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This study was initiated to design and develop new devices to obtain better data for use in highway traffic studies. One of our developments was the Portable Disposable Loop. This loop can be installed in ten to 15 minutes by two people with only a minimum inconvenience to the motorist.

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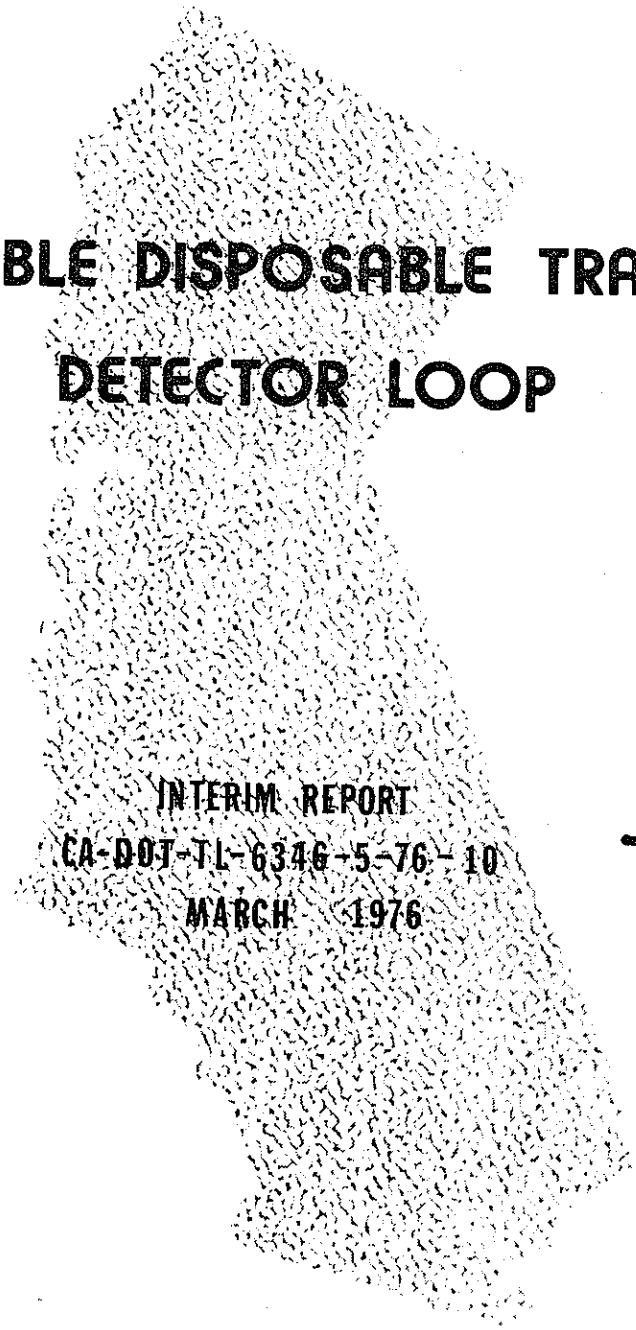
DIVISION OF STRUCTURES AND ENGINEERING SERVICES

TRANSPORTATION LABORATORY

RESEARCH REPORT

PORTABLE DISPOSABLE TRAFFIC DETECTOR LOOP



INTERIM REPORT

CA-DOT-TL-6346-5-76-10

MARCH 1976

76-10

Prepared in Cooperation with the U.S. Department of Transportation,

Federal Highway Administration

Caltrans

CALIFORNIA DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

March 1976

FHWA No. C-1-2
TL No. 636346

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

PORTABLE DISPOSABLE
TRAFFIC DETECTOR LOOP

Study made by . . . . . General Services Branch

Under the Supervision of . . . . . W. H. Ames, P.E.

Principal Investigators . . . . . R. L. Donner, P.E.
L. E. Welsh, P.E.

