of the data transmission session. Numbered from left to right, digits 1 and 2 are checksum error counters, which are incremented in the event of checksum error of a cassette tape data block. Digits 5 and 6 are sync error counters, incremented each time a data character is out of sync within a data block. Both of the above counters are modulo 100, i.e., a count of 99 is followed by 00, etc. Generally speaking a display of all zeros is desirable. If nonzero, it is probably worthwhile to delete the data transmitted to the D-19 computer's disk file by initiation of procedures through the District terminal. If errors cannot be cleared up, treat the resulting data as suspect.

D. <u>Terminating Data Transmission</u>

After the data transmission session is completed (characterized by a steady, bright display of all 6 digits and no further tape movement), the

1. Remove the telephone handset from the acoustic muffs and hang up.
2. Remove and store the cassette tape until it can be determined that the data was processed successfully in Austin. Thereafter, the tape may be erased.
3. Press the red "RESET" button to stop the computer.
4. Disconnect the Amphenol connector (attached to the cable to the acoustic coupler) from the TRIDAQS unit.
5. Disconnect the TRIDAQS power cable from the AC source.
6. Place the protective cover on the TRIDAQS and fasten the latches.

E. Transmitting Data to TAMU

1. Connect the 3-plug gray multiconductor cable to the TRIDAQS, acoustic coupler and teletype.
2. Plug in the AC power cable to the TRIDAQS and press the red reset button.
3. Establish a connection to WYLBUR, using established procedures.
4. After COMMAND? is received, type in COL UNN, followed by carriage return.
5. Press any button in the fourth column of the keyboard: "END TAPE", "RESET LINK", "A", "B", "C", "D".
6. A FILE? prompt will appear in the displays. Enter the file number of the data to be transmitted. Simply press "ENTER" to transmit file 1.
7. The tape will be seen to move each time a data block is read. There will be a delay while that data is transmitted to TAMU. Successive data blocks are transmitted until the entire file has been sent.
8. At the conclusion of this operation, the displays should indicate 000000. Press any button on the keyboard to return control to the teletype. Press the teletype interrupt key to receive a WYLBUR COMMAND? prompt.
9. Store the data file on disk using the SAVE command.

F. Changes in Data Communication

Refer to Appendix I, Data Communications Direction, for further comments on data transmission to the SDHPT mainframe.

VI. DATA PROCESSING PROGRAMS

A. Introduction

A battery of data processing progress has been written to process the field data collected by the TRIDAQS unit. These programs are written in Fortran 77 and installed on the SDHPT D-19 IBM computer and the Texas A&M University (TAMU) Amdahl computer. Both computers utilize the OS/VS IBM operating system.

While all aspects of data input format, program execution, files, and program output are the same for both systems, the methods of invoking program execution for the two systems are different. This is the point of natural distinction between two different computer installations, usually referred to as "local installation convention." In this research study, programs were developed and tested on the Texas A&M computer and then later installed on the SDHPT computer. Both systems use the IBM Job Control Language (JCL), with only minor differences.

The SDHPT uses the ROSCOE terminal system for user interaction with the IBM system, and TAMU uses the WYLBUR terminal system for user interaction with the Amdahl system. Thus, there will be a natural difference in the procedures to follow in reaching the point where the input data has been prepared in the prescribed format and the JCL is ready to be invoked.

B. Program Battery

The program battery consists of programs to perform file maintenance, (2 programs), preprocess field data, process individual study data, and process aggregate study data. A total of 5 main programs and various subroutines comprise the nucleus of this program group, represented by approximately 2,500 Fortran source statements. Utility programs exist to dump data from various files.

C. Data Files

Eleven data files are used in the process of exercising all options available to the user. A brief description of each file will be presented in this section, but it is not necessary for the user to know the details of the file structure to operate the programs. The casual reader may skip this section.

The various files are accessed by their Fortran logical unit numbers from the program battery. The file references and basic descriptions are given below. A more detailed description of pertinent files is given in Appendix F. A diagram of file accession is shown in Figure 5, and Table 2 shows the basic file description.

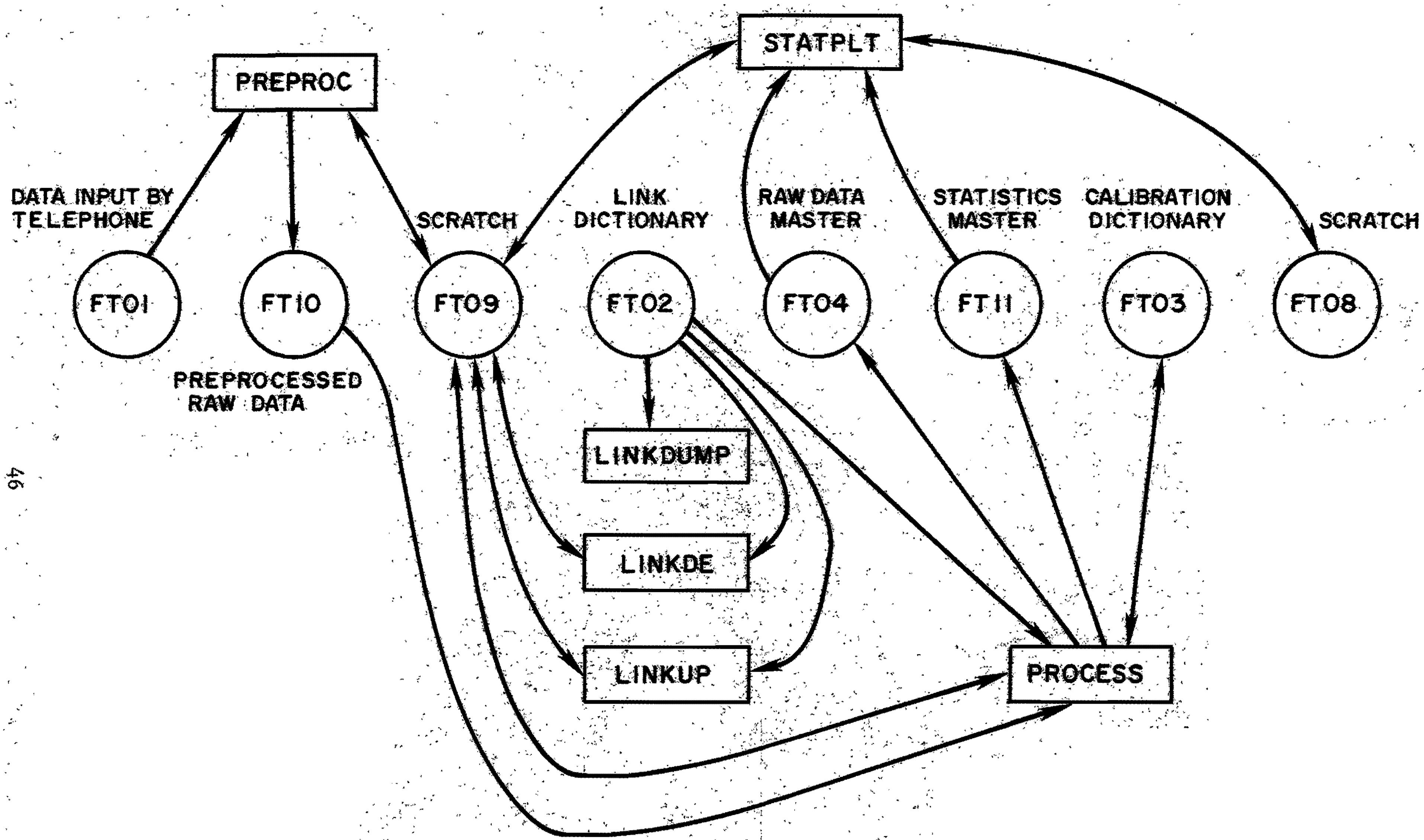

Figure 5. Program File Accession Diagram

TABLE 2 - BASIC FILE DESCRIPTION

Fortran Designation	Record Length (Bytes)	Data Set Name	Description
FT01F001	128	HOUSTON	Field Raw Data File
FT02F001	22	LINKDICT	Link Dictionary
FT03F001	22	CALDICT	Calibration Dictionary
FT04F001	128	RAWDATA	Raw Data Master File
FT05F001	80	SYSIN	Program Data Input
FT06F001	133	SYSOUT	Program Output
FT07F001	-	-	Unused
FT08F001	Varies	-	Utility Scratch File
FT09F001	Varies	-	Utility Scratch File
FT10F001	128	PREPIN	Preprocessed Studies File
FT11F001	60/78	SUMDATA	Study Summaries Master File
FT12F001	133	SYSOUT1	Experimental Program Output

D. PREPROC Program

Program PREPROC preprocesses the raw field data from the telemetry file of accumulated data from TRIDAQS telephone transmissions. The basic purpose of PREPROC is to verify the correctness of checksums, which is a basic indicator of whether or not the data were correctly received by the host computer. The message

STUDY X OK

is issued each time a checksum is verified to be correct, where X = 1,2,..., n (n is the number of different studies on the file). When an incorrect checksum is encountered, the message

INVALID CHECKSUM FOR STUDY X OF THIS DATA SET RECORDED = YY CALCULATED ZZ

is issued. YY is the one byte hexadecimal checksum that was received by the host computer, and ZZ is the checksum calculated from the study data. Studies verified to be correct are appended to FT10, while studies with checksum errors are ignored.

Since occasional errors do occur during telephone transmissions, it is advisable to erase files FT01 and FT10 if any study has a checksum error. The TRIDAQS data file should then be retransmitted and reprocessed by PREPROC to determine if the same error is occurring. If the same error occurs, then the data error may be considered permanent and the next stage of processing may be entered. If a different error occurs, then the telemetry problem is random and it will be worthwhile to continue erasing files FT01 and FT10 and retransmitting until error-free processing is achieved.

There is no program card input for PREPROC. It processes all studies found on FT01. Sample output is shown in Figure 6.

E. PROCESS Program

Program PROCESS processes the verified data from the preprocessed file FT10. If new vehicle calibrations are noted in the data, the appropriate update is made in the calibration dictionary. Studies are processed and the raw data is appended to the raw data master file FT04. Study statistics are printed out and also appended to the statistics master file FT11. The link dictionary file FT02 is checked for an entry for the link being processed. If an entry is present, additional statistics will be printed out for the study's sublinks (termed segments), and the segment statistics will also be appended to the statistics master file FT11.

It is essential that the link dictionary entries be made by program LINKUP prior to processing studies for given links. At the present time, there is no provision for file maintenance to purge studies processed without segment definition so that later processing utilizing link dictionary entries can occur. In the event this situation arose, the study in question would have multiple entries in the statistics master file, once without segment statistics, and once with segment statistics. Also, the raw data master would contain the study data twice.

There is no program card input for PROCESS. It processes all studies found on FT10. Sample output is shown in Figure 7.

F. STATPLT Program

Program STATPLT compiles the aggregate statistics of multiple studies over a given link and provides an optional speed profile plot or event plot.

