Some Results of Cooperative Vehicle Lighting Research

THOMAS R. KILGOUR, Chrysler Corporation

● THE FIRST ELECTRIC LAMPS installed on motor vehicles replaced kerosene and acetylene lamps which were troublesome and inconvenient accessories, in the opinion of early motorists, but necessary to provide what was then a maximum of safety for night driving. Perhaps in some cases the amount of illumination was no better with the electric lamps than that which had been provided by the earlier devices, but the greater convenience was an obvious advantage.

Questions of convenience and safety have continued to dominate the automotive lighting problem. Increasing use of motor vehicles at night, greater concentrations of traffic, and the development of lens systems for more efficient lighting have been the principal factors affecting development of automotive lighting equipment in the years since then.

Lighting came to be more than just the provision of marker lamps or even the provision of a beam of light to give the motorist a path to steer. There came problems of controlling glare so other motorists would not be inconvenienced or subjected to hazard. In addition, lighting equipment became a primary source of signalling. First, the stop lamp at the rear of the vehicle came into existence and, in more recent years, turn signal lamps and other variations of signalling devices, both for daytime use and nighttime use.

The technical problems associated with motor vehicle lighting have thus changed substantially. The modern highway systems and new conditions of driving continue to exert influences that will change the technical problems to be dealt with in the future.

Meanwhile, the responsibilities for the performance of lighting equipment also shifted. Initially, the electric lamps were supplied by electrical manufacturers as optional equipment, entirely at the discretion of the motorist himself. Legal requirements early appeared in the laws and regulations of various states, making it necessary to provide a minimum of lighting equipment on every vehicle, so the vehicle manufacturer then had an interest and a responsibility.

As the motor vehicle and its use problems developed in complexity, there were increasing demands for more efficient equipment. The adoption of electrical systems on vehicles soon reached the point where basic lighting was standard equipment, usually considered as an integral part of the vehicle structure and assembly even though the lamp units were still mounted separately on brackets rather than being incorporated into the structure physically.

A great deal of originality was displayed in some of the early lighting equipment, but sometimes with disregard for such practical problems as the glare which annoyed other drivers or the inconvenience of trying to find a source of replacement for some unusual shape of lamp, reflector, lens or other component. Incidentally, it appears that lamp brackets, bases and sockets were among the earliest items of automotive equipment to be standardized on a national level.

Vehicle manufacturers accepted an increasing responsibility for the development and installation of lamps and were well oriented to the complexities of the vehicle lighting problem at the time that state motor vehicle administrators first began to deal on a cooperative and more or less uniform basis with lighting problems in the early 1920's.

For about 15 years this cooperative approach was largely centered in the northeastern section of the country, where the concentration of motor vehicles was greatest. During this period a more national point of view developed to the point where, about 1935, the time was ripe and the circumstances right for a national approach to the problem, both by the manufacturers and the motor vehicle administrators. Here, again, motorists' convenience in terms of ability to get interchangeable parts easily at any time and in any part of the country paralleled the interest in the strictly technical problem of better and more uniform lighting and control of glare.

In 1935 there began a more formal relationship between those who share the respon-

sibility for motor vehicle lighting. A cooperative program was developed which has since sponsored very important research, engineering development and design programs which have contributed vastly to the improvement of lighting and signalling equipment. A first major product of the cooperative effort was the sealed-beam headlighting system and a series of other comparable programs has followed to form a basis for today's active program in this field.

The cooperation on lighting equipment integrates the interest and responsibilities of

