CHAPTER 4
TRAFFIC BEHAVIOR MEASURING EQUIPMENT

4.1 INTRODUCTION

Three basic types of equipment were used to determine vehicle behavior under specific geometric and traffic conditions with regard to speed and changes in speed. The equipment included a radar speed meter, a photographic speed and time recording unit (camera box) which was later replaced by a tape recorder version (recorder box), and a tachograph.

Also used, although in a very limited scale, were the Photo Electric Light Intensity Detector (PELID), for evaluating the effect of dust on traffic behavior, and the Traffic Flow Data Logger, developed to record traffic parameters indicative of congestion effects.

4.2 RADAR

The radar unit used was the TR6 speed radar, manufactured by Kustom Signal, Inc.. Four units were acquired. Three were used in the field and one was kept as a spare. The TR6 system consists of three pieces: Figure 4.1 shows the indicator; Figura 4.2 the antenna and tripod; and Figure 4.3 the power source. The power source was manufactured by the Instrumentation Group using a high-capacity 12-volt truck battery enclosed in a wooden box with carrying handles. The box had an automobile cigar lighter socket to mate with the plug supplied by the radar manufacturer.

4.2.1 *Field Operation*

Since the radar was used in several different traffic behavior experiments, various procedural configurations were used to obtain the particular information wanted. In the case of speed changes while descending or ascending a grade, three mirror boxes were placed down the road from each radar antenna. The mirror boxes were built by the project staff and one is illustrated in Figure 4.4. As the vehicle passed a mirror box (Figure 4.5), the observer noted the speed on the radar readout (Figure 4.6) and then recorded the vehicle's speed. In this way nine points on a grade could be monitored with three radar sets. In

