VARIABLE MESSAGE FOG HAZARD WARNING SIGNS TO CONTROL VEHICLE OPERATING CHARACTERISTICS

OREGON HPR-1(6) - Interim Report
Interstate 5 - North Albany

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OREGON DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY DIVISION

Traffic Engineering Section
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Prepared in Cooperation With
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Federal Highway Administration

A B S T R A C T

OREGON FOG HAZARD STUDY

RESEARCH AGENCY:

Oregon State Department of Transportation
State Highway Division

In Cooperation With

U. S. Department of Transportation
Federal Highway Administration

This project is aimed at determining the effectiveness of variable message signs in controlling traffic on an Interstate highway during periods of hazardous driving conditions such as fog, vehicle accidents, or congestion.

The effectiveness of the signs is being measured quantitatively by use of accident records, vehicular speeds, and headways. Insufficient data preclude drawing quantitative conclusions; however, based on data available, interviews with the State Police, and visual observation of vehicular operations, it appears that the signs are effective in controlling traffic operations and thereby preventing accidents during periods of reduced visibility due to fog.

ILLUSTRATIONS AND PHOTOGRAPHS

SUMMARY

The warning sign system was completed on November 15, 1968. It has been used by the Oregon State Police for a variety of reduced visibility driving conditions and for various emergency road conditions. The signs have been activated during periods of dense local fog, during a hail storm, during a severe snow storm, during periods of heavy smoke caused by field burning in the area, during icy periods, during a period of construction on the highway, and during periods after vehicle accidents. The signs have also been activated during periods of generalized area fog when the entire Willamette Valley from Portland to Eugene was experiencing fog conditions.

The research project associated with the warning signs has not yet been completed and the amount of data accumulated is not statistically significant; consequently, no quantitative conclusions may be made concerning the effectiveness of the signs in altering vehicle operating characteristics. However, early indications are that the vehicular stream does in fact very closely observe the indicated speeds shown on the variable message sign. Time headways between the vehicles in specified speed ranges also indicate that the drivers not only are obeying indicated speeds, but are also driving in a safe manner.

The accident experience since November 15, 1968, has been extremely favorable. There have been no chain-reaction type collisions occurring, or any other serious type of motor vehicle accidents during the periods of limited visibility when the signs have been in use. The only accident which might at least partially

be attributed to fog was one which occurred on December 18, 1970. Fog signs were on at the time, and visibility had dropped to 300'-600', but the main cause of the accident was listed as ice as well as freezing fog.

The Oregon State Police, through mutual agreement with the Highway Division, are regulating the use of the signs on a very strict basis. They are used only when warranted by weather conditions or other abnormal conditions. As a result, State Police reports indicate that driver observance of the signs is very good. During periods of generalized Willamette Valley fog, police reports indicate that the speeds shown on the signs in this section are still being observed by vehicle operators many miles beyond the signed section. Verbal reports from the local patrol officers indicate a surprising amount of driver observance for the signs and also an increase in reliance on the part of the State Police to use the signing system as an important supporting system for their reduced visibility patrol activities. State Police also indicate that one less patrolman is needed in the signed section when the signs are in operation.

INTRODUCTION

Restricted driver visibility due to fog and its relationship to safe traffic operation, particularly on high speed freeways, has been a national concern. Changes must be made in vehicular operating characteristics to maintain safe traffic operations. This is also true for periods of emergency conditions involving other severe weather conditions or vehicular accidents.

This problem was illustrated dramatically in March, 1968, by a severe series of chain-reaction collisions on Interstate 5 near Albany, which involved 44 vehicles.

After a thorough study of all traffic data and as a result of reviewing the small amount of research which had been done pertaining to traffic operations in fog, variable message warning signs were installed. This research project to determine the effectiveness of the signs is being conducted in conjunction with the operation of the signs.

STUDY LOCATION

The North Albany section of Interstate 5 extends from the Conners Road Interchange (M.P. 239.67) to the Santiam Highway Interchange (M.P. 233.23). This section of freeway consists of a four-lane, divided highway. The two northbound lanes are of asphaltic concrete from the North Albany Interchange to the north end of the section. The two southbound lanes and the remainder of the northbound lanes are Portland Cement concrete. The median varies from 50 to 80 feet in width, with no median guardrail except on bridge approaches and at other obstructions. There are eight interchanges in this section. The entire length is speed zoned for 70 MPH (60 MPH for trucks).

The North Albany section of Interstate 5 is located in an area that was geographically a portion of an old river drainage system. The old drainage system and the surrounding territory acting in conjunction with historical weather patterns make the six-mile section of Interstate 5 extremely susceptible to radiation type of fog during certain periods of the year. Radiation fog occurs when moist air contacts the earth's surface and, due to cooling, is condensed to form fog. The conditions conducive to this type of fog are as follows:

1. A long, clear night which allows the heat stored in the earth during the day to radiate away.
2. A considerable amount of moisture in the air (humidity of 80% or more). Fog produced at humidities of 80 to

90% is particularly dense and dry and consists of a number of very fine particles. 1/

3. A light wind of about three to six miles per hour.
4. A type of terrain which permits a collection of air such as a valley depression.
5. A sufficient amount of nuclei in the air on which fog can form. This condition exists at almost any time in the mid-Willamette Valley.
6. The difference between the dew point and the temperature of the air of not more than 4°F. The dew point is defined as the temperature at which air becomes saturated when cooled under constant pressure and with constant water-vapor content. 2/

A Western Kraft Corporation paper mill is located adjacent to the freeway at the Millersburg Interchange. Whether or not the effluents discharged into the air by the mill initiate or are conducive to additional periods of fog is a point at issue on which local physicists and meteorologists have not agreed.

