Aiming for Better Headlighting

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●RECOGNIZING the complexity of the night driving situation, and realizing the problem of evaluating some very pertinent factors that are difficult to include in laboratory or stationary testing, in the early 1930's it was decided to conduct dynamic tests using observer-drivers.

Such dynamic testing automatically includes such factors as the time it takes to see, or one might say the lack of time for seeing under driving conditions, the general environment of the driving condition, and the actual physical effort required in the act of driving.

Over the years, instrumentation was developed to permit the taking of a large number of individual observations over a short period of time, under controlled test conditions. The arrangement used most frequently involves the use of a straight, level, two-lane highway with a useful test stretch of one mile in length. Obstacles were placed at both edges of the travelled road, in known positions. Two opposing cars were placed at each end of the one-mile stretch, at fixed starting points. Each car was equipped with a tape recorder, geared to the transmission. Upon signal, the observer-drivers start, accelerate uniformly to a predetermined speed, and hold that speed for the entire test run. A pen on the tape recorder draws a continuous straight line on the tape. This pen is connected through a circuit to the horn ring. When the observer-driver perceives an obstacle (he watches for those on his right side of the road only), he touches the horn ring which effects a pip in the line on the tape. Since the obstacle positions

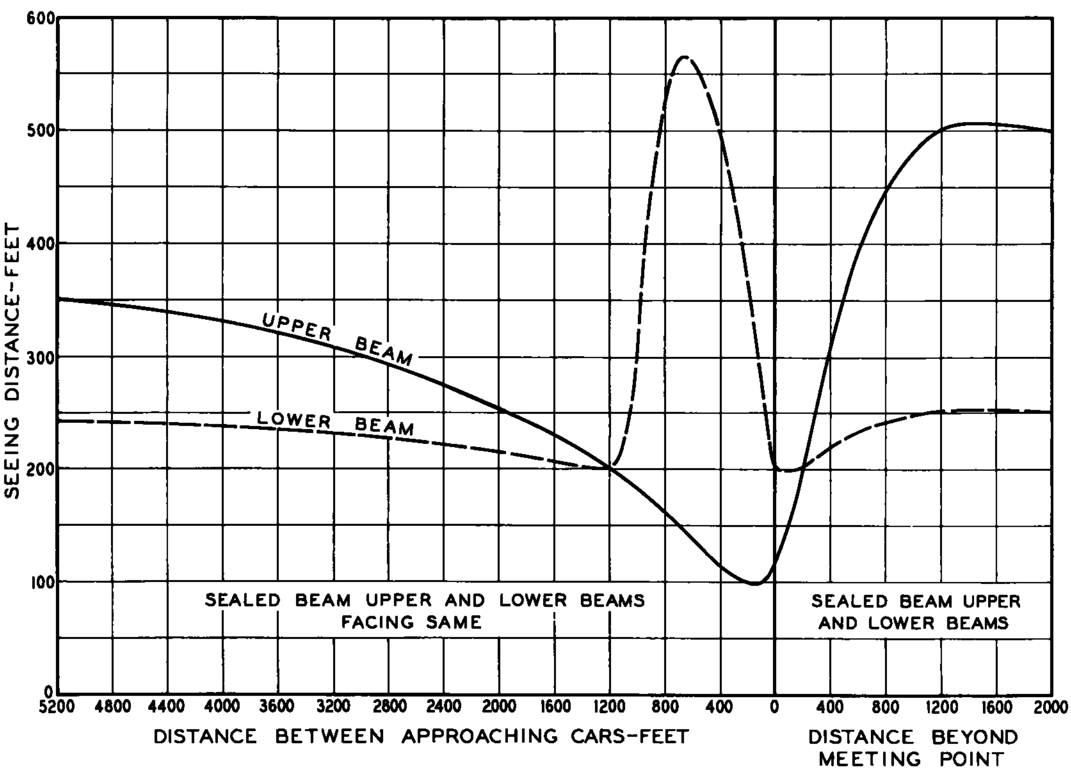

Figure 1. Typical seeing distance curves as two cars approach and pass obstacle - man-size dummy in dark clothing at right edge of road, speed 40 mph.

are known and fixed, their positions may also be plotted on the tape. A dozen or more individual observations may be obtained with each observer for each one-mile test run. This permits the plotting of a seeing distance curve with seeing distance as the ordinate and distances between cars as the abscissa.