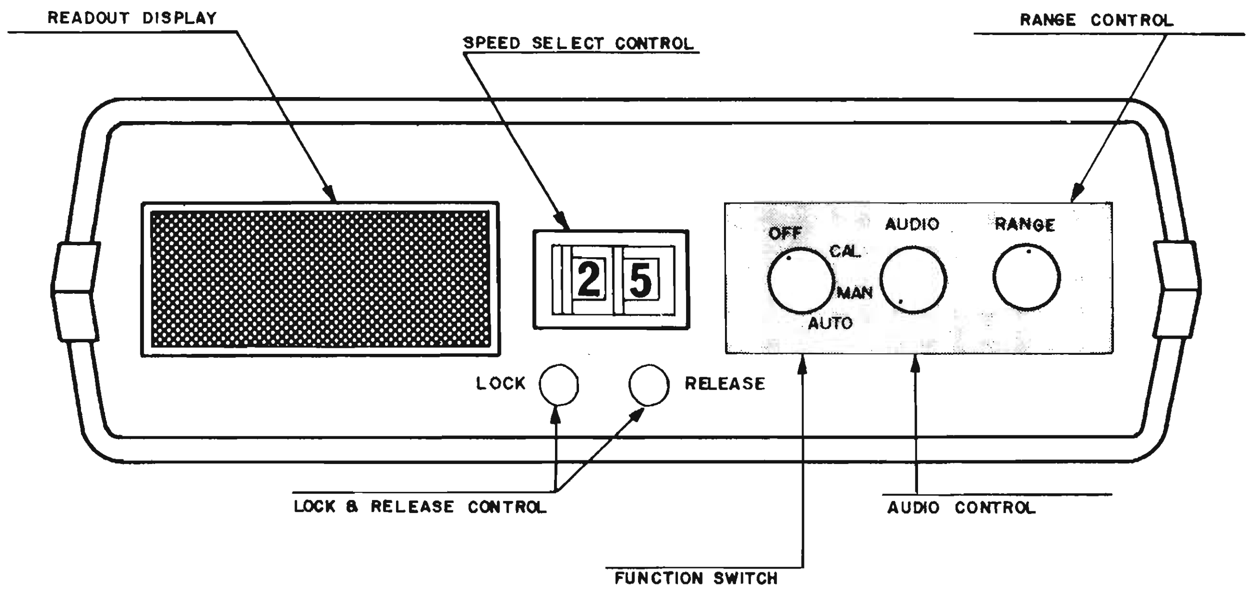

FIGURE 4.1 - RADAR PANEL

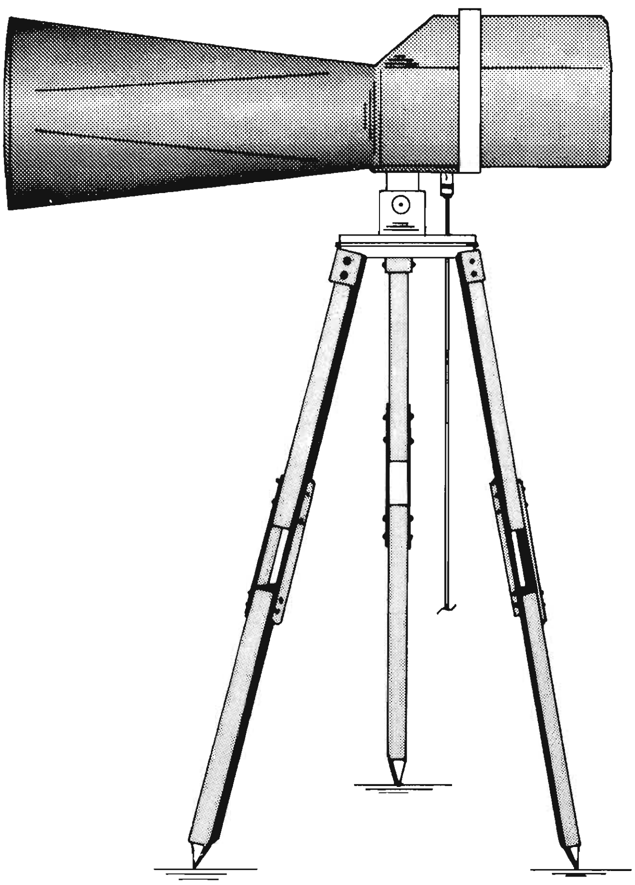

FIGURE 4.2 - RADAR ANTENNA

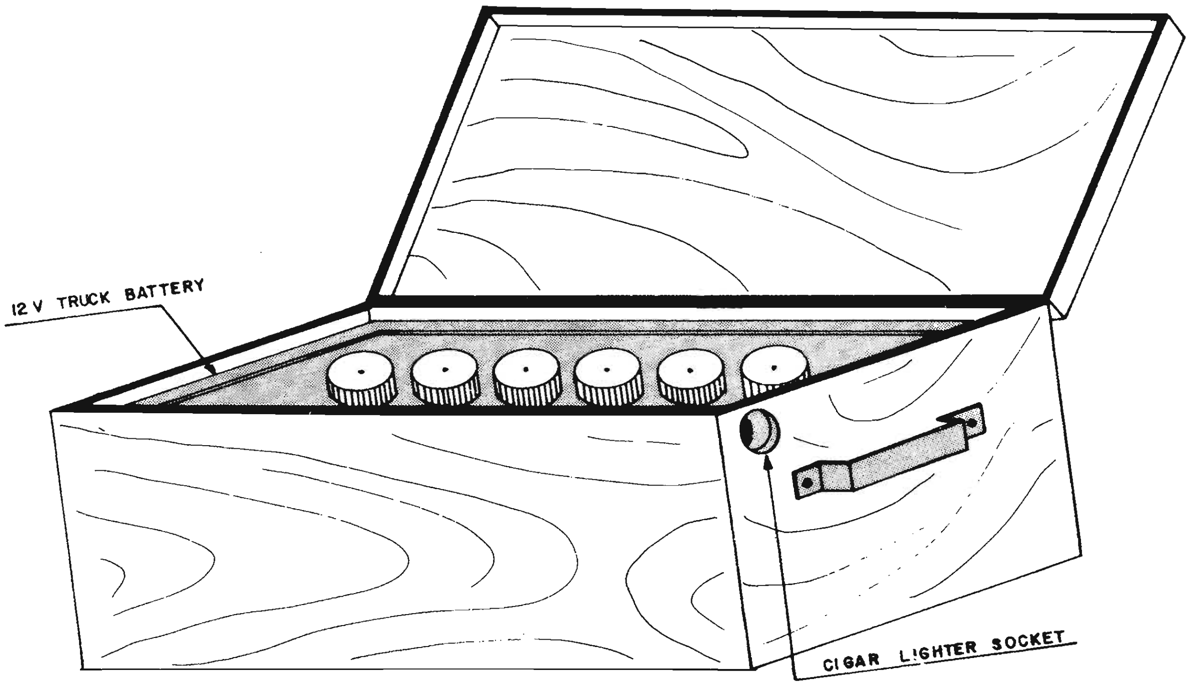

FIGURE 4.3 - RADAR POWER SOURCE

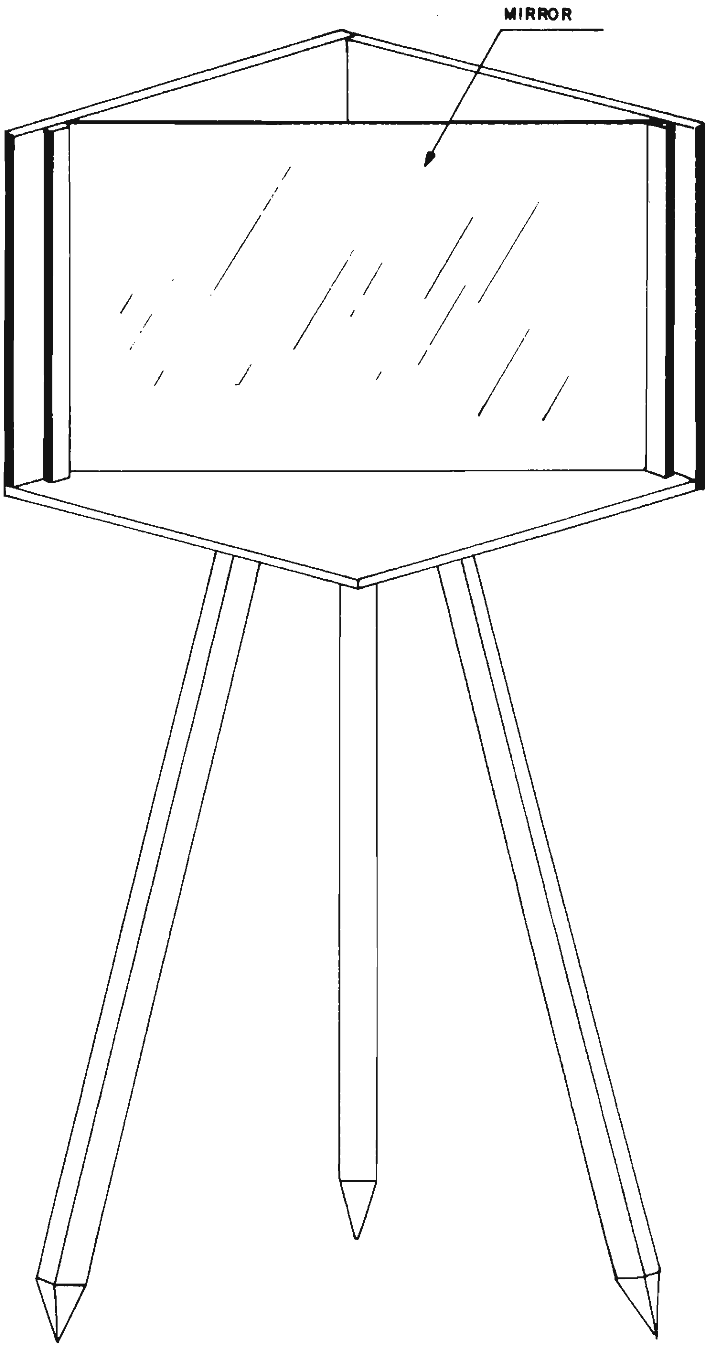

FIGURE 4.4 - MIRROR BOX

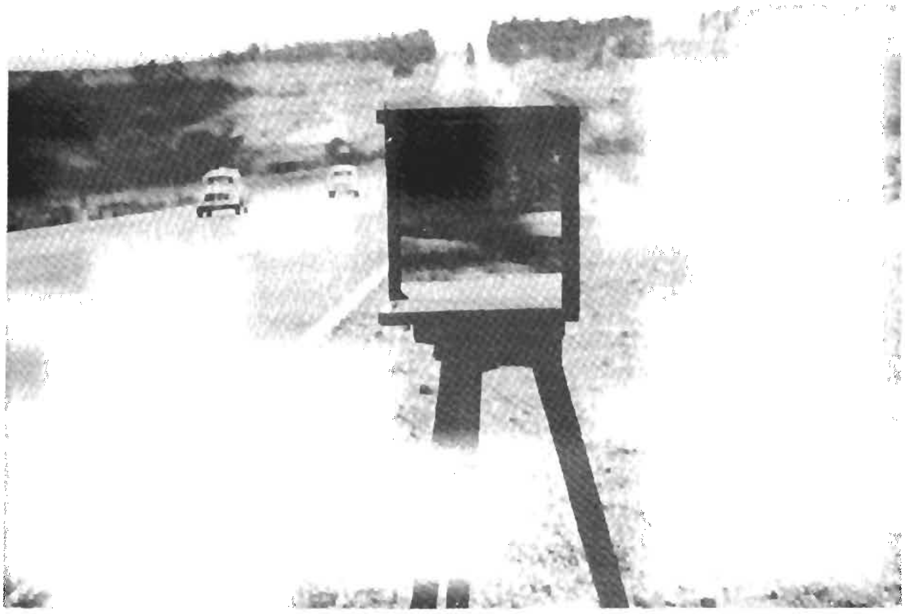

FIGURE 4.5 - MIRROR BOX AT RADAR TEST SITE

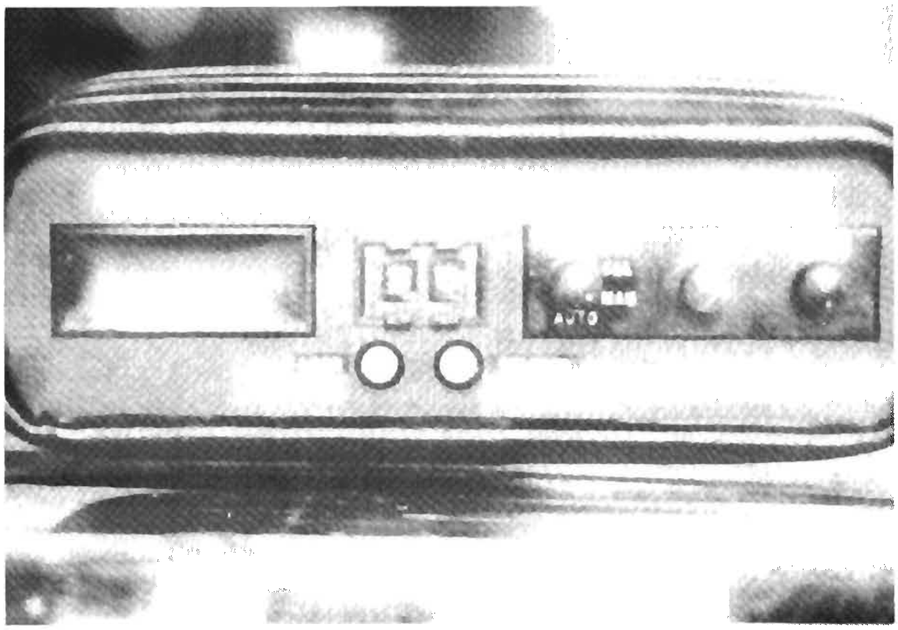

FIGURE 4.6 - RADAR PANEL

another case, the radar was set up on the tangent to a curve and the speed of vehicles as they passed through the curve was recorded. In this experiment the three radar sets were deployed on three different curves.

Only one observer is required to operate a single radar set. However, traffic frequently moves past an observation point too quickly to allow one person to record all required data. In some cases, the recording of additional information, such as time, vehicle class, direction and vehicle load estimate, requires an additional observer.

In general, the radar antenna is aimed down the road in line with the lane of traffic under study. A unit positioned beside a test section is shown in Figure 4.7. The radar automatically detects the vehicle whose speed is being measured and displays the speed in kilometers per hour. Table 4.1 shows a typical radar data field recording form.

4.2.2 *Maintenance*

In the beginning, it was difficult to convince the radar operators to charge the radar set batteries. Most radar failures early in the project were caused by discharged batteries. As time passed, the practice of daily charging of the batteries became firmly established and ceased to be a problem.

Initially the radar set antenna internal power regulator unit was unreliable on all of the radar sets. The regulator failed on every set. It was thought the radar sets were experiencing these failures due to the high ambient temperatures in the field. To test this hypothesis, the antenna cover was painted white to help reflect the heat. Whether or not overheating was the cause, the problem failed to reappear once all of the original regulators were replaced.

With the exception of an antenna which was knocked down and damaged by a passing vehicle, the radar sets performed trouble-free for the last two years of the project.

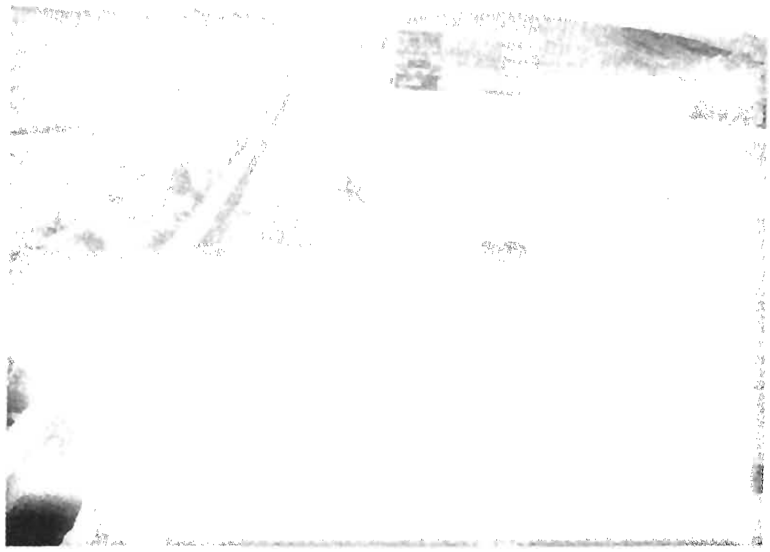

