More Light on the Headlighting Problem

VAL J. ROPER and G. E. MEESE
Miniature Lamp Department, General Electric Co., Nela Park, Cleveland, Ohio

•IS there any practical way that seeing can be improved with the lower beam? Can the annoyance of headlamp glare be reduced? What is the effect of the headlamp mounting height on today's cars? How about the new quartz iodine headlamps that are being promoted in Europe? How much does alcohol—in the driver—affect seeing distances? Answers to these questions were sought in a recent series of seeing-distance tests using opposing cars with observer-drivers and observer-passengers. The procedure was similar to that described in "Seeing Against Headlamp Glare." (1)

Two opposing cars, radio equipped and with the test headlamps, were started some 4,000 ft apart on a 2-lane highway, accelerated uniformly to 40 mph with this speed maintained throughout the test run. Test obstacles 16 in. square and with 7 percent reflectance (dark gray) were placed at the right edge of the traveled roadway. There were a total of 10 obstacles, 5 ahead and 5 behind the meeting point. The observer-driver and observer-passenger ignored the obstacles on the left side of the road. They watched for the obstacles on the right side of the road only and indicated the moment of detection by pushing a button. The button actuated a pen which marked a tape recorder geared to the transmission.

A sufficient number of repeat runs were made to get a fair average of the seeing distance values as the two cars approached, passed at the meeting point and proceeded beyond. The data were plotted in curves with the seeing distances as ordinates and the distance between cars as abcissae up to the point of meeting, and the distance behind the meeting point after the point of meeting.

Referring to the question on lower beams of sealed beam headlamps, present lower beams are now manufactured to meet specifications established by the Society of Automotive Engineers. These specifications are intended to cover a beam pattern which represents the best compromise between the requirements of seeing and glare relief. Minimum candlepower values are prescribed for those parts of the beam which are important from the standpoint of seeing ahead, and maximum candlepower values are provided for those parts of the beam which are apt to be directed at the opposing driver's eyes. A very important seeing distance point in the lower beam is the so-called $\frac{1}{2}^\circ$ down, 2° right point, which is $\frac{1}{2}^\circ$ below the level of the headlamp centers and 2° to the right of straight ahead of each headlamp.

Present SAE specifications call for a minimum of 6,000 candlepower at this point from each headlamp and a maximum of 10,000 candlepower at this point from each headlamp.

Figure 1 shows the average seeing distance values on a straight level roadway obtained in these tests for 6,000, 10,000 and 20,000 candlepower (lower beam) at this $\frac{1}{2}^\circ$ down, 2° right point when approaching, meeting and proceeding beyond an opposing car with exactly the same beam candlepower values. Lamps were properly aimed and at 31-in. mounting height. A considerable gain in seeing distances is obtained with the beam providing 20,000 candlepower at the point $\frac{1}{2}^\circ$ down, 2° right.

In reference to the alleviation of headlamp glare, anyone who has the opportunity to take part in tests of this kind soon learns that if the driver when meeting other vehicles at night will always direct his attention along the right edge of the lane of travel (and particularly avoid looking at the opposing headlamps) the annoyance of glare is greatly reduced and the seeing distances considerably increased. Under this condition, one need not focus the attention exactly straight ahead, nor to the left side of the road.

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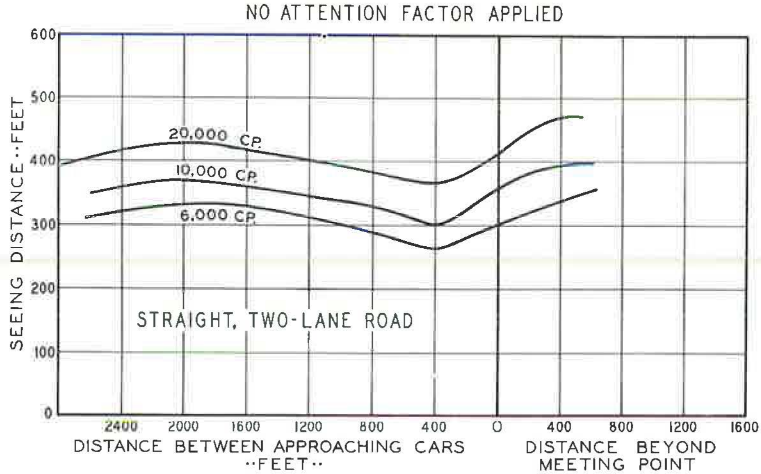

Figure 1. Average seeing distances.