1/ Edited by Thomas F. Malone, "Compendium of Meteorology," page 1179, American Meteorology Society, Boston, Massachusetts, 1951.

2/ R. K. Linsley, Jr., M. A. Kohler, J. L. H. Paulus, "Hydrology and Engineers," Page 16, McGraw-Hill, 1958.

DISCUSSION

Following the March 1968 accident, operating conditions on the North Albany portion of the freeway were investigated, as well as possible corrective measures. A detailed analysis of accidents occurring in this section as to type, location and relationship to design features and weather conditions was made. The fog-related accident history in the six years preceding the installation of the warning sign system consisted of a total of 13 accidents involving 127 vehicles. There were seven fatalities and 73 injuries. Accident records indicated that during periods of reduced visibility due to fog, this section of freeway was experiencing almost the same number of accidents as the remaining 300-mile section of Interstate 5 in Oregon.

In 1966, orange diamond-shaped warning signs were installed in the area on an experimental basis. These signs were installed with battery-operated flashing lights fixed to the top of the post. With the onset of fog, they could be manually turned to face approaching traffic. This increased the work load of already busy State Policemen. Fog duty required the activation of the signs, patrolling in an attempt to warn or aid, and the apprehension of violators. Despite attempts to warn motorists and control speed, the results were discouraging. From eight to ten police cars were needed to hold speeds to a tolerable level within the fog bank. As a result of the failure of these attempts to modify traffic operations, and due to the unusually severe accident history, this section of Interstate 5 was

selected for installation of a fog warning system. After a review of all reduced visibility work on a national basis was made, an Oregon design was developed for a variable message fog warning sign system.

PROCEDURE

The six fog warning signs for the North Albany section of Interstate 5 were conceived and designed by the Traffic Engineering Section of the Oregon State Highway Division. Each sign consists of a seven-foot by 32½-foot variable message panel, mounted over the center of each roadway. The signs contain two 12-inch yellow flashing beacons and the word "SLOW" in three-foot high letters. They also include the words: "WRECK", "FOG" and "SPEED" in letters 1½ feet high with speeds of 10 to 50 MPH in 10 MPH increments. All letters and numerals are formed with 10 mm. high-intensity red neon tubing. The "SLOW" message comes on whenever the sign is activated. The legend "FOG" or "WRECK" and "SPEED" with a numerical indication are chosen. The activation of the signs, the legend used, and the speed used are based on the judgement of the patrol officer on the section of freeway involved. The decision is generally based on visual estimates of existing visibility distance, although sometimes it is based solely on the patrol officer's judgement. Normally, there is a State Police patrol on this section of freeway 24 hours per day.

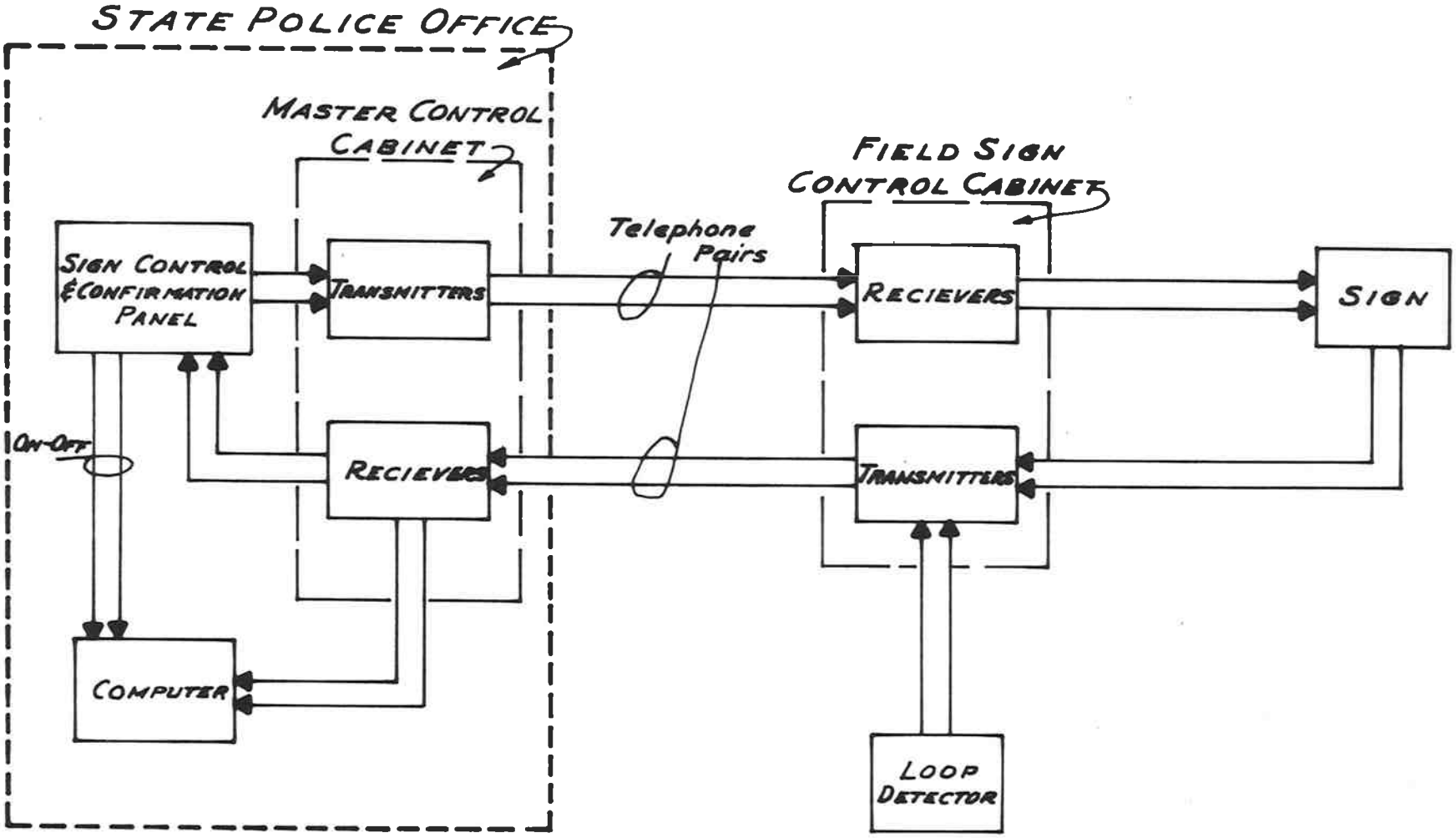
The necessity for rapid sign activation resulted in the use of a remote telemetered control for the signs from the Albany office of the State Police. Twenty-four hour radio contact between the police mobile units on the freeway and the Albany Office is used as an early warning system on which decisions are based to activate the signs if there are indications of a dense fog or other hazardous conditions. Activation of the signs