FIGURE 4.7 - RADAR UNIT AT TEST SITE

PICR

OBSERVAÇÕES DE ACELERAÇÃO E DESACELERAÇÃO

POPULAÇÃO DOS VEÍCULOS

FOLHA ______ DE ________

FICHA DE IDENTIFICAÇÃO 1 [0][6]

NÚMERO DA SEÇÃO 3 [ ][ ][ ]

DATA 6 — DIA | MÊS | ANO [ ][ ][ ][ ][ ][ ]

Nº DA ESTAÇÃO INICIAL 12 [ ]

DIREÇÃO 13 [ ]

TIPO DE TESTE
ACELERAÇÃO (1)
DECELERAÇÃO (2) 14 [ ]

ESPAÇAMENTO DAS SUB-ESTAÇÕES (m) 15 [ ][ ][ ]

	VELOCIDADES OBSERVADAS NAS SUB-ESTAÇÕES (KM/H)				PLACA DO VEÍCULO	CLASS.	CARGA	
18								
36								
54								71
18								
36								
54								71
18								
36								
54								71
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36								
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OBSERVADOR ______________________

TABLE 4.1 - RADAR DATA RECORDING FORM

4.2.3 *Recommended Maintenance Facilities*

One senior electronics technician
Volt-ohm meter
Oscilloscope
Hand tools

4.3 *CAMERA BOX AND RECORDER BOX*

Both the Camera Box and the Recorder Box served the same purpose. They were used to record accumulated distance travelled at known time intervals to determine vehicle speed changes. Both were constructed by the Instrumentation Group.

4.3.1 *Camera Box*

The camera box consists of a DMI (Linder, "Distance Measuring Instrument - DMI"), a crystal controlled digital stopwatch, and an 8 mm or 16 mm movie camera, all installed in a wooden box. The DMI is supplied distance information by a set of eight magnets fixed to the vehicle's front wheel and a magnet sensor attached near to the magnets on the steering columns. As the front wheel revolves, impulses are generated by the magnet sensor and sent to the DMI where they are summed and scaled to be represented on a six character digital display. The stopwatch was modified to send a HOLD impulse to the DMI and a trigger impulse to the camera at one-second intervals. The DMI was modified to allow its display to freeze during the HOLD impulse so that the resulting photograph of the stopwatch and DMI would have maximum clarity. Remote controls attached to the stopwatch allow the operator to start and stop the system at convenient times. Three camera boxes were constructed. Construction details of the camera box are covered in a Project Instrumentation Memo (Buller, "Camera Boxes"). The camera box layout is shown in Figure 4.8 and illustrated in Figures 4.9 and 4.10.

