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This is a report concerning the design development and testing of a vehicle classifying counter. Materials and Research Department to classify vehicles by their wheelbase and number of axles. Tests were performed on I-80 near Sacramento under heavy traffic conditions for time durations from one half hour to eight days. These operational tests and extensive laboratory testing proved the capability of the classifying counter to perform according to the design goals.

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HIGHWAY RESEARCH REPORT

VEHICLE CLASSIFYING COUNTER

FINAL REPORT

69-16

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 36346-1

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads November, 1969

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, *Governor*

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

November 1969
Final Report
M & R No. 36346-1

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

VEHICLE CLASSIFYING COUNTER

ERIC F. NORDLIN
Principal Investigator

L. G. KUBEL and A. F. BAILEY
Co-Investigators

Assisted By
T. F. Grillo and L. E. Welsh

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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ABSTRACT

REFERENCE: Nordlin, Eric F., Kubel, L. G., and Bailey, A. F., "Vehicle Classification Counter". State of California, Department of Public Works, Division of Highways, Materials and Research Department. Research Report No. 36346-1, August 1969.

ABSTRACT: This is a report concerning the design, development and testing of a vehicle classifying counter. The vehicle classifying counter was developed at the Materials and Research Department to classify vehicles by their wheelbase and number of axles. Tests were performed on I-80 near Sacramento under heavy traffic conditions for time durations from one half hour to eight days. These operational tests and extensive laboratory testing proved the capability of the classifying counter to perform according to the design goals.

KEY WORDS: Vehicle classification, axles, traffic counters, instrumentation.

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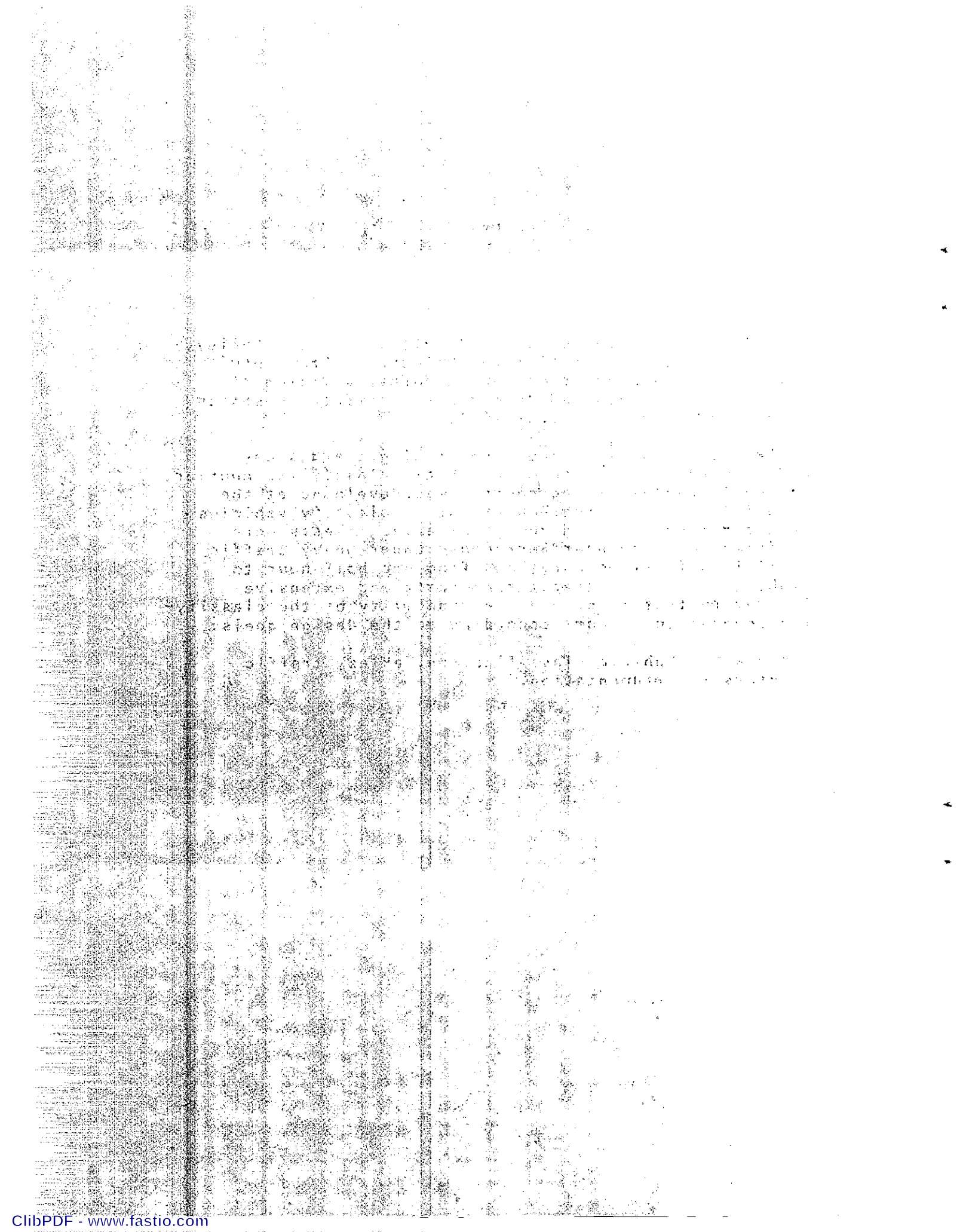

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ACKNOWLEDGMENT

This paper reports on work performed under Research Project C-1-2 conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings, and conclusions are those of the authors and not necessarily those of the Bureau of Public Roads.

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I. INTRODUCTION

A. Need and Application.

The utilization of an adequate axle classified truck counting program will be a significant contribution to highway planning.

1. One use is for capacity analysis. Trucks, particularly on grades, restrict traffic flow far out of proportion to their individual numbers.

2. Truck volume and classifications are used to determine the Traffic Index for use in the structural design of pavements.

3. The percentage of trucks is required for economic comparison of alternate routes.

4. The truck classifier will enable statistically based sampling procedures to be incorporated into the traffic counting program. This should enable the State of California to realize some savings in field operation expense when the periodic count stations are replaced by an adequate number of representative truck classifiers.

B. History.

The State of California has been utilizing a mechanized traffic count program since 1961 when the expensive old manual traffic counters were supplanted.

One of the early units used was a Streeter-Amet, Jr. Traffi-counter which is a small, rugged, inexpensive nonrecording device. Although this unit is capable of counting the total number of axles, no provision was made for classifying cars and trucks.

Later work incorporated the use of a Fisher Porter traffic count recorder. This device accepts a pneumatic input and provides a 4 digit in-line punched tape output. The method of punch programming is manually adjustable to 5, 15, 30 or 60 minute punch-out intervals. Although the counting procedure is cumulative, there is no provision for classifying cars and trucks.

In 1965 a truck classification counter was developed around transistorized counting. This unit utilized four electro-mechanical counters indicating one of four axle groups, 2, 3, 4 or 5 through 7 axle vehicle. Although this unit did provide for a breakdown of vehicles into distinct axle groups, limitations of this unit were that tandem axles could not be detected, two axle trucks could not be separated from two axle cars, and three axle car-trailer combinations could not be separated from three axle trucks. The present truck classifier essentially incorporates these features.

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II. SUMMARY AND RECOMMENDATION

A. The truck classifier is a portable, battery operated device utilizing logic and counting circuitry consisting of silicon transistors and integrated circuits. This device has the capability of distinguishing between two axle cars and two axle trucks, as well as three axle car-trailer combinations and three axle trucks. A variable time delay compensates for typical traffic speed patterns at different count sites so that one vehicle is not read as two vehicles.

B. The truck classifier provides the capability of counting and classifying information with reasonable accuracy. Some correction factors will have to be applied to some of the specialized classes.

C. Some of the potential areas which could be investigated to increase the over-all capability of this unit are:

1. Expansion of the input lines to count two lanes of traffic simultaneously.

2. Utilization of the delta-R strip to replace the rubber hose and its associated air switch to decrease the response time of the unit.

3. Utilization of an electronic timer that provides for hourly, daily or weekly readout. This could be expanded to a 12 hour on, 12 hour off routine for two week intervals.

4. Utilization of a method such that a full truck will not be counted the same as an empty one.

5. Utilization of a readout requiring less power and enabling the data to be transferred to the office.

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III. SYSTEM DESCRIPTION

General

The truck classifier is a portable, battery operated, solid state device. It is capable of detecting and classifying traffic in one lane of a roadway according to wheelbase and the number of axles.

The circuitry, consisting of binary counters, logic and gating modules, is activated when the initial presence of a vehicle, in the vicinity of the loop, is sensed by the loop detector (see Figure 1, Appendix A.

The number of axles of a vehicle are counted by the first of two rubber hoses and designated First Detector Hose. The other hose detector, designated Second Detector Hose, is physically spaced eleven feet from the first hose.

This physical separation of detector hoses is compared to spacing between the first two axles of a vehicle. If this wheelbase is greater than eleven feet, the vehicle is classified as a truck.

The output of the truck classifier is terminated in one of six electromechanical counters which correspond with the following classifications:

2 axle car, 2 axle car with trailer, 2 axle truck, 3 axle truck, 4 axle truck, and 5 through 7 axle truck.

A. Transducers

The operation of the truck classifier is based on the use of two types of vehicle transducers, namely, the inductive loop presence detector and the road tube axle detector.

1. Road Tube.

   The air switch axle detector consists simply of a rubber hose and a pneumatic switch. The air switch has a flexible diaphragm operating a spring loaded contact against a stationary contact. The air pulse from the road tube moves the diaphragm and contacts against the stationary contact giving one contact closure per axle.

2. Loop Detectors.

   The Vehicle Presence Loop detector provides the capability of detecting the passing of any metal vehicle over a six foot by six foot three-turn wire loop embedded in the roadway. Power requirements are less than 6 ma at 12 V DC during standby operation (no vehicle) and less than 15 ma at 12 V DC with a vehicle passing over the loop.

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The loop detector is completely transistorized, and includes a built-in tuning meter to assist the operator in setting the unit for optimum performance. The detector will detect presence during the time a vehicle is over the loop.

B. Circuit Description

The truck classifier experiences the following sequence of events for each cycle of operation:

Standby, Presence, and Recording Modes.

Each of these modes, briefly explained below, activates the pertinent circuits such that maximum power is utilized during a very small portion of the operating cycle, thereby keeping battery drain to a minimum. The functional block diagram is shown in Figure 9, Appendix A.

1. Standby Mode.

Minimum power is utilized during this mode. Those circuits which are active are the loop sensor, the first detector circuit, and the loop interface circuitry. No vehicle is in the vicinity of the loop.

2. Presence Mode.

This mode utilizes about ten times more power than the standby mode. As the loop responds to a vehicle, all circuits are activated except the electromechanical registers and their drive circuitry. The logic and gating circuits are energized, the first detector circuit draws additional power to count the appropriate axles, and the second detector circuit is activated to classify a vehicle as car or truck.

3. Recording Mode.

Maximum power is utilized during this portion of the operating cycle. All circuits, including the pertinent driver and electromechanical registers, are activated enabling the count, which is held in temporary storage, to be recorded. When the recording mode is terminated, the counting cycle is now complete and the truck classifier is restored to its standby mode. A brief description of the circuits which are activated during some or all of the previous modes mentioned are included in Appendix G, Circuit Operation.

C. Design Consideration.

The criteria employed in the truck classifier comprises both electrical and mechanical design features and are listed in the subsequent paragraphs. For additional information, a set of specifications is given in Appendix F.

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1. Mechanical.

   a. The truck classifier is a moderately lightweight, completely portable unit with a self contained power supply and easily installed detecting elements.

   b. The operating power consists of a package of ten nickel cadmium rechargeable batteries and is easily removable.

   c. The truck classifier is capable of detecting and classifying traffic in one lane of a roadway according to wheelbase and number of axles.

   d. All electronic components are arranged in functional groupings on etched circuit boards. These circuit boards are easily removable and there is easy access to all components.

   e. The adjustments are easily operated by inexperienced personnel.

      (1) The loop detector has a coarse and fine control and an indicating meter for quick adjustment of the loop.

   f. Silicon transistors, medium-power integrated circuits and off-the-shelf components were used.

   g. The output pulses from the logic circuitry are counted on six separate electromechanical counters. These counters are five digit counters and are positioned so they are easily read with the box cover opened.

   h. To facilitate the use of more than one type of detector, the axle detector signal conditioning circuitry is constructed on a circuit board separate from the logic and driver circuitry.

   i. The logic circuitry is totally solid state and utilizes no moving parts.

   j. The truck classifier can detect tandem axles.

2. Electrical.

   a. The function of the loop detector and sensor is to sense the presence of a vehicle for the entire time the vehicle is in the detection zone and switch power to the logic circuitry.

   b. The unit is operated from a single voltage source of +12 volts.

   c. The first and second detector circuits are separated electronically to prevent one detector circuit from causing unwanted pulses in the other.

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d. The first detector circuit takes on-off levels, caused by contact closure, and converts them to a clean wave shape with a minimum duration of 25 milliseconds.

e. Since the total number of axles to be counted is seven, 3 flip-flops are required.

f. The power consumption during standby position is less than 400 milliwatts.

g. When the vehicle is in the detecting zone and the logic circuitry is operating the power consumption is less than 4 watts.

h. The operating power will consist of a battery of sealed nickel cadmium rechargeable cells with a minimum watt-hour rating of 175 watt hours, computed at the 10 hour rate.

i. The power supply is capable of providing 8 days of continuous unattended operation under moderately heavy traffic conditions.

j. To compensate for different speed patterns at different test sites, a variable loop delay was incorporated into the unit. This delay can be varied from 200 to 900 milliseconds.

k. An auxiliary indicator lamp is provided to monitor operations and is normally kept off to conserve power. When the loop is properly tuned and the power is applied to the appropriate IC logic gates, this lamp will light.

l. The use of relays in the loop detector or counting circuitry is avoided so that problems of contact bounce and noise are minimized.

3. Classifying Characteristics.

The truck classifier employs a loop detector to determine the presence of a vehicle, and two axle detector strips, positioned eleven feet apart on the roadway (see Appendix A, Figure 1).

When the wheelbase of the first two axles of a vehicle is greater than eleven feet, the truck classifier interprets this condition as the truck mode. Conversely, when the wheelbase of a vehicle is less than eleven feet, this condition is interpreted by the truck classifier as the car mode.

The requirement of eleven feet between axles for separate car/truck classifications only applies to two and three axle vehicles. Further discussion of this is covered in Section V, Part A, Accuracy of Counts.

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The following table summarizes the classification capability of the truck classifier:

TABLE 1

Truck-Car Classification

Type of Vehicle	*Wheelbase	Output Pulses	Mode Truck	Mode Car
2 axle	WB > 11	One	Yes	-
2 axle	WB < 11	One	-	Yes
3 axle	WB > 11	One	Yes	-
*3 axle	WB < 11	One	-	Yes
4 axle	Not considered	One	Yes	-
5, 6, 7 axle	Not considered	One	Yes	-

*Wheelbase: WB > 11 When distance of wheelbase (first two axles) is greater than 11 feet.

WB < 11 When distance of wheelbase (first two axles) is less than 11 feet.

4. Certain Trucks Classified as Cars.

The nature of the truck classifier is based on the following propositions:

a. That the difference between a car and a truck is reflected in the axle spacing.

b. Any vehicle having more than 3 axles, regardless of wheelbase, is classified as a truck.

c. Contributing factors such as height, width, over-all length and cross sectional area of the vehicle are not considered.

Data on some critical and overlapping areas are shown in Table 2, "Wheelbase of Passenger Cars, Trucks, and Truck Combinations".

* Three axle car should be interpreted as a two axle car with trailer.

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TABLE 2

WHEELBASE OF PASSENGER CARS, TRUCKS, AND TRUCK COMBINATIONS

	Vehicle	Axle Spacing in Feet A-B	B-C	C-D	D-E	Wheelbase (ft.) Min.	Max.	Classification Apparent	True
(1)	Truck	10	4	27	4	10		*5 axle truck or a 3 axle car and a 2 axle car	5 axle truck
(2)	Truck	11	4	28	4	11		*5 axle truck or a 3 axle truck or a 2 axle car	5 axle truck
(3)	Truck	11	17					3 axle truck	3 axle truck
		8	17					***3 axle car	3 axle car
(4)	Truck (Ford)								
	F-950-D (cab)					12.1	17.6	2 axle truck	2 axle truck
	H-1000-D (cab)					10.5	14.6**	2 axle car or 2 axle truck	2 axle truck
	CARS								
(5)	Buick					10.2	10.5	2 axle car	2 axle car
	Cadillac					10.2	11.1**	2 axle car or 2 axle truck	2 axle car

* These will only classify incorrectly when the loop drops out between axles C-D, and then comes on for Axles D-E.

** These discrepancies are due to the choice of 11' as the breakpoint for cars and trucks.

*** Three axle car should be interpreted as a two axle car with trailer.

IV. TESTING PROCEDURE

The truck classifier was subjected to laboratory tests to determine the capability of the classifier to meet predetermined design standards and field tests to determine if circuit operations were compatible with vehicle flow on existing highways.

A. Laboratory Tests

1. Speed of Operation.

   This covers the capability of the truck classifier to detect vehicles and count axles from 10 mph to 70 mph.

2. Transient Immunity.

   Transients were introduced into the circuit during turn on and turn off of the loop via switch noise to both detectors to insure that no false counts were generated.

3. Power Requirements.

   Checks were made to correlate the power drawn by the Standby, Presence, and Recording Modes. These checks were used to insure that minimum power is drawn by the circuitry in Standby, and yet maximum power is available to register a count during the Recording Mode.

4. Environment.

   The truck classifier was environmentally tested to insure reliable operation under wide temperature variations.

B. Field Tests

These tests were conducted to obtain data to correlate with laboratory results. Two different test sites were chosen to include external conditions as well as electrical considerations. Criteria used are outlined below:

1. Electrical.

   a. Short term testing varying from ten minutes to two hours.

   b. Long term testing varying from one to eight days.

   c. Tests at low and high speeds to determine working range of loop delay.

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d. Tests in which both hoses were positioned from 10.5 feet to 11.5 feet apart.

e. Positioning of the first detector hose with respect to the loop to determine a practical operational distance.

f. Voltage range. The unit successfully underwent a long term test lasting more than eight days. The power supply voltage varied from approximately 13.5 volts to 11.3 volts.

2. Physical.

a. Antelope Test Site (Vicinity of Sacramento, California). Good traffic conditions.

(1) High volume of traffic per lane.

(2) Reasonably high volume of trucks.

(3) Good sight distance in vicinity of test site.

(4) Straight level section of two lane road, a sufficient distance from any interchange to reduce the number of "weavers".

b. Lodi (Vicinity of East Lockeford Street Overcrossing). Poor traffic conditions.

(1) Low volume per lane.

