EVALUATION OF ICE DETECTING SYSTEM

FLINT RIVER BRIDGE

Conducted by the

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EVALUATION OF ICE DETECTING SYSTEMS - FLINT RIVER BRIDGE

The problem of slippery bridge decks caused by ice and frost formation on the supercooled bridge deck, where the remainder of the roadway is either wet or dry, has resulted in numerous accidents throughout the State.

During the past two years, the Traffic Research Section has been evaluating two different ice and frost detecting systems which determine when ice and frost conditions exist on bridge decks. The site chosen for this evaluation was the bridge over the Flint River on I-75 west of the city of Flint. The reasons for choosing this location were twofold. First, the number of accidents caused by slippery bridge decks due to icy or frosty conditions was higher in comparison to other sites which were considered, and, second, the site was within a reasonable driving distance for servicing, installing and maintaining the equipment necessary to carry out the evaluation.

The approaches used to evaluate the effectiveness and reliability of the detection systems were:

1. To compare "surface condition" on accident report records, for accidents at the study site during the seasons when frost and ice conditions could be expected to occur, with detection system output.
2. To compare official weather bureau data with recorded information regarding humidity, temperature and precipitation during the time system was operating.

3. Personal observations at the location when ice and frost conditions existed.
4. Simulation of icing conditions by applying water to the deck probes when conditions for ice formation, if precipitation were present, were ideal.

In addition to the above methods of analysis, the manufacturer of one of the detectors used a "cold room" where weather conditions could be simulated to test their detector. Extensive tests of their equipment in this "cold room" prior to installation in the field, indicated that the system output from their device occurred at the predetermined values assigned to the logic within the system for ice and frost formation at $32^{o}F$.

Discussion of Method of Evaluating Effectiveness and Reliability of Detecting Systems

The first method used to study these systems was to use accident reports from the state police for accidents at the study site. In this method, accident data for the period after the detectors were installed and detector output recorded was analyzed and a determination made as to the relationship of each accident to icy or frosty deck conditions. Accidents which occurred off the structure which were caused by an accident on the structure due to icy conditions were included in the list of those accidents caused by icy bridge decks.

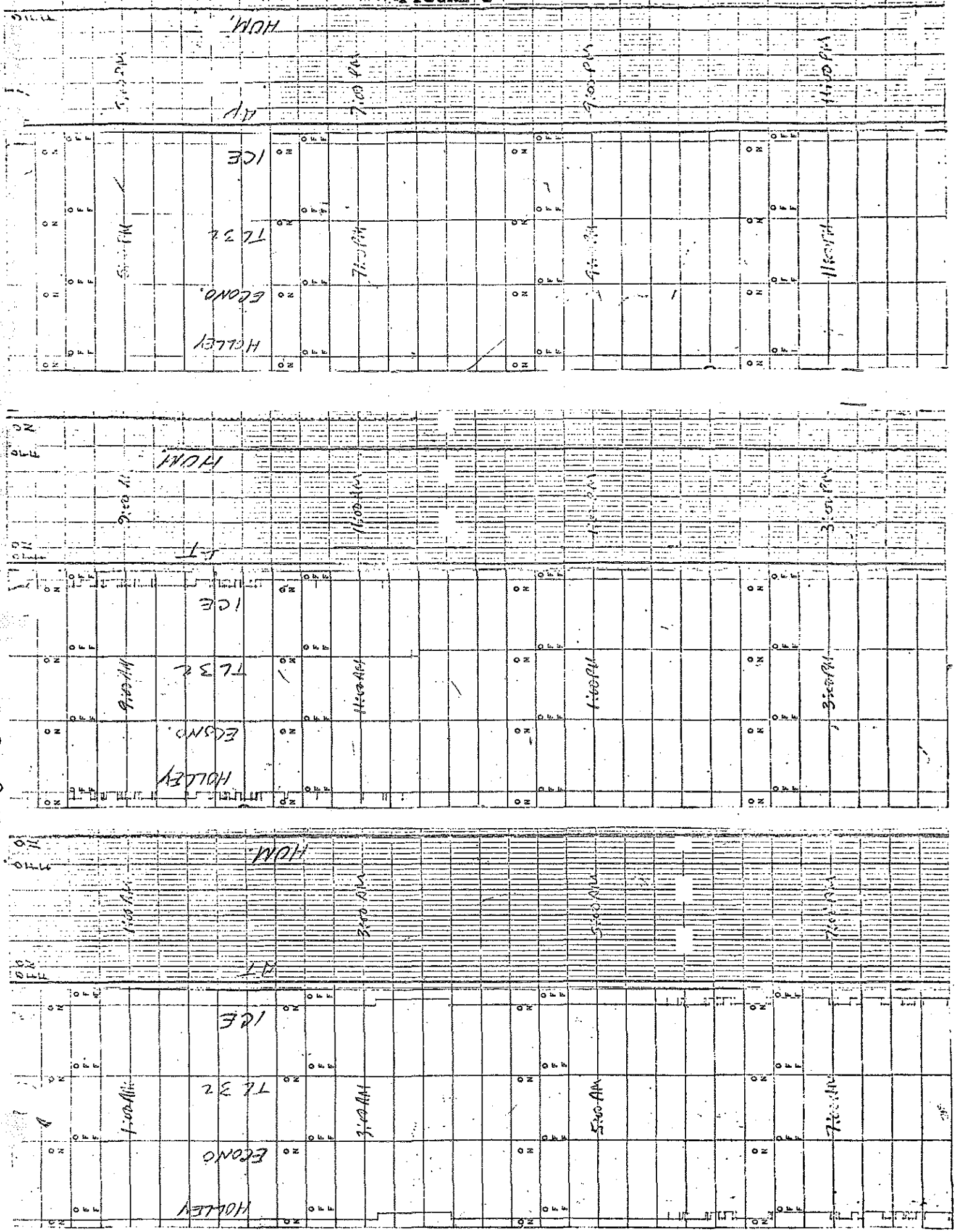
The listing of accidents in Table 1 shows there were 9 accidents caused by icy or frosty bridge decks after November 15, 1965. Recorder output for this period indicated that system #1 detected