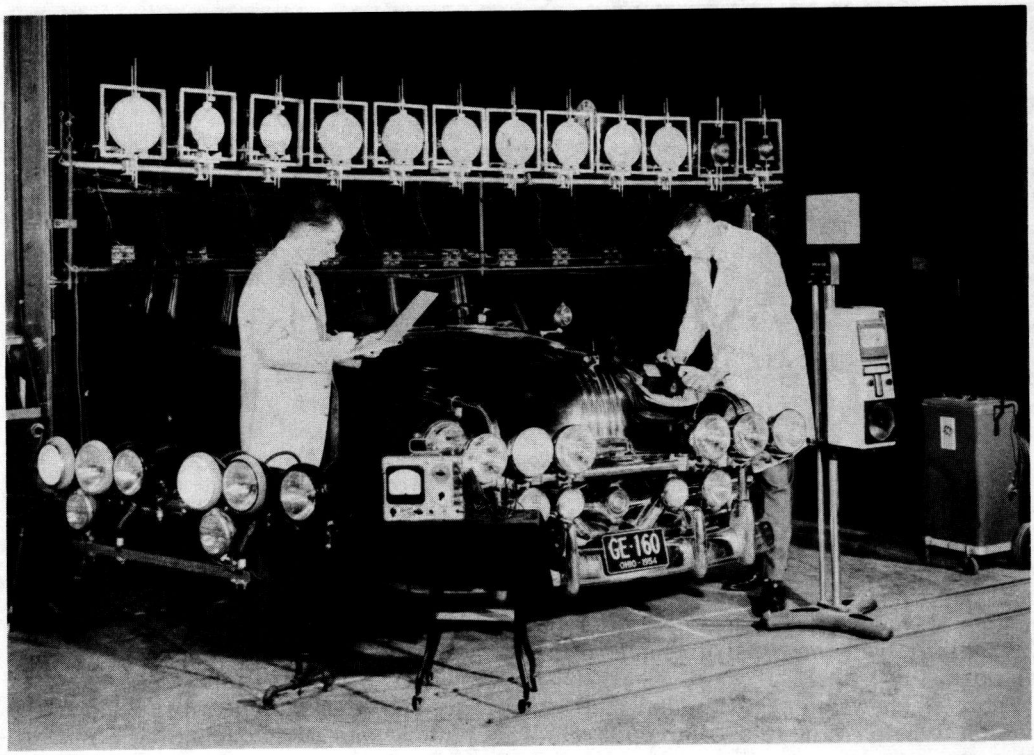

Figure 1. Vehicle lighting laboratory.

the lamp manufacturer, who has the technical capabilities in research, development and production, the vehicle manufacturer, with comparable facilities and responsibilities for the equipment on his product, and the motor vehicle administrators, who by virtue of their state laws and regulations have responsibilities in terms of the public use of lighting equipment.

The basic group that brings about industry coordination of effort, in this formal program, is the Vehicle Lighting Committee of the Automobile Manufacturers Association. This committee is composed of the chief electrical engineers of the various vehicle companies.

Cooperating is the Lamp Manufacturers Subcommittee, a group of leading engineers from the vehicle lamp manufacturers.

These committees have almost unlimited equipment and facilities at their disposal. Numerous laboratories, similar to that shown in Figure 1, are available for lamp development and testing. Several specially equipped lighting test cars, such as those shown in Figure 2, are maintained to allow field observation work. Proving ground facilities are available which have geographic locations that permit tests to be conducted under any weather conditions at any time of year.

For example, the vehicle lighting tests held in 1959 were at Kingman, Ariz., in

March; at Milford, Mich., in May and June; at Cleveland, Ohio, in August; at Detroit in October; and at Phoenix, Ariz., in December. At each location complete testing facilities have been available, together with all required instrumentation, vehicles, shops, equipment and personnel.

The procedures followed in these testing programs have been evolved over a period of more than 20 years. These procedures are constantly being refined to reflect tech-