(2) Test site in vicinity of curve plus sloping grade.

(3) Poor sight distance.

(4) Greater number of "weavers" plus lane straddling.

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V. DISCUSSION

A. Accuracy of Counts.

1. Definition:

The following table shall indicate the manner in which the test results shall be interpreted:

TABLE 3

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

Manual Count Taken as Reference

	Reading	Interpretation
a.	[N-2 Axle Cars] + [M-2 Axle Trucks] = (N+M) Two Axle Vehicles	Accuracy is based on the combined number of vehicles within each classification.
b.	[N-3 Axle Cars] + [M-3 Axle Truck] = (N+M) Three Axle Vehicles	
c.	M-4 Axle Vehicle = (M) Four Axle Vehicle	Accuracy of the total number of vehicles directly related to the sum of the individual 4 axle vehicles.
d.	M - (5-7) Axle Vehicles = (M) 5 Axle Vehicles	There is no separate count for 5 or 6 or 7 axle trucks. Accuracy of the separate individual vehicles solely determined by the sum total of all vehicles falling within this classification.
	[(Manual counts indicate a preponderance of 5 axle vehicles)]	

e. For a count within a particular classification: if the total number of vehicles counted is between $0 < x < 50$, then the difference shall not be designated percentage difference but only acceptable or not acceptable.

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f. Long Term Testing. This type of testing shall be used to indicate the total number of vehicles within a given testing period or the average hourly traffic on one lane during this time. This test shall not be interpreted as an indication of the accuracy to be found within individual classifications.

g. Short Term Testing. This mode of testing shall be used to indicate the total number of vehicles within a given testing period. This mode can be interpreted as an indication of the accuracy to be found within groups of classification.

2. Test Results.

a. Long Term Tests.

The percentage difference in counts between the truck classifier and the Fisher Porter ranged from a low of 0.4% to a high of 10.9%. The reading of 10.9% is quite a bit out of line with the other two readings. This can be attributed to a damaged hose during one portion of the test period resulting in a lower count by the Fisher Porter unit. The differential loss in counts was between 10,000 and 12,000 counts. The difference when added to the Fisher Porter unit would reduce the error to about 1.5% (see Appendix C, Page 1).

b. Short Term Testing.

2-Axle Vehicles. The percentage deviation in counts between truck classifier count and manual count varied from 0.8 to 5%. Two of the readings were not classified in percentage deviation due to the sample size being small. The notation "acceptable" was used. In view of the small sample size and some expected difference due to the variables between Manual Count and Truck Classification Count, the 5% deviation, three count difference, was considered acceptable (see Appendix C, Page 2).

3-Axle Vehicle. Due to the small sample involved, the results were considered acceptable for the reasons enumerated above (see Appendix C, Page 2).

4, 5-7 Axle Vehicles. The results indicate perfect correlation between Manual Count and Truck Classifier Count (Appendix C, Page 3). Due to small sample size and the expected difference between some preselected criteria and the actual count, the results were termed acceptable.

B. Reasons for Inaccuracies.

1. Eleven Foot Criteria.

The difference between a car and a truck is reflected in the spacing between the first two axles which, for these tests,

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was chosen to be eleven feet. Consequently, trucks (with two or three axles) having a wheelbase less than eleven feet will be recorded as cars; conversely, cars with a wheelbase greater than eleven feet will be classified as trucks.

2. Operational Criteria.

a. Vehicles having 4 or more axles will be classified as trucks; however, cars towing 2 or 3 axle trailers will be classified as 4 or 5 axle trucks.

b. Since there are very few trucks in California with more than 7 axles, then the number of vehicles having more than 7 axles can be ignored.

c. A variable delay is incorporated into the truck classifier so that, when the loop cannot sense trucks having high, narrow metal tillers, the circuits will remain on until all the axles of the truck have been counted. This delay is generally set according to the rate of traffic flow at a particular count site. If the traffic rate is changed due to abnormal road conditions, then certain trucks may be recorded as two separate vehicles.

3. Loop Criteria.

The loop detector will accurately detect each vehicle that passes over the loop. However, erratic operation can be caused by vehicles tailgating, vehicles straddling the lane, or the loop detector being slightly detuned.

4. Road Tubes and Contact Switches.

The criteria is that each axle of a vehicle that passes over the road tube will result in operation of the respective contact switch, and enable the truck classifier to record the cumulative count. However, incorrect counts in the truck-car classification can result from any of the following conditions:

a. Decreasing sensitivity of road tubes to tire pressure over a period of time.

b. Incorrect placement of the road tubes on the highway. Road tube not placed normal to centerline.

c. Unequal length of first and second detector road tubes.

d. Coincident counts may be introduced by road tubes.

e. Noise introduced into circuit by operation of contact switch.

C. Over-all Analysis

General. The truck classifier was subjected to both long term and short term tests and operated satisfactorily within a nominal

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voltage range from 11.0 to 14.0 volts. Noise pulses, introduced into the circuitry via contact bounce of the air switch, were damped out by means of delay and timing circuitry. A tunable loop detector, hose strips, and truck classifier enables detection of 2 to 7 axle vehicles at various speeds at the test site location.

1. Accuracy.

   During the testing period the count procedure was closely monitored. Hourly, daily, and weekly volumes of traffic were counted by two or three different methods and their results analyzed. These evaluations indicate that the truck classifier is comparable in accuracy to present units utilized in the traffic program. The truck classifier has the additional capability of providing a differentiation of type of vehicle for both short and long term tests.

2. Dependability.

   The unit operated unattended for both short and long term tests. Operations in excess of eight days were realizable with the average daily count exceeding 11,000 vehicles or total counts exceeding 99,000 equivalent two axle vehicles prior to recharging the battery.

3. Flexibility.

   The classifier normally operates on a pneumatic type input. However, by modifying the input board the truck classifier can be adapted to an electrical input. Similarly, the power supplied to the electronic circuitry is by means of ten nickel-cadmium batteries. By proper modification, the unit can be adapted to work from a 120v, 60 Hz auxiliary source.

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OVERALL LAYOUT OF SYSTEM

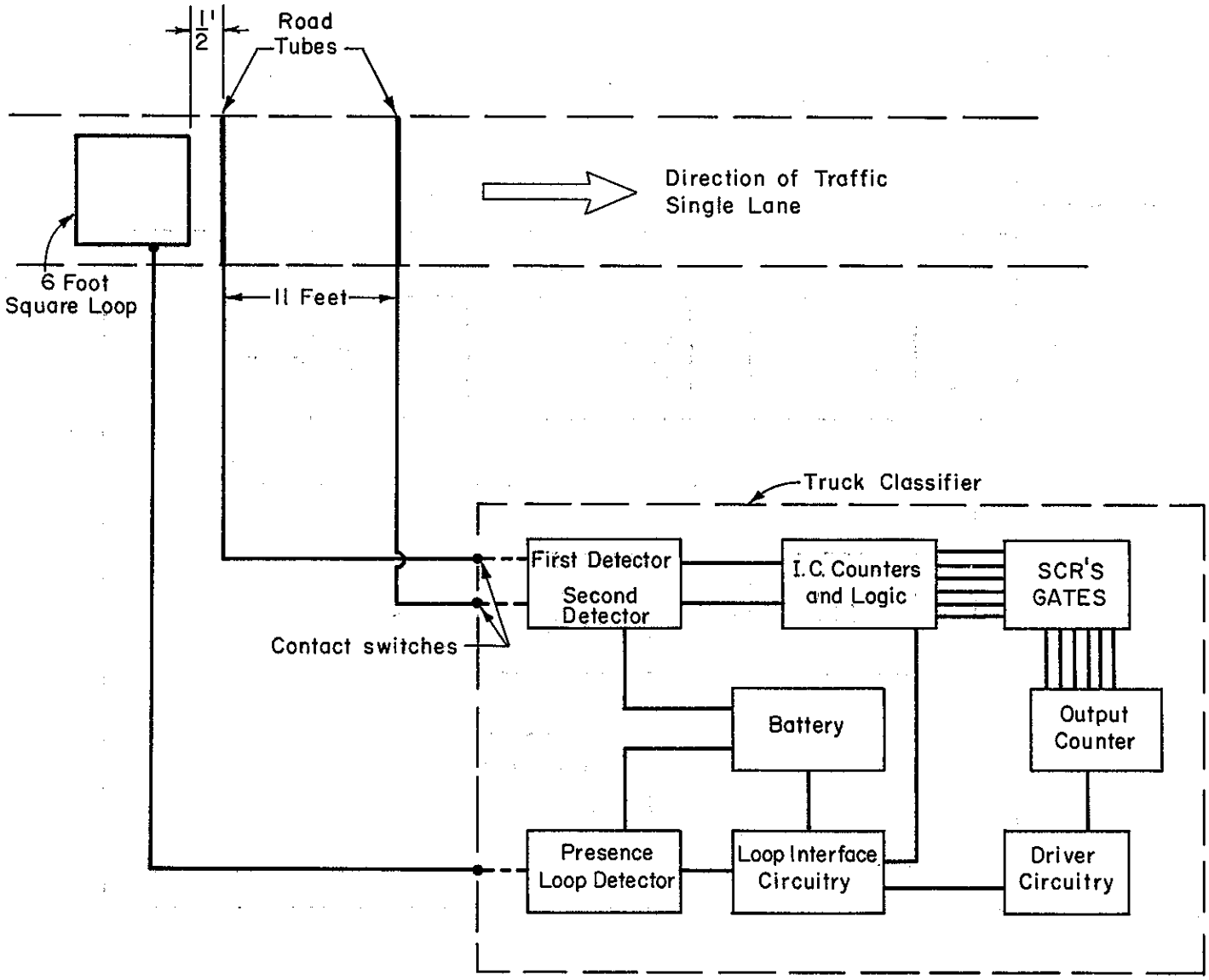

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Figure 2

PRESENCE LOOP DETECTOR

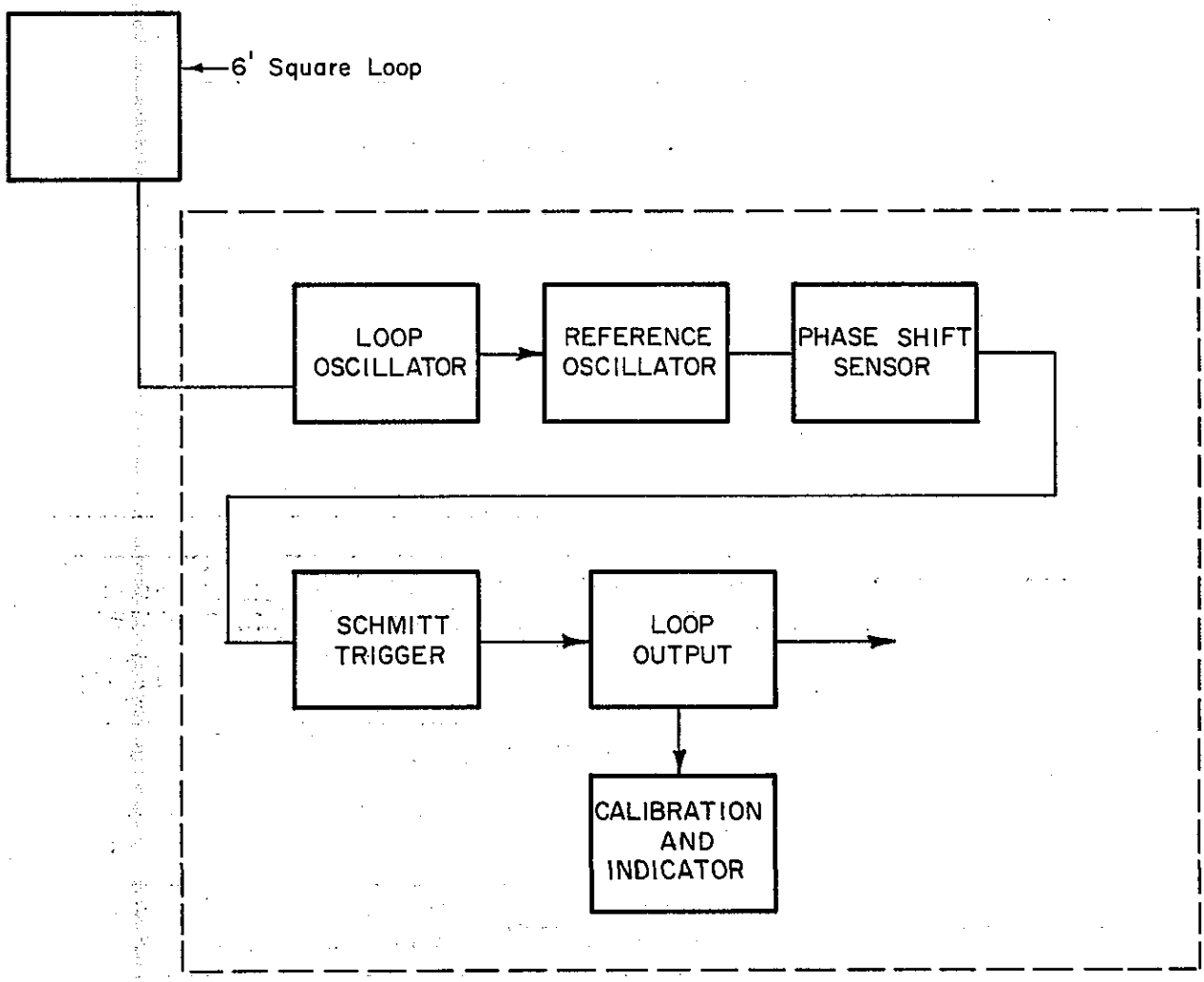

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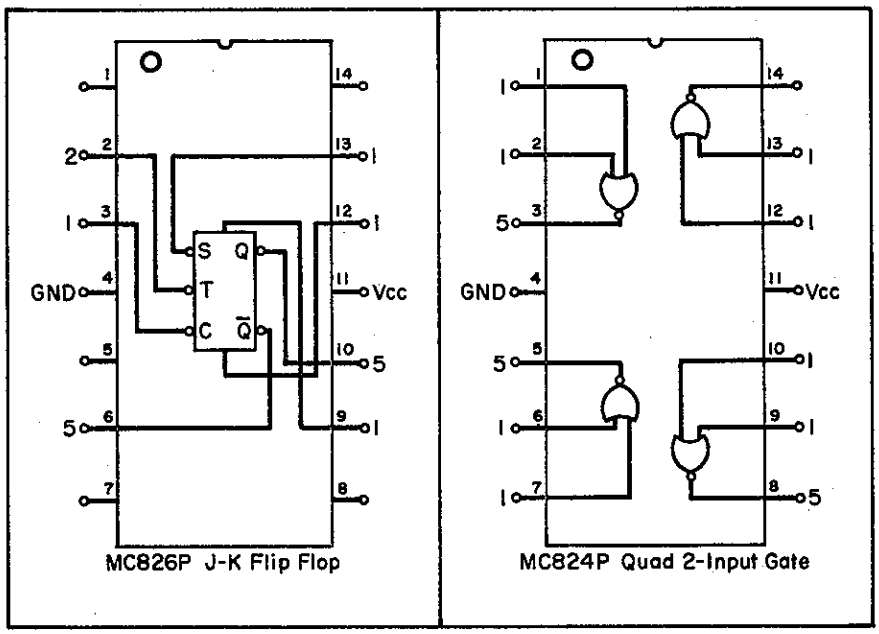
Figure 3

