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16. Abstract

The B-1 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 aquired 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.

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TRAVEL INFORMATION DATA ACQUISITION SYSTEM (TRIDAQS) USERS MANUAL

by

Charles W. Blumentritt

Research Report 269-1F
On Board Vehicle Traffic Parameter Recording System
Research Study Number 2-18-79-269

Sponsored by the 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

March 1981

ABSTRACT

The B-1 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 Study HPR 2-18-79-269 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 cassette tape recorder for the TRIDAQS is 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,

*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.

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.

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I. DESCRIPTION

The B-1 TRIDAQS (Travel Information Data Acquisition System) is the result of Research Study HPR 2-18-79-269 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 National Multiplex Digital Data Recorder, and housed in a Halliburton aluminum suitcase. The unit's single power source is +12 volts DC, intended to be derived from the cigarette lighter receptacle 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, a reset button, and cassette control switches complete the switches on the operation panel, which is generally in the plane of the line of separation betweeen 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 coil-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 initalized, 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. Two external units are required to transform the unit into a data transmission device: 1) a +12 volt DC power supply and 2) an acoustic coupler. The 12 volt power supply serves the power needs of the portable unit (substituting as the automobile cigarette lighter receptacle), and the acoustic coupler links the unit to a standard telephone for transmitting the field data to the large-scale processing

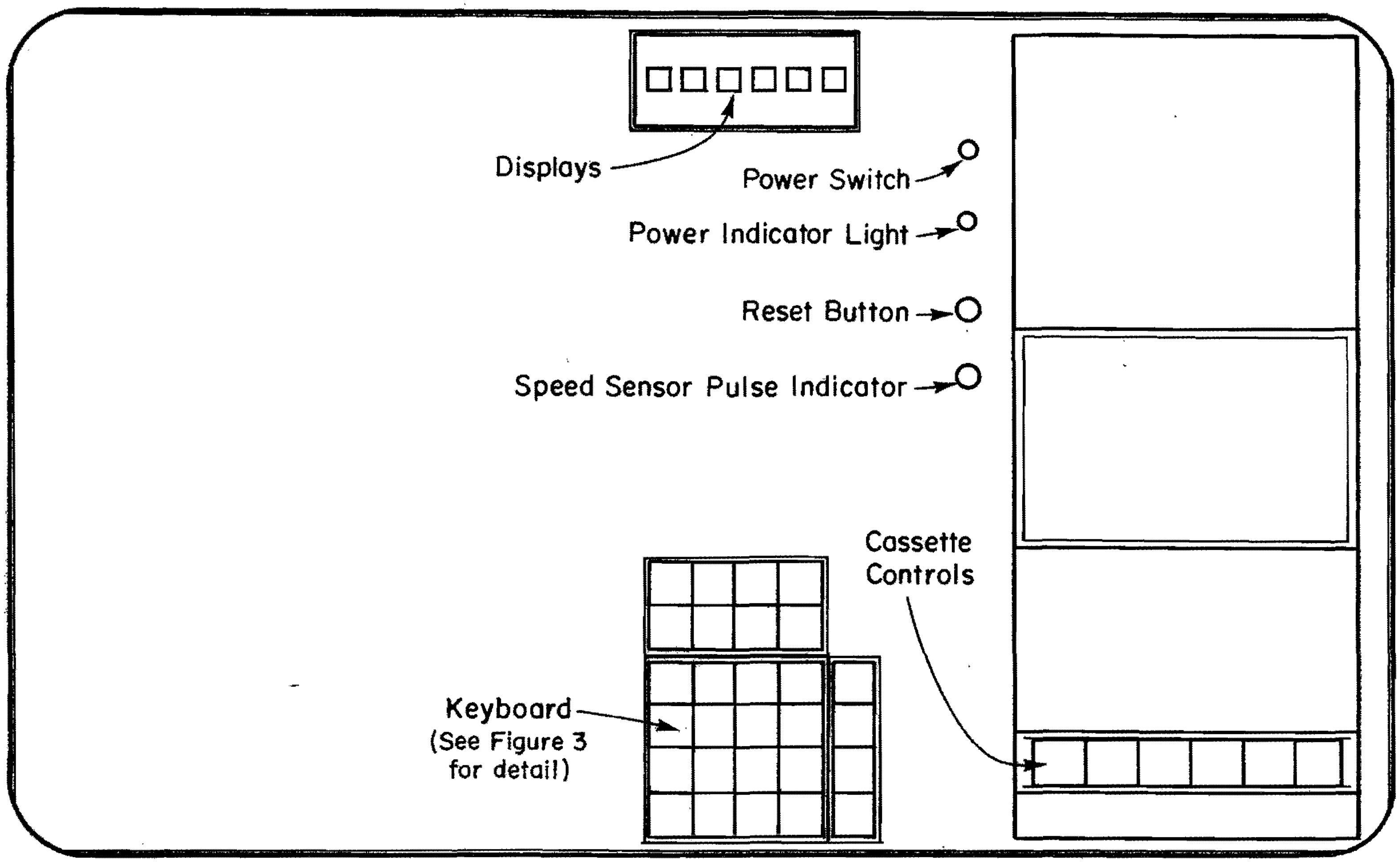

Figure 1 - Front View of Operation Panel.

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 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. Approximately four minutes of travel time data are accumulated within the computer, at which time they are written to the cassette tape. This sequence is repeated during the cumulative time period that studies are in progress.

This is an overview of the background and configuration of the B-1 TRIDAQS. The unit described is a prototype and undoubtedly will be modified as future needs warrant. Specific details of operation are given in Chapters III and IV of this report.

The terms "link" and "study" are used throughout 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.

II. SPEED SENSOR INSTALLATION

The only component of the B-1 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 unit, 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 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, this vehicle will travel the distances noted below:

# Poles	Distances (feet)
2	2.64
4	1.32
6	.99
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-1 TRIDAQS.

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

The microcomputer is programmed for an 8 pole speed sensor. The B-1 will still work with a 4 or 6 pole speed sensor, but the speed- and distance- related information that is displayed on the readouts will be incorrect. The computer printout associated with the final data reduction,

