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16. Abstract

An evaluation was conducted of a mechanical beam switching system that may be appropriate for use with HID lamps. Subjects rated the adequacy of the beam change time at several rates, compared with an electrical beam changing system.

The results indicate that subjects rated the mechanical and electrical systems the same, at the shortest change time for the former. Longer change times elicited poorer ratings for the mechanical system. The change from low to high beam was rated better than the change from high to low beam in the mechanical system. This difference was statistically significant at the two slower change rates investigated.

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INTRODUCTION

Switching between high and low beams in a motor vehicle is normally accomplished electrically. The high-intensity discharge (HID) lamps currently under development are characterized by relatively long warm up times. Until this limitation can be overcome, electrical beam switching with such sources may not be practical. In response to this problem a mechanical system has been developed. In this paper the system will be described and an evaluation reported.

THE MECHANICAL BEAM SWITCHING SYSTEM

The mechanical system utilizes a single light source and an internal, motor-driven shutter. On high beam the shutter is retracted. When the operator activates the dim switch, the shutter rotates approximately 90° to its closed position. The relative position of the lens and bulb is also changed slightly.

While the change from one beam to another can be effected in about the same time with either the mechanical or electrical systems, there is a difference in the appearance of the beam in transition. This is illustrated in Figure 1, which compares the appearance of an electrical and mechanical system in transition from low to high beam. It is difficult to accurately capture the appearance photographically, but the mechanical system results in a change that is more evolutionary compared to the electrical system.

PERFORMANCE EVALUATION

An investigation was conducted in which subjects viewed beam changes produced both electrically and mechanically from a driver's perspective. They provided ratings based primarily on the time for the change to take place.

Independent Variables

Time in transition. An electrical and mechanical system were compared. The time required for the mechanical system to change from one beam to the other was varied from 0.3 to 0.9 second in four steps.