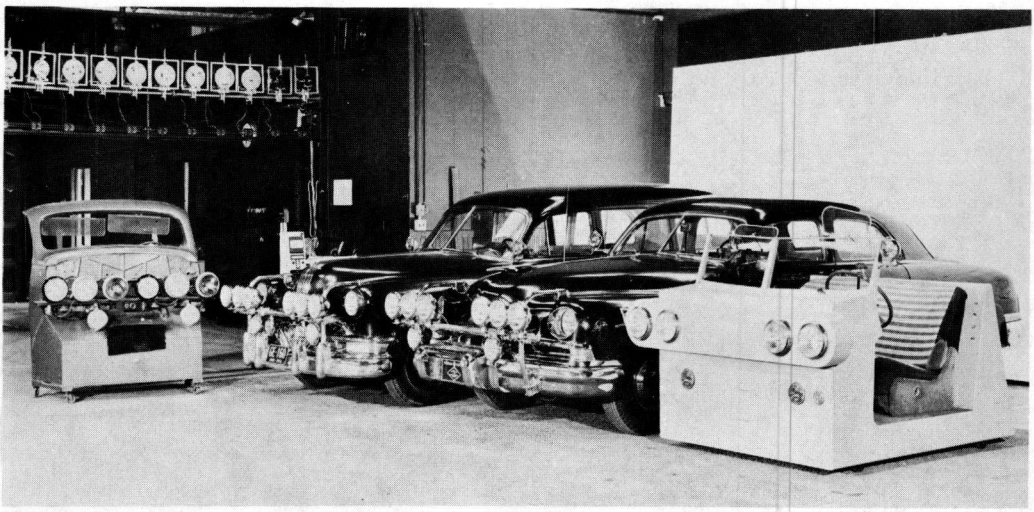

Figure 2. Lighting test cars.

nological advances and changing traffic conditions on the highway.

When required, new instrumentation is designed and developed specifically for the test work.

Figure 3 shows an experimental meter currently under development by Guide Lamp Division to help evaluate headlamp glare. This picture was taken during the Kingman tests last spring, at a time when Detroit was experiencing a late snow storm.

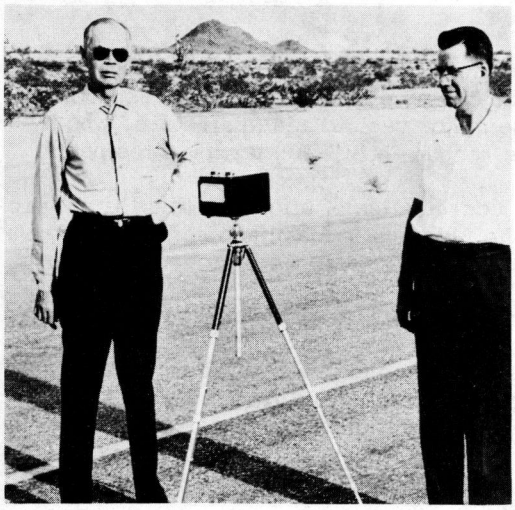

Figure 3. Experimental glare meter.

Another device, designed and built in the laboratory of GMC Truck and Coach Division, was specifically developed for the testing program. This unit allows flashing lights, as turn signals, to be demonstrated under a wide variety of precision flashing rates and filament "on" times.

Of course, the work of industry could not have advanced without the assistance of many other groups, including particularly the Lighting Committee of the Society of Automotive Engineers.

The development and promotion of better vehicle lighting practices are not confined to this country alone. The American industry groups work actively with the committees of the International Electro-Technical Commission, the International Standards Organization and the Economic Commission for Europe.

During the past year the industry has sent delegates to six overseas meetings where vehicle lighting subjects were being discussed.

The foregoing is background information indicating the scope, goals and organizational approach involved in the industry cooperative program. The remainder of this paper outlines the main aspects of the industry's research and testing program in the recent past, covering about the last 18 months.

EQUAL SIGNAL EFFECTIVENESS

In cooperation with members of the SAE Lighting Committee a series of tests were conducted to re-evaluate the candlepower requirement ratios specified for signals of

Figure 4. Equal signal effectiveness test setup.

different colors. These tests were conducted both under the more or less average sunshine conditions of Michigan and under the high-intensity sunlight and high-contrast conditions of Arizona. The test arrangement (Fig. 4) consisted of two test lamps set in a background panel which could be either yellow, white or black. Against each of these backgrounds one of the test lamps was at a fixed candlepower of red, while the other was varied through a wide range of candlepower in amber until jury opinion established that both signals had equal effectiveness.