DIAGRAMS - INTEGRATED CIRCUTS

VALID FROM 0°C TO + 75°C WITH Vcc = 3.6 V ± 10% — TOP VIEWS



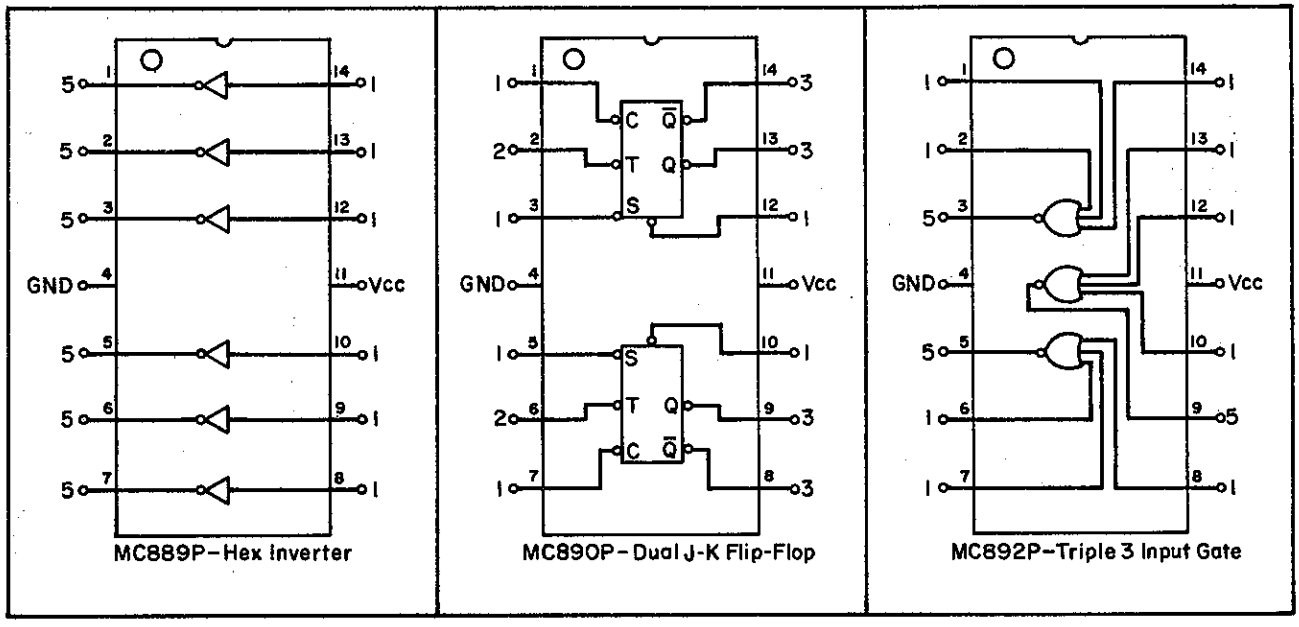


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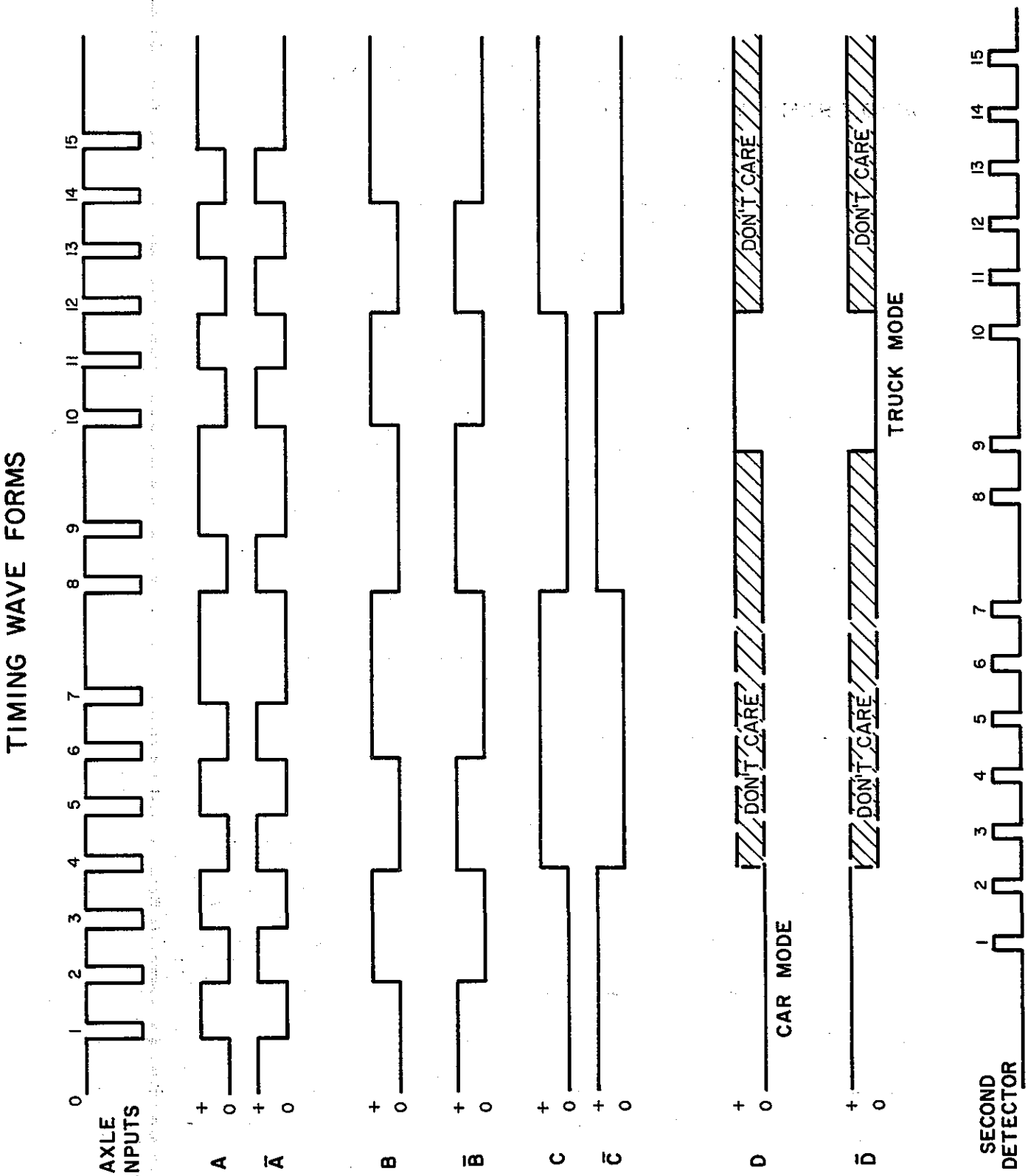
Figure 4



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VEHICLE TYPE VERSUS CAR-TRUCK MODE

VEHICLE TYPE	CARS									TRUCKS								
	LOGIC	NUMBER OF AXLES COUNTED								LOGIC	NUMBER OF AXLES COUNTED							
		0	1	2	3	4	5	6	7		0	1	2	3	4	5	6	7
2 AXLE	ACD	1	0	1	0	0	0	0	0	$AC\bar{D}$	1	0	1	0	0	0	0	0
*3 AXLE	$\bar{A}CD$	0	1	0	1	0	0	0	0	$\bar{A}C\bar{D}$	0	1	0	1	0	0	0	0
4 AXLE	—	0	0	0	0	0	0	0	0	$AB\bar{C}$	0	0	0	0	1	0	0	0
5 AXLE	—	0	0	0	0	0	0	0	0	$A\bar{C}+B\bar{C}$	0	0	0	0	0	1	0	0
6 AXLE	—	0	0	0	0	0	0	0	0	SAME	0	0	0	0	0	0	1	0
7 AXLE	—	0	0	0	0	0	0	0	0	SAME	0	0	0	0	0	0	0	1
		DON'T CARES									DON'T CARES							

*CAR MODE - INDICATES 2 AXLE CAR WITH TRAILER

TRUCK MODE - INDICATES 3 AXLE TRUCK.

Figure 5

Figure 6

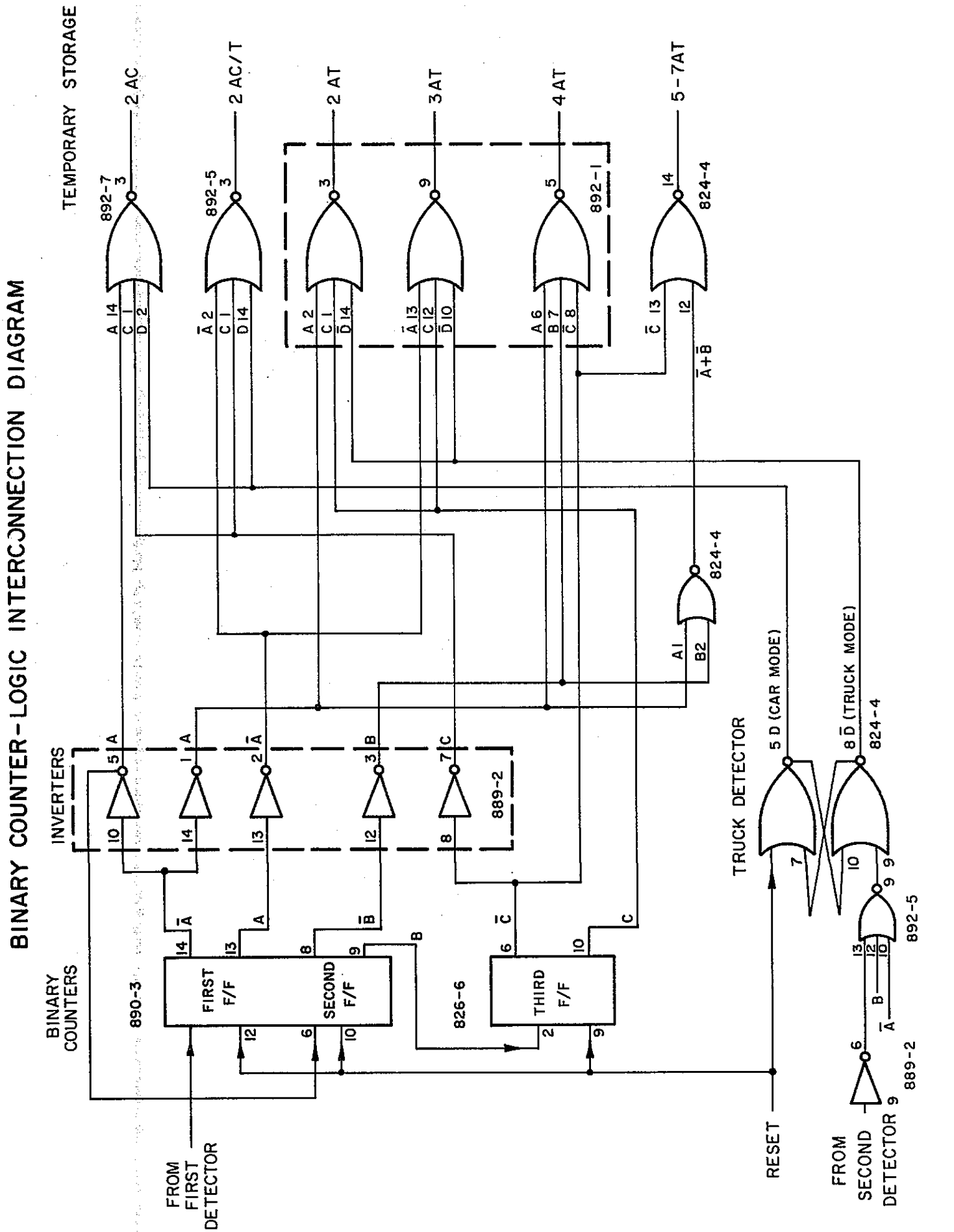

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Figure 7

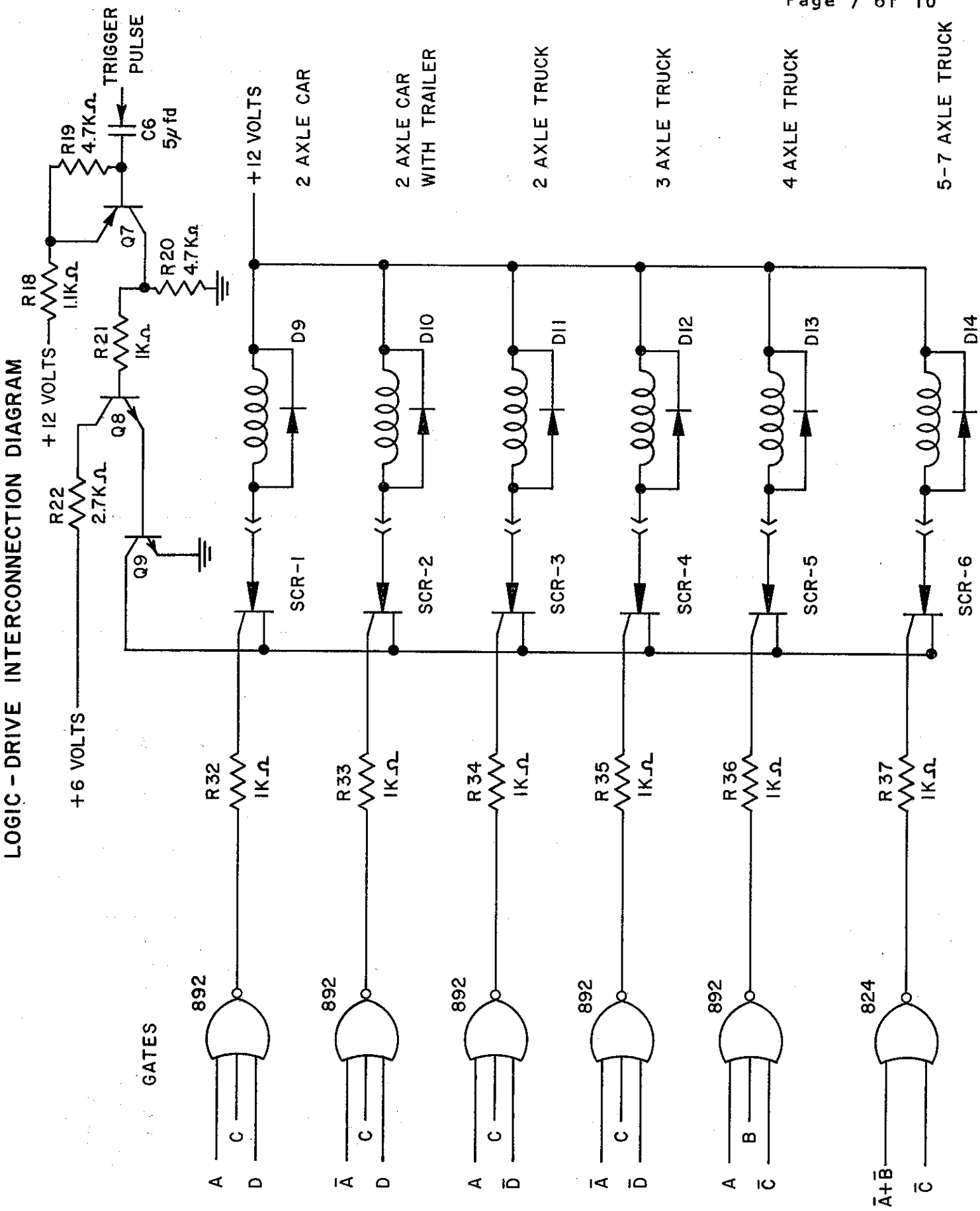

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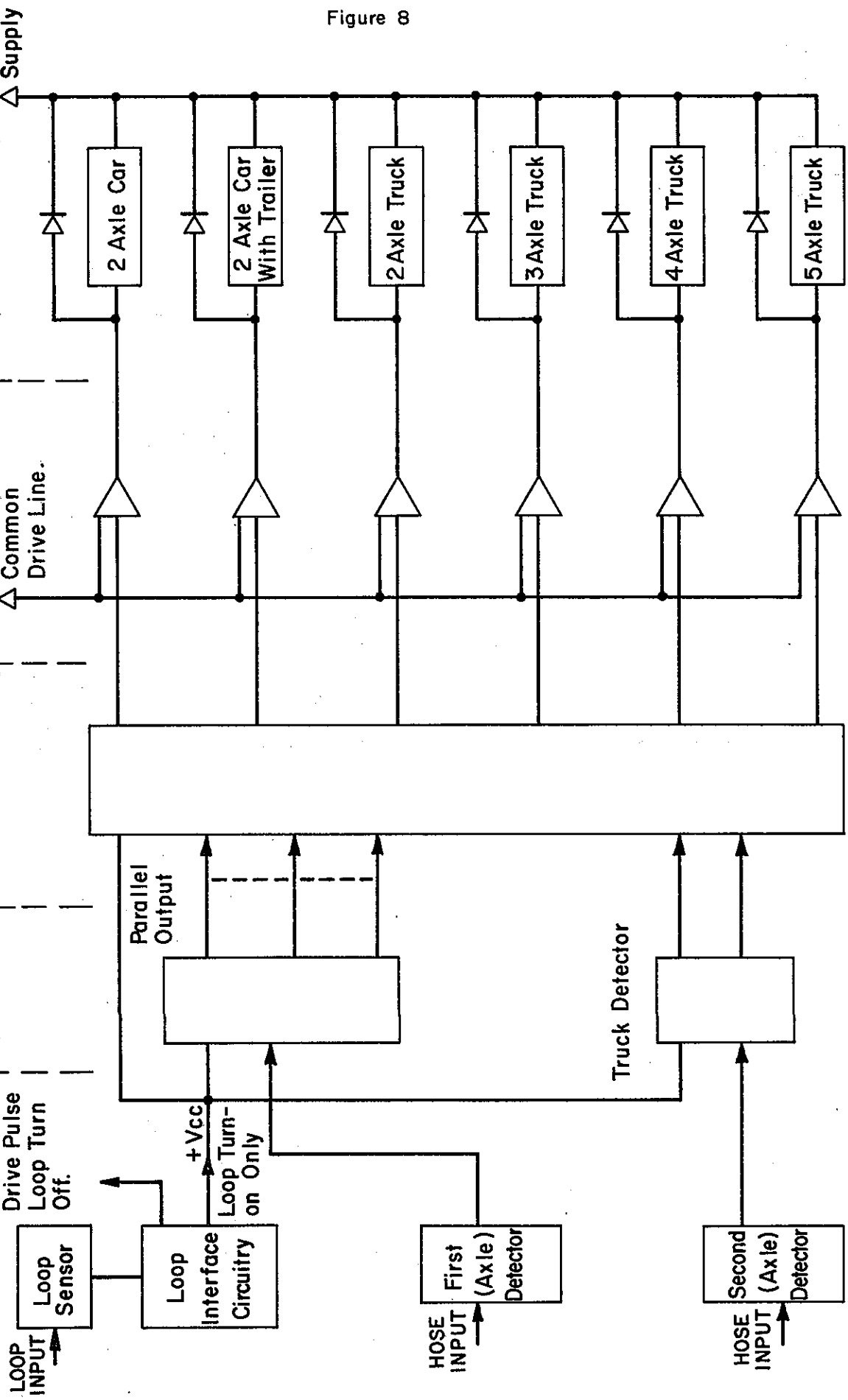
Figure 8

OVERALL BLOCK DIAGRAM



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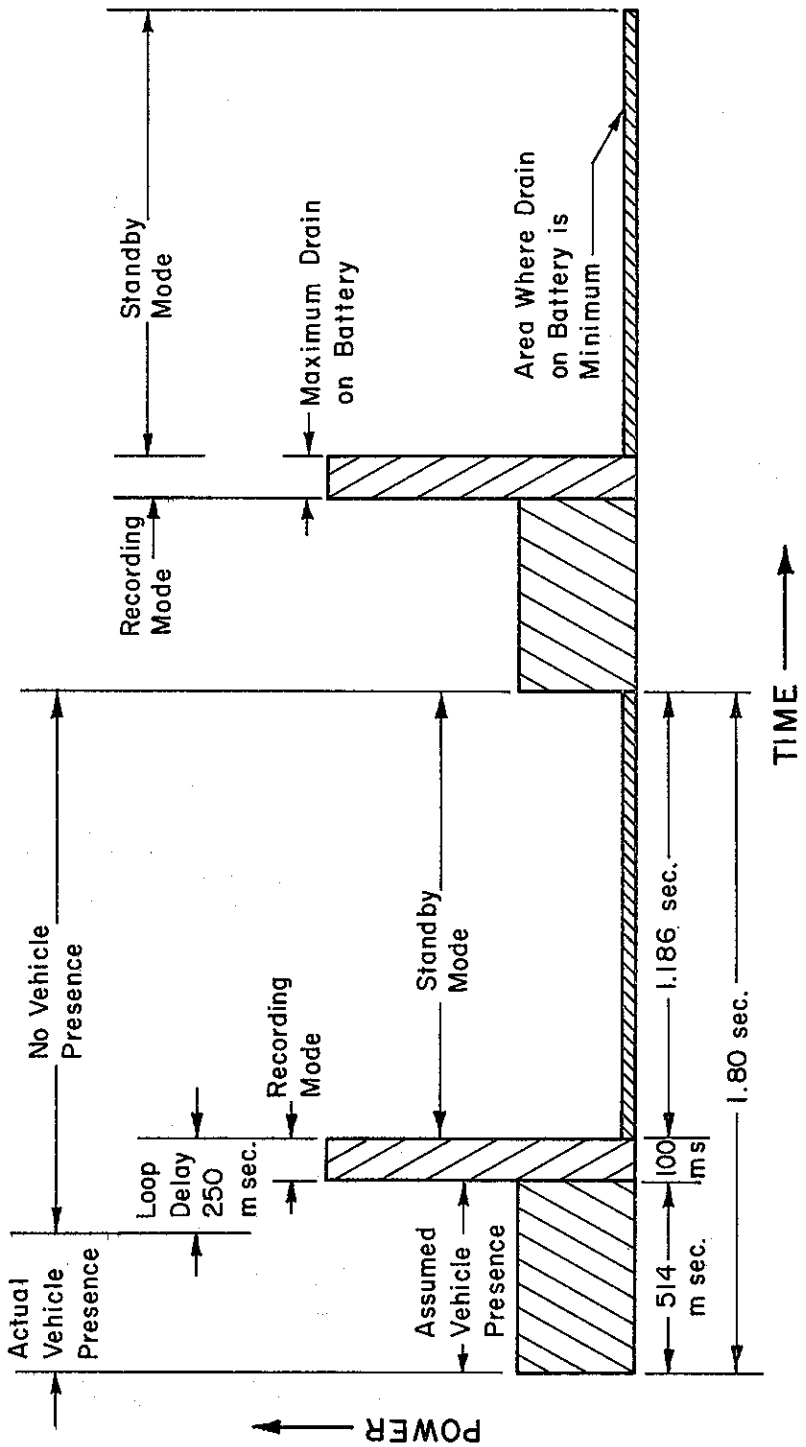
RELATIVE PULSED POWER DRAWN FROM BATTERY
VERSUS VEHICLE TRAVEL PAST LOOP



Assumptions: Minimum overall car length 15.2 feet.
Loop energized when front bumper of car is over leading edge (in direction of travel) of loop.
Loop denergized when rear bumper of car is over lagging edge of loop.
High rate of speed - 100 feet per second.
Distance between cars constant.

