STATE OF CALIFORNIA
HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A REPORT ON INDUCTIVE LOOP TRAFFIC DETECTION UTILIZING A COMMON SLOT

A STUDY MADE BY THE
CALIFORNIA DIVISION OF HIGHWAYS
IN COOPERATION WITH THE
U.S. DEPT. OF COMMERCE
BUREAU OF PUBLIC ROADS

May 1965

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State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

May 1965

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HPR 1 (2) C-1-2
Proj. W. O. 6346

Mr. J. E. Wilson
Traffic Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A REPORT ON

INDUCTIVE LOOP TRAFFIC DETECTION

UTILIZING A COMMON SLOT

Study made by - - - - - - - - - - Structural Materials Section
Under general direction of - - - - - - - - - - - E. F. Nordlin
Work supervised by - - - - - - - - - - - - - - - J. E. Barton
Report prepared by - - - - - - R. L. Donner and M. E. Wilson
Field work by - - - - - - - - - - M. E. Wilson and L. F. Peters

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

MEW/LFP:mw

cc: LRGillis

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This is one of a series of investigations and reports undertaken under a project entitled "Testing Traffic Counting and Detecting Equipment". The work was done under the 1964-65 Work Program HPR 1 (2) C-1-2 in cooperation with the U. S. Department of Commerce, Bureau of Public Roads.

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I. INTRODUCTION

This test was initiated by the Traffic Department in a letter dated October 21, 1964, from Mr. J. E. Wilson to Mr. John L. Beaton.

The object of the test was to conduct a controlled traffic count at one of the new inductive loop locations constructed in accordance with Circular Letter No. 64-174 and Standard Plan No. ES-36-3 to determine if any interaction was occurring.

In operation, loop configurations are currently being constructed with a common slot for the loop wires and lead wires as opposed to recommendations of two leading inductive loop manufacturers. This is because of the feeling that the RCA (Ve-Det) recommendation of a 2 foot offset between lead wire slots and loop slots increases the possibilities of concrete pavement spalling.

To obtain further information, a test of an installation utilizing a common slot was conducted in District 07 on the eight lanes of a ten-lane section of the Santa Monica Freeway. The site was approximately 100 feet east of the West Boulevard Overcrossing on Interstate 10.

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II. SUMMARY

Interaction resulting in extra counts was not observed on this common slot installation during test.

The over-all system error for the four hour count at this test installation was 2.2% high. This compares favorably with the +1% to +3% error obtained in a two month field test conducted by the Materials and Research Department in 1962 and with the +1% error reported by District 06 during a one year field test in early 1964. The District 06 installation utilized a common slot. The earlier Materials and Research Department installation did not.

It is believed that the system error of +2.2% is higher than the +1% of District 06 because of the high incidence of weaving vehicles which caused overcounting.

The Count Summator lost 0.3% during a 2½ hour period.

The Ve-Det and F-P Count Summator can be packaged in an F-P Counter case. However, a much more efficient arrangement of components could be achieved by use of newer detectors on the market.

A.C. power can be brought in with direct burial cable, stepped down to a lower voltage and back to 115 VAC. Where it is necessary, power could be brought in for distances up to 2000 feet.

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III. TEST PROCEDURE

The following equipment was purchased for this test:

2 each - RCA Ve-Det, 4 Pak M144127-4 with one power supply and 4 detectors

2 each - Fischer Porter Count Summator Model 55 CP 1010 with 4 input channels

2 each - Fischer Porter Traffic Counter Boxes Assorted Cannon plugs and receptacles

(For the accessory parts list, see Exhibit 8)

The Ve-Det 4 Pak was mounted on a 16 gauge sheet of aluminum 11-5/8" x 11-5/8" which was secured to the box mounting bracket by 3 Simmons Quick Lock fasteners (see Exhibit 3). In order to mount the Summator in the bottom of the box, approximately one inch of the Summator case was cut off the top. Wiring connections between Ve-Dets and Summator were made at a terminal strip in front of the detectors. This was for purposes of troubleshooting and connecting a tape recorder. These connections could be made with Jones plugs.

Two Fischer Porter Traffic Counter Recorders were wired to accept counts from the Summators. The 60 minute cams in the Recorders were replaced with 15 minute cams to aid in correlating the manual counts with the Traffic Counter at the 15 minute punch out period.

The equipment was transported to District 07 and connections made to loops previously installed by District 07 forces and to power already made available by District 07 at the test site (see Exhibit No. 7). The following steps were then taken:

1. Counters were operated by 117 volts A.C. which was brought in by 1000 ft. of #10 two-conductor, Type UF, underground cable. Voltage was stepped down to 26.8 volts at the power pole and transformed back to 117 volts at the counters by a 24.0 volt to 115 volt transformer.

2. A four-hour manual traffic count was taken with traffic recorded at 15 minute intervals coincidental with the Fischer Porter punch-out periods. When the Fischer Porter punched the tape, the personnel conducting the manual count were notified by two-way radio to record their counts.