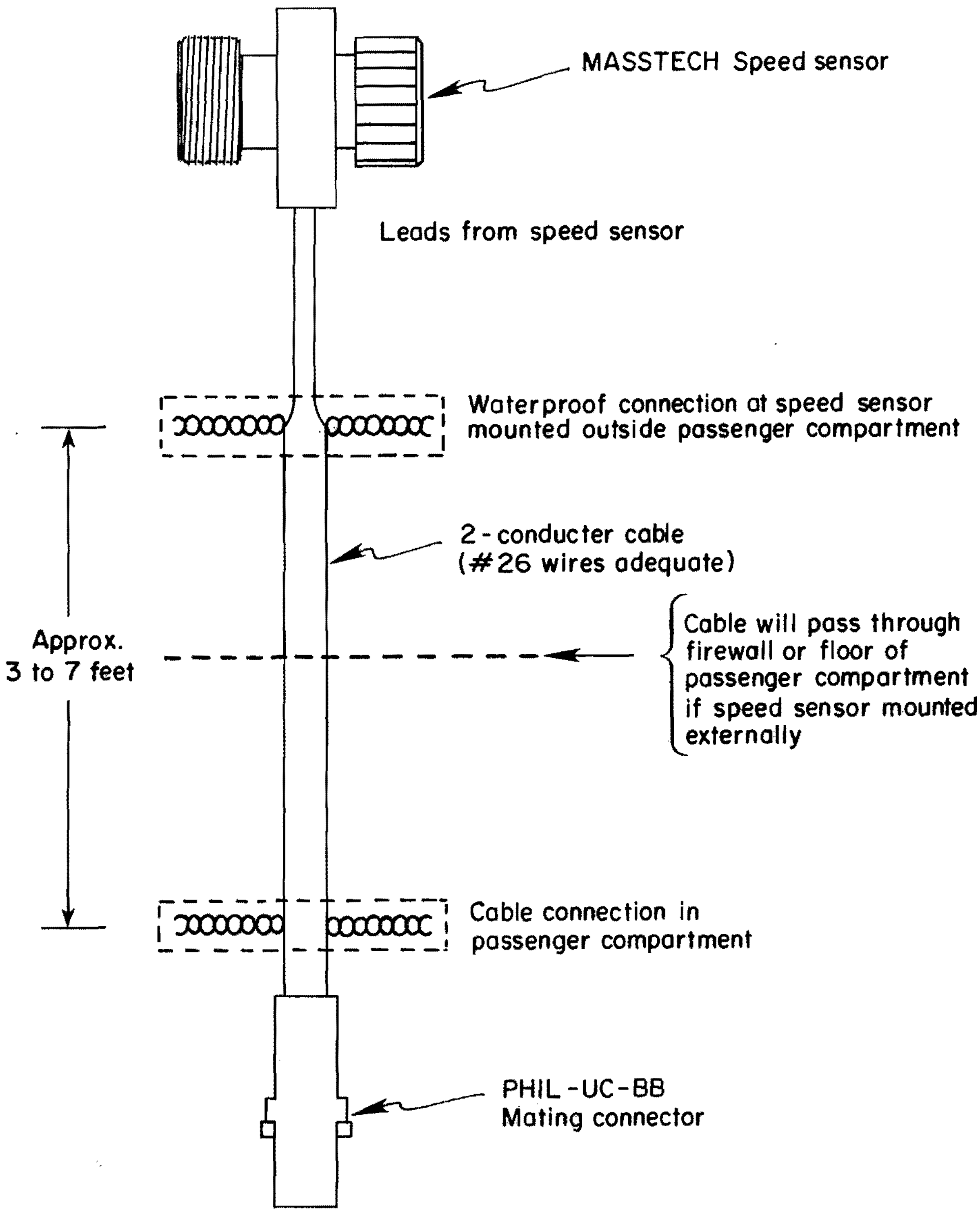

Figure 2. Detail of Wiring to Speed Sensor

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.

III. 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 by using the auxiliary 12 volt power supply. 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. There are two coil-cord cables supplied with the unit. Plug the heavier cable (the power cable) in the connector on the end of the case that is opposite the tape recorder.

c. Plug the other cable (the speed sensor cable) 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 II, Speed Sensor Installation.

e. Plug the power cable into the cigarette lighter receptacle of 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. After the POWER-ON switch is depressed, press the red RESET button to properly initiate operation of the computer. When any keyboard key or the reset button is pressed, an audible beep will be heard as a confirmation of this action.

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 re-appear 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 in 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:

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.

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 not made. Again, the accuracy of the date entered is vitally 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 is the only driver number the computer will not accept.

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 nonzero numeric identifier of up to 6 digits may be used.

WEATHER CODE

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

01 Clear

02 Partly Cloudy

03 Cloudy

04 Rain

05 Sleet

06 Fog

07 Dust

08 Snow.

PAVEMENT CODE

The pavement code is a two-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:

01 Dry

02 Damp

03 Wet

04 Ice

05 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 traversed 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 is 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 may be:

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

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

Ordinarily, additional power-up actions and attendant computer initialization sequences would not have to be followed to enter the new starting link numbers. These would be entered by a numerical command code as described in the Command Code Section. In this first prototype version of the TRIDAQS, however, the feature for entering a new starting link number, at any time other than during the computer initialization sequence, has been omitted. Thus, the driver must go through the computer initialization sequence each time a new link sequence is being initiated. This requires that a new (erased) cassette tape be used each time a new link sequence is initiated. This limitation will be removed when the next version of the microcomputer program is generated.

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 II, the computer is programmed for a speed sensor which produces 8 pulses per revolution of the speedometer cable. Since the U.S. standard for speedometer drives is 1000 revolutions per mile, the computer will detect 8000 pulses per travel mile, or 5280/8000 = 0.66 feet per pulse. This is the basic distance resolution for the TRIDAQS when using an 8 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 of fewer than 8 pulses per revolution (2, 4, and 6 are also available), the above calculations a), b), c), and d) would have a substantial error. Beyond that, a small margin of error might be experienced even with an 8 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 an 8 pulse speed sensor). Certainly, if a 2, 4, or 6 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	0.3%
4	1.32	132	0.8%
6	0.88	88	1.1%
8	0.66	Exists by default.	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 inverserly with the number of pulses per revolution provided by the speed sensor. Referring to the "Resolution of Change" column in the title above, it can be seen that a distance error of at least 1.5% would have to exist before a change to the default parameter of 0.66 would be meaningful. This means a distance error greater than ± 40 feet per mile would have to be experienced before a change from 0.66 to 0.67 or 0.65 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 flows. 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 am would be entered as 090015, and nine seconds before 4:15 pm would be entered as 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 the 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 for alphanumeric characters are given in Appendix C.

Prompt	Response
none	Press "POWER ON" pushbutton switch. The red pilot light will be illuminated if power is present.
none	Press the red "RESET" button. An audible beep will be heard as the button is depressed.
none	Put an erased cassette (has been passed by the tape eraser) in the recorder. If any key of the cassette recorder manual controls is down, press "STOP" on the recorder to disengage that key. Press the "EJECT" lever on the cassette recorder, which will cause the transparent plastic door to swing open. If a cassette is already in the recorder, it will be ejected. If so, remove the previous tape and install the erased tape, either side up, with the exposed tape portion facing the control levers. Snap the new cassette in place and close the door.
none	Press any button in the second column (from the left) of the buttons of the keyboard. These are "BEGIN CALIB," "ENTER," "8", "5" "2" or "F".
Rewind	Press the "REWIND" key on the cassette recorder, followed by pressing "STOP" to cancel the rewind. Minimize the time that the "REWIND" key is down while the tape is not moving, because a belt is slipping on a pulley during this time, resulting in a high-wear situation.

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Beyond this point, the operator will press the "ENTER" key after each response, signaling the computer that an action (either keyboard or non-keyboard) has been taken. In the case of a non-keyboard action, pressing "ENTER" signals the computer to proceed to display the next prompt in sequence. Since the requested action is external to the computer, there is no way for the computer to verify that such action has been taken. In the case of a keyboard action, the computer will verify the reasonableness of the data quantity entered, using a test that is appropriate for the data item. If the computer is expecting a numeric quantity to be entered, pressing "ENTER" in response to the prompt is equivalent to entering a zero quantity.

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Prompt	Response
RdYrEC (Ready Recorder)	Simultaneously depress the "RECORD" and "PLAY" levers of the cassette recorders. This places the unit in record mode, as with a standard cassette recorder. Both levers will remain down for the duration of the data acquisition period.
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., 81 implies 1981). 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 MM=01-12, DD=01-31, or YY=80-89, the date prompt will reappear and the correct date should be entered.

Prompt	Response
DrivEr	Enter a nonzero driver identification number via the keyboard and press"ENTER."
VEhcLE (Vehicle)	Enter a nonzero vehicle indentification number via the keyboard. For Texas state vehicles, this is generally the exempt license plate number. Press "ENTER."
WEATH? (Weather Condition)	Enter a two-digit weather code via the keyboard. Weather codes are 01 Clear, 02 Partly Cloudy, 03 Cloudy, 04 Rain, 05 Sleet, 06 Fog, 07 Dust, and 08 Snow. Press "ENTER."
PAvET? (Pavement Condition)	Enter a two-digit pavement code via the keyboard. Pavement codes are 01 Dry, 02 Damp, 03 Wet, 04 Ice, and 05 Snow. Press "ENTER".
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 digits 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 a calibration run.