that snowy or icy condition existed for 7 out of the 9 accidents. System #2 didn't indicate icy conditions during any of these periods. There were instances where an accident happened on the northbound bridge due to ice or frosty and the system didn't indicate icy conditions as having existed. This is due to the fact that the deck probes are mounted in the southbound roadway only. There were also instances when icy conditions caused accidents on the southbound bridge but the detectors didn't sense the icy conditions. This could be due to the fact that there is only one small area of the total deck surface covered by the sensor. This problem can be overcome by installing other sensors at various locations in the bridge deck. The logic unit used can accept up to 12 different deck sensors so that adding more deck sensors will not be a problem.

The second method used to evaluate these systems was to compare the weather bureau data from the U. S. Weather Bureau at the Bishop Airport 4 miles away to the recorded weather information at the Flint River Bridge. This output was recorded on Rustrak event recorders. An example of this tape is shown in Figure 1. This tape was for the weather on 2-3-66. Figure 2 is a plot of weather data from the U. S. Weather Bureau for the same day.* The weather data compares very favorably between the two sites. The only difference which was noted in the weather data is that regarding humidity. The relative humidity at the river appears to range about 8% above that recorded at the weather bureau. There were days, however, when the humidity at the bridge exceeded that at the weather bureau by 20-25%. This was particularly noticeable

*A complete set of tape and weather bureau plots are available from Traffic Research for the period November 15, 1965 to May 15, 1966.