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3. Accuracy of the Fischer Porter Count Summator was checked with a PMR-500, 4 channel magnetic tape recorder manufactured by Pacific Electro Magnetics Co. Impulses from each lane detector being fed into the Summator were simultaneously recorded on separate channels of the tape recorder. These recorded impulses were later counted at the laboratory by playing back the tapes into Berkeley Electronic Counters, Models 5010 and 5001.

4. Flat traffic hose was placed adjacent to the loops and connected to counters in both the westbound and eastbound lanes. A 20 hour count was made for comparison of hose counts with induction loop counts.

5. The 4 hour and 20 hour tests with the inductive loop equipment were made with the frequency of each detector 2 kilocycles apart. After the completion of these tests one of the oscillator crystals was replaced with a 91KC frequency. This gave a frequency arrangement of 90-91-94-96KC in the westbound lanes. A 100KC crystal was then substituted for the 96KC crystal in Lane 1. Another 100KC crystal was in Lane 2 of the eastbound lanes approximately 40 feet away. No interaction was observed during these two short visual tests.

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IV. DISCUSSION

Circular Letter No. 64-174, issued on June 17, 1964, states, "Inductive loop vehicle detector conductors will be installed in each traffic lane between all interchanges of all new freeway contracts." Standard Plan No. ES-36-3 specifies a 6 foot loop with lead and loop wires in a common slot. Although RCA (Ve-Det) recommended a 2 foot offset between the lead wire slot and the loop slot, the Design and Construction Departments objected to two parallel slots that close together, due to the increased possibility of pavement spalling.

The only previous experience with a common slot on California highways was obtained by District 06 during the installation and testing of Link and Ve-Det detectors (see Report E. W. Taylor to J. E. Wilson dated March 25, 1964). No interaction was observed on this four-lane divided freeway with frequencies that were 10KC apart. These tests were conducted over a one year period.

In August of 1964, Mr. Roy Matthews of Headquarters Traffic Department verbally requested that the lab investigate the common slot problem during the testing of a Muni Quip Autotector. An inductive loop installation similar to the circular letter instructions was made in the laboratory parking area. Three 6' x 6' loops were cut with about 50' of common lead-in slot. One Muni Quip Detector and two Ve-Det Detectors, Model MI-37221 were operated from one Ve-Det Power Supply MI-37220. No interaction was observed with frequencies of 90, 100, and 110 KC.

Because experience with the common slot type of installation was so limited, plans for further testing were made in October 1964. A site was selected on the Santa Monica Freeway in District 07 (see Exhibits 5 and 6) and 115 AC power was brought in to a pole near the R/W line. The equipment was requisitioned on October 30, 1964, and the last items, the Count Summators, were received on February 15, 1965. The two units were assembled and checked out on District 03's control station 301 on Rt. 160 near the American River Bridge. Incidentally, this installation has a two foot offset between the slots.

The equipment was transported to District 07 and was connected on March 9, 1965, to eight lanes, Lanes 1, 2, 3, and 4, of the ten at the site. A block diagram of the equipment is shown in Exhibit 1. The fifth lanes were not recorded because the Ve-Det units used were 4 Pak with only four detectors. A Ve-Det 4 Pak can be tuned for counting in approximately five minutes. After the sensors are counting the sensitivity of each sensor must be adjusted for optimum performance for the type of traffic expected on that lane. For example, adjustment on Lanes 1, 2, and 3 was set approximately 100° CCW from full

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sensitivity because the vehicles are mainly two axle cars. Lane 4 was difficult to adjust because of the high incidence of weavers and trucks. Sensitivity must be kept high enough to prevent truck-trailer combinations from double counting; however, when this is done, the weavers who are straddling the white stripe will be detected by two loops. In this particular test the traffic in Lane 4 was overcounted by 6%, although the sensitivity was 90° CCW from maximum. The sensitivity in this lane should have been reduced slightly. Sensitivity that is available on Lane 4 will be higher than the other lanes because lead length is one factor that determines sensitivity. The total time necessary to set up the equipment is approximately 20 minutes (5 minutes to start detecting and 15 minutes to adjust sensitivity). As the counter men become familiar with the equipment and the traffic behavior at the different locations they will be able to make the initial adjustment of the sensitivity control very close to the final setting.

The test was conducted on power brought to the detecting equipment over 1000 feet of #10 two-conductor, Type UF, underground cable. This was done to demonstrate the feasibility of transmitting low voltage A.C. over underground cable to counter locations that are not in the immediate vicinity of the power drop. The line voltage during most of this test was about 119 VAC. To transmit at low voltage, two filament transformers with one amp secondary rating were used. A combination of 26,8 V and 24.0 V secondaries were used to compensate for voltage drop in the wire plus transformer loss. An output of 117 V was supplied to the Ve-Det 4 Pak power supply. This arrangement or a similar one will be able to supply 115 VAC ± 10%. The 24.0 V filament transformer would be mounted in the detector box.

