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THE EFFECT OF VEHICLE INTERIOR LIGHTING SYSTEMS ON DRIVER SIGHT DISTANCE

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16. Abstract

A study was conducted to measure the effect of various vehicle interior lighting systems on driver sight distance at night. A new lighting system, in which the sources were contained in the rearview mirror, was compared with the standard system and a control (no lights) in three different vehicles for both forward and rearward visibility. It was found that turning on the interior lights could reduce forward sight distance by as much as 20%. The effect was much more pronounced for rearward sight distance. The new lighting system was better than the standard system in two of the three cars for forward sight distance, and better in all three for rearward sight distance.

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CONTENTS

Introduction

Motor vehicles have long been equipped with interior lighting systems. By and large, these systems seem to be designed to aid in entry and exit, and perhaps in locating articles within the vehicle while it is stationary. However, some form of interior lighting is frequently very convenient and/or desirable while the vehicle is in motion. The most common example is seeking route information (e.g., from a map). Turning on a general interior light for that purpose can significantly alter the driver's level of dark adaptation and create reflections in the windshield, both of which will reduce the drivers's forward sight distance.

In response to this problem, manufacturers have begun equipping vehicles with supplemental lights that are designed to reduce the problems described above. These are often referred to as "map lights." They come in a variety of types, locations, and degrees of effectiveness.

Donnelly/Fisher-Guide have developed a new type of map light, which is built into the inside rear-view mirror. This location is much lower than roof-mounted units, so that the hot source is generally out of the driver's field of view and the area illuminated is smaller and easier to control. The purpose of the research project described in this report was to evaluate the Donnelly/Fisher-Guide system for its effect on driver visibility.

Method

Approach. The intent of this study was to measure effects of various interior lighting systems and map lights on driver forward visual distance under nighttime driving conditions. To do this, measures were made of the threshold luminance of a disk target, seen by the subject through the windshield of a car, under three interior lighting conditions. These were:

a. None

b. Standard system

c. Donnelly/Fisher-Guide system

In addition, with the first car, measures were made with and without the dashboard covered with a black cloth. This was intended to eliminate reflections from the dashboard into the windshield, giving some idea of the extent to which any sight distance decrements were attributable to that source.

Changes in threshold luminance of the disk associated with the vehicle's interior lighting system can be translated to changes in visibility distance. Measures were made in three cars, viewing the target both through the windshield and through the rear window via the interior mirror. The three standard systems used were as follows:

1. Two map lights, located on the ceiling in the center, just to the rear of the front seat (1983 Chevrolet Impala Station Wagon).
2. Two map lights, located near the header in the center (1985 Pontiac Grand Am).
3. Single dome light, located on the ceiling in the center, just to the rear of the front seat (1984 Buick Regal).

In all vehicles, the standard interior mirror was removed and replaced with a mirror supplied by Donnelly/Fisher-Guide that contained the new lighting system. The standard lighting systems were powered by the car battery in the usual way. The Donnelly/Fisher-Guide system was powered by an external, regulated power source operated at 12 volts.

Equipment. Figure 1 is a diagram showing the essentials of the test setup. An indoor storage facility was used, which gave the necessary combination of privacy and control over illumination. The target disk was presented by a piece of equipment located about 20 feet in front of the subject. On the left side of the box as shown in Figure 1 was a solid panel with a three-inch diameter hole cut through. This was covered with white paper.

To the left of the box in the figure was a 35mm Kodak Carousel random access slide projector, its tray containing 22 neutral-density slides ranging from 100% transmission to 0.105%, in steps of about 20%. The output of the projector impinged on the paper-covered hole in the panel mentioned earlier. Inside the display box was a piece of plate glass, set at an angle of about 45 degrees. This reflected about 8% of the illumination reaching it from the projector toward the subject seated in the car.

Behind the display box a fluorescent desk lamp was located, with its output directed toward the far wall of the room. This provided illumination necessary to keep the subject adapted to the mesopic level (i.e., about 0.01 ft-L).

The experimenter was seated at a desk to the right of the test equipment. He was hidden from the subject by a plywood panel. All necessary test controls were located at this desk.