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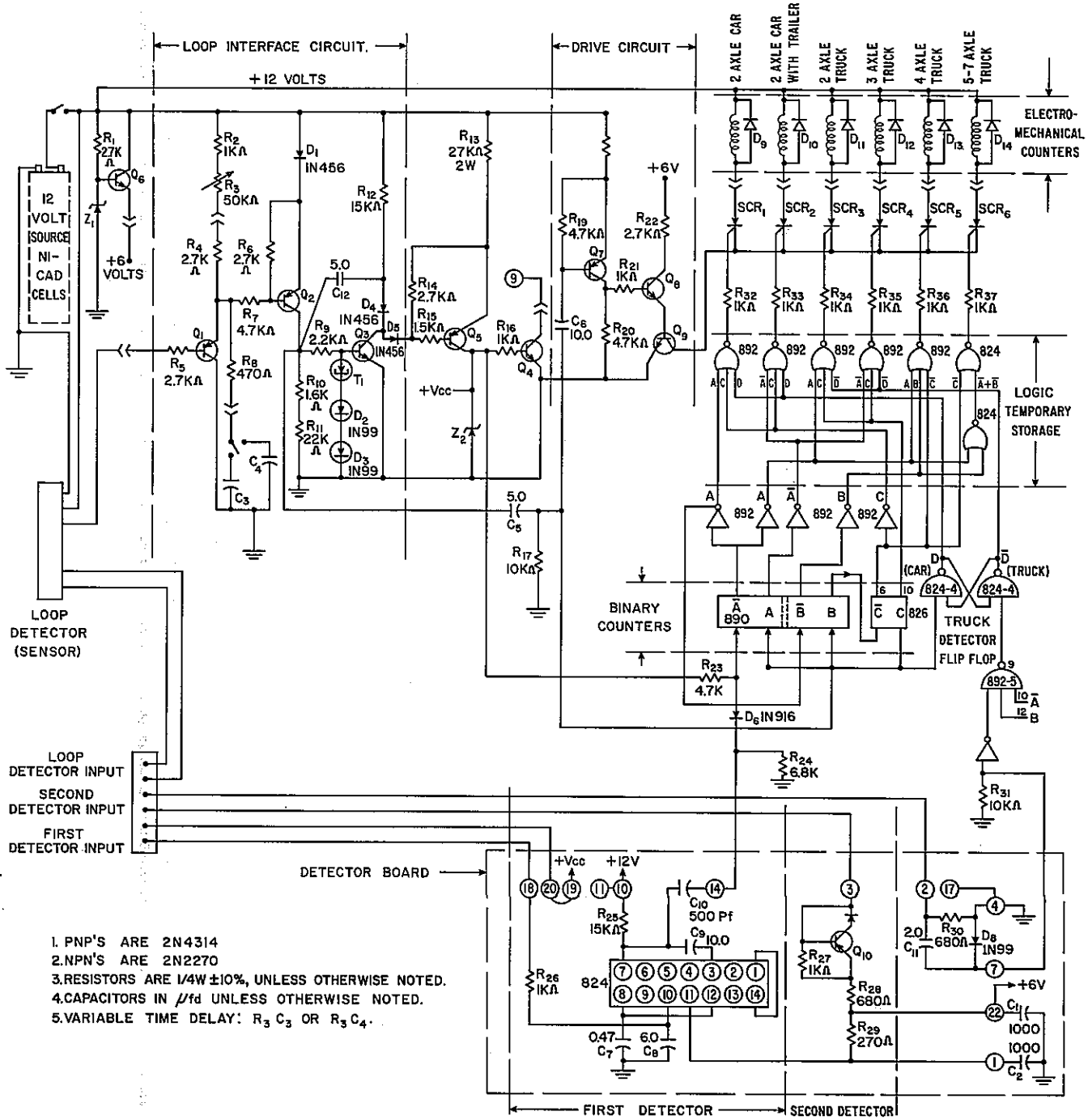
Figure 10

TRUCK CLASSIFIER SCHEMATIC



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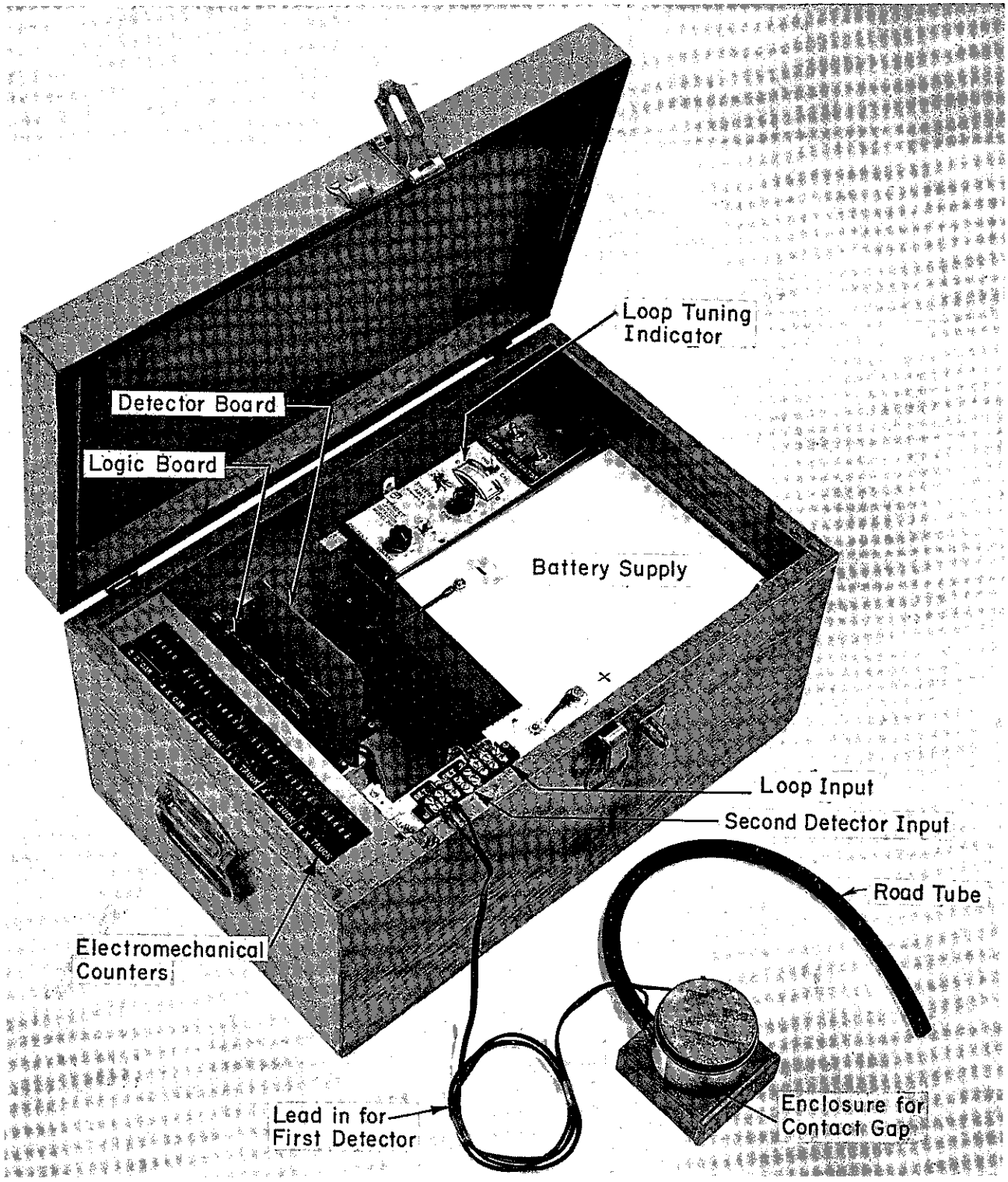

TRUCK CLASSIFIER
TOP VIEW - COMPLETE UNIT

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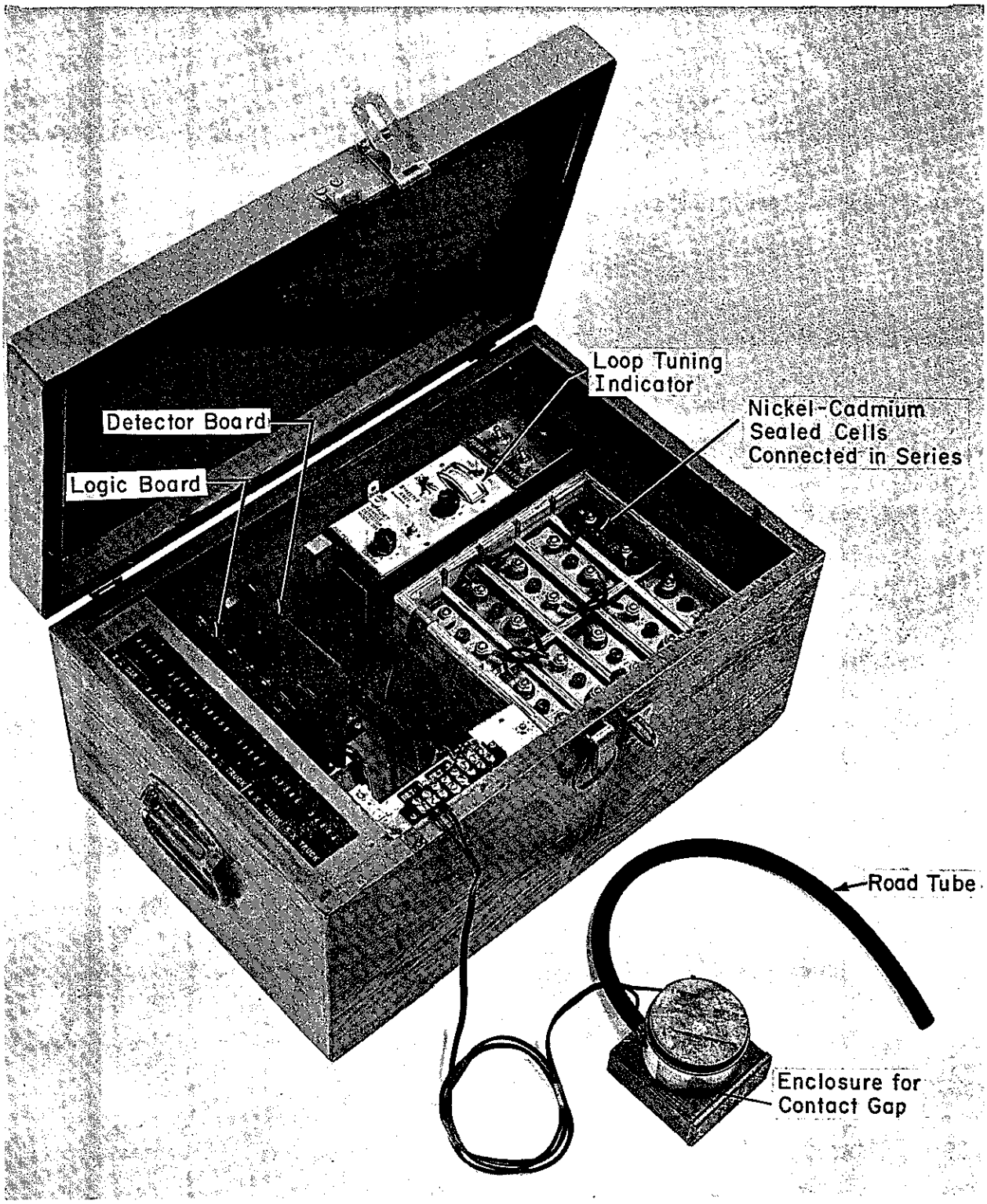
Exhibit 2



TRUCK CLASSIFIER

TOP VIEW - EXPOSED VIEW OF CELLS

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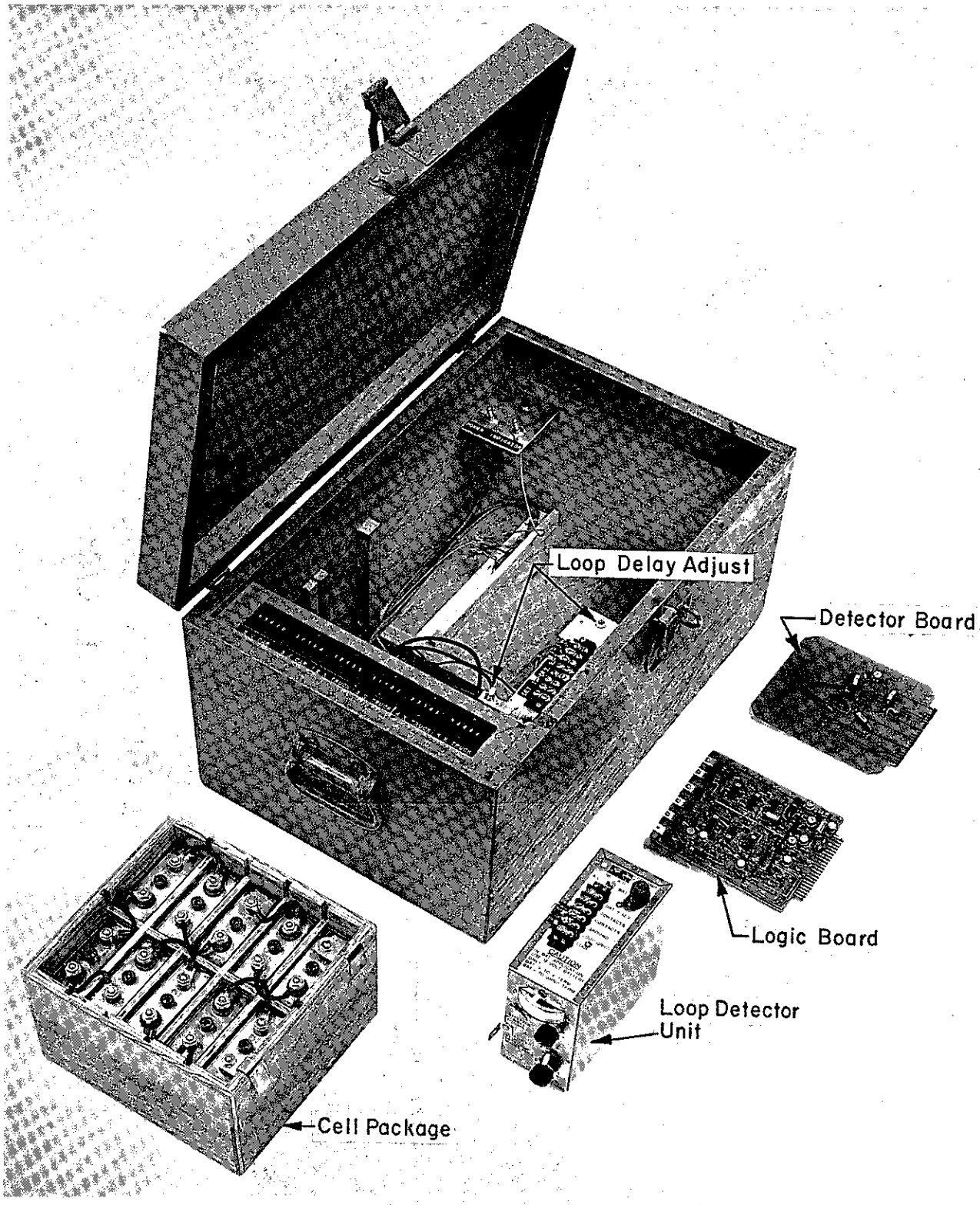

TRUCK CLASSIFIER

VIEW OF INDIVIDUAL STANDARD UNITS

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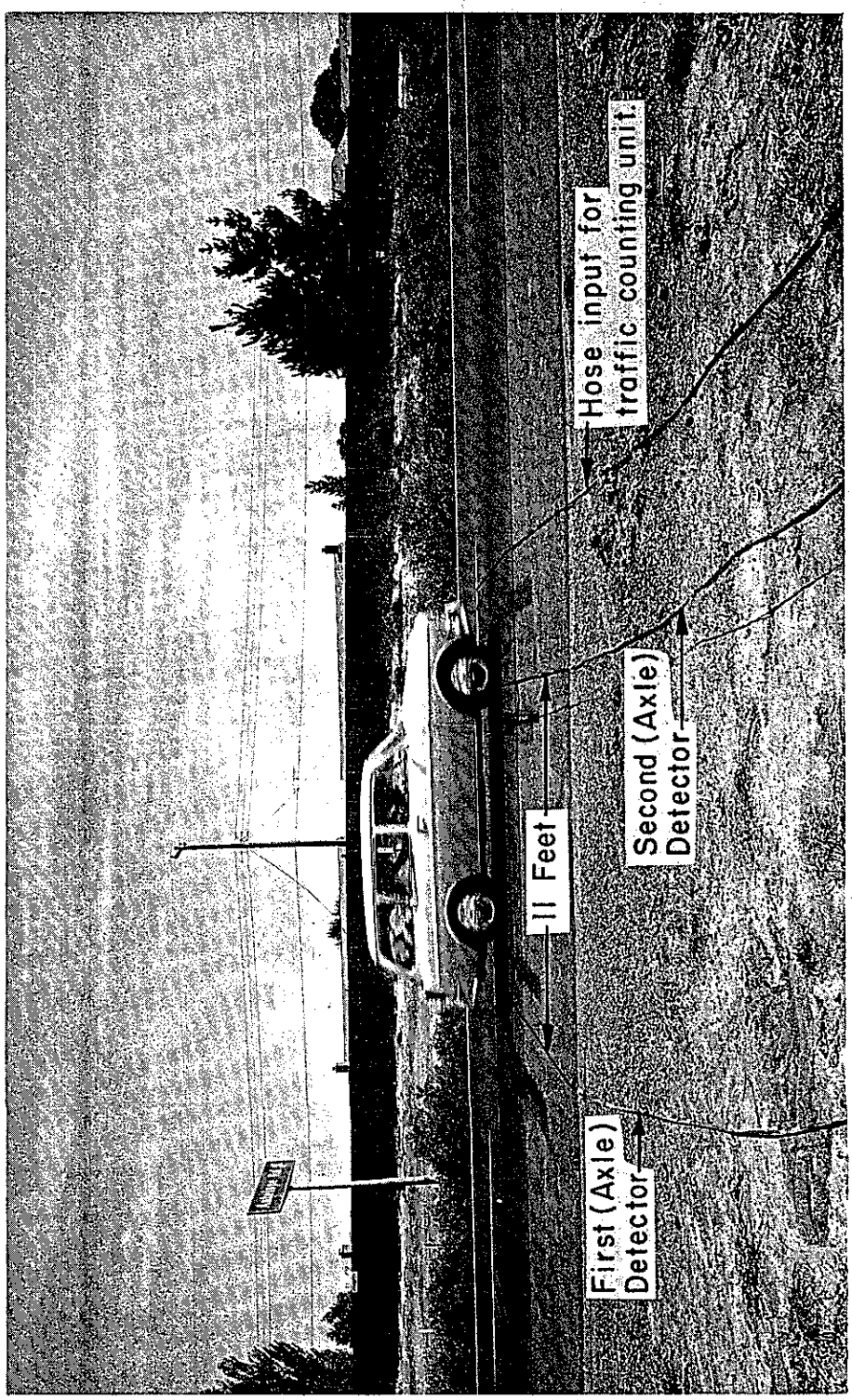
Exhibit 4