Co-Investigator . . . . . T. F. Grillo

Report Prepared by . . . . . T. F. Grillo

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

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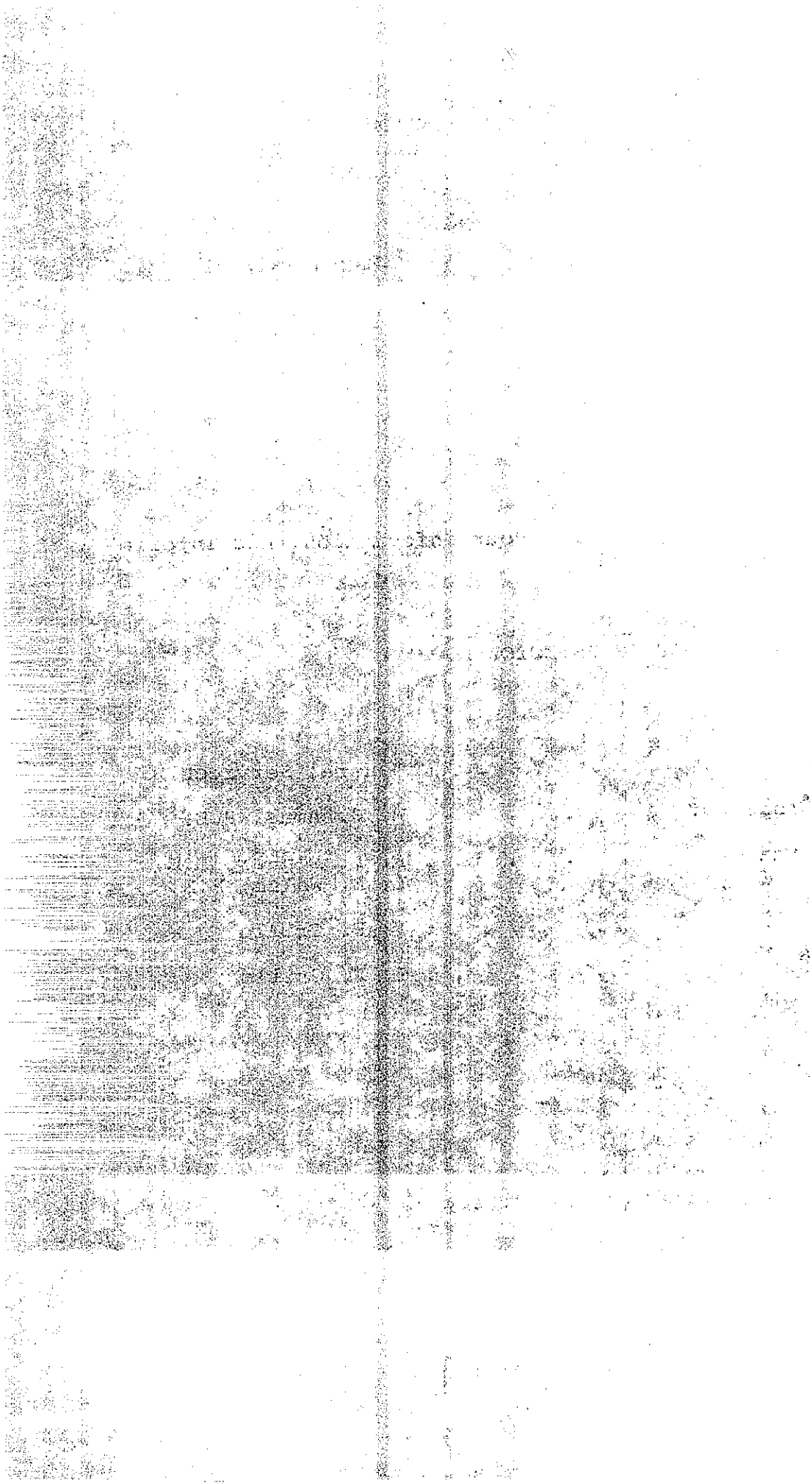

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ACKNOWLEDGEMENTS

This project was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration, under agreement No. C-1-2.

The assistance of Mr. Allen F. Bailey and Mr. James J. Majestic of Traffic Branch is sincerely appreciated.

The contents of this report reflect the views of the Transportation Laboratory which is responsible for the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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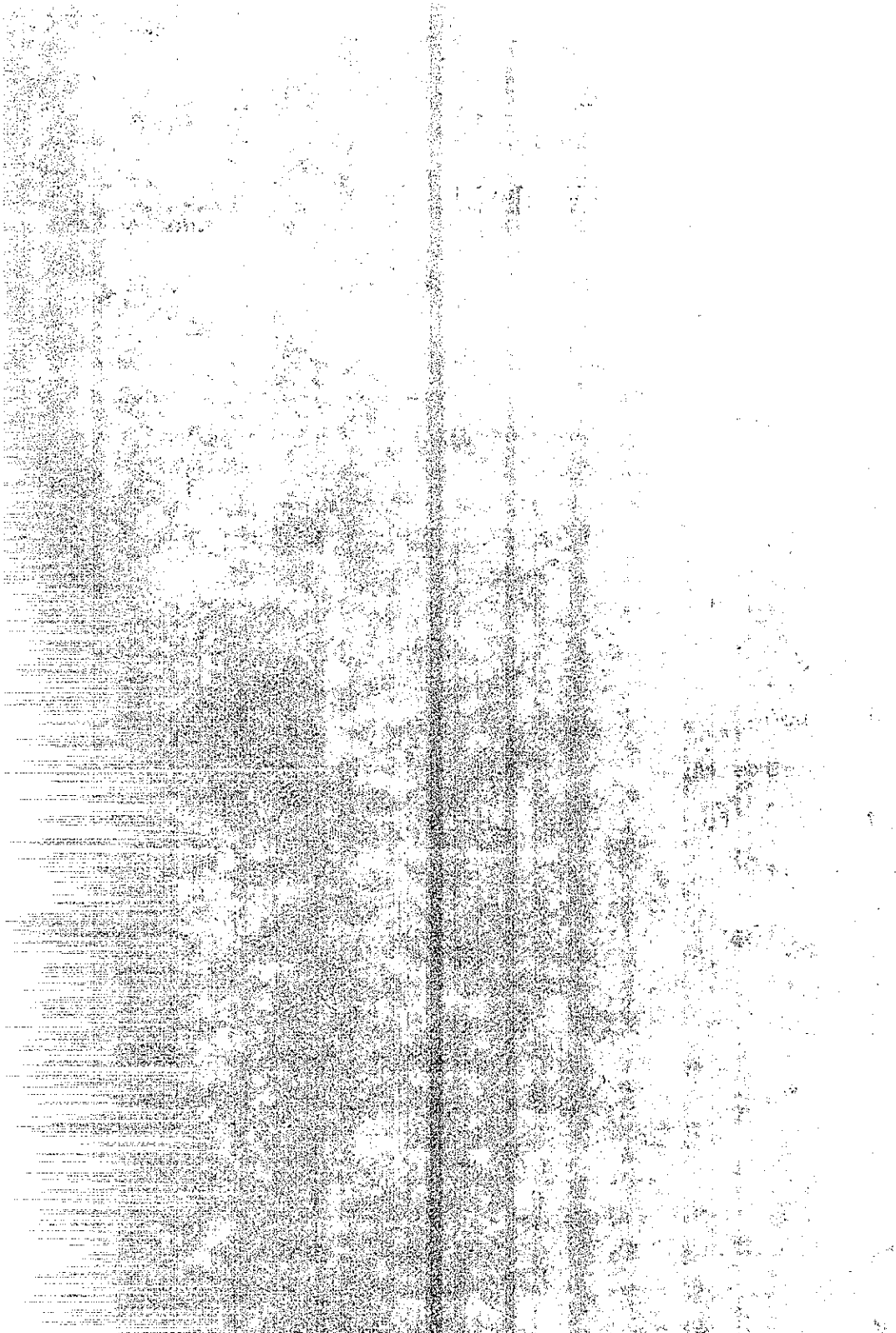