The counting equipment (see Exhibit 7) was operated for 1½ hours with satisfactory counting accuracy and normal transformer heating. All portable equipment was disconnected and removed at the end of the first day to avoid the possibility of vandalism and to assure its availability for the manual check.

On March 10, 1965, at 0700 hours District 07 installed "flat" pneumatic hose near the loops in both the westbound and eastbound lanes. The hose in the westbound lanes came loose in mid morning and was replaced after some effort. Minor repairs to the Fischer Porter counter operating on traffic hose were made by the Headquarters Traffic representative.

The portable counting equipment was connected to the loops once more and to the 115 V by 750 feet of the #10 cable. The remaining 250 feet of cable was used to provide power for the operation of the tape recorder. Testing continued from 0900 to 1245 hours without any noticeable problems. There was no overheating of the transformers so the remainder of the test, which lasted for approximately 20 hours, was conducted with the same wiring method.

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A manual count, which was simultaneous with the pneumatic hose count and the inductive loop count, was begun at 1300 hours and lasted until 1700 hours (see Exhibit 6). The manual traffic counts were recorded when the 15 minute periods ended and the data recording tape was being punched. Coordinated with these two events was the marking of the magnetic tape with identification markers. The manual counts, magnetic tape recorder counts by the inductive loops of the individual lanes, and the accumulated counts recorded by the Fischer-Porter counter on the pneumatic hose are shown in Exhibit 2. Over-all system error for the 4 hours was +2.2%.

By inserting the magnetic tape recorder at the input of the Count Summator (see Exhibit 1) we were able to determine that:

1. The Count Summator lost 0.3 of 1% of 11,358 vehicles over a 2½ hour period.

2. Lanes 2 and 4 were overcounting while Lanes 1 and 3 were adjusted for optimum counting.

Examination of the magnetic tape recorder counts showed overcounting on Lanes 2 and 4 with a maximum error of 25% from manual count occurring between 1530 and 1545 hours on Lane 4. We cannot account for this discrepancy. Although most of our error can be attributed to overcounting of weavers, we cannot definitely report that interaction of the loops did not contribute to this error. Personnel from the Materials and Research Department, Headquarters Traffic, and District 07 spent considerable time during the test observing the operation of the Fischer Porter Counter. By "feeling" the end of the worm shaft, which is rotated as a result of the stepping motor action, the impulses can be matched to the vehicles passing over the loops at that instant. Except for periods of heavy coincidence traffic, it is possible to detect the weavers being overcounted and any trucks being overcounted. However, no one was able to cite a definite case of interaction, resulting in an extra count, being observed.

In our latest correspondence with Fischer Porter Company, representing RCA Ve-Det, they remain unyielding in their recommendations. They report interference during tuning and during operation. We have observed interaction between detectors while tuning, but since only minor readjustment was required we had not considered this a problem. If interference is sufficient to trigger extra counts, we should be concerned and continue to look for a "worse case condition". Conversely, if only an occasional extra count occurs, we are seeking accuracy beyond reasonable limits.

A brief test using two crystals 1KC apart was discussed in the test procedure. Although no interaction was noticed, this should <u>not</u> be interpreted as an approved method. All frequencies should be kept at least 2KC apart. There is no problem in obtaining crystals 2KC apart from 90KC to 110KC.

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A secondard aspect of this test was the establishment of standard equipment, connections, and techniques so that installations could be made by one counter man in a minimum of time. The portable case selected to hold the equipment was the Fischer Porter counter case. These cases will fit into the truck storage racks currently being used by many districts. Although the case is compatible, the packaging inside it presents a problem (see Exhibits 3 and 4). The Summator was reduced 1 inch in height and placed in the bottom of the case. A mounting plate, with the Ve-Det 4 Pak secured to it, was placed on the normal mounting support. Two corner braces in the top section were removed to permit closing of the case. An alternate method would be to raise the mounting plate an inch and not have any corner braces. The reason that the 4 Pak and Summator are difficult to arrange in a satisfactory layout is the requirement that both must be operated in a level position (no more than 30° from the horizontal) to prevent the mercury-wetted relays from shorting out. This is more of a problem when the equipment is in a portable case. If a controller cabinet is being used in a permanent or semi-permanent installation, there is no packaging problem. Since the original decision to buy Ve-Det 4 Paks for the test was made, the Fischer Porter Company has placed the Tacdet detector on the market. These units use mechanical relays and are packaged in modules of one or two. This type of detector allows a much more efficient arrangement of components and permits fuller utilization of equipment by the more rural districts who may not need the multilane capability of the Ve-Det 4 Pak. The Tacdet should be evaluated for traffic counting application.

As a safety precaution a ground rod or pipe should be driven to a depth of 8 feet at each counter location to provide electrical ground for the counting equipment.