The selection of the studies to be processed by STATPLT is by data

```
TRIDAQS DATA PREPROCESSOR 16:11:54 12/17/83
STUDY  1 OK
STUDY  2 OK
STUDY  3 OK
STUDY  4 OK
STUDY  5 OK
```

Figure 6. Program PREPROC Sample Output

RESULTS FROM TOTAL STUDY LINK 45626

STUDY BEGAN 14:42: 4 11/22/83 PROCESSED 12/17/83 DRIVER 1 VEHICLE 366318 WEATHER OCST PAVEMENT DRY

DIST (FT)	TRVL TIME (MIN)	STOP TIME MIN	PCT STOP TIME	TRVL TIME /MI	AVG SPD MPH	VELOCITY (FT/SEC) MEAN	VELOCITY (FT/SEC) NOISE	ACCELERATION (FT/SEC/SEC) MEAN	ACCELERATION (FT/SEC/SEC) NOISE	MEAN VEL GRAD	GREEN-SHIELDS INDEX	NO. OF STOPS	STOPS PER MILE
271677	59.6	0.3	0	1.2	51.8	76.0	18.5	-0.00	1.06	0.014	960.56	2	0.0

**** SPEED DISTRIBUTION ****

SPEED	#MIN>=	%TIME>=
0	59.6	100.0
5	59.2	99.4
10	58.8	98.7
15	58.2	97.7
20	56.8	95.3
25	55.8	93.6
30	55.5	93.1
35	54.6	91.7
40	52.2	87.6
45	48.2	80.9
50	40.4	67.8
55	4.1	6.8
60	0.0	0.0
65	0.0	0.0
70	0.0	0.0
75	0.0	0.0

A TOTAL OF 20 PUSHBUTTON EVENTS WERE RECORDED FOR THIS STUDY AS FOLLOWS

TIME (SEC)	TIME (MIN)	DIST (FEET)	DIST (MILES)
9	0.1	630	0.1
21	0.3	1503	0.3
96	1.6	7309	1.4
157	2.6	11012	2.1
200	3.3	14152	2.7
222	3.7	15685	3.0
257	4.3	18156	3.4
292	4.9	20175	3.8
329	5.5	22407	4.2
355	5.9	24111	4.6
424	7.1	28270	5.4
463	7.7	31043	5.9
486	8.1	32954	6.2
542	9.0	37181	7.0
588	9.8	41007	7.8
621	10.3	43784	8.3
690	11.5	49428	9.4
722	12.0	52016	9.9
752	12.5	54348	10.3
791	13.2	57309	10.9

RESULTS BY SEGMENTS LINK 45626

DIST (FT)	TRVL TIME (MIN)	STOP TIME MIN	PCT STOP TIME	TRVL TIME /MI	AVG SPD MPH	VELOCITY (FT/SEC) MEAN	VELOCITY (FT/SEC) NOISE	ACCELERATION (FT/SEC/SEC) MEAN	ACCELERATION (FT/SEC/SEC) NOISE	MEAN VEL GRAD	GREEN-SHIELDS INDEX	NO. OF STOPS	STOPS PER MILE	CNTL	SECT	MILPNT	LANDMARK
														4632	1	00.0	US290 @ FM1960
26382	6.5	0.0	0	1.3	45.9	67.3	9.0	0.01	1.34	0.020	493.25	0	0.0				
														4632	1	5.0	US290 @ FM529
36906	7.9	0.0	0	1.1	53.0	77.7	8.0	0.06	0.95	0.012	766.44	0	0.0				
														4632	1	12.0	US290 @ BINGLE
14584	3.3	0.0	0	1.2	51.0	74.8	6.2	0.00	0.72	0.010	1155.56	0	0.0				
														4632	1	14.7	US290 @ ANTOINE
10576	2.3	0.0	0	1.1	53.4	78.3	4.0	-0.02	0.77	0.010	2088.53	0	0.0				
														4632	1	16.8	US290 @ IH610
9198	1.9	0.0	0	1.1	56.0	82.1	3.2	0.02	0.66	0.008	1968.04	0	0.0				
														4632	1	18.5	IH610 @ IH10

Figure 7. Program PROCESS Sample Output

card specification. Basic selection is made for a link, and thereafter specific runs can be selected that were made on particular dates, at specified times, with a particular vehicle, by a particular driver, and under specified pavement and weather conditions. For studies selected, the date, starting time, distance, travel time in minutes, percent stop time, travel time/mile, average speed, mean velocity gradient, Greenshields Index, stops/mile, and distance discrepancy are listed. For all items except date and starting time, the sum, mean, standard deviation, minimum, maximum, and coefficient of variation are calculated. A sample of the numerical print-out is shown in Figure 8.

The speed profile plot is a printer plot of the average speeds over the specified plot intervals. An example speed profile plot is shown in Figure 9. If only a single study is being plotted, the pushbutton event markers will be plotted as well, as shown in Figure 10. The plotting symbol for a pushbutton event is a "+". For speed profiles of multiple studies, the event markers are not plotted. Up to 52 speed profiles can be uniquely represented on a single plot, using the upper and lower case letters as plot symbols. Beyond that, the plotting symbol will be repeated, i.e. speed profile #53 will be plotted with "A", #54 with "B", etc.

An event plot is a subset of a single study speed profile, where only the plot intervals that include pushbutton events are plotted. An example of an event plot is shown in Figure 11.

The selection card format for STATPLT is shown in Figure 12. Any number of selection cards may be specified.

G. LINKUP Program

Program LINKUP is a link dictionary update program used to add entries

LINK 290107 SUMMARY STATISTICS 12/17/83

BEGIN DATE **/**/** END DATE **/**/** BEGIN TIME **** END TIME **** DRIVER **** VEHICLE **** WEATHER **** PAVEMENT ****

(ASTERISKS ABOVE DENOTE ITEM WAS UNSPECIFIED)

DATE	TIME	DISTANCE (MILES)	TRAVEL TIME MIN	PERCENT STOP TM	TRAVEL TIME/MIL	AVERAGE SPED MPH	MEAN VEL GRADIENT	GREENSHLD INDEX	STOPS /MILE	VEH DIST DSRP(FT)
12/ 9/83	654	10.20	14.98	9.00	1.47	40.84	0.03	292.92	0.88	53844.00
12/ 9/83	730	10.76	14.58	10.00	1.35	44.28	0.02	439.04	0.37	56820.00
12/ 9/83	1144	11.23	13.15	6.00	1.17	51.22	0.02	806.83	0.27	59276.00
12/ 9/83	1219	10.76	12.55	7.00	1.15	51.45	0.02	945.91	0.19	56825.00

LINK 290107 SUMMARY STATISTICS 12/17/83

BEGIN DATE **/**/** END DATE **/**/** BEGIN TIME **** END TIME **** DRIVER **** VEHICLE **** WEATHER **** PAVEMENT ****

(ASTERISKS ABOVE DENOTE ITEM WAS UNSPECIFIED)

NUMBER OF OBSERVATIONS = 4

	DISTANCE (MILES)	TRAVEL TIME MIN	PERCENT STOP TM	TRAVEL TIME/MIL	AVERAGE SPED MPH	MEAN VEL GRADIENT	GREENSHLD INDEX	STOPS /MILE	VEH DIST DSRP(FT)
SUM	42.95	55.27	32.00	5.13	187.79	0.10	2484.70	1.71	********
MEAN	10.74	13.82	8.00	1.28	46.95	0.02	621.18	0.43	56691.25
ST DEV	0.42	1.15	1.83	0.15	5.26	0.00	305.97	0.31	2222.25
MIN	10.20	12.55	6.00	1.15	40.84	0.02	292.92	0.19	53844.00
MAX	11.23	14.98	10.00	1.47	51.45	0.03	945.91	0.88	59276.00
COFVAR	0.04	0.08	0.23	0.12	0.11	0.16	0.49	0.73	0.04

Figure 8. Program STATPLT Sample Output

SPEED PROFILE PLOT FOR LINK 290107

```
CUML   CUML           1         2         3         4         5         6         7      EVENT
MILES  FEET 0123456789012345678901234567890123456789012345678901234567890123456789012345 ('+') CTL/SC/MP  FEET  LANDMARK NAME
 0.00      0 I---------------------------------------------------------------------------
 0.09    500 I   B A
 0.19   1000 I                              B A
 0.28   1500 I                                     AB
 0.38   2000 I   B  A
 0.47   2500 I                           BA
 0.57   3000 I                                    AB
 0.66   3500 I                                      A B
 0.76   4000 I                                      AB
 0.85   4500 I                                      A  B
 0.95   5000 I                                     A       B
 1.04   5500 I                                        A     B
 1.14   6000 I                                           A B
 1.23   6500 I                                          *
 1.33   7000 I                                    A  B
 1.42   7500 I         A                                      B
 1.52   8000 I                   A                B
 1.61   8500 I                                A     B
 1.70   9000 I                                     A   B
 1.80   9500 I                                     A  B
 1.89  10000 I                                    AB
 1.99  10500 I                                     *
 2.08  11000 I                                  AB
 2.18  11500 I                                    A  B
 2.27  12000 I                                        AB
 2.37  12500 I                                         A  B
 2.46  13000 I                                        A     B
 2.56  13500 I                                         A      B
 2.65  14000 I                                          A     B
 2.75  14500 I                                           A    B
 2.84  15000 I                                             A   B
 2.94  15500 I                                            A   B
 3.03  16000 I                                            A   B
 3.12  16500 I                                               A B
 3.22  17000 I                                                 AB
 3.31  17500 I                                                A     B
 3.41  18000 I                                               A      B
 3.50  18500 I                                               A     B
 3.60  19000 I                                               A     B
 3.69  19500 I                                               A     B
 3.79  20000 I                                                A     B
 3.88  20500 I                                                A    B
 3.98  21000 I                                               A     B
 4.07  21500 I                                             A      B
 4.17  22000 I                                             A      B
 4.26  22500 I                                               A    B
 4.36  23000 I                                               A    B
 4.45  23500 I                                              A    B
 4.55  24000 I                                               AB
 4.64  24500 I                                               B A
 4.73  25000 I                                                BA
             0----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+
 4.83  25500 I                                                 AB
 4.92  26000 I                                                 B A
 5.02  26500 I                                                  *
 5.11  27000 I                                                  BA
 5.21  27500 I                                                  B A
```

Figure 9. Multiple Study Speed Profile Sample Output

```
                              LINK    290107 SUMMARY STATISTICS          12/17/83
BEGIN DATE 12/ 9/83  END DATE **/**/**  BEGIN TIME 1200  END TIME ****  DRIVER ****  VEHICLE ****  WEATHER ****  PAVEMENT ****
(ASTERISKS ABOVE DENOTE ITEM WAS UNSPECIFIED)
              DISTANCE   TRAVEL   PERCENT    TRAVEL    AVERAGE   MEAN VEL GREENSHLD    STOPS  VEH DIST
  DATE   TIME  (MILES)  TIME MIN  STOP TM   TIME/MIL  SPED MPH  GRADIENT   INDEX      /MILE  DSRP(FT)
12/ 9/83 1219   10.76     12.55     7.00       1.15     51.45      0.02    945.91      0.19  56825.00

                              SPEED PROFILE PLOT FOR LINK 290107
CUML    CUML           1         2         3         4         5         6         7      EVENT
MILES   FEET 0123456789012345678901234567890123456789012345678901234567890123456789012345 ('+') CTL/SC/MP  FEET  LANDMARK NAME
  0.00      0 I---------------------------------------------------------------------------
  0.09    500 I   A                                                                            +
  0.19   1000 I                              A                                                ++
  0.28   1500 I                                      A
  0.38   2000 I                                A
  0.47   2500 I                           A
  0.57   3000 I                                     A
  0.66   3500 I                                        A
  0.76   4000 I                                       A
  0.85   4500 I                                         A
  0.95   5000 I                                             A
  1.04   5500 I                                              A
  1.14   6000 I                                             A
  1.23   6500 I                                          A
  1.33   7000 I                                       A
  1.42   7500 I                                      A
  1.52   8000 I                                    A                                          ++
  1.61   8500 I                                      A
  1.70   9000 I                                         A
  1.80   9500 I                                        A
  1.89  10000 I                                     A                                        +++
  1.99  10500 I                                     A
  2.08  11000 I                                   A
  2.18  11500 I                                       A
  2.27  12000 I                                         A
  2.37  12500 I                                            A
  2.46  13000 I                                              A
  2.56  13500 I                                                A
  2.65  14000 I                                                A
  2.75  14500 I                                                A
  2.84  15000 I                                                 A
  2.94  15500 I                                                A
  3.03  16000 I                                                A
  3.12  16500 I                                                 A
  3.22  17000 I                                                  A
  3.31  17500 I                                                      A
  3.41  18000 I                                                      A
  3.50  18500 I                                                     A
  3.60  19000 I                                                     A
  3.69  19500 I                                                     A
  3.79  20000 I                                                      A
  3.88  20500 I                                                     A
  3.98  21000 I                                                     A
  4.07  21500 I                                                    A
  4.17  22000 I                                                    A
  4.26  22500 I                                                    A
  4.36  23000 I                                                    A
  4.45  23500 I                                                   A
  4.55  24000 I                                                A
  4.64  24500 I                                               A
  4.73  25000 I                                                A
             0----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+
```