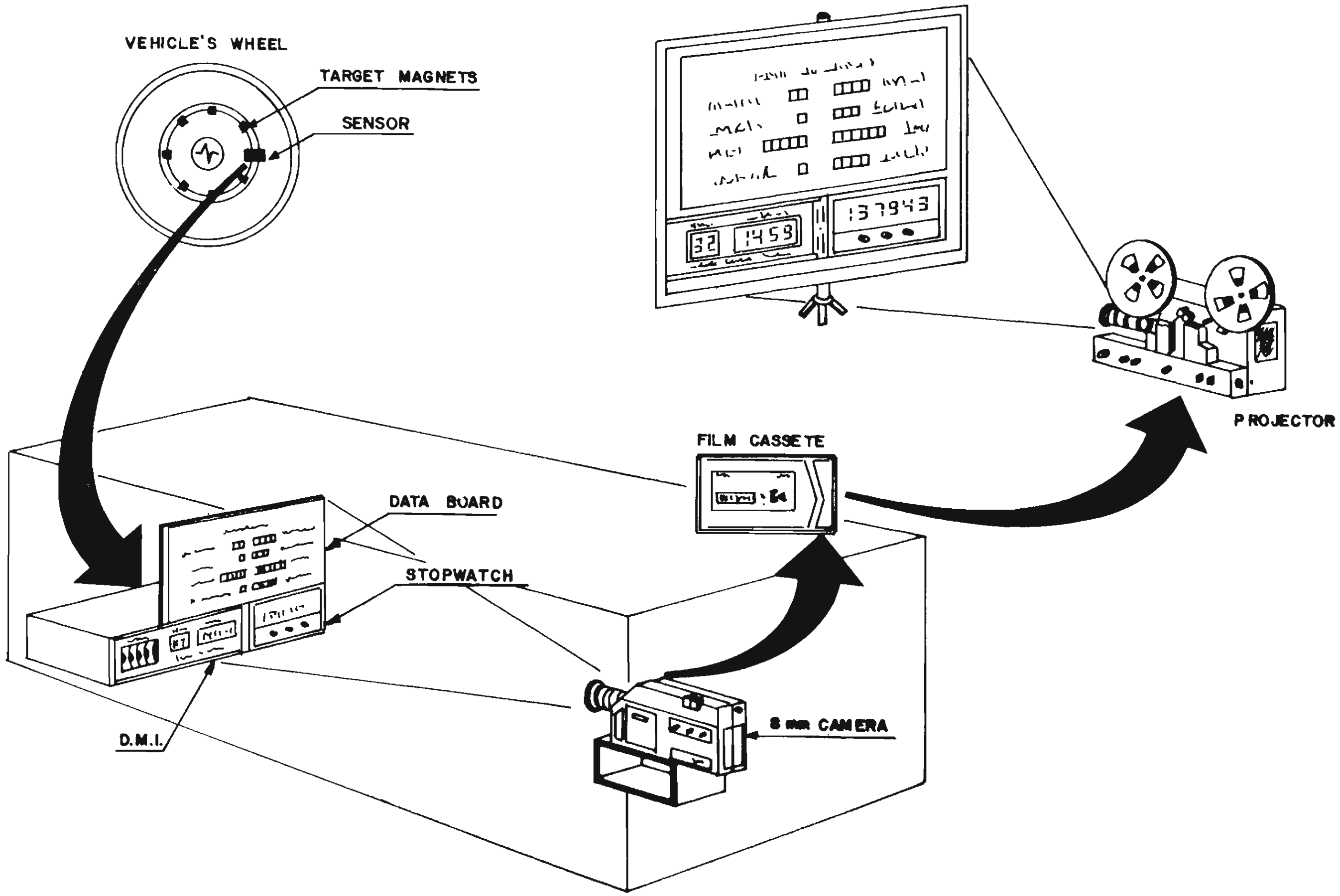

FIGURE 4.8 - CAMERA BOX BLOCK DIAGRAM AND DATA FLOW

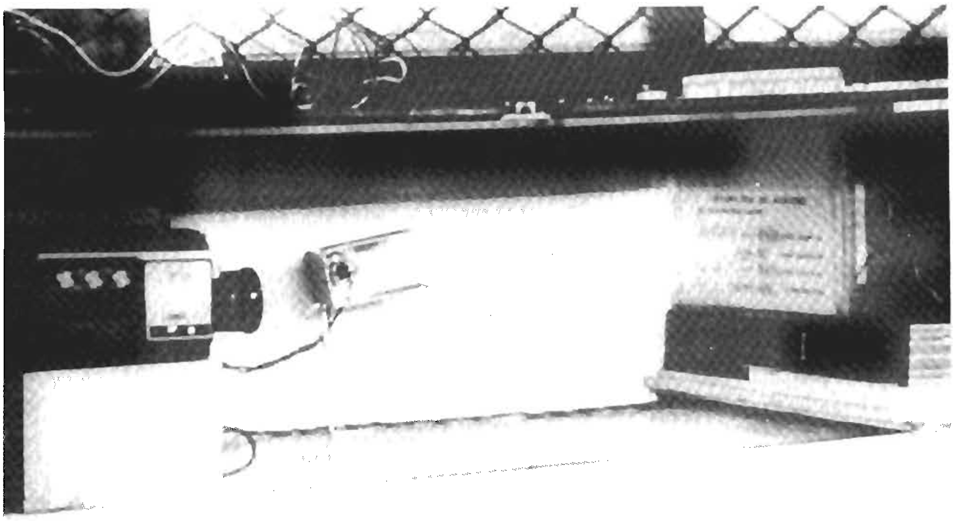

FIGURE 4.9 - CAMERA BOX (8 mm)

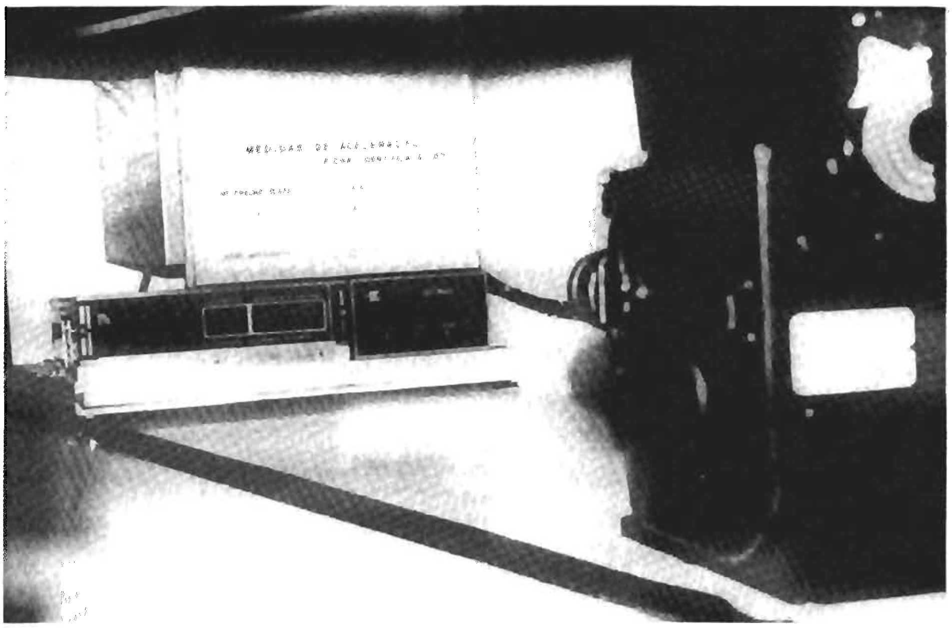

FIGURE 4.10 - CAMERA BOX (16 mm)

4.3.2 *Recorder Box*

The camera box was used for most of the acceleration experiments. Camera boxes suffered the drawback of having all their output on film that required approximately three weeks for developing in local photo shops. It also took a clerk hours to read the time and distance information from the projected film. At the suggestion of the Traffic Group, the Instrumentation Group developed the recorder box as a replacement instrument, the fabrication of which is detailed in a Project Instrumentation Memo (Linder, "Recorder Box").