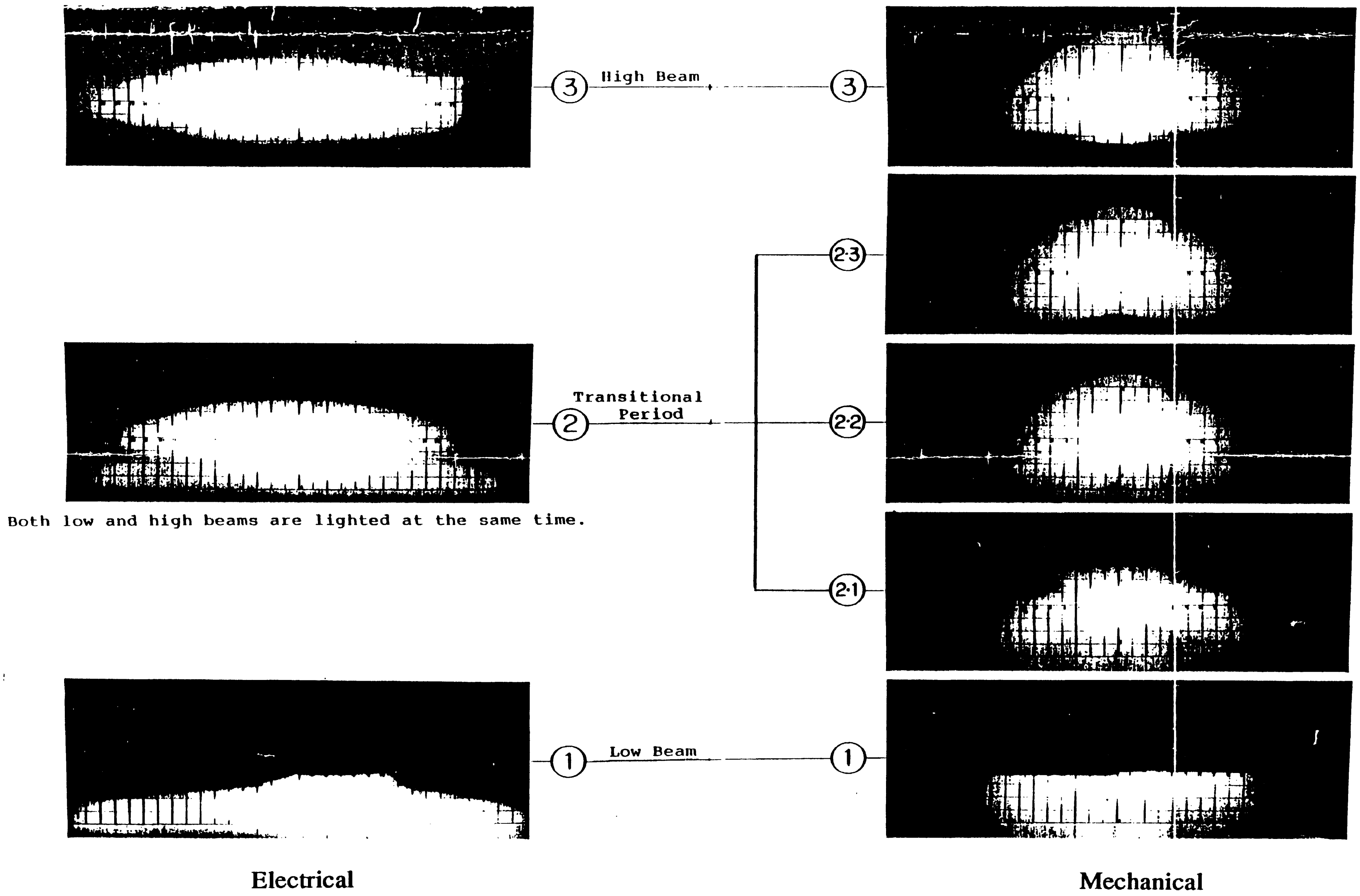


Figure 1. Photographs of high beam, low beam, and transition from one to another effected electrically and mechanically.

Direction of transition. Changes from high to low and low to high beam were evaluated.

Dependent Variable

Subjects provided a rating after each beam change presentation using a five-point scale, ranging from "good" to "too slow."

Subjects

Twelve subjects participated in the study. These were licensed drivers of both sexes. Their ages ranged from 22 to 75.

Equipment

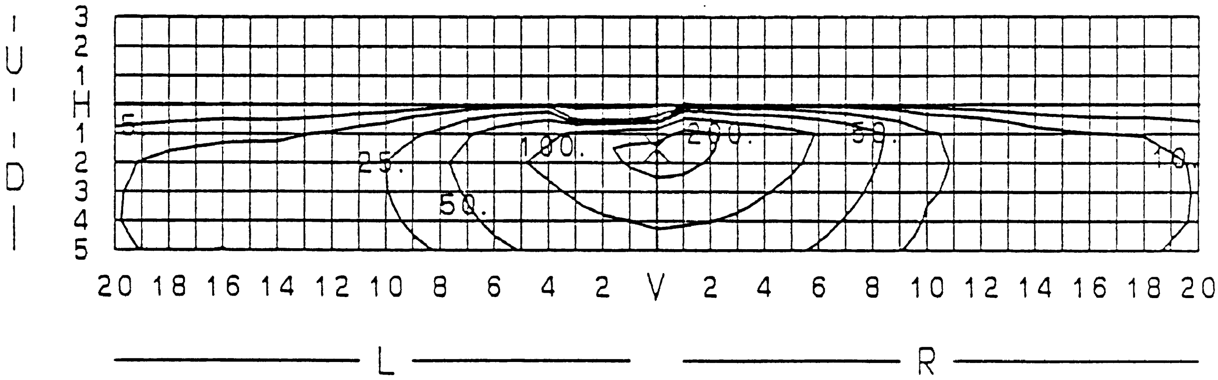
Test lighting units were prepared by the sponsor. There were two such units, complete with necessary controls. They were intended to be mounted on each side of the car and used in place of the conventional headlamps. Each lighting unit contained two halogen lamps. The outboard one incorporated mechanical switching, and could provide both a high and low beam. The inboard lamp was used for high beam only.

Low beam was always provided by the outboard lamp. When using electrical switching the change was between the outboard and inboard lamp. When using mechanical switching only the outboard lamp was used. Thus, low beam was identical for either system. The high beams differed slightly (see isocandela diagrams in Figure 2), but not to an extent that was noticeable to the subjects.

