THE POLARIZED HEADLIGHT SYSTEM

DR. EDWIN H. LAND

President and Director of Research, Polaroid Corporation

SYNOPSIS

The technical evolution of a polarized headlight system consisting of polarizing filters on two 125-watt headlamps and a viewer-filter before the driver's eyes has been completed. The polarizing direction of the viewer is parallel to his own headlights and crosses automatically with that of oncoming cars, thereby reducing the brightness of approaching headlights on the average to one-seventh of the down beam of the current Sealed Beam headlamps The higher wattage overcomes the light loss at the polarizing filters sufficiently to make open road visibility of critical hazards seen through the viewer at least as good as present open road seeing with the upper beam.

This system has been referred by the Automobile Manufacturers Association to the American Association of Motor Vehicle Administrators for consideration

The limitations of beam control in dealing with the glare problem and the particular properties of polarizing light are cited. The period of transition to the polarized system need introduce no new hazards not found in the current transition from pre-Sealed Beam to Sealed Beam lamps. Research data from General Electric Company is presented which indicates that even misuse of the new headlamps would be no more hazardous than misuse of Sealed Beams now.

The cost of such a system would not be out of line with the benefits obtained.

The importance of public education and support of glare elimination by consumer organizations is stressed. The technical acceptability of the system has been established. The only problematical areas remaining are related to methods and results of introduction

It is a pleasure to report the present status of glare elimination to a group representing the driving public of this country. For a decade we have been engaged in engineering activities with the automotive industry which have resulted in a system that is ready technically for immediate adoption. There is general agreement that it eliminates glare and at the same time provides visibility by and beyond oncoming cars.

The industry has found itself unable to go further at this time because of the nationwide problems of introduction, and has asked the American Association of Motor Vehicle Administrators for help in solving them, indicating their readiness to consider proceeding if the public shows sufficient interest in glare elimination.

Not Polaroid, not the automotive industry, not the vehicle administrators, not even your group alone should presume to arrange this program; but all of us working together can arouse the public to an awareness of the remarkable fact that a practical means for eliminating glare is now available. How much do they want it? Until November 18, 1947, they had scarcely heard of it. Neither the public nor consumers associations were re-

presented during the development stage.

We believe the most feasible method of introduction is to build the equipment into all new cars on a certain date, and make universally available viewers for removing the glare from the new headlights.

The Polaroid headlight system rests on the fundamental fact in physics that two polarizers with their axes parallel, such as your own Polaroid viewer and your own Polaroid headlights, pass a substantial part of the light; whereas two polarizers with crossed axes, such as your viewer and oncoming Polaroid headlights, block it out.

THE CLASSIC PROBLEM OF HEADLIGHTING

When you meet a car on the highway at night, you play two parts. Because you have to see where you are going, you have to point a beam of light down the road with your headlights. The approaching driver has to do likewise. You are necessarily on the receiving end of his light beam, and he is on the receiving end of your light beam. If you use ordinary natural light, there is only one thing you can do: you must compromise between your need to illuminate the road and your need not to illuminate, and blind, the driver who forms a part of the scene ahead. You can direct the beam a little away from the other car, deliberately avoid lighting up a part of the road that you would like to light up, to reduce somewhat the glare in the other driver's eyes. That compromise has been made in many ways, with great ingenuity. It has never been a comfortable compromise, or a safe one. You always come down to this: for safe night driving, each driver needs to put a powerful beam right where it will blind the other.

Beam Control Cannot Be Final Solution Using ordinary, unpolarized light under any circumstances, you find that it is impossible to keep the glare out of the approaching driver's eyes by controlling the direction of the beam alone. To drive safely at a reasonable speed, you have to direct a shaft of light of many thousands of beam candle power several hundred feet down the road. To avoid blinding an approaching driver, you must not allow that beam to extend more than three feet above the road. That proves to be impossible, even with the finest headlighting equipment available today. To give relief from glare, the present Sealed Beam system provides a foot button which allows drivers to switch from an upper to a lower beam, but here again beam control is not satisfactory even under ideal conditions, and in practice leaves a great deal to be desired.