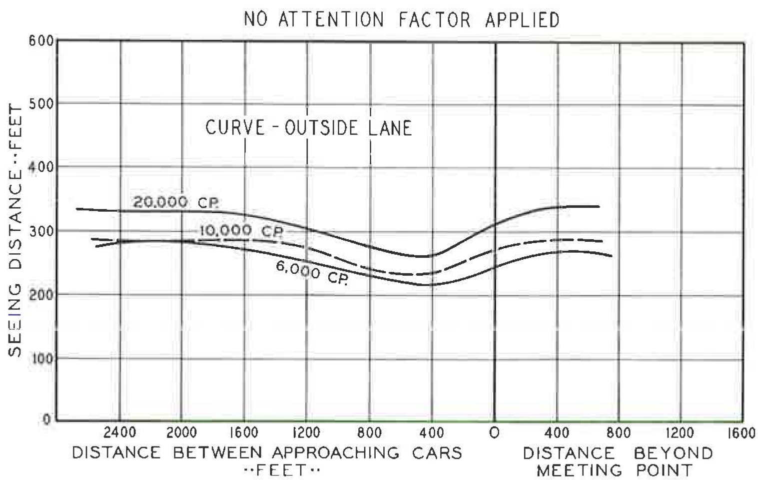

Figure 2. Seeing distances (12,000-ft curve radius).

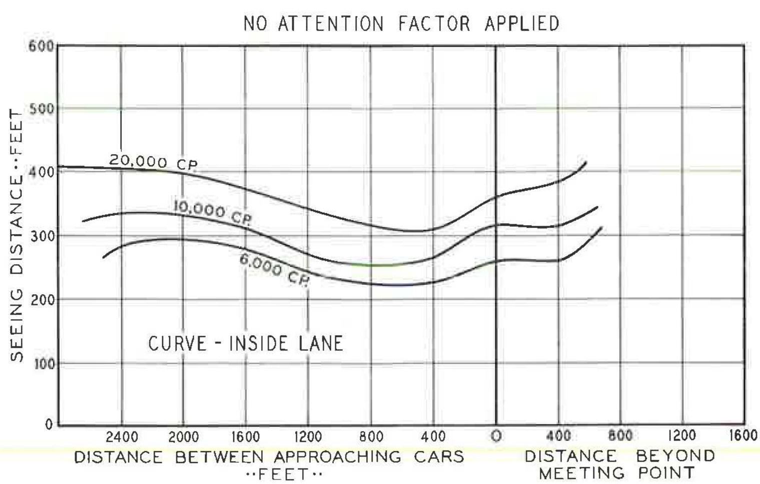

Figure 3. Seeing distances (12,000-ft curve radius).

Peripheral vision is sufficient to detect anything which crosses the road from left to right between the two cars. Fortunately, silhouette seeing (2) also serves to disclose such obstacles.

Although greater seeing distances would result from increasing the candlepower at the specified point to 20,000 on a straight road, what is the effect when negotiating a curve against oncoming traffic? To answer this question, tests were repeated in a similar manner, but while negotiating a curve having a radius of 12,000 ft. During the period of approaching the other vehicle, one of the two cars had its headlamps pointed almost directly toward the opposing vehicle, and the other of the two cars had its headlamps pointed away from the opposing vehicle (Figs. 2 and 3). Figure 2 covers the situation of the driver and observer having the opposing headlamps pointed directly at them; Figure 3 covers the situation wherein the opposing headlamps are pointed away from the driver and observer.

Again, the observers were purposely directing their attention along the right side of the traveled lane, and definitely avoided staring at the opposing lamps. If drivers can be educated to do this, a lower beam providing higher candlepower values near the center of the road or the center of the traveled lane can definitely provide added safety in terms of seeing distances versus stopping distances.