ANTELOPE ROAD TEST SITE
I-80 WEST BOUND
2 AXLE CAR

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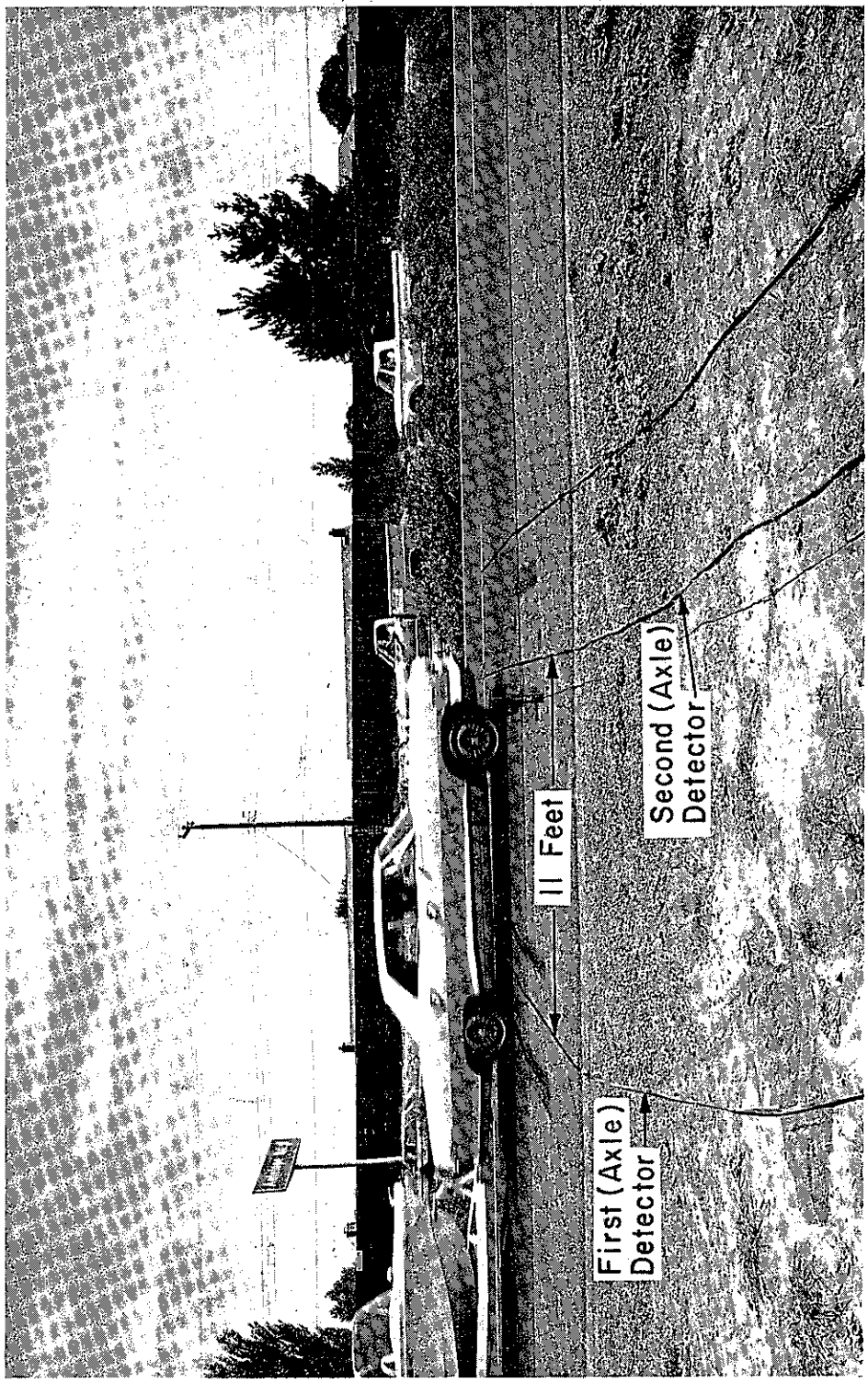

ANTELOPE ROAD TEST SITE
I-80 WEST BOUND
2 AXLE CAR WITH TRAILER

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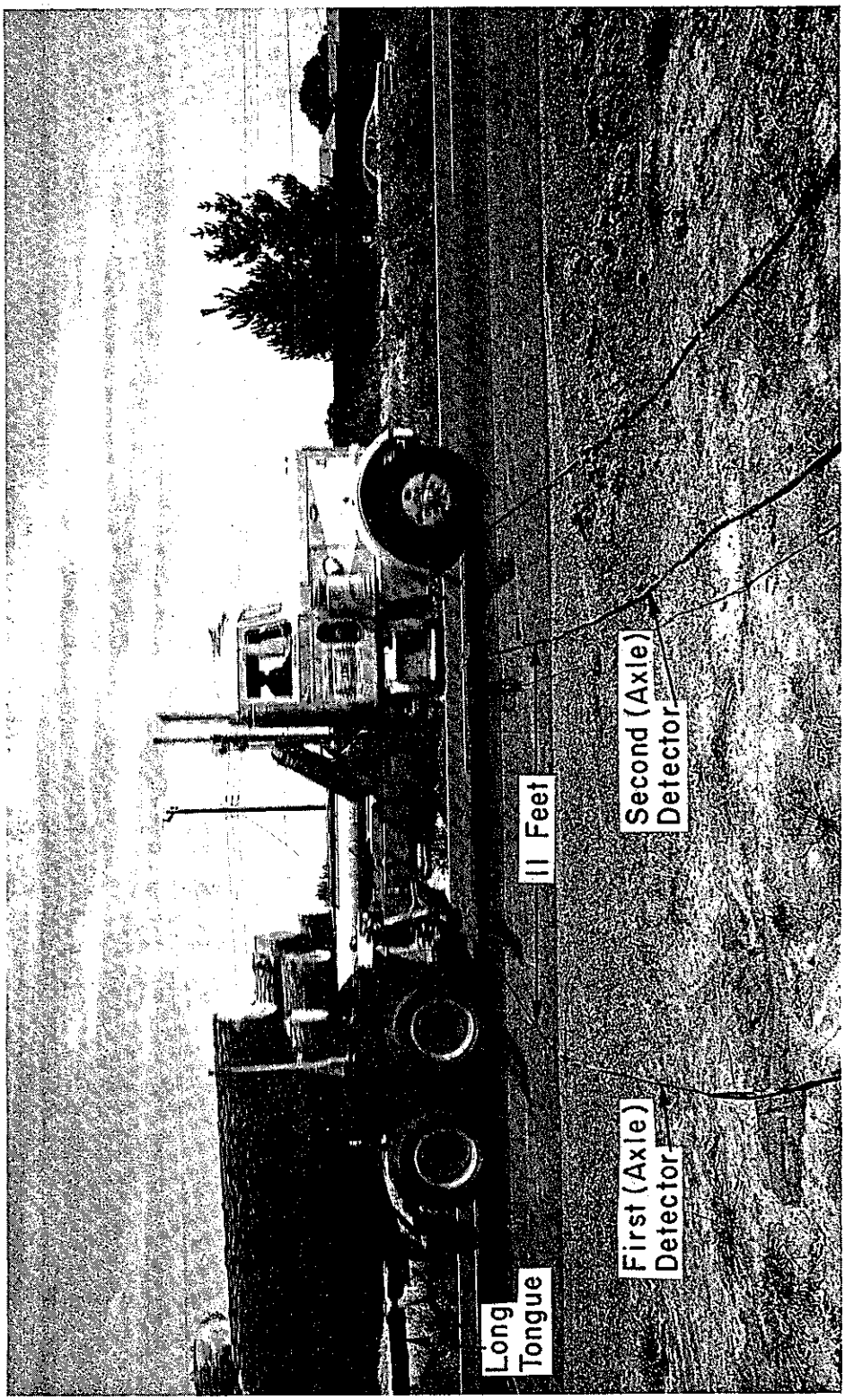
Exhibit 6



ANTELOPE ROAD TEST SITE
I-80 WEST BOUND
5 AXLE TRAILER - LONG TONGUE

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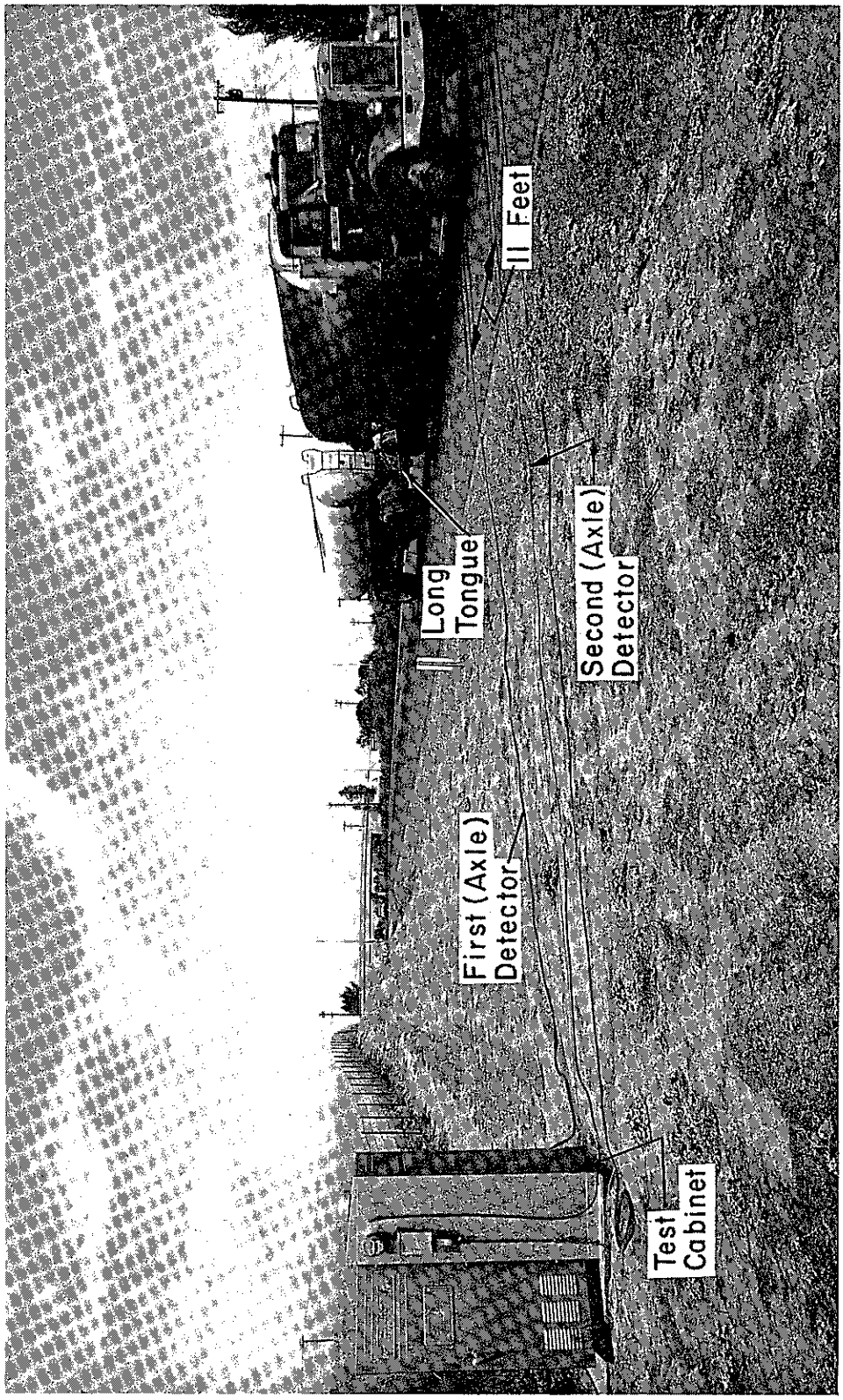

ANTELOPE ROAD TEST SITE
I-80 WEST BOUND
5 AXLE TRAILER - LONG TONGUE

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TABLE 4

LONG TERM TESTING OF TRUCK CLASSIFIER

Date	Truck Classifier	Fisher Porter	Percentage Difference	Total Hours	Equivalent Days	Truck Classifier Vehicles Per Hour	Remarks
1968							
6-11 to 6-23	137,110	123,551	10.90	264.0	11.0	520.00	Damaged road tube resulted in lower count for Fisher Porter unit.
6-26 to 7-5	113,683	114,130	0.39	235.0	9.8	483.75	NOTE:
7-5 to 7-22	117,668.5	117,006	0.56	228.0	9.5	515.63	Equivalent days are for continuous unattended operation for the dates shown.

TABLE 5

SHORT TERM TESTING LESS THAN ONE DAY

PERIOD FROM 10-25-68 TO 1-9-69

a.

Test Number	Device Used	2 Axle Car	Truck	Total	Percent Difference	Remark
1	*TC	45	0	= 45		Acceptable
	MC	48	0	= 48		
2	TC	53	3	= 56	5	
	MC	53	6	= 59		
3	TC	9	0	= 9		Acceptable
	MC	9	0	= 9		
4	TC	248	0	= 248	.8	
	MC	240	10	= 250		
5	TC	206	1	= 207	.9	
	MC	205	4	= 209		
6	TC	91	23	= 114		
	MC	99	14	= 113	.88	
7	TC	105	11	= 116		
	MC	99	16	= 115	.8	

b.

Test Number	Device Used	2 Axle Car-Trailer	3 Axle Car	Total	Percent Difference	Remark
1	TC	1	0	= 1		Acceptable
	MC	2	0	= 2		"
2	TC	2	0	= 2		"
	MC	1	1	= 2		"
3	TC	1	0	= 1		"
	MC	0	1	= 1		"
4	TC	10	0	= 10		"
	MC	6	3	= 9		"
5	TC	8	0	= 8		"
	MC	6	2	= 8		"
6	TC	0	3	= 3		"
	MC	1	2	= 3		"
7	TC	0	0	= 0		"
	MC	0	0	= 0		"

* TC denotes Truck Classifier
MC denotes Manual Counter

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TABLE 5

SHORT TERM TESTING LESS THAN ONE DAY

PERIOD FROM 10-25-68 TO 1-9-69

c. Test Number	Device Used	4 Axle Truck	Remark	5-7 Axle Truck	Remark
1	TC	0	Acceptable	4	Acceptable
	MC	0	"	4	"
2	TC	1	"	12	"
	MC	1	"	12	"
3	TC	1	"	1	"
	MC	1	"	1	"
4	TC	1	"	15	"
	MC	1	"	15	"
5	TC	2	"	15	"
	MC	2	"	15	"
6	TC	1	"	5	"
	MC	1	"	5	"
7	TC	1	"	2	"
	MC	1	"	2	"

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TABLE 6

SHORT TERM TESTING - LESS THAN ONE DAY

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

		← Cars →		← Trucks →				Equivalent	Inter-	
Date	Recorder	2 Axle	2 Axle W/Trailer	2 Axle	3 Axle	4 Axle	5-7 Axle	2 Axle Vehicles	Hose Spacing	Remarks
6-10-68	*TC	240	9	5	2	5	18	316.5	11 feet	From 6-10-68 to 8-7-68 the following conditions adhered to:
	MC	243	8	4	1	4	20	318.5		
	TC	152	4	3	1	1	14	199.5		
	MC	149	2	4	3	1	14	197.5		
6-11-68	TC	249	7	4	3	4	16	316.0		
	MC	257	6	3	3	1	15	313.0		
6-12-68	TC	234	10	7	1	1	12	289.5		Battery Voltage monitored - Range: 11-14 Volts
	MC	217	5	6	5	1	12	270.0		
6-13-68	TC	234	11	6	2	3	20	315.5		
	MC	203	9	7	4	2	20	283.5		
6-14-68	TC	243	10	5	7	5	20	333.5		Contact Gap for first detector input: 0.008"
	MC	240	8	9	6	4	20	328.0		
6-17-68	TC	247	9	10	2	3	15	317.0		
	MC	247	6	10	5	4	15	319.0		Contact Gap for second detector input: 0.003"
6-19-68	TC	232	4	6	1	2	15	287.0		
	MC	231	2	5	3	3	14	284.5		
6-20-68	TC	215	4	9	4	7	18	295.0		Loop Delay - 250 m sec.
	MC	201	5	10	4	7	17	281.0		
6-21-68	TC	204	9	11	5	2	15	277.5		
	MC	202	6	13	5	2	16	275.5		
6-26-68	TC	274	16	10	4	3	15	357.5		
	MC	271	14	15	8	2	17	365.5		
6-27-68	TC	330	10	10	4	3	24	427.0		
	MC	320	6	11	7	3	**15	394.0		
6-28-68	TC	244	17	5	3	3	16	325.0		
	MC	240	12	8	7	4	15	322.0	11 feet	

NOTE: * TC Denotes Truck Classifier
MC Denotes Manual Counter
** Should be Higher

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TABLE 6

SHORT TERM TESTING - LESS THAN ONE DAY

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

Date	Recorder	Cars: 2 Axle	Cars: 2 Axle W/Trailer	Trucks: 2 Axle	Trucks: 3 Axle	Trucks: 4 Axle	Trucks: 5-7 Axle	Equivalent 2 Axle Vehicles	Inter-Hose Spacing	Remarks
7-1-68	TC	295	12	9	1	6	24	395.5	11 feet	
	MC	282	10	16	3	7	23	389.0		
7-2-68	TC	261	5	5	2	2	22	335.5		
	MC	262	5	7	3	1	21	335.5		
7-3-68	TC	240	4	13	2	6	18	318.0		
	MC	239	4	11	1	6	19	317.0		
7-10-68	TC	104	6	8	4	0	11	154.5	11 feet	
	MC	103	6	7	4	0	11	152.5		
7-12-68	TC	239	19	14	9	7	20	359.0	10.5 feet	Only Inter Hose Spacing Changed
	MC	238	14	15	9	6	21	352.0		
7-15-68	TC	239	11	13	5	6	17	330.5		
	MC	233	10	10	3	5	17	315.0		
7-16-68	TC	178	8	8	2	5	9	233.5		
	MC	180	8	5	2	4	8	228.0	*	
7-29-68	TC	234	10	8	3	5	18	316.5		
	MC	233	9	9	4	4	17	312.0		
7-31-68	TC	242	19	19	5	1	26	364.0		
	MC	250	17	16	5	2	24	363.0		
	TC	263	21	11	4	2	29	388.0		
	MC	269	19	9	5	2	28	388.0		
8-1-68	TC	223	12	15	4	4	21	322.5		
	MC	219	13	13	2	5	21	317.0		
	TC	195	14	14	5	11	12	289.5		
	MC	215	9	5	3	9	18	301.0		
8-2-68	TC	283	12	20	3	8	13	374.0		
	MC	282	11	20	6	7	15	379.0		
	TC	226	12	10	3	5	14	303.5	10.5 feet	
	MC	215	11	11	3	7	14	296.0		

* See Page 4, Table 6 - Same Conditions as shown under Remarks.