The recorder box eliminated the filming constraint by recording the DMI distance data on a cassette recorder at 200 millisecond intervals. The cassette was played back onto a printer which printed the DMI data in an easily-readable format. The printing of the cassette takes exactly the same amount of time as required to record the cassette. The recorder box data flow is presented in Figure 4.11.

4.3.3 *Field Operation*

The camera box was located on the bed of a truck or on the rear seat of a passenger vehicle or bus. The operator must turn on the power for the unit and reset the equipment. At the marked initial point of the section, the START switch is pushed and this starts the camera box automatically recording data. At the end of the section, the operator pushes the STOP switch to terminate the recording process.

The use of the recorder box is similar to that of the camera box. The major difference is that the recorder box is much smaller and therefore is kept inside the cab of the trucks and inside passenger vehicles and the bus. Besides the power on/off switch and normal tape recorder controls, there are only two switches for the operator to use. The recorder run/stop switch is shifted on just before the beginning of a section, while the reset switch is held in. At the start of the section the RESET switch is released. The operator waits until the end of the section is reached, then switches the tape recorder off.

The film in the camera box is identified by photographing a data sheet containing information as to the road section, date, load, etc. For the recorder box, that information is handwritten on the outside of the cassette. Further operational details about the camera box

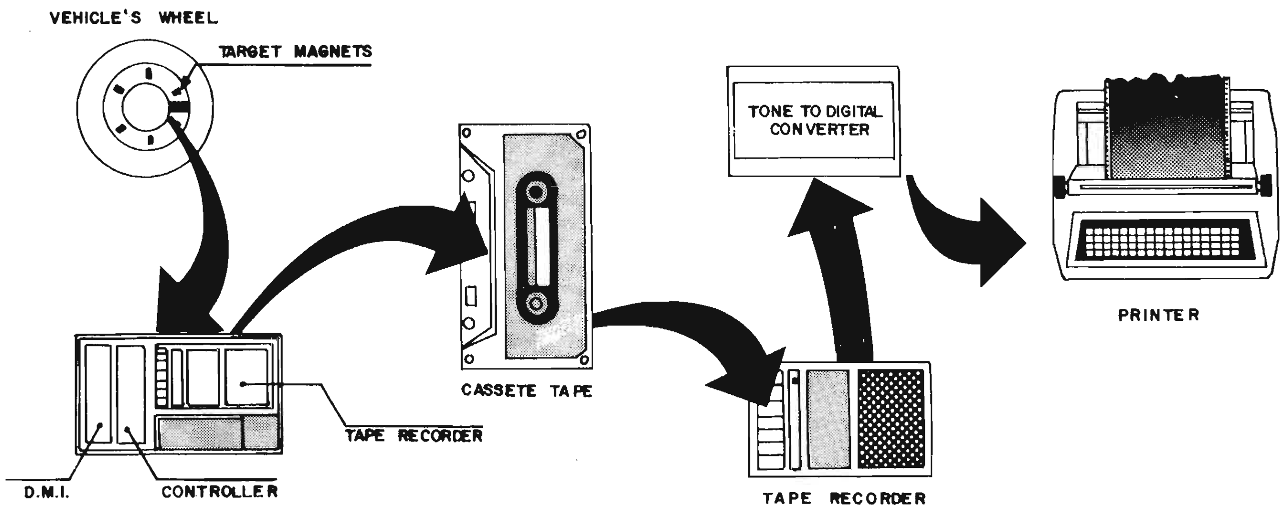

FIGURE 4.11 - RECORDER BOX DATA ROUTE DIAGRAM

and the recorder box are presented in Project Instrumentation Memos (Buller, "Camera Boxes"; Linder, "Recorder Box").

4.3.4 *Maintenance*

The camera box proved difficult to maintain because it was positioned in the bed of trucks that operated on very rough surfaced roads. The camera box with the Bolex 16 mm camera was removed from service permanently. It proved too difficult to maintain because it was more complex than the Minoltas. The other units with 8 mm cameras stood up very well. No camera problems developed despite the hostile environment that they were required to operate in. The DMI and stopwatch were very serviceable with the major problems being broken electrical connections and defective switch units.

The recorder boxes proved reliable during their short service period. Of the three boxes, one was taken out of service because its tape recorder failed and locally available tape recorders were unsuitable as replacements.

4.4 *TACHOGRAPH*

Two types of tachographs were available for project use, one 24-minute type (Figure 4.12) and six 24-hour models of the type shown in Figure 4.13. The 24-minute model is a special research unit manufactured by ARGO Instrument Co., while the other tachographs are manufactured by SANGAMO Electric Co..

The tachograph makes a record of a vehicle's speed profile over a period of time. This record may be used to study vehicles' behavior over long periods of time. Also marked on the record is a distance signature that correlated the speed profile with the geometric features of the road used by the vehicle. A SANGAMO chart is illustrated in Figure 4.14.