may also be initiated by flipping toggle switches in the doors of the field cabinets which are located near the signs.

A relatively simple panel controls the signs. The control panel actuates transmitters in the master control cabinet. The transmitter emits a tone via a voice-grade telephone line to a receiver which keys the switch that turns on the signs. Functions on each sign are controlled in the same manner. This switch in turn keys a return transmitter to a receiver back in the master controller which activates a confirmation light in the control panel to show that the function initiated at the panel is working in the field. Figure 1 illustrates the system with an equipment block diagram.

The placement and number of signs were determined following an analysis of accidents of the chain-reaction type and of fog conditions throughout the section. Figure 2 shows accident locations and corresponding temperature ranges for fog related accidents in this section from 1961 through 1968. The analysis considered temperature range during the days of occurrence, humidity and weather conditions as far as was practicable from past Weather Bureau records, plus data from the adjacent Albany Airport weather office. These records indicated the most critical area to be about a 6.5 mile long section, which in turn was considered the logical location for signing.

The section showing the highest concentration of accidents required about one sign per one and one-half miles of roadway. It was decided that three signs should be sufficient for each

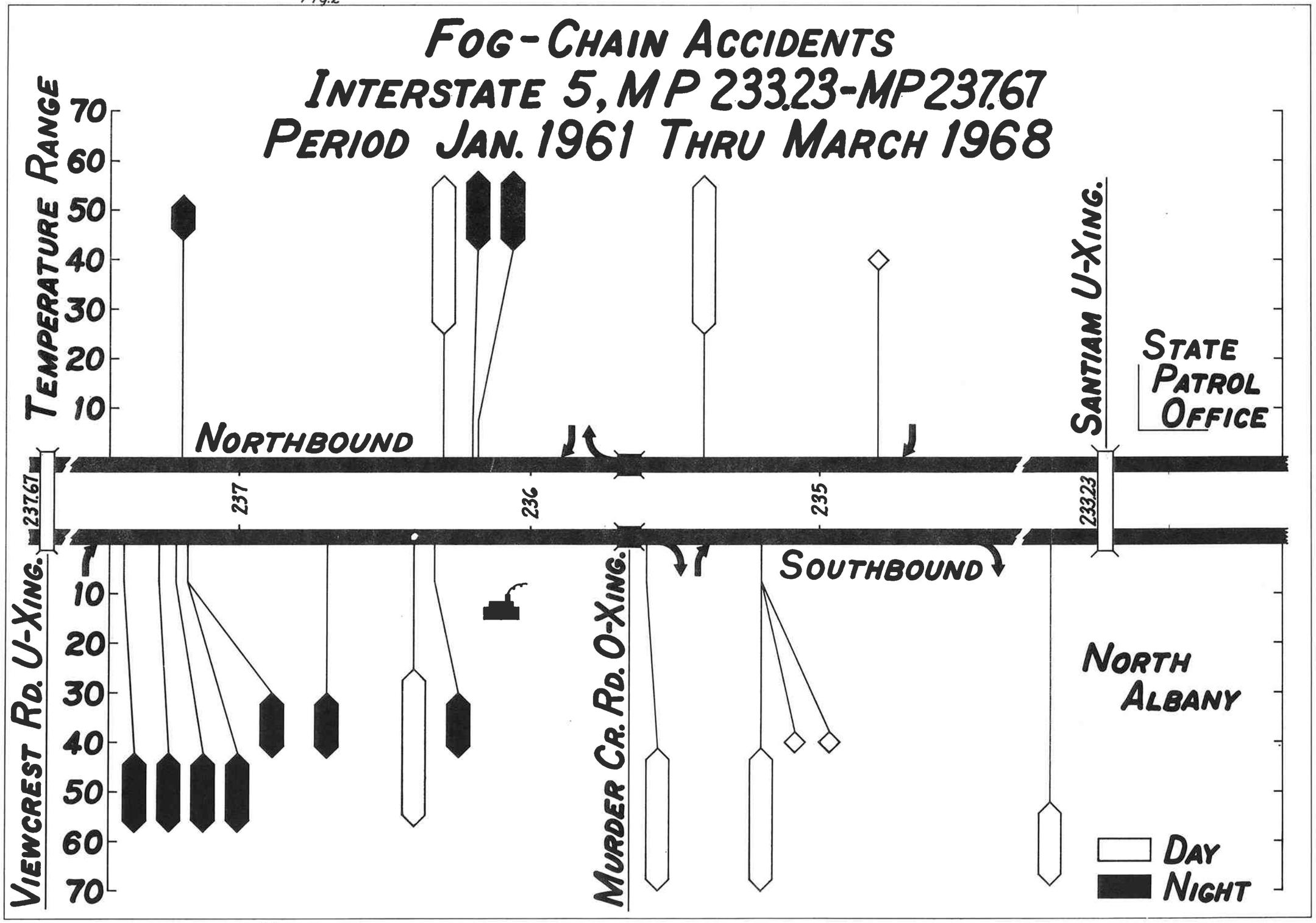


EQUIPMENT BLOCK DIAGRAM

Figure 1

Fig.2

FOG-CHAIN ACCIDENTS
INTERSTATE 5, MP 233.23-MP 237.67
PERIOD JAN. 1961 THRU MARCH 1968



direction if the first one was located somewhere near the beginning of the section, and the third one was located near the center of the section (in the proximity of the Millersburg Interchange). One intermediate sign location for each direction was chosen near points of greatest accident occurrence. These signs are shown with various posted speeds and messages in Figures 3 through 8.

The first northbound sign (Figure 3) is mounted on the Santiam Highway Interchange overpass. The next two northbound signs are mounted on sign bridges 3500 feet north of the North Albany Interchange (Figure 4) and 2000 feet north of the Millersburg Interchange (Figure 5).

The first two southbound signs are mounted on the Conners Road Interchange overpass (Figure 6) and the Viewcrest Interchange overpass (Figure 7). The third sign is located on a sign bridge 4000 feet north of the Millersburg Interchange (Figure 8).

The fog warning sign system was built and installed under a Federal-Aid Interstate contract. The total cost was $151,000.

To measure the effect of the warning signs on vehicle operating characteristics, a research program was developed to operate concurrently with the first years of installation. This program is designed to measure parameters that are considered to be indications of traffic flow characteristics. These parameters are volume, speed, and headway distribution.

Vehicle induction loop detectors were installed to monitor the traffic stream. At each detector location each traffic lane has two loops spaced eight feet apart along the lane, thus enabling