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TABLE 6

SHORT TERM TESTING - LESS THAN ONE DAY

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

Date	Recorder	Cars: 2 Axle	Cars: 2 Axle W/Trailer		Trucks: 2 Axle	Trucks: 3 Axle	Trucks: 4 Axle	Trucks: 5-7 Axle	Equivalent 2 Axle Vehicles	Inter-Hose Spacing	Remarks
8-7-68	TC	246	20		9	3	6	12	331.5	10.5 feet	Overcount: 2 Axle C. T. 2nd Detector Contact Gap Reset: 0.002". Still have overcount. Noise on input to detector board. Made following changes examined results: 1. Placed butyl rubber under road tube. 2. Varied contact gap settings. 3. Loop detuned slightly. 4. Damper spring replaced. One cause - interaction between 1st, 2nd detector circuits.
	MC	240	13		8	3	4	13	312.5		
	TC	244	27		13	5	5	19	362.5		
	MC	260	6		11	5	4	19	343.0		
8-9-68	TC	248	19		18	2	3	27	371.0		
	MC	239	9		15	2	6	30	357.5		
8-12-68	TC	237	17		6	3	8	16	329.0		
	MC	242	13		5	4	10	16	332.5		
	TC	245	8		5	2	3	16	311.0		
	MC	252	7		5	2	4	16	318.5		
8-13-68	TC	221	12		9	4	6	23	323.0		
	MC	229	8		8	5	5	21	319.0		
	TC	209	9		7	2	0	11	260.0		
	MC	203	5		12	4	0	11	256.0	*	
8-15-68	TC	171	9		9	2	4	10	229.5		
	MC	182	3		8	2	3	10	228.5		
	TC	176	9		5	2	4	9	228.0		
	MC	172	8		9	2	3	9	224.0		
	TC	131	10		4	0	3	8	176.0		
	MC	132	9		4	1	2	8	175.0		
8-22-68	TC	197	11		62	7	7	16	340.0	10.5 feet	
	MC	240	10		8	5	5	11	308.0		
8-23-68	TC	123	10		22	3	5	6	189.5	10.5 feet	
	MC	146	9		6	0	4	5	186.0		
	TC	135	8		4	0	1	6	168.0	11.0 feet	
	MC	136	4		7	0	0	5	161.5		
8-27-68	TC	83	4	**	-	-	1	4	101.0	11.0 feet	
	MC	83	4		-	-	1	6	106.0		
	TC	98	4		-	-	3	8	130.0		
	MC	100	3		-	-	3	6	125.5		
	TC	91	9		0	0	2	10	133.5		
	MC	91	2		4	1	1	9	124.0		

* From 8-7-68 to 10-7-68. The unit was modified and field tested.
** Not used.

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TABLE 6

SHORT TERM TESTING - LESS THAN ONE DAY

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

Date	Recorder	Cars: 2 Axle	Cars: 2 Axle W/Trailer		Trucks: 2 Axle	Trucks: 3 Axle	Trucks: 4 Axle	Trucks: 5-7 Axle	Equivalent 2 Axle Vehicles	Inter-Hose Spacing	Remarks
8-30-68	TC	165	14		0	0	2	10	215.0	11 feet	Modified both Detector Circuits.
	MC	154	11		7	1	1	10	206.0		
	TC	86	2		5	4	3	4	116.0		
	MC	88	2		4	2	2	4	112.0		
9-4-68	TC	97	7	**	-	-	5	3	125.0		Contact Gap 1st Detector: 0.010"
	MC	101	5		-	-	4	3	124.0		
	TC	124	4		-	-	4	11	165.5		
	MC	127	4		-	-	2	12	167.0		
9-5-68	TC	114	10		2	2	2	7	155.5		Added Additional Capacitance to Circuit for +3.4 Volts Line - Greater Stability
	MC	115	2		5	2	1	5	140.5		
	TC	106	6		4	1	2	4	134.5		
	MC	111	1		3	0	0	5	128.0	*	
	TC	114	5		10	0	2	4	145.5		
	MC	105	2		11	1	1	4	132.5		
	TC	106	11		2	1	5	3	143.5		
	MC	112	5		7	2	2	2	138.5		
	TC	109	6		5	3	4	6	150.5		
	MC	113	0		5	2	2	9	147.5		
	TC	111	8		7	3	3	17	183.0		
	MC	124	5		5	4	2	16	186.5		
	TC	100	5		4	0	3	4	127.5		Further testing required
	MC	116	2		5	1	2	3	137.0		
10-7-68	TC	106	1		5	4	3	11	152.0	11 feet	1st Detector: C_s = 9 µfd
	MC	106	3		6	0	3	11	150.0		
	TC	98	0		2	9	1	13	148.0		
	MC	92	4		5	2	0	15	143.5		C_s = 5 µfd
	TC	104	2	**	-	-	0	7	124.5		
	MC	105	1		0	1	0	9	130.5		C_s = 7 µfd
	TC	134	1	**	-	-	6	8	167.5		
	MC	123	0		5	1	4	9	160.0		C_s = 11 µfd

* See Page 6 footnote.

** Second detector not used.

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TABLE 6

SHORT TERM TESTING - LESS THAN ONE DAY

TRUCK CLASSIFIER COUNT VERSUS MANUAL COUNT

Date	Recorder	Cars: 2 Axle	Cars: 2 Axle W/Trailer	Trucks: 2 Axle	Trucks: 3 Axle	Trucks: 4 Axle	Trucks: 5-7 Axle	Equivalent 2 Axle Vehicles	Inter-Hose Spacing	Remarks
10-25-68	TC	45	1	0	0	0	4	56.5	11 feet	C_s=6 µfd
	MC	48	2	0	0	0	4	61.0		
	TC	53	2	3	0	1	12	91.0		Testing resumed
	MC	53	1	6	1	1	12	94.0		No modifications; contact gap: 1st Detector: 0.008" 2nd Detector: 0.003"
11-8-68	TC	9	1	0	0	1	1	15.0		
	MC	9	0	0	1	1	1	15.0		
	TC	248	10	0	0	1	15	302.5		
	MC	240	6	10	3	1	15	303.0		
	TC	206	8	1	0	2	15	260.5		
	MC	205	6	4	2	2	15	262.5		
1-9-69	TC	91	0	23	3	1	5	133.0		Road Tubes 1st: 44'-3" 2nd: 38'-5"
	MC	99	1	14	2	1	5	132.0		
	TC	105	0	11	0	1	2	123.0	11 feet	
	MC	99	0	16	0	1	2	122.0		1st: 38'-3" 2nd: 38'-5"
										Loop Delay: 250 msec.

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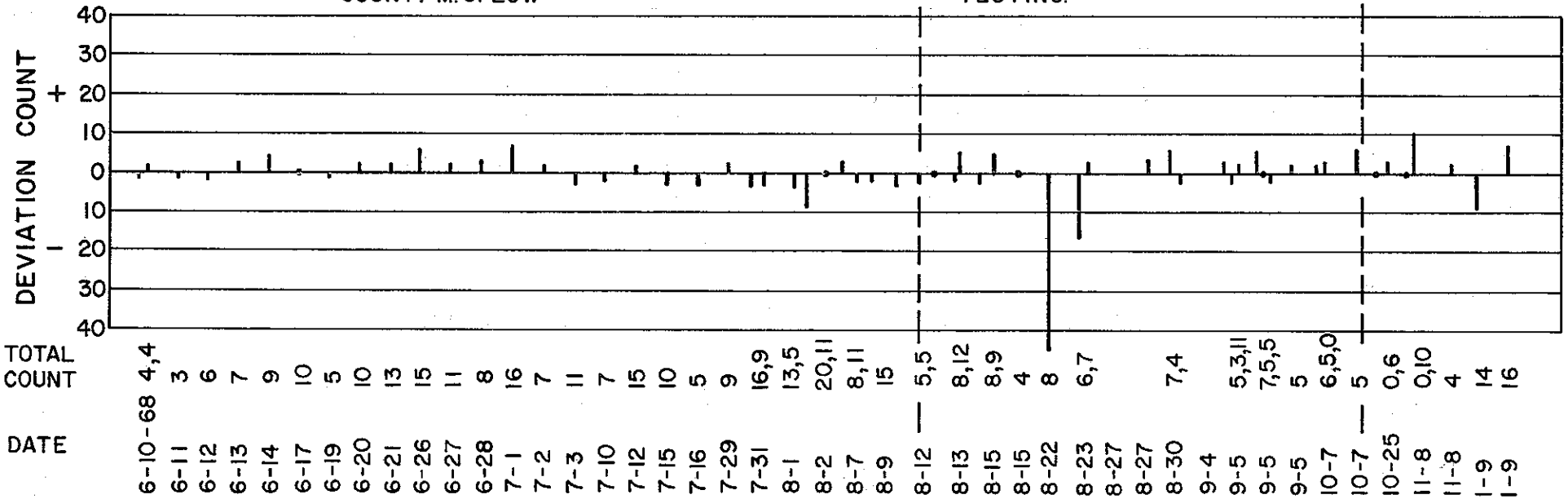
TWO AXLE TRUCKS - DEVIATIONS FROM MANUAL COUNT

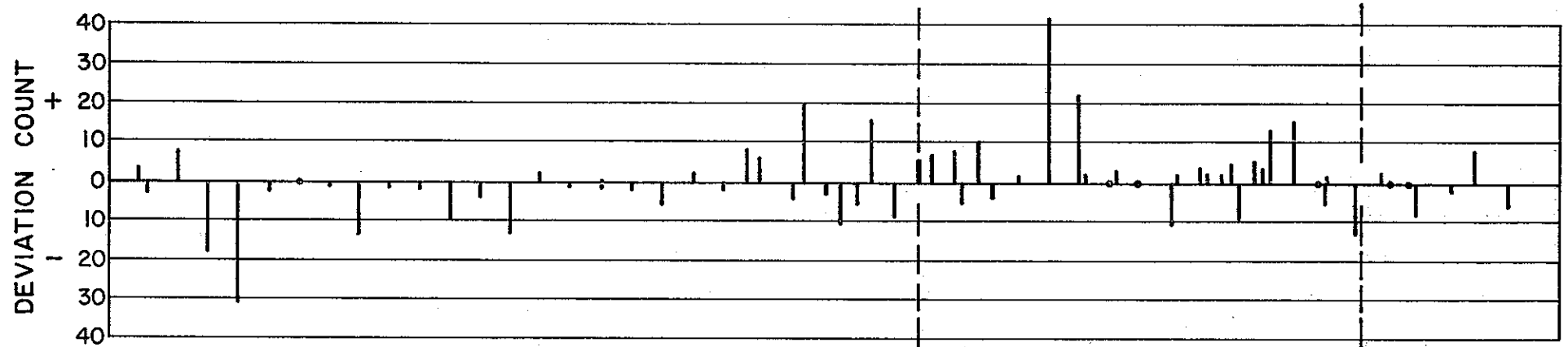
MANUAL COUNT
TAKEN AS REFERENCE
+ COUNT: M.C. HIGH
- COUNT: M.C. LOW

DURING THIS TIME UNIT WAS
MODIFIED AND FIELD TESTED
SEE APPENDIX C-SHORT TERM
TESTING.



DATE	TOTAL COUNT
6-10-68	4,4
6-11	3
6-12	6
6-13	7
6-14	9
6-17	10
6-19	5
6-20	10
6-21	13
6-26	15
6-27	11
6-28	8
7-1	16
7-2	7
7-3	11
7-10	7
7-12	15
7-15	10
7-16	5
7-29	9
7-31	16,9
8-1	13,5
8-2	20,11
8-7	8,11
8-9	15
8-12	5,5
8-13	8,12
8-15	8,9
8-15	4
8-22	8
8-23	6,7
8-27	7,4
8-27	5,3,11
8-30	7,5,5
9-4	5
9-5	6,5,0
9-5	5
9-5	0,6
10-7	0,10
10-7	4
10-25	14
11-8	16
11-8	
1-9	
1-9	

TWO AXLE CARS - DEVIATIONS FROM MANUAL COUNT



TOTAL COUNT
243,149
257
217
203
240
247
231
201
202
271
320
240
282
262
239
103
238
233
180
233
250,269
219,215
282,215
240,260
239
242,252
229,203
182,172
132
240
146,136
83,100
91
154,88
101,127
115,111,105
112,113,124
116
106,92,105
123
48,53
9,240
205
99
99

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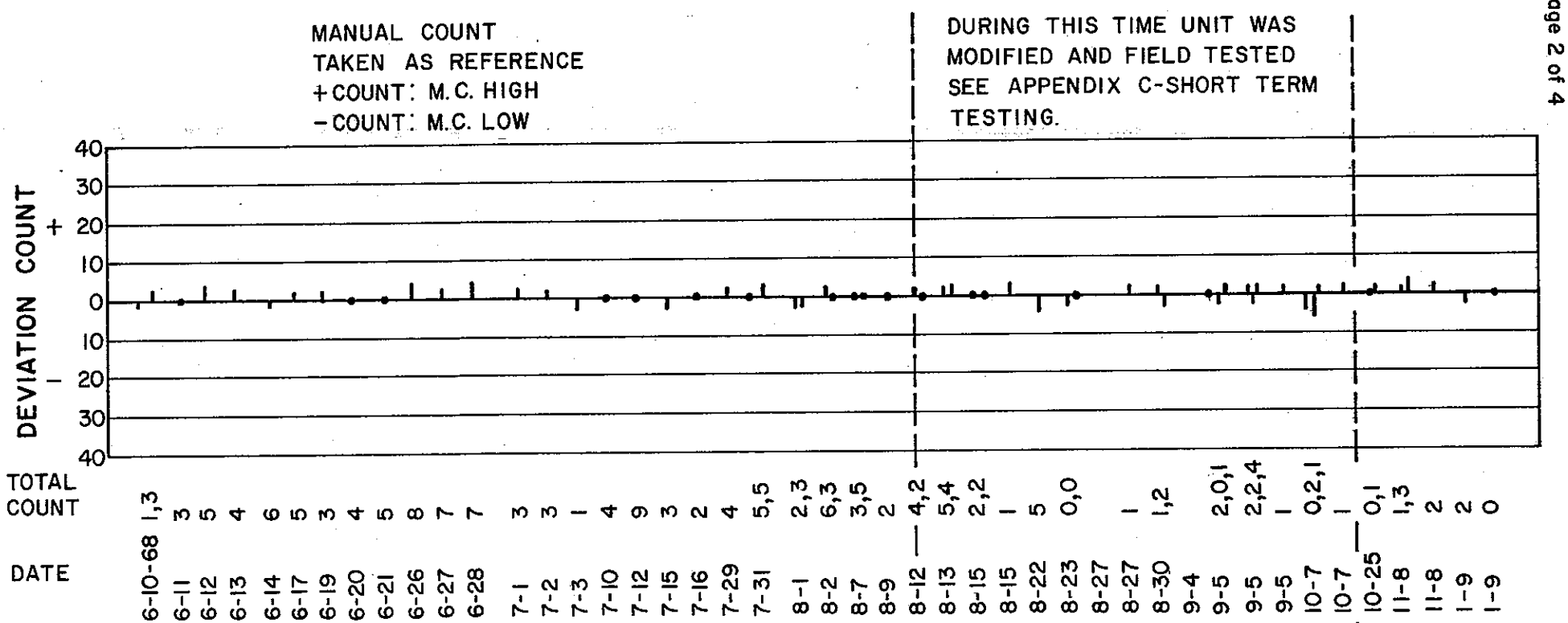
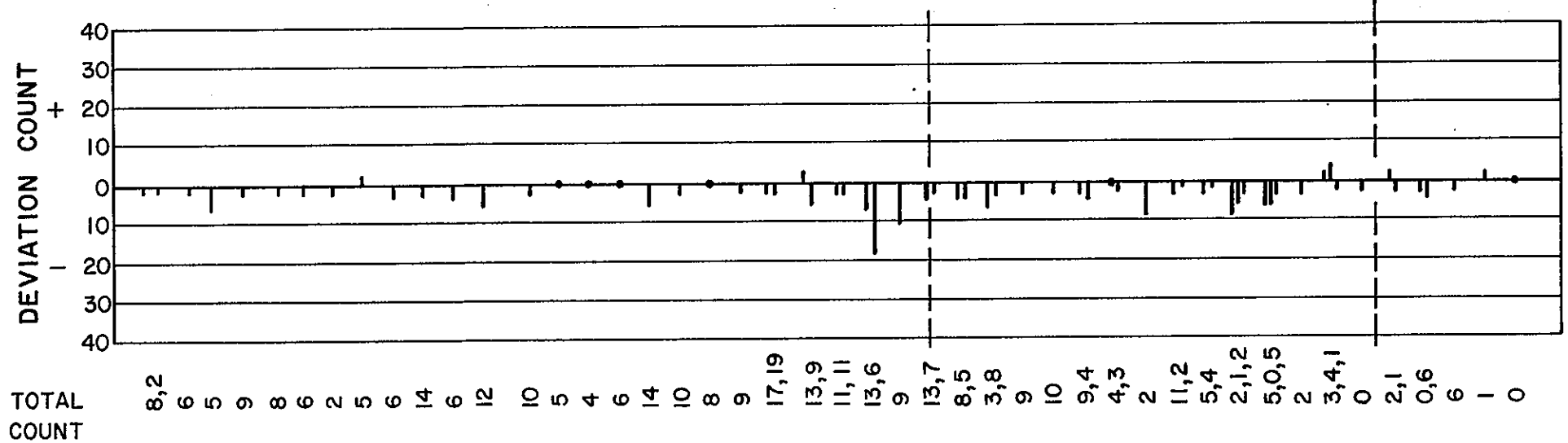
THREE AXLE TRUCKS - DEVIATIONS FROM MANUAL COUNT