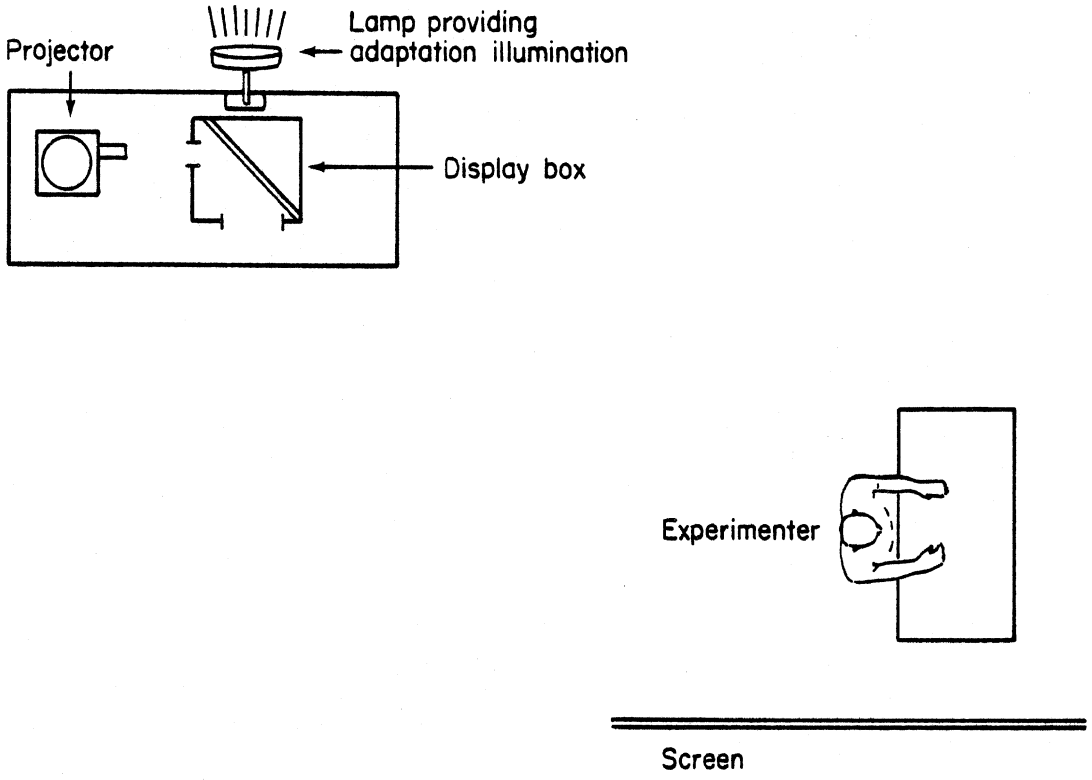

Figure 1. Schematic representation of test setup.

Procedure

The "staircase" method of stimulus presentation was used. In this approach the next stimulus given the subject depends on his/her response to the preceding one. If the subject did not see the disk, on the next trial it is made brighter. If they did see the disk, on the next trial it is made dimmer. To prevent the subject from becoming aware of the strategy being used, two separate sequences are used, with the experimenter switching between them in a random fashion.

Each trial sequence began with the experimenter pushing a "start" button. This caused a beeper to sound as long as the button was depressed. Two seconds after the button press a shutter on the projector opened for two seconds, presenting the stimulus. The subject then pressed one of two buttons on a box in his/her lap, indicating that she/he had or had not seen the disc. This action caused a red (not seen) or green (seen) light to be illuminated on a panel in front of the experimenter. The response was entered and the experimenter then set the projector appropriately for the next trial.

Twelve subjects were used with each configuration. Each was exposed to all of the appropriate conditions in an order that was systematically changed to balance out sequence effects.

Results

The principal results of this study are shown in Table 1 and Figures 2 through 4. These show the threshold luminance of the target disc (averaged across 12 subjects in each case) measured for each condition in the study. Statistical tests were run (T tests), comparing the various conditions. All differences noted are statistically significant at a $p \leq 0.05$ level.

Forward Vision

Results for the subjects looking forward through the windshield are given in Table 1 and Figure 2.