Figure 10. Single Study Speed Profile Sample Output

```
                                    LINK    290107 SUMMARY STATISTICS           12/17/83
BEGIN DATE **/**/**  END DATE **/**/**  BEGIN TIME 1100  END TIME 1200  DRIVER ****  VEHICLE ****  WEATHER ****  PAVEMENT ****
(ASTERISKS ABOVE DENOTE ITEM WAS UNSPECIFIED)

              DISTANCE   TRAVEL   PERCENT    TRAVEL   AVERAGE   MEAN VEL GREENSHLD    STOPS  VEH DIST
  DATE   TIME  (MILES)  TIME MIN  STOP TM   TIME/MIL  SPED MPH  GRADIENT   INDEX      /MILE  DSRP(FT)
12/ 9/83 1144   11.23     13.15      6.00      1.17     51.22      0.02    806.83      0.27  59276.00


                                     EVENT PLOT FOR LINK 290107


CUML    CUML             1         2         3         4         5         6         7     EVENT
MILES   FEET 0123456789012345678901234567890123456789012345678901234567890123456789012345 ('+') CTL/SC/MP  FEET  LANDMARK NAME
 0.00      0 I-----------------------------------------------------------------------------
 0.05    264 I                        A                                                       ++
 0.07    396 I                    A                                                            +
 1.42   7524 I  A                                                                             ++
 2.05  10824 I                                   A                                             +
 8.40  44352 I                                                 A                               +
 8.42  44484 I                                                 A                               I
```

Figure 11. Event Plot Sample Output

Column	Content
1-6	Link number - must be specified.
8-13	Beginning date. Col. 8-9 = month, 10-11 = day, 12-13 = year. Do not use imbedded blanks, fill with zeros. If left blank, all dates on file before the ending data will be used.
15-20	Ending date. Col. 15-16 = month, 17-18 = day, 19-20 = year. Do not use imbedded blanks, fill with zeros. If left blank, all dates on file after the beginning date will be used.
	Note: If both beginning and ending dates are left blank, all dates on file will be used.
22-25	Beginning time. Col. 22-23 = hour, Col. 24-25 = minute. Do not use imbedded blanks, fill with zeros. Use military time.
27-30	Ending time. Col. 27-28 = hour, Col. 29-30 = minute. Do not use imbedded blanks, fill with zeros. Use military time.
	Note. The nonspecification of times is the same as with dates.
32-37	Driver number. All drivers will be used if left blank.
39-44	Vehicle number. All vehicles will be used if left blank.
46-47	Weather index. All weather conditions will be used if left blank.
49-50	Pavement index. All pavement conditions will be used if left blank.
52	Plot indicator. = 0 denotes no plot = 1 denotes speed profile plot = 2 denotes event plot
54-56	Plot interval in feet.

Figure 12. STATPLT Selection Card Format

to the link dictionary. A link is a predefined study section from point A to point B. Along the way, the link is composed of sublinks which are delineated by landmarks, such as street intersections, under/overpasses, interchanges, ramps, etc. Link dictionary entries for a link allow the compilation of statistics for sublinks within a study, plus allow the annotation of landmarks on the printer plots.

The card format for LINKUP's input data is shown in Figure 13.

H. LINKDE Program

Program LINKDE is a link dictionary update program used to delete entries from the link dictionary. Link numbers are input to the program and all sublink definitions associated with the link are deleted. The link dictionary can become quite large. It may become necessary to purge the file of links that are not actively being studied. Additionally, roadway redefinition will occasionally necessitate the use of this program.

The card format for program LINKDE input data is column 1-6 = link number, column 7-80 = ignored. Any number of links may be deleted with a run. No other header or trailer cards are required.

I. Utility Programs

Three utility programs exist to dump the contents of data files:

Program LINKDUMP dumps the contents of the link dictionary (FT02). Sample output from LINKDUMP is shown in Figure 14.

Program DUMPRAWD dumps the raw data master file (FT04). Sample output from DUMPRAWD is shown in Figure 15.

Program DUMPSUMM dumps the statistics master file (FT11). Sample output from DUMPSUMM is shown in Figure 16.

Column	Content
1-6	Link number must be right justified with no imbedded blanks.
8-9	Card sequence numbers: Blank or 0 = First card 1 = Second card 2 = Third card (second segment) . . .
11-14	Control number
16-17	Section number
19-21	Milepoint. XX.X, specified without decimal point
23-28	Distance in feet from last landmark
30-45	Landmark. 16 character name of marker.

Figure 13. Link Dictionary Update Card Format

LINK	CONTROL	SECTION	MILEPOINT	FEET	LANDMARK
45626	4632	1	1	0	US290 @ FM1960
45626	0	0	0	26400	US290 @ FM529
45626	0	0	0	36960	US290 @ BINGLE
45626	0	0	0	14520	US290 @ ANTOINE
45626	0	0	0	10560	US290 @ IH610
45626	0	0	0	9240	IH610 @ IH10
45626	0	0	0	9900	IH610@WASHINGTN
45626	0	0	0	25740	IH610 @ IH45
45626	0	0	0	6600	IH45@WASHINGTON
45626	0	0	0	1320	IH45@MEMORIAL
45626	0	0	0	1848	IH45@ALLEN PKY
45626	0	0	0	6072	IH45 @ MAIN
45626	0	0	0	7128	IH45 @ US59
45626	0	0	0	15840	IH45@M.L.KING
45626	0	0	0	7392	IH45@WAYSIDE
45626	0	0	0	14520	IH45 @ IH610
45626	0	0	0	5808	IH45@BROADWAY
45626	0	0	0	18480	IH45@ ARPT BLVD
45626	0	0	0	8712	IH45 @EDGEBROOK
45626	0	0	0	7128	IH45 @ SHAVER
45626	0	0	0	18744	IH45 @ FM553
45626	0	0	0	6072	IH45 @ FM1959
45626	0	0	0	16104	IH45 @ FM 2351
45626	0	0	0	12672	IH45@NASA RD 1
45626	0	0	0	6600	IH45 @ FM528
45626	0	0	0	13728	IH45 @ FM518
45626	0	0	0	16104	IH45 @ FM646
45626	0	0	0	11880	IH45 @ FM517

Figure 14. LINKDUMP Sample Output

12098306540729010701010000013663180000000000000001111171D2023232424A52627262423201D1A1A1A191A1A1B1B1C1D1F1F1F201F1F1F1F1F1D1D1B1B1A
1B1B1A1B1B1B1A1B1B19130D0A0401000000000000000000102080D13161B1B1C1C1B1C1B1B1A19140E0B0A09070706060505080A0C0F1115141515151517191B1D1F
212323211E1C1B1A1A191919181818 1A1B1B1D1C1D1C1B1C1C1B1817120A050100000000000104090D11141618 1B1B1B1C1B1B1B1B1C1C1C1F1F2222232424 24
24232323222322201E1D1E1D1B161310100F0D0E0E0B06020000000000000000000000000040A11151C2021212122242527272626262525231D150C090806060702
000000000000000000000000000000000000002060A1014181D1E1F1E1B18120D08040000000000000000000000001060D13191E22282B2F32353637373635343 22E2A
251E18110D0806030000000000000000000003080F161A1F22272B2E31333538393D3F414344444547484A4B4A494A4A4B4A4B4A47494949474847464545444444434240
403E3A332C26221F1B140F0809060602000002090F141A1E2326292C2D31323535383A3C3E40434447494B4D4F505052535455575758585758575654545355555 6
5758595A5C5C5D5E5E5E5F5F5E5D5C5B5958585758585859595A5C5C5D5C5C5E5C5B595A5B5D6063656666646363656768676769686 96A6A6B6B6B6C6D6D6E6F
6F71707071706F70707171727373747575747473727373727271706E6E6E6D6F6E6F6F70717072717272727372737373737171 6E6D6C6B6B6C6C6D6E6D6E6F6F
70717172727373737372737273737371717170707071707070 6F706F6F706E6F6E6E6E6D6E6E6E6E6E6E6E6F6E6D6C6D6C6B6C6A6B6B6A6B6B6C6C6D6D6E6D6F
6E6F6E6F6F6F6F6F6E6F6F6E6D6D6D6D6C6A6B6A6A6A6B6A6A6B6A6B6B6B6B6A6B6B6C6C6D6E6F6F706F70706F6F6E6E6D6E6D6C6C6C6B6D6C6B6C6C6C6C6C6C
6D6D6E6E6D6D6D6D6D6D6D6D6E6D6D6E6E6F6D6E6E6E6E6B6A6966656462636163636463656465656567676868696869696969696A696A696A69696869676 8
67676767686868696968696868686768686767676666462626161616261626 1E3E263646666667676868696A6B6A6B6B6B6A6A6867E6E5E3636160 5E5C5C5B5A5A59
5A59595859585A595A595A5A5C5C5C5D5D5C5E5E5E6060626262626160605E5D5D5C5E5C5D5D5D5B5C5ADBD9DADA5C5D5E5F5D5D5B5C5B5C5D5C5D5D5D5C5B5A59
595656545452504F4E4D4CCAC9C0B9B8383A3B3C3D3F4042433B
1209830730292901070101000001366318000000000000000000000000504040200000000000000001010304080600000000000000000000000000000000000000
0000000000070B0A0602040B131C242B32373C414547C94BCB4C4C4C49C9484848454444 13B37302B231D140D08030100000000000000000000000000000000000
000000000000000000000000000000000000001070B101415181C2023242627292A2D3030323436393B3E3F424546494A4B4A4C4C4E4F505050525252525252
524F4F4D4E4D4E4E4C4B4B4B4B4B4D4D4F515153535555575758595A5B5C5C5D5E5E5D5C5D5B5B5B59595A59595858575553535352514F4E4C4B49484848494C
4E4F51535253545452504F4D4B4A48423D37322F2D2C29282725252524222121212426 2A2D3134383A3D3B38353336363 83A3C3E3F4243464649 4A4C4C4E4F4D
4E4D4E4E4F4F4F4F4E4E4D4C4D4E4E4D4D4E4E4F4E4E4F4E4F5050505150515050505252535555545354535554555455555657585 85A5A5B5B5C5D5D5D5F5E60
5F606061606161616262626261616161 5F605F5F5E5F5F5E5F5E5E5D5D5C5C5A595959585A5B5C5C5C5C5D5E5E5F5E5F6061606161616160 5F5F5E5E5E5D5D5B
5A58565655556555452525151515153545456555655555555545556565757585859595A5A5B5B5B5C5D5E6061636362606161636363636263626261626260 5E5A
5552504E4E4C4A494644443434345464648494B4C4B4C4B4A4A4A4B4B4D4D4E4F4F4F504F504F4E4E4D4D4D4D4D4E4F4F4F4E4E4E4F4F504F50504F4F4F4E4F4E
4F4E4E4F50504F515150515152525353535354535555555656555656565656555655556575 85A5B5E60626366676 86A6969686665646465646363646363636464 65
656667676869686666462626 0605F5D5D5C5C5C5B5C5C5D5D5D5E5E5E605F5F60616061616261626262626263626161616060 5F5F5F5E5E5E5E5D5E5D5F616162
636262616 15F5F5E5D5D5C5D5D5D5E5E5E5E5F5F60605F5E5F5E5E5D5D5C5C5DDCDCDC5B5B5A5959585757575758585757575556555759595B5B5D5D5E5F5F60
5F5F5F5D5D5D5B5B5B59585857565553545454555453535353535252515150 4F4E4C4B494849484849 4A4C4D4C4C4C4C4D4D4F51504E4F505252535354535354
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5957
1209831144462901070101000001366318000000000000000000003060B1013181B2022A72AAEB134373A3D404345484A4D4E5052535354544F4A413B31281F17
0F0A070503000000000000000000000000000000000000000000000001060C141921262A2F34363A3C404345474A4C4D4E4F4E50505052525353545 5525352
53535353545453535353535252535252525354545658585 95A5B5B5C5D5C5C5B5A595959585755514F4D4B46403B34322E2A25211B150E0A040100000008080
000000000000107101 51C2024282C2E303335383B3D40424445484A4D4E50525153525352525352525253515252 51504F4F4E5051525152525 2504E4E4DCD4C
4C4D4D4D4E4F5153535454555556575859585857575757585757565756575757585858585859585A595A5A595A5A5B5C5C5D5E5F5F605F605E5F5C5C5C5B5C5C5B5D
5D5E6061616363646465656565656463636262616262616161616161616161616160606162616261616261626262636363626362626261626362616 15F5F5F5F
5E5F5F5E5F5F5F60606162626262636161616161616060616060616062626364656566666666666766656666565666566666686868696868686767666766 68676 96869
6A6A696A6A696A69696A696869696969686969686867686868676867676767676766666666666666767686 8696A6A6A6B6A6968686766666564646364626363626 36465
65656666667666667676767676768696869686A6A6A69686767666665656564646463646463636364636364636464656565666565646464636463636464646566
666768696A6A6B6C6C6D6D6E6E6D6C6B696866656463616 05F5F5E5D5D5C5C5C5C5C5B5D5C5D5D5D5E5D5D5C5D5B5B5B5A5B5C5C5D5E5E5F60606161626362 63
64E464E46566668676869686868696869696 96A6B6B6C6D6D6F6F6F71716F6E6D6A6A6767646462616060616061616262636365656565656666666666667676766 65
646565656666665656464636363636463656565666666665656463626263626363636464646464646262605F5D5D5C5D5E5F60626465666666666656564646564656 5
66656667666868686767676666463626162616262605E5D5D5D5D5C5A58575656585 95A5C5C5B5A5957555 42C
1209831219512901070101000001366318000000000000000000000205080B0E101112141417191C1F23262A2F3235B83CBEC14345484A4C4E51525456 57574F43
382E2217100902000000000000000000000000000000000000000000000000000000000000000000000000001050C141B21252A2E
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55555545453535351 4FCD4DCE4E505150525253555555565657575757585958585756555545 3D152D051D0515152525252504F4D4B4B4D4D4F4F5153555556 56
56565657585 85A5A5B5B5D5C5E5E5F5F6061626263636363636364646464646565656564656464656666565656465636462636263646465656566656566 65666768
6A6C6C6E6E6E6E6E6E6E6F6D6E6C6D6B6C6B6B6B6B6C6C6B6D6E6E6F6E6E6D6D6D6D6C6C6B6B6B6B6A6A6A6A696A696B6A6B6B6A6B6A6B6A6A6A6B6A6A6A6A
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6565656463636261616061606061616162616262626363646364656465656564656464636463636363636363626364646665656565636 2615F605F5E5D5B5B5A59
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646463636463636363636364636362636363646464646363646462626161605F6060616262626364636 2605F5D5C5B5A5A5A5A5A5B5B5B5C5B5A5B5B5B5A5B5A
5A5B5B5B5B5C5D5D5E5F5F5F6162636263626363636363626161605F5F5F5F5F6160626163636465656666666676666766666666766676667676667676767686768
67686767686867696868686767666463605E5E5C5D5B5C5D5C5D5D5E5E5F60605F5F5E5D5C5BD9D959DA5BDB5B5C5A5A5A5B5B5BDBDA5BDA5BDCDD5DDE5E5F5F
5E5E5C5959585516

