FIELD EVALUATION OF SIX-VOLT AND TWELVE-VOLT FLASHERS

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ABSTRACT: Ten types of battery-operated flashers of different voltages (6 and 12), flash rates (60 and 100 per min), and dwells (10, 25, and 50 percent), were observer-tested under night driving conditions. The test included both hazard-warning and delineation situations. Four different light configurations were used in the delineation phase of the study, viz, random flashing, synchronous flashing, sequential flashing, and constant burning. The following general recommendations were an outgrowth of the study: 1. flash rate of hazard warning lights should be increased to 100 flashes per min 2. length of dwell should remain at 25 percent 3. twelve-volt flashers are not recommended for use 4. steady burning lights should be used for delineation.

KEY WORDS: Flashers, traffic control devices, warning lights, batteries, barricades, traffic diversion, hazard markers.

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The subject flashers were evaluated in a field test on October 11, 1966 by obtaining observer preferences for hazard warning lights and lights used for delineation. The results of these preferences indicate that a revision of Department Specifications and current practices should be considered. This report is intended to review the field test, present the results, and discuss indicated specification revisions.

Field testing of flashers was of special interest to the Laboratory because of the HPR study on Lights and Lighting for Hazard Warning and Delineation. Laboratory work had been hampered because an appropriate or meaningful psychophysical observer reaction to flashers was not known. However some knowledge of flashers had been gained and a limited field study was expected to substantiate some of the available information. We had learned that light characteristics should be considered on the basis of at least two different situations: (1) A hazard warning situation in which maximum attention value is most important, and (2) a delineation situation in which the display of information, such as outlining a selected route of travel, is necessary. We also found instrumental methods of evaluating flashing lights and one method proposed measuring "effective intensity." Effective intensity, in this case, was defined as a quantity of light related to human eye response near threshold.

Other information had been obtained from a laboratory comparison of 6- and 12-volt flashers manufactured by the R. E. Dietz Co. and this had been reported on September 1, 1966, by E. A. Finney to C. B. Laird. Data included in the report related the economics of 6- and 12-volt flashers. For example, the useful battery life of a 6-volt flasher was determined to be approximately 418 hours while the useful battery life of a 12-volt flasher was 168 hours. Useful battery life was established as the time required under load to reach 4.5 and 9 volts for 6- and 12-volt flashers, respectively. The report showed that the 6- and 12-volt flashers maintained approximately 1/3 of their original intensity at the end of useful battery life and that the 12-volt flasher produced a flash with approximately three times the intensity of the 6-volt flasher. The information, however, was insufficient to substantiate a recommendation to use 12-volt flashers instead of 6-volt flashers and therefore a field test was recommended to obtain observer reactions. On September 6, 1966 in a memorandum to

C. S. Lundberg, Mr. Laird indicated approval of the study. He also requested D. L. Wickham to represent both Construction divisions and to meet with the Office of Testing and Research for planning purposes. A proposed method of evaluation was prepared on September 16, 1966 and this was transmitted to D. L. Wickham on that date by E. A. Finney. The proposal was discussed and approved on September 27, 1966 by Messrs Wickham, Weinbrauck, Greenman, and Finney. A test area on the new US 127 near the Holt Rd. interchange was considered satisfactory, provided the test could be completed prior to the scheduled roadway opening on October 14, 1966.

Detailed plans were prepared on the basis of obtaining the necessary flashers from rental agencies. The two largest agencies in Michigan, Visi-Flash Inc. of Taylor (agent for Dietz Flashers), and the Michigan Barricade Co. of Kalamazoo were given the opportunity of each furnishing 1/2 the required number of flashers. Both companies were very enthusiastic and considered the test important. They agreed to meet the test date on an emergency basis and to furnish the necessary manpower for installing the flashers.

The test was divided into two phases. In the hazard warning phase, 6-volt and 12-volt flashers with various flash-rate and "on time" characteristics were compared. A comparison between 12-volt flashers was also included in this phase to study flash characteristics of the higher intensity lights. The delineation phase was planned to obtain a comparison of various flash configurations and did not include comparison between 6- and 12-volt lights.