The possibility of substituting the Streeter-Amet Jr. Counter for the Fischer Porter Counter was suggested by several people. It cannot be easily accomplished except by wiring up a circuit equivalent to that manufactured by Fischer Porter under the description of an "Interface Board". These boards sell for $75 and provide 6VDC to the Summator and switch closure for counters.

The input cable used during testing consisted of four cables of three conductor #16 made up as one cable. If a smaller cable is preferred, one of the ten conductor 22 gauge cables that are available such as the Belden 8456 Sound Cable or 8784 Phono Cable should be investigated. Lead length must be kept short, i.e. five feet.

The Cannon Plugs selected were a larger size than necessary but were chosen to handle any test situation. A smaller diameter would be possible on the Detector Box by use of eleven contacts of #16 (shell size of 20/16th of an inch) instead of the ten #12 plus four #16 (shell size of 28/16th of an inch) type of plug.

Exhibit 9 is a summary of the cost of the various components that might be employed in the counting systems discussed in this report.

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V. APPENDIX

Exhibit 1	Block Diagram of Equipment
Exhibit 2	Tabulations of Manual, Magnetic Tape and Counter Counts
Exhibit 3	Photographs of Counting Equipment
Exhibit 4	Photographs of Counting Equipment
Exhibit 5	Photographs of Test Site
Exhibit 6	Photographs of Manual Count Crew
Exhibit 7	Photographs of Power Run to Detectors
Exhibit 8	Equipment Used on Test
Exhibit 9	Comparative Equipment Cost of Several Manufacturers

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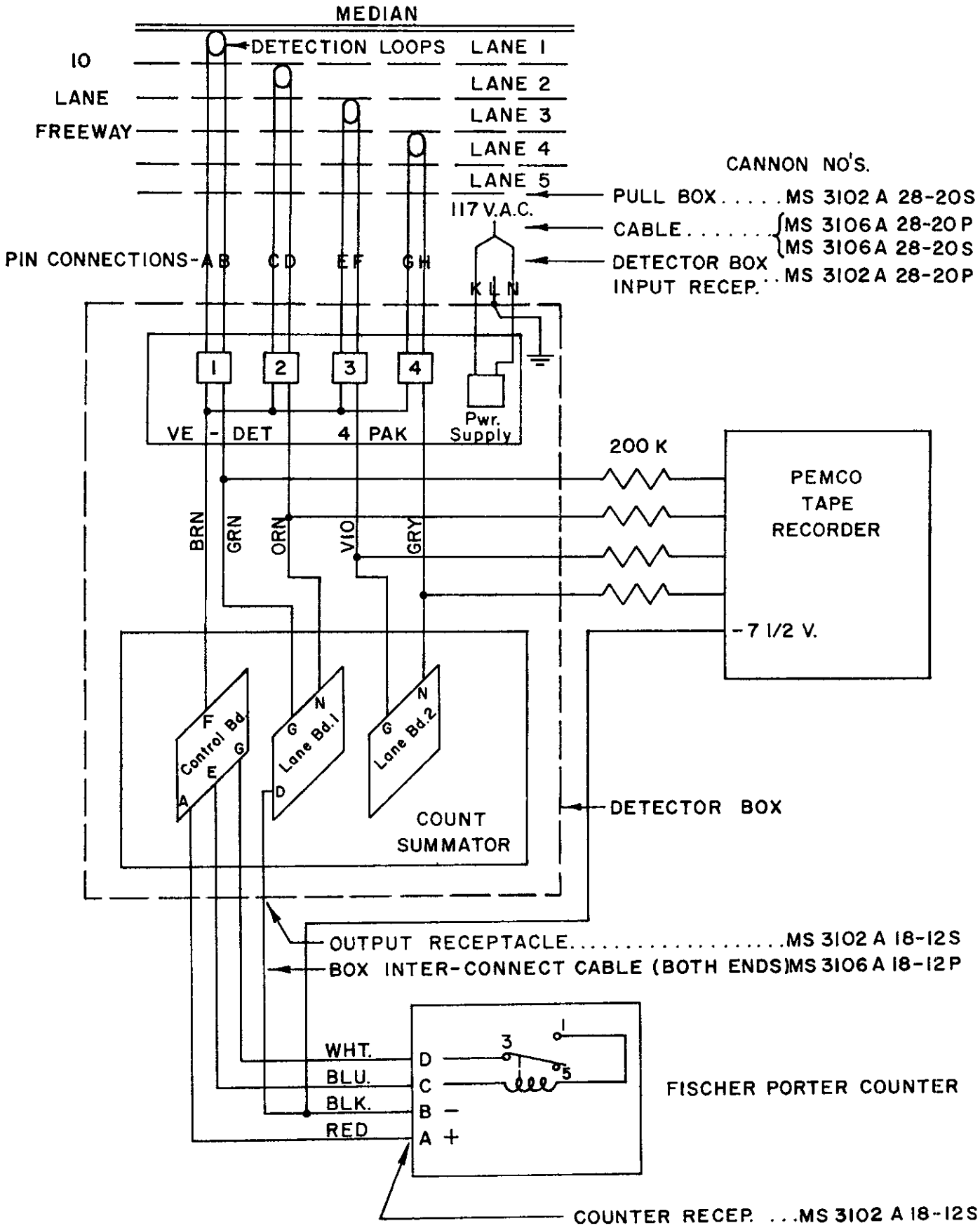
EXHIBIT I