From these tests the following new equal signal effectiveness ratios for different colors of vehicle lamps and signals were established:

Red		Amber		White
1	:	3	:	5

COLOR OF FRONT TURN SIGNALS

Drawing on this new information, tests then were conducted in daylight on amber and white front turn signals mounted on passenger cars. These tests were arranged so that sunlight was shining on the front of the car. Under these conditions it was the consensus of the observers that an amber signal was definitely more visible than white signal of identical candlepower. (Obviously red lights were not compared in this test because red lights to the front of the vehicle are prohibited.)

Comments by the observers indicated that their preference for amber was occasioned by the "masking" of the white signal by sunlight reflections from the vehicle's bumper, headlamp lenses and other areas.

Similar visibility tests were made at night; but to simulate actual driving situations, separate observations were made:

1. From a car located on the right side of the roadway.
2. From a car so situated that the observers were located in the high-intensity portion of the test car's headlamp beams.

Under both of these conditions the observers expressed unanimous preference for an

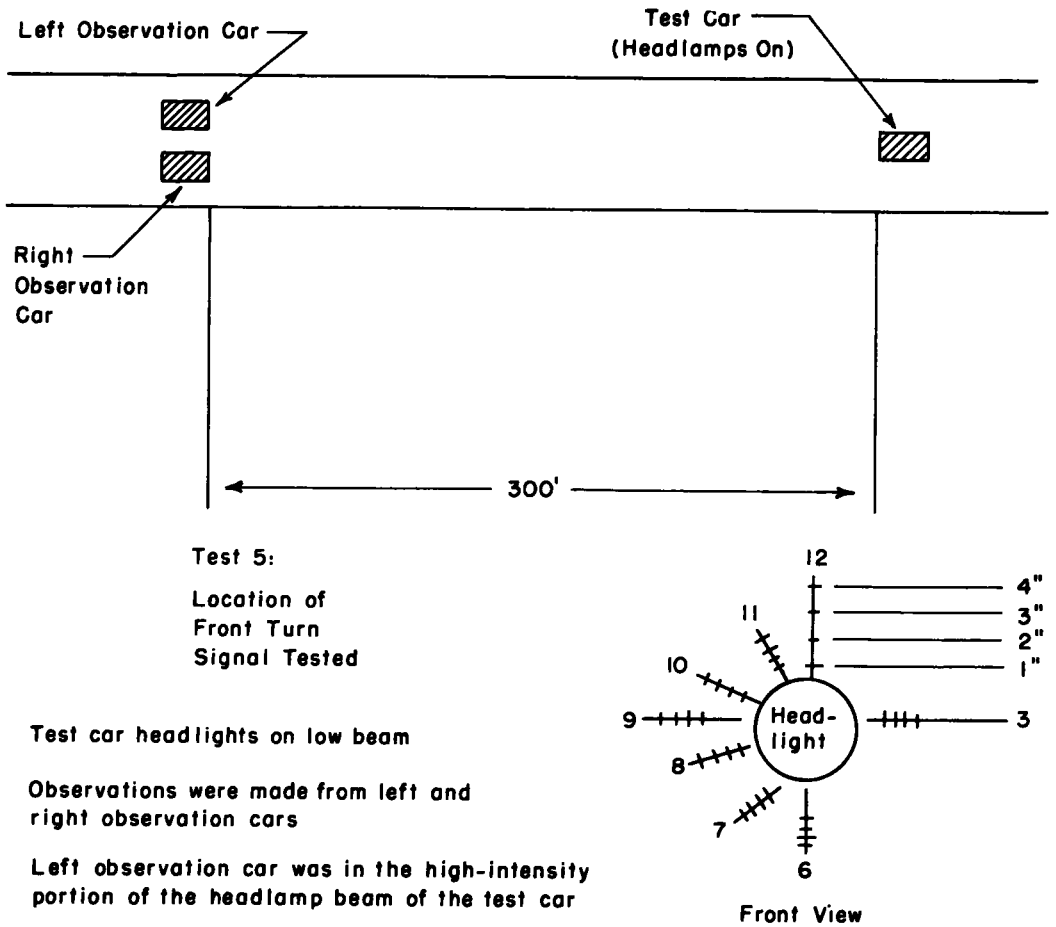

Figure 5. Test setup E used for tests 5 and 19; test site, Military Straightway, General Motors Proving Ground, Milford, Mich.

amber front turn signal as compared to a white signal of equal candlepower. Reports indicated that the amber signal was definitely more visible because it offered more contrast with the illuminated areas of the test car headlamps.