For system one – ceiling mounted maplight:

a) The Donnelly/Fisher-Guide system allowed the same forward vision as with no lights.

b) The Donnelly/Fisher-Guide system and no-lights conditions gave better forward vision than the ceiling mounted maplight.

TABLE 1

THRESHOLD LUMINANCE VALUES FOR TARGET DISC
UNDER VARIOUS VIEWING CONDITIONS

Vehicle	Configuration	Threshold Target Luminance (Ft-L)	
		Front	Rear
System 1 (Chevrolet)	No lights	0.00359	0.00918
	Std. Lights Dash Covered	0.00405	
	Std. Lights Dash Uncovered	0.00433	0.02161
	Donnelly/Fisher-Guide Lights Dash Covered	0.00338	
	Donnelly/Fisher-Guide Lights Dash Uncovered	0.00361	0.01091
System 2 (Pontiac)	No Lights	0.00276	0.00265
	Std. Lights	0.00431	0.01193
	Donnelly/Fisher-Guide Lights	0.00344	0.00394
System 3 (Buick)	No Lights	0.00278	0.00297
	Std. Light	0.00322	0.01360
	Donnelly/Fisher-Guide Lights	0.00303	0.00343

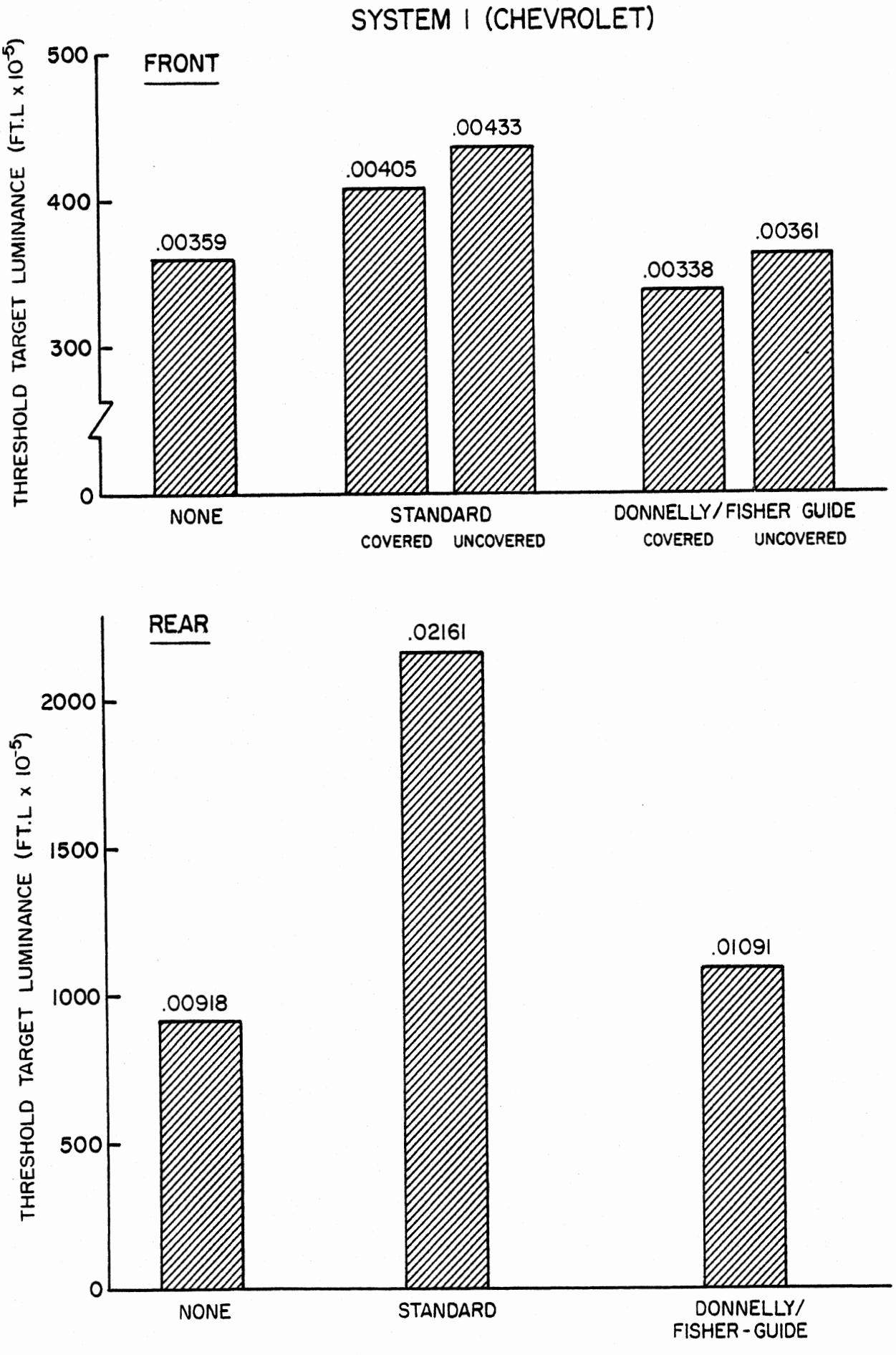

Figure 2. Mean threshold target disc luminance values for system 1.