INTERCONNECTION DIAGRAM

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Time	Lane 4 Manual	Lane 4 Mag. Tape	Lane 3 Manual	Lane 3 Mag. Tape	Lane 2 Manual	Lane 2 Mag. Tape	Lane 1 Manual	Lane 1 Mag. Tape	Summator Veh/15 Min. Input	Summator Veh/15 Min. Output
1300-1315	214	238	193	209	216	239	177	189	875	880
-1330	268	284	244	243	220	235	214	214	976	960
-1345	234	245	242	241	242	277	207	206	969	980
-1400	281	290	256	255	248	254	245	242	1041	1040
1400-1415	275	282	269	270	257	271	231	220	1043	1040
-1430	Changed Tape Reels									
-1445	280	295	289	278	325	340	278	280	1193	1180
-1500	322	325	312	306	310	333	328	328	1287	1280
1500-1515	296	304	306	309	296	313	311	308	1234	1240
-1530	273	289	328	326	353	362	365	360	1337	1320
-1545	277	345	326	316	323	355	393	387	1403	1400
	F-P Summator Efficiency over 2½ hour period.								11358	11320
	Manual Count (4 lanes 4 hours)									20345
1300-1700	Ve-Det Count (4 lanes 4 hours)									20780
Wed. 1300 to Thur. 0900	Ve-Det Count (4 lanes 20 hours)									60490
Wed. 1400 to Thur. 1000	Pneumatic Hose Count (5 lanes 20 hours)									56390

EXHIBIT 2

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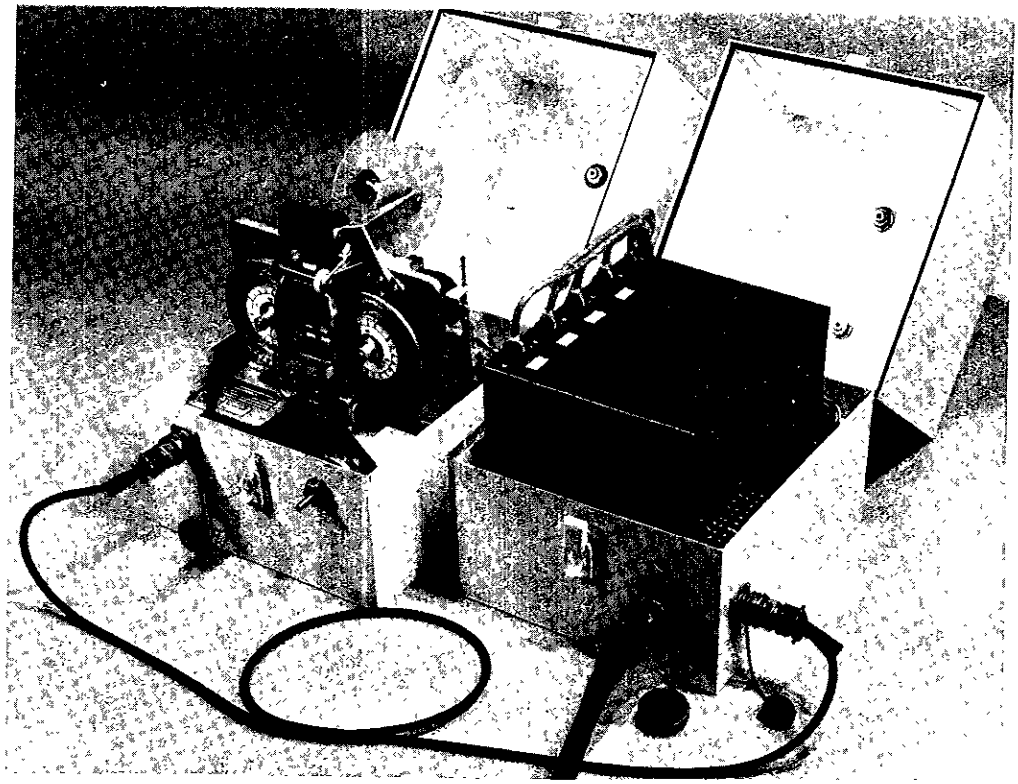
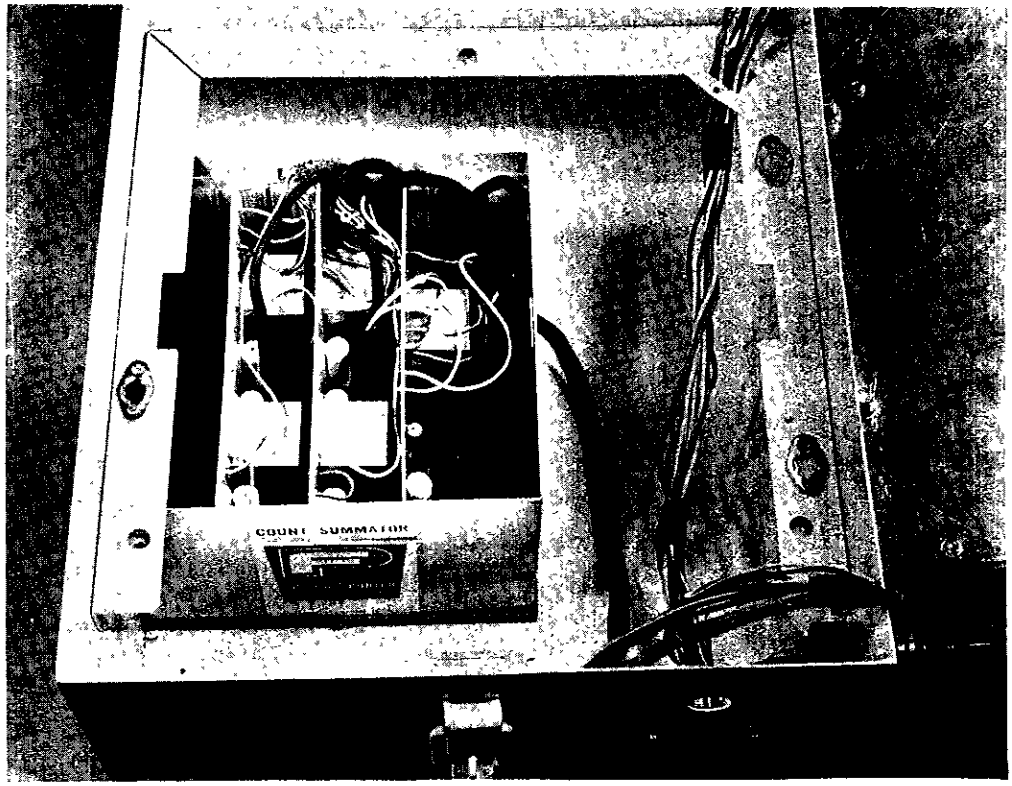