Figure 15. DUMPRAWD Sample Output

290122	726	1	12	9	83	6	34	36	1 366318	1	1	0.88	0.0	
28261	12.10		5.65	47	135	26.54	38.73		40.21	0.07	3.10	0.08	242.70	2
0.37	0		0	0										
290107	899	1	12	9	83	6	54	7	1 366318	1	1	0.88	0.0	
53844	14.98		1.37	9	88	40.84	59.89		35.72	0.06	1.79	0.03	292.72	7
0.88	0		0	0										
290501	669	1	12	9	83	7	17	46	1 366318	1	1	0.88	0.0	
49599	11.15		0.27	2	71	50.55	74.14		17.79	0.03	1.62	0.02	850.26	1
0.11	0		0	0										
290107	875	1	12	9	83	7	30	29	1 366318	1	1	0.88	0.0	
56820	14.58		1.42	10	81	44.28	64.94		25.69	0.07	1.40	0.02	439.04	4
0.37	0		0	0										
290501	723	1	12	9	83	7	48	23	1 366318	1	1	0.88	0.0	
55776	12.05		0.48	4	68	52.60	77.15		20.46	-0.00	1.87	0.02	776.43	1
0.09	0		0	0										
905107	739	1	12	9	83	8	3	42	1 366318	1	1	0.88	0.0	
56541	12.32		0.08	1	69	52.17	76.51		18.12	0.06	1.28	0.02	1057.77	1
0.09	0		0	0										
290501	714	1	12	9	83	11	26	18	1 366318	1	1	0.88	0.0	
56178	11.90		0.28	2	67	53.65	78.68		19.30	0.04	1.35	0.02	930.58	2
0.19	0		0	0										
290107	789	1	12	9	83	11	44	46	1 366318	1	1	0.88	0.0	
59276	13.15		0.77	6	70	51.22	75.13		24.91	0.07	1.66	0.02	806.83	3
0.27	0		0	0										
290501	190	1	12	9	83	12	2	10	1 366318	1	1	0.88	0.0	
16587	3.17		0.0	0	60	59.52	87.30		5.70	0.21	2.59	0.03	1416.78	0
0.0	0		0	0										
290507	597	1	12	9	83	12	7	14	1 366318	1	1	0.88	0.0	
36486	9.95		0.63	6	86	41.67	61.12		25.52	0.07	1.41	0.02	449.67	2
0.29	0		0	0										
290107	753	1	12	9	83	12	19	51	1 366318	1	1	0.88	0.0	
56825	12.55		0.93	7	69	51.45	75.46		25.77	0.06	1.78	0.02	745.71	2
0.19	0		0	0										
290501	145	1	12	9	83	12	37	13	1 366318	1	1	0.88	0.0	
9685	2.42		0.07	3	79	45.54	66.79		24.56	0.08	2.11	0.03	221.34	1
0.55	0		0	0										

Figure 16. DUMPSUMM Sample Output

APPENDIX A

SPEED SENSOR DATASHEET

YELLOW JACKET

THE YELLOW JACKET FAMILY . . .

A complete line of low-cost speed sensors for driving electric tachometers, speed switches and other speed controlled or speed actuated devices.

OPERATING PRINCIPLES

Magnetic actuated reed switch
Hall Effect speed sensor
Optical speed sensor
Magneto type speed sensor

MassTech CORPORATION

Subsidiary of TransTechnology Corporation

SWAMP ROAD, ROUTE 313, P.O. BOX 2001
DOYLESTOWN, PENNSYLVANIA 18901
PHONE: (215) 345-5300, TWX: 510-665-8128

GENERAL SPECIFICATIONS

Operating Temperature:
140° C maximum
-40° C minimum

Wiring:
Potted for waterproof requirements

Operating Life:
Can be provided upon receipt of Customer's application specifications

Materials:
Housing — Glass-filled nylon
Fittings — Plated steel
Bearings — Oilite

SPECIFICATIONS FOR REED SWITCH MODELS

Maximum Switching Voltage:
40 VDC

Maximum Switching Current:
0.25 Amps

Initial Resistance:
1 Ohm

Capacitance:
0.3pF

Maximum Switching Rate:
300 Contacts/second

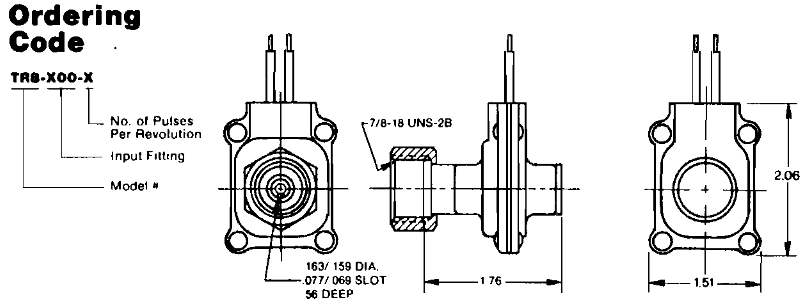
Contact Bounce:
Closing 0.5 millisecond (typical)

Pole Repeatability:
±3%

STANDARD MODELS

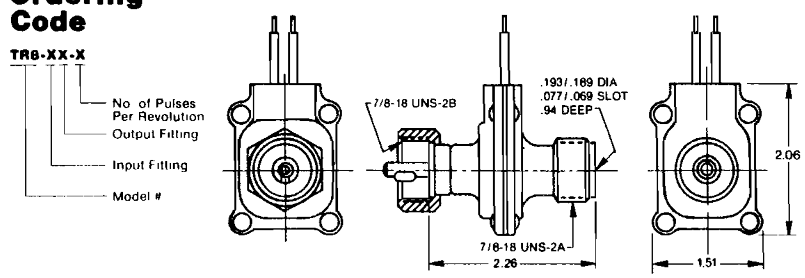
Model No.	**TR8**
Standard Fittings	#10, #11, #18, #25
No. of Pulses Per Revolution	2, 4, 6, 8
Wiring Terminations	8" Leads, Special connectors available
Reed Switch	

Ordering Code



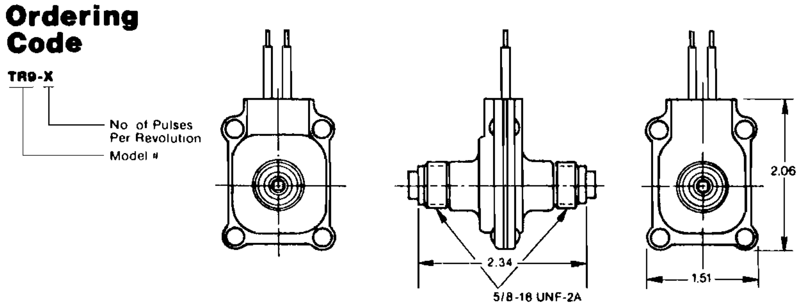
Model No.	**TR8**
Standard Fittings	Input #, 10, 11, 18, 25 Output #, 10, 11, 18, 25, 35
No. of Pulses Per Revolution	2, 4, 6, 8
Wiring Terminations	8" Leads, Special connectors available
Reed Switch	