Depressing the beam only reduces the glare reaching your eyes. It by no means eliminates it. With cars 400 ft. apart, even with a properly aimed lower beam, and with the car loaded evenly and not too heavily, and with the road perfectly level, you receive the glare of 900 beam candle power (Fig. 1). But perfectly level roads are few and far between. With an angular elevation of 3 deg. and a curve in the road, you may be confronted with the glare of 20,000 beam candle power from the lower beam of the Sealed Beam system. With the upper beam under ideal aiming and loading circumstances and on a straight level road, you receive the glare of about 20,000 beam candle power. With an angular elevation of only 1 deg. in the road, the upper beam throws the glare of 40,000 beam candle power into your eyes.

Many accessory devices have been offered for sale through the years to protect you against headlight glare. These have usually taken the form of colored viewers. Some

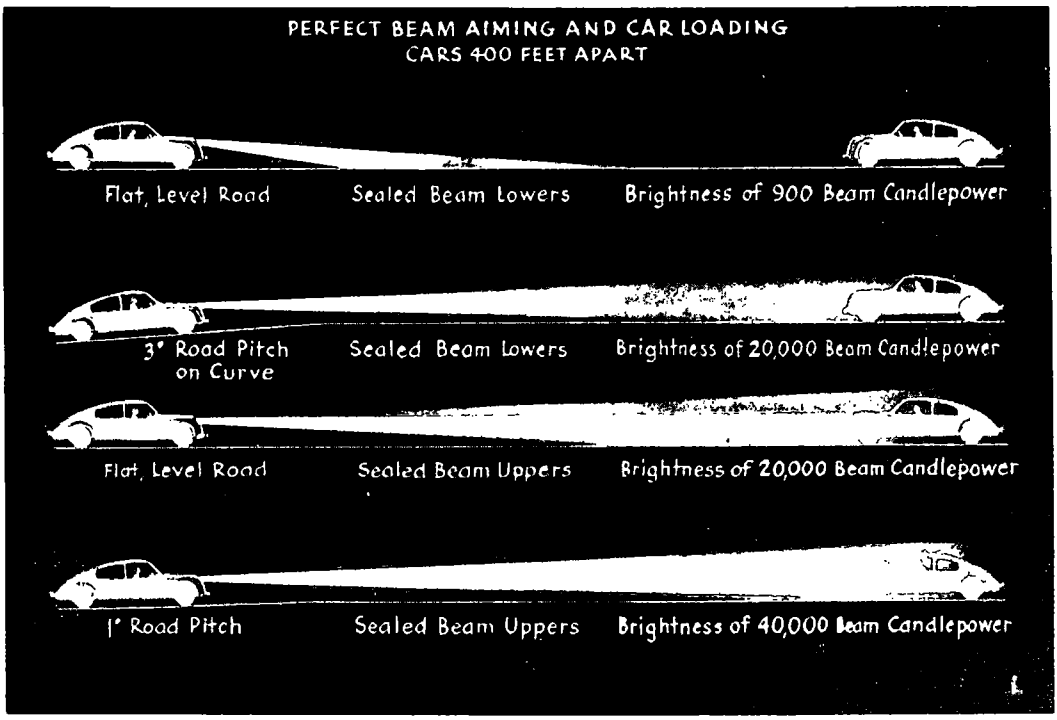

Figure 1. The Glare of Ordinary Headlights

are designed for installation directly in the line of sight, while others are intended to be used as shields in back of which a driver may "hide" oncoming lights while he views the roadway around the edge of the shield. I venture to say that no one considers any one of these to be an acceptable answer to the problem of glaring headlights.

The only known final solution to the problem of glaring headlights is a system that uses polarized light.

THE POLAROID VIEWER-HEADLIGHT SYSTEM

We believe that there are two main questions that the public wants to have answered about Polaroid headlights:

Does the Polaroid headlight system really put an end to headlight glare?

Does it also give enough light for really safe driving?