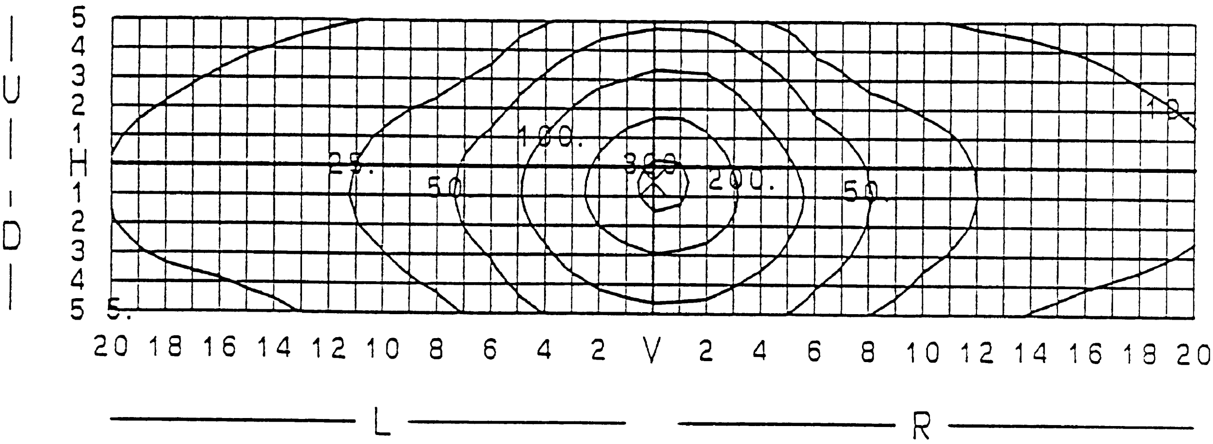
Note in Figure 2 that the appearance of the low beams is suggestive of lamps meeting ECE requirements. They did, however, generally meet SAE standards, as shown in Table 1. Table 2 provides a comparison of SAE high beam standards and the measured performance of each of the four high beam units used in the test.

The lighting units were mounted on the front of a car, at the level of the stock headlamps (i.e., with their centers 30 inches above the pavement). They were driven at 12.8 volts by a regulated power source.

MECHANICAL BEAM-SWITCHING H/L
LOWER BEAM R. H.



MECHANICAL BEAM-SWITCHING H/L
UPPER BEAM R. H.



HIGH-BEAM HEADLAMP
UPPER BEAM R. H.