On the basis of the data from these tests a report has been made to motor vehicle administrators with the suggestion that restrictive laws or regulations in several jurisdictions should be amended to permit use of the amber front turn signals, as is permitted in the Uniform Vehicle Code and most state laws.

LOCATION OF FRONT TURN SIGNALS

Another series of tests was conducted to determine the effect of location of the front turn signal with respect to the headlamp.

During these tests the observers were asked to compare the visibility, at night, of front turn signals of various areas when the turn signals were positioned at eight different locations radially around the headlamp, with each location checked at four different spacings away from the headlamp along the radial path.

Figure 5 shows that evaluations were made from two observer locations in order to simulate the actual conditions which a driver might be expected to meet.

From this series of observations it was determined that, to be most clearly visible, a front turn signal should be located at least 4 in. from the nearest edge of a headlamp.

At the completion of the tests the results which had been obtained were referred to the Society of Automotive Engineers. As the result the SAE standard for Turn Signal Units was revised to specify that "The optical axis (filament center) of a Class A and Class B front turn signal lamp should be at least 4 in. from the inside diameter of the retaining ring of the headlamp unit providing the lower beam."

VISIBILITY OF SCHOOL BUS SIGNALS

As a public service the possibility of bringing about improvements in school bus warning signals was investigated.

Tests were conducted in bright sunshine with a jury of lighting engineers as observers.

Numerous lamp intensities were viewed against the characteristic chrome yellow background which is prevalent on school buses. These tests culminated in the following action:

1. SAE intensity specifications for school bus warning lamps were increased by a factor of 3.
2. The recommendation was made to school bus authorities that the area surrounding school bus warning lamps be painted black. The tests showed that this contributes materially to contrast, and thus effectiveness, of these signals.

OTHER ASPECTS OF TURN SIGNAL PERFORMANCE

One of the outcomes of the industry program on turn signals has been expressed in the action of industry representatives on the Uniform Vehicle Code Lighting Sub-committee; under instruction from the AMA Vehicle Lighting Committee and based on test observations they were instrumental in having the minimum visibility distance for turn signals increased in the Code from 100 ft to 300 ft. This change in the Code is expected to require an increase in SAE minimum specification values.

To provide data for the specifications work several field tests have already been run and the data are currently being evaluated.

Another recent test series dealt with the performance requirements for flasher units used in turn signal systems. Information from this series of tests is also currently being evaluated by the SAE Lighting Committee.

REAR LIGHTING OF VEHICLES

In initial stages at the present time is a major testing program to re-evaluate all of the performance requirements of all lamps used on the rear of vehicles. The concept here is to examine lighting and signal characteristics in terms of the now prevailing types of highways and driving situations where the driver of any vehicle has need to know more about the exact positioning and the relative motion of vehicles ahead of him on the roadway. It is hoped that results of these tests can be published in the near future.

7-IN. TYPE 2 SEALED-BEAM HEADLAMPS

Headlighting provides a constant challenge to the designer, the mechanic who aims the lamps and the safety lane inspector. The goal constantly is "improved visibility without increase in glare."

The most recent significant result of industry activity in this area is the 7-in. Type 2 sealed-beam headlamp.

To properly evaluate the value of the 7-in. Type 2, the history of headlighting since the introduction of the sealed beam should be reviewed.

1939. — The sealed-beam headlamp was introduced as the result of combined work by vehicle and lamp manufacturers, through the Automobile Manufacturers Association, in cooperation with the Society of Automotive Engineers and American Association of Motor Vehicle Administrators (AAMVA).