In these tests, the opposing vehicles were in adjacent lanes, with no separation between lanes other than a white line.

On turnpikes or freeways where there is separation between the opposing lanes, the effect of glare is reduced, the more the separation between lanes, the greater the reduction in glare. Therefore on freeway or turnpike driving, the seeing distance capability can be expected to be considerably greater than the values shown in Figures 1, 2, and 3 (1).

In the previous cases, the headlamps on both test cars were properly aimed. Misaim of the lower beam either reduces the seeing distance or increases glare to the approaching drivers. If the candlepower is increased near the top of the lower beam and near the center of the road, there is of course a likelihood of increased glare if the lamps are misaimed high, and/or to the left. To determine the effect of misaim with candlepower at the $\frac{1}{2}^{\circ}$ down and 2° right point, another series of tests was run with 20,000 candlepower from the headlamps on one car and 8,000 candlepower from the headlamps on the other car. The latter candlepower was selected because it is midway between the minimum and maximum candlepower specified by the SAE for this point. Figure 4 shows the results of 20,000 candlepower misaimed up and to the left facing 8,000 aimed correctly and 8,000 candlepower facing 20,000 (misaimed) compared with 8,000 candle-

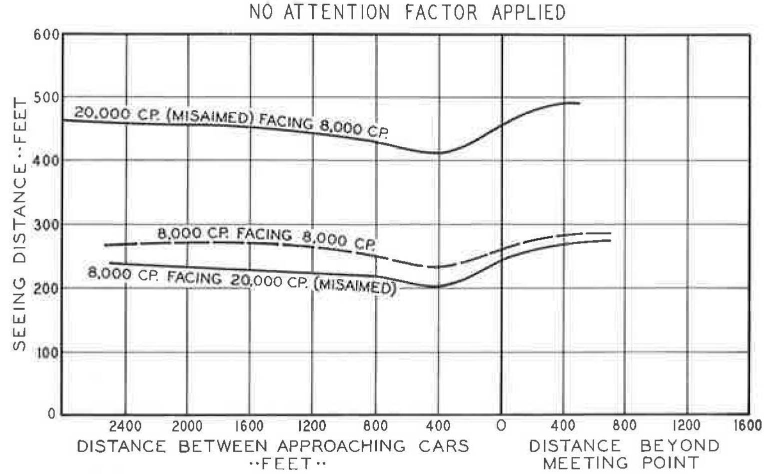

Figure 4. Seeing distances on a straight 2-lane road (for reference the dashed curve shows two cars using production lamps properly aimed).

power facing 8,000. If the lower beam candlepower is increased, the drivers of old cars will suffer some loss in seeing distance when facing new cars if the new car headlamps are misaimed high and to the left, but practically no loss in seeing distance if the new headlamps are correctly aimed.

The effect of headlamp mounting height on seeing distance, in the case of the upper beam which provides high beam candlepower values at the level of the headlamp centers and above, is negligible. Should the upper beam headlamps be mounted much lower than at present (for example, 12 or 18 inches above the ground) shadows would be cast by rough spots in the road which could be annoying; however, this is not a serious factor at the present minimum mounting height of 24 inches from the ground to the center of the lamps.

In the interest of a low silhouette which seems to have popular public approval, the headlamps have been lowered from an average of 30 to 32 inches several years ago to 24 or 25 inches from ground to center of lamps at present. This definitely reduces the seeing distances available with the lower beam because the high candlepower values in the lower beam must be directed below the level of the headlamp centers.