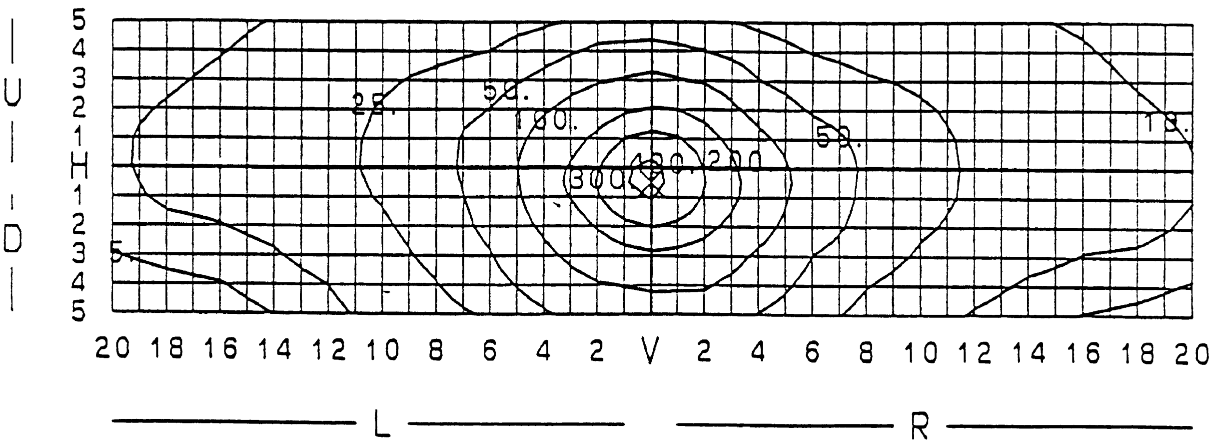
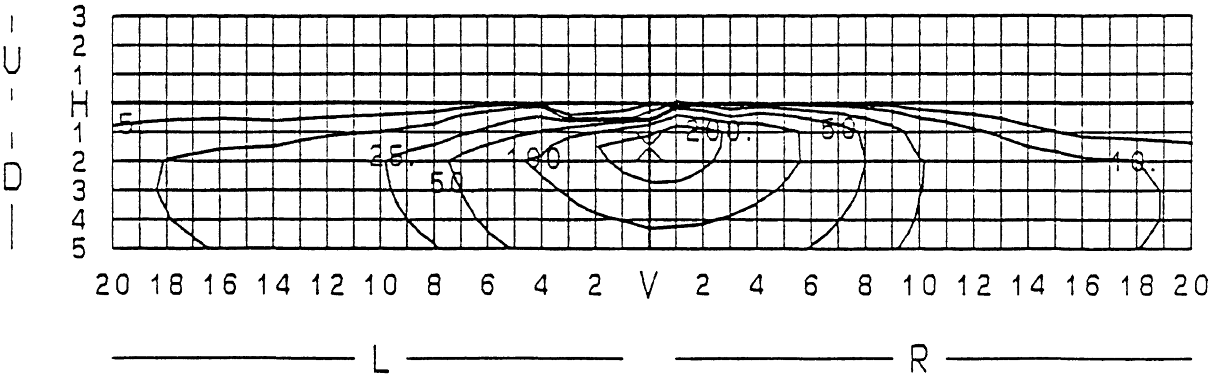
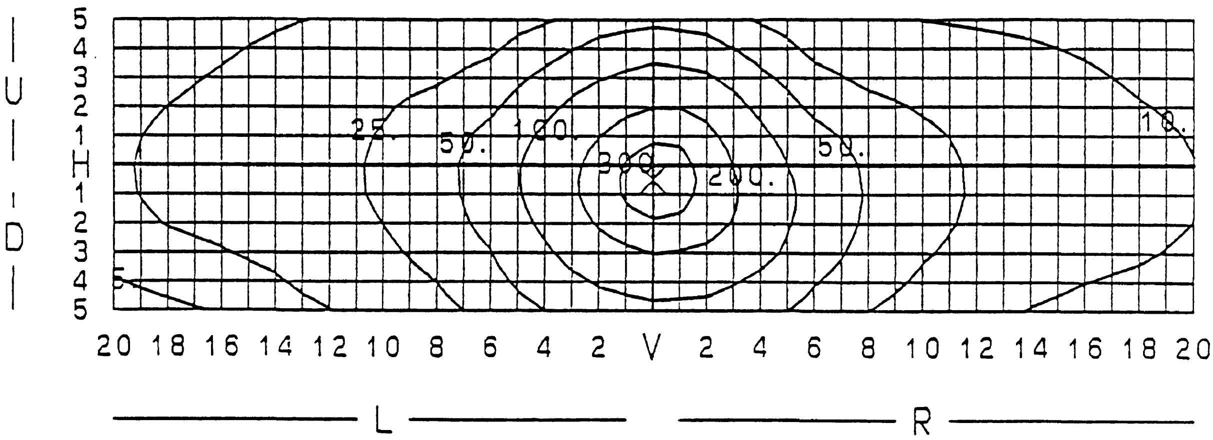


Figure 2. Isocandela diagrams of lamps used in test.
R.H. = Right (passenger) side of car
L.H. = Left (driver) side of car

MECHANICAL BEAM-SWITCHING H/L
LOWER BEAM L.H.



MECHANICAL BEAM-SWITCHING H/L
UPPER BEAM L.H.



HIGH-BEAM HEADLAMP
UPPER BEAM L.H.

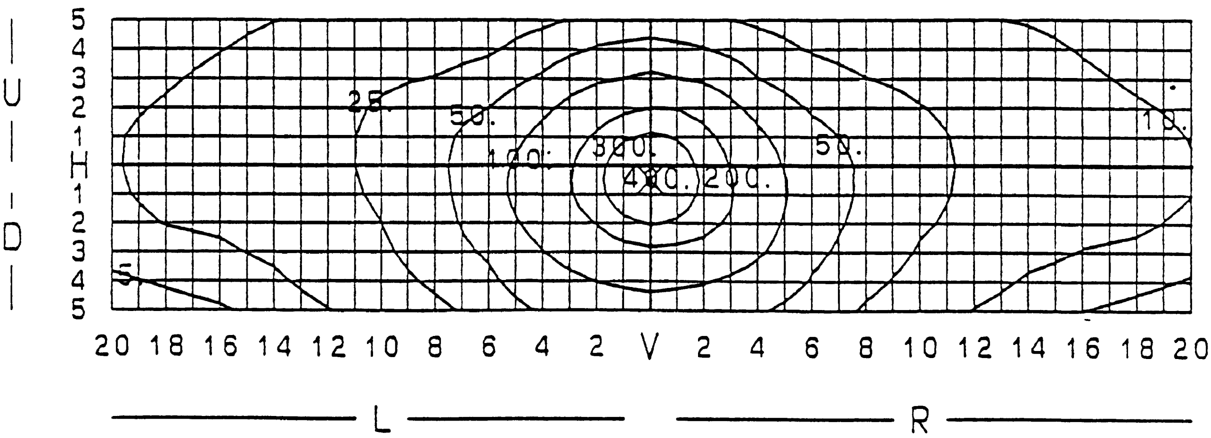


Figure 2. (continued)