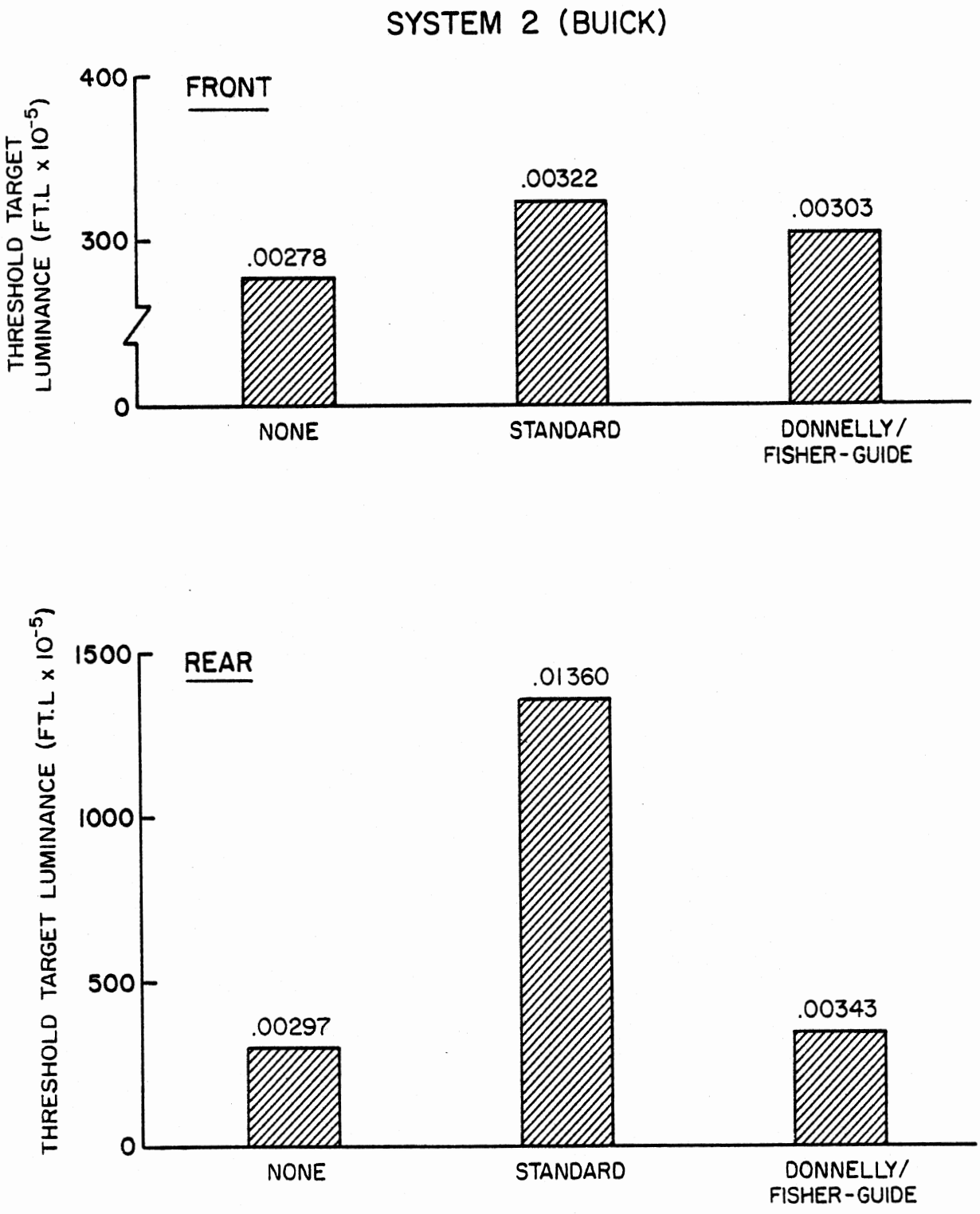

Figure 3. Mean threshold target disc luminance values for system 2.