The test was designed to force an observer choice in a very short time interval in order to obtain "first impression" preferences. The personal preference method of evaluation was known to have undesirable limitations but other simple and rapid methods of obtaining meaningful observer responses were not practical at this time.

Twenty observers were used in the study. Ten of the observers served as drivers and the remaining ten were passenger-observers. Driver-observers were necessary to complete the test in one night. Drivers were selected from the Research Laboratory to permit convenient briefing prior to the test concerning driving speed, test route, and coordination between observer cars. All of the observers were licensed drivers, and represented various offices and divisions of the Department; i.e., Maintenance, Construction, Traffic, and the Research Laboratory. Eleven of the observers were in a 30 to 50 year age group and five of the observers ranged in age from 50 to 70 years. The rest of the observers were less than 30 years of age.

The flashers were mounted on commercial flasher barricades and the barricades were placed parallel to the direction of traffic to eliminate effects of various reflective barricade markings. Two barricades, each with a mounted flasher of the same type, were spaced approximately three feet apart as a pair and approximately 12 feet separated each pair to permit vehicle passage between them. Similar pairs were located at three test sites in the area as shown in Figure 1.

Ten types of battery-operated warning flashers were used in the test. The various types are given in Table 1.

TABLE 1
TYPES OF BATTERY-OPERATED
WARNING FLASHERS

Voltage	Flash Rate, flashes per min.	Dwell, percent
6	60	10
6	60	25
6	60	50
6	100	10
6	100	25
6	100	50
12	60	10
12	60	25
12	100	10
12	100	25

Each 12-volt light was compared directly but in random sequence with each 6-volt light for a total of 24 combinations, and each type of 12-volt light was compared in random sequence with the other 12-volt lights for another six combinations. The 30 combinations were expected to be a sufficient number to show that effective intensity would be the most controlling factor for observer choices.