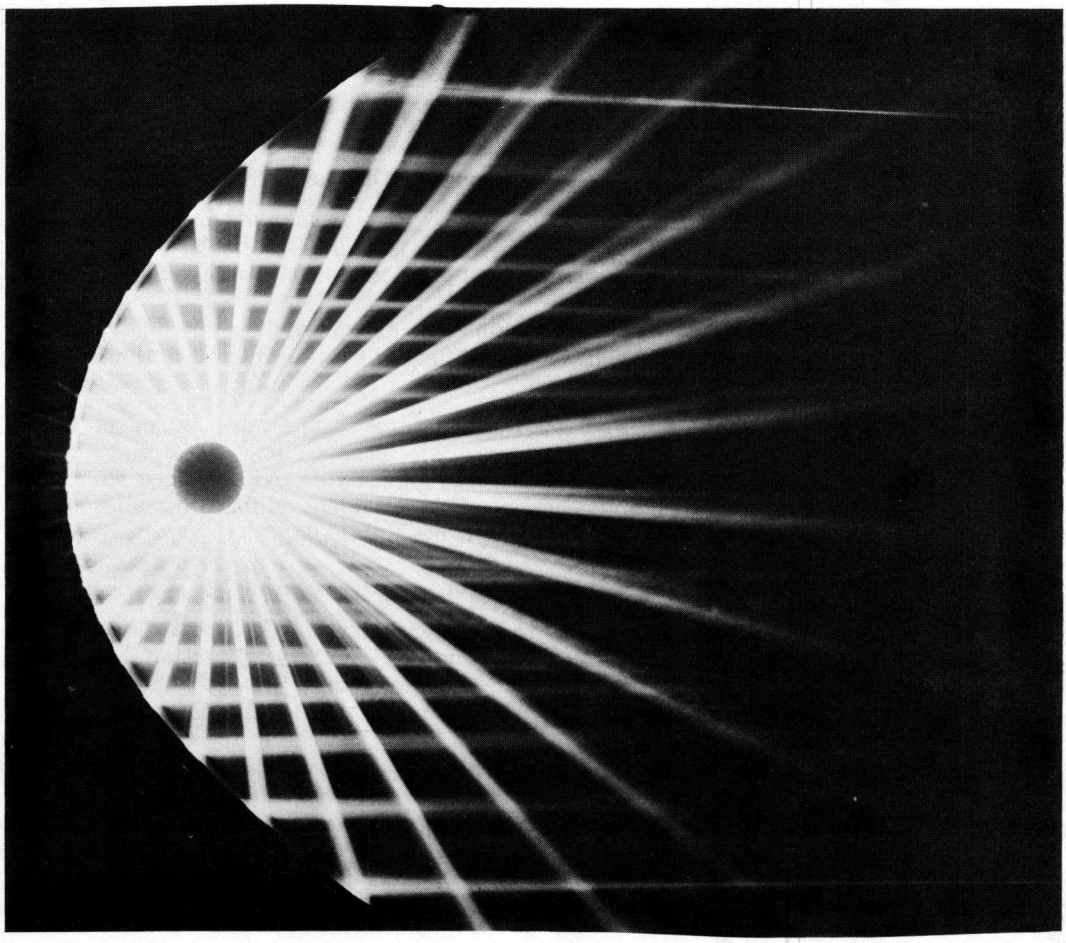

Figure 6. Lamp "A" without fog cap (side view of cut away model).

The lamp construction, interchangeability, dimming switch, upper beam indicator and aiming features made it a noteworthy contribution to night driving safety. Subsequent improvements in the design have come from continuation of this cooperative program.

1955. — In response to AAMVA desires for a better low beam, the improved sealed-beam headlamp was introduced. This sealed-beam unit gave improved visibility in adverse weather.

Improved visibility in adverse weather was the result of the addition of a fog cap. The fog cap is a metal shield which is placed so that it will block off light rays that emanate forward and upward from the low beam filament.

The rays that are intercepted by the reflector become controlled and are transmitted as part of the beam.

The rays that the fog cap now intercepts are those which are not controllable.

Without the fog cap these rays would project forward and upward and would reflect from moisture particles (which constitute fog or rain) back into the driver's eyes causing glare and eye strain. Elimination of this hazard by use of the fog cap is a major contribution. The effectiveness of the fog cap is readily demonstrated (Figs. 6 and 7).