D. Keyboard Function Buttons.

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. These 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 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

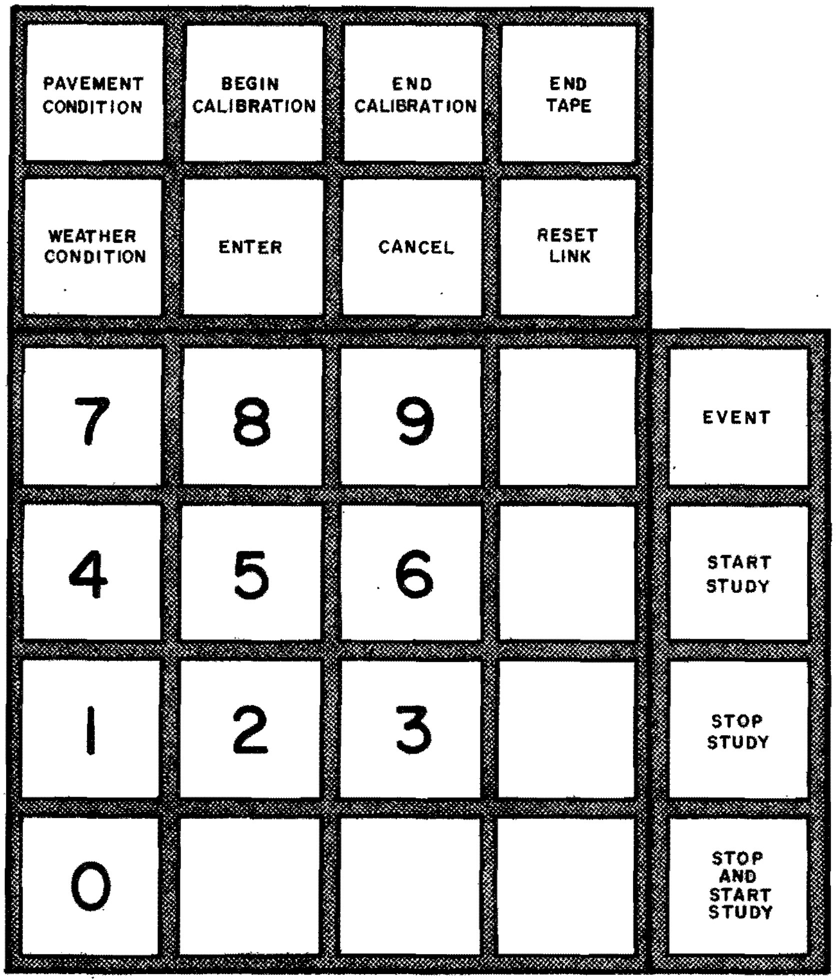


Figure 3 - Keyboard Detail

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.)

The procedure for updating weather and pavement conditions is as follows: Enter a nonzero two-digit code through the keyboard, noting appearance in the two right hand digits of the display. Press PAVMT COND or WEATH COND as appropriate. if more than two digits are specified, only the rightmost two will be accepted. If the code is a zero, then "ERROR" will be displayed. The "ERROR" message can be cleared by either entering a new numeric code or by pressing the "CANCL" key. Valid codes which are interpreted by the data processing computer program in Austin are

Weather Codes	Pavement Codes
01 Clear	01 Dry
02 Partly Cloudy	02 Damp
03 Cloudy	03 Wet
04 Rain	04 Ice
05 Sleet	05 Snow
06 Fog	
07 Dust	
08 Snow	

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 07 (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 the completion of an external operator action in response to a prompt, such as rewinding the cassette tape. Also, 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 they 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 after 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 next 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 (as previously mentioned, the procedure for updating the starting link number is unimplemented at this time).

(d) End Tape

The use of the "END TAPE" key is vital to 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 computer for approximately 4 minutes 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 tape. 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, the "STOP" key on the recorder should be pressed to remove the cassette recorder from the recording mode. 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 keys 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. A record mark, which is used by the data processing program to discern the points of separation between studies.
2. Month
3. Day
4. Year
5. Hour
6. Minute } at instant study begins
7. Second
8. Link number
9. Weather code
10. Pavement code
11. Driver number
12. Vehicle number
13. Calibration counts
14. Calibration distance } generally zero

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

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 256 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 0.66 feet intervals in the case of an 8 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 occurrence of an external event. Its use is not necessary in signalling the passing of landmarks, since the accuracy of the distance measurement surpasses the accuracy of the operator, and the landmark 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. At this time, the event markers are not utilized by the data processing program, but this feature is available for special purposes. 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 run over a measured mile had produced 7,990 distance pulses, then the pulse factor used by the data processing computer in travel distance calculations would be

$$\frac{5,280}{7,990} = .66082603 \text{ feet/pulse.}$$

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. Naturally, 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, preferably 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 ensure 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 an 8 pulse speed sensor, a maximum calibration distance of 124 miles (999,999 distance pulses) is possible with the TRIDAQS.

Periodic calibration runs should be made to compensate for time 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.

Table 1 - Query Codes and Descriptions

Code	Action
00	none
01	Display the date (MMDDYY).
02	Display time of day (HHMMSS; military format).
03	Display elapsed time (HHMMSS) since "START STUDY" or "STOP/START STUDY" function button was pressed.
04	Display distance traveled in hundreths of miles (MMMM.MM) since "START STUDY" or "STOP/START STUDY" function button was pressed.
05	Display distance traveled in feet (FFFFFF) since "START STUDY" or "STOP/START STUDY" function button was pressed.
06	Display current speed in miles per hour (0000MM).
07	Display current speed in feet per second (000FFF).
08	Display last weather code entered (0000XX).
09	Display last pavement code entered (0000XX).
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.

Table 1 - Query Codes and Descriptions (Continued)

Code	Action
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.
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.

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 for a few seconds. As an added measure, press the END TAPE button again after the tape stops moving. This procedure ensures that the last study is written to tape, and that the end of tape signals have been recorded for later use.
2. Press "STOP" on the cassette recorder to cancel the "PLAY" and "RECORD" functions. All cassette controls should now be in the up position.
3. Press "EJECT", remove the data cassette, and place in its protective carrying case. This cassette will be used later during the data transmission phase.
4. Close the plastic door on the cassette unit.
5. Press the red "RESET" button to stop the computer.
6. Press the POWER pushbutton to turn off power.
7. Remove the power plug from the cigarette lighter receptacle.
8. Disconnect the power cable from the TRIDAQS unit.
9. Disconnect the speed sensor cable from the TRIDAQS unit and from the speed sensor connector on the cable that enters the passenger compartment.
10. Stow the power cable and speed sensor cable.
11. Place the protective cover on the TRIDAQS unit and fasten the latches.

IV. 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.

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 auxiliary 12 volt power supply, 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 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 will 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 to 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 should be set at FULL.

d. Plug the main power cord of the auxiliary power supply into the AC receptacle. Slide the power switch to the ON position. The power indicator lamp to the left of the switch should light.

e. Plug the heavy power cable of the TRIDAQS unit into the connector on the end of the case that is opposite the tape recorder. Plug the other end of the cable into the cigarette lighter receptacle attached to the rear of the auxiliary power supply.