FIGURE 1



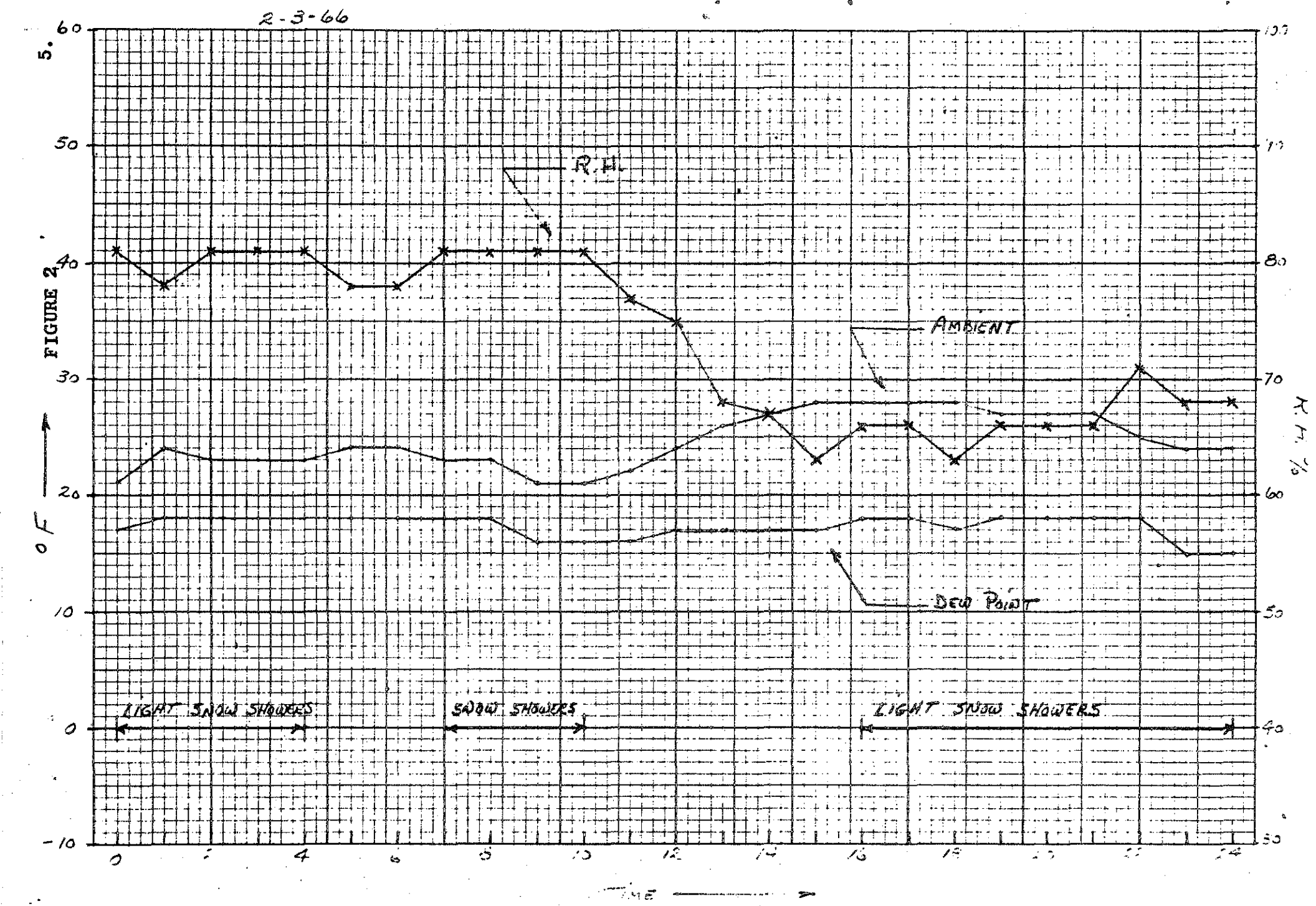


FIGURE 2.

on extremely cold days. This would indicate that moisture, which is at a warmer temperature than the air, leaves the surface of a body of water faster on a cold day. This case can be shown theoretically. The measurements of humidity at the bridge equalled those for the airport during the time the river was completely frozen over.

The third method used to evaluate the detecting systems was personal observations by personnel from the Research Section and from the suppliers of the detectors. This occurred on a number of occasions. There were, when personal observations were made, two instances when system #1 was activated by an accumulation of packed snow on the deck sensors. On one of these occasions, salt was applied by Genesee County as part of routine maintenance, and as the snow melted, the detectors indicated that the bridge deck was wet, but that icy conditions no longer existed. This is an indication of the ability of the sensors to determine saline conditions.

The fourth and final field method of evaluating the detectors was to apply a small amount of moisture to the deck sensors when the temperature of the deck was below $32^{o}F$. This was done repeatedly on a number of occasions. Each time moisture was applied, the units indicated that icy conditions existed. This method gave a quick way of determining the ability of the sensing probes to detect icy conditions. After each application of water, the ice was removed from the sensors and the detector no longer indicated icy. Both detector systems indicated ice when tested in this manner; however, this, with the exception of a few other instances, was the only time system #2 activated.

Summary

In reviewing all information about the system, it appears that system #1 is very effective in determining when icy or frost conditions occur. To date, the reliability of this system has been 100%.

System #2 appears to need re-adjustment (something which has been done once) before any reliable data can be obtained. System #2, based upon the data to date, has not performed as well as had been expected. Continued evaluation of this sytem in the fall will determine whether future use of this system will be given any consideration. At the present time, system #1 seems to be functioning extremely well. The two systems will remain in operation for experimentation at this location throughout the next year to determine whether a reduction in the number of accidents caused by icy bridge decks can be reduced through the use of warning signs which were installed on 2-10-66 and were in final operation on 3-4-66. These signs are activated by the output from system #1. This information will be included in a final report on the subject.

APPENDIX

Background Information for Tables

The accident record for this location for the period 1963, 1964, 1965 and the first part of 1966 are included in Table 1. All accidents after the November 15, 1966 date which occurred when the bridge deck was icy or frosty are shown in Table 2. There were times after November 15, 1965 that the recorder was not in operation due to system repair and modification.