The two cars pass at the center point and then the seeing distance values become "clear road" values, with no opposing glare.

Figure 1 shows the results of a series of observations (1) made using the original type sealed beam headlamps, not the new improved variety which appeared on 1956 cars nor the dual-unit type appearing on some 1957 and most 1958 cars.

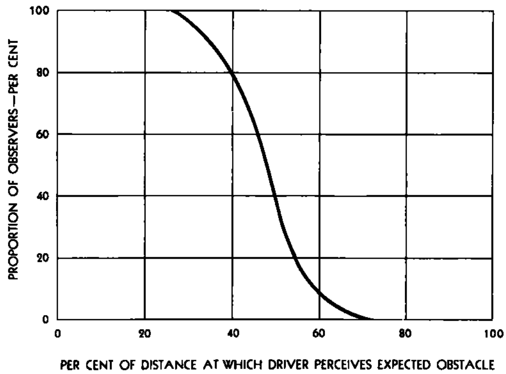

Figure 2. Distance at which driver perceives unexpected obstacle.

The solid curve is for the upper beam, facing the same. The dashed curve is for the lower beam, facing the same. The point where the two curves cross (at 1, 200 ft) represents the optimum distance for depressing the beams.

The sharply rising portion of the lower beam curve (after the two cars approach from 1, 200 ft apart) represents silhouette seeing. That is, for this portion of the curve, the obstacles were seen as dark obstacles against a lighted background.

A dynamic test of this kind is still not fully representative of a typical driving situation. The observer-drivers were knowingly engaged in a test, and therefore they were paying more attention than would the normal driver. They know that there are obstacles ahead, and they are alert to the situation.

It is necessary to know what attention factor should be applied to these data to obtain seeing distance values which would be more typical of normal driving situations.

An I. E. S. paper presented in 1937 (2) described a dynamic test procedure to establish this attention factor, and presented data obtained with a number of observer-drivers. The objective was to use observer-drivers who were unaware of the fact that they were participating in a seeing distance test. This was accomplished by having each drive a test car with the stated objective of criticising the beam pattern. On the return part of the trip, he was directed to a test stretch of roadway in which an obstacle was placed in the center of his lane of travel. Incidentally, the obstacle was attached to a rope, the other end of which was held by a person hiding in the ditch at the side of the road, just in case it would be necessary to avoid physical contact of the obstacle and the car.

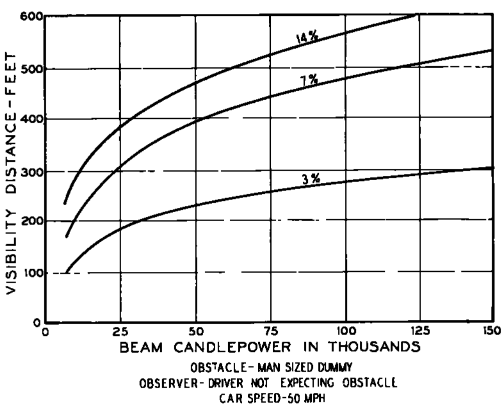

Figure 3. Seeing distance as affected by reflection factor of obstacle.

Upon perception of the obstacle, the driver's reaction was invariably to release pressure on the accelerator. Enough light was provided under the dash so that an engineer sitting beside the driver could observe the instant when the pressure on the accelerator was released, and press a button which actuated a wheel revolution counter. The counter was stopped upon reaching the obstacle. The driver was then informed that this was the real reason for the test trip, and was asked to repeat the test, knowing that the obstacle was there.