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	Press "POWER-ON" pushbutton switch. The red pilot light will be illuminated if power is present.
none	Press the red "RESET" button. An audio beep will be heard as the button is depressed.
none	If any key of the cassette recorder manual control is down, press "STOP" on the recorder to disengage that key.
none	Place the data tape to be transmitted in the cassette unit. All manual controls of the unit are to remain in the upright, or neutral, position.
none	Press any button in the first column (leftmost) of buttons of the keyboard. These are "PAVMT COND", "WEATH COND", "7", "4", "1", or "0".
REWind	Press the "REWIND" key on the cassette unit, followed by pressing "STOP" immediately as tape motion ceases. Press the "ENTER" function button on the keyboard.
RdyPLA (Ready Playback)	Depress the PLAY lever on the cassette unit.

- - - - -

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. Immediately press "ENTER" on the keyboard.

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.

c. At this point, the conversation between the computers is entirely automatic. The gist of this private 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, the first 5 digits of the display will be blank, and the last (rightmost) 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 the 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 a checksum error of a cassette tape data block. Digits 3 and 4 are parity error counters, incremented each time a parity error is sensed for a data character within a 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.

(9) (Cont'd.)

All three 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. It is recommended that the tape head be cleaned between trials. If errors cannot be cleared up, treat the resulting data as suspect.

D. Terminating Data Transmission.

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

1. Remove the telephone handset from the acoustic muffs and hang up.
2. Press "STOP" on the cassette unit, followed by "EJECT". 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, and press the "POWER" pushbutton switch to turn off power.
4. Switch the acoustic coupler power switch to the "OFF" position.
5. Slide the power switch on the auxiliary power supply to the "OFF" position.

D. Terminating Data Transmission (Cont'd.)

6. Disconnect the Amphenol connector (attached to the cable to the acoustic coupler) from the TRIDAQS unit.
7. Disconnect the TRIDAQS power cable from the cigarette lighter receptacle on the auxiliary power supply, and also from the connector on the TRIDAQS unit itself. Store the power cable.
8. Place the protective cover on the TRIDAQS and fasten the latches.

V. ROUTINE OPERATIONS

A. Cleaning the Cassette Recording Head.

The cassette recording and erase heads should be cleaned daily prior to making studies. A supply of cotton swabs and liquid head cleaner (available commercially, or use rubbing alcohol) should be kept in the vehicle. Press the "EJECT" button on the recorder and remove the cassette to gain access to the heads.

B. Erasing Tapes.

While the cassette recorder has an erase head, it is inadequate to totally erase a previously recorded tape. For this reason, all used tapes, once their contents have been telemetered to Austin and verified by the data processing program, should be erased by a bulk tape eraser. Depending on the style of bulk tape eraser, this will involve either slowly moving the eraser past the tape, or vice versa. Exercise proper caution in operating the bulk tape eraser at a location remote from tapes that are not intended to be erased, as well as distant from the TRIDAQS unit. To prevent possible damage from the strong magnetic field, it is recommended that a wristwatch not be worn while operating the bulk tape eraser.

C. Audio Monitoring of Data.

There is a volume control on the cassette unit, yet it does not affect the recording or playback levels of the digital data. It's use however, is a convenient check on operation of the TRIDAQS.

During data acquisition, the volume should be fully advanced to confirm by audible means that data are being recorded at approximately 4 minute intervals. Additionally, the operator will learn to detect the associated sounds of various vehicle speeds as reflected by a continuous tone of varying frequency during data recording bursts. Otherwise, the operation of the unit is entirely silent and unconfirmed.

During data transmission, the volume control should be set at a level which is not distracting in the office environment. A similar sound of recorded data is experienced as with vehicle use, except the sound reflects the data as they are being read from tape. The transmission of data occurs at a speed approximately fifteen times that at which it is acquired. Thus, one hour of recorded data will require approximately 4 minutes to transmit. During the data transmission sequence, there will be several periodic tape reads. The uniform period of these tape reads can be audiby monitored to verify that data transmission errors are not occurring.

APPENDIX A

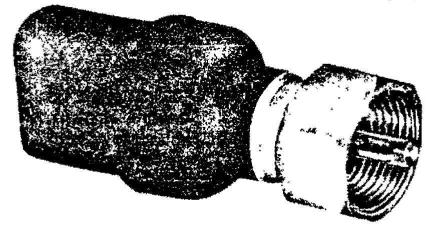
SPEED SENSOR DATASHEET

yellow jacket

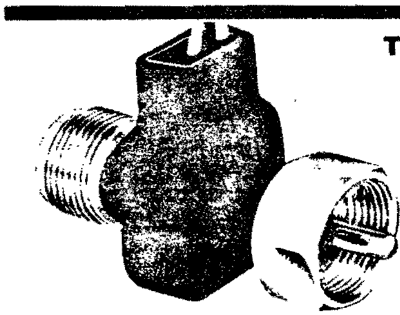
The YELLOW JACKET family . . . A complete line of low-cost speed sensors for driving electric tachometers, speed switches and other speed controlled or speed actuated devices.

- Positive sensing to zero speed
- Operating principle using magnetic actuated reed switch
- Choice of 2, 4, 6, 8 pulses -on and off- per input revolution
- Available with full range of SAE engine and transmission connections

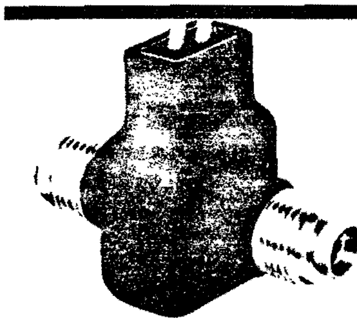
TR7



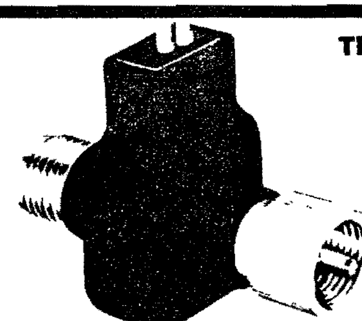
TR8



TR9



TR10



MassTech

Division of
Curtis & Marble Corporation
Telephone (617) 791-8118
80 Cambridge St., Worcester, Mass. 01603

TYPICAL SPECIFICATIONS

Maximum Switching Voltage:
40 VDC

Maximum Switching Current:
.25 Amps

Initial Resistance:
.1 Ohm

Maximum Switching Rate:
800 Contacts/second

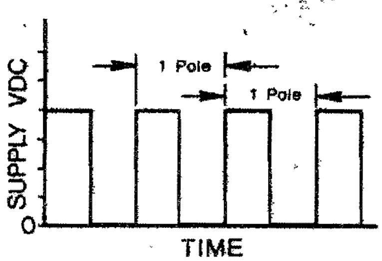
Materials:
Housing - Glass-filled nylon
Fittings - Plated steel
Bearings - Oilite

Wiring:
Potted for waterproof requirements (except TR7 selected with blade terminals)

Operating Temperature:
To 280° F.