TABLE 1
COMPARISON OF REQUIRED AND MEASURED CANDELPOWER VALUES OF TEST LAMPS (LOWER BEAM)

TEST POINT	REQUIRED CANDLEPOWER max. (cd)	REQUIRED CANDLEPOWER min. (cd)	Mechanical Beam-Switching MEASURED APPARENT CANDLEPOWER RIGHT HAND	Mechanical Beam-Switching MEASURED APPARENT CANDLEPOWER LEFT HAND
1U-1.5L to L	700		251	166
0.5U-1.5L to L	1000		266	183
0.5D-1.5L to L	3000		1020	633
1.5U-1R to R	1400		231	166
0.5U-1R to 3R	2700		306	245
0.5D-1.5R	20000	10000	12660	10490
1D-6L		1000	5180	2600
1.5D-2R		15000	19540	22900
1.5D-9L		1000	3300	2850
1.5D-9R		1000	3250	3230
2D-15L		850	1600	1188
2D-15R		850	1725	1181
4D-4R	12500		7020	8340
10U to 90U	125		83	115

TABLE 1 (continued)
COMPARISON OF REQUIRED AND MEASURED CANDELPOWER
VALUES OF TEST LAMPS
(UPPER BEAM)

TEST POINT	REQUIRED CANDLEPOWER max. (cd)	REQUIRED CANDLEPOWER min. (cd)	Mechanical Beam-Switching MEASURED APPARENT CANDLEPOWER RIGHT HAND	Mechanical Beam-Switching MEASURED APPARENT CANDLEPOWER LEFT HAND	Standard High Beams MEASURED APPARENT CANDLEPOWER RIGHT HAND	Standard High Beams MEASURED APPARENT CANDLEPOWER LEFT HAND
2U-V		1500	27300	20300	19250	22800
1U-3R		5000	17320	13330	18860	20300
1U-3L		5000	17630	15070	14840	15420
H-V	75000	40000	41800	43300	40300	41700
H-3R		15000	20200	18380	23700	24200
H-3L		15000	20000	18980	17990	18040
H-6R		5000	7600	7170	8310	8620
H-6L		5000	7720	7010	5860	7000
H-9R		3000	4530	4140	3910	4300
H-9L		3000	4130	3820	3080	3490
H-12R		1500	2960	2800	2360	2630
H-12L		1500	2740	2430	1944	2240
1.5D-V		5000	29700	38500	36400	35000
1.5D-9R		2000	4080	3970	3660	3990
1.5D-9L		2000	3870	3330	2700	3090
2.5D-V		2500	18110	27400	23600	21800
2.5D-12R		1000	2270	2310	1950	2050
2.5D-12L		1000	2130	1752	1431	1721
4D-V	12000		8600	11840	10860	10930
Maximum Candle Power			42000	43300	41700	42100
Location			0.2D-V	0.4D-V	0.4D-V	0.3D-V

PROCEDURE

The original intent was to run the study while driving. After some thought, however, this plan was abandoned. A driving test would have slowed data collection greatly, due to the necessity of waiting for clear spaces before using high beams. We were also concerned about safety, since the driver would be, to some extent, concentrating on the beam change instead of the driving task.

The test was run on an asphalt pad in an unlighted area at night with the test vehicle stationary. Four subjects were run at a time, two seated in front and two in the rear. To start each trial the headlamps were turned on, exhibiting either a high or low beam. After a period of about five seconds the lamps were switched to the other beam and remained in that position for another five seconds. The lamps were then switched off while the subjects made their ratings.

A total of ten conditions were tested (electrical switching, plus four transition time levels of the mechanical switching, plus high to low and low to high beam on each). Seven replications of each of these were shown to the subjects, in a random order, making a total of 70 trials. With time for instructions and practice, the actual testing took about one hour for each subject group.

RESULTS AND DISCUSSION

The data were analyzed by ANOVA, and followed up with post-hoc tests (Student-Newman-Keuls). The original analysis found that all main effects were significant at or beyond the 0.01 level.