Lamp A does not contain a fog cap. Notice the divergent rays above horizontal.

Lamp B contains a fog cap. Notice the reduction in rays above horizontal.

Use of the fog cap has been so effective that this feature has been incorporated in all subsequent headlamp development.

1956. — A substantial improvement in headlamp aiming techniques was realized with the introduction of aiming pads on sealed beams. Three pads placed on the periphery of the lens established a plane.

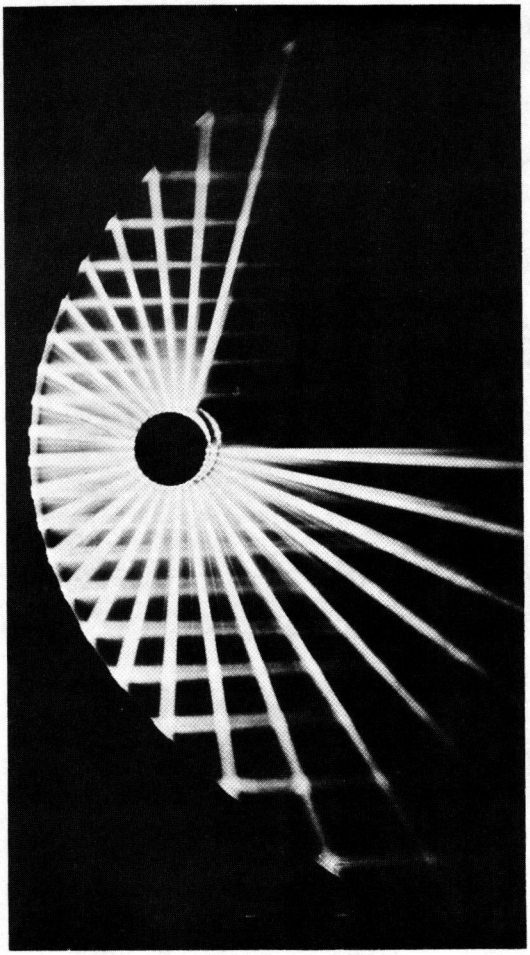

Figure 7. Lamp "B" with fog cap (side view of cut away model).

The relationship of this plane to the beam pattern is controlled during manufacture. As a result, it is only necessary to "aim the plane." This can be done with a simple tool and the guesswork of visual aim is eliminated.

1956. — The dual headlamp system was introduced on some 1957 cars. This development provided improved upper and lower beam performance. This improvement resulted from increased wattage, improved lens design, and elimination of compromises required in the original 7-in. sealed-beam units.

1959. — A new 7-in. unit, designated as a Type 2 unit, was introduced to provide original equipment and/or service replacement for earlier 7-in. units.

This new unit provides a lower beam comparable in performance to the dual system low beam. This improvement was accomplished without wattage change by placing the lower beam filament on focus and by aiming with the pads.

This unit does not have the upper beam performance of the dual system, but, as mentioned has comparable low beam performance. A reason why upper beam output cannot match the dual system is that generator capacity of older cars would not permit use of higher wattage lamps.

Figure 8 shows graphically the improvements which have been realized in lower beams of 7-in. lamps since 1939.

In addition to the extensive program, the industry lighting group has been active in public service programs to promote good vehicle lighting practices.

Three books on aiming procedures have been prepared, and approximately 100,000 copies of these booklets have been printed. The majority of these have been distributed to dealerships, garages, service stations, law enforcement agencies, inspection stations and others directly concerned with headlamp aiming.

In addition, a team of lighting engineers has visited several states to assist in local headlamp aiming problems. For example, in 1958 officials of one jurisdiction asked

for help in setting up a local headlamp aiming inspection program. In response to this request this task force comprised of industry experts gave a presentation on headlamps and how to aim them. On this visit the task force told the headlamp story and headlamp aim story to more than 600 inspectors, officials, gas station attendants, garage and dealer mechanics. As a result of this, the government unit involved now has a successful headlamp aim inspection program.