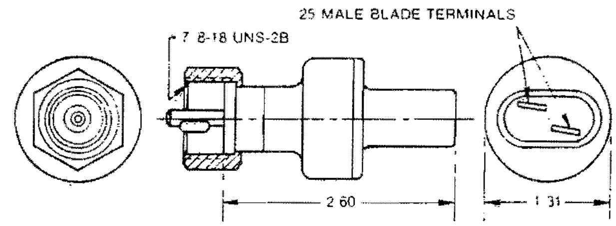
Pole Repeatability:
±3%

Pole Definition:

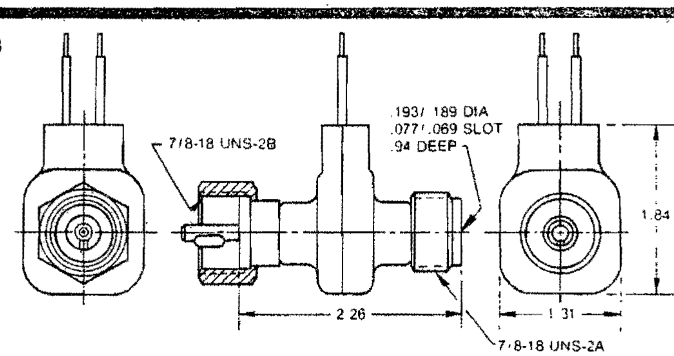


MODEL

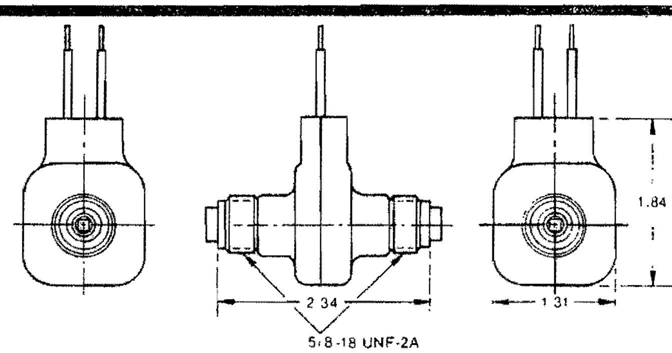
TR7



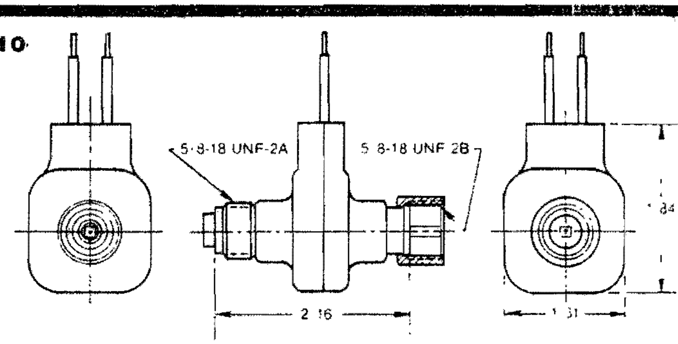
TR8



TR9



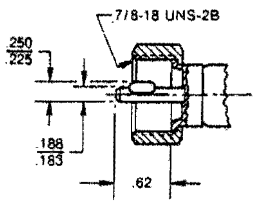
TR10



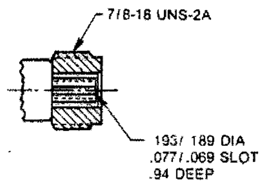
ORDERING CODE	STANDARD FITTINGS (See next page)	NO. OF POLES OF MAGNET	WIRE TERMINATIONS	REMARKS
TR7-XX-XX Wire Termination No. of Poles of Magnet Standard Fitting Model #	#10, #11, #18, #25	2, 4, 6, 8	Blank - 1/4" Blade Terminals A - 8" Leads B - 12 ' 2-Conductor Leads	TR7 For direct connection to standard engine or transmission fittings
TR8-XX-X No. of Poles of Magnet Output Fitting Input Fitting Model #	Input: #10, #11, #18, #25 Output: #10, #11, #18, #25, #35	2, 4, 6, 8	8" Leads	TR8 For direct connection to standard engine or transmission fittings where flexible shaft continuation is necessary
TR9-X No. of Poles of Magnet Model #	#35 Input (Both ends)	2, 4, 6, 8	8" Leads	TR9 For splitting speedometer or tachometer cables with union nuts on both ends
TR10-X No. of Poles of Magnet Model #	#35 Input and Output	2, 4, 6, 8	8" Leads	TR10 For mounting direct to speedometer or tachometer fittings

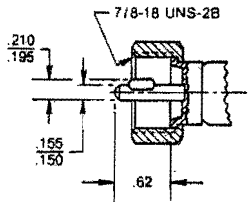
STANDARD FITTINGS

INPUT | **OUTPUT**

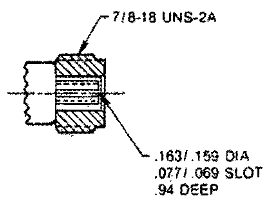


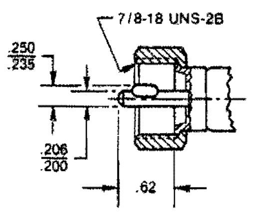
FITTING #10
SAE MARINE



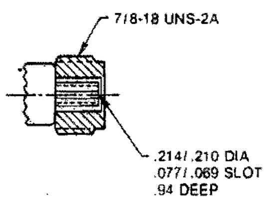


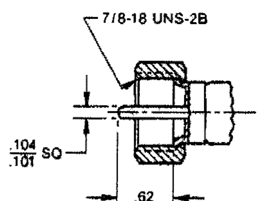
FITTING #11
SAE AERO



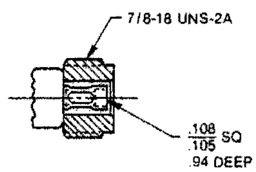


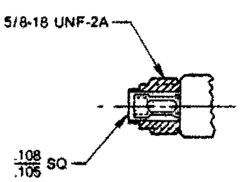
FITTING #18
SAE MARINE HVY



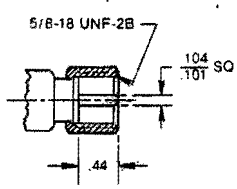


FITTING #25
SAE LIGHT
(7/8" threads)



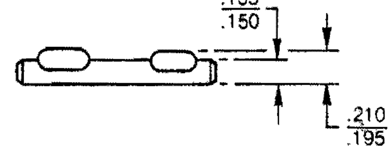


FITTING #35
SAE LIGHT
(5/8" threads)



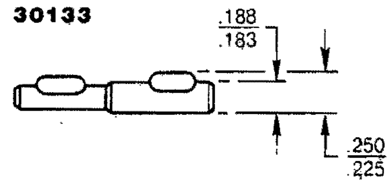
DRIVE TIPS

30134



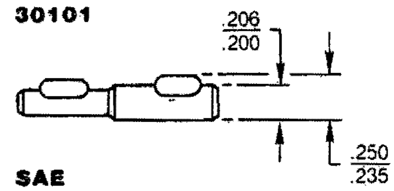
SAE MARINE - Used with Fitting #10

30133



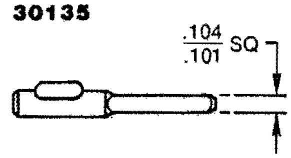
SAE AERO - Used with Fitting #11

30101



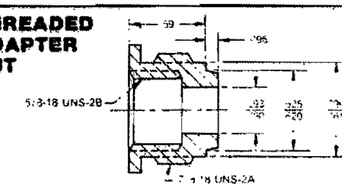
SAE
MARINE HVY - Used with Fitting #18

30135

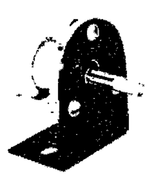


SAE REGULAR - Used with Fitting #25

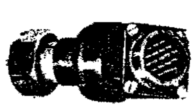
THREADED ADAPTER NUT



Used to convert from 5/8" to 7/8" threads, i.e., using nut, Model TR-8-2535 can be used with either thread system.



Base Mount



Multi-Wire Connection

OPTIONS

Special mounts and wiring connections are available for your requirements. Consult MassTech.