TWO AXLE CAR WITH TRAILER - DEVIATIONS FROM MANUAL COUNT



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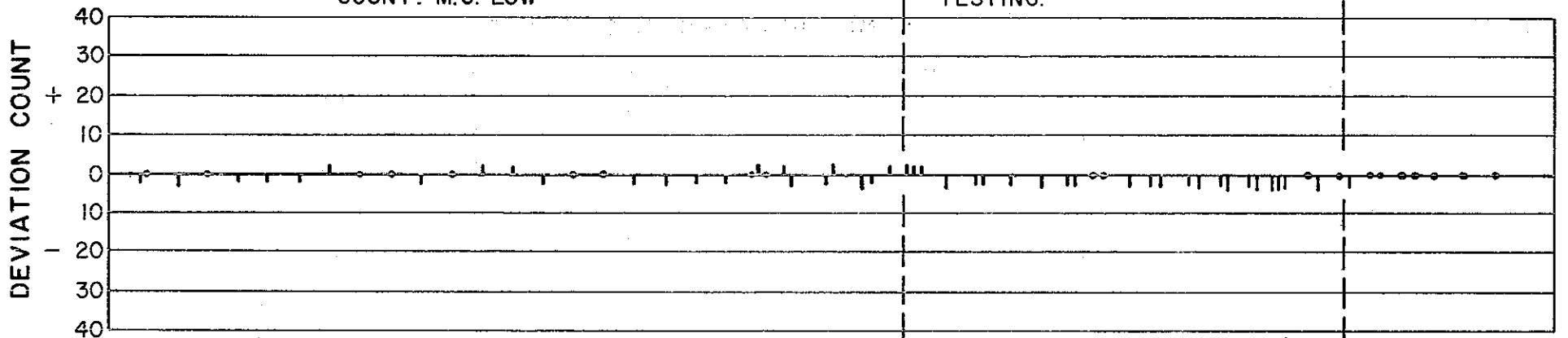
FOUR AXLE TRUCKS - DEVIATIONS FROM MANUAL COUNT

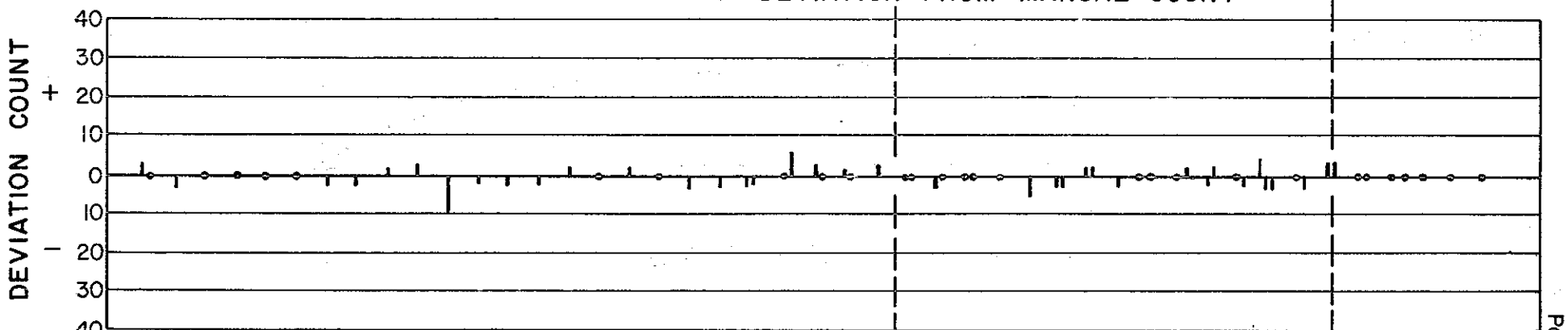
MANUAL COUNT
TAKEN AS REFERENCE
+ COUNT: M.C. HIGH
- COUNT: M.C. LOW

DURING THIS TIME UNIT WAS
MODIFIED AND FIELD TESTED
SEE APPENDIX C-SHORT TERM
TESTING.



DATE	TOTAL COUNT
6-10-68	4,1
6-11	1
6-12	1
6-13	2
6-14	4
6-17	4
6-19	3
6-20	7
6-21	2
6-26	2
6-27	3
6-28	4
7-1	7
7-2	1
7-3	6
7-10	0
7-12	6
7-15	5
7-16	4
7-29	4
7-31	5,2
8-1	5,9
8-2	7,7
8-7	4,4
8-9	6
8-12	10,4
8-13	5
8-15	3,3
8-15	2
8-22	5
8-23	4,0
8-27	1,3
8-27	1
8-30	1,2
9-4	4,2
9-5	1,0
9-5	1,2
9-5	2,2,2
10-7	3,0
10-7	0,4
10-25	0,1
11-8	1,1
11-8	2
1-9	1
1-9	1

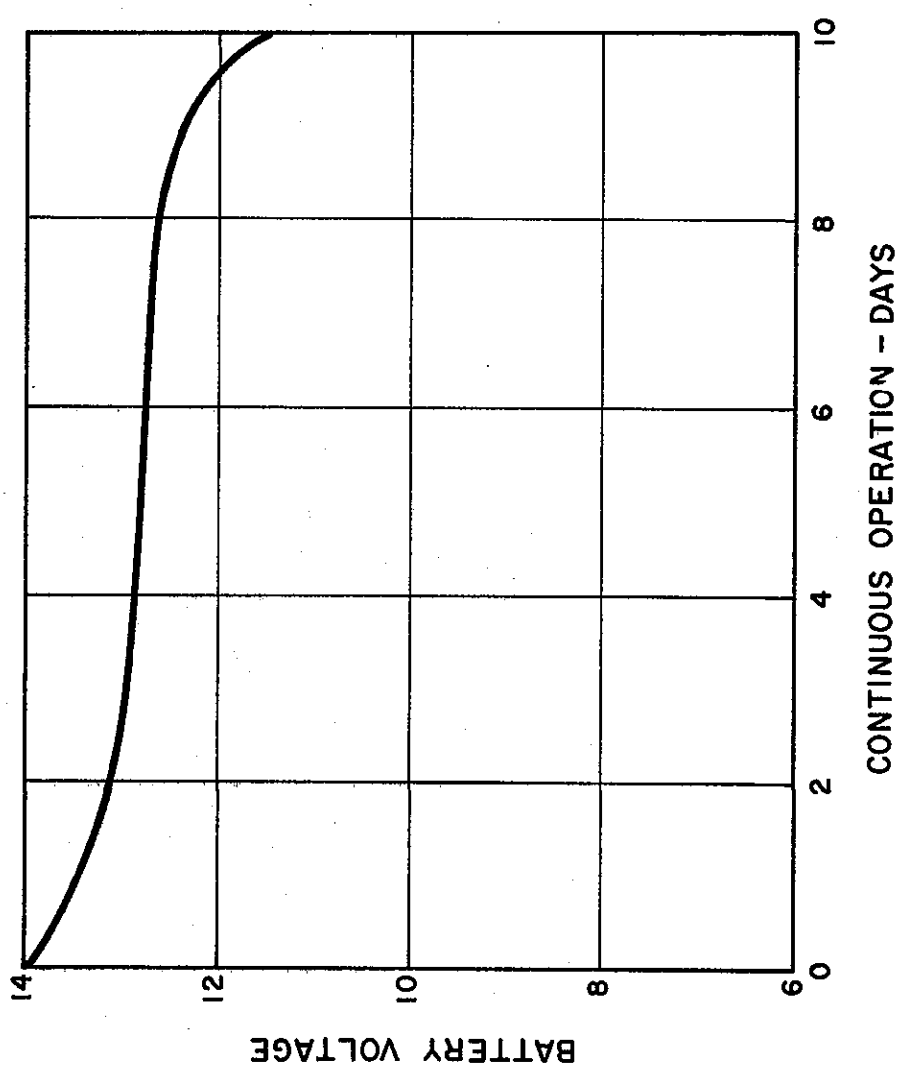
FIVE - SEVEN AXLE TRUCKS - DEVIATION FROM MANUAL COUNT



TOTAL COUNT
20,14
15
12
20
20
15
14
17
16
17
15
15
23
21
19
11
21
17
8
17
24,28
21,19
15,14
13,19
30
16,16
21,11
10,9
8
11
5,5
6,6
9
10,4
3,12
5,5
4,2
9,16,3
11,15
9,9
4,12
1,15
15
5
2

BATTERY VOLTAGE VERSUS DAYS OF OPERATION

NOTE:
Nicad P-15 rechargeable battery.
Sealed cells.
15 Ampere hour capacity.
Service capacity - 10 hour rate.
Traffic flow- 490 vehicles per hour.



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RECOMMENDATIONS FOR FIELD INSTALLATION

1. The loop should be centered in the traveled lane with the recommended 6 foot square configuration.

2. Placement of the hoses on the highway may not necessarily correspond to the normal axis of the road. The hoses should be positioned perpendicular to the direction of the vehicle flow.

3. The length of both hoses should be approximately the same so that no differential delay in air pulse arrival time may be introduced into the circuit to cause inaccuracies in the truck, no truck classification.

4. The settings of the diaphragm air switches will vary at different locations. Manual counts will be required to ascertain the correct setting.

5. Although the setting of the loop sensor is not complicated, care should be exercised to assure that the loop is not slightly detuned. This could cause inaccurate readings.

6. The portable counter is capable of continuous unattended operation over a period of 8 days. This period should be adhered to and the nickel-cadmium batteries recharged for 19 hours at a 1 ampere rate at the completion of the count.

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1. EQUIPMENT HOUSING

A. Construction

The housing shall be constructed of 16 gage galvanized sheet metal or an equivalent material.

B. Size

The volume of the housing shall be a maximum of 2500 cubic inches. The longest dimension of the case shall be no greater than 20 inches.

C. Finish

The exterior of the case shall be finished in a gloss white color. The finish shall be capable of withstanding temperature variations from 0° F to 160° F, and the range of environmental conditions such as rain, snow, sand, and wind normally encountered in California.

D. Water Resistant

The truck classifier shall be raintight, with the exception of the bottom six inches which shall be waterproof. A rubber composition weather seal shall be installed in the cover housing in such a manner that it is in full contact with all portions of the door or cover when the housing is closed.

E. Access

The box shall be equipped with a door or cover to permit ready access to the circuitry and mechanism without disturbing any circuit adjustments. A hasp or equivalent will be provided to lock the case with a standard padlock and shall be placed opposite the hinged side.

F. Portable

The over-all width and weight will be determined to facilitate one person carrying the unit. The handles will be of such size as to be compatible with the over-all weight of the unit.

G. Content

The housing shall be capable of containing all electronic, mechanical, and associated equipment and circuitry required to count one lane of traffic with the following exceptions:

1. The six foot loop or equivalent sensor that is normally embedded in the road, and

2. Any rubber hoses or equivalent axle sensing devices that are normally placed on the roadway.

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H. Interface Connectors

An electrical connector shall be installed on the latch side of the housing at a distance of seven inches or greater from the base of the unit. Provision shall be made to provide access for the two rubber hoses to their respective air switches via mounting holes and still maintain the condition of a rainproof unit.

II. WIRING AND INSTALLATION

A. Wiring and Cabling

Wiring and cabling shall be neat and sturdy, with sufficient slack to prevent excessive stress on connections and terminals. Strain relief shall be provided where necessary.

B. Wrapping

Mechanical wrapping of soldered connection shall be performed in a manner to permit any one wire to be removed from a terminal without disturbing others that may be connected to the same terminal.

C. Wire Placement

1. Wires and cables shall be suitably protected against abrasion and secured to the frame, chassis or other points necessary to prevent damage to the wire or cable during normal vibration and shock.

2. All wires and cables shall run in continuous lengths between terminal supports.

3. There shall be no splices.

4. A minimum of insulating sleeving shall be used.

5. Connections shall be mechanically secured before soldering.

6. Ground connections to shields and other mechanical parts, except chassis, shall be made only for the purpose of eliminating high potential A.C. points and not for the purpose of completing electrical circuits.

7. Ground connections to the chassis shall be made mechanically secure by soldering to spot welded terminal lugs or to portions of the chassis that have been bent up to form soldering lugs by using a terminal as the ground wire and securing the terminal by a screw with lock washer on both sides of the terminal. The screw shall fit either a tapped hole in the chassis or shall be held in a through hole by a third lock washer and a nut.

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8. All soldered connections shall be made with a non-corrosive core, soft solder.

9. Where a screw is to be secured by means of a tapped hole or a lock washer and nut, the metal around the screw hole shall be plated or tinned to provide a corrosion resistant connection.

10. All screws, nuts, and lock washers shall be galvanized, plated or tinned to provide corrosion resistant connections.

11. Shielding on wires, cables or components shall also be grounded to the chassis in the manner specified in paragraphs 9 and 10.

D. Installation

1. The component layout on a chassis shall be straightforward.

2. All components shall be accessible when the enclosure is opened. If special tools are required to maintain or install a unit, these tools shall be provided with the classifier as standard parts. All I.C.'s shall be mounted in sockets.

3. All potentiometers shall be dust proof and humidity proof.

4. The unit shall have test points to monitor critical voltages.

5. The unit shall have provision to use a power switch capable of removing all power from the classifier.

6. All adjustment and calibrator controls shall be grouped whenever possible and easily accessible to the operator.

7. A set of schematics shall be included with the truck classifier.

8. Meters and indicating devices shall be easily read, suitably scaled, and rugged enough to withstand sustained operation.

9. All components, excepting proprietary items, shall be available from at least two independent manufacturers. All proprietary items shall be shelf stock items of the manufacturers.

10. All circuit components, including printed circuit assemblies associated with a particular logic function, shall be mounted on a single module.

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11. All counters, switches, controls, and test points shall be labeled in a durable manner and easily read.

12. In addition to these specifications, all electrical and mechanical workmanship shall conform to the standards of the National Electrical Manufacturers (NEMA), the Underwriters Laboratories, Inc. (UL), and the Electronic Industries Association (EIA) wherever applicable. All work shall exhibit high quality workmanship and be of the highest standards currently in use by industry.

III. LOOP DETECTOR

General:

A. Source

The unit shall operate from a 12 volt battery source.

B. Environment

1. The loop detector shall be able to operate at temperatures ranging from 0° F to 160° F.

2. The unit shall be able to operate with loops of standard sizes and shapes, and of varying lengths of lead-in wires with no modification to the detector.

3. The unit shall be an outdoor, all weather type, and capable of normal operation without adjustments to compensate for weather conditions.

4. The unit shall have the capability of being matched to different size loops by means of coarse and fine tuning controls. The incorporation of a meter as part of the tuning feature is recommended.

5. The field of influence for all detectors shall be such that a vehicle with 1/4 of its width in the lane of detection shall be detected.

6. The use of a relay or other type of mechanical switching is prohibited.

7. Material and workmanship throughout the unit shall conform to the best commercial standards.

C. Operation

1. The loop detector shall be capable of producing one count per vehicle regardless of height, weight or length.

2. The unit shall be capable of detecting vehicles tailgating at a minimum distance of 25 feet at the vehicle rate of 100 feet/second.

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3. The detector shall be capable, after 10 seconds delay, to ignore a vehicle which has parked over the loop and return to a standby condition.

4. Power requirements shall be less than 10 ma at 12 volts D.C. during standby and less than 15 ma at 12 volts D.C. with a vehicle over loop.

5. The final criteria is the relationship of the power drawn by the loop in relation to the power required for the rest of the truck classifier. For standby conditions, the combined power drawn by the loop circuit plus the current drawn by the remaining circuit shall not exceed 25 ma at 12 volts D.C.

IV. PRINTED CIRCUITRY

A. Electrical

1. The following specification shall apply for digital ICS:

   Supply Voltage - Vcc = 5 volts $\pm$ 1 volt.

   Noise Immunity - Typical 1 volt at 25 C.

   Temperature Range - 0° to 160° F.
   RTL or RCTL shall not be used.

   Package - TO-116 dual in-line package.

   Power Dissipation - 250 milliwatt.

2. Transistors shall be of the diffused planar PNP and NPN silicon type.

3. All semi-conductor devices shall be silicon solid state devices.

4. Each semi-conductor device shall be temperature compensated to ensure reliable operation from 0° F to 160° F.

B. Mechanical

1. Dimensions

   The size of the printed circuit boards shall be governed by the available space in the housing. In addition, all electronic components shall be arranged in functional groupings on the circuit boards.

2. Board Material

   a. The board shall be double sided and composed of NEMA Grade G.10, Glass cloth base, epoxy resin board of 1/16 inch thickness.

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b. That portion of the printed circuit boards which mates with the standard circuit connector shall be plated with a non-corrosive conductor, such as gold, rhodium or high silver contact.

c. The minimum plating material shall consist of 2 oz. copper.

3. Connector Contacts.

The connector shall be standard, high quality, and conform to the highest standards currently in use today.

4. Keying.

Keying should be accomplished in a manner that enables the circuit boards to be easily removed. A recommended feature would be polarization to prevent the card from being inserted incorrectly in the connector.

5. Extender Boards.

To facilitate trouble shooting, extender boards will be considered as a satisfactory method of providing this capability. If extender boards are used, one for each type of printed circuit card shall be included as standard equipment with the classifier.

6. Fusing.

Provision shall be made to provide short circuit protection.

7. Support.

The circuit boards shall be mounted in a manner such that at least two edges and the connector end are supported. A circuit card guide in conjunction with the connector would be considered a satisfactory method of providing this feature. Where the card fits into a guide, a card extractor shall be provided.

8. Temperature.

These printed circuit boards shall retain their physical properties while subjected to temperature variations from 0° F to 160° F. All work shall exhibit high quality workmanship and be of the highest standards currently in use today by industry.

C. Coatings

1. Moisture Permeability and Absorption.

Coatings should have low moisture absorption and low moisture permeability.

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2. Mechanical Durability.

The finished coating should be tough and abrasion resistant to withstand rough handling and the effects of blown dust or sand.

3. Repairability.

The coating should be easily repairable so that processing flaws can be patched up and so that components on the board can be replaced.

4. Temperature Characteristics.

The material should withstand local hot spots, caused by dissipation of circuit components, in addition to the ambient temperature.

5. Material.

The modules shall be coated with a clear, transparent, fungus resistant material. All work shall exhibit high quality workmanship and be of the highest standards currently in use today by industry.

V. POWER SUPPLY

A. Battery

1. Watt-Hours.

The operating power will consist of a minimum rating of 250 watt-hours, computed at the ten hour rate.

2. Standby Period.

The power consumption during the standby period shall not exceed 350 milliwatts.