To assist other jurisdictions in the future, the AMA is planning to create a film to tell the headlamp and headlamp aim stories. It is the hope that this film will contri-

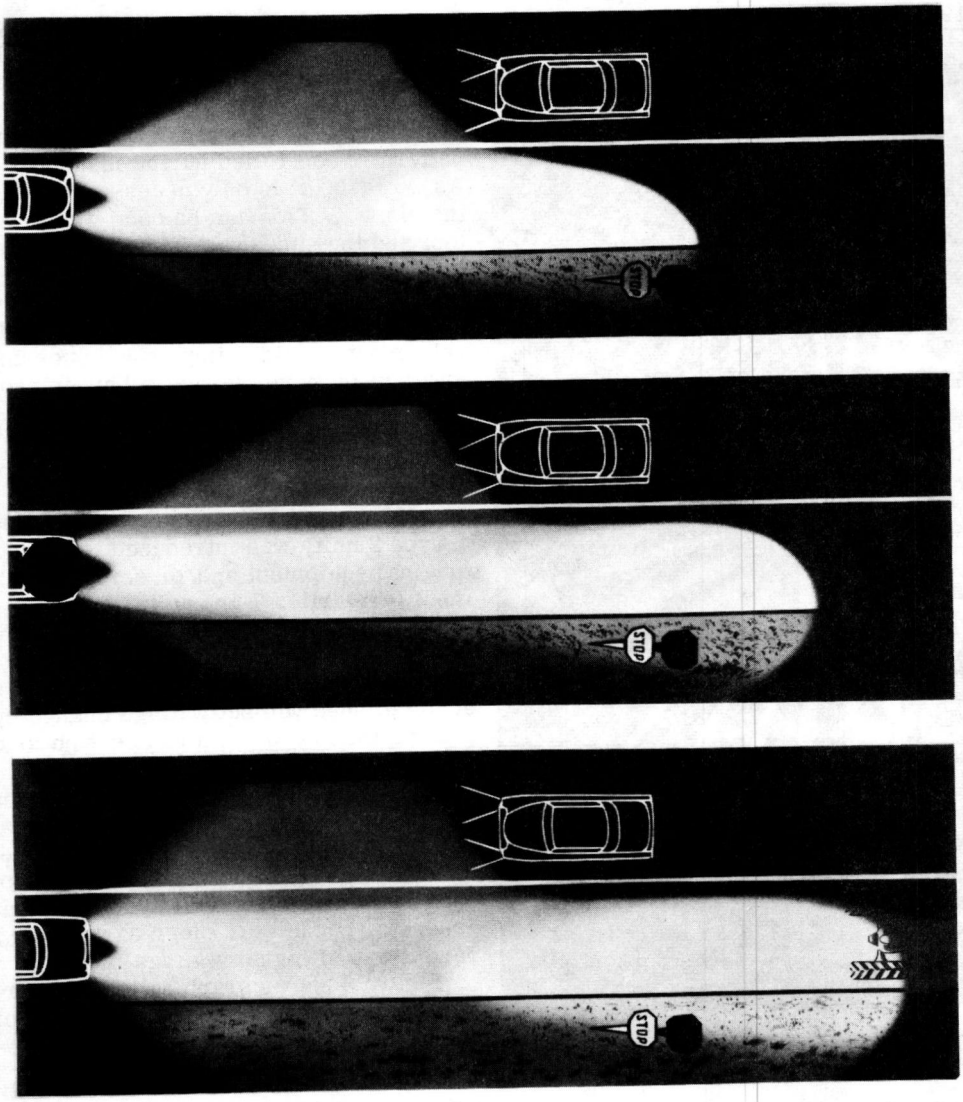

Figure 8. Lower beam improvements, showing: (top) 1939 sealed beam, (center) 1955 improved sealed beam, and 1959 7-in. Type 2 sealed beam.

bute to the establishment of more headlamp aim inspection programs.

It is recognized that headlamp aim inspection is required to insure that maximum visibility with minimum glare is maintained on vehicles. All automotive assembly plants aim headlamps. Enforcement is required to insure that this aim is maintained in the field.