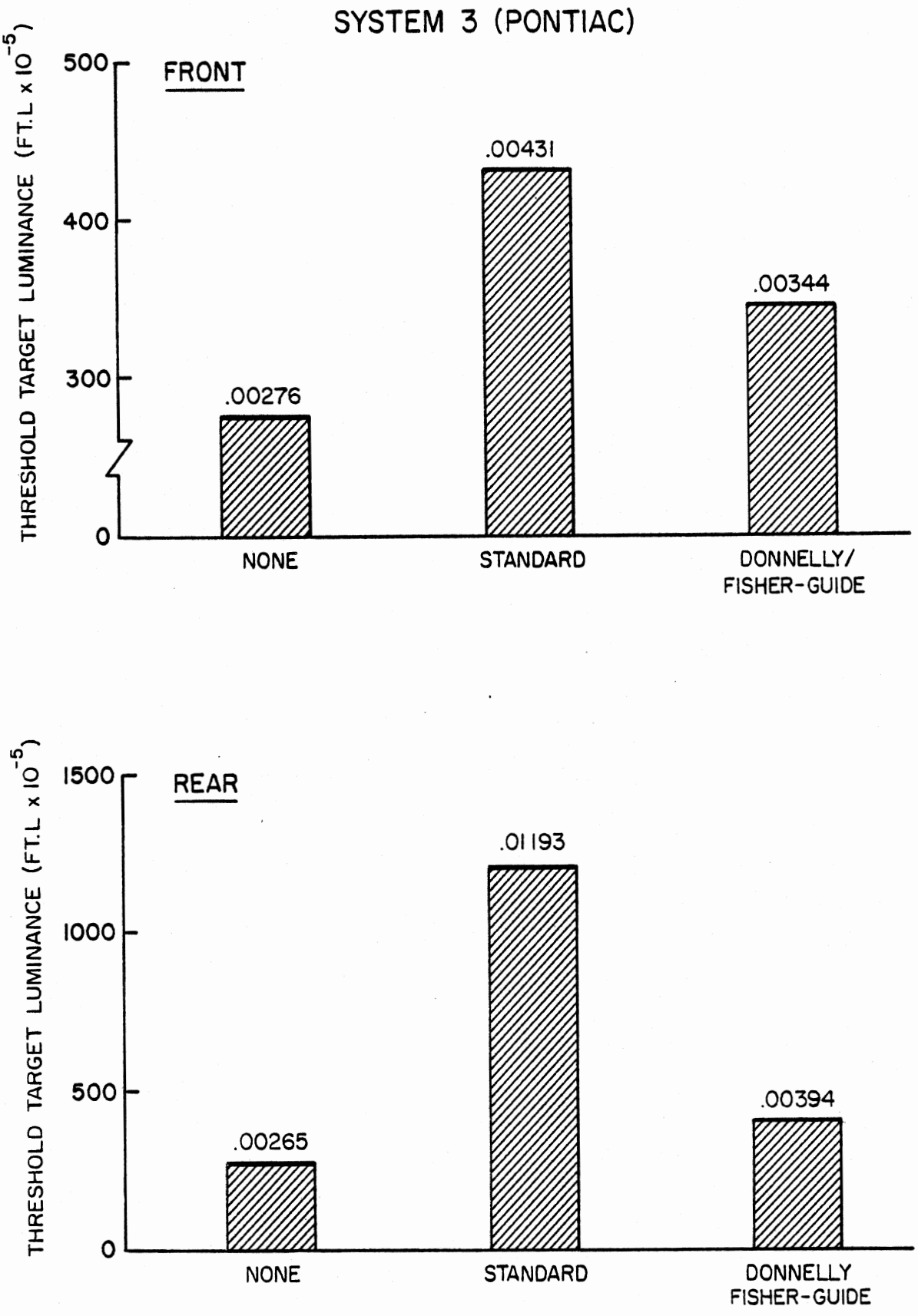

Figure 4. Mean threshold target disc luminance values for system 3.

For system two – header mounted maplight

a) The Donnelly/Fisher-Guide system allowed better vision than the header mounted maplight.

b) No lights gave better forward vision than either system.

For system three – dome light only

a) The no-light condition gave better forward vision than with the dome light.

b) Other differences, although similar to system one and two, were not significant.

The threshold luminance values shown in Table 1 can be translated into approximations of visibility distance. To do this it was assumed that the disk target represented an object having 10% reflectivity, and was so situated that it received 4,000 cd of illumination from each headlamp, for a total of 8,000 cd. Table 2 summarizes the results of these calculations.

TABLE 2

ESTIMATED THRESHOLD VISIBILITY DISTANCES TO A TARGET HAVING 10% REFLECTANCE, ILLUMINATED by 8,000 cd

Car	Configuration	Visibility Distance (feet)
System 1 (Chevrolet)	Donnelly/Fisher-Guide & none (assuming mean of 0.00360)	471
	Standard, covered	444
	Standard, uncovered	430
System 2 (Buick)	None	537
	Donnelly/Fisher-Guide & Standard (assuming mean of 0.00312)	506
System 3 (Pontiac)	None	538
	Standard	431
	Donnelly/Fisher-Guide	482

The information presented in Table 2 suggests that turning on the interior light can have a significant effect on forward visibility. Reductions in these cases range from about 10 to 20%. However, the Donnelly/Fisher-Guide system seems to have the capability of significantly reducing this loss for test systems one and two.

Only system one was tested with the dashboard covered and uncovered. These two conditions were found to be equivalent for both lighting systems.

Rear Vision

Results for subjects looking at the target through the rearview mirror are given in Table 1 and Figure 3. Differences between systems can be summarized as follows ($p \leq 0.05$):

For system one – ceiling mounted maplight

a) The Donnelly/Fisher-Guide system allowed better vision than the standard system.