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INTRODUCTION

Traffic Engineers, faced with the problems of moving traffic quickly and safely, have made use of embedded loops as roadway sensors. These loops are positioned and installed before the roadway is officially opened to traffic. However, there are situations that arise while the roadways are opened to traffic that require monitoring and/or regulating of vehicle movement, because of hazardous locations or unnecessary queueing of vehicles.

Therefore the Transportation Laboratory, in cooperation with the Traffic Branch, set out to purchase or develop an on-the-surface road sensor. The final device was a Portable Disposable Loop developed at the Transportation Laboratory (see ATTACHMENT B).

Preliminary testing to determine the type of encapsulant, was started during the second quarter of 1971. By September 1971 work was underway to find a suitable wire for this loop. Both tests ran concurrent and were performed at I-880 Eastbound outside Sacramento. During June through August of 1972 testing was conducted in District 02, I-5 and Cottonwood Creek, and in District 03, Hammonton Road outside of Maryville. Additional testing sites during the 1972-1973 period were:

District	Site	Average Daily Rate	Description
10	I-5	5,000	Rest Stop
9	US-395	1,400	Maintenance Count Station
9	US-395	2,300	District Headquarters
6	US-99	9,000	Count Station
8	SR-18	4,000	Big Bear Lake
5	US-101	5,800	Count Station

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These test sites covered temperatures ranging from 32°F to 135°F. Other factors resolved by these tests were: cure times to prevent delamination, various ways to position loops on the highway, the number of turns in a loop, and the configuration of the loop to ensure proper lane coverage and sensitivity. See ATTACHMENT B.

CONCLUSIONS AND RECOMMENDATIONS

The use of a Portable Disposable Loop is desirable in terms of site location, ease of installation and low cost. Since the device effectively detects vehicles from compacts to large trucks, at low and high speeds, there are no restrictions as to site location. The device can be safely installed on the roadway without long, costly lane closures. These loops are flexible so that storage and transportation is no problem.

The Portable Disposable Loop can aid traffic planners in such applications as 1) metering ramps to indicate or control the rate at which vehicles enter and leave a freeway, 2) determining volume occupancy, which helps in optimizing the volume of traffic on a freeway to ensure smoother vehicle flow, and 3) determination of traffic speed.

IMPLEMENTATION

Since the Portable Disposable Loops are rather easily made, it is recommended that organizations desirous of using them, obtain the materials and make their own.

Our experience in making approximately forty to fifty loops showed that costs, including labor and materials to be about $47 per loop.

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DISCUSSION

General

The Portable Disposable Loop is an on-the-surface type of sensor. It consists of insulated turns of wire encapsulated within a polyurethane rubber type of material. This material, known as Permapol "440", is flexible which provides ease of handling and can physically withstand the impact loads of highway traffic. The wires inside are of copper and galvanized steel. The copper wire ensures proper electrical operation; the galvanized steel provides improved resistance to impact loads. The Portable Disposable Loop, found suitable as a road sensor as a result of our testing consists of a rectangle five feet long by six feet wide using the type of wire mentioned above in an encapsulant.

Testing

General

Two permapol "440" strips six feet in length were positioned at different test sites during the initial stages of testing. The first strip lasted over 50 days with 800,000 activations. The second strip endured over 70 days with activations exceeding 800,000.

Continued field tests indicated that a multi-strand type of wire was required in an encapsulant. A wire such as WD-1/TT, a U.S. Army communication wire, or equivalent, could be used. This wire incorporated strands of copper interwoven with strands of galvanized steel (see Testing, Part C, Wire).