A brief summary of Table 1 shows that a total of 64 accidents have occurred at this location in the past $3\frac{1}{2}$ years. Of these total accidents, icy or frosty bridge conditions accounted for 40 of the accidents.

System #1 - Holley Carburetor Unit (See Figure #3)

The manner in which this system activates is as follows: Deck temperature, ambient temperature, humidity and precipitation are monitored constantly by various probes and sensing devices. The output from the probes, either in the form of conductance or resistance, is transformed into logic within the system (NOR logic which acts in an either-or manner) and when certain inputs are realized, a relay is closed indicating that ice or frost conditions exist. The values of resistance or conductance for each of the conditions which must be satisfied are those simulated for deck temperature of 32^{o}, humidity of 75% and a difference between deck and ambient temperature of $3.9^{o}F$. These values are those which will cause ice or frost to form at $32^{o}F$. The system will activate when certain two or more of these conditions exist. This system can determine saline conditions and will turn off when they exist.

System #2 - Econolites Kartrol Unit (See Figure 4.)

This system activates in a manner similar to system #1; however, it doesn't have the humidity sensor and cannot determine the presence of frost until there is a substantial accumulation of frost. The ability of this system to detect saline conditions has not been demonstrated as yet.

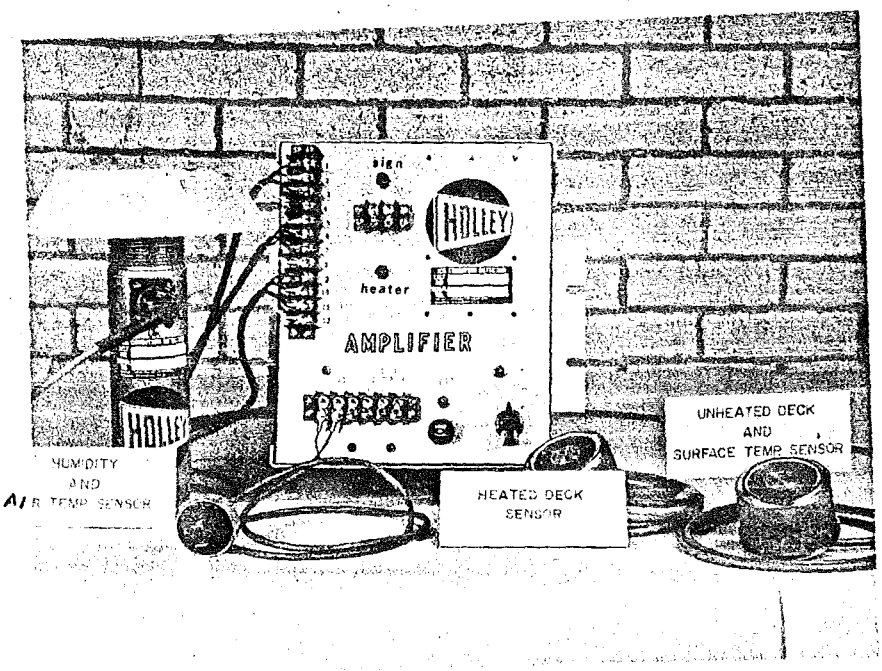


FIGURE 3

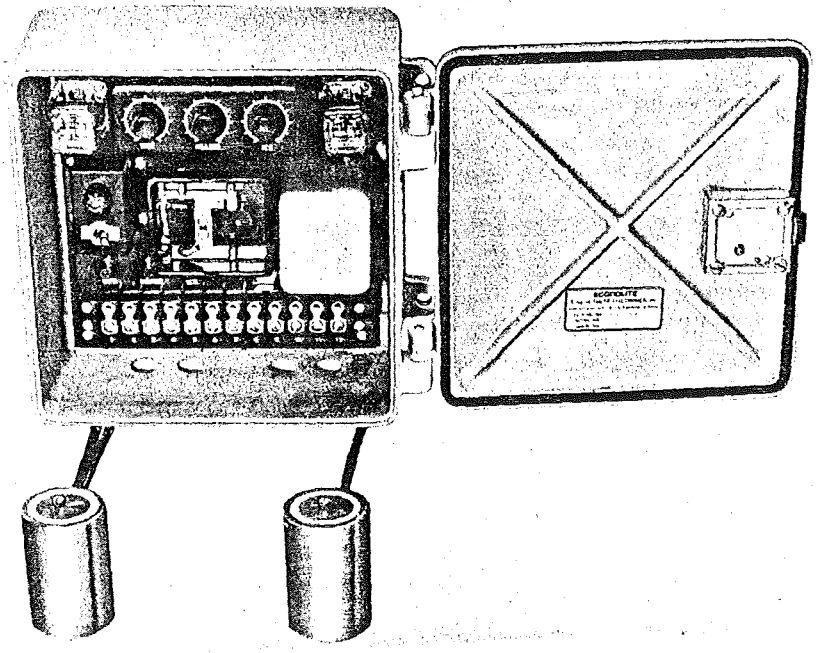


FIGURE 4

TABLE 1

ALL 1963 FLINT RIVER BRIDGE ACCIDENTS

No.	Date	Time	Day	Direction	Roadway Condition
1	1-12	0700	Sat.	North	dry
2	1-20	1200	Sun.	"	icy
3	7-4	2000	Thurs.	"	dry
4	8-13	0000	Tues.	"	wet
5	10-5	1400	Sat.	"	?
6	11-14	0900	Thurs.	"	?
7	12-26	1500	Thurs.	"	wet

TABLE 1 cont'd.

ALL 1964 FLINT RIVER ACCIDENTS

No.	Date	Time	Day	Direction	Roadway Condition