Figure 2 shows the distribution of these observations. On the average, the unexpected obstacle was seen just half as far away as the expected obstacle, for the situation of clear road driving.

No test has been devised to determine

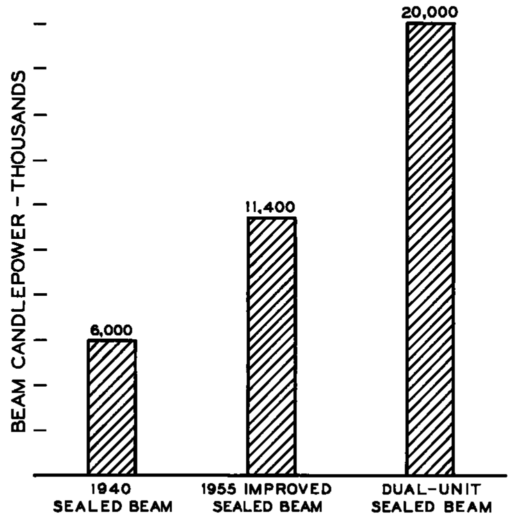

Figure 4. Relative beam candlepower directed 300 ft ahead at right side of road by lower beam.

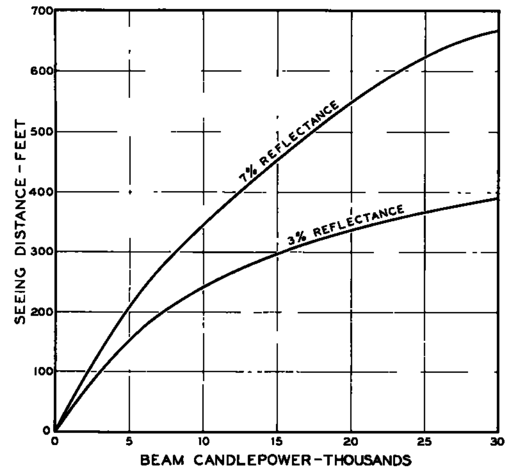

Figure 5. Relation of beam candlepower and seeing distance alert driver - speed 50 mph, no opposing glare.

the attention factor for the situation of meeting other cars. However, it is reasonable to assume that under this condition, one is paying somewhat more attention to one's own lane of travel, and therefore the attention factor is higher than 0. 5, although certainly lower than 1, perhaps about 0. 7 or 0. 8.

Having the attention factor, it becomes relatively easy to obtain a large number of observations with observers knowingly engaged in a test, and establish a relation between beam candlepower values and seeing distance, for clear road driving. Figure 3 shows the relationship of beam candlepower and seeing distance for obstacles of three different reflection factors: 3 percent, which is black; 7 percent, medium gray; and 14 percent, light gray. In this case the car speed was 50 mph and the 50 percent attention factor was applied (2).

Any present-day discussion of headlighting would be incomplete without emphasis of the importance of proper headlamp aiming.

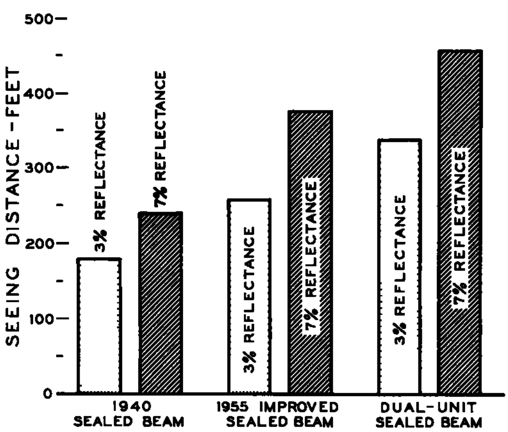

Figure 6. Relative seeing distance capability in direction of area on road 300 ft ahead at right-hand side. Lower beams - alert driver, speed 50 mph - no opposing glare.