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Having found a suitable encapsulant and a durable wire, work proceeded on the casting or encapsulation of prototype portable loops. Two versions were made: the first used a single turn of the multi-stranded insulated wire in the encapsulant; the second version used three turns of the multi-stranded insulated wire in the encapsulant. The use of a portable loop having less than three turns of wire necessitated the use of a matching transformer obtained from Traffic Data Systems (TDS Part No. 16-0007). These prototype loops were five feet square.

The three turn loop operated 17 days at a vehicle rate of 3,000 vehicles per lane per day. The single turn loop operated over twenty days at a vehicle rate of 5,000 vehicles per lane per day. Ease of fabrication and durability led to the initial choice of single turn loops for future use. These five foot by five foot single turn loops were than distributed to the Districts for evaluation. Their findings, along with those of the Laboratory, were that a single turn loop (one turn of multi-strand wire) does not provide adequate detection capability. This means that the loop placement on the highway does not provide adequate lane coverage and the loop does not have an effective detecting height to sense some high bed trucks.

Both problems were resolved concurrently by using two turns of the WD-1/TT communication cable in a five foot long by six foot wide loop. The extra width expanded the vehicle coverage of a lane while the additional turn produced enough sensitivity to detect the high bed trucks.

A. Mold

The initial effort to produce a workable loop began with the construction of a 2 inch by 4 inch wooden mold, with a milled

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semicircular groove, 3/8 inch deep and 1-7/8 inches wide. The height of the mold was influenced by factors of safety and the need to present a low profile to highway traffic as shown in ATTACHMENT B. The overall size was five feet by five feet, with one leg extending an additional foot for lead-in connections. The use of floor wax as a release agent did not assure complete release of the encapsulant from the mold. Therefore a type simular to PolyKen 2310 D or Permacel P 162 was positioned in the groove and coated with silicon release compound to affect a good release from the mold.

Production was improved using a mold with dimensions similar to the first, constructed of 2 inch by 5/8 inch aluminum bar. The only preparation, prior to pouring, that the new mold required, was the application of a silicon release agent.

B. Encapsulants

Prior to the start of this project the Transportation Laboratory had experimented with such encapsulants as Polyurethane and Flexane. Both of these were tested on the highway and failed the Tear and Flex life tests (see ATTACHMENT C). Another type of encapsulant called Permapol "440" produced by Product Research and Chemical Corporation was tried. This material exhibited better overall characteristics than the former encapsulants and hence was chosen as part of the loop sensor (see ATTACHMENT D).

C. Wire

Initially insulated, multi-stranded stainless steel wire was used and proved to have excellent abrasion resistance qualities. However, the resistance per foot was too high to enable this wire to be used as an inductive loop. Plain insulated, multi-

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stranded copper wire fulfilled the electrical quality of low resistance per foot, but poor abrasion resistance qualities quickly eliminated copper wire as a roadway sensor. Finally a wire was found that incorporated both qualities. The wire called WD-1/TT, a U. S. Army Communication wire, was found to be most durable without excessive resistance per foot.

The two-turn loop proved to be the best compromise fabrication method because it is easier to fabricate than the three-turn loop. The small cross section of the encapsulant makes wire placement critical in the three-turn loop resulting in early failures and a high rejection rate of the fabricated loops, although it does have the highest sensitivity. The single turn loop is the easiest to fabricte but it results in too low a sensitivity.

D. Process

Permapol "440" is a tough, abrasion resistant two component chemically curing polyurethane mix. The two components are individually heated to a temperature of 125°F for about 15 minutes. Then the two components are mixed and poured into the mold. The material was permitted to cure at temperatures of 70 to 75°F for a total time of 72 hours. The material can actually be removed after 24 hours of curing, but an additional 48 hours of cure time is still required before placing the sensor on the road (see ATTACHMENT D).

Butyl rubber adhesive is placed on the flat side of the cast loop and the entire package positioned on the road.

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AREAS OF APPLICATION

The Portable Disposable Loop was used in conjunction with a loop matching transformer and a loop detector board, in the vehicle Classifying counter. Both of these are supplied by Traffic Data Systems in the VCC 106 and information can be found in ATTACHMENT E. See Figure 1 for block diagram.

The loop board consists of a voltage controlled oscillator. The frequency output is fed to a frequency divider. One side of this (A) is fed to a loop driver which in turn feeds a tuned circuit consisting of a capacitor and the roadway loop. The other output of the frequency divider is fed to a phase detector (B).

When a vehicle enters the presence of the loop, a change in inductance occurs. This, in turn, varies the frequency. This change in frequency is fed to one side of a phase detector board (C).

The phase detector translates the phase difference between B and C into an integrated voltage level change. A portion of this change is eventually fed to an A. F. C. Circuit to maintain the oscillators operational frequency. Another portion is fed to circuitry that provides an output.

The Portable Disposable Loop was also used with another traffic sensing device called the Traffic Congestion Monitor (Report No. CA-DOT-TL-6346-3-73-42). This device uses two portable loops positioned approximately 15 feet apart in a traffic lane to determine speed and alert motorists if slowing traffic would constitute a hazard.