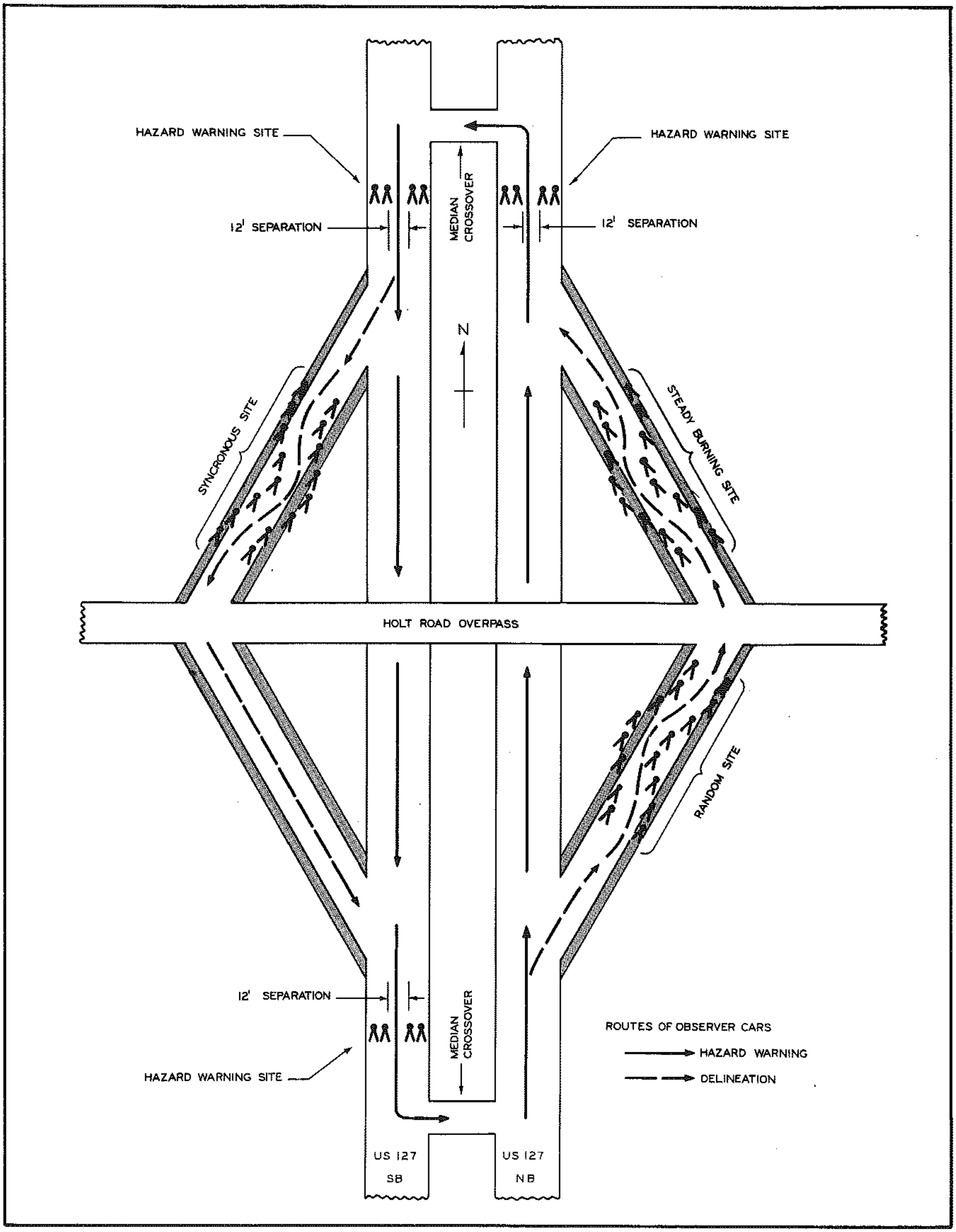

Figure 1. Hazard warning and delineation sites.

Drivers were instructed to proceed through the three test sites at 35 to 40 mph passing between the two pairs of flashers. Sufficient interval was maintained between vehicles to avoid observer distraction from preceding tail lights. The observers were instructed to indicate their preference for the flasher pair at each site that would give the better warning of a serious road hazard. First impressions were desired and therefore observers simply marked their choice in the left or right column of a data sheet corresponding with the chosen left or right pair of flashers.

The test area was in total darkness except for the headlights on the observer cars. Visibility was not affected by haze and there were no distractions from traffic. Data sheets were taken from the observers following the 24 comparisons between 6- and 12-volt flashers and new data sheets were used for the 12-volt flasher comparisons to avoid discussion of selections.

In general the observer data showed that effective intensity was not the only factor affecting observer preferences. Flash rate was a significant factor as well as the peak intensity of the flasher. For purposes of this report, peak intensity can be considered as the maximum intensity or candlepower that a light will achieve during a flash cycle.

Observer data was examined by means of a graph showing the ratio of flash energies or effective intensities as calculated from each flasher comparison, versus the percentage of observer choices for the pair of flashers with the higher energy. This presentation of the data was expected to show that small differences in flash energy between flashers would result in an equal number of observer choices for each pair of flashers, and as the energy difference increased the observer choices would approach a 100-percent choice for the flasher pair with the highest flash energy. The observer choices, however, ranged from 55 percent to 100 percent when the flash energies were equal and from 55 percent to 90 percent when the ratio between flash energies was greater than 6 to 1. From this we concluded that flash energy was not the only factor which controlled observer choices and therefore the data was examined in detail for the effects of other factors. Those factors which characterize light flashers were defined and observer data was tabulated on the basis of each factor and combinations of these factors. These factors are:

1. Flash Energy, i.e., the product of the flash duration in seconds and the average intensity of the flash.

2. Peak Intensity, i.e., the maximum intensity or candlepower achieved by a light during a flash cycle. Peak intensity of flashers in this test was much greater for 12-volt flashers than for 6-volt flashers.

3. Flash Rate, i.e., the number of flashes per minute. Two flash rates were used in this test: 60 and 100.

4. Dwell or Percent on Time, i.e., the percentage of time that a light is on during one complete "on and off" cycle. Three dwells were used in this test: 10, 25, and 50 percent.

5. Flash Duration, i.e., the time in seconds that a light is "on" during each cycle.

The percentage of choices based on the total possible choices was calculated and tabulated for the factors and combinations of factors listed above. For example, each comparison having a pair of flashers with a higher flash energy and higher flash rate than the other pair was considered a possible choice and therefore was tabulated for each observer. In the test there was a total of 120 possible choices involving this energy and rate combination of factors; 99 choices or 82.5 percent of the possible choices favored the higher energy and higher flash rate combination. Table 2 shows the percentage of choices for some of the factors.