3. Vehicle Presence.

The power consumption while the vehicle is being sensed shall not exceed 4 watts.

4. Firing Mode.

The additional power to enable the electro-mechanical counter to record the results shall be less than 8 watts. The total power consumed by the system shall be less than 12 watts.

5. Capacity.

The capacity rating of nickel-cadmium batteries is based upon a discharge period of ten hours (10 hour rate) and an end point voltage of 1.1 volts per cell.

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The capacity of the battery shall be high enough to ensure continuous unattended operation for eight consecutive days with traffic rates as high as 900 vehicles/hour at 100 feet per second and as low as 250 vehicles/hour at 14.7 feet per second.

Capacity shall include the power sustained by each of three modes:

a. Standby period.

b. Vehicle presence.

c. Recording mode.

6. Temperature.

The batteries shall have the capability of being discharged at a temperature of 160° F.

7. Discharge.

The amount of ampere seconds per pulse shall be withdrawn at no greater average per complete discharge than recommended by the manufacturer.

8. Charge.

The battery shall be charged at a charge rate determined by the manufacturer. An ampere-hour input approximately 30 percent greater than the preceding discharge is necessary to return the battery to its previous state of charge.

9. Charging Methods.

The battery shall be charged by a method approved by the manufacturer. Where power is accessible, a means shall be provided to keep the battery charged by a trickle current, approved by the manufacturer or an equivalent alternate.

B. Regulator

1. Input Voltage.

Nominal value of the battery voltage. For a nominal voltage of 12 volts, this value may vary from 14 volts no load to 11 volts at discharge.

2. Input Current.

This current shall include the current required to drive the load plus the current absorbed by the regulator circuitry.

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3. Input Impedance.

The internal impedance of the cells varies with state of charge and frequency. For a 15 ampere-hour capacity battery, the D.C. nominal resistance would be 13 milliohms and the impedance for 100 cps would be 5 milliohms.

4. Load Regulation.

The no-load to full load change shall be no more than ± .2%.

5. Transient Response.

The time required to return and stay within specified voltage limits surrounding the regulation band is one millisecond.

6. Output Voltage.

The output voltage should be specified as that voltage between the nominal voltage rating of the battery and the voltage rating of cutoff, including that voltage difference due to the regulator.

7. Output Current.

The output current required by the load should be a minimum of 1.5 amperes providing a service capacity of 15 ampere-hours computed at the 10 hour rate.

8. Temperature Coefficient.

± 0.01% per ° F.

9. Temperature.

From 0° F to 160° F at both low and high load currents.

10. Isolation.

To prevent interaction between the various sections of the truck classifier, such as loop detector, signal detector, suitable buffers shall be provided.

11. Mounting.

The regulator shall be packaged and mounted so that removal of the battery will not affect it. The package shall provide provision for suitable test points and components for stabilization.

12. Short Circuit Protection.

Short circuit protection shall be included in the circuitry. An acceptable method would be foldback current limiting.

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13. Overvoltage Protection.

This shall be included in the regulator. An acceptable method would be by means of a crowbar circuit.

14. Discharge Protection.

Provision shall be made to incorporate a low voltage cutoff. This would effectively remove the battery supply from the circuit proper. Provision shall be made for programming this circuit.

C. Mechanical

1. Mounting.

The battery supply shall be housed in a portable self-contained casing and shall consist of sealed nickel cadmium rechargeable cells. When cells are electrically connected to increase their over-all voltage rating, suitable separators shall be used to isolate the steel case of each cell, where nickel plated steel is utilized for battery casing.

2. Removable.

Whenever the battery is removed or inserted, provision shall be made to have the supply electrically disconnected from the rest of the truck classifier.

3. Weight.

The total weight of the cells shall be no more than 35 pounds.

4. Volume.

The displacement of the individual cells shall be no more than 30 cubic inches.

5. Leads.

Leads from the terminals of the battery shall be terminated in a single polarized plug. This plug will serve to connect all the required voltages for both charge and discharge cycles.

6. Charger.

a. A battery charger with a charge rate approved by the manufacturer and of sufficient capacity to recharge the nickel-cadmium battery in a maximum of 16 hours shall be supplied with each truck classifier.

b. The charger will be designed to operate from a standard 110-120 volt AC 60 cycle power source.

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c. The charger shall be included in the truck classifier case and shall be removable without tools.

VI. IMPULSE COUNTERS

A. Electrical

1. Operating Rate.

The impulse counter shall be capable of recording traffic rates from 250 vehicles per hour at 14.7 feet per second to 900 vehicles per hour at 100 feet per second. An impulse counter with rates between two impulses per second to ten impulses per second, inclusive, would be considered satisfactory.

2. Supply.

These counters shall be capable of operating from standard available voltages such as 6 or 12. Current consumption shall not exceed 400 ma at 6 volts or 200 ma at 12 volts.

3. Noise.

The counters shall provide consistent and stable operation unaffected by common electric and magnetic disturbances.

4. Temperature.

These counters shall operate reliably at temperatures ranging from 0° F to 160° F.

5. Interface.

The counters shall have direct drive, so that solid state devices can operate the impulse counters.

6. Duty Cycle.

The coils may have the capability of being energized continuously.

B. Mechanical

1. Number of Counts.

The counter shall be capable of counting any digit from 1 to 99,999.

2. Environment.

a. The mechanism shall be housed in an atmosphere resistant case.

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b. The counter shall be an outdoor, all weather type, and capable of normal operation without adjustments to compensate for weather conditions.

3. Reset.

The counters shall be provided with a manual zero reset. The mechanism shall be protected from tampering by means of a hinged cover.

4. Dimensions.

The counters will have provisions for flush panel mounting. The over-all cover dimension shall be less than 1.7" wide by 1.3" high by 4" long.

5. The counters shall be removable for ease of replacement. A plug-in type of arrangement would be considered satisfactory and would provide access to electrical connections. Thus the counter may be removed from the housing without access to the permanent connection.

6. The figures should be of such size as to provide ease of reading.

7. The quality of workmanship and the selection of proper materials shall assure long life and operating dependability at the maximum speed of the counter. Certainty of operation exceeding 10 million impulses would be considered satisfactory.

VII. OVER-ALL SPECIFICATION

A. Electrical.

1.	Watt Hours:	Minimum rating of 250 watt-hours computed at the ten hour rate.
2.	Standby:	350 milliwatts, no vehicle.
3.	Vehicle Presence:	4 watts or less.
4.	Recording Mode:	8 watts or less.
5.	Circuitry:	DTL silicon monolithic devices or equivalent. RTL or RCTL shall not be used. Transistors shall be of the diffused planar PNP or NPN silicon type.

B. Operational.

1.	Detection:	Capable of detecting and classifying traffic in one lane of a roadway according to wheelbase and number of axles.

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2. Vehicle Presence:
   a. Utilizes loop detector in conjunction with a 6 foot by 6 foot loop embedded in the roadway.
   b. Unit has the capability of being matched to different size loops.
   c. No output relay.

3. Classification:
   a. Record 2 axle cars, 2 axle car/trailer. Record 2, 3, 4, 5-7 axle trucks.
   b. Record semi-trailer, truck, and full trailer combinations.
   c. Tandem axles at 100 feet per second shall be recorded.

4. Operation: Continuous unattended operation of 192 hours (eight days).

5. Loop Delay: Variable loop delay from 150 millisecond to over 1 second.

6. Speed: 250 vehicles/hour at 14.7 feet/second to 900 vehicles/hour at 100 feet/sec.

7. Axle Counting: Two hoses placed on roadway.
   a. One hose provides one output pulse for each axle.
   b. Combination of two provide truck-no truck capability.

8. Recorder:
   a. Six electromechanical counters.
   b. One count for each vehicle.
   c. Interfaced with solid state circuitry.
   d. Count is cumulative.
   e. Resettable.

C. Physical.

1. Weatherproof: Truck classifier contained in a galvanized sheet metal unit with raintight construction, the bottom six inches shall be waterproof.

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2.	Circuitry:	Solid state integrated circuitry utilized for logic operations. For hybrid construction PNP, NPN semiconductors on etched printed circuit boards shall be used.
3.	Availability:	All of the components shall be "off-the-shelf" or readily available.
4.	Regulator:	a. Low voltage cutoff. b. Crowbar overvoltage protection. c. Foldback current limiter protection.
5.	Test Points:	Provision for test points to monitor battery voltage, signal points.
6.	Power:	Operation from a single power source.
7.	Temperature	0^{o} F to 160^{o} F ambient.
8.	Adjustment:	Easily adjusted by personnel. Can be permanently or temporarily installed at desired locations.
9.	Flexibility:	a. Elimination of any exposed detection elements enables coverage counts in any weather, at any time of year. b. Detector - The truck classifier will accept pneumatic or electric input.
10.	Portable:	a. Self contained power unit. b. Easily installed detecting elements such as 6 foot by 6 foot loop, road tube, portable truck classifier, and air switches. c. Moderately lightweight.

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TRUCK CLASSIFIER - Circuit Operation

The over-all block diagram for the truck classifier is shown in Appendix A, Figure 8. The schematic diagram for the circuit is shown in Appendix A, Figure 10. A brief description of circuit operation follows:

1. Sensing Functions

A. Loop Detector.

The loop detector shown in Appendix A, Figure 2, was used in the truck classifier. This detector is a solid state device operating on 12 volts at 15 ma. The detector can be operated with a 6-foot square loop consisting of three turns of wire embedded in a roadway. The loop forms a portion of a parallel resonant circuit; when a vehicle passes over this loop, the change in inductance causes a phase shift between the loop oscillator and a reference oscillator. Normally, an output relay would operate on the resulting change of phase voltage. However, to avoid unnecessary mechanical contacts, the output circuitry was modified to interface directly with solid state circuits.

B. Hose Detectors.

The first and second axle detectors are composed of the rubber hoses and their associated contact switches (see Appendix A, Figure 1). A vehicle passing over these hoses causes pockets of air to move transversely to the direction of traffic and to deflect a thin diaphragm. The diaphragm movement results in the closure of metal contacts which activate the solid state circuitry. Since the contacts must operate once for each axle, any extraneous contact closure due to noise will result in false counts. Hence, there is a variable contact gap which can be adjusted in the field for optimum conditions. A contact closure setting of 0.008 inches proved satisfactory.

Setting the contacts further apart resulted in a decrease in sensitivity or less counts than there were axles. Setting the contacts closer resulted in extraneous counts being introduced.

C. Detector Board.

(1) Axle Detectors.

The circuit is shown in Appendix A, Figure 10, schematic. The entire circuit for the first axle detector is contained in an M824P-Quad 2-input gate. The closure of the contact switch, due to a vehicle passing over the appropriate hose and +Vcc being turned on, introduces a positive pulse to this input circuit.

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Resistor R26, Capacitors C7 and C8 and both NOR Gates 1 and 2 enable a trigger pulse to be applied to the other portion of this M824P chip. The other two NOR Gates, 3 and 4, in conjunction with R25 and C9 produce a negative going output pulse of 25 millisecond duration.

This output pulse is short enough to ensure correct counting of tandem axles at a vehicle speed of 100 feet per second and long enough to lock out extraneous noise pulses. This output pulse is coupled through C10 to the counter portion of the board.

(2) Truck Detector

The second detector consists of a PNP silicon transistor that is normally not conducting and provides an output pulse each time the second axle hose is activated. The only pulse which is of interest is that produced by the front axle of any vehicle. If this pulse is generated before the vehicle can travel a predetermined distance, the truck classifier will register a truck; otherwise, the truck classifier will register a car. This applies only to two and three axle vehicles. This output pulse is fed to a NOR Gate through coupling capacitor C11. Since only one pulse is of interest and the remaining pulses are locked out, this circuit is not as critical as that used in the axle counting first detector.

D. Loop Interface Circuitry.

Transistors Q_1, Q_2, and Q_3 comprise the loop interface circuitry (see Figure 10). Q_1 is employed as an emitter follower to match the output of the loop detector with the input of the truck classifier. When a vehicle is sensed by the loop detector, the base of Q_1 is driven negative turning on Q_1. As Q_1 conducts, the base of Q_2 is driven negative turning on this transistor.

Q_2 provides sufficient drive to cause tunnel diode T_1 to conduct. The tunnel diode is used to develop a snap on-snap off action which is required to maintain the logic circuit on for a minimum amount of time. Diodes D_2 and D_3 are used to raise the reference voltage of the tunnel diode to a stable point of operation, maintaining Q_3 on. Q_3 in turn provides base drive to Q_5, turning on Q_5 and, by zener action of Z_2, applying power to the logic and counting circuitry.

Q_2 also generates a reset pulse during the turn on time. R17 and C5 serve to maintain the reset pulse so as to ensure complete resetting of the logic and counting circuits prior to any vehicle counts. When Q_3 turns off, the voltage turn-off time will be controlled by a variable loop delay, further mentioned in Part 4C, Variable Time Delay. This negative going pulse is applied through C6 to Q_7 which forms part of the drive circuitry for the electromechanical register. The

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operation of Q_7 and subsequent circuitry will be discussed in Part 3, Recording Function.

E. Power Supply.

The power source consists of ten nickel cadmium cells connected in series to provide an operating voltage of 12.5 volts (see Appendix B, Exhibit 2). This voltage is used to furnish the power required by the loop detector, loop interface circuitry, first axle detector, and the drive circuitry.

A six volt output is derived by the combination of zener diode Z_1 and transistor Q_6. This output is further reduced to + 3.4 volts.

The separate supplies of +6 volts and +3.4 volts DC were necessary to furnish the power required for the axle detector and axle counting circuits and to reduce any interaction between these two units and the main circuitry. Q_5 and zener diode Z_2 are used to provide +3.4 volts (+Vcc) for the binary counter and logic circuits.

The main power is switched on through a four pole single throw switch.

2. Counting and Logic Functions

A. Counters.

(1) The counter and logic circuitry consists of integrated circuits with NOR logic. These are essentially medium power devices with a given power dissipation of 250 milliwatts, operating temperature of 0° to 75° C, and a logic input voltage of 4 volts.

The binary counter consists of a dual J-K flip flop and a single J-K flip flop (see Figure 3). Since axle counts of from two axles to seven axles are being considered, only three binary divider states are required. The binary stages are wired for asynchronous toggle operation. The binary counter receives the data input in serial form, temporarily stores it, and presents this information, in parallel, to the logic circuitry. Due to fan out considerations the outputs of these binary dividers, indicated by Q and $\overline{Q}$, are presented to some inverters. The inverters provide a means of interfacing the output of the binary dividers with their respective output loads (see Figure 6). The relationship between the output of the First Detector Axle Counter and the outputs of the 1-2-4 binary counter is shown in Figure 4.

(2) The only function of the second detector is to change the state of the truck classifier from the car to the truck mode at the appropriate time. This is only applicable for two or three axle vehicles. The inverted second detector output in conjunction with inputs $\overline{A}$ and

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B form a three input NOR gate. When all three inputs are negative, the output of the inverter, Pin 9 will be of the correct polarity to enable the truck detector flip-flop to transfer to the truck mode.

B. Gating

The logic circuitry takes the coded information from the binary counter and in conjunction with a D, $\overline{D}$ level from the truck detector flip flop, translates it into a sequence that selects one of six electromechanical registers. This is indicated in Figure 6, Appendix A.

The car (D), truck ($\overline{D}$) mode is obtained by combining two Quad 2 input gates into a bistable mode denoted as truck detector flip flop. When the unit is first energized, a reset pulse activates the D mode and the truck classifier is conditioned to count 2 or 3 axle cars. The corresponding registers which can be activated are indicated in Figure 7, Appendix A.

If an input is applied to Pin 9 of the truck detector flip flop, the selection of output registers is purely in the truck mode. The condition for an input to Pin 9 is determined by the proper gating levels of $\overline{A}$, B, and the second axle detector. This is indicated in Figure 4, Appendix A. Section III, Part C3 - Classifying Characteristics, contains a table indicating the conditions for the car-truck mode (reference Table I).

A series of triple NOR gates is utilized for selection of the proper axle counter. By designating a logic "1" as a plus voltage, then any gate having all three inputs at logic "0" will result in the output being high and subsequently gating the required register.

3. Recording Functions.

Six electromechanical counters are incorporated in the circuit. There is one counter actuation per vehicle. Figure 7 indicates these and their associated circuitry.

Twelve volts are always applied to the coils of the counters. The coils in turn are connected to the anode of their respective SCR's. Whenever a series of axles are recorded, the gate of one of these SCR's is driven positive. When the vehicle leaves the loop, a negative trigger pulse is applied to Q_7 causing this transistor to conduct.

This in turn provides base drive to Q_8 which causes the final transistor, Q_9 to conduct. The respective SCR fires the counter to indicate one count.

The outputs for the different electromechanical registers are defined in the following manner:

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Two Axle Cars: One output pulse for each 2-axle car. The spacing between the first two axles is less than the physical placement on the road between the two hose detectors.

Two Axle Car with Trailer: One output pulse for each car with a single axle trailer. Same spacing between axles requirement as indicated for 2 axle cars.

Two Axle Truck: One output pulse for each 2-axle truck. The spacing between the first two axles is greater than the physical placement on the road between the two hose detectors.

Three Axle Truck: One output pulse for each 3-axle truck. The inter-axle spacing requirements are the same as for the two axle truck.

Four Axle Truck: One output pulse for each four axle vehicle. No inter-axle spacing requirement.

Five, Six, Seven Axle Truck: One output for each five, six or seven axle vehicles. No inter-axle spacing requirement.

4. Auxiliary Function.

A. Battery Operation.

Appendix D, Page 4, depicts the variation in cell voltage versus the number of days of vehicle counts. In the graph the number of days of operation was approximately ten days. The number of days of continuous unattended operation will vary according to the number of vehicles detected in any given period of time. Field tests have resulted in variations from 9 to 11 days of operation.

The nickel cadmium cells have a 15 ampere-hour capacity. By utilizing a charging current of 1 amp, these cells can be charged to 130 percent of capacity in about 19 hours.

These cells have a nominal watt-hour rating of 188 watt-hours computed as follows:

$$\left[\frac{15 \text{ ampere-hour}}{\text{cell}}\right]\left[10 \text{ cells}\right]\left[1.253 \text{ volts}\right] = 188 \text{ watt-hours}$$

B. Indicator Light for Maintenance.

In the event the unit does not count, an additional feature is provided. By activating another circuit, an indicator light is incorporated into the truck classifier operation. This light is operated by the collector current of Q_4, the base of which is taken off the logic power supply.

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When this light either fails to come on or glows dimly, then the logic circuitry is not receiving enough energy to operate properly and the unit should be inspected.

C. Variable Time Delay.

This time delay or loop delay compensates for typical traffic speed patterns at different test sites so that any two vehicles are not read as one, or that a multi-axle vehicle is not read as two separate vehicles. This delay can be varied from 200 to 900 milliseconds.

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