4.4.1 *Field Operation*

The 24-hour model tachograph is equipped with a 7-day chart

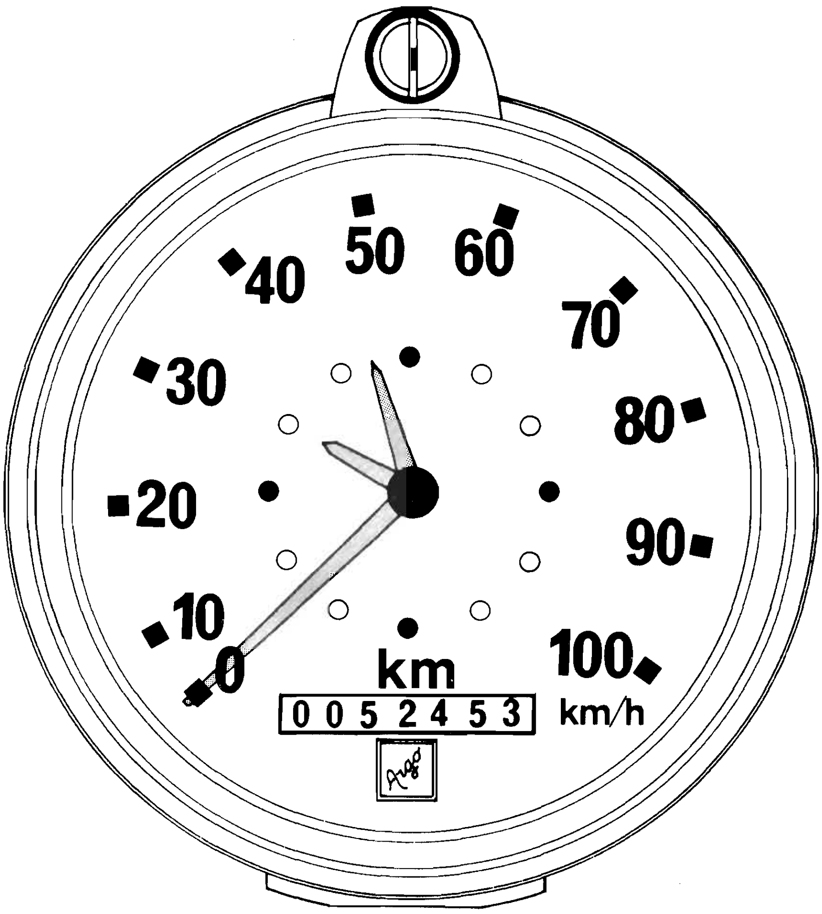

FIGURE 4.12 - ARGO TACHOGRAPH

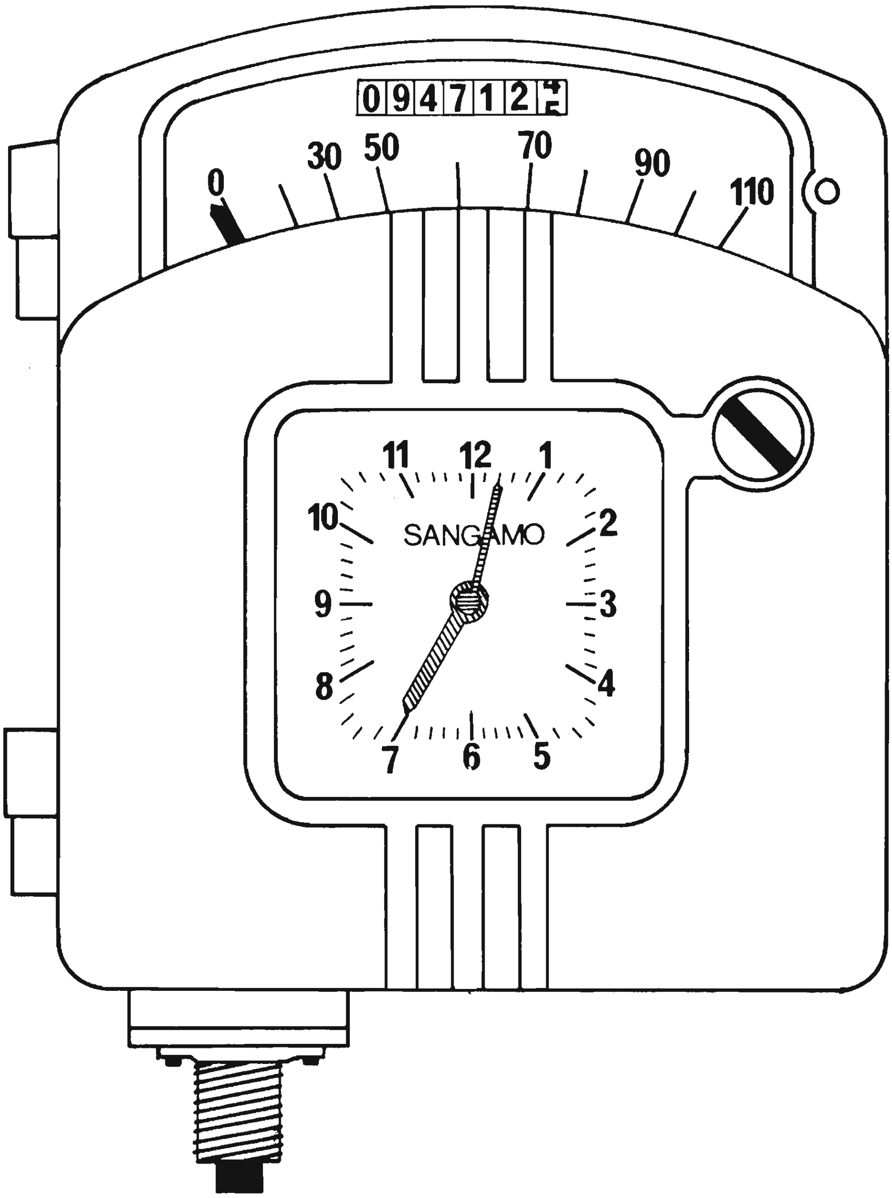

FIGURE 4.13 - SANGAMO TACHOGRAPH

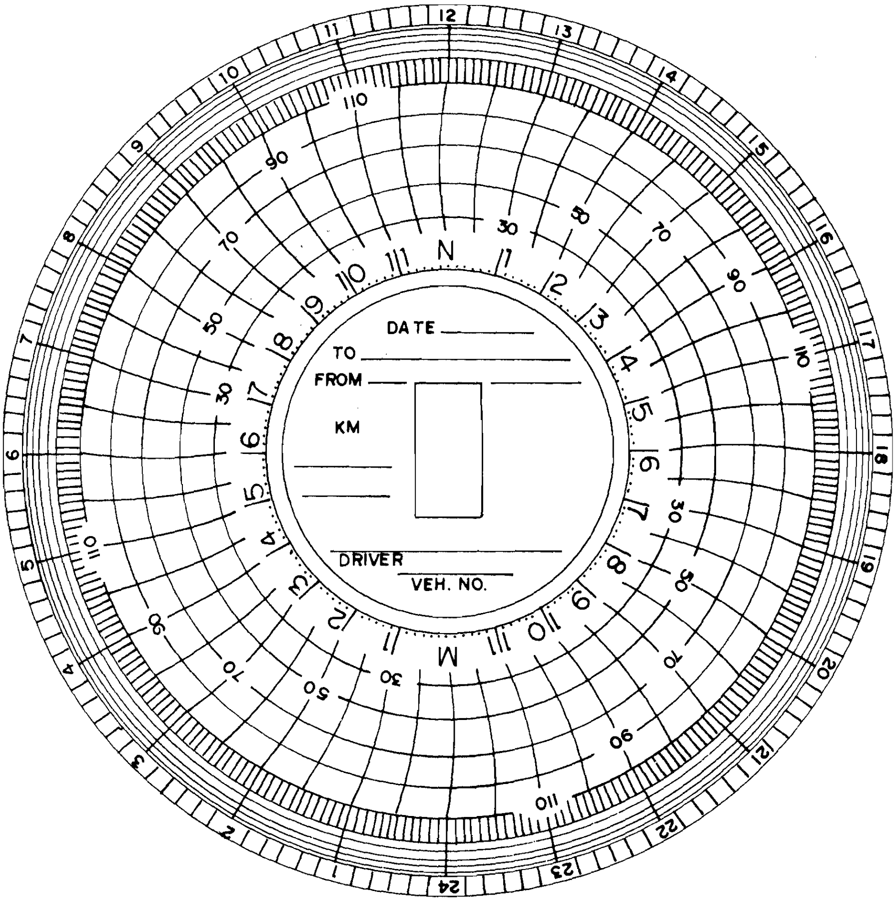

FIGURE 4.14 - SANGAMO TACHOGRAPH CHART

pack. The only requirement is that the chart pack be changed at the end of each 7-day period. The driver needs to take no action concerning the tachograph's operation.

The ARGO tachograph is equipped with a button-activated event pen that may be used to mark particular points on the route being used. Its chart makes one complete revolution every 24 minutes and it is necessary to wind the watch mechanism. Otherwise it is the same as the 24-hour model.