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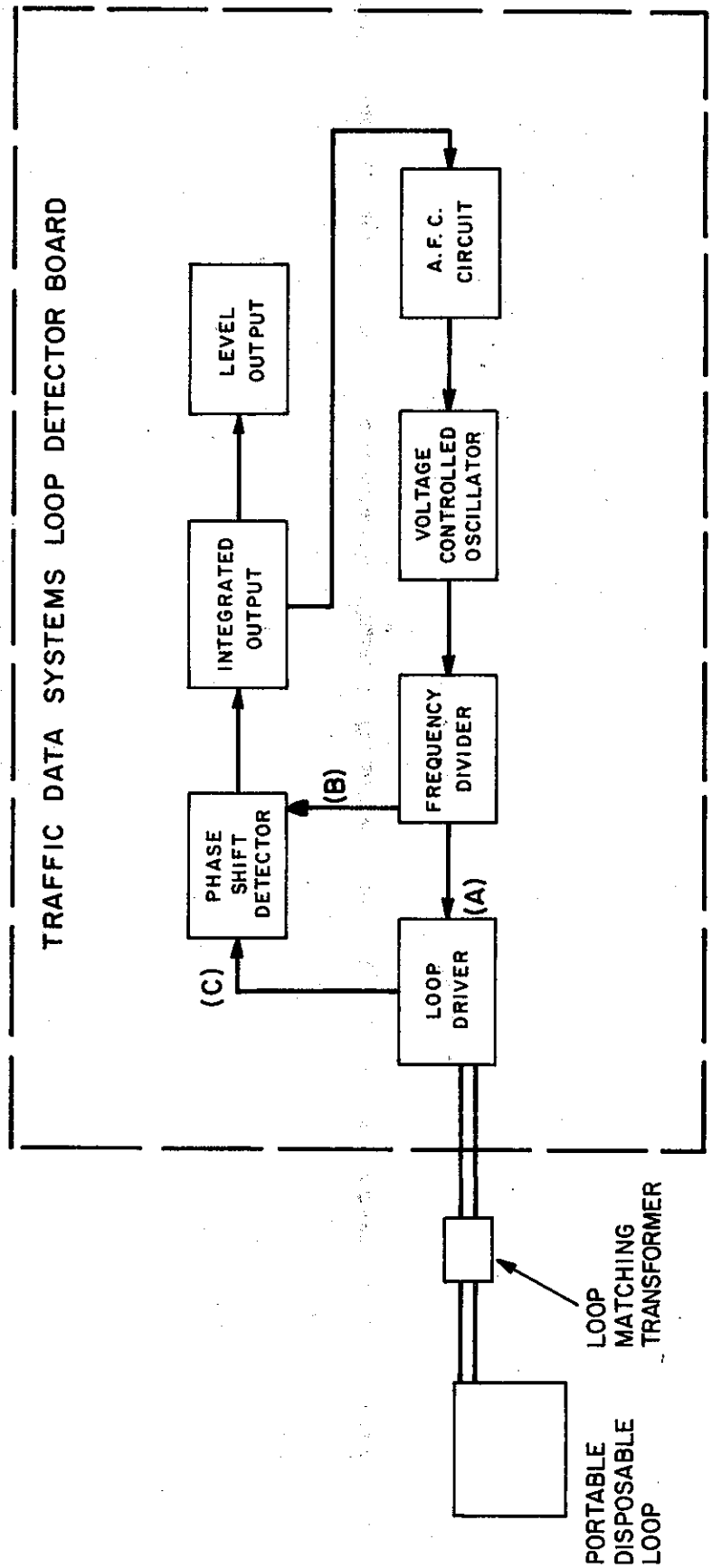

BLOCK DIAGRAM

Figure 1

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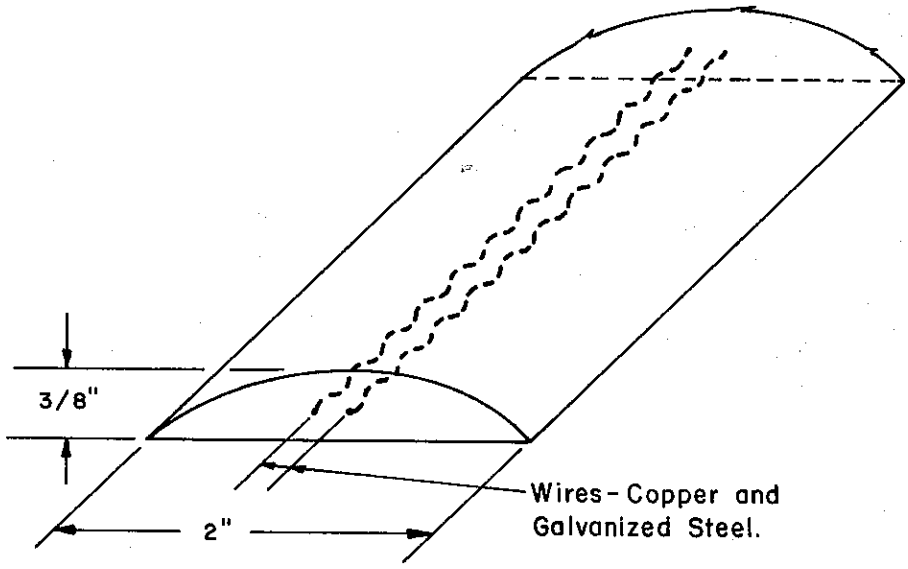
PORTABLE LOOP



NOTES:

Length - One leg, 5 feet

Material - Polyurethane Rubber, type known as Permapol "440"

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Attachment C

Figure 1

Jim Majectic of the Traffic Branch holding a Portable Disposable Loop. Jim has worked in cooperation with the Lab over the past two years on this development.