b) The no-lights condition allowed better vision than either system.

For system two – header mounted maplight

a) The Donnelly/Fisher-Guide system allowed better vision than the standard system.

b) The no-lights condition allowed better vision than either system.

For system three – dome light only

a) The Donnelly/Fisher-Guide system and the no-light condition were equivalent.

b) The no-lights and the Donnelly/Fisher-Guide system allowed better vision than the standard system.

While the differences in threshold luminance are generally much greater for the rear-facing condition, this cannot be translated to visibility distance. However, in the vehicles tested, it is clear that objects behind them, and viewed in the rearview mirror, are much more likely to not be visible when the standard interior light is on. On the other hand, the use of the Donnelly/Fisher-Guide system seems to have relatively little adverse effect.

Summary and Conclusions

The study described in this report was designed to provide information about the relative merits of a new concept in interior lighting for motor vehicles produced by Donnelly/Fisher-Guide Corporation. In particular, the study was concerned with measuring its effect on driver visibility compared to standard lighting systems under night driving conditions. Three cars were tested. In each car a comparison was made between the Donnelly/Fisher-Guide system, the standard configuration and no lights. In addition, some tests were run with the dashboard covered with a black cloth. In general, the findings were that visibility was best with no lights on, and poorest with the standard maplight configuration. The Donnelly/Fisher-Guide system was better than either maplight configuration and in two cases equivalent to the no-light condition.

It seems clear that turning on any interior light has the potential to reduce visibility for the driver. However, the system proposed by Donnelly/Fisher-Guide, and tested by us, seems to offer a significant improvement over at least some of the configurations in use today.