4.4.2 *Maintenance*

Maintenance was not a problem for the tachographs. Some repair was required when an operator used them incorrectly. The 24-minute tachograph created a problem because it had a hand-wound clock. The drivers frequently forgot to wind it. Consequently, the speed profile and distance pens would eventually wear a hole in the chart paper. The pen would stick in the hole and the speedometer needle of the tachograph could not move properly.

4.4.3 *Maintenance Facilities*

A tachograph distributor's speedometer repair shop is recommended for maintenance and repairs.

4.5 *THE PHOTO-ELECTRIC LIGHT INTENSITY DETECTOR (PELID)*

This equipment was designed and constructed by the Measurement Instrument Group to quantify the change in visibility from dust raised by a vehicle travelling over an unpaved road. It consists of a light detector/amplifier, a target board and an indicator/metronome unit. The unit is shown in Figure 4.15 and schematically as set up in the field in Figure 4.16.

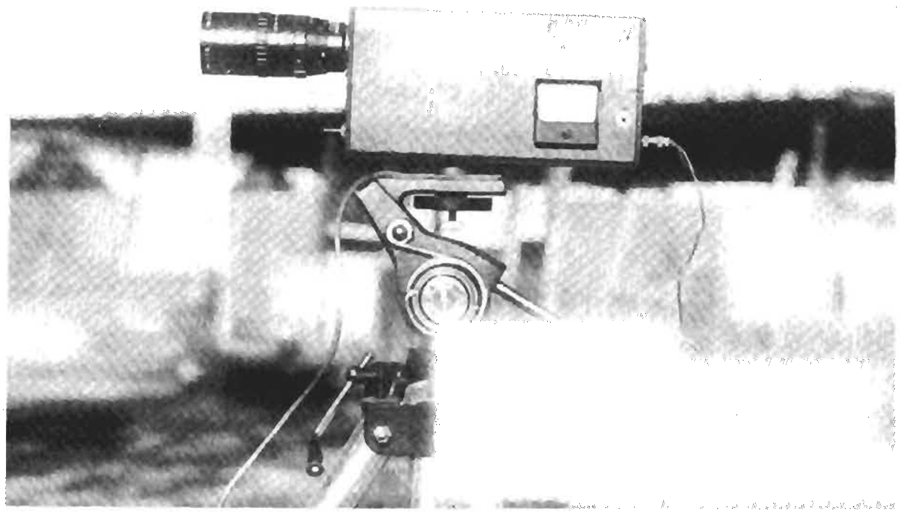

FIGURE 4.15 - PELID MOUNTED ON A TRIPOD

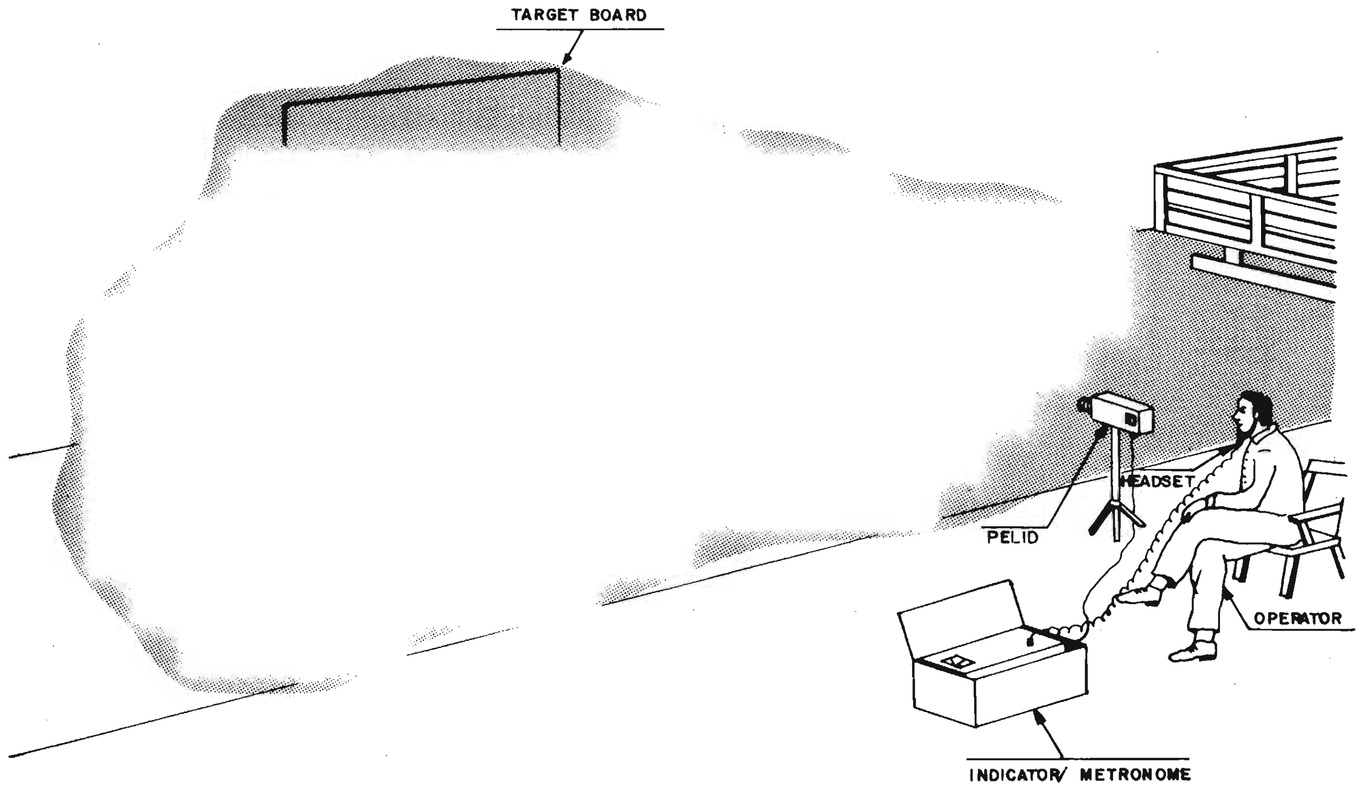

FIGURE 4.16 - PELID IN THE FIELD

4.5.1 *Operating Principle*

The target board, a 1.5 square meter white board, is set-up on one side of an unpaved road and the other two units on the far side of the road, directly opposite the target. The light reflected from the target is collected by a telephoto lens and focused onto a photo-cell in the detector circuit, which also contains a moving coil meter to permit setting the amount of ambient light received by the photo-cell to a standard value for each measurement. This is accomplished by changing the lens aperture setting and, in bright sunlight, by means of a blue filter mounted in front of the lens.

When a vehicle passes and raises dust, the amount of light seen by the photo-cell is reduced and an electrical signal proportional to the reduction is produced in the detector circuit. This signal is amplified and the portion from the vehicle itself is backed-off, so that the much smaller portion due to dust can be adequately displayed on the read-out meter.

Readings are taken at discrete intervals, indicated to the operator via a head-set from an electronic metronome. The intervals may be varied to suit the ambient conditions of the day to ensure that a sufficient number of readings is obtained before the dust settles or is dispersed by wind. Details on the PELID are presented in a Project Instrumentation Memo (Buller, "Photo Electric Light Intensity Detector - PELID").