Fischer Porter Counter and Ve-Det 4 Pak Detector



Fischer Porter Count Summator

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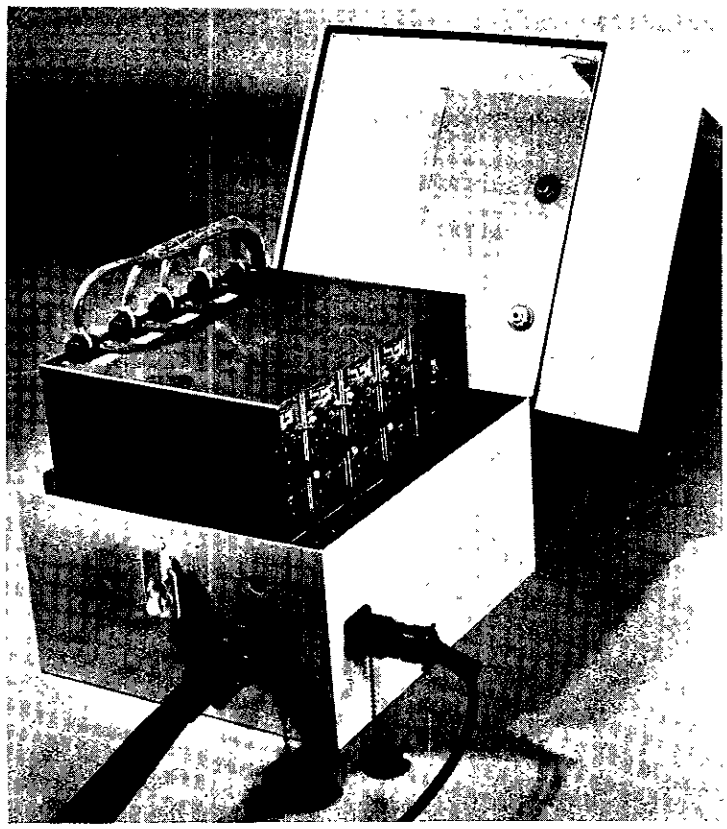
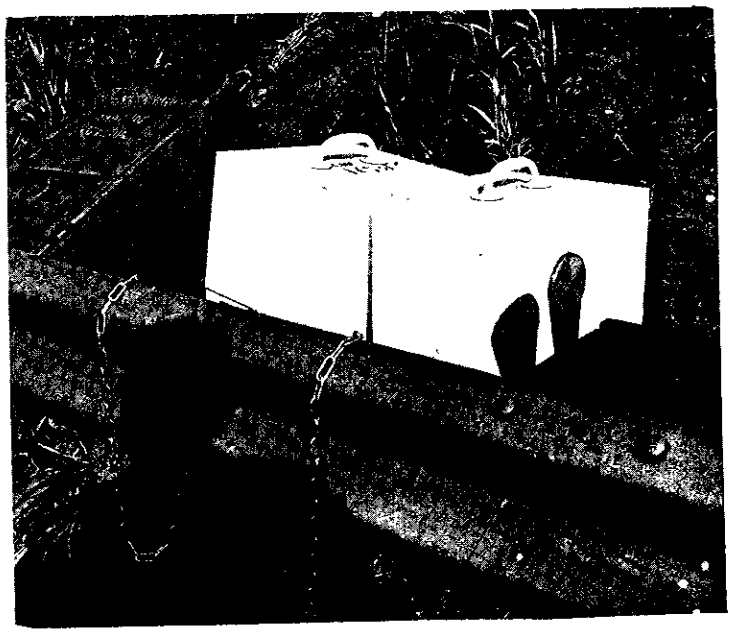