Perhaps the simplest way to answer is by summing up the performance of the Polaroid system in this way: with the Polaroid system, it is as if you were always driving with a light at least comparable to the upper beam of your present Sealed Beam lamps, and as if the approaching car were getting along with the lower beams of his Sealed Beam lamps cut, furthermore, to about one-seventh of their present brightness.

The Polaroid system, as evolved under the ground rules laid down by the industry, is composed of a pair of 125-watt Polaroid headlamps for country driving, and a pair of special non-polarizing passing lamps that are used for city driving and for passing old cars during the transition period when both Polaroid and Sealed Beam headlights are

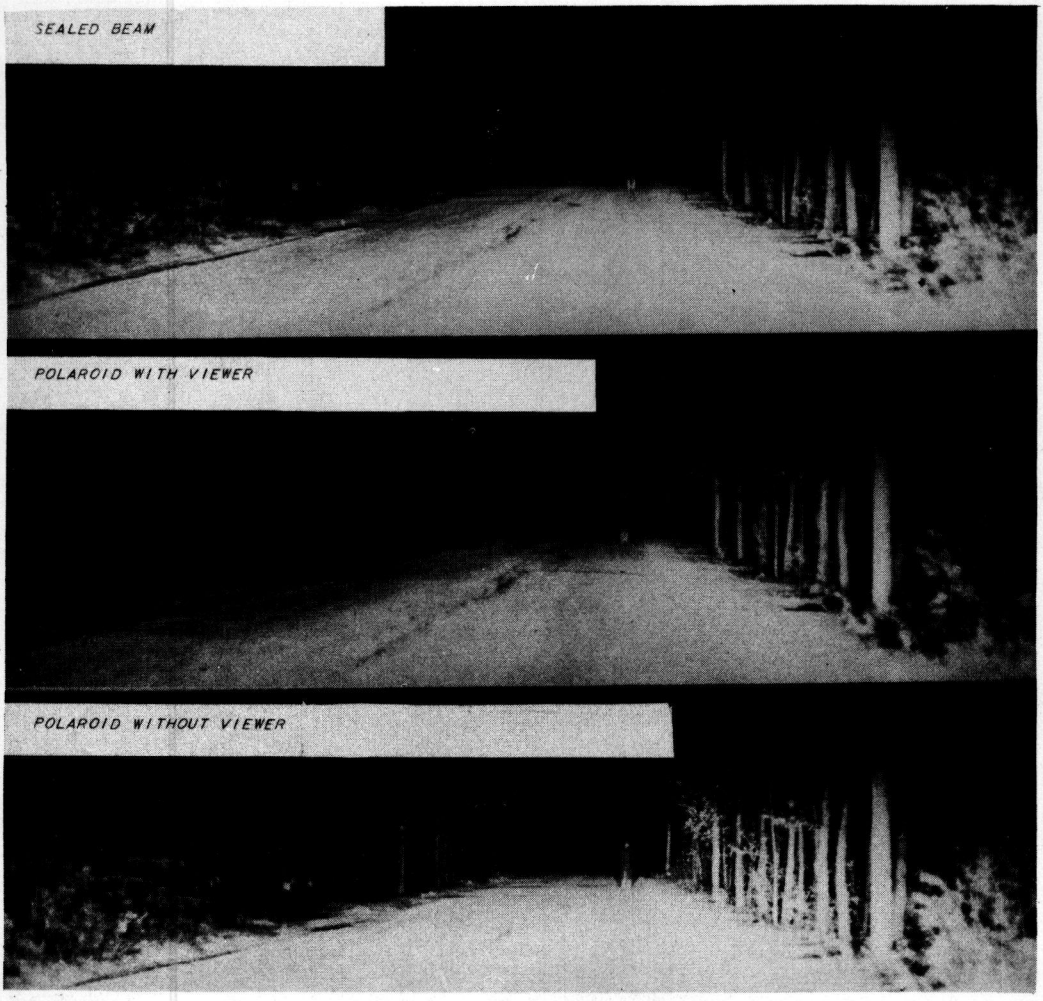

Figure 2. Comparative Illumination Down the Road

on the road together. A Polaroid viewer completes the system. It eliminates the glare. Through it, the approaching Polaroid lamps have an unmistakable, characteristic blue color.