1	2-15	2220	Sat.	North	*S or I
2	2-23	2045	Sun.	"	"
3	3-26	0840	Thurs.	South	"
4	"	0850	"	"	Icy
5	"	0920	"	"	*S or I
6	"	1810	"	"	"
7	3-31	0700	Tues.	"	"
8	3-31	0815	"	North	"
9	"	0820	"	South	"
10	"	"	"	"	"
11	4-9	0600	Thurs.	"	"
12	"	0620	"	"	"
3	"	0645	"	"	"
14	"	0735	"	"	"
15	"	1910	"	"	"
16	6-15	0240	Mon.	"	Wet
17	11-14	0940	Sat.	North	Dry
18	11-20	2314	Thurs.	South	*S or I
19	"	0015	Fri.	"	"
20	"	0020	"	"	"
21	"	0030	"	"	"
22	"	0210	"	"	"
23	"	0240	"	"	"
24	11-21	2225	Sat.	"	"
25	11-22	0930	Sun.	"	"
26	"	1015	"	"	"
27	"	1015	"	"	"

* Snowy or Icy

TABLE 1 cont'd.

ALL 1965 FLINT RIVER ACCIDENTS

No.	Date	Time	Day	Direction	Roadway Condition
1	1-4	0300	Mon.	South	dry
2	1-17	0750	Sun.	"	"
3	1-17	0800	"	"	"
4	1-27	2149	Wed.	"	"
5	2-22	1535	Mon.	"	"
6	2-24	0755	Wed.	North	*S or I
7	2-24	0840	"	"	"
8	2-24	0900	"	"	"
9	2-24	1005	"	"	Wet
10	3-26	0601	Fri.	"	*S or I
11	4-1	1015	Thurs.	"	"
12	6-24	1150	"	"	Dry
13	7-10	0700	Sat.	"	"
14	7-14	1645	Wed.	South	"
15	7-30	2100	Sat.	"	"
16	8-14	2245	"	"	"
17	8-31	1600	Tues.	North	"
18	11-19	1815	Fri.	"	"
19	11-29	0825	Mon.	South	*S or I
20	11-29	0830	"	"	"
21	12-4	0045	Sat.	North	Wet
22	12-5	0110	Sun.	"	*S or I
23	12-5	0120	"	"	"
24	12-25	0230	Sat.	South	"

*Snowy or Icy

TABLE 1 cont'd.

ALL 1966 FLINT RIVER BRIDGE ACCIDENTS

No.	Date	Time	Day	Direction	Roadway Condition
1	1-19	0815	Wed.	North	*S or I
2	1-30	0730	Sun.	North	icy
3	1-30	1049	Sun.	North	icy
4	4-7	0600	Thurs.	South	*S or I
5	4-8	0430	Fri.	North	dry
6	4-16	0315	Sat.	South	dry

*Snowy or icy

TABLE 2

ACCIDENTS CAUSED BY SNOWY OR ICY BRIDGE DECKS
AFTER NOVEMBER 15, 1965

No.	Date 1965	Time	Day	Direction	Roadway Condition
1	11-29	0825	Mon.	South	*S or I
2	11-29	0830	Mon.	South	*S or I
3	12-5	0110	Sun.	North	*S or I
4	12-5	0120	Sun.	North	*S or I
5	12-25	0230	Sat.	South	*S or I
	1966				
6	1-19	0815	Wed.	North	*S or I
7	1-30	0730	Sun.	North	Icy
8	1-30	1049	Sun.	North	Icy
9	4-7	0600	Thurs.	South	*S or I

* Snowy or Icy