MassTech
Division of
Curtis & Marble Corporation
Telephone (617) 791-8118
80 Cambridge St., Worcester, Mass. 01603

APPENDIX B

ABBREVIATED PROMPT/RESPONSE LIST FOR TRIDAQS

ABBREVIATED PROMPT/RESPONSE LIST FOR TRIDAQS

Date Acquisition Operation

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

Prompt	Response
rEWind	Press cassette REWIND; press STOP immediately when tape stops; press ENTER.
rdyrEC	Simultaneously press RECORD and PLAY on cassette recorder; press ENTER.
dATE?	Enter date MMDDYY, press ENTER.
drivr?	Enter driver identification number, press ENTER.
VEhiCL	Enter vehicle identification number, press ENTER.
WEATH?	Enter two digit weather code, press ENTER.
PAvET?	Enter two 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 first column of keyboard to initiate)

Prompt	
rEWind	Press cassette REWIND; press STOP immediately when tape stops; press ENTER.
rdyPLA	Press PLAY on cassette recorder; press ENTER.

APPENDIX C

SEVEN-SEGMENT DISPLAY CHARACTER REPRESENTATIONS

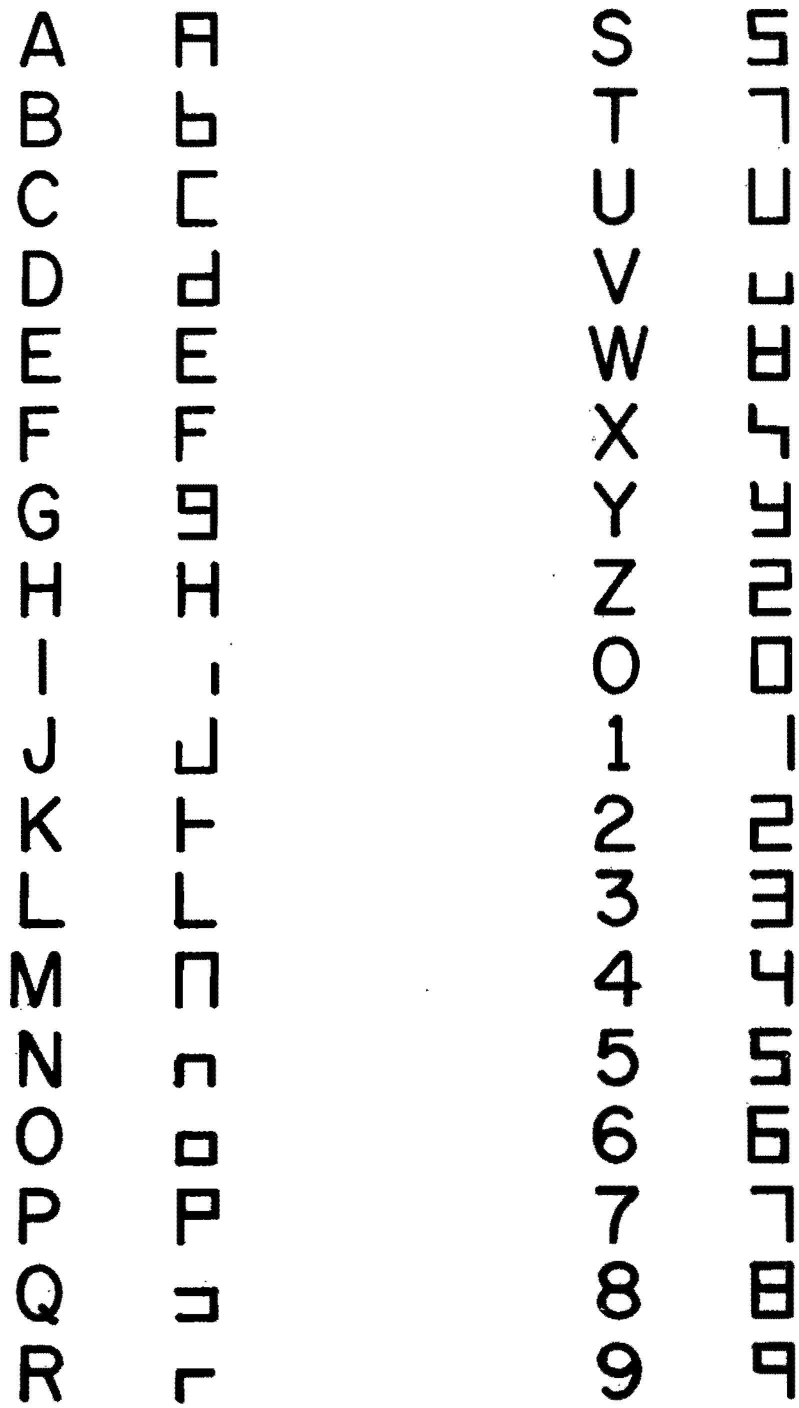


Figure C-1. Seven Segment Display Alphanumeric Characters.

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.

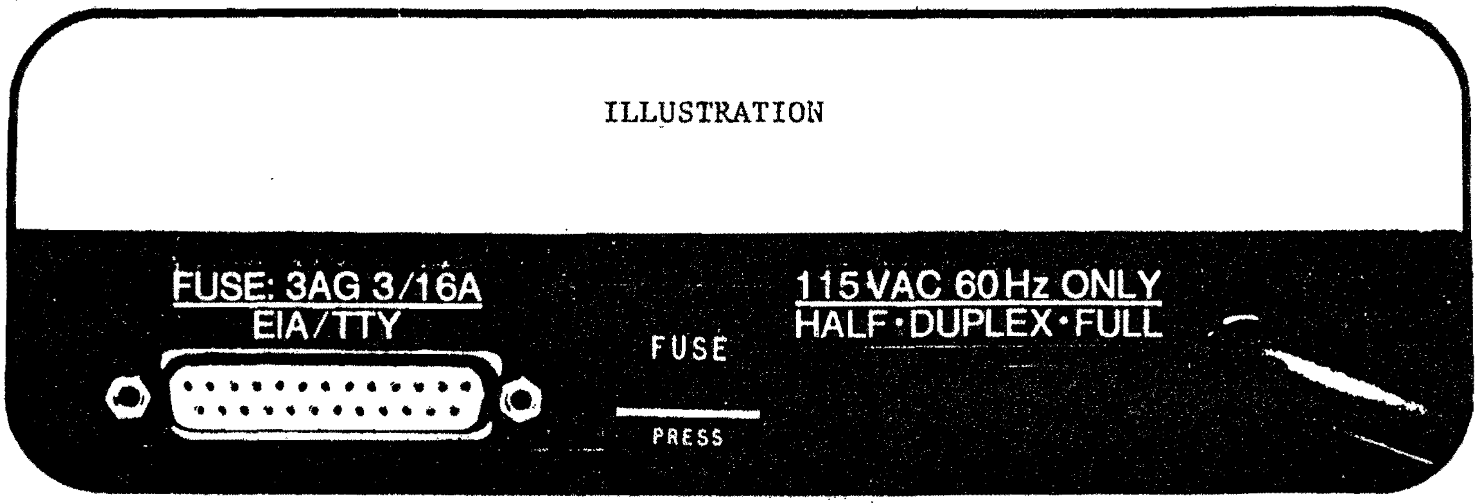
MODEL AC103-3

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 TRIDAQS unit was designed using very low cost components. While this is a prudent course to follow, it can sometimes sacrifice reliability for the lower cost. This was the situation that occurred with the cassette recorder. Therefore, it is recommended that a higher quality digital recorder be utilized. Further comments on suggested changes to the TRIDAQS unit may be found in Appendix H, Recommendations for Further Research.

Approximate cost of parts for the prototype unit were:

ITEM	COST
SD Sales Z-80 Starter Kit	$ 300.00
Halliburton Aluminum Camera Case	90.00
Machined Face Plate	275.00
National Multiplex CC-8 Digital Data Recorder	295.00
Terminal Strips	6.00
Switches	13.00
Indicator Lights	8.00
DC/DC Converter (+12v to $\pm$ 8v)	10.00
Five Volt Regulator and Heat Sink	7.00
Audio Tone Oscillator	11.00
Connectors, Plugs, and Jacks	19.00
Miscellaneous Hardware	25.00
	$1,059.00

The cost of data acquisition using the TRIDAQS unit is the cost of 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 control 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.