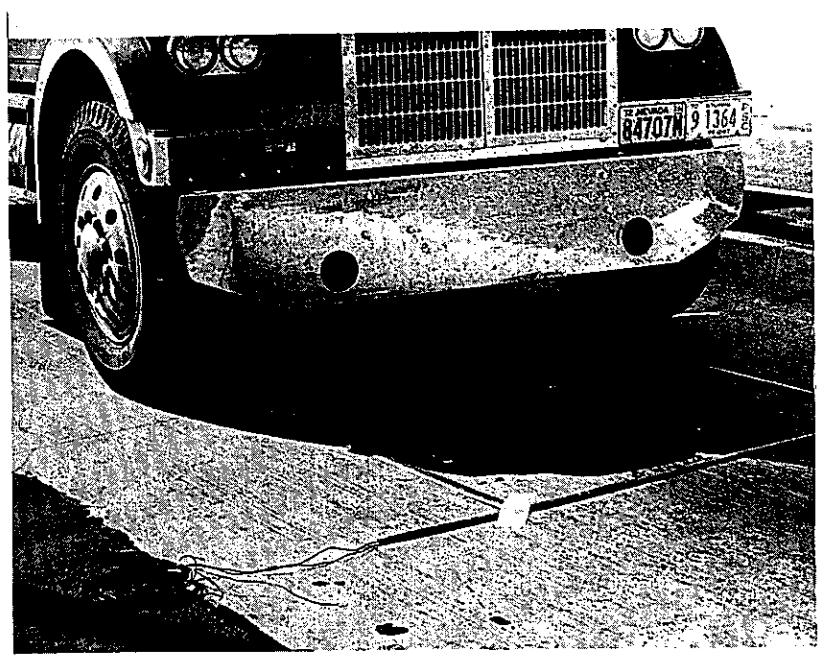

Figure 2

This shows one type of vehicle that will impact this sensor.

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SPECIFICATION FOR ELASTOMER STRIP

I. CONSTRUCTION

A. Quality - The elastomer strip shall be of good quality and workmanship.

B. Size - The length shall adequately span one lane of vehicle traffic. The width shall be no wider than 3 inches. The height shall not exceed 0.75 inches and shall not constitute a traffic hazard.

C. Finish - The exterior of the strip shall be a neutral or black finish such that driver visibility is not impaired.

II. RESISTANCE CHARACTERISTICS

A. Water Absorption - The elastomer shall be constructed such that prolonged periods of exposure to water shall not affect the operation of a sensing element within.

B. Abrasion - The elastomer shall be able to withstand the pounding of 500,000 vehicles before experiencing failure.

C. Cutting - See remarks under B.

D. Tear - See remarks under B.

E. Impact - See remarks under B.

F. Ozone - See remarks under B.

G. Cut Growth - See remarks under B.

H. Temperature - The physical characteristic shall not change over a temperature range of 0°F to 160°F.

III. OPERATIONAL

A. Flex Life - The strip shall be able to withstand 1,000,000 axles or 500,000 vehicles passing over its surface before failure.

B. Tensile Strength - See remarks under A.

C. Resilience - See remarks under A.

D. Compression Set - See remarks under A.

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E. Adhesion - The strip shall be bonded to the road or affixed in such a manner that no essential configuration change takes place, due to impact loads, and no hazardous condition exists.

IV. SENSING ELEMENT

Construction - a. The strip shall be constructed such that one or more sensing elements can be encapsulated, or suitably affixed, within its physical configuration.

b. The sensing elements shall be of uniform physical qualities.

Access - The sensing elements shall be suitably provided with adequate means of accessibility by external instrumentation.

Operational - The sensing element shall be able to function continuously and satisfactorily for 500,000 vehicles or 1,000,000 activations.

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Attachment E

PRC

protective coatings

caulking compounds

sealants • adhesives

INTERIM TECHNICAL DATA SHEET

PRC DECK COATING SYSTEM
PERMAPOL® 440 RUBBER COATING AND PERMAPOL® 445 NONSKID COATING

USE

PRC Deck Coating System is a two-product system using Permapol® 440 Rubber Coating and Permapol® 445 Nonskid Coating for wood, steel, aluminum, and concrete surfaces. This system will provide a seamless, protective, high abrasion resistant, sound deadening, waterproofing, nonskid coating for use on concrete, metal and wood decks, ramps, parking decks, and walkways.

DESCRIPTION

Permapol® 440 Rubber Coating is a tough, abrasion resistant, flexible, two-component, chemically curing polyurethane coating. The excellent flow and self-leveling characteristics of Permapol® 440 Rubber Coating insures ease of application and provides a one coat system for the elimination of surface defects and excellent surface protection. Permapol® 440 Rubber Coating may be used with or without a topcoating of Permapol® 445 Nonskid Coating.