The table gives the percentage of choices which favored the factor or combination of factors with the higher value, i.e., longest dwell, highest rate, highest intensity, etc. The chi-squared statistical test was applied to this tabulation of data and the calculation showed that all of the comparisons were significant at the 95-percent level. This means that the observed deviations from 50 percent are considered real and not due to chance alone. This is true both for individual comparisons as well as the experiment as a whole. Peak intensity appears to be the most important single factor affecting observer choices but the factor was not strong enough to influence more than seven out of ten choices. The higher flash rate along with the higher peak intensity of flash energy was a stronger combination and influenced eight out of ten choices. Flash rate, then, appears to have influenced the observers choices and probably explains why flash energy or effective intensity was not the controlling factor as expected. It is significant to note that none of the factors or their combinations had a 90-percent or better influence. This shows that some of the 6-volt flashers at various flash rates and dwells were preferred over 12-volt flashers. In other words, the higher flash intensity of the 12-volt flasher was not high enough to obtain an overwhelming control over observer preferences. The influence of the various flash characteristics was shown in the observer preferences for one of the 12-volt flashers. In this comparison all of the 20 observers preferred a 12-volt, 100 flash per minute, 10-percent dwell light when compared with a 6-volt, 60 flash per minute, 10-percent dwell light. However, when the dwell was increased to 25 and 50 percent on the 6-volt flasher, 1/4 of the observers preferred the 6-volt flasher. When the

TABLE 2

Factors	Percent Favorable Choices	Possible Choices
Peak Intensity	70.2	480
Flash Energy	61.4	580
Flash Rate	60.3	320
Dwell	55.8	400
Duration	51.1	520
Flash Energy & Flash Rate	82.5	120
Peak Intensity & Flash Rate	80.0	120
Peak Intensity & Dwell	77.5	80
Flash Energy & Peak Intensity	72.2	360
Flash Energy & Dwell	63.3	180
Flash Energy & Peak Intensity & Flash Rate	73.3	60
Flash Energy & Rate & Dwell	72.3	40

flash rate of the flasher pairs was equal at 100, and the dwell on the 6-volt flashers was increased to 25 and 50 percent, the observers were almost equally divided in their preferences. A similar comparison with a 12-volt, 100 flash per minute, 25-percent dwell light and the various 6-volt flashers showed that some of the observers preferred the 6-volt flashers, but in this case the 12-volt flasher had an even greater flash energy, and preferences for the 12-volt were slightly greater. When the 12-volt, 100 flash per minute, 10-percent dwell light was compared with the 12-volt, 100 flash per minute, 25-percent dwell light the observers preferred the light with the longer dwell nine out of ten times.

In summarizing these results we found that the higher, or 100 flash rate, strongly influenced observer preferences. Peak intensity apparently had a greater effect than flash energy but this was understandable after realizing the observers were making their preferences at light levels well above threshold. (Literature data regarding effective intensity, or in this case flash energy, was obtained under threshold conditions). When intensities and flash rates were approximately equal, flashers with the longest dwell were definitely preferred.

The second phase of the field test involved delineation lighting. This test was designed to determine the preference for the flash configuration of lights which would most readily guide a driver around a hazard. Since this test was run concurrently with the hazard warning light phase, the same observers, the same general test area, and the same type of test was used. Again the lights were barricade-mounted and 25 lights were used on both sides of the routes through each test site. As shown in Figure 1, four sites were available, one site on each ramp of the Holt Road, US 127 interchange. Four different light configurations, one on each side, were prepared as follows:

1. Random Flashing, i.e., 6-volt flashers operating at 60 flashes per minute with a 25-percent dwell. This flasher conforms to present Michigan Department of State Highways specifications.

2. Synchronous Flashing, i.e., 6-volt flashers operating at 60 flashes per minute with a 25-percent dwell. All flashers on one side of the route flashed on and off at the same time. Flashers on one side were not synchronized with the other.