4.5.2 *Field Operation*

The target board is set up and the detector mounted on a tri-pod on the opposite side of the road. The operator then focuses the lens on the target by means of the through-the-lens focusing system to reduce unwanted light to a minimum. The detector light level is set by adjusting the lens aperture, the correct level being indicated by a datum point on the meter. The read-out meter is then set to show full-scale deflection by means of a variable resistor and, when a vehicle passes, the reduced readings on the read-out meter are recorded at discrete intervals until the air between the target and lens is clear.

4.5.3 *Maintenance*

This mainly consists of keeping the lens and target board clean.

The original 9 volt batteries were troublesome because of their small capacity and different rates of discharge. This caused difficulty in balancing the back-off voltage. To overcome this, two heavy-duty 12 volt batteries were used externally and connected by means of a 4-core cable directly into the detector case.

This equipment is impossible to use on a day with numerous small clouds since the ambient light value is constantly changing and therefore the detector circuit cannot be set up.

4.6 *TRAFFIC FLOW DATA LOGGER*

The Traffic Flow Data Logger (TFDL) was designed and built by the Measurement Instrument Group to capture on cassette tape the following information:

- The time of day that a specific vehicle passes a test site.
- The period of time required for a specific vehicle's axles to travel one meter.
- The direction of travel of a specific vehicle.
- A photograph of the specific vehicle.

The purpose of the TFDL is to gather data to determine vehicle speed, headway, density, class, and passing meneuvers, all to be used to calibrate the Model for Simulating Traffic (MST) (See Kaesehagen and Moser, and Volume 10 of this Report).

The equipment was originally designed to include a data entry terminal for the operator, in the form of a hand-held keyboard connected to the control box via a cable. The operator entered coded numerical data into the data record of each vehicle for identifying, classifying and estimating the load of the passing vehicle. After months of training the operators could not master this procedure. This, coupled with problems associated with maintaining the keyboard units, prompted revision of the equipment, excluding the keyboard and relying solely on the photographic record for vehicle identification.

The equipment was originally designed to include a magnetic vehicle sensor. This device would have isolated each vehicle record. The sensor proved unreliable, so other techniques were tried. Among these were a hastily-constructed timer whose time-out period was related to vehicle speed. This unit would not stand up to field temperatures. The last attempt involved an operator using a push button to identify each vehicle. The operators again could not be trained to reliably operate this equipment. Vehicles were finally recognized through a computer analysis, where the logic was based on the fact that the axles of each vehicle travel at the same speed and that there is a limited range of feasible axle spacings.

4.6.1 *Operating Principle*

The traffic flow data logger is a microprocessor-controlled device containing a precision timer, a clock giving the time-of-day, an interface to a cassette tape recorder and switch closure sensors. Pneumatic road tubes are laid out on the road at each of the six sites. The road tubes are interfaced to the traffic flow data logger via traffic counter road tube detectors which issue a contact closure to the processor unit when a vehicle's axle passes over the road tube. At the same time, a camera at each site is triggered for vehicle identification. The processor is programmed to read and record the precision timer reading and time-of-day when the vehicle passes over a road tube. The construction and design details of the traffic flow data logger are presented in a Project Instrumentation Memo (Linder, "Traffic Flow Data Logger", Memo No. 012/78).

4.6.2 *Field Operation*

The field crew installed road tubes on premarked and prepared sites, connected all the cables and tubes to the unit and simultaneously started all three traffic flow data loggers to syncronize their time-of-day clocks.

Every 15 minutes, the crew exposed a data board containing the time of day to the camera to aid in locating a particular time segment on the film, and also for correlating the cassette data record to the film record.

The crew checked the tape recorder periodically to see if its cassette needed changing. A technician constantly patrolled the six sites, checking for equipment malfunctions and for low battery voltages. A typical field layout is depicted in Figure 4.17 and a description of field operations is given in a Project Instrumentation Operational Memo (Linder, "Traffic Flow Data Logger", Memo No. 013/78).

4.6.3 *Maintenance*

The maintenance of the TFDL was a major problem. The road tubes deteriorated rapidly under heavy traffic conditions, especially on coarse textured roads. The main batteries required daily charging and for this reason two sets of batteries were on hand, one being charged and one in use. The equipment did not function well at high ambient temperatures and occasionally stopped working.

4.6.4 *Recommended Maintenance Facilities*

One electronics engineer
One senior electronics technician
Vclt-ohm meter
Oscilloscope
Hand tools.

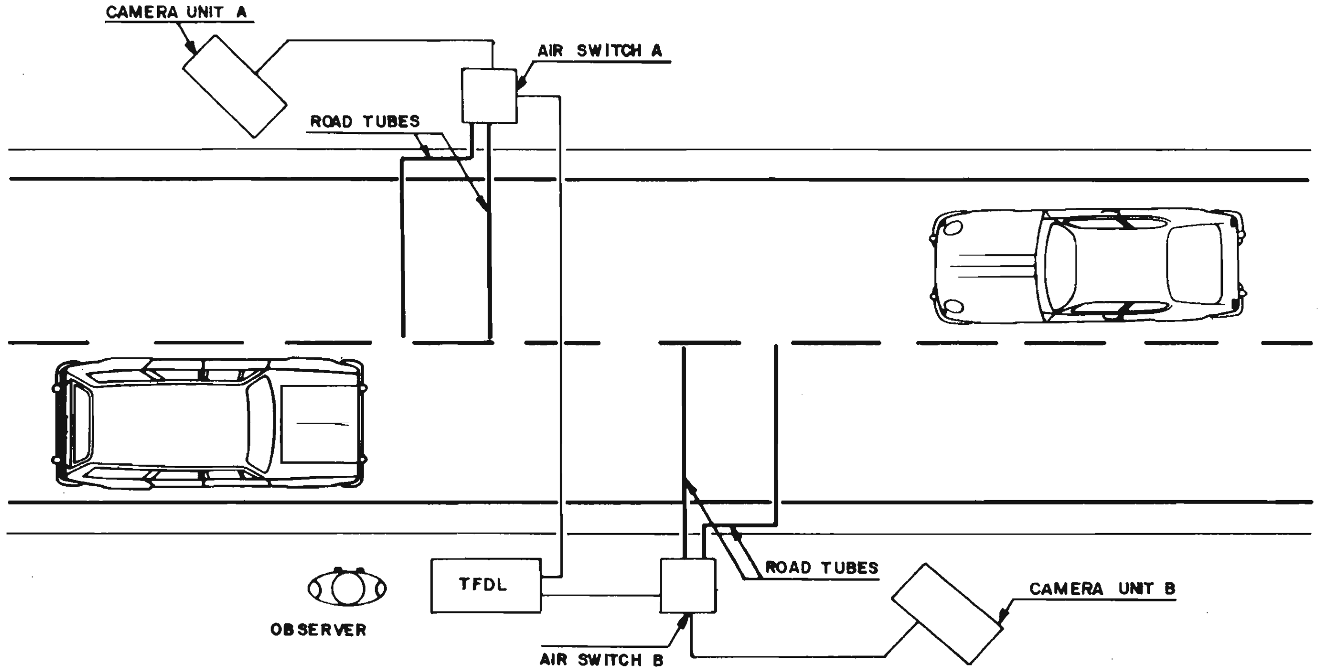

FIGURE 4.17 - FIELD LAYOUT FOR TFDL