RCA Ve-Det 4-Pak Detector



In position at test site

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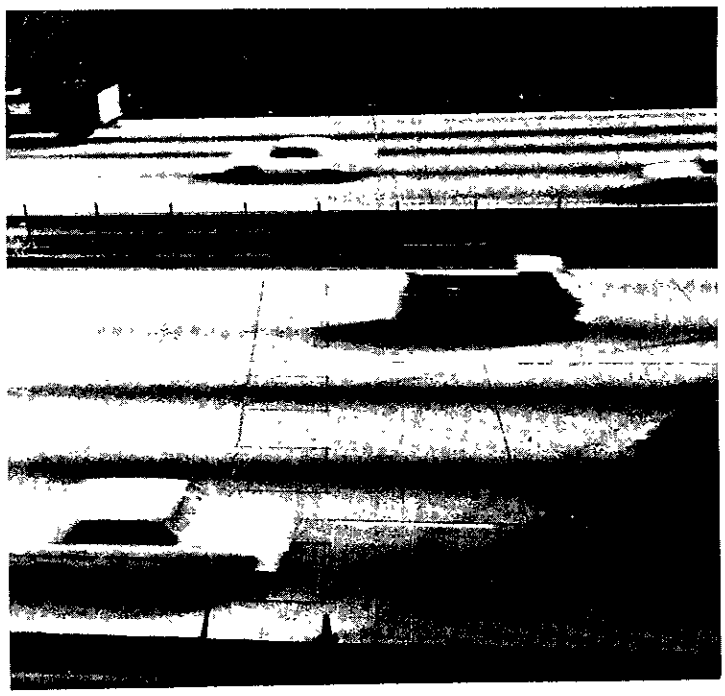

Loops in Westbound Lanes.
Eastbound in Background.

Eastbound Lanes - 0830

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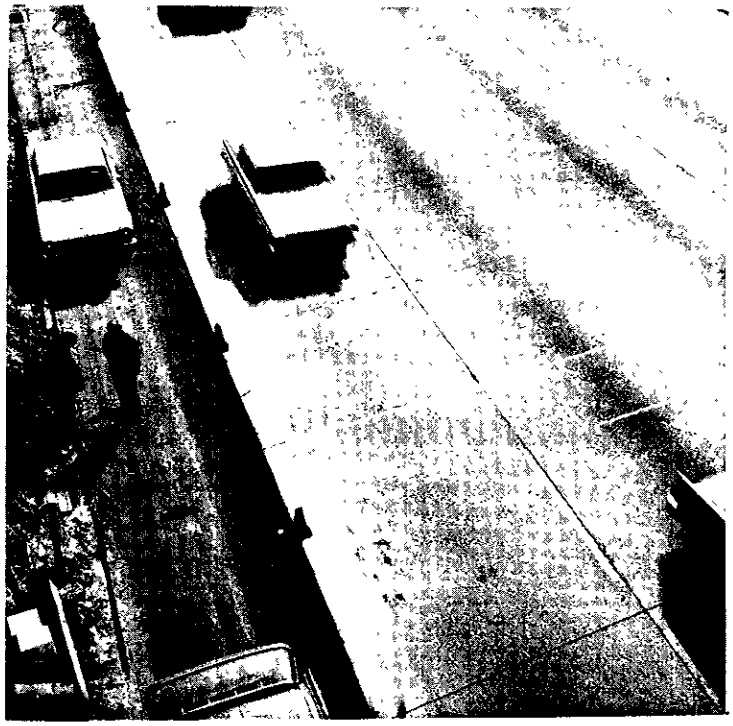
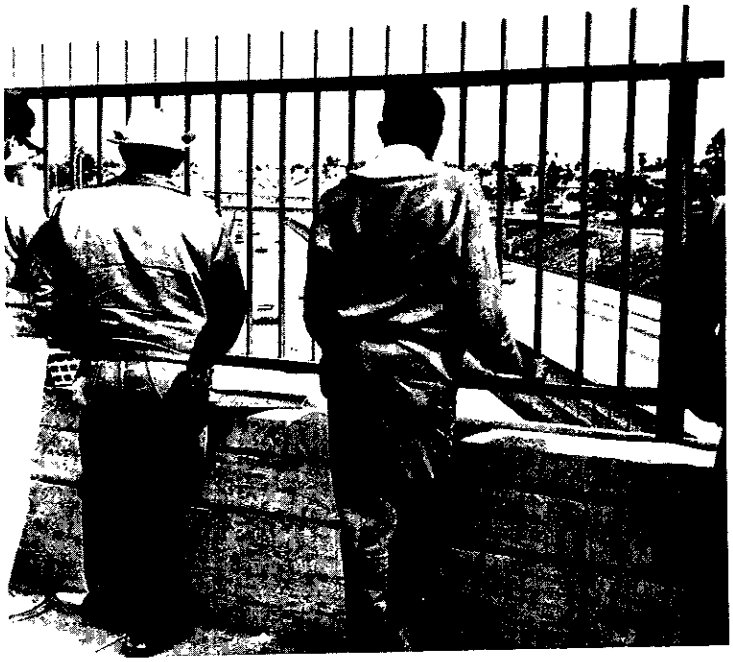
EXHIBIT 6