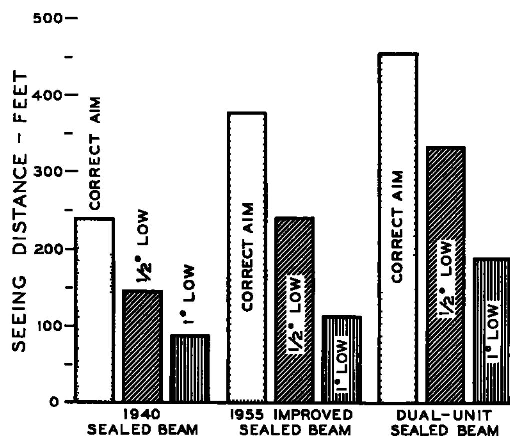

Figure 7. Effect of misaim (low) on seeing distance. Lower beams - alert driver, speed 50 mph - obstacle reflectance 7 percent, no opposing glare.

The specifications of the Society of Automotive Engineers call for minimum and maximum values at various specification points covering both upper and lower beams. One important seeing specification point in the lower beam should be considered. This is a point ½ deg below the horizontal at the level of the headlamp centers, and 2 deg right of the vertical, or right of straight ahead. For average headlamp mounting height, this is a point at the right edge of a two-lane road, 300 ft ahead. It is apparent that this is an important seeing distance specification point in the lower beam. Figure 4 shows the beam candlepower values directed at this point by a pair of lower beams of the 1940 sealed beam variety, the 1955 improved sealed beam, and the 1957 dual-unit sealed beam, all properly aimed.

Figure 5, taken from previous data, shows what these candlepower values mean in terms of seeing distance, with no opposing glare and considering an alert driver—that is, no attention factor applied. The lower curve is for an obstacle of 3 percent reflectance; the upper curve, for an obstacle of 7 percent reflectance. Now combine these data to obtain the charted information in Figure 6—that is, the relative seeing distance capability in a direction of an area on the road 300 ft ahead at the right-hand side with the lower beams, considering an alert driver proceeding at a speed of 50 mph and with no opposing glare. It should be emphasized that these data represent seeing distance capability. It is what may be achieved with the concentrated attention of an alert driver with good eyesight.

It is obvious that the manufacturers have made two improvements recently: with the improved sealed beam lamps installed on 1956 cars, and in the dual-unit system.

However, this is for the condition of perfect aim of the headlamps. What happens when they are misaimed low? Figure 7 shows the more favorable condition of the obstacle of 7 percent reflectance. The left bar for each system shows the seeing distance capability at the point 300 ft ahead with correct aim, the 1940 sealed beam, the 1955 improved sealed beam, and the 1958 dual-unit system.

The center bar shows the seeing distance capability at this same point with the headlamps misaimed ½ deg low, and the right-hand bar for the situation of misaim 1 deg low. Also, this is for the condition of no opposing glare. It can be appreciated from this, that with misaimed headlamps, in normal traffic, and an inattentive driver who may be fatigued after hours of driving, the seeing situation can indeed be serious.

Experience shows that the average headlamps are misaimed by at least ½ deg, oftentimes more. So without spending any money on equipment, the average driver can obtain a considerable increase in seeing distance by simply having his headlamps aimed exactly right.

All sealed beam headlamps are now manufactured with three aiming pads on the front surface of the lens. The front surfaces of these pads are correctly aligned with respect to the aim of the beam. Hence this permits the use of simple, inexpensive mechanical aimers to seat on the front surfaces of these pads and to align the lamps correctly without the need for a darkened area, and hardly more space than that for the car itself.

If the proper attention to headlamp aiming were "sold" to the public and to the service trade, the manufacturers could provide further improvement in headlighting performance, with still more light directed along the right side of the road from the lower beam.

REFERENCES

1. "Seeing Against Headlamp Glare," Illuminating Engineering, Vol. XLVII, No. 3 (March 1952).

2. "Seeing with Motor Car Headlamps," I. E. S. Transactions, Vol. XXXIII, No. 5 (May 1938).