Ordering Code



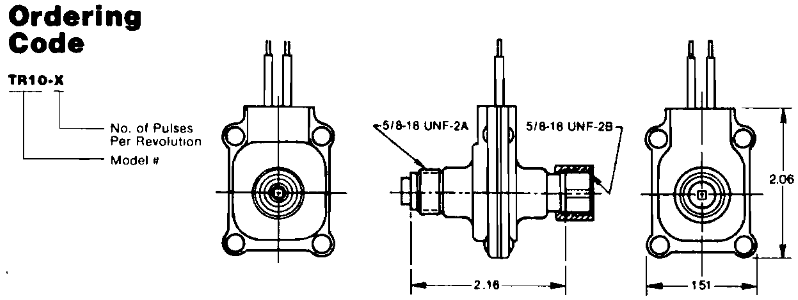
Model No.	**TR9**
Standard Fittings	#35, (Both ends)
No. of Pulses Per Revolution	2, 4, 6, 8
Wiring Terminations	8" Leads
Reed Switch	

Ordering Code



Model No.	**TR10**
Standard Fittings	#35 Input and Output
No. of Pulses Per Revolution	2, 4, 6, 8
Wiring Terminations	8" Leads
Reed Switch	

Ordering Code



Model No.	TR12
Operating Principle	Reed Switch
Standard Fittings	Input Only #10, #11, #18, #25
No. of Pulses Per Revolution	2, 4, 6, 8
Wiring Termination	Burndy 19 Pin Connector MS 3112-E

SPECIFICATIONS

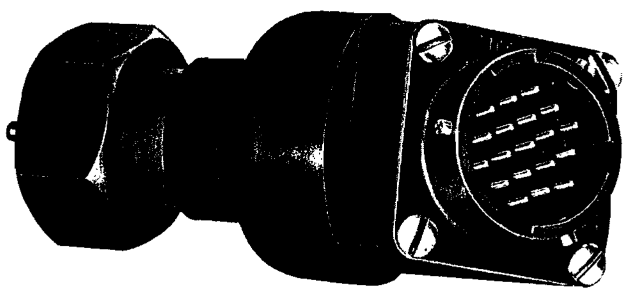
Max. Switching Voltage: 40 VDC
Max. Switching Current:
  0.25 AMPS
Initial Resistance: 0.1 Ohm
Capacitance: 0.2pF
Max. Switching Rate:
  300 Contacts Per Second
Contact Bounce:
  Closing 1.0 Millisecond
Pole Repeatability: 1.0 Millisecond
  @ Speeds up to 5000 RPM

Operating Temperature:
  125° C Maximum
  -40° C Minimum
Wiring: Potted for waterproof requirements internal/exterior through specified connector
Materials:
  Housing - 30% Glass Filled Mondmer Cast Nylon 6
  Fittings - Plated Steel 12 L15
  Bearings - Oilite

TR12 MULTI WIRE CONNECTION

Ordering Code

TR12-XX-X
- No. of Pulses Per Revolution
- Output Fitting
- Input Fitting
- Model #



Model No.	TR14
Operating Principle	Hall Effect
Standard Fittings	Input and Output #10, #11, #18, #25, #35
No. of Pulses Per Revolution	1, 2, 3, 4
Wiring Termination	3 Wires

SPECIFICATIONS

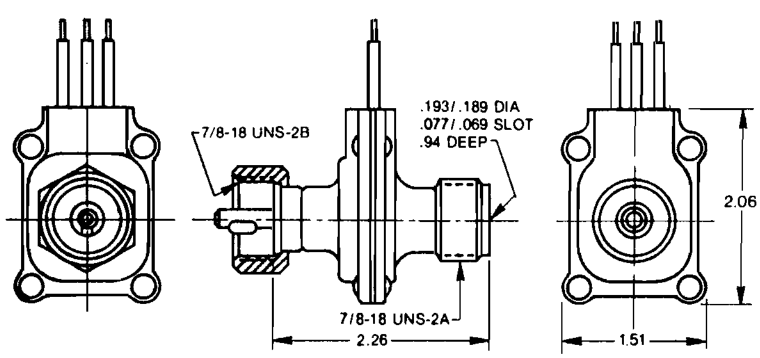
Input Voltage:
  4.5 VDC to 25 VDC

Output:
  45 Milliampheres Maximum
  Peak to Peak
  Constant Amplitude to all Speeds

TR14 HALL EFFECT SPEED SENSOR

Ordering Code

TR14-XX-X
- No. of Pulses Per Revolution
- Output Fitting
- Input Fitting
- Model #



Model No.	TR18/TR18-A
Operating Principle	Optical
Standard Fittings	Input and Output #10, #11, #18, #25, #35
No. of Pulses Per Revolution	1 to 160
Wiring Termination	TR18 4 Wires TR18-A 3 Wires

SPECIFICATIONS TR18/TR18-A

TR18

Outwave Form: Sine Wave
Output Voltage: 6 V. Peak to Peak
Input Voltage: 10 VDC

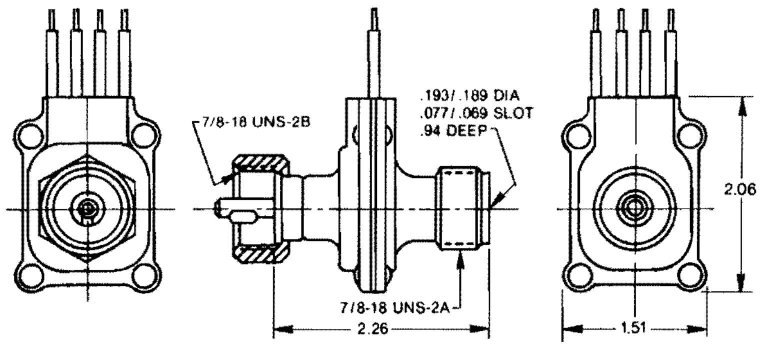
TR18-A

Outwave Form: Square Wave
Output Voltage: Constant 5.1 V Peak to Peak
Input Voltage Range: 5.1 VDC to 24 VDC
Zero Speed Sensing
High Impedance

TR18/TR18-A OPTICAL SPEED SENSOR

Ordering Code

TR18-XX-X
- No. of Pulses Per Revolution
- Output Fitting
- Input Fitting
- Model #



Model No.	TR19
Operating Principle	Magneto
Standard Fittings	Input and Output #10, #11, #18, #25, #35
No. of Pulses Per Revolution	1, 2, 3, 4
Wiring Termination	2 Wires

SPECIFICATIONS

Output:
Self Generating Signal

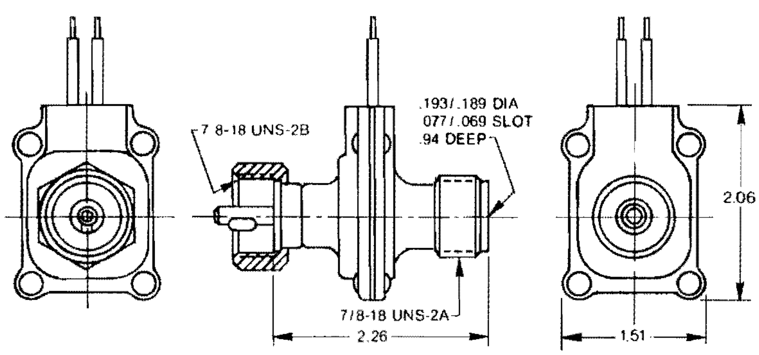
Wave Form:
Each Pulse -
Sine Wave Type Above and Below Ground

Impedance:
30 Ohms

TR19 MAGNETO TYPE SPEED SENSOR

Ordering Code

TR19-XX-X
- No. of Pulses Per Revolution
- Output Fitting
- Input Fitting
- Model #

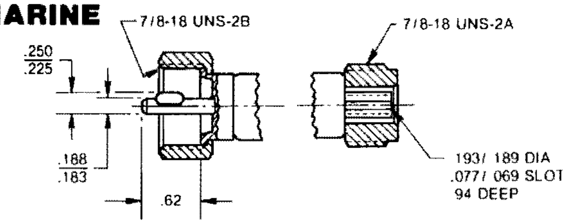


STANDARD FITTINGS

DRIVE TIPS

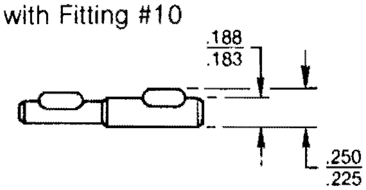
INPUT OUTPUT

FITTING #10
SAE MARINE

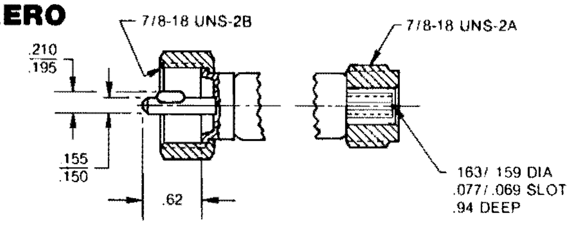


30134
SAE MARINE

Used with Fitting #10

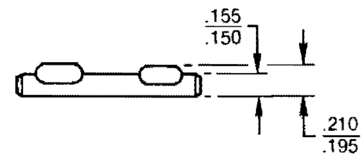


FITTING #11
SAE AERO

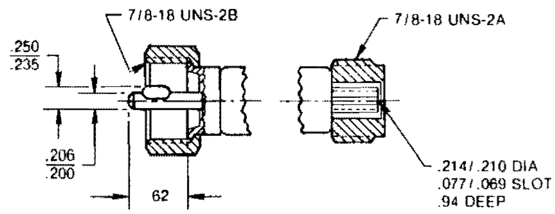


30133
SAE AERO

Used with Fitting #11

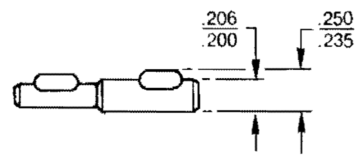


FITTING #18
SAE MARINE HVY

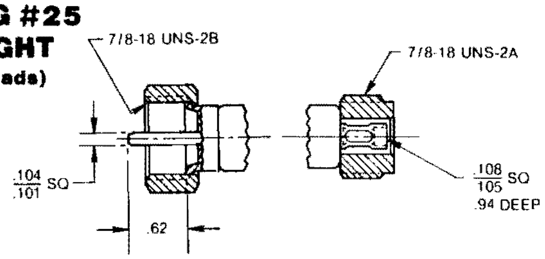


30101
SAE MARINE HVY

Used with Fitting #18

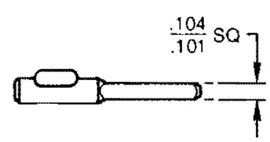


FITTING #25
SAE LIGHT
(7/8" threads)

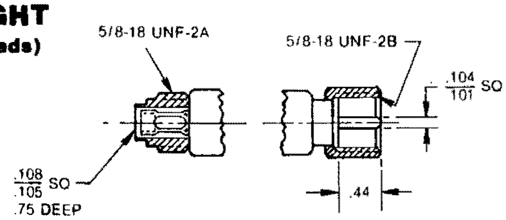


30135
SAE REGULAR

Used with Fitting #25

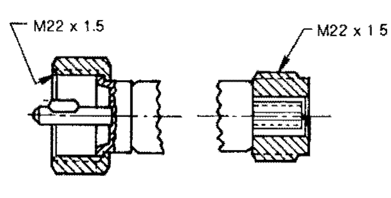


FITTING #35
SAE LIGHT
(5/8" threads)

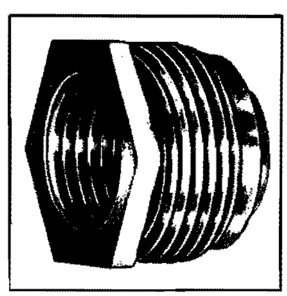


METRIC FITTING

Will accept all input/output drives



THREADED ADAPTER NUT



Available to convert 7/8" threads to 5/8" threads. Order part number 30431.