Test Site



Manual Count from Overcrossing

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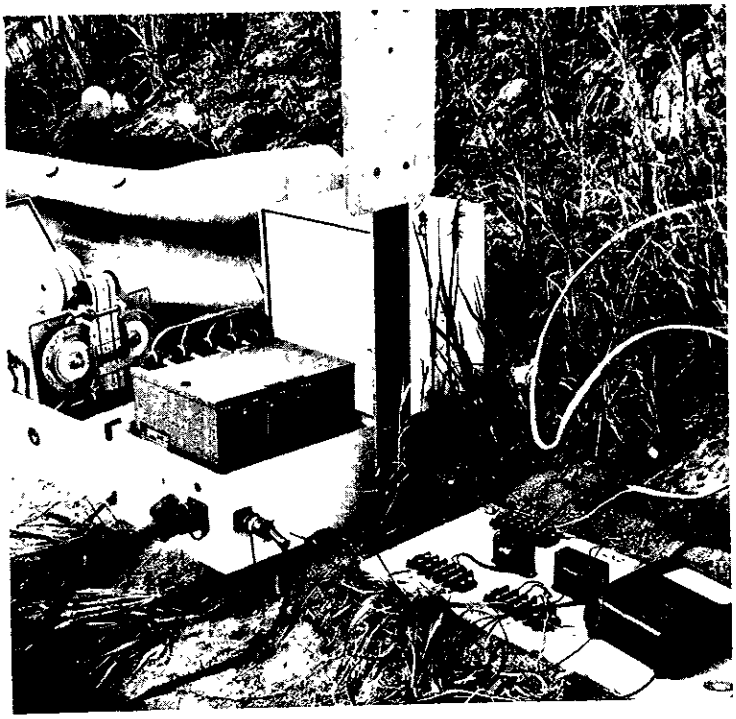
Power Pole on R/W
Stepdown Transformer on Pole



Equipment during Test

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ACCESSORY EQUIPMENT USED ON TEST

1000 ft.	Type "UF" underground cable No. 10 wire, 2 conductor	$ 85.00
1 each	Triad F-40X Fil. Transformer 26.8 1 amp.	3.40
1 each	Triad F-45X Fil. Transformer 24.0 1 amp.	3.40
2 each	Cannon MS3106A 28-20S Plugs Approx.	$3.71 ea.
2 each	MS3106A 28-20P " "	3.42 ea.
2 each	MS3102A 28-20P Recep. "	2.22 ea.
2 each	MS3102A 28-20S " "	2.51 ea.
4 each	MS3106A 18-12P Plugs "	1.59 ea.
4 each	MS3102A 18-12S Recep. "	1.13 ea.
4 each	MS25043-28C Dust Caps "	1.80 ea.
4 each	MS25043-18C " " "	1.11 ea.
4 each	MS3057-16A Cable Clamp " with telescoping bushing	0.92 ea.
4 each	MS3057-10A Cable Clamp w/telescoping bushing	0.71 ea.

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EQUIPMENT COSTS

	No. of Lanes	With Power Supply	Without Power Supply
RCA Ve-Det	1	$ 385	$ 302
	2	736	636
	3	988	888
	4	1240	1140
F-P Summator 55CP1010	2	285	
	3	300	
	4	315	
	5	330	
	6	345	
F-P Case		50	
"G" Cabinet		300	
"M" Cabinet		600	
"R" Cabinet		800	
F-P Portable Counter		650	
F-P AC Counter		590	
Streeter Amet RC		410	
Streeter Amet Jr. (Transistorized)		65	
F-P Tacdet (1-9 units)	1	230	
14 April 1965	2	375	
	3	510	
	4	645	

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