APPENDIX F

DATA COMMUNICATIONS AND JOB PROCESSING

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 accessable by the general data processing program. A schematic of this operation is shown in Figure F-1.

The procedures for obtaining printouts at the district terminal have not been finalized at this time. A sample printout obtained from a study conducted during the testing phase is shown in Figure F-2. This is the detailed printout that can be obtained from a single study over a particular link. This level of detail may or may not be useful.

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. For example, the master selection criterion is the link number. For a given link number, none, any, or all of the following criteria may be specified:

Beginning date

Ending date

Beginning time

Ending time

Driver number

Vehicle number

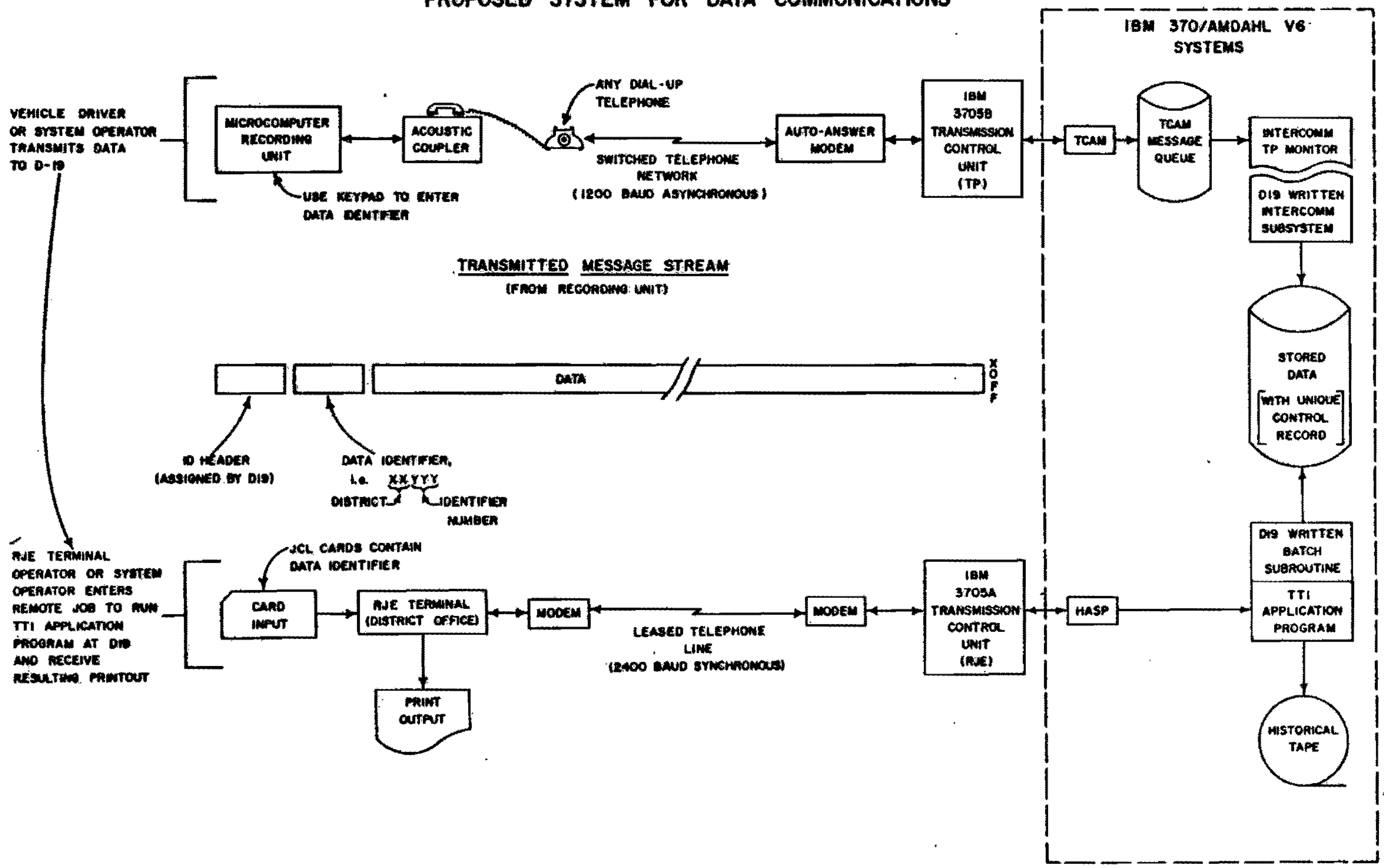
Weather condition

Pavement condition.

An example printout for a combination of six studies is shown in Figure F-3. The direct measurement of fuel consumption is not a feature of the

Figure F-1. **INSTRUMENTED VEHICLE RESEARCH PROJECT**

PROPOSED SYSTEM FOR DATA COMMUNICATIONS



Source: Texas State Department of Highways and Public Transportation

RESULTS FROM TOTAL STUDY LINK 5

STUDY BEGAN 19:49:32 7/ 4/80 PROCESSED 08/27/80 DRIVER 1 VEHICLE 259266 WEATHER CLR 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
12609	4.5	0.2	5	1.9	32.1	47.0	27.7	-0.00	1.95	0.041	231.14	3	1.3

RESULTS BY SEGMENTS LINK 5

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
5415	1.4	0.0	2	1.4	42.9	63.0	18.7	0.93	1.40	0.022	567.60	1	1.0
7149	2.8	0.0	1	2.0	29.5	43.3	26.7	-0.43	2.08	0.048	157.80	1	0.7

CNTL	SECT	MILPNT	LANDMARK
4016	32	23.460	BRIARCREST DRIVE
4016	32	24.500	WASH CREEK BRDG.
4016	32	25.840	UNIVERSTY DRIV.

STUDY LENGTH DISCREPANCY = 43.

Figure F-2. Example Study Printout.

LINK 1 SUMMARY STATISTICS 09/13/79

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

DATE	TIME	DISTANCE (MILES)	TRAVEL TIME MIN	PERCENT STOP TM	TRAVEL TIME/MIL	AVERAGE SPED MPH	MEAN VEL GRADIENT	GREENSHLD INDEX	STOPS /MILE	BRAKES /MILE	FUEL CONSUMPT	VEH DIST DSRP(FT)	STUDY NUMBER
4/ 2/79	622	3.97	7.43	0.0	1.87	32.04	0.03	224.89	0.0	1.76	14.12	306.00	1
4/ 2/79	646	3.96	6.67	0.0	1.72	34.63	0.02	238.24	0.0	2.52	14.18	276.00	2
4/ 2/79	717	3.97	7.83	0.0	1.97	30.40	0.02	237.06	0.0	1.26	14.20	304.00	3
4/ 2/79	746	3.97	9.90	8.00	2.48	24.04	0.04	67.95	1.51	4.79	11.61	294.00	4
4/ 2/79	825	3.96	9.32	6.00	2.35	25.50	0.04	70.60	1.26	3.54	11.89	250.00	5
4/ 2/79	849	3.96	8.62	8.00	2.17	27.58	0.03	133.06	2.78	3.53	13.27	262.00	6

LINK 1 SUMMARY STATISTICS 09/13/79

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

NUMBER OF OBSERVATIONS = 6

	DISTANCE (MILES)	TRAVEL TIME MIN	PERCENT STOP TM	TRAVEL TIME/MIL	AVERAGE SPED MPH	MEAN VEL GRADIENT	GREENSHLD INDEX	STOPS /MILE	BRAKES /MILE	FUEL CONSUMPT	VEH DIST DSRP(FT)
SUM	23.79	49.97	22.00	12.55	174.20	0.19	971.79	5.55	17.41	79.28	1692.00
MEAN	3.96	8.33	3.67	2.09	29.03	0.03	161.97	0.93	2.90	13.21	282.00
ST DEV	0.01	1.16	4.08	0.29	4.05	0.01	81.78	1.14	1.30	1.19	23.08
MIN	3.96	6.67	0.0	1.72	24.04	0.02	67.95	0.0	1.26	11.61	250.00
MAX	3.97	9.90	8.00	2.48	34.63	0.04	238.24	2.78	4.79	14.20	306.00
COFVAR	0.00	0.14	1.11	0.14	0.14	0.27	0.50	1.23	0.45	0.09	0.08

Figure F-3. Example of Combination of Studies Printout.