APPENDIX B

ABBREVIATED PROMPT/RESPONSE

LIST FOR TRIDAQS

Data Acquisition Operation

(After computer reset, press any key in second column of keyboard to initiate)

Prompt	Response
ErASE?	Press "ENTER" to bypass erasing procedure. Enter any nonzero quantity and press "ENTER" to initiate erasing procedure.
FiLE?	Enter nothing, "0", or "1", and press "ENTER" to record on file 1. Enter specific file number and press "ENTER" to record on designated file.
dATE?	Enter date MMDDYY, press ENTER.
drivr?	Enter driver identification number, press ENTER.
vEHCL?	Enter vehicle identification number, press ENTER.
WEATH?	Enter one digit weather code, press ENTER.
PAvET?	Enter one digit pavement code, press ENTER.
STLin?	Enter nonzero starting link number, press ENTER.
FTdiS?	Enter feet/distance pulse factor (0 to ignore), press ENTER.
CLoC?	Enter time of day HHMMSS military time, press ENTER.

Data Transmission Operation

(After computer reset, press any key in third column of keyboard to initiate)

Prompt	Response
FiLE?	Enter nothing, "0", or "1", and press "ENTER" to transmit file 1. Enter specific file number and press "ENTER" to transmit designated file.

APPENDIX C

SEVEN-SEGMENT DISPLAY CHARACTER REPRESENTATIONS

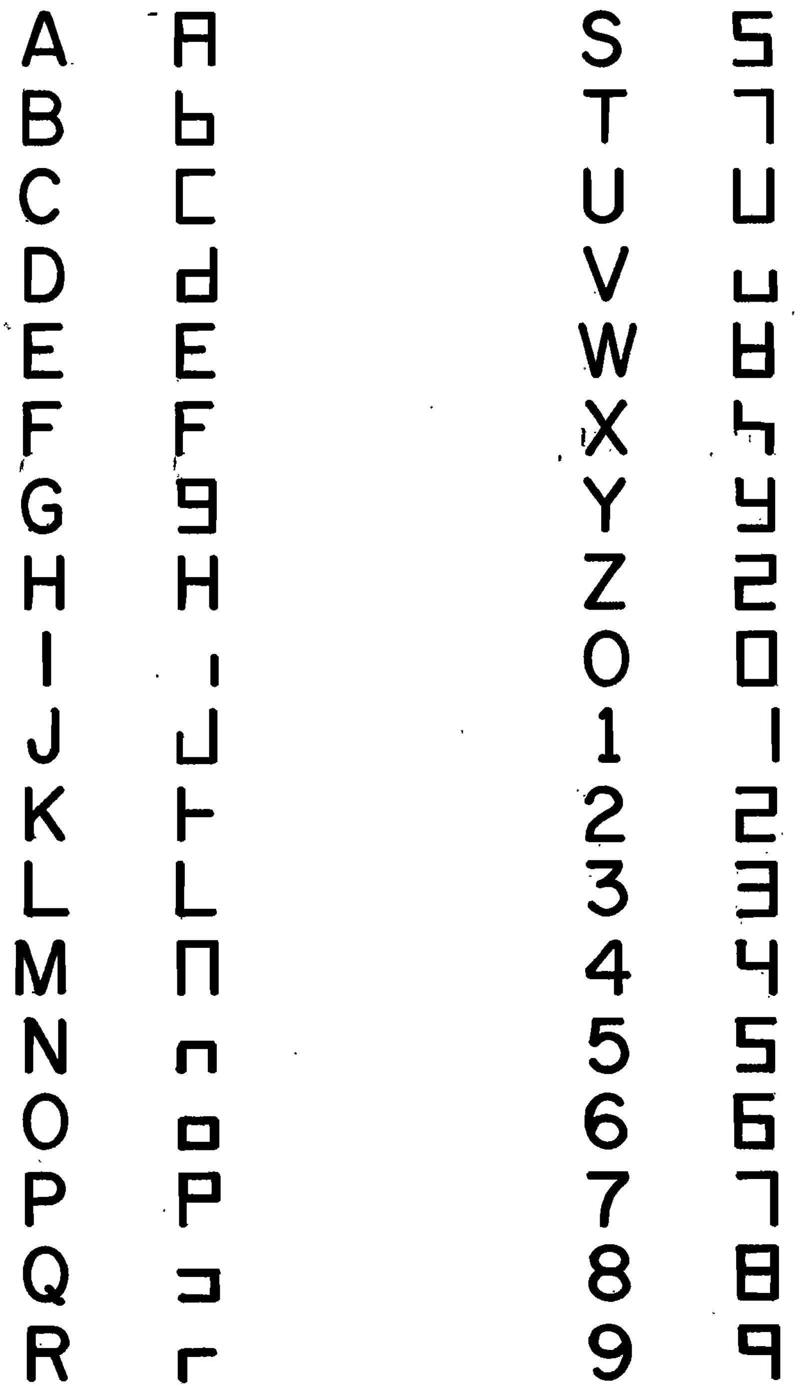


Figure C-1. Seven Segment Display Alphanumeric Characters.

APPENDIX D

ACOUSTIC COUPLER OPERATOR'S MANUAL

VEN-TEL, INC.

OPERATOR'S MANUAL

Ven-Tel
Acoustic Coupler

Models AC103-1, AC103-3
Originate Only
Originate/Answer

September 1, 1978

2360 WALSH AVE. • SANTA CLARA, CALIFORNIA 95050 • (408) 984-2727

Ven-Tel, Inc.

OPERATING PROCEDURES

MODEL AC103-1

Originate Only

1. Remove acoustic coupler from carton and check for any shipping damage.

2. Plug in coupler and turn power switch located on the front to ON position. Power LED will light up.

NOTE

On Originate/Answer Model AC103-3, switch on right front side should be in originate position.

3. Attach EIA or 20Ma current loop cable, normally supplied by the business machine manufacturer or can be obtained from your Ven-Tel supplier, to the 25 pin connector on the back of the coupler. Pin assignment sheets have been provided with the shipment.

4. Set the Half/Full duplex switch, located on the back of the coupler, to correspond with the terminal setting.

SEE ILLUSTRATION

5. Dial up the computer or remote station.

6. Wait for the high pitched tone indicating contact has been made at the CPU end.

7. Firmly place the Western Electric 500 data handset, or equilvalent, into acoustic muffs recognizing the cord end. Carrier LED will light up.

   When using Option "A", D.A.A., pull up on white exclusion key after contact has been made. DO NOT replace handset on telephone cradle. Place next to telephone on the table.

When all data has been completely transmitted or call needs to be terminated, simply remove handset from the coupler and hang up the phone.

Ven-Tel, Inc.

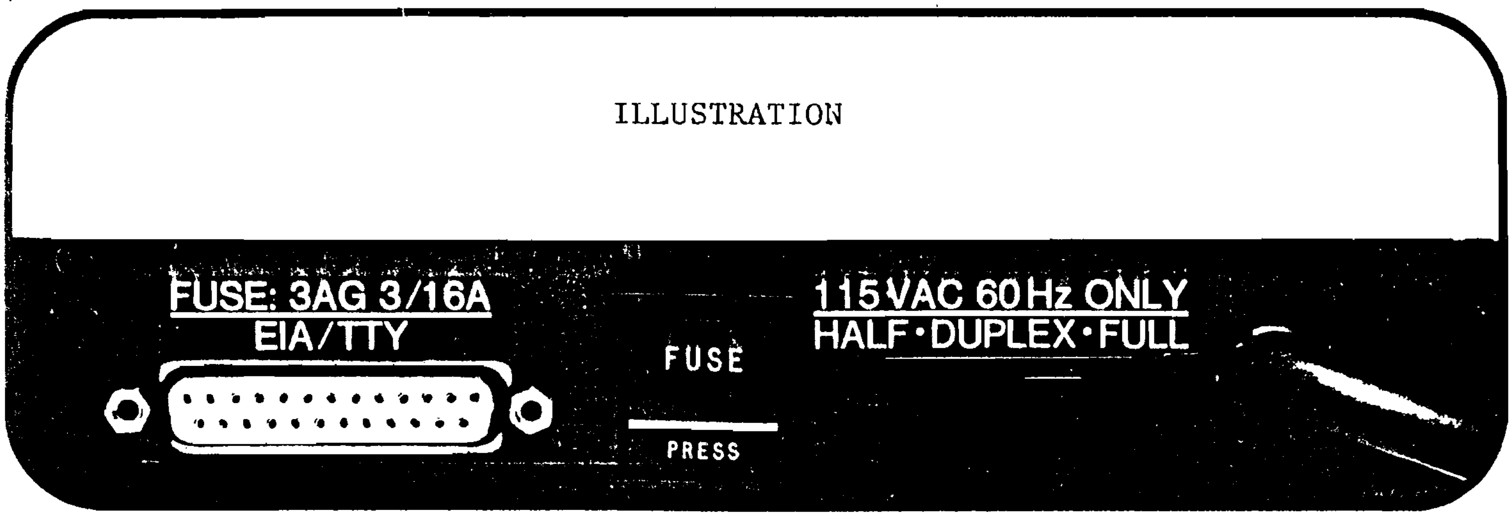
MODEL AC103-3

Originate/Answer

Coupler should be placed in the same operating mode as Originate only steps 1, 2, and 3.

4. When receiving calls from an originating location, firmly place handset into acoustic muffs again recognizing cord end. Push originate/answer switch into answer position. Carrier LED will light up.

The call can be terminated in the same manner as the Originate only model.



The AC103 comes in two model configurations:

MODEL 103-1 — Originate only, half/full duplex, and both RS232C and 20Ma interface
MODEL 103-3 — Originate/answer, switch selectable, half/full duplex, and both RS232C and 20Ma interface

Options available on the above models are:

Option A	DAA for direct connection to telephone lines
Option B	Provides for simultaneous operation of both RS232C and 20Ma interfaces.*

THE MODEL AC103 SPECIFICATIONS

OPERATING MODE

Originate: Half/full duplex, MODEL AC103-1
Originate/answer, MODEL AC103-3

ELECTRICAL

Receiver frequencies:	2225Hz (mark), 2025Hz (space)
Transmit frequencies:	1270Hz (mark), 1070Hz (space)
Sensitivity:	45 dbm ±2
Carrier detect delay:	1.5 sec (on); 150 ms (off)
Data rate:	0 to 30 characters per second (300 bps)
EIA interface:	RS-232C compatible
Current loop:	20Ma
Power input:	115VAC ±20v, 60Hz

INDICATORS

Power on
Carrier detect

ENVIRONMENTAL

Temperature: 40°F to 120°F
Humidity: 10 to 95%

OPERATOR CONTROLS

Power on-off
Half/full duplex (RS232C or 20Ma)
Originate/Answer Switch (AC103-3)
Acoustic/DAA Switch (Option A)

WARRANTY: 1 year factory, parts and labor

CONNECTOR* (Pin Assignmsnts)

EIA PIN #	DESCRIPTION	SYMBOLS
14	Positive pull up	+ transmit
2	Transmit data	BA
3	Receive data	BB
5	Clear-to-send	CB
6	Data-set-ready	CC
7	Signal ground	AB
8	Carrier detect	CF
9	+12 VDC supply	+V
10	−12 VDC supply	−V
13	Receive current loop	20Ma

*Connector cables available on request

PHYSICAL

Size: 10-1/2" x 6-1/4" x 4-1/2"
Weight: 2.5 pounds

W A R R A N T Y

1. Ven-Tel offers a one (1) year parts and labor warranty upon return to factory.

2. Ven-Tel further guarantees a twenty-four (24) hour turn-around time for those items returned to the factory for repair, whether in our out of warranty. If the unit is covered under the warranty, freight out is paid by Ven-Tel, if the unit is out of warranty, the freight out charges are the responsibility of the end user.