Permapol® 445 Nonskid Coating is a three-component, polyurethane base, flexible, nonskid coating formulation for use on primed wood, aluminum, steel, and concrete, either coated or uncoated with Permapol® 440 Rubber Coating.

Permapol® 440 Rubber Coating and Permapol® 445 Nonskid Coating must be used with PRC Primer #19 on metal surfaces and PRC Primer #18 on concrete and wood surfaces to obtain optimum adhesion. No primer is required on Permapol® 440 Rubber Coating when it is to be coated with Permapol® 445 Nonskid Coating.

SUPERSEDES

May 1968

PRODUCTS RESEARCH & CHEMICAL CORPORATION

CORPORATE OFFICES AND WESTERN MANUFACTURING DIVISION
2919 EMPIRE AVENUE
BURBANK, CALIFORNIA 91504

EASTERN SALES AND MANUFACTURING DIVISION
410-416 JERSEY AVENUE
GLOUCESTER CITY, NEW JERSEY 08030

DATE ISSUED

April 1969

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Attachment F

P. O. BOX 3337, 100 EAST COMMERCE STREET
COLORADO SPRINGS, COLO. 80907 (303) 473-5210

TRAFFIC DATA SYSTEMS, INC.

Model VCC106

Vehicle Classification Counter

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SECTION I

MODEL VCC 106

1.1 GENERAL DESCRIPTION:

The Vehicle Classification Counter (VCC) is a portable solid-state device capable of classifying and counting vehicles. The classification is accomplished by determining the spacing of the first two axles and counting the number of axles. Typically, the vehicles are classified into six categories. These are: two axle cars; two axle cars with single axle trailer; two axle trucks; three axle trucks; four axle trucks; and five or more axle trucks.

The VCC requires one roadway loop and two pneumatic road tubes as inputs. The loop size is not critical, but is normally a 6' x 6' three or four turn loop. The first road tube is placed across the roadway such that a vehicle is over the loop before the front axle makes contact with the road tube. The second road tube is placed 11 feet beyond the first tube. This dimension is critical since the criterion for classifying a vehicle as a car is based upon a wheel base less than 11 feet. Trucks are classified as those vehicles with spacing between the first two axles greater than 11 feet or having four or more axles.

Classification of a vehicle occurs in the following way: When an approaching vehicle is detected by the loop detector, electrical power is applied to the logic networks which are reset to an initial zero state. As the vehicle passes over the loop and the front axle is detected by the first road tube, one count is made in the logic register. In the event that the vehicle is an automobile, the rear axle of the automobile will be detected by the first road tube before the front axle has reached the second road tube. The result will be to advance the logic register to two counts. Two counts from the first road tube, before a count is received from the second road tube, classifies the vehicle as an automobile. When only two counts are registered by the first road tube, the vehicle is classified as a two axle automobile. When three counts are registered, the vehicle is classified as an automobile with trailer. In the event that the vehicle is a truck, two possible conditions may occur. One condition is that only one count will be registered from the first road tube before a count is received from the second road tube, indicating a wheel base greater than 11 feet. The second condition that may occur is four or more axles are counted thereby classifying the vehicle as a truck regardless of the wheelbase length. Either condition results in the vehicle being classified as a truck. The VCC is designed to operate with traffic speeds of one to 100 MPH.

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The electrical power turns on when the loop detector indicates that a vehicle is present. The power is turned off after the vehicle has cleared the loop and the classification has been recorded. The loop detector, which is operating continuously, controls the logic network power and determines when a vehicle is in the classification zone.

1.2 EQUIPMENT HOUSING:

The housing is constructed of 14 gauge cadmium plated sheet metal finished in a gloss white color. The finish is capable of withstanding all weather environmental conditions normally encountered in roadside use. The unit is raintight and the bottom six inches of the case is waterproof. A rubber composition weather seal is installed in such a manner that it is in contact with all portions of the housing when the lid is closed. The housing is provided with external fixtures such that the lid may be locked with a standard padlock and may be clamped shut providing a raintight seal.

The size of the unit is approximately 12"H x 16"W x 12"D and weighs approximately 60 pounds. Two handles are provided on the sides for carrying the unit.

1.3 SUBASSEMBLIES:

The housing contains all electronic and electromechanical devices required to count one lane of traffic excluding the roadway loop and hoses. The loop and hoses are not supplied with the unit. The basic subassemblies are the battery, battery charger, electronic circuits, pneumatic switches and electromechanical counters.

The battery is a 25AH, 12 volt vented-cell nickel-cadmium battery capable of supplying power for eight days of continuous service. The capacity of the battery is based upon a 10 hour discharge rate to an end point battery voltage of 11 volts. The battery charging current is not more than three amperes. The battery is connected to the electronics and charger through a connector such that the battery may be easily removed from the VCC. The battery is held in place mechanically with one metal strap connected to two bolts with nuts.

The battery charger is a complete and separate subassembly in the VCC. A three position switch is provided which allows the charger to be turned off, operated as a trickle charger or as a high current charger. When operated in the high current mode, the charge rate is typically 2.25 amperes and will automatically transfer to a trickle charge rate of 100±20 milliamperes when the battery terminal voltage has reached 14.75±0.5 volts. The input voltage to the charger is 117±15 VAC. The input connector on the VCC housing contains the power input pins for the charger.