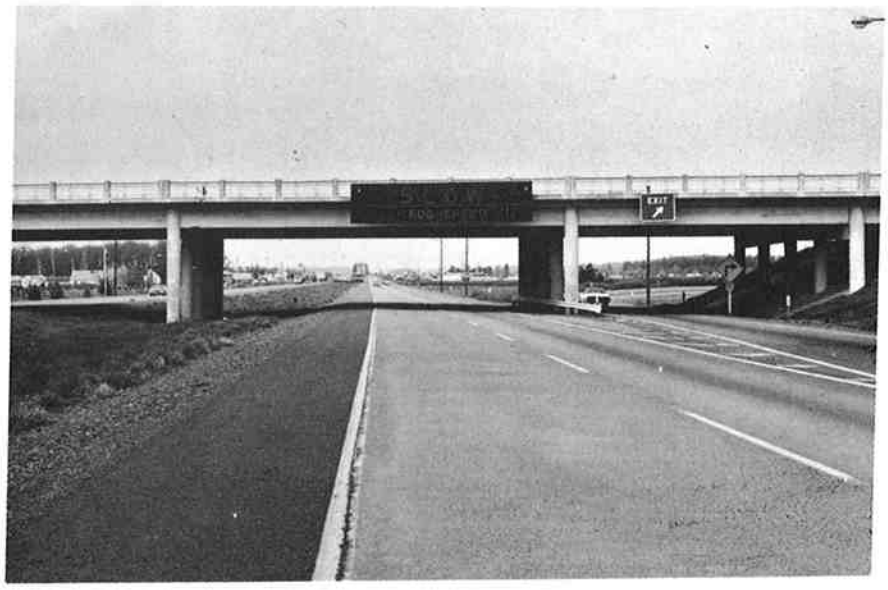


Figure 3
Northbound at the Santiam Highway Interchange

Figure 4
Northbound north of the North Albany Interchange

Figure 5
Northbound north of the Millersburg Interchange

Figure 6
Southbound at the Conners Road Interchange

Figure 7
Southbound at the Viewcrest Interchange

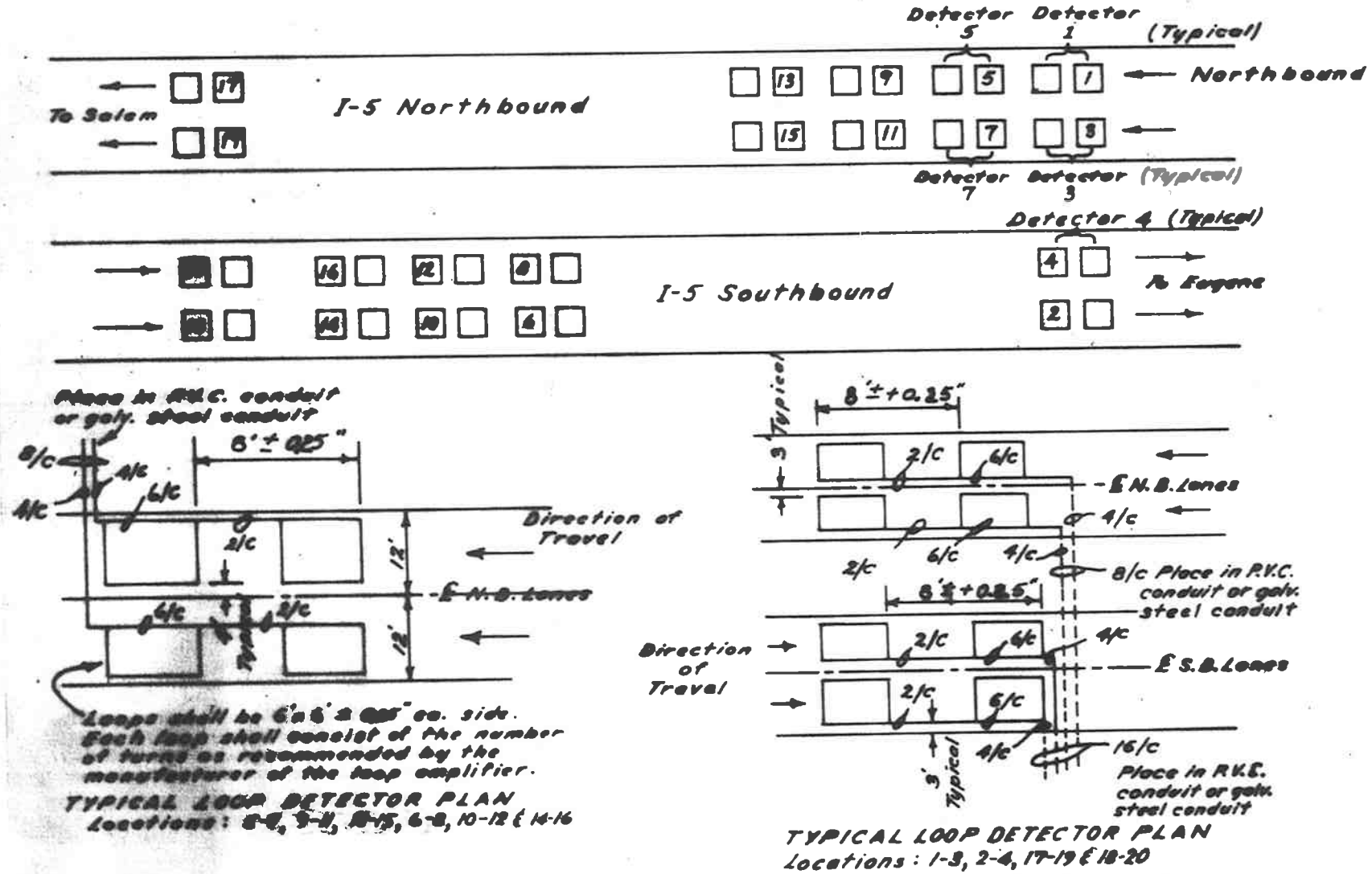
Figure 8
Southbound at the Kraft plant

the detector to measure the speed of each vehicle passing over it (see Figure 9).

Two loops in each of two traffic lanes results in a total of four loops at each detector location. There are ten detector locations, five for each direction of flow (see Figure 10). Six of the data stations correspond to the six signs with the other four stations monitoring flow in advance of and beyond the signed section. Two of these four stations are located south of the Talbot Road Interchange, one station for each direction of travel. The other two stations are the Grand Prairie Road crossing.

All detector locations relay the gathered information back to a central recording station located at the State Police office at Albany. At this point, the data is fed into a digital computer, which calculates the speed of the vehicles and the headways between vehicles. A high speed teletypewriter then prints out the data arranged in 10 MPH speed ranges and one-second headway increments. (Figures 11 through 16 show typical views of a field cabinet, the master control panel, computer, and teletypewriter. Figure 17 is a typical printout from the teletypewriter.) The total cost of the detectors and data processing equipment was $112,740, which was allocated from Federal Highway Planning and Research Fund.

There have been a number of problems with the data collection system, most of which have involved maintenance or minor adjustments, and they have been solved without too much trouble. However, two major problems still confront the system. These involve the computer and the loop amplifiers.