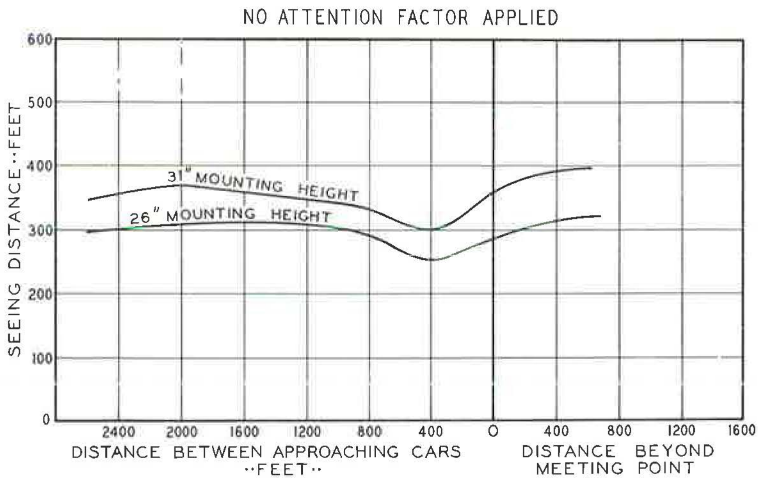

Figure 5. Effect of lamp mounting height.

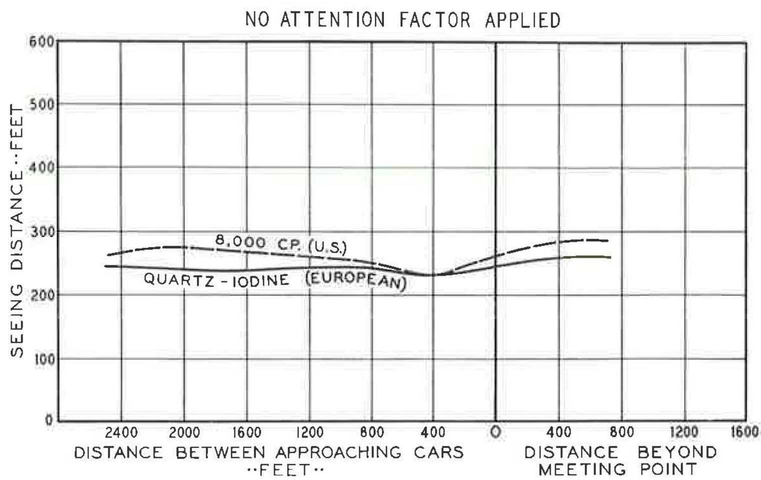

Figure 6. Comparison of production American and European (Form E) lower beams with 62-w quartz-iodine bulbs.

Theoretically, the geometry of the situation indicates that, considering the important seeing distance point $\frac{1}{2}°$ down and 2° right, 10 feet in seeing distance should be lost for every inch the headlamp height is lowered. Therefore, when the headlamp height is lowered from the 31 inches of several years ago to 25 inches now, 60 feet in seeing distance is lost.

As a check, the test of the 10,000 candlepower curve (Fig. 1) was repeated but with the headlamps mounted at 26 inches above the ground instead of the 31-in. mounting height. Figure 5 shows that the average seeing distance loss checks very well with the theoretical calculation.

Although the stylists and the public would probably not accept car designs that would place the tops of the headlamps above the fender or hood line, it should be feasible to raise them a few inches above the present 24-in. minimum value (ground to headlamp centers) with a substantial gain in seeing distances.

In this country, the maximum beam candlepower allowed from the upper beam of headlamps is 75,000. The Uniform Vehicle Code and the laws of the states do not in-

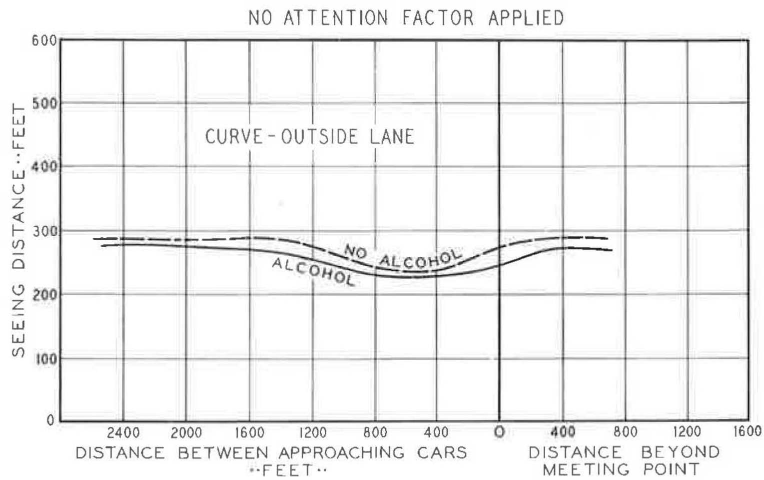

Figure 7. Effect of two "short" drinks on seeing distance.