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The electronic circuits are mounted on three circuit boards and one interconnecting mother board. The circuit boards are functionally grouped into the power supply board, the axle decoder logic board and the loop detector board. All boards are constructed from G10, 2 oz. copper circuit board material. The printed circuit lines are tin plated and a protective coating covers the circuit board thereby protecting the circuit lines from oxidation and corrosion. The exposed connector pins on the board are gold plated. Each circuit board is keyed to prevent improper installation. All circuit boards are provided with test points for monitoring and testing the circuit functions. One extender board is provided with each VCC system. This board allows maintenance personnel to test each circuit board under operating conditions.

The power supply board provides the +5±0.25 VDC power supply for the integrated circuits and the automatic shut-off for the battery. The +5 VDC regulator includes short circuit protection which is adjusted to a nominal short circuit current of 0.275±0.1 amperes. An over voltage protection circuit is also provided which protects the circuits from any excessive supply voltages. The over voltage circuit is set to turn the supply off when the regulator output voltage reaches 5.7±0.25 VDC. The regulator will resume normal operation when the next vehicle enters the classification zone if the over voltage condition has cleared. The regulator is capable of operating with an input voltage of 13±2 VDC. The automatic shut-off for the battery is programmed to switch when the battery terminal voltage reaches 11.30±0.35 VDC. This shut-off protects the battery from being discharged to a point below the operating level and serves as an automatic system shut-down. Approximately 4 milliamperes is drawn after the automatic shut-down. The power must be completely shut off via a manual switch to recycle.

The axle decoder logic board is constructed with TTL integrated circuits which provide the logic necessary to classify vehicles. All components are in accordance with good commercial practice and are commercially available. Discrete semiconductors are used to interface the TTL logic with the pneumatic switch inputs and the counter driver outputs. The switch input circuits are designed to eliminate switch contact bounce. This circuit card requires 100±25 milliamperes of +5 VDC current during a classification cycle. The power to the board is controlled by the power supply board and is on only when a vehicle is in the classification zone.

The loop detector is contained on a plug in printed circuit board. The input power to the detector comes from the battery through the automatic power shut down circuit. The detector requires less than 20 milliamperes of current with an input voltage of 13±2 VDC. The detector is an automatic tuning detector which operates with loops of 75 to 400 microhenry inductance. The detector will continually track the loop inductance changes due to changing environmental conditions. The detector will rephase, i.e., tune out any vehicle within 60 seconds, thereby reducing power drain in the logic networks. The output of the detector is a

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solid-state switch compatible with the requirements of the associated VCC circuits. Test points are provided to monitor the operation of the detector. The semiconductor components used in the detector circuit are all silicon-discrete devices.

Two pneumatic switches and six electromechanical counters are contained in the VCC housing. The switches have adjustable contacts which provide the detect signals to the logic board. The electromechanical counters are a five digit resettable counter. The counters may be individually removed and have rugged continuous duty coils. The counters are capable of operating at a 10 impulse per second rate. The mounting for the counters are silk screened in a manner which identifies the count category.

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SECTION II

OPERATION

2.1 LOOP DETECTOR:

The loop detector board features automatic tuning and needs no adjustment for tuning or sensitivity. Connect the loop wires, pins D and E of J1, to the roadway loop and turn the power on. The detector will tune to the loop within 5 minutes. The detector output may be monitored at TP5 of the regulator board with a scope or a 1000 ohm/volt DC meter. A detection will be a DC level of approximately 12 volts and no detection will be 0.

2.2 REGULATOR:

The regulator board provides all of the DC voltages required for the unit. The only adjustment necessary is the Loop Delay which is mounted on the Counter Panel. This adjustment determines the delay after a vehicle clears the loop until the count is registered on the appropriate counter. This delay is variable from 100 milliseconds to greater than 1 second as indicated by the markings on the front panel.

2.3 AIR SWITCHES:

The air switches have been factory set for .010 inches and may be adjusted as required. Closing the gap increases the sensitivity and opening the gap decreases contact bounce. Attach axle counter input #1 to the upper hose fitting and truck classifier input #2 to the lower hose fitting.

2.4 BATTERY CHARGER:

The battery should be fully charged before putting the unit into service where AC power is not available. Set the charger power switch in the Auto position and put the VCC power switch in the On position. The battery will be charged to 14.75±0.5 volts and when fully charged will automatically go to a trickle charge. The cover of the VCC must remain open during the Auto charge cycle. The battery will be fully charged in 16 hours or less and is ready to be put in service. Turn the battery charger power switch to the Off position.

For service where AC power is available, put the battery charger power switch in the Trickle position and the VCC power switch On. This will maintain the battery charge, when used in the VCC, for an indefinite period without damage to the battery.

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2.5 COUNTER PANEL:

Always turn the main power to the Off position before attaching the loop lines and when resetting the counters. The detector will not be damaged but will fail to tune properly if power is on before connecting the loop. If this condition does occur the detector will automatically reset by turning power off momentarily. The counters may be damaged if a count is being registered during reset.

Make certain the panel is down in the normal transport position before closing the cover of the main enclosure.

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