LOCATION & IDENTIFICATION OF LOOP VEHICLE DETECTORS

Figure 9

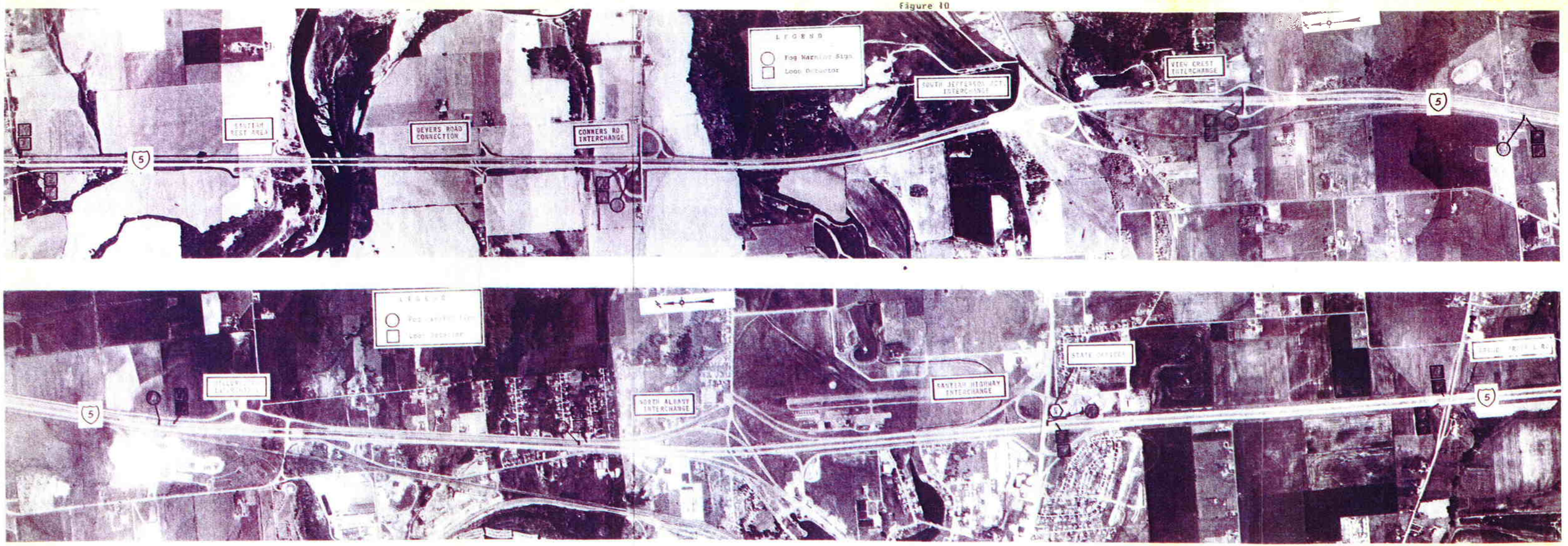

LEGEND
Fog Warning Sign
Loop Detector
SOUTHBOUND REST AREA
DEVERS ROAD CONNECTION
CONNERS RD. INTERCHANGE
SOUTH JEFFERSON JCT. INTERCHANGE
VIEW CREST INTERCHANGE
5
NORTH ALBANY INTERCHANGE
SANTIAM HIGHWAY INTERCHANGE
STATE OFFICES