3. Out of warranty returns are repaird at a flat rate of $35.00 per Modem (not including freight). Each out of warranty repair is returned with a six (6) month extended warranty.

4. A one (1) year extended warranty is available prior to the expiration of the original 1st year warranty.

5. At this time, Ven-Tel does not offer on-site maintenance. However, any and all components used in the Modems are off the shelf items available from most local electronic distributors.

6. Ven-Tel will provide all technical specifications requested by the State of Texas or any State Agency.

APPENDIX E

COSTS OF TRIDAQS UNIT HARDWARE AND OPERATION

The approximate cost of parts for the TRIDAQS B-2 prototype unit were:

ITEM	COST
SD Sales Z-80 Starter Kit	$ 300.00
Halliburton Aluminum Camera Case	90.00
Machined Face Plate	275.00
Memodyne M-80 Read/Write Cassette Unit	1,845.00
Terminal Strips	6.00
Switches	13.00
Indicator Lights	8.00
Power Supply	100.00
Power Inverter	40.00
Connectors, Plugs, and Jacks	19.00
Miscellaneous Hardware	25.00
Total	$2,721.00

The cost of data acquisition using the TRIDAQS unit is the cost of the driver and floating vehicle over the study section. Further, this cost is related to the number of studies that are conducted on a link. It is expected that the study vehicle would traverse each link a specified number of times for each particular time period under investigation. The travel runs might be associated with a "before" and "after" study, or else could be a series of continuing studies. Thus, the cost of data acquisition for a link is strictly a function of the vehicle and driver costs over that link, multiplied by the number of studies conducted. The use of the TRIDAQS in a vehicle does not increase the operating cost of that vehicle.

The cost of processing these acquired data is related to the long distance telephone charges for telemetering the data to Austin, and the computer time charges for checking, storing, formatting, and printing results. These central computer facility charges are not known at this time. Based on test runs conducted by Texas Transportation Institute on the Texas A&M University Amdahl computer, the estimated processing charge per study would be less than five dollars.

The cost of the MassTech speed sensor described in Chapter III is twenty-five dollars.

APPENDIX F

DETAILED FILE DESCRIPTIONS

A. FT01 File

Raw data is transmitted from the TRIDAQS to the host computer in ASCII format to the FT01 file. Both BCD and binary data is transmitted in this data stream. In the case of binary data, the 8 bit binary data byte is divided into two 4 bit segments and the ASCII equivalent of the 4 bit segment is transmitted, i.e. 0-9 or A-F. The first 23 bytes of data for a study is header information, and it is in BCD. For a study of X seconds duration, the header data is followed by X bytes of binary data where each byte represents the data accumulated by the TRIDAQS in one second. The byte format internal to the TRIDAQS and prior to being sent to the cassette recorder is

Bit 8 (most significant) = event pushbutton indicator

Bits 7-0 = speed sensor pulse count.

Following the last second of data in a study, an end of record indicator of four ASCII G's is present. Following this is a one byte, end around carry binary checksum of the ASCII representation of all the header data and one second study data, excluding the four G's. Following the checksum there will be either the header information for a successive study or else an end of file indicator of at least eight H's.

The raw data file is read under format control.

The general record format of the raw field data as it appears in FT01 is:

Byte #	Data Represented	Item
1	BCD	Month digit 1
2	BCD	Month digit 2

Byte #	Data Represented	Item
3	BCD	Day digit 2
4	BCD	Day digit 2
5	BCD	Year digit 1
6	BCD	Year digit 2
7	BCD	Hour digit 1
8	BCD	Hour digit 2
9	BCD	Minute digit 1
10	BCD	Minute digit 2
11	BCD	Second digit 1
12	BCD	Second digit 2
13	BCD	Link number digit 1
14	BCD	Link number digit 2
15	BCD	Link number digit 3
16	BCD	Link number digit 4
17	BCD	Link number digit 5
18	BCD	Link number digit 6
19	BCD	Weather code digit 1
20	BCD	Weather code digit 2
21	BCD	Pavement code digit 1
22	BCD	Pavement code digit 2
23	BCD	Driver number digit 1
24	BCD	Driver number digit 2
25	BCD	Driver number digit 3
26	BCD	Driver number digit 4

Byte #	Data Represented	Item
27	BCD	Driver number digit 5
28	BCD	Driver number digit 6
29	BCD	Vehicle number digit 1
30	BCD	Vehicle number digit 2
31	BCD	Vehicle number digit 3
32	BCD	Vehicle number digit 4
33	BCD	Vehicle number digit 5
34	BCD	Vehicle number digit 6
35	BCD	Calibration counts digit 1
36	BCD	Calibration counts digit 2
37	BCD	Calibration counts digit 3
38	BCD	Calibration counts digit 4
39	BCD	Calibration counts digit 5
40	BCD	Calibration counts digit 6
41	BCD	Calibration distance digit 1
42	BCD	Calibration distance digit 2
43	BCD	Calibration distance digit 3
44	BCD	Calibration distance digit 4
45	BCD	Calibration distance digit 5
46	BCD	Calibration distance digit 6
47	Binary	Study data for second #1 (upper half)
48	Binary	Study data for second #1 (lower half)
49	Binary	Study data for second #2 (upper half)
50	Binary	Study data for second #2 (lower half)

Byte #	Data Represented	Item
51	Binary	Study data for second #3 (upper half)
52	Binary	Study data for second #3 (lower half)
.	Binary	.
.	Binary	.
m	Binary	Study data for last second of study
m+1	Binary	Study data for last second of study
m+2	-	"G"
m+3	-	"G"
m+4	-	"G"
m+5	-	"G"
m+6	Binary	Checksum (upper half)
m+7	Binary	Checksum (lower half)
m+8		*
m+9		* Month, day, year
m+10		* and hour data for
m+11		* next study
m+12		* -OR-
m+13		*
m+14		* 8 H's denoting end of file
m+15		*

B. FT02 File

This is the link dictionary which contains the landmark information for annotating the printout with feature names for roadway location, and for determining sub-link locations within a study. In this instance, a sub-link is the intersection-to-intersection roadway segment in a street system, or the overpass-to-overpass, interchange-to-underpass, or similar feature identification in a freeway system.

The link dictionary is read and written without format control.

The format of the link dictionary is

Byte #	Item
1- 4	Link number
5- 6	Control number
7- 8	Section number
9-10	Milepoint number
11-14	Distance in feet
15-30	Name of landmark

C. FT03 File

This is the calibration dictionary which contains the calibration data for each vehicle that is being used to collect data. Study data cannot be processed for a vehicle that has not been calibrated. Updates to the calibration dictionary are automatically generated by program PROCESS whenever new calibration information is encountered during normal processing.

The calibration dictionary is read and written without format control.

The format of the calibration dictionary is

Byte #	Item
1 - 4	Vehicle number
5 - 8	Calibration counts
9 -12	Calibration distance

Byte #	Item
13 -14	Month of calibration
15 -16	Day of calibration
17 -18	Year of calibration

D. FT04 and FT10 Files

Each study is represented by a group of 128 byte records. Since study lengths vary, the records are padded with one or more -1's to complete the record. Fortran access to each record is by a 2-byte integer array dimensioned 64, such as defined by the Fortran statement

```
INTEGER*2 DATA (64) .
```

Each study has a fixed section of header information, followed by the actual study data. FT04 and FT10 are read and written without format control.

The record format for preprocessed studies and the raw data master file is:

Byte #	Item
1- 2	Month
3- 4	Day
5- 6	Year
7- 8	Hour
9-10	Minute
11-12	Second
13-14	First 2 digits of link number
15-16	Second 2 digits of link number
17-18	Third 2 digits of link number
19-20	Weather code
21-22	Pavement code

Byte #	Item
23-24	First 2 digits of driver number
25-26	Second 2 digits of driver number
27-28	Third 2 digits of driver number
29-30	First 2 digits of vehicle number
31-32	Second 2 digits of vehicle number
33-34	Third 2 digits of vehicle number
35-36	First 2 digits of calibration counts
37-38	Second 2 digits of calibration counts
39-40	Third 2 digits of calibration counts
41-42	First 2 digits of calibration distance
43-44	Second 2 digits of calibration distance
45-46	Third 2 digits of calibration distance
47-48	First second of study data
49-50	Second second of study data
51-52	Third second of study data
.	.
.	.
.	.
127-128	Forty-first second of study data*

* Note: All two byte quantities following the last second of the study will be -1, until a 128 byte record is completed. The number of records is completed. The number of records representing a study is the integer of

$$\frac{\text{study length in seconds} + 23}{64} + 1.$$

E. FT11

The study summary file is augmented each time program PROCESS processes a new study and obtains the statistics for that study. It is used as input to program STATPLT when the aggregate statistics for a link are compiled. FT11 is read and written without format control. There are a minimum of 2 records per study. The first record is a header record, which is followed by the summary statistics for the entire study. If link dictionary entries are present for the link, then summary statistics will follow for each of the segments defined along the link. Thus, a study without link dictionary entries will generate 2 records in the study summary file, and a study with 8 sublinks defined in the link dictionary will generate 10 records.

The format of the study summary header record is

Byte #	Item
1- 4	Link number
5- 8	Measured study length in feet
9-12	Number of records following
13-16	Month
17-20	Day
21-24	Year
25-28	Hour
29-32	Minute
33-36	Second
37-40	Driver number
41-44	Vehicle number
45-48	Weather index
49-52	Pavement index
53-56	Vehicle pulse factor
57-60	Study length as defined by link dictionary

The format of both the total study and segment (if present) records is

Byte #	Item
1- 4	Distance (feet) for entire study or segment
5- 8	Travel time in minutes
9-12	Stop time in minutes
13-16	Percentage stop time
17-20	Travel time in minutes/mile
21-24	Average speed in miles per hour
25-28	Mean velocity in feet/second
29-32	Velocity noise in feet/second
33-36	Mean acceleration in feet/second/second
37-40	Acceleration noise in feet/second/second
41-44	Mean velocity gradient
45-48	Greenshield's Index
49-52	Number of stops
53-56	Number of stops per mile
57-58	Control number
59-60	Section number
61-62	Milepoint number
63-78	Landmark name

APPENDIX G

TRAFFIC FLOW QUALITY PARAMETERS, RELIABILITY AND USE

As shown in Figure 7, a number of traffic flow quality parameters are printed out for an individual study. A subset of these parameters is included in the printout for combined studies (Figure 8). A description of each traffic flow quality parameter and associated data items follows:

DIST(FT)

This is the distance traveled (in feet) by the vehicle during the course of the study. This quantity is derived from the speed sensor pulses, which occur at the approximate rate of one each 0.88 foot. This is very accurate distance measure which, through the calibration procedure, can produce an exceptionally high accuracy for precision distance measurements.

TRVL TIME(MIN)

This is the number of minutes in the study.

STOP TIME MIN

This is the time in minutes during the study that the one-second distance traveled is less than or equal to 5 feet.

PCT STOP TIME

The percentage stop time is calculated by the stopped time (as defined above), divided by the study length (in minutes), and multiplied by 100.

TRVL TIME/MI

This is the average number of minutes to traverse a mile during the study.

AVG SPD MPH

This is the average speed in miles per hour during the study.

MEAN VELOCITY (FT/SEC)

This is the average speed in feet per second during the study.