TRIDAQS unit, and that column of the printout should be ignored. Note that Figure F-3 has asterisks adjacent to all of the selection criteria mentioned above. When a criterion is unspecified, an asterisk is printed. Thus, the printout lists all studies for link 1 regardless of date, time, driver, vehicle, or weather or pavement condition. As a detailed example of the selection process, all studies conducted by driver number 121 in vehicle number 456 on wet pavement under cloudy skies on September 19, 1979 from 8 to 10 am could have been selected.

Using the same criteria, a speed profile plot may be obtained as shown in Figure F-4. This is a plot of the average speed from all previous studies conducted over link 5.

While the general data processing program is functioning for the described activities as of August, 1981, it remains to be made fully operational in the SDHPT District terminal environment. This enhancement is scheduled for the near future.

LINK 5 SUMMARY STATISTICS 08/27/80

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)
[illegible]	1549	2.39	4.47	5.00	1.87	32.08	0.04	231.14	1.26	42.58

SPEED PROFILE PLOT

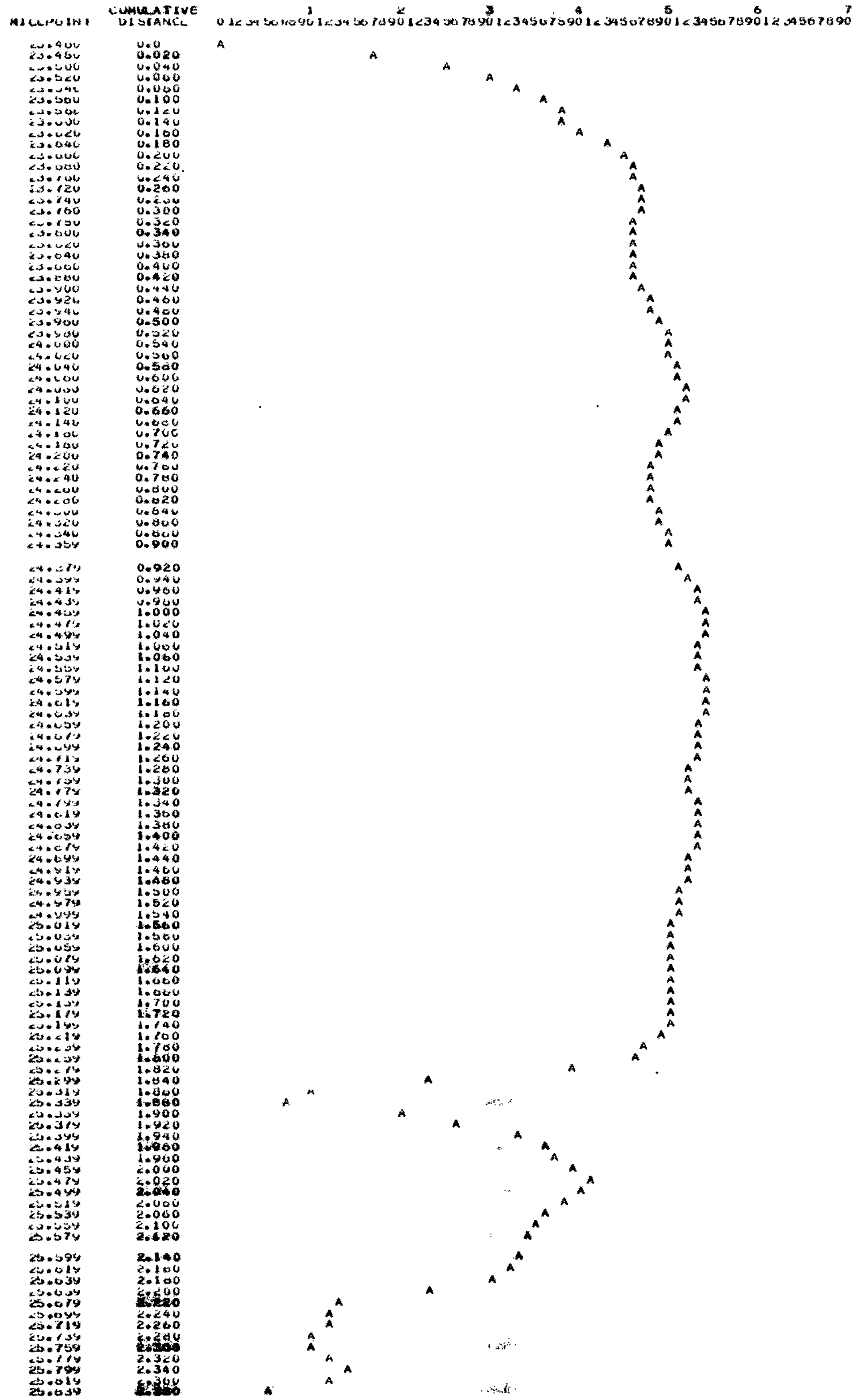


Figure F-4. Example Speed Profile Plot.

APPENDIX G

TRAFFIC FLOW QUALITY PARAMETERS, RELIABILITY AND USE

As shown in Figure F-2 (Appendix F), 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 F-3). 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 0.66 foot. This is a 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. This 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 frequency of speed changes per mile.

The Greenshield 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 TRUDAQS unit.

APPENDIX H

RECOMMENDATIONS FOR FURTHER RESEARCH AND ENHANCEMENTS

The TRIDAQS unit is a prototype model which forms the basis for much improvement. The following is a list of items that apply both to the hardware unit and data processing software:

1. A higher quality digital tape recorder should be utilized. A sacrifice in reliability for this unit is a significant detriment.
2. The displays should be liquid crystal for easier viewing, and have an alphanumeric capability.
3. Considerations should be given to utilizing a large memory, either CMOS or Bubble, and doing away with the tape recorder. In the case of CMOS, a battery backup would be required.
4. The physical size of the unit needs to be reduced from attache case down to that of a Simpson 260 multimeter, which would occupy perhaps 25% of the existing space.
5. The microcomputer program needs various operational enhancements made, such as allowing multiple link sequences without initializing the computer and changing tapes. Also the recognition of calibration parameters is inoperative and needs further debugging.
6. The scale and format of speed profile plots needs updating.
7. Additional maintenance procedures for the master file need to be added to the battery of data processing program.
8. The Z-80 cross assembler used for microcomputer program development could not accommodate the entire program due to symbol table overflow, and a system of transfer vectors was established for communicating between the partitioned programs. Even so, some numeric relative addressing was required to reduce the symbol count. An improved method of obtaining assemblies and resultant PROM programming is needed.

9. The addition of the data transmission capability to the TRIDAQS unit caused the program size to increase to the point that some features had to be deleted. A reorganization of the program is needed to reduce the program size so that other features may be added.

Other suggested enhancements have been mentioned during the discussion of specific topics in this report.