The results of the investigation are summarized in Figure 3. The figure shows the mean ratings assigned each of the conditions. Each data point is the mean of 84 ratings. It was found that the electrical and 300 msc. mechanical systems yielded ratings that do not differ significantly (i.e., $p > 0.05$). Ratings became poorer as transition time increased.

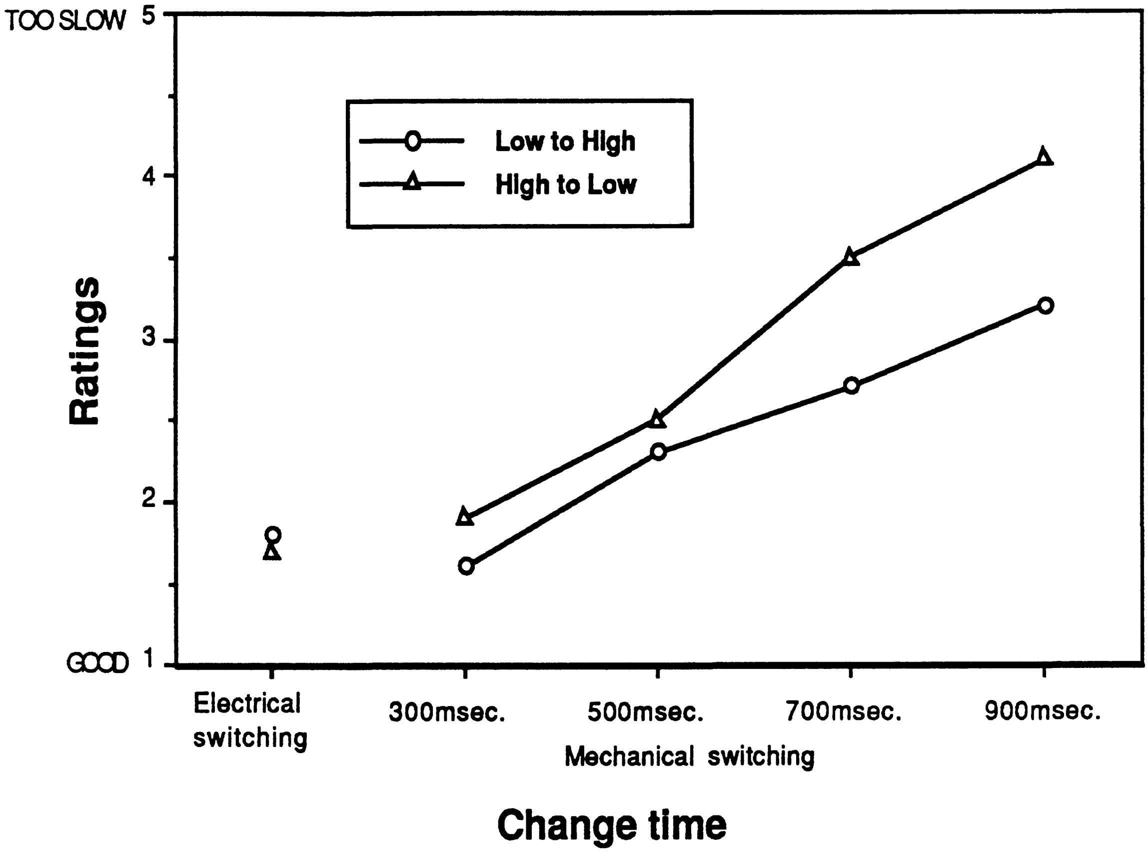


Figure 3. Mean ratings of configurations tested.

There was a tendency with the mechanical system to rate the transition from low to high better than the transition from high to low. This difference is not significant at the two faster speeds, but is ($p < 0.05$) at the two slower speeds. Indeed, at the 700 and 900 msc. transition speeds the mean difference in ratings is almost one unit on the rating scale. Since the focus of the ratings was on the adequacy of the speed of the transition, and the transition time was the same regardless of the direction, these findings are surprising. Whatever the explanation, it does suggest that the transitioning characteristics of the mechanical system are such that a noticeable qualitative difference exists between changes from high to low and low to high. This difference apparently becomes easier to see and more objectionable at slower transition speeds.

The results of this investigation indicate that the mechanical system tested, when used at a transition speed of approximately 300 msc., is as effective as conventional electrical switching. It thus appears to be a viable approach for use with HID lamps or any other system in which conventional electrical switching is not practical for any reason.