VELOCITY NOISE

This is the standard deviation of the velocity (feet/second) as expressed by

$$\sqrt{\frac{\sum_{i=1}^{M} (\Delta V_i)^2 - \frac{\left[\sum_{i=1}^{M} \Delta V_i\right]^2}{M}}{M-1}}$$

where ΔV is the one-second velocity in feet/second

and M is the number of seconds in the study.

MEAN ACCELERATION (FT/SEC/SEC)

This is the average acceleration as expressed by

$$\frac{\sum_{i=1}^{M-1} (\Delta V_{i+1} - \Delta V_i)}{M}$$

where ΔV is the number of feet traveled during a one-second time slice

and M is the number of one-second time intervals during the study.

ACCELERATION NOISE

This is the standard deviation of the acceleration (feet/second/second/ as expressed by

$$\sqrt{\frac{\sum_{i=1}^{M-1} (\Delta V_{i+1} - \Delta V_i)^2 - \frac{\left[\sum_{i=1}^{M-1} (\Delta V_{i+1} - \Delta V_i)\right]^2}{MM}}{MM-1}}$$

where M is the number of one-second time intervals during the study

and MM is the number of one-second time intervals reduced by 1 for each (ΔV_{i+1}, ΔV_i) pair that is zero.

MEAN VEL. GRAD

The mean velocity gradient is the acceleration noise divided by the mean velocity. The acceleration noise computation for this parameter is

$$\frac{\sum_{i=1}^{M-1} (\Delta V_{i+1} - \Delta V_i)^2 - \frac{\left[\sum_{i=1}^{M-1} (\Delta V_{i+1} - \Delta V_i)\right]^2}{M}}{M-1}$$

where M is the number of one-second time intervals during the study.

Note that this is different from the primary computation of acceleration noise as previously defined in that a zero (ΔV_{i+1}, ΔV_i) pair is not treated as a special case.

GREENSHIELDS INDEX

This is an index of the quality of traffic flow as proposed by Bruce D. Greenshields. It is based on the premise that the higher the average speed within practical limits, the more satisfactory the flow. Conversely, the more turbulent or uneven the flow as measured by the change of speed per mile and the number of changes, the less satisfactory is the flow. The expression may be stated as

$$Q = \frac{S}{\Delta_s f}$$

where Q is the quality of flow,
S is the average speed,
Δ_s is the speed changes per mile, and
f is the frequence of speed changes per mile.

The Greenshields Index produced by the program is uncorrelated with actual traffic conditions and seems to have substantial fluctuations. Some correlation studies and sensitivity adjustments would be useful in applying this index to SDHPT needs.

NO. OF STOPS

A stop is defined as 3 consecutive seconds during which the distance traveled each second was less than or equal to 10 feet, providing that at least 5 seconds (not necessarily consecutive, and each with distance traveled greater than 10 feet) have elapsed since the last stop was recorded.

STOPS PER MILE

This is the number of stops divided by the number of miles in the study.

Reliability of Results

The reliability of results is a matter of interpretation of the term "reliability," coupled with an appreciation of the sampling requirements of the traffic stream. For example, for a given study of one mile length, the printout reflects exactly the travel quality experienced by the floating vehicle within its travel space. The distance traveled should be accurate to within a foot, and the average speed is correspondingly exact. Yet, this single study could not be deemed a reflection of traffic flow on that link except between the time the study started and the time it ended.

The question arises, then, as to how many studies are to be conducted over a given link to obtain an average that is indicative of traffic flows on that link? Time of day, day of week, day of year, weather and pavement conditions, and other factors are to be considered. These topics are beyond the scope of this document. For a good discussion on the number of travel time were required to achieve statistically sound results, the reader is referred to a monograph entitled "Minimum Number of Travel Time Runs Required to Obtain Statistically Significant Results." This is Staff Report No. 51.06 by D. S. Terry, Victor L. Hernandez, and S. S. Taylor, Bureau of Traffic Research, Department of Traffic, City of Los Angeles. The report is dated May 21, 1971.

Use of Results

Typically, the TRIDAQS Unit is used wherever it is necessary to monitor the quality of traffic flow, and where that measurement can be satisfied by means of a series of travel time runs performed by a floating vehicle. Naturally, a number of studies must be made on a link to obtain representative results as described above. The frequency with which these groups of studies are made is dependent on the purpose of the investigation. A "before" and "after" study would obviously require two groups of studies. Bottleneck evaluation would require only one series, while threshold monitoring of flows might dictate periodic studies for trend analysis. Groups involved in traffic operations and planning would be the most likely to utilize the results of travel time studies performed with the TRIDAQS unit.

APPENDIX H

RECOMMENDATIONS FOR FURTHER RESEARCH AND ENHANCEMENTS

The TRIDAQS unit is a prototype model that has been very useful for developing the hardware and software for an automated travel time and data reduction system. The following recommendations are made for further work in this area:

1. The displays should be liquid crystal for easier daytime viewing, and have an alphanumeric capability.
2. The physical size of the unit needs to be smaller.
3. The recent availability of protable computers is a significant event. The first generation of portable computers can be more properly characterized as transportable. These systems require hefty power supplies and close proximity to a power outlet. New advances in very large scale integration complimentary metaloxide semiconductor (CMOS) technology are paving the way to lightweight battery-operated computers that can be carried and used anywhere. The TRIDAQS uses the Z-80 microprocessor chip, and CMOS versions of this chip are just becoming available. Recently announced handheld computers using this technology are the Canon X-07, the Sanyo HHC, the Lexicon LEX-31, and the Anthena I. Many more products along this line can be expected shortly.

   Several other lap computers utilizing CMOS technology are the NEC PC-8201A and the Radio Shack Portable 100 (both use the 80C85 microprocessor chip, compatible with the venerable 8080), the Epson HX-20 (which uses the Hitachi-made 6301 microprocessor), and the Xerox 1810 portable.

   Development work should now be directed toward a simple interface to receive speed sensor and pushbutton inputs, and transmit these to a portable computer in the RS-232 format for auxiliary keypad, capable of being operated without visual reference, would be used to generate the pushbutton inputs. The QWERTY keyboard of the portables will also be necessary to input location and route information in the field, while the vehicle is stopped. Not only will this be useful in conducting travel time studies, but also it will be useful in conducting "training" runs over study routes to pinpoint landmarks and their distances for purposes of network definition. A study should be made of the various lap computers on the market and selected brands should be tested for suitability in the vehicle environment.

4. Data recording should be done in memory rather than on tape. Plug-in CMOS memory packs allow any quantity of data to be collected. For the relatively small quantities of data that are acquired during travel time studies, it should be no problem to accumulate these data with nominal memory capacities.

5. A single event pushbutton is insufficient for special studies. An additional six event pushbuttons are proposed for the TRIDAQS as shown in Figure H-1. The total of 7 pushbuttons and 7 bits of distance data would require 2 bytes of data to be recorded per second. For a 32K memory, this would still allow 4.5 hours of data to be recorded.

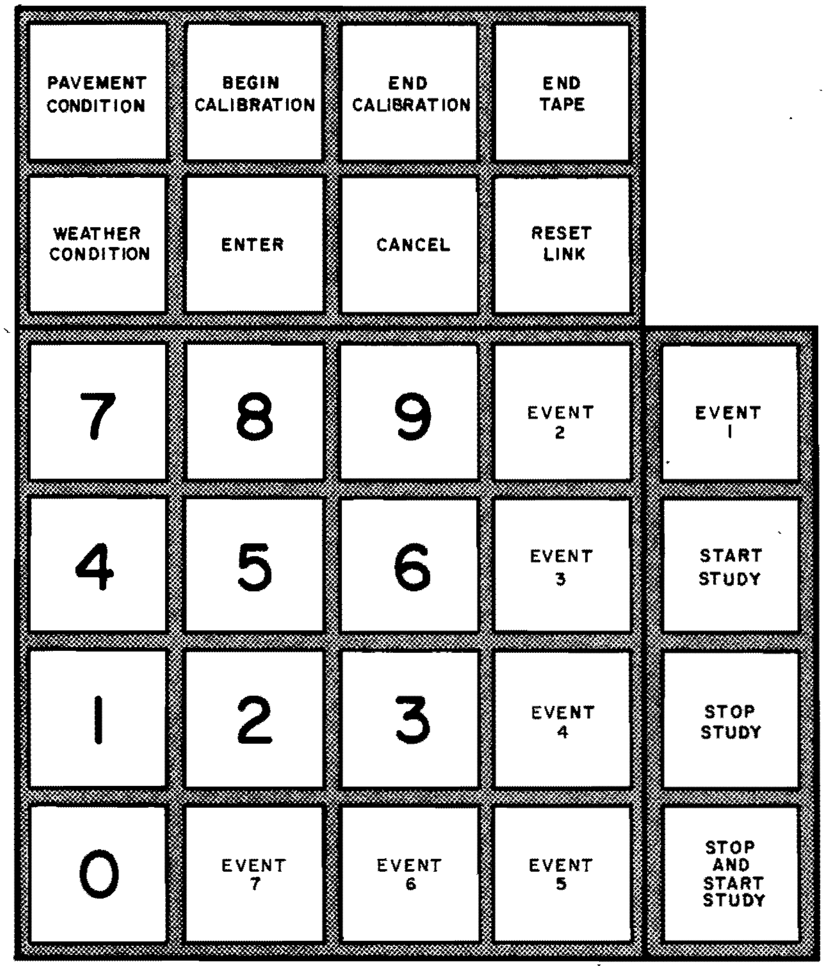


Figure H-1. Proposed TRIDAQS Keyboard Layout

6. The current philosophy of predefining long links will not stand the test of time, for at least 2 reasons. First, different links will eventually have some sub-links in common, or a link may be a sub-link of a link. Second, the proposed traffic database will require information at the network component level, that is, the roadway segments connecting nodes. Here, nodes are considered to be roadway junctions where traffic can enter or exit from more than one direction.

7. It is recommended that a link-node system of data collection be followed. A study, then, will be a run over a series of links. The route that this study follows must be logged either before or after the study is made, and either in the field or office. The point of origination, route, and field data combine to form the data for that study. From this, total flexibility is gained in processing studies and in entering studies in the database. It is essential that the components of the study data be sufficiently detailed so that database queries such as

   WHAT ARE THE AVERAGE OUTBOUND U.S.
   75 SPEEDS BETWEEN LOVERS LANE
   AND SOUTHWESTERN DURING 1700 TO
   1800 WEEKDAYS?

   can be answered by determining which studies have passed over the designated link during the specified time interval. The ability to use the portable computer's keyboard to enter route information will be a benefit.

7. A host computer program should be developed to process a series of short studies which are the result of the first run over a

link to develop landmark and distance information.

8. Some of the low cost, low vocabulary audio input units should be tested as a method for replacing function buttons for controlling data recording.

9. The TRIDAQS program should be modified to edit the date input more accurately. For example, the day of the month should be correlated with the month to reject September 31. Leap years should also be considered. The valid year range should be changed to 84-89.

10. The feet/pulse logic in the TRIDAQS program should be modified to accommodate 4 digits, to make the unit display distances at the same accuracy of the internal measurement.

11. Presently, the event pushbutton is only registered for the first second it is pressed. The TRIDAQS program should be changed to register the duration of time that the button is held down.

12. The TRIDAQS procedure for handling calibration data should be changed, so that a study does not have to be run after a calibration is conducted, for the purpose of forcing parameter recording on tape. A separate data processing procedure should be implemented to handle calibration runs.

APPENDIX I

DATA COMMUNICATIONS DIRECTION

At present, dial-ups to the SDHPT mainframe computer are being discouraged. The trend is to use an IBM compatible microcomputer to receive the Tridaqs data, place it on floppy disk, and forward it to the mainframe (or regional computer) through an SDLC adapter device. This technique is being implemented in research study 421, and reports on progress will be coming from that study.