3. Sequential Flashing, i.e., 6-volt flashers flashing at 60 flashes per minute with 25-percent dwell. Flashers on one side flashed in a sequence of the first, then the second, the third, etc. This circuit failed and was finally deleted from the test.

4. Constant Burning, i.e., 6-volt battery-operated units with the lamp burning constantly.

The test was designed so that the observers would drive through the four test sites and select the best and the worst delineation light. The worst was to be removed and the observers would again select the best and the worst. Since the sequential flash circuit failed, only one pass through the test area was necessary. Observer data obtained is shown in Table 3.

TABLE 3
OBSERVERS PREFERENCE DATA

	Considered Best By	Considered Worse By
Random Flashing	2	13
Synchronous Flashing	4	7
Constant Burning	14	0

The table shows the number of observers who considered the particular flash configuration best or worse.

Obviously the constant burning light was preferred by most of the observers and it is significant to note that none of the observers considered this light the worst. There was considerable interest in the synchronous flash configuration and a number of observers indicated that both sides of the route should have been synchronized.

Motion pictures were taken while driving a camera car through the delineation test sites. A limited number of viewers of the resulting films expressed preferences similar to the observer-field preferences and therefore planning was initiated to photograph all of the delineation lights at a later date.

Effects of intensity were not included in the delineation tests and the effects of placement were not considered. These factors can be resolved through experience.

In considering recommendations, we wish to stress the point that observations in this field test were based on personal preference which may not be an accurate index of the warning value of the light. In all cases the observer was comparing one type of light with another. Further, under actual conditions, the driver does not compare, but relies on the type of light he sees to effectively make him aware of a hazard or to efficiently guide him around it.

Recommendations, therefore, are limited and conservative since laboratory work in progress may provide additional data to support further recommendations. Results from the hazard warning light phase of the field test indicate the following:

1. The flash rate of hazard warning lights should be increased to 100 flashes per minute. Further work may indicate that even higher flash rates should be used, but only two rates, 60 and 100, were tested. Laboratory work shows that increasing the flash rate beyond 100 for lights that flash "off and on" may not be feasible, since the time of applied voltage becomes so short that the lamps fail to achieve complete incandescence.

2. The length of dwell of present hazard warning lights should remain at 25 percent. Observer results indicate that longer dwells were preferred but the only direct comparisons involved 10- and 25-percent dwells. We doubt that these results can be extrapolated to include the 50-percent dwell. Laboratory results, based on observer reaction times, tend to support the necessity of dwells over 10 percent but only slight improvements in reaction time are noted for dwells over 25 percent.

3. Twelve-volt flashers should not be considered as a high intensity light to be used in extremely hazardous locations. Observer data showed that 12-volt flashers were preferred by a large majority when compared with all 6-volt flashers. However, in those comparisons between 6-volt flashers operating at 100 flashes per min, 25-percent dwell and all 12-volt flashers, observer preferences were more equally divided. This shows that the 12-volt flasher was not an overwhelming choice over certain 6-volt flashers and that the characteristics of 6-volt battery-operated flashers presently specified can be revised sufficiently to gain the preference of a significant number of individuals. We believe that a special warning light or a light to be used in extremely hazardous locations should be unquestionably superior to other commonly used hazard warning lights because a driver must receive the special warning without reference to other warning lights.

4. An investigation of high intensity flashers is recommended. The flashers should have sufficient energy while operating at the optimum

dwell for the lamp used, to be an overwhelming preference over the 6-volt flasher operating under any given flash characteristic. A flasher with 50 times the intensity of a 6-volt flasher is suggested.

5. As noted below, flashing lights are recommended only for hazard warning and therefore we recommend the use of monodirectional flashers to improve the warning effect in the desired direction.

Results from the delineation phase of the field test indicate that steady burning lights should be used for delineation. Flashing lights should be used as necessary to provide advance warning and warning at a hazard, but steady burning lights should describe the traffic route around the hazard.

It is interesting to note that hazard warning lights and delineation lights operated and used as suggested above would conform with the recommendations of the National Manual for Uniform Traffic Control Devices.

Present specifications for hazard warning lights would only require a simple revision of the flash rate requirements to conform with the above recommendations. Specifications for delineation lights could also be prepared by adaptation of the present battery-operated flasher specifications.