While several types of viewers are suitable, including windshields, visors, and various types of spectacles, for the purposes of simplicity and uniformity of impression, we are standardizing on an available visor.

COMPARISONS OF POLAROID SYSTEM WITH PRESENT SYSTEM

Let us now examine the Polaroid system and the present Sealed Beam system side by side and see what the Polaroid system offers in safety and comfort as compared with the Sealed Beam system that you are now using.

Polaroid System Provides Excellent Illumination Figure 2 presents a comparison of the old and the new systems simultaneously and under

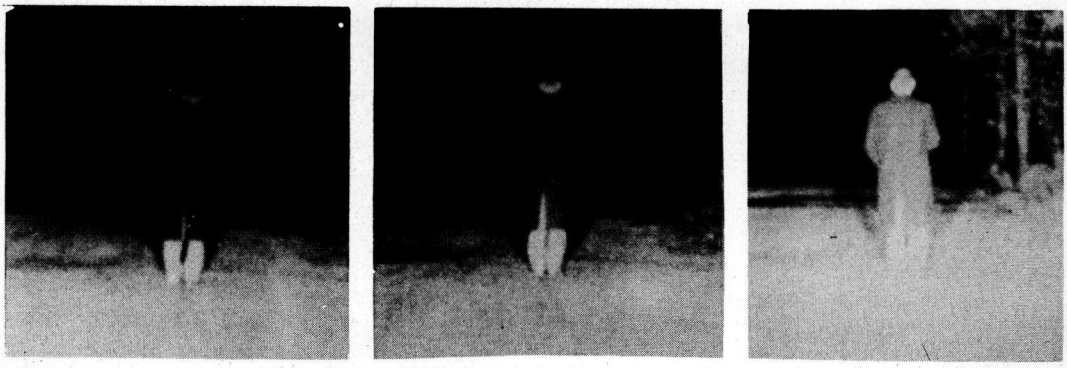

Figure 3. Comparative Contrast of Pedestrian in Figure 2

identical road conditions, by means of photographs made with careful photogrametric control.

We have a road with a dark-coated pedestrian about 200 ft. ahead; at the top - as seen with the Sealed Beam upper beam; in the middle - Polaroid headlights with viewer in position; and at the bottom - Polaroid headlights without the viewer. The figure shows several interesting points.

First is the greater sense of distant illumination with the Polaroid headlamps. The light from the horizontally-aimed Polaroid headlamps, viewed through the visor, is a safer light to drive by because it is directed to intercept obstacles in the roadway at a considerable distance. The foreground illumination from Sealed Beam upper beams appears brighter than from the Polaroid lamps with the viewer, partly in consequence of the Sealed Beam lamps being aimed below the horizontal.

Secondly you see, in the lower section, Polaroid lighting without the viewer. It is clear that you can see farther down the road, a result of the greater candle power and the higher aiming of the Polaroid beam.

We have made a number of measurements of the actual illumination down the road. At one typical, critical point just short of the pedestrian, though not at all points, the road has a measured brightness with the Polaroid lamps seen through the viewer which is actually 30 percent brighter than the brightness provided by the Sealed Beam lamps.

Figure 3 shows the relative visibilities of the pedestrian. Note especially his dark coat.

Polaroid System Has No Blind Drivin Zone A comparison of the amount of illumination provided by the two systems, favorable as it may be to the Polaroid system, does not take into account what is probably your most important concern as a night driver: How far can you see ahead when another car is approaching?

I should like to mention here that the numerical data in many of our subsequent illustrations are based on visibility distance measurements made by Mr. Val Roper of General Electric Company, but the interpretations are our own. We feel that the conditions under which the data were taken, mainly on a flat, straight road, are more favorable for glare reduction by the Sealed Beam system than ordinary driving conditions would be.

When present day Sealed Beam headlights come toward you, you