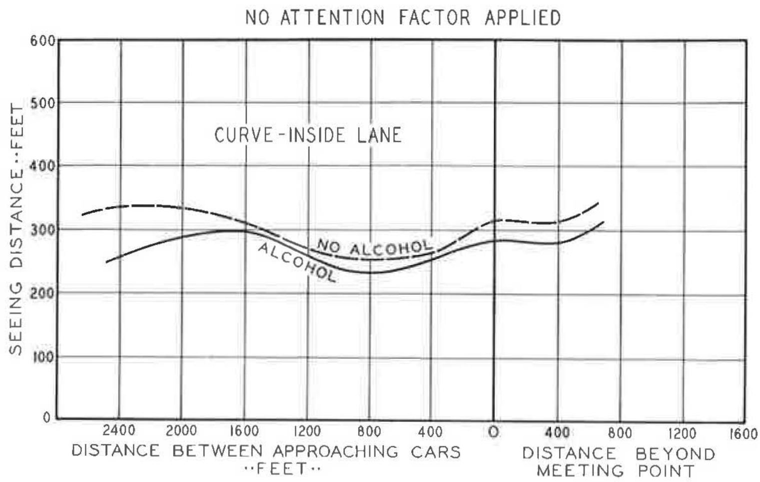

Figure 8. Effect of two "short" drinks on seeing distance.

clude this value. However, it is part of the SAE specifications which most states use as a criterion to determine whether the headlamps justify their approval. The European and international maximum is 300,000 beam candlepower. American engineers and lighting experts feel that any values much above the present SAE maximum of 75,000 would make it virtually impossible to use an upper beam, in view of traffic conditions in the United States. However, for many areas in Europe outside of towns, there is very little traffic, hence their upper beam of considerably higher candlepower gives very pleasing results.

The European lower beam (not including the English lower beam) features a very sharp edge at the top. The filament in the usual parabolic reflector is placed considerably ahead of the focal point, with a shield underneath which shadows the entire lower half of the reflector. This in effect throws away half of the possible light output in the beam, but it provides above horizontal candlepower values which are a fraction of ours.

Comparative tests of the type described in this paper have shown that the typical European lower beam provides less seeing distance along the right side of the road, but more seeing distance along the left side of the road. The reason has been that our sealed beam lower beams have provided more candlepower near the top of the beam on the right-hand side, but the depression on the left-hand side has been an average of about a degree more than that in the case of the European lower beam.

One of the major advantages of the sealed beam headlamp is the elimination of the effect of "bulb blackening." In the case of the quartz iodine lamp, there is very little bulb blackening. Instead of depositing on the bulb surface, the evaporated tungsten redeposits upon the filament. This permits the use of a tungsten filament of higher efficiency and therefore higher brightness.

Through the courtesy of Carello of Turin, Italy, two pairs of European headlamps using quartz iodine bulbs were obtained. These headlamps provided a lower beam only. They were part of a 4-lamp system, the upper beam provided by a separate pair of lamps. Figure 6 shows the comparison of results on the straight level 2-lane road of the Carello lower beam powered by a 62-w quartz iodine bulb and a typical average sealed-beam lower beam of 8,000 candlepower at the specified point. The authors feel that the European design does not take full advantage of the possibilities with the quartz iodine lamps.

Inasmuch as the test road (an as yet unused section of a new freeway) had no traffic other than our own, we decided to measure the effect of "two drinks" after dinner. Therefore, immediately after the test covered by the 10,000 candlepower curves of Figures 2 and 3, in the course of about one-half hour, the drivers and observers had two drinks totaling a little less than three 86 proof ounces and repeated the test. The results are shown in Figures 7 and 8. Incidentally, none of the participants felt that they were at all under the influence of alcohol, yet their seeing distance was reduced.

REFERENCES

1. Seeing Against Headlamp Glare. Illuminating Engineering, Vol. 47, No. 3, March 1952.
2. Silhouette Seeing with Motor Car Headlamps. Trans. IES, 1939.