OVERHEAD SIGN - ILLUMINATION RELATIONSHIPS

By

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Introduction

Adequate signing is necessary to give the driver assistance in taking full advantage of our ever-improving Texas highway system. Signs must be located to attract the driver's attention and to give him time for proper response. The problem of sign location, recognition, and readability at intersections at night is of particular importance. Only one of the numerous studies of night target value and highway sign legibility has made a quantitative consideration of changes in the legibility of signs caused by the presence and location of standard roadway lighting or special fixtures designed to illuminate the sign. It has been observed that placing signs so that roadway luminaires illuminate them increases their legibility, but there is no information that such improvement is great enough to warrant the importance of this as a consideration in coordinating the design of roadway illumination and sign location.

The performance of a traffic sign is dependent on its attention value and legibility. Forbes (6) reported that attention value and legibility are functions of target and priority value, and pure and glance legibility. Each factor is related directly to contrast. Contrast is the result of an apparent difference in brightness and color alone, and a subjective experience given to extreme variation at night according to Elstad (5) and his associates.

Signing for traffic moving at night poses a more difficult problem than it does for daylight operations. The highway facilities are frequently illuminated by highway lighting and the problem of the interaction between highway illumination and high quality signing is a significant one. The Texas Highway Department policy is that all overhead signs shall be illuminated except at remote locations where power is not readily available. All overhead sign supports shall have provisions for the independent illumination of the individual signs. Illumination shall be by means of rapid start fluorescent lighting fixtures placed in a position in front of the bottom edge of the sign. If necessary, due to the height of the sign, lighting fixtures may be placed at the top edge of the sign also. The American Association of State Highway Officials (3) has adopted the policy that all interstate highway signs shall be either reflectorized or illuminated, or possibly both (3).

The most important factors involved in sign illumination are sign area and brightness. Several complex factors affect the legibility of signs. Some of these factors are:

1. Adaptation level of the eye.

2. Sign brightness.

3. Brightness contrast and direction of contrast.

4. Color contrast.

5. Reflecting characteristics of sign surface.

6. Minimum separation distances between parts of the message.

7. Angle of viewing.

8. Letter size.

9. Letter style.

10. Ratio of stroke width to letter height.

11. Other brightness in the field of view.

At great distances headlamp illumination on a sign face is understandably low. Concurrently the divergence angles between the driver, the sign and the headlamps are small, contributing to high efficiency and compensating for the low illuminance. With decreasing distances, however, large increases in headlamp illumination offset reductions in efficiency at the higher divergence angles associated with the shorter distances.

Purpose of Study

The purpose of this study was to examine the relationships between the legibility of overhead signs and the brightness configurations which can result when various vehicle, sign, and roadway lighting conditions exist for a number of commonly used high-type sign materials. The effects of the variables are expressed in legibility distances to enable the designer to compare the relative improvements in legibility for various sign-illumination systems.

The studies have included the effects of one and two roadway luminaires, the longitudal positioning of the luminaires with respect to the sign, differences between two headlamp and four headlamp automobile lighting systems and the effects of high and low beams. All studies described in this report are for standard interstate sign letters using 16-inch capitals and 12-inch lower case letters.

The figure of merit used in this study, pure legibility distance, is not used to compare specific materials. The investigation had as its objective the understanding of the characteristics of different types of sign and materials in their relationship to brightness in typical highway sign applications.

Previous Studies

Very little research on the legibility of reflectorized signs was reported before 1956. Much of the significant work was accomplished by the Virginia Highway Department and has been reported by Allen and Straub (1), (2), (9).

Allen and Straub (3) concluded that illumination conditions surrounding a sign are important. More sign brightness is needed in a brightly-lit area and in an area of this type higher brightness is possible without irradiation effects being felt. In 1956 (9) they described and illustrated a method of determining the brightness of a sign in place on the highway, taking into account the reflective characteristics of the sign materials, the illumination reaching the sign from the headlamps, and the geometric relationships between the automobile, the sign, and the road alignment. In 1958 Allen (1) used an experimental bank of lamps to produce four levels of illumination on the face of a roadside sign. He concluded that in a dark rural area overhead signs using reflective materials only can give satisfactory performance.

A series of unpublished tests of signing was conducted in Illinois in 1955 and 1956 (7). The study concluded that mercury vapor highway lighting did not reduce the legibility distance of signs made with three types of letter materials. It was recommended that overhead signs should not have reflectorized backgrounds. The improved sealed beam headlight system was shown to reduce night legibility by 6% when compared to the sealed beam headlight system in use before 1955.

The Roadway Lighting Committee of the Illuminating Engineering Society investigated practices with regard to sign lighting in 1959. Of the eight agencies with extensive experience in sign lighting two used bottom lighting only, two used top lighting only, and four used both types or both top and bottom lighting extensively. Four agencies used fluorescent fixtures only, one used only incandescent lamps and three used both types and/or neon. Six agencies had experience with internally illuminated signs. No consistent policy with regard to the location of the overhead signs with respect to highway illumination was apparent. The main concern seemed to be with obscuring sign faces with luminaire poles.

Decker (4) reported on the results of a study of the effects of illumination level on sign message legibility for large signs mounted at the roadside. The studies were conducted under daylight conditions and at night with low beams and high beams using the dual sealed beam system. His findings were that high beams gave 75 per cent of the daytime legibility and that low beams gave 67% of the daytime legibility, a distance difference of approximately 50 feet for the two headlight conditions.

Most studies of reflective treatment of signs have been largely confined to a comparison of the performance of available materials in a dark environment. However, marked differences are experienced in field brightness and headlamp illumination with varying sign location and position. These conditions impose widely different illuminance demands on signs and their legends for optimum contrast.

Elstad, Fitzpatrick, and Woltman (5) after a consideration of the night traffic sign environment suggested three representative conditions for studying reflective treatment of signs. They are: (a) dark rural, (b) illuminated suburban, and (c) bright urban. They reported on legibility tests conducted on a section of roadway with illumination provided by luminaires spaced 190 feet apart at a mounting height of 30 feet. The legibility of 12-inch letters was evaluated on a straight level section of this roadway. This test was expected to reveal the nature of change produced in legibility distance for every letter size by relying on established legibility distance and letter height relationships. A front illuminated sign was used. The signs were mounted 14 feet from the pavement surface and 16 feet to the right of the pavement. Signs were located close to the luminaires. Forty-five male observers viewed the illuminated sign and reflective materials with high and low beams under dark and illuminated conditions.

Nearly identical results under conditions of moderate illumination and total darkness indicated that changes in the effective legibility are negligible for either low or high beams. Legibility does not deteriorate but marginally improves in changing from the dark conditions to illuminated suburban.

The results of measurements in standard highway lighting conditions showed improvement in reflective sign legibility compared to the dark condition, notwithstanding the presence of luminaires and associated glare. The luminance of existing reflective materials provides adequate brightness for good legibility of most information and traffic control signs in rural and illuminated suburban environments.

Description of Study

Legibility criteria are generally employed in the assessment of luminance for optimum performance. Luminance is dependent on illuminance, angular position relative to the vehicle, and the angle subtended at the sign by the motorist and his headlamps. Each of the above factors is affected by sign position and distance.

A comprehensive controlled study of the legibility distance of overhead signs under various conditions of illumination was completed at a specially constructed test area on the Texas A&M campus. Overhead signs with several types of commonly used reflectorized backgrounds were tested. An internally illuminated sign was also evaluated to determine the legibility response to variations in illumination conditions.

The test course was laid out along a 3,000-foot tangent roadway. At one end of the course a sign support structure was erected with necessary gear to make it convenient to mount different legends. A number of standard luminaires were positioned as shown in Figures 1 and 2.

Every 25 feet a station marker was placed and legibility readings could be estimated to the nearest 5 feet. When the signs were in position they were perpendicular to the road and approximately 17 feet above the surface of the road.

Two automobile headlamp systems were used in the various tests; the two-lamp improved sealed beam system introduced on 1955 models, and the four-headlamp dual sealed beam system introduced in the late 1950's. The chief operational feature of the new four-lamp system is the improved lower or passing beam used when there is other traffic in the vicinity of the vehicle (8). The dual sealed beam system puts more light near the top of the beam on the right side. This results in greater lower beam seeing distance on the right-hand side of the road. The upper or driving beam is similar in the two systems.

Standard 400-watt mercury vapor luminaires were located above the edge of the pavement at a height of 30 feet. Two types of fluorescent sign lighting fixtures were used in the study. One unit, referred to as the standard unit, was developed by the California Division of Highways and adopted by the Texas Highway Department. The other unit was designated as a Fluoroflood fixture. Both fixtures were mounted on the signs, and were tested in positions above and below the sign. Figure A-10 shows the fixtures used.

The sign used was 4 feet high 12 feet in length. The three 16-inch letter types used were mounted on the four backgrounds as needed. The words in the message were achieved by applying cut-out letters to reflectorized aluminum panels. The message panels could be placed over the background with no visible change in the characteristics of the background. Manufacturers of the various materials cooperated by providing materials and suggestions regarding the use of their products in the test. The letter spacings used were those recommended by the manufacturers. The test words selected were six-letter pronounceable place names such as BEAVER, BAXTER, etc.

The letter and background types tested are listed below:

Letter Material	Background Material
Stimsonite	Scotchlite-

(cont'd.)

Letter Material	Background Material
Scotchlite Parkway Letters	Scotchlite-Flattop
Scotchlite Signal Letters	Porcelain Enamel T.H.D. Reflectorized Material

The signs were evaluated by observers riding in slow moving cars. The test record was the distance at which the legend on the sign could be read, a measure of "pure legibility." The study was conducted with the test vehicle moving at a speed of approximately 15 miles per hour. At the typical legibility distance for the overhead signs used this speed was considered satisfactory in representing the dynamic situation for the typical highway at night and made it possible to record legibility distance more accurately.

The observers used in the study were students at Texas A&M University. The observers had no prior knowledge of the signs or materials used.

Experimental designs were used which made it possible to assign "pure" effects for each study made.

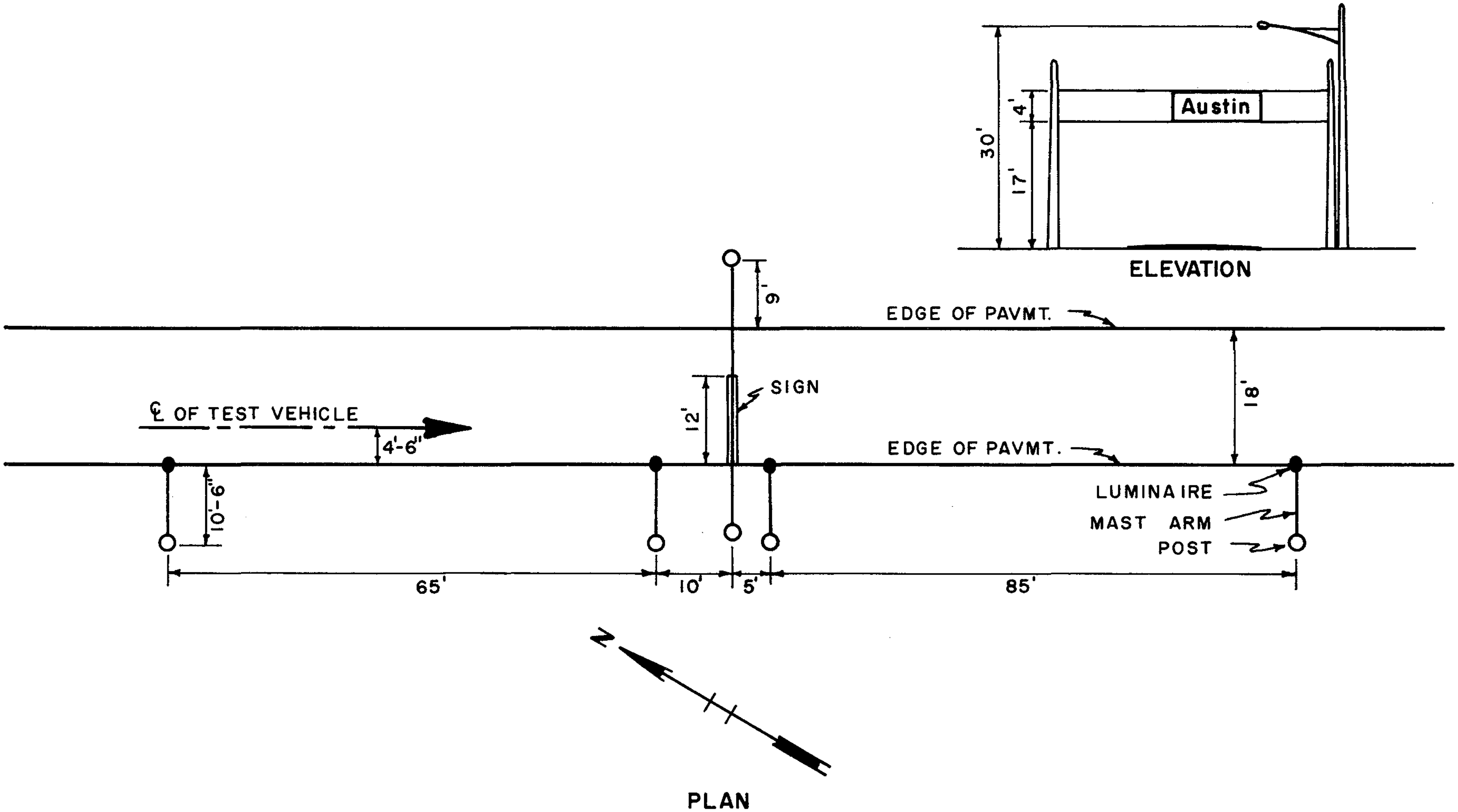
Analysis of Data

After completion of the field work in each phase of the study, the data were reviewed, placed on punch cards and processed by standard statistical techniques using an electronic digital computer. The results have been summarized graphically in Figures A-1 through A-9.

As can be seen from Figures A-1 through A-9, a vast amount of data is presented in each graph. In order that each graph is understood in the fullest extent, the reader's attention is directed first to Figures 1 and 2 which show the test site, the direction the vehicle is traveling and the relative position of the sign with respect to the luminaire position. In each of the graphs, A-1 through A-9, the dots represent the luminaire condition, i.e. the black dots represent the luminaires off and the white dots represent the luminaires on. The vertical line separating the dots depicts the position of the sign with respect to the luminaire condition for a test driver approaching from the left. The 2L and 4L used in the graphs refers to two-headlamp systems and four-headlamp systems.

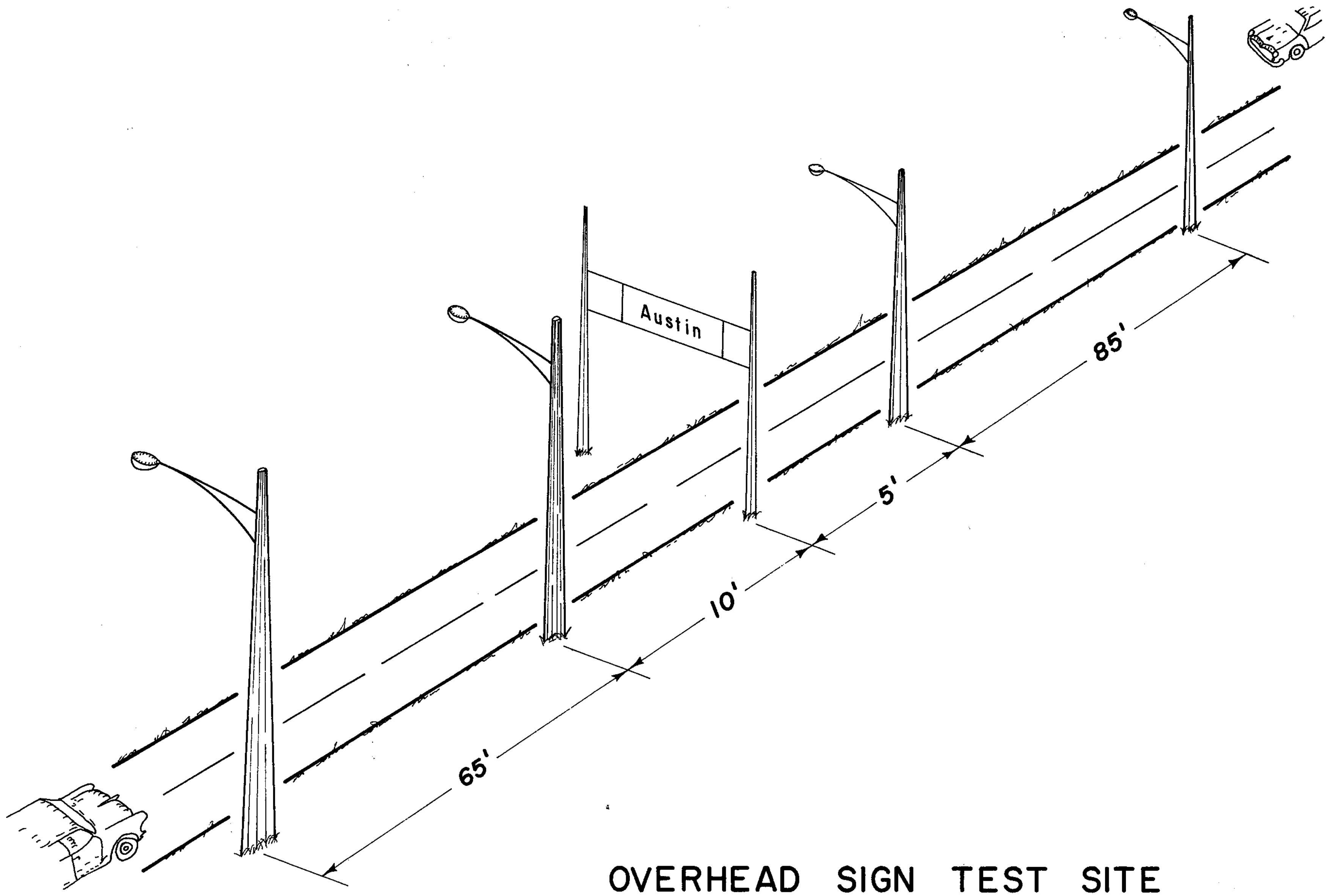
Results

Figure 3 presents legibility distance results for 12-inch Stimsonite letters on a porcelain enamel background. It is noted that the variation in legibility

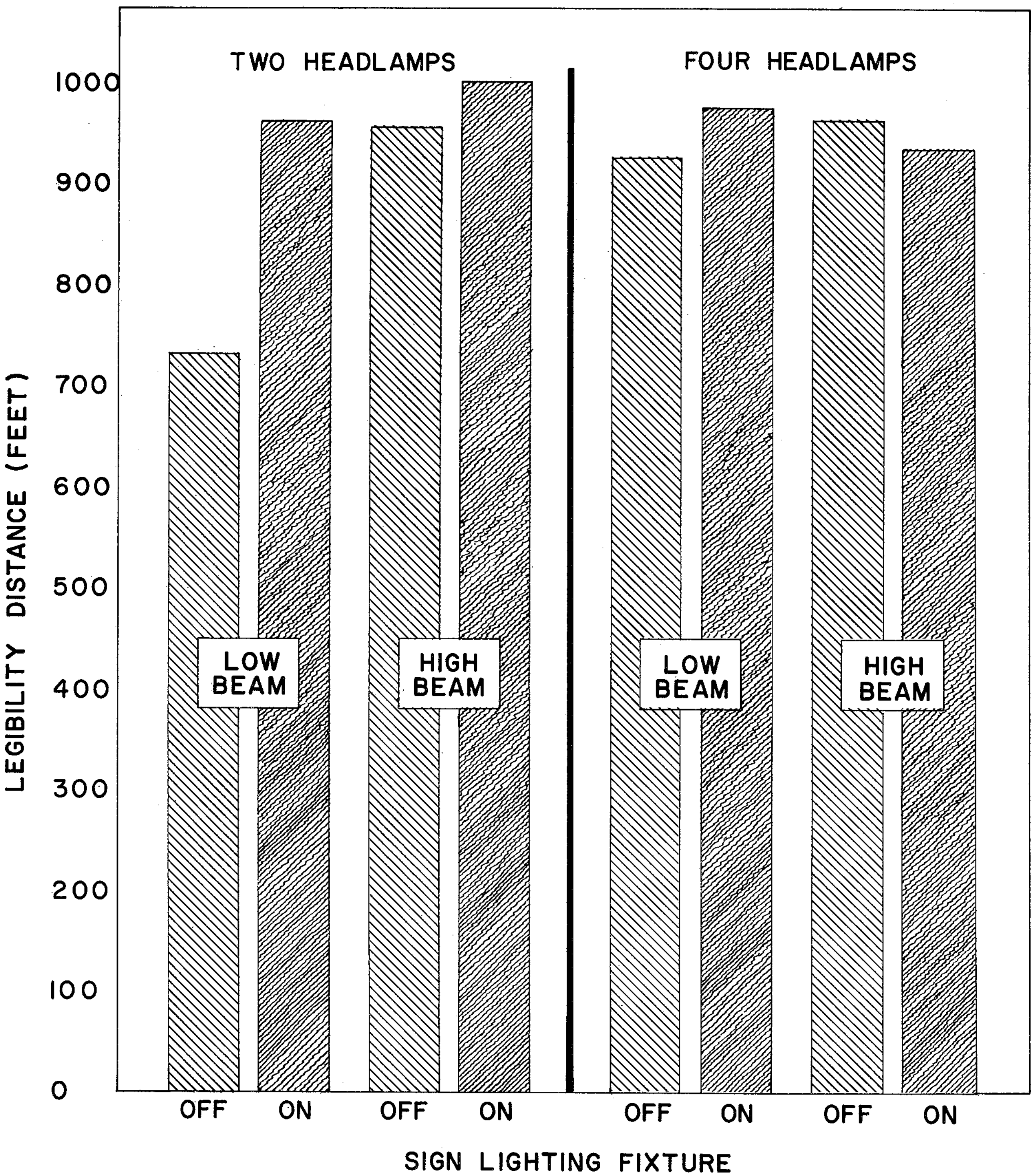


OVERHEAD SIGN TEST SITE

FIGURE I



OVERHEAD SIGN TEST SITE
FIGURE 2



RESULTS FOR STIMSONITE LETTERS ON PORCELAIN ENAMEL BACKGROUND

FIGURE 3

distance is small when the four-headlamp automotive lighting system is used. Seeing distance was not improved by switching from low to high beams nor in turning on the standard sign lighting fixture mounted below the sign.

On the other hand with the older two-headlamp system there was a substantial improvement in legibility distance from the low beam, no-sign-lighting-fixture condition as the sign lighting fixture is turned on. With the addition of the sign lighting fixture all legibility distances average more than 900 feet, a seeing distance which compares favorably with daylight conditions.

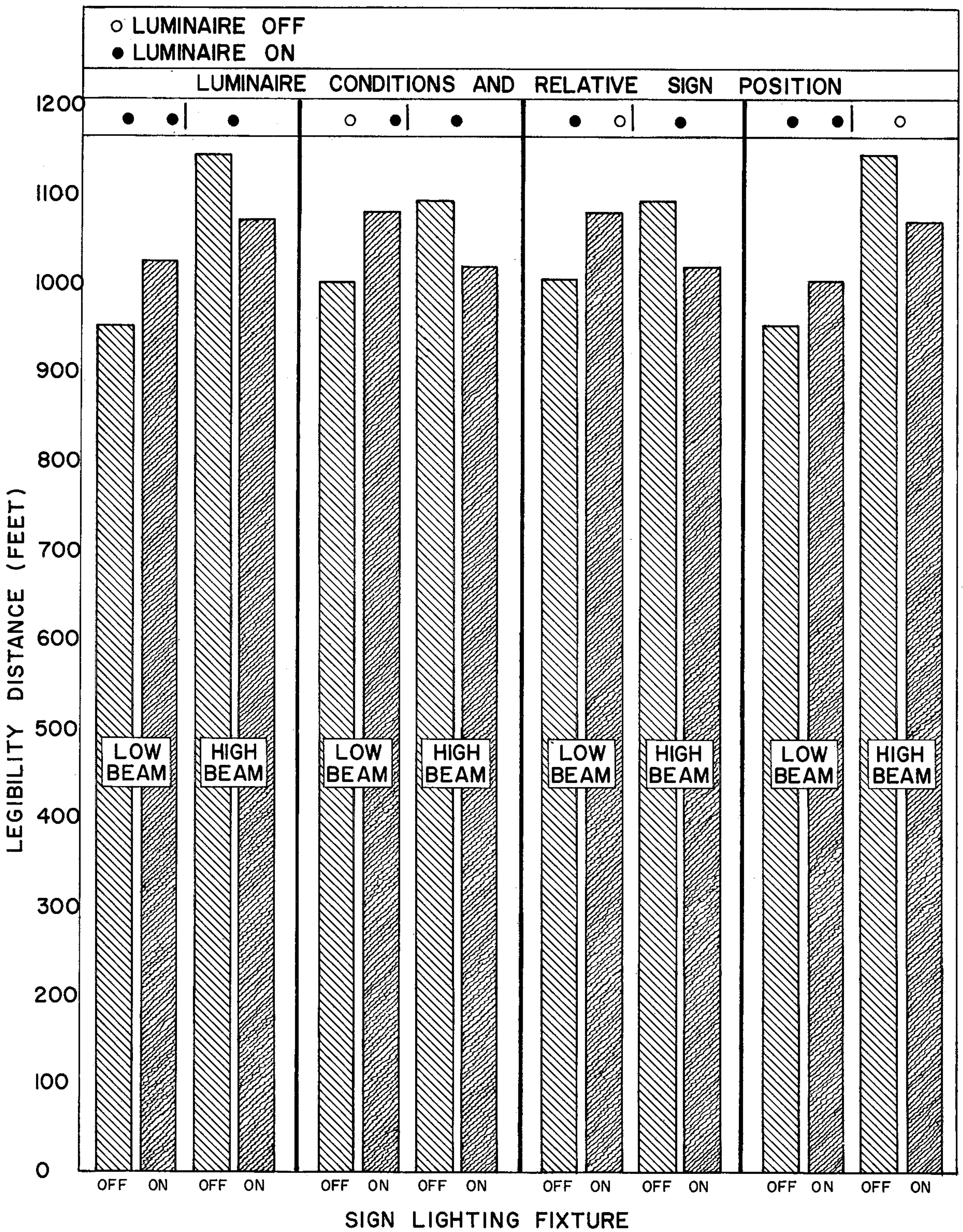
Figure 4 shows the legibility results using a two-headlamp automobile system facing Stimsonite letters on a porcelain enamel background under a variety of roadway luminaire conditions and with the sign lighting fixture on and off. (See Figures 1 and 2). The black dots in Figure 4 indicate the luminaire is not on, the white dot indicates the luminaire is on and again the vertical line represents the relative position of the sign with regard to the luminaires for a driver approaching from the left. The nomenclature selected to describe the roadway luminaire condition for Figure 4 will be used repeatedly throughout this report without any further explanation unless it is believed necessary to clarify the meaning of future figures. Under low beam operating conditions the sign lighting fixture improved legibility distance approximately 5% under all external illumination conditions. Interestingly enough, under high beam operating conditions the addition of the sign lighting fixture illumination reduced legibility distance 5% under all illumination conditions.

There was no consistent pattern in legibility distance as the luminaire conditions varied from full dark to illumination both in front and in back of the sign.

Figure 5 presents results for the Stimsonite letters on the porcelain enamel background under a variety of roadway luminaire conditions. For the two-lamp, low beam headlamp condition with no sign illumination there seemed to be improvement in legibility distance as additional illumination was added. The improvement is seen to be due to illumination on the front of the sign from the luminaire and measured as much as a twenty per cent improvement.

For the same low beam headlamp condition with the sign illumination fixture on there was no apparent improvement as the luminaire condition was varied. The same results were found with the high beam headlamps and the sign fixture on. For the high beam headlights with the sign fixture off illumination seemed to give a small improvement in legibility and distance.

Figure 6 compares the legibility distance for Stimsonite letters mounted on a Porcelain Enamel background under low and high beam conditions for two- and four-lamp vehicles and compares a standard fluorescent sign lighting fixture mounted below the sign with the commercial Fluoroflood fixture mounted above the sign.



RESULTS FOR STIMSONITE LETTERS ON PORCELAIN ENAMEL BACKGROUND

FIGURE 4

Front and back roadway illumination is also compared. "Front" in Figure 6 refers to the light from the luminaires in front of the sign and likewise "back" means the luminaires behind the sign are on. Significant differences between "front" and "back" of sign illumination were recorded for the high beam two headlight system. In general the high beams gave no improvement in legibility distance over low beam. For this group of observations there was little difference between the headlamp conditions.

Figure 7 shows the legibility response under a variety of roadway luminaire conditions for the two- and four-headlamp systems operated at low and high beams and with a standard fixture mounted below the sign when a reflectorized background prepared by the Texas Highway Department was used. No significant differences in legibility distance were recorded for this configuration.

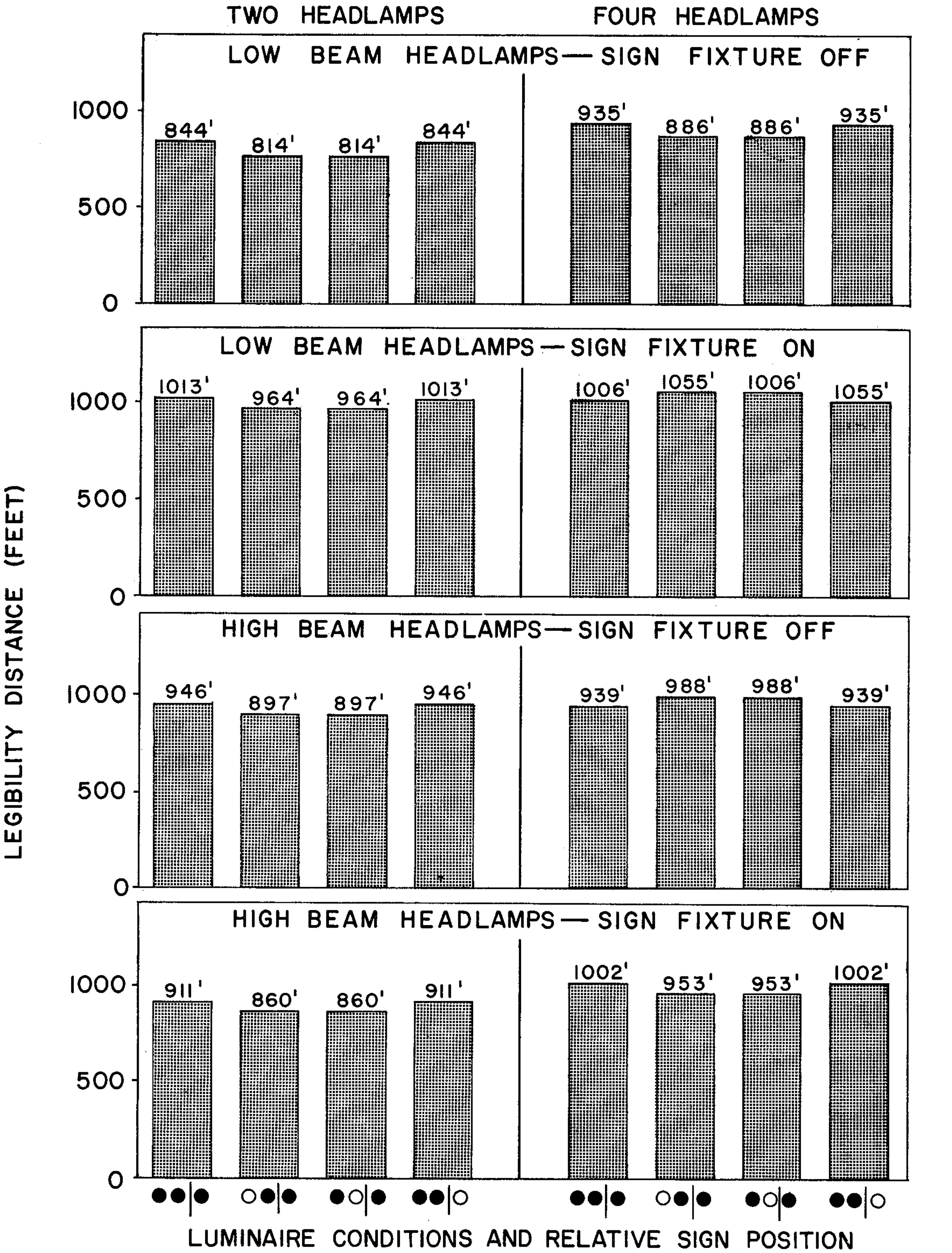
Figure 8 presents the legibility results for Scotchlite Signal letters on Scotchlite Flattop background when the Fluoroflood fixture mounted below the sign was used for special sign illumination. No significant results were recorded.

Figure 9 presents the results for Scotchlite Parkway letters mounted on a Scotchlite Flattop background with the standard sign lighting fixture mounted below the sign. For the two-headlamp system operating without the sign fixture and with low beam headlights, the placement of a luminaire in front of the sign increased legibility be more than 20%. An improvement of over 10% was noted for the four-headlamp systems when the vehicles were operating on high beams and with no sign lighting fixture on.

Figure 10 presents legibility results for Scotchlite Signal letters on a Scotchlite Flattop background with a Fluoroflood fixture mounted above the sign. In all cases the sign lighting fixture improved legibility distance by at least 20%. The illumination from roadside luminaires seemed to have no substantial effect on legibility. Figure 11 presents results for Scotchlite Signal letters mounted on the T. H. D. reflectorized background with the standard sign lighting fixture mounted below the sign. For the two-lamp system on low beams and with no sign fixture the luminaires in front of the sign gave improved legibility distance. Under high beam conditions the placement of the lamp of the luminaire near the sign resulted in a substantial improvement in legibility. For the four-lamp system, some improvement was noted when a luminaire was located near the front of the sign.

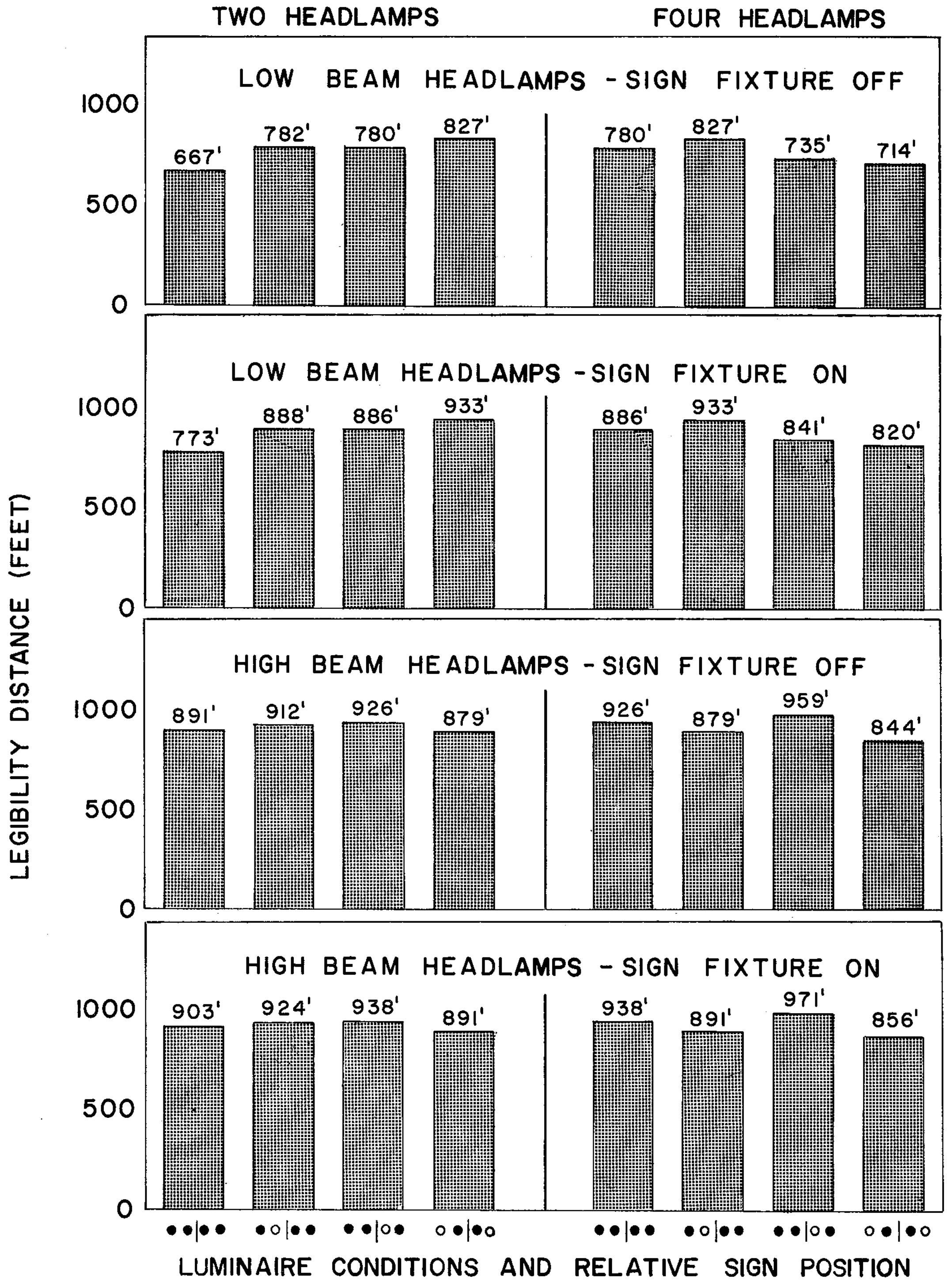
Figure 12 presents the results for an internally illuminated sign. The total range in average legibility distance for eight illumination conditions was less than 75 feet under both low and high headlamp conditions. These differences have no practical or statistical significance.

Figure 13 presents information on sign face luminance as a function of the relative location of the sign and luminaires. The greatest effect was observed when the luminaire was less than 20 feet in front of the sign position.



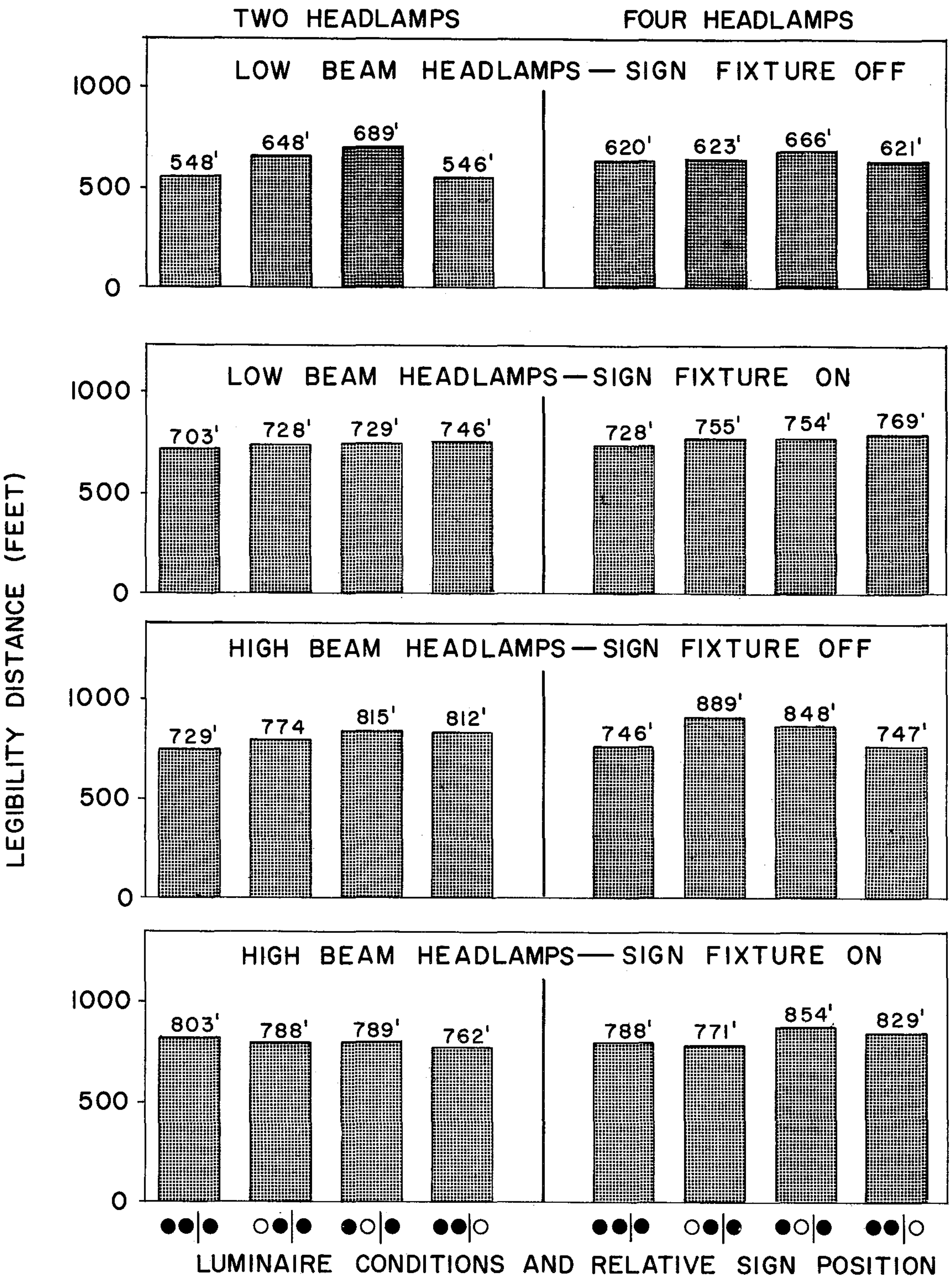
RESULTS FOR STIMSONITE LETTERS ON T.H.D. REFLECTORIZED BACKGROUND

FIGURE 7



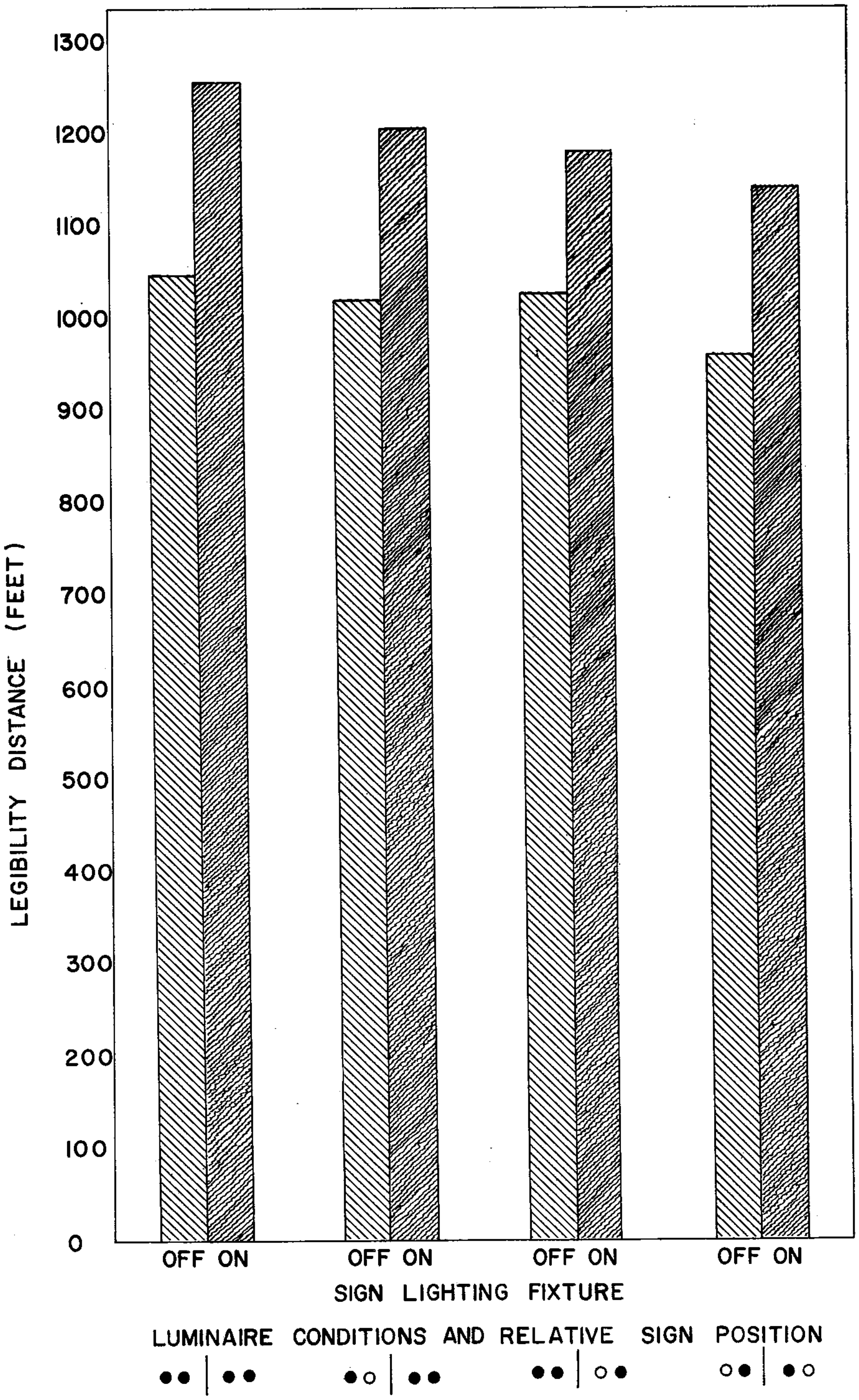
RESULTS FOR SIGNAL LETTERS ON SCOTCHLITE FLAT TOP BACKGROUND (FLUOROFLOOD FIXTURE)

FIGURE 8



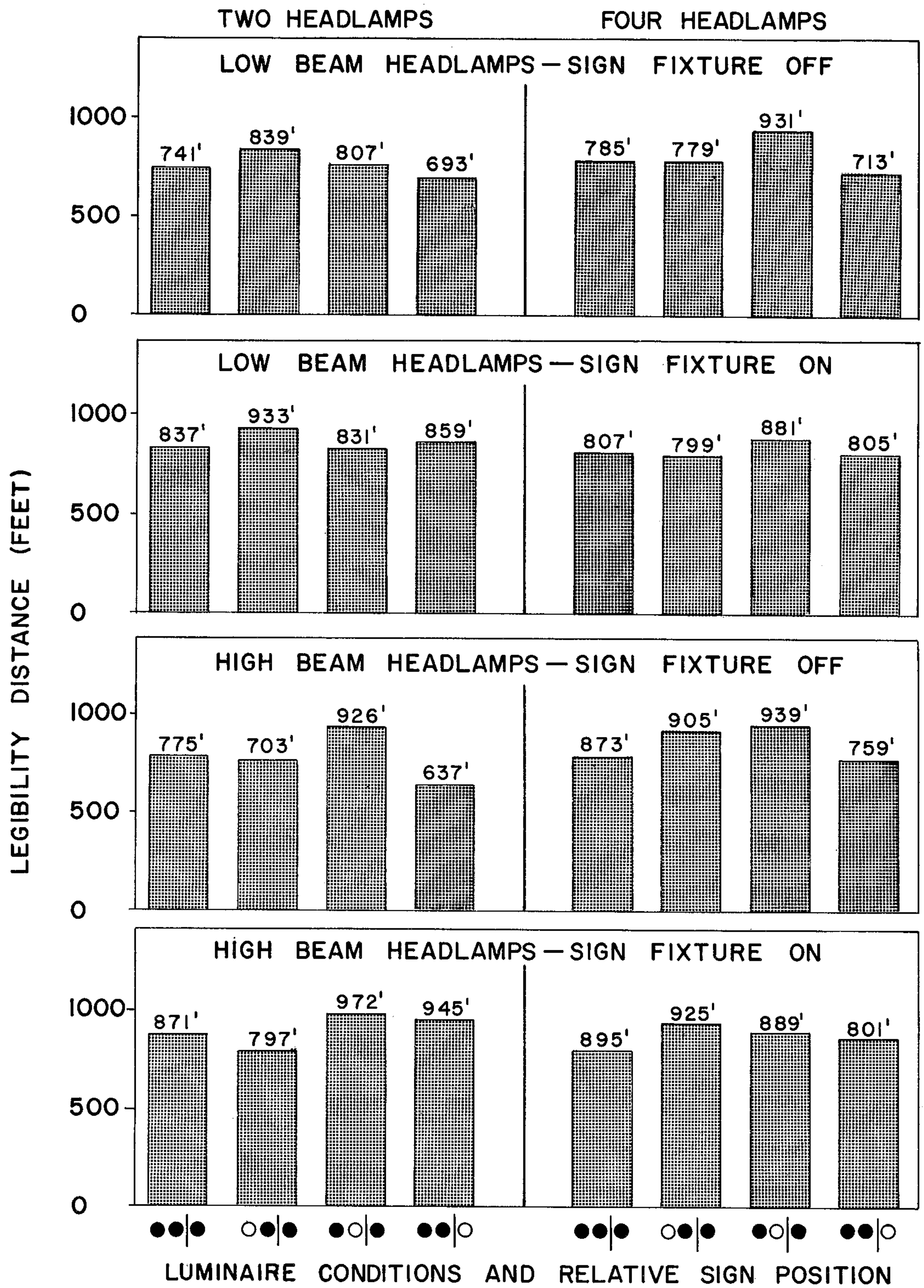
RESULTS FOR PARKWAY LETTERS ON SCOTCHLITE FLATTOP BACKGROUND

FIGURE 9



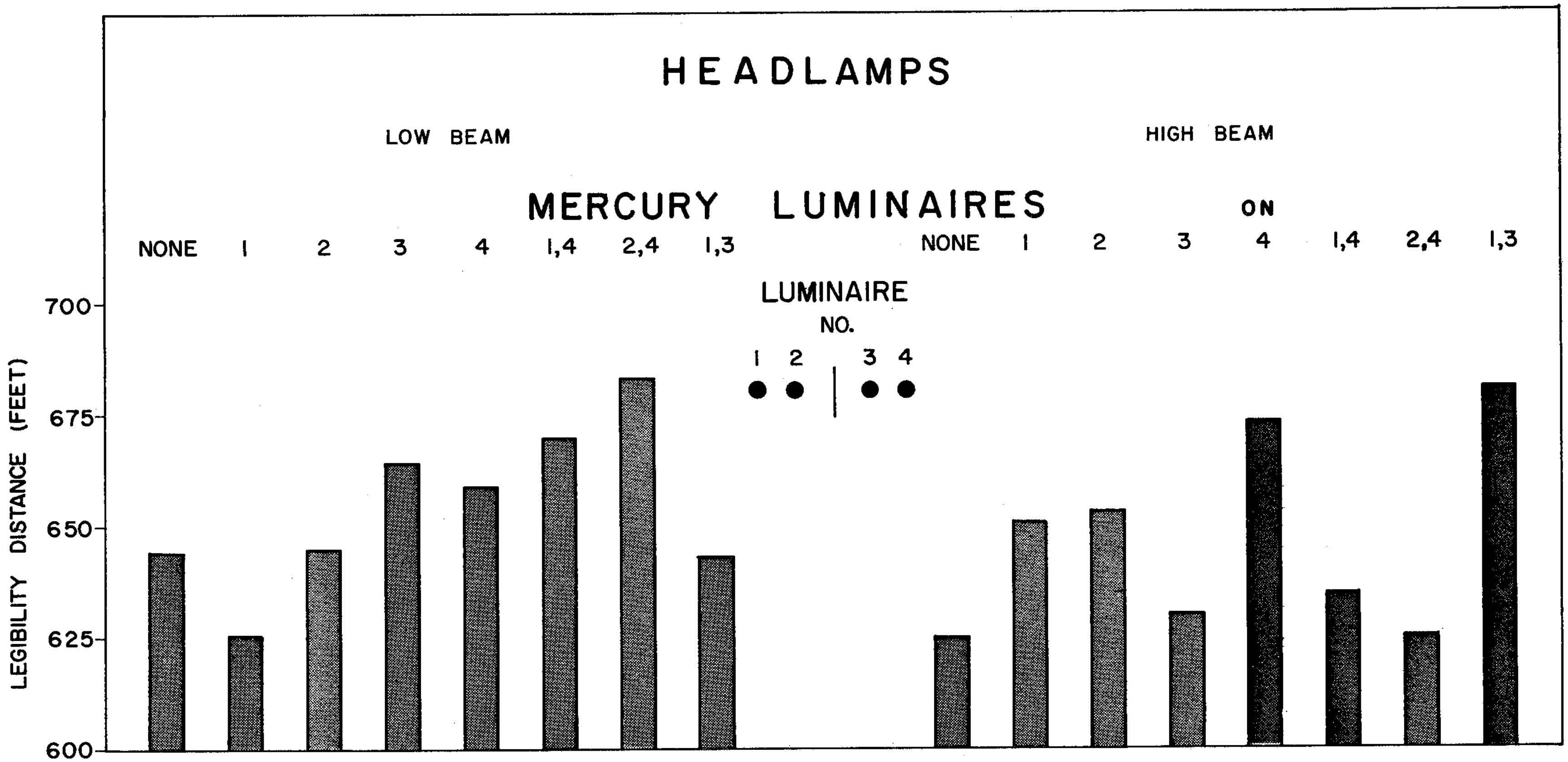
RESULTS FOR SIGNAL LETTERS ON SCOTCHLITE FLATTOP BACKGROUND (FLUOROFLOOD FIXTURE MOUNTED ABOVE SIGN)

FIGURE 10



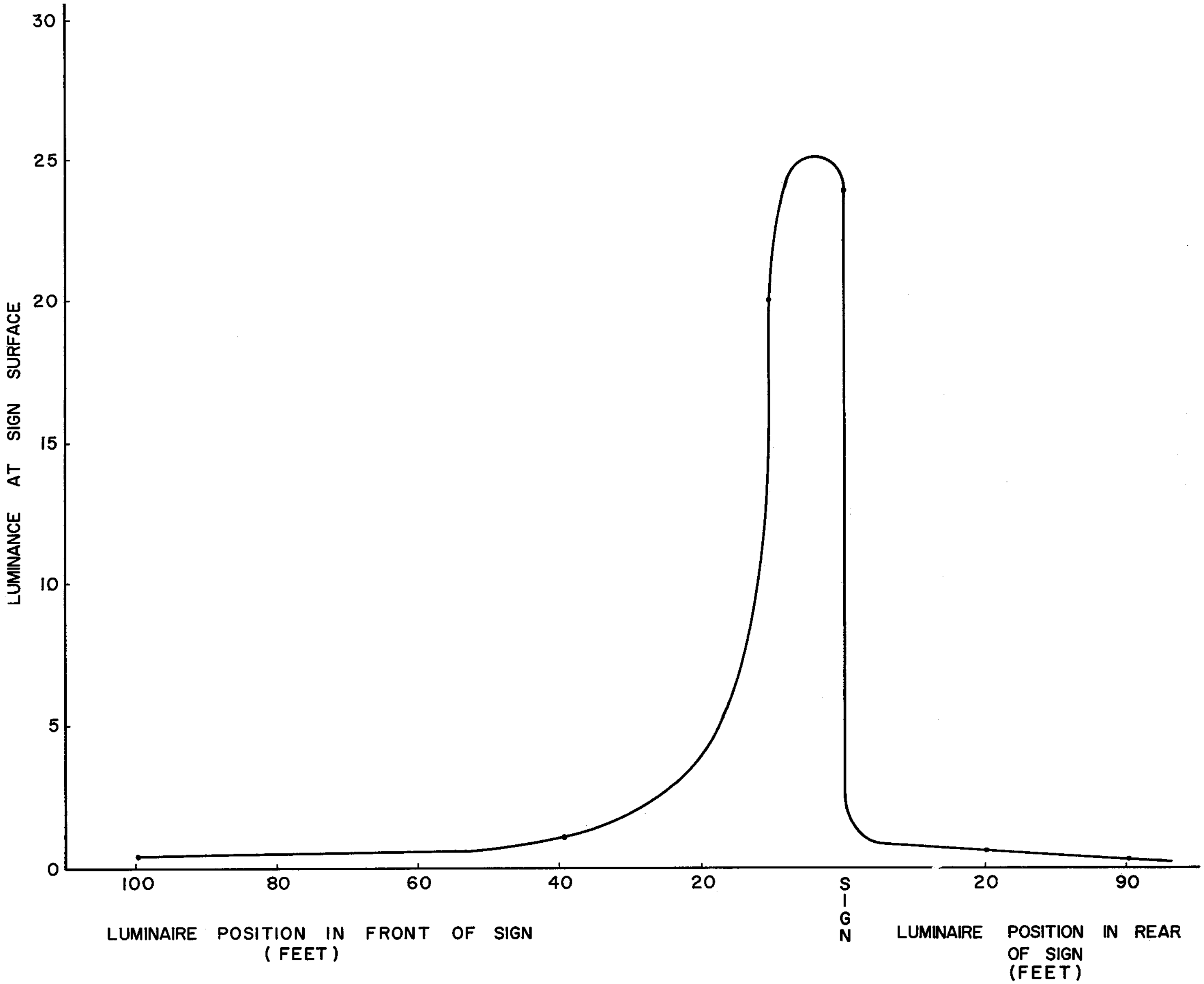
RESULTS FOR SIGNAL LETTERS ON T.H.D. REFLECTORIZED BACKGROUND

FIGURE 11



INTERNALLY ILLUMINATED SIGN

FIGURE 12



SOURCE: ELSTAD, FITZPATRICK, AND WOLTMAN

LUMINANCE VS LUMINAIRE-SIGN LOCATION

FIGURE 13

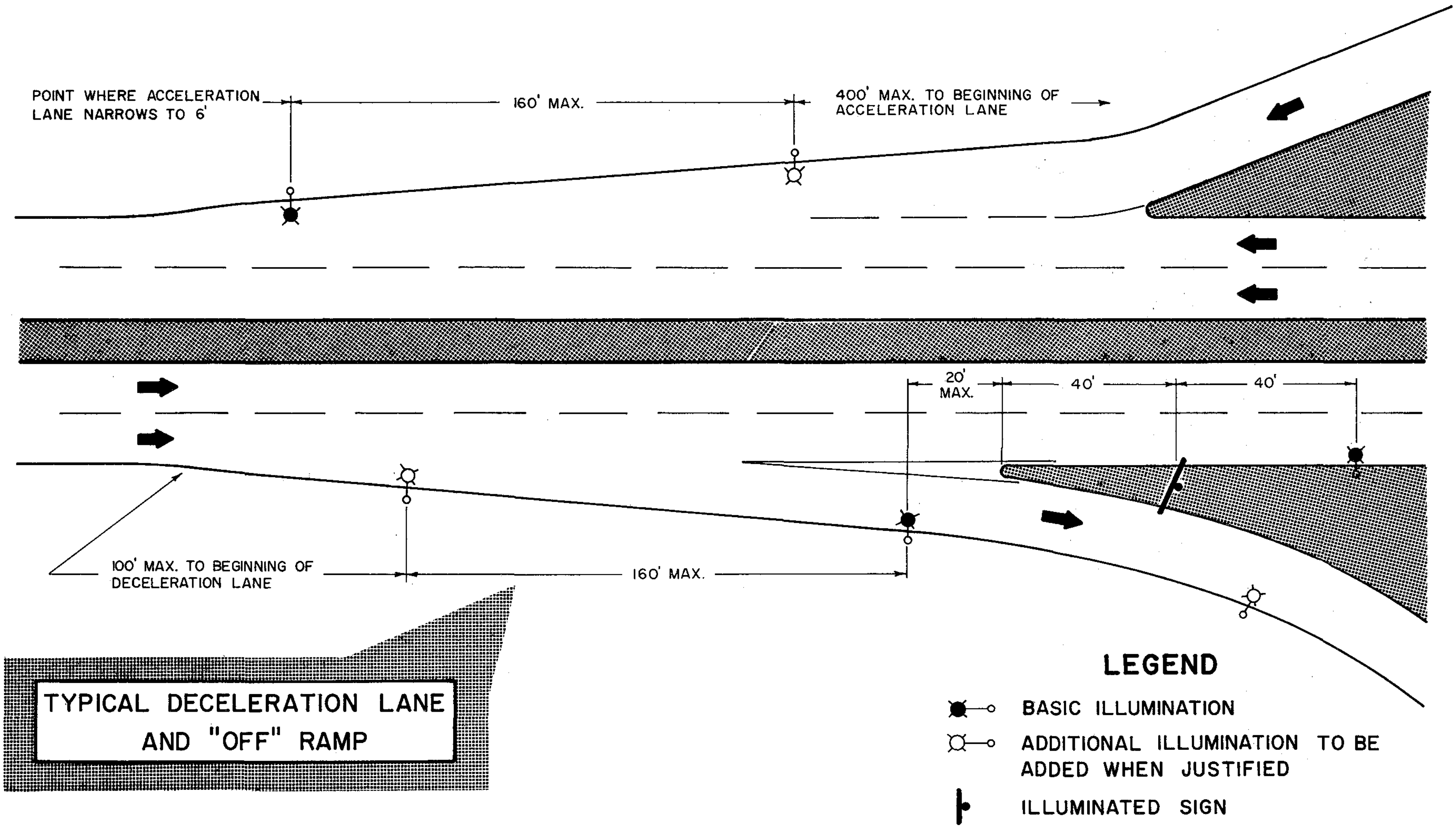
Figure 14 presents the lighting and signing standards for freeway connections adopted by the California Division of Highways. It should be noted that in comparing this recommended placement with the results observed in the various signing tests that for certain materials placement of the luminaire nearest the ramp gore at a location closer to the sign might be expected to improve the legibility distance of sign mounted in the gore.

Conclusions

Under rural conditions it is possible to use several methods of improving the legibility of overhead signs that are not internally illuminated. It was found that the legibility distance of various high type signing materials under generally dark surrounding conditions varied as much as 20 per cent as the external illumination of the sign varied. Sign fixtures, high beam operation and roadway luminaires will each make a contribution. The effects are not additive and the use of any one of the above makes the need for the other two less apparent. Also, it is apparent that differences in illumination result in meaningful differences in legibility and that this should be taken into account in design. This is an individual problem and very difficult to standardize. From a legibility point of view, it is concluded that satisfactory legibility can be achieved under many conditions without the use of overhead sign lighting fixtures.

LIGHTING AND SIGNING OF FREEWAY CONNECTIONS CALIFORNIA

FIGURE 14



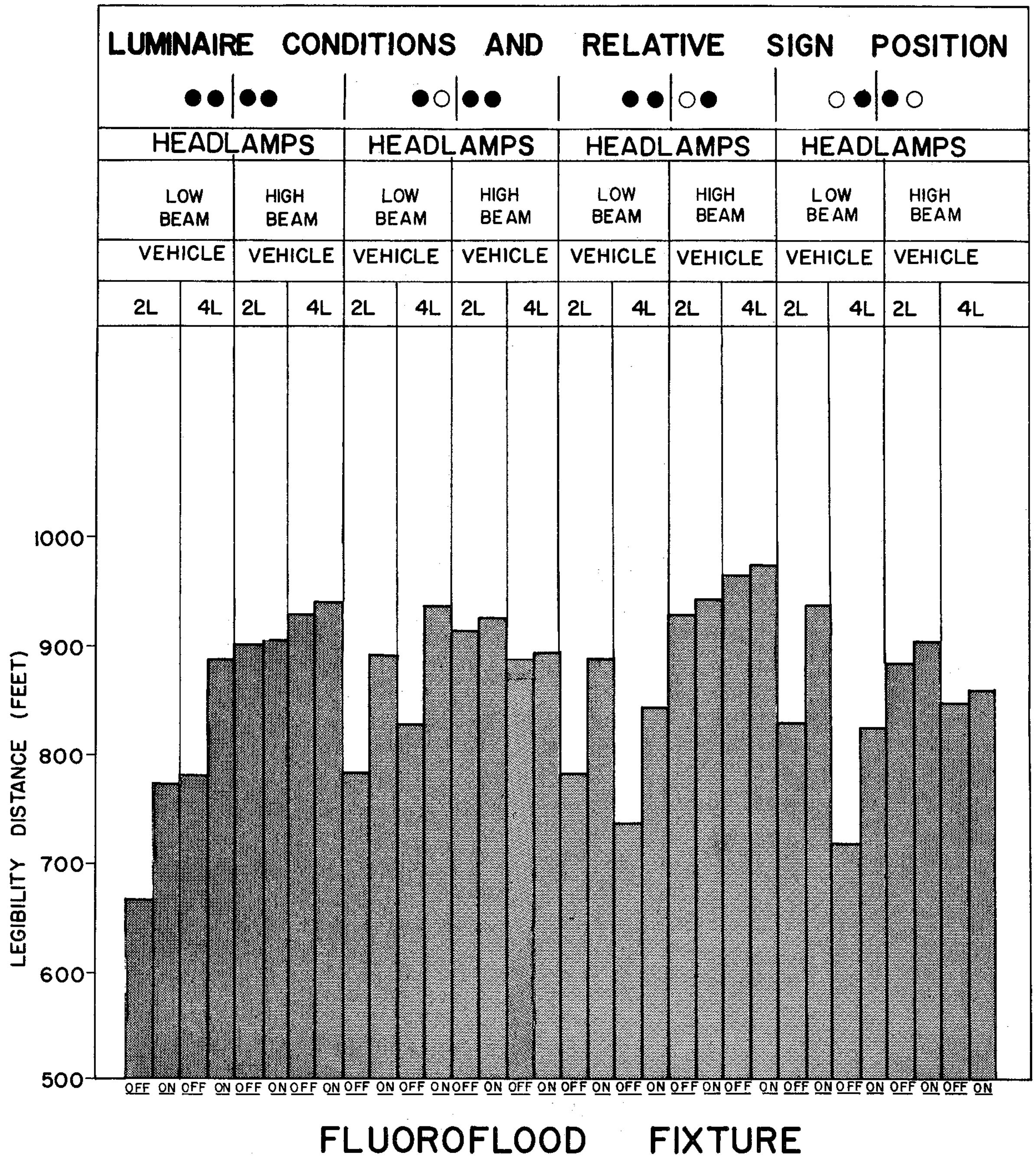
Acknowledgment

The studies reported in this paper are part of the intersection illumination project jointly sponsored by the Texas Highway Department and the U. S. Bureau of Public Roads.

Grateful acknowledgment is made to the manufacturers of the materials used for guidance and for supplying samples. These include Minnesota Mining and Manufacturing Company, California Metal Enamel Company, Stimsonite Division of Elastic Stop Nut Corporation, and Winkomatic Signal Corporation.

The contributions of personnel at the Texas Transportation Institute are significant. These include C. J. Keese, H. H. Bartel, W. R. McCasland, W. C. Franklin, S. N. Van Winkle, L. Lynch, and R. Watt.

APPENDIX



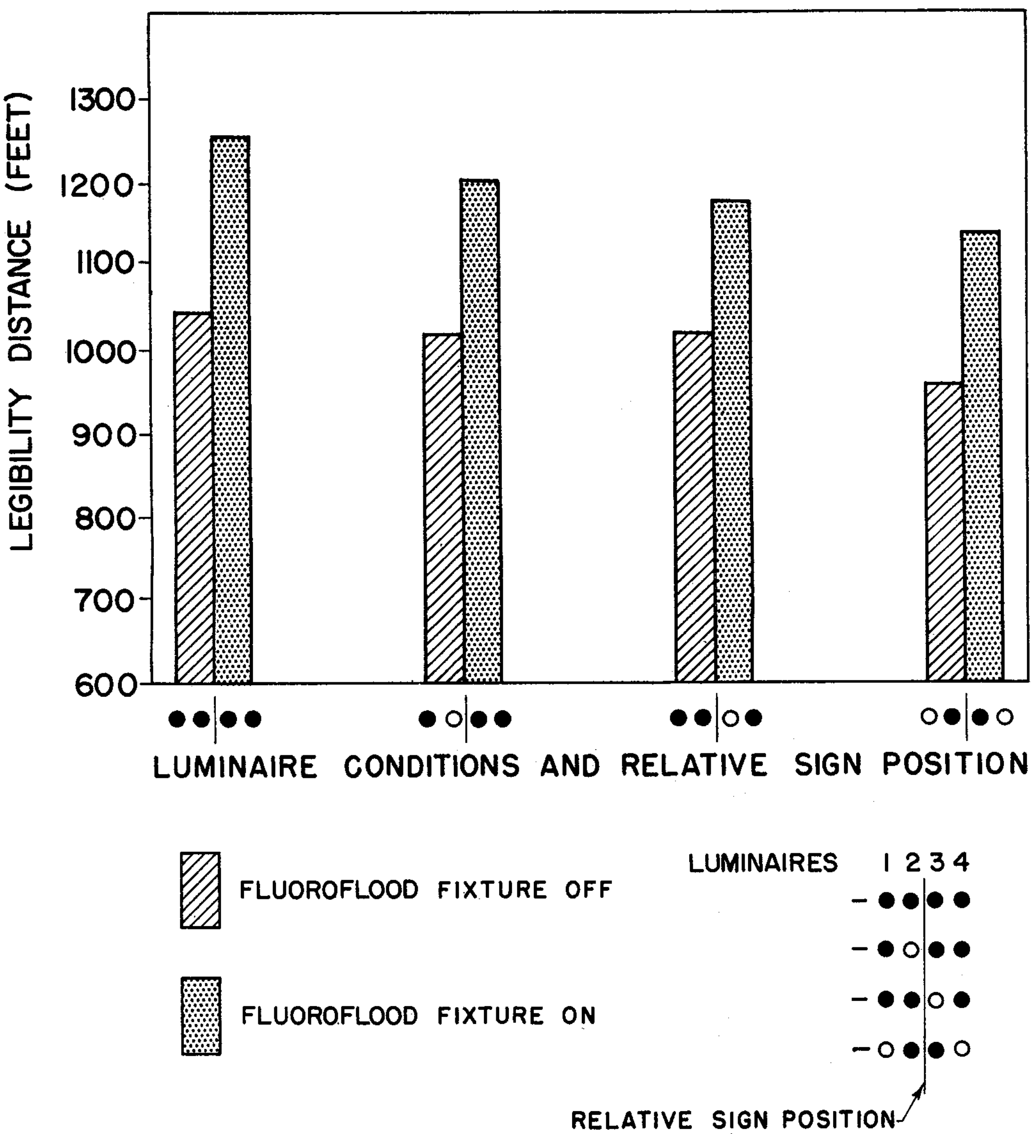
LETTERS: 16" SIGNAL

BACKGROUND: SCOTCHLITE (FLATTOP)

FIXTURE: FLUOROFLOOD (T-12)

MOUNTED BELOW SIGN

FIGURE A-1

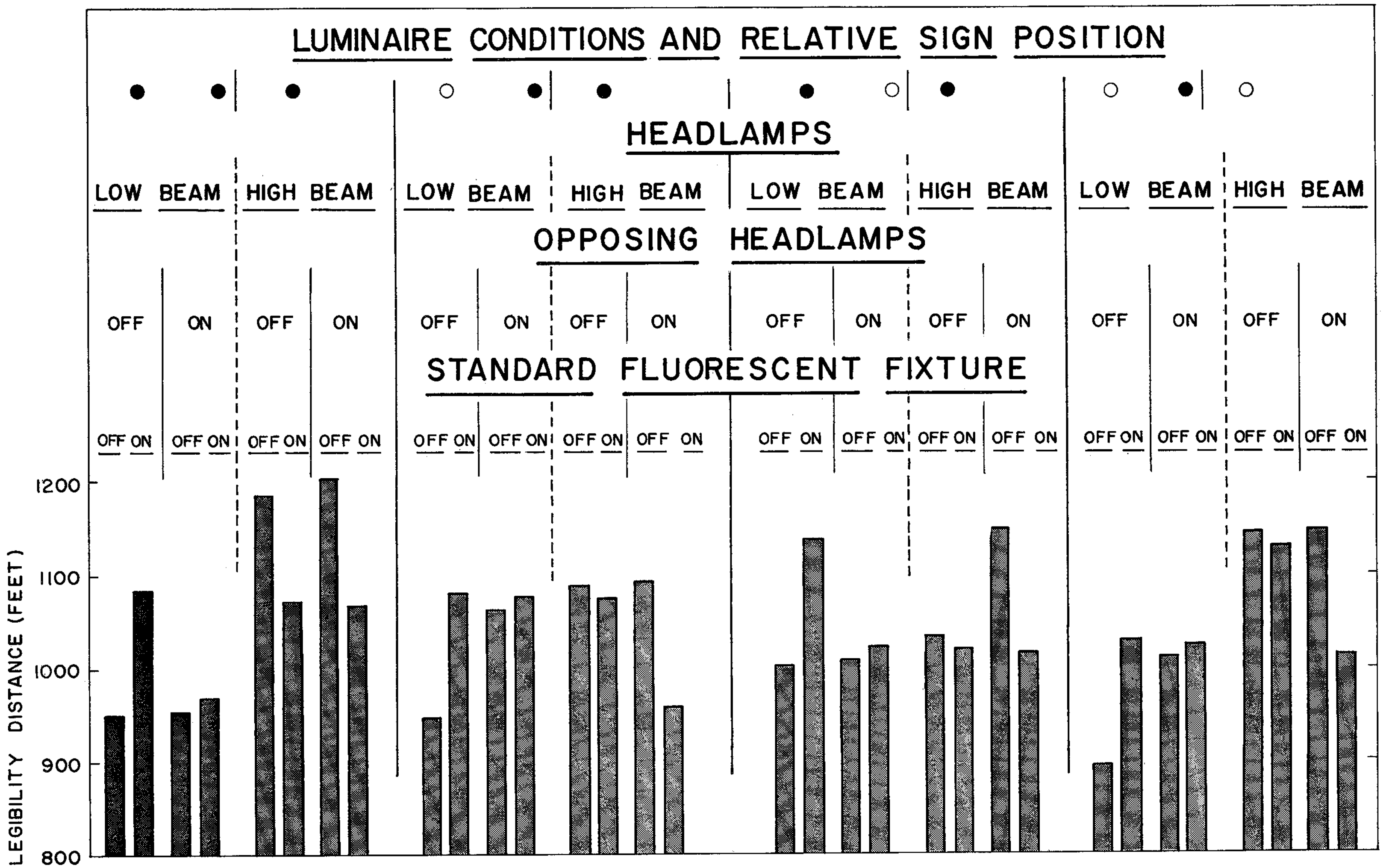


LETTERS: 16" SIGNAL

BACKGROUND: SCOTCHLITE (FLATTOP)

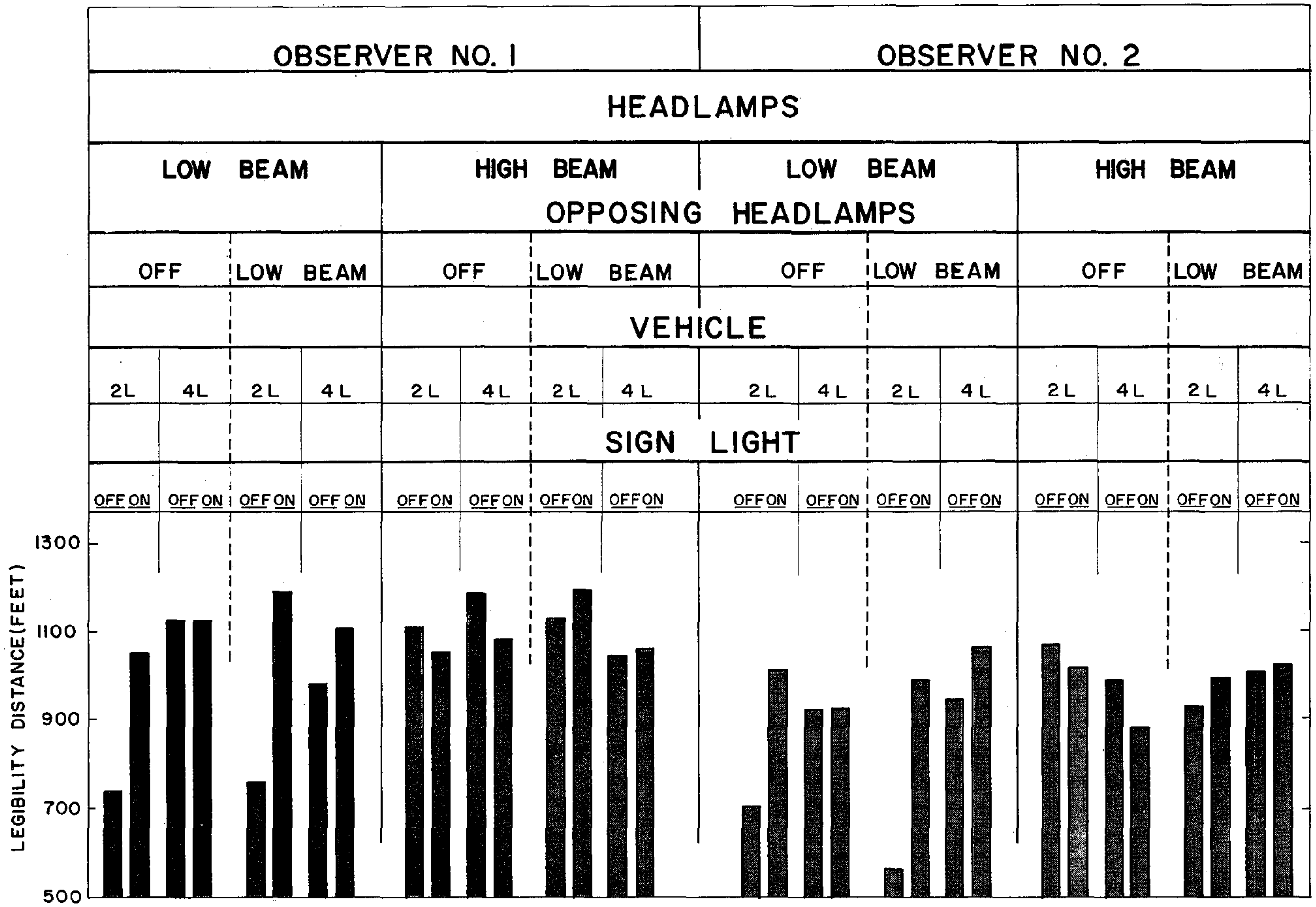
FIXTURE: FLUOROFLOOD (T-12)
MOUNTED ABOVE SIGN

FIGURE A—2



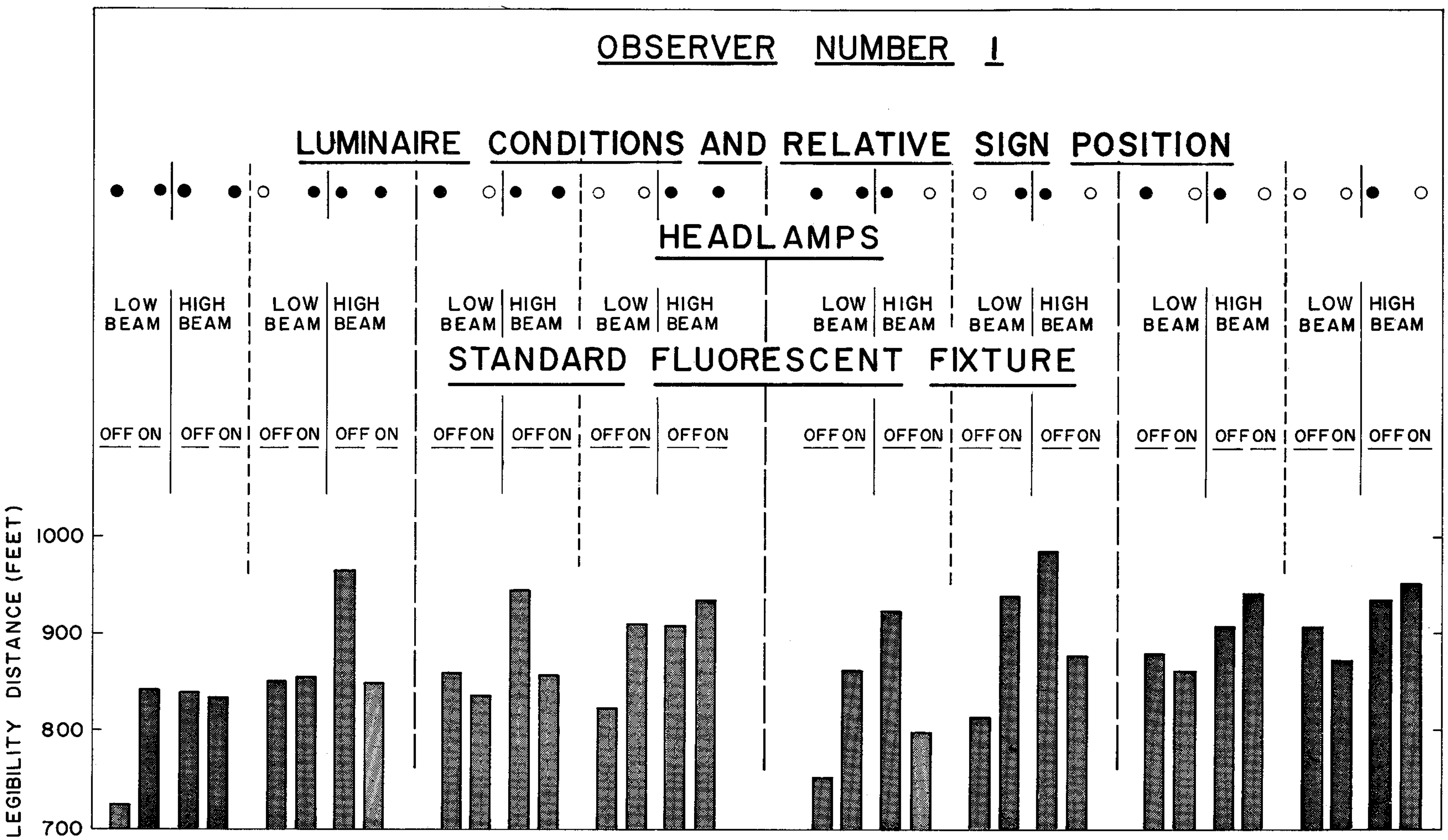
LETTERS: 16" STIMSONITE
BACKGROUND: PORCELAIN ENAMEL
FIXTURE: STANDARD (T-12)
MOUNTED BELOW SIGN

FIGURE A-3



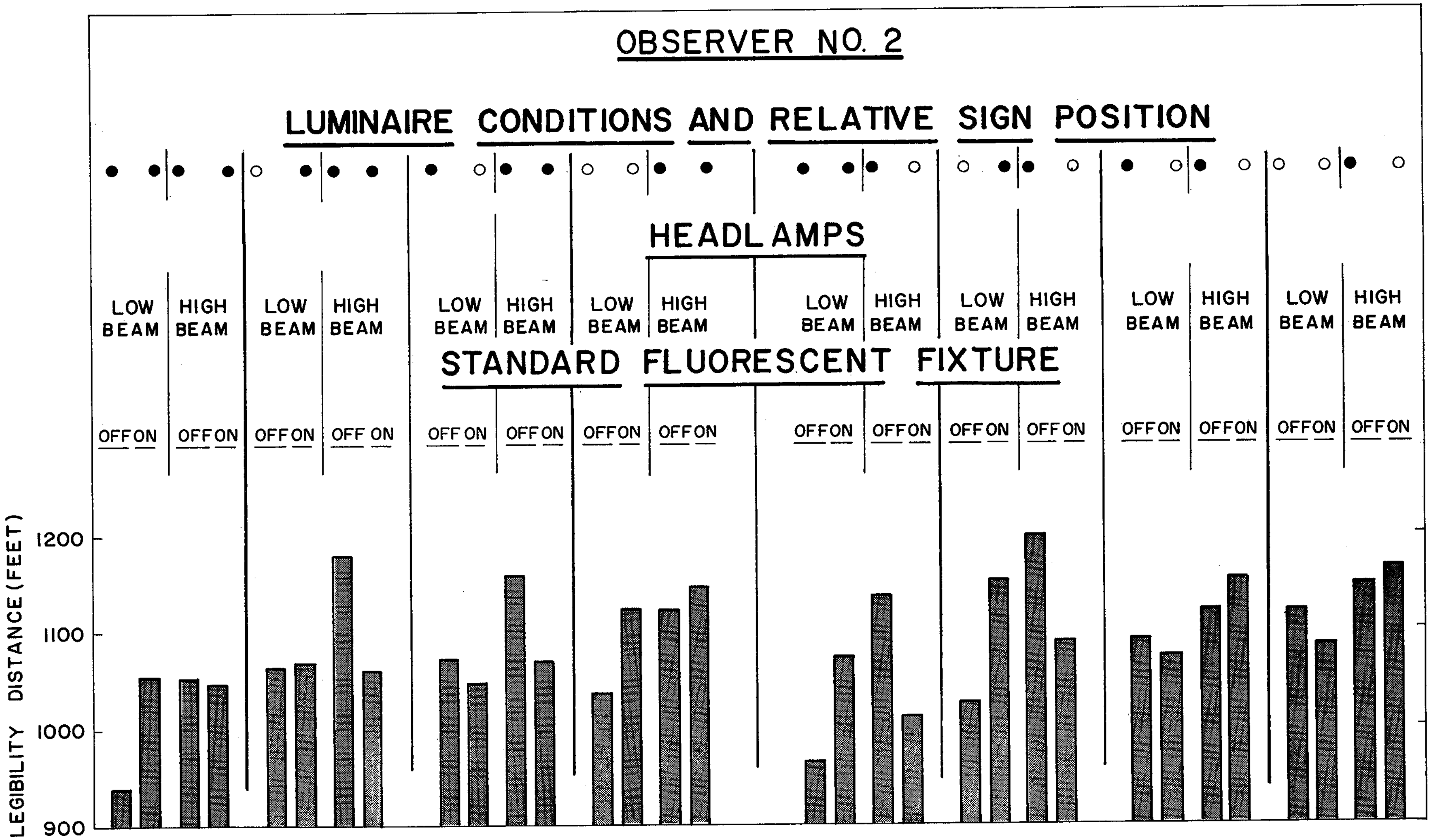
LETTERS: 16" STIMSONITE
BACKGROUND: PORCELAIN ENAMEL
FIXTURE: STANDARD (T-12)
MOUNTED BELOW SIGN

FIGURE A-4



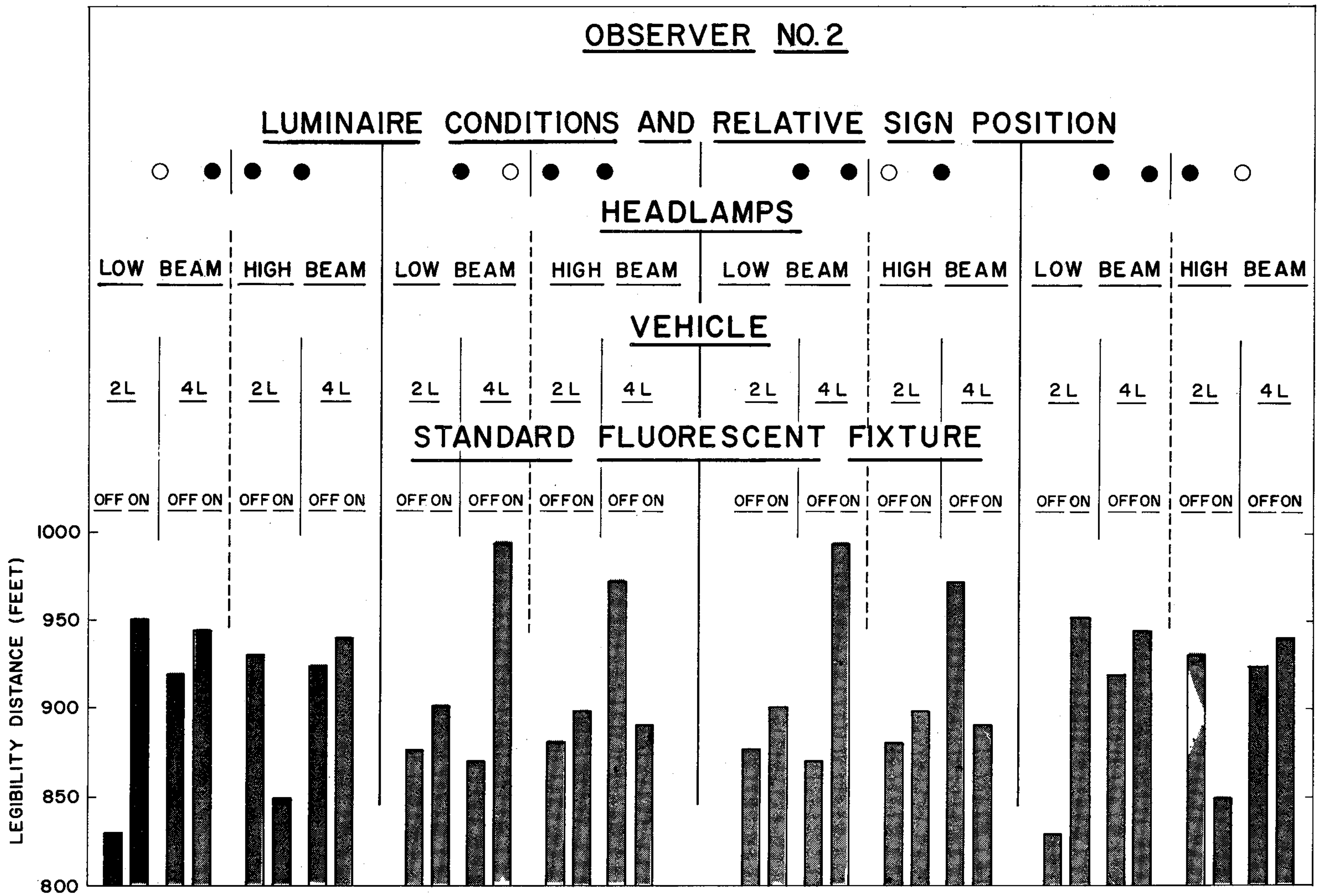
LETTERS: 16" STIMSONITE
BACKGROUND: PORCELAIN ENAMEL
FIXTURE: STANDARD (T-8)
MOUNTED BELOW SIGN

FIGURE A-5



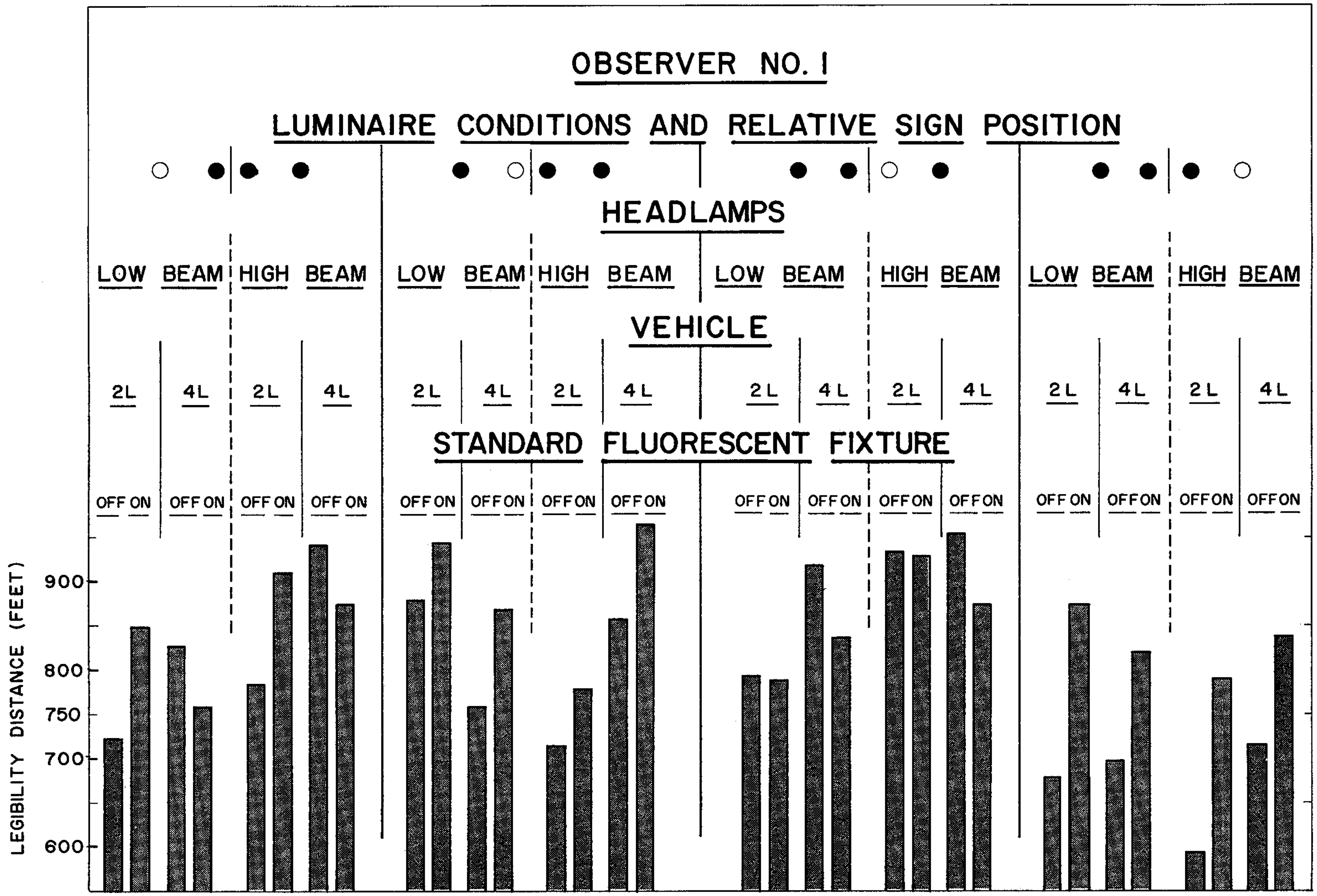
LETTERS: 16" STIMSONITE
BACKGROUND: PORCELAIN ENAMEL
FIXTURE: STANDARD (T-8)
MOUNTED BELOW SIGN

FIGURE A-6



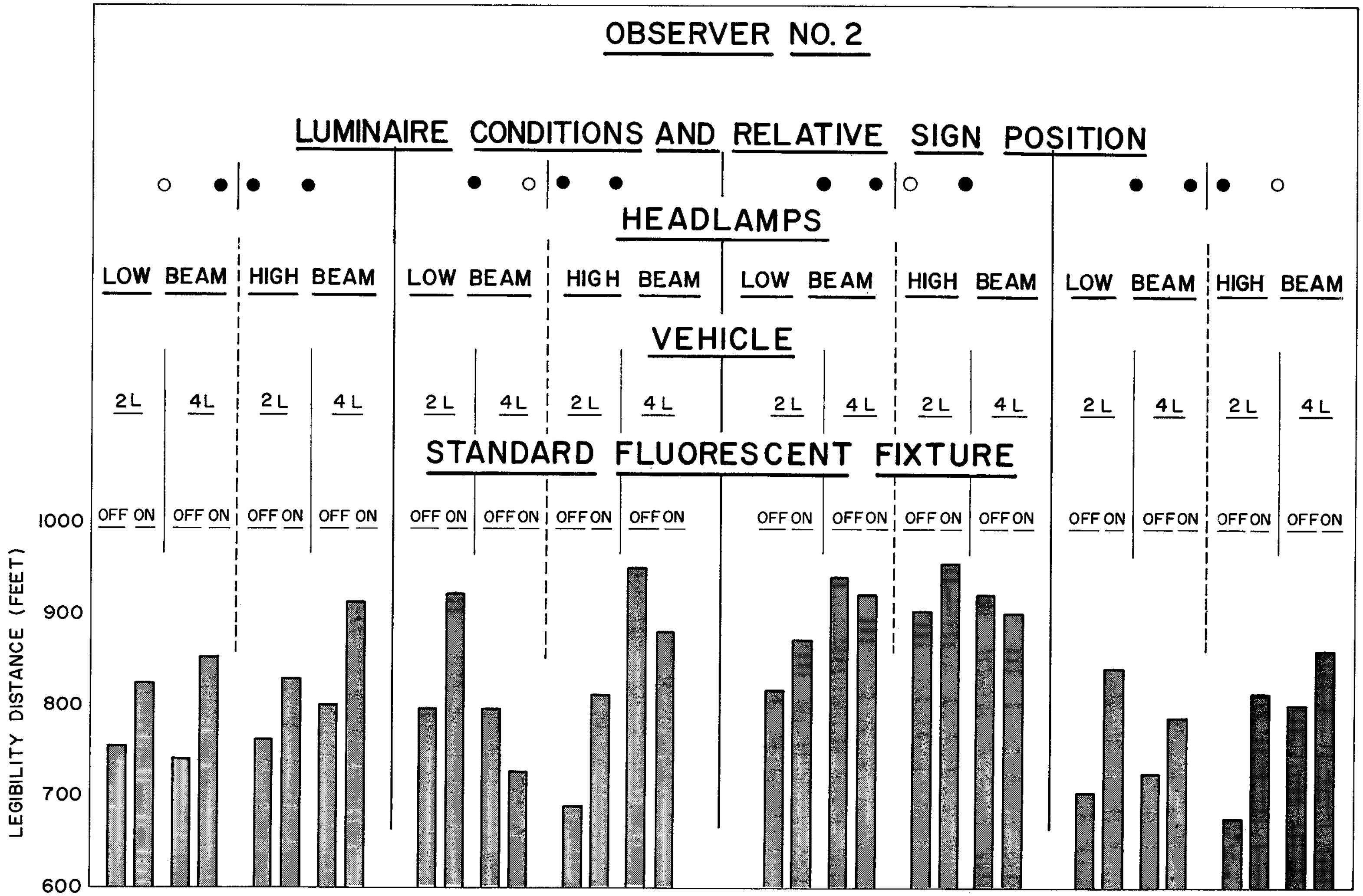
LETTERS: 16" STIMSONITE
BACKGROUND: T.H.D. REFLECTORIZED
FIXTURE: STANDARD (T-8)
MOUNTED BELOW SIGN

FIGURE A-7



LETTERS: 16" SIGNAL
BACKGROUND: T.H.D. REFLECTORIZED
FIXTURE: STANDARD (T-8)
MOUNTED BELOW SIGN

FIGURE A—8



LETTERS: 16" SIGNAL
BACKGROUND: T.H.D. REFLECTORIZED
FIXTURE: STANDARD (T-8)
MOUNTED BELOW SIGN

FIGURE A-9

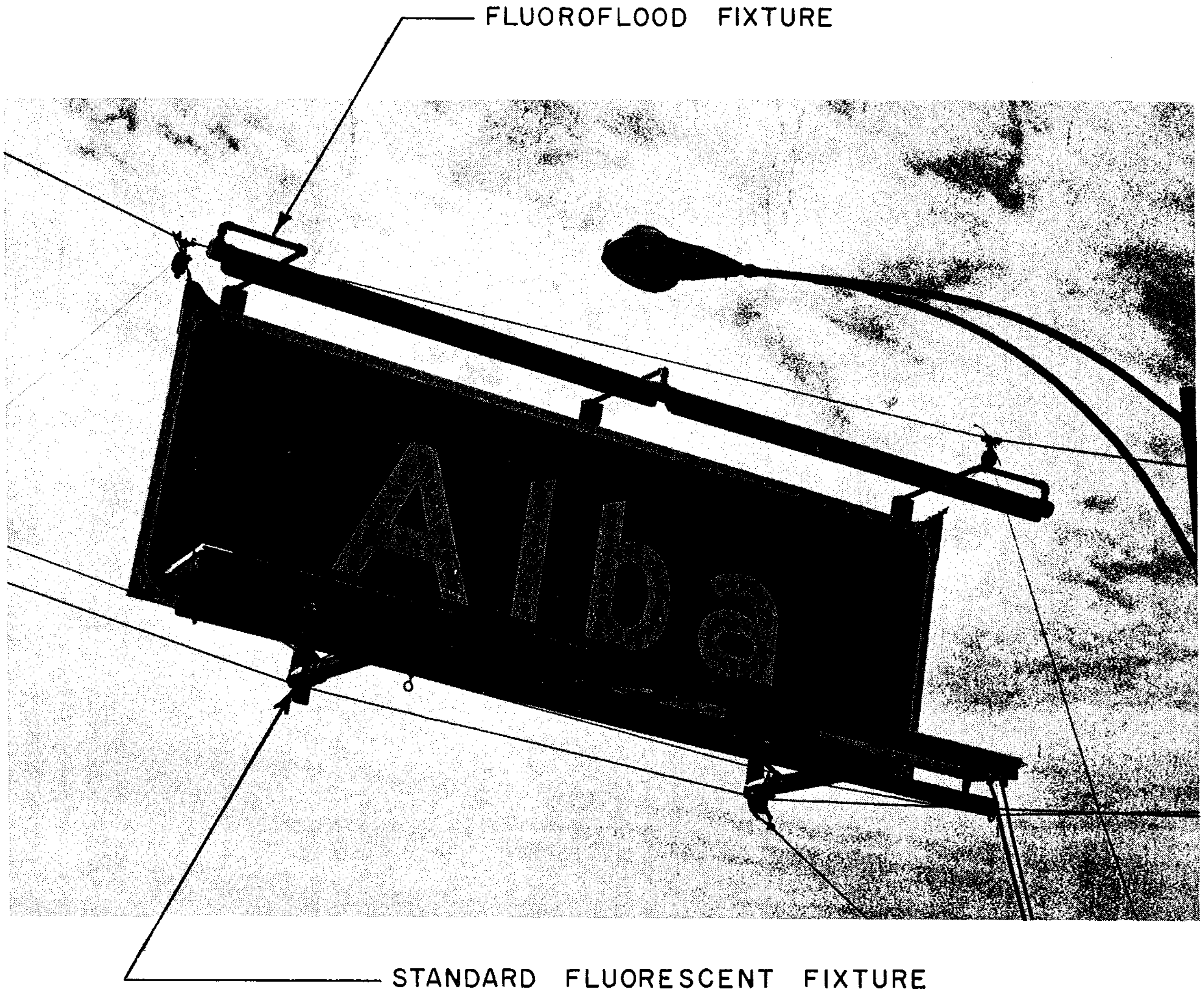


FIGURE A-10