Figure 11
Field cabinet - typical outside view

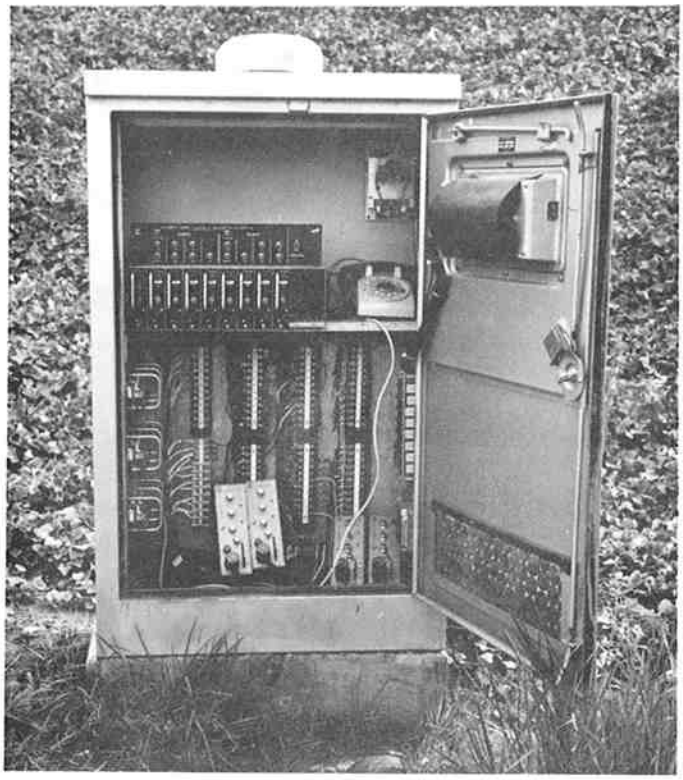


Figure 12
Field cabinet - typical inside view

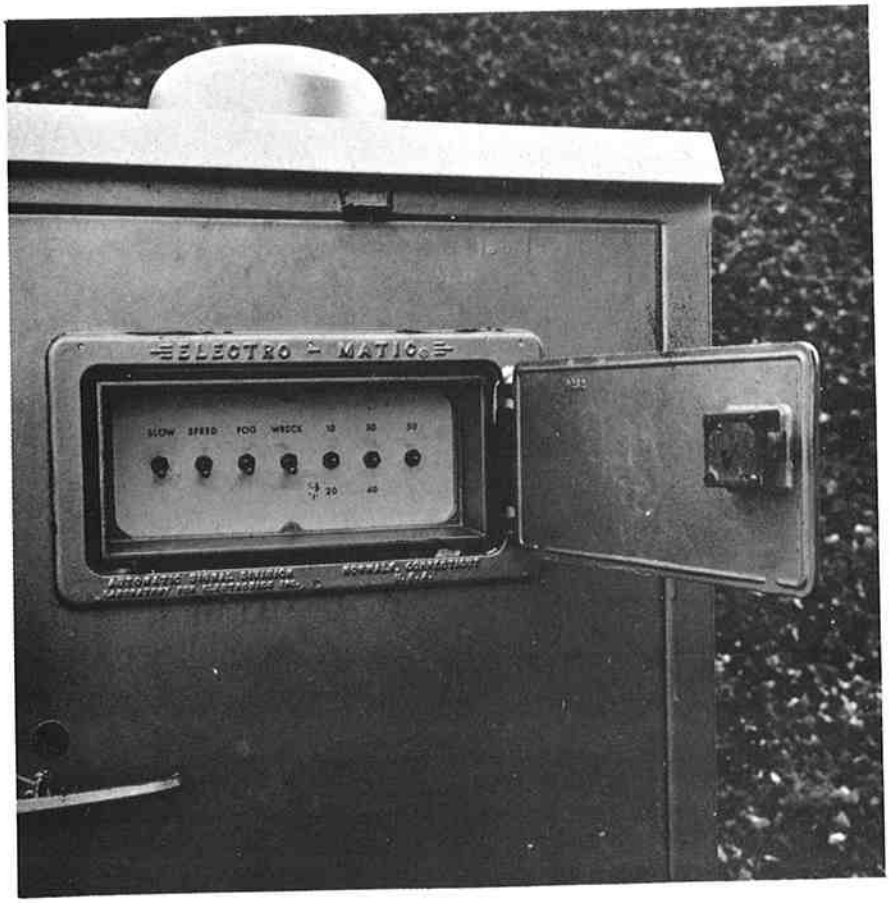


Figure 13
Field cabinet - typical view of sign control panel

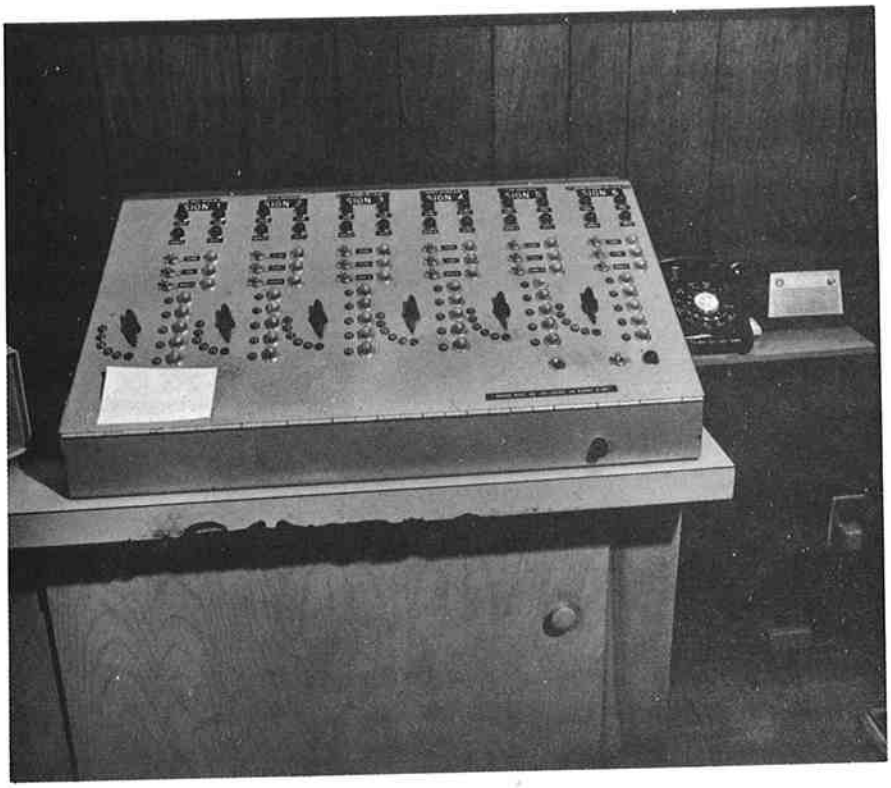


Figure 14
Master control panel for signs in State Police Office, Albany

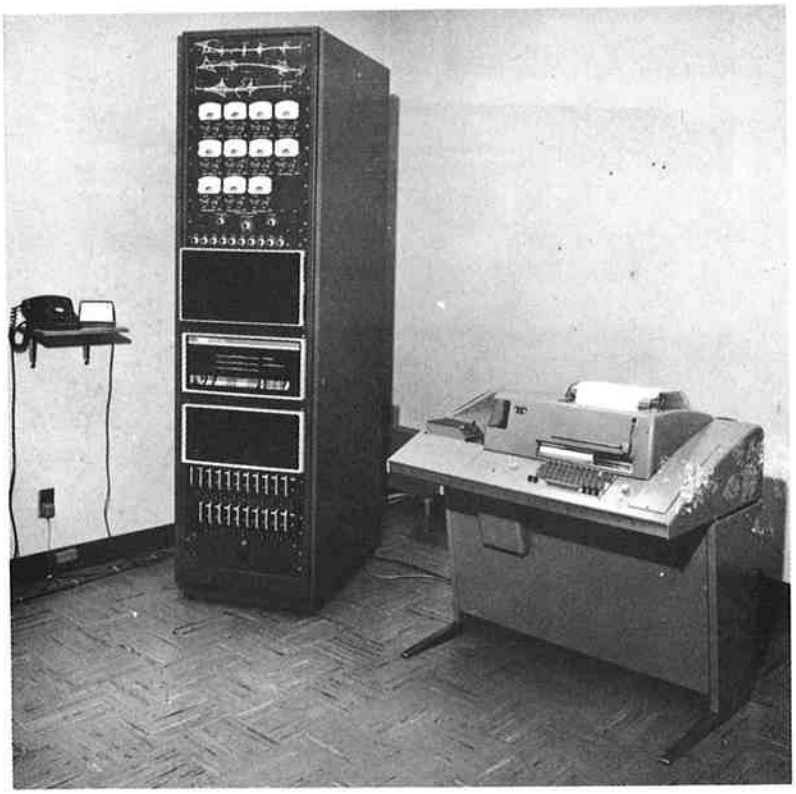


Figure 15
Telephone, computer, and teletypewriter at Albany

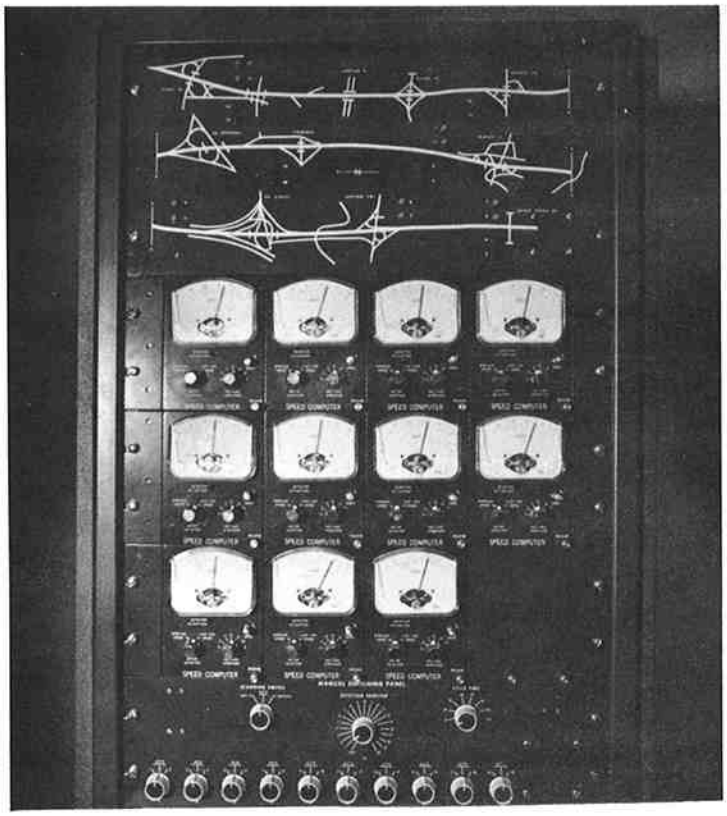


Figure 16
Computer panel showing controls and indicator dials

Figure 17

11: 48: 00 PM 12/ [redacted]

[redacted] HEADWAY REPORT
INTERVAL 0015
DETECTOR 0012

HEADWAY		----SPEED IN MPH---- 20	30	40	50	60	70	70+	TOTAL
00	01	0000	0000	0000	0000	0000	0000	0000	0000
00	02	0000	0000	0000	0000	0000	0000	0000	0000
00	03	0000	0000	0000	0000	0000	0000	0000	0000
00	04	0000	0000	0000	0001	0001	0000	0000	0002
00	05	0000	0000	0001	0001	0000	0000	0000	0002
00	06	0000	0000	0000	0000	0000	0000	0000	0000
00	07	0000	0000	0000	0000	0000	0000	0000	0000
00	08	0000	0000	0000	0001	0000	0000	0000	0001
00	09	0000	0000	0000	0000	0000	0000	0000	0000
00	10	0000	0000	0000	0000	0000	0000	0000	0000
TOTAL		0000	0000	0001	0003	0001	0000	0000	0005

11: 48: 00 PM 12/ 23/ 70
SPEED HEADWAY REPORT
INTERVAL 0015
DETECTOR 0014

HEADWAY		----SPEED IN MPH---- 20	30	40	50	60	70	70+	TOTAL
00	01	0000	0000	0000	0000	0000	0000	0000	0000
00	02	0000	0000	0002	0001	0000	0000	0000	0003
00	03	0000	0000	0002	0003	0000	0000	0000	0005
00	04	0000	0000	0003	0001	0000	0000	0000	0004
00	05	0000	0000	0001	0003	0000	0000	0000	0004
00	06	0000	0000	0000	0001	0001	0000	0000	0002
00	07	0000	0000	0001	0001	0000	0000	0000	0002
00	08	0000	0000	0001	0000	0000	0000	0000	0001
00	09	0000	0000	0000	0002	0000	0000	0000	0002
00	10	0000	0000	0000	0001	0000	0000	0000	0001
TOTAL		0000	0000	0010	0013	0001	0000	0000	0024

The computer itself appears to be functioning normally, but there have been several instances of disk failures. Stabilization of the power supply may also be a problem.

The loop amplifiers have caused many continuing problems. It appeared that part of the problem was inherent in the equipment design so the manufacturers were contacted. To eliminate ballistic errors in pulse width transmission to the computer amplifier, output stages were redesigned from electro mechanical to a solid state type of output. This has partially corrected the data gathering problem. Ease of periodic calibration of each data gathering station still remains to be solved. As of this time a proposal to correct this problem has not been finalized.

There is also a separate research project underway involving a backscatter device for measuring visibility in fog. The possibility of using this device to automatically actuate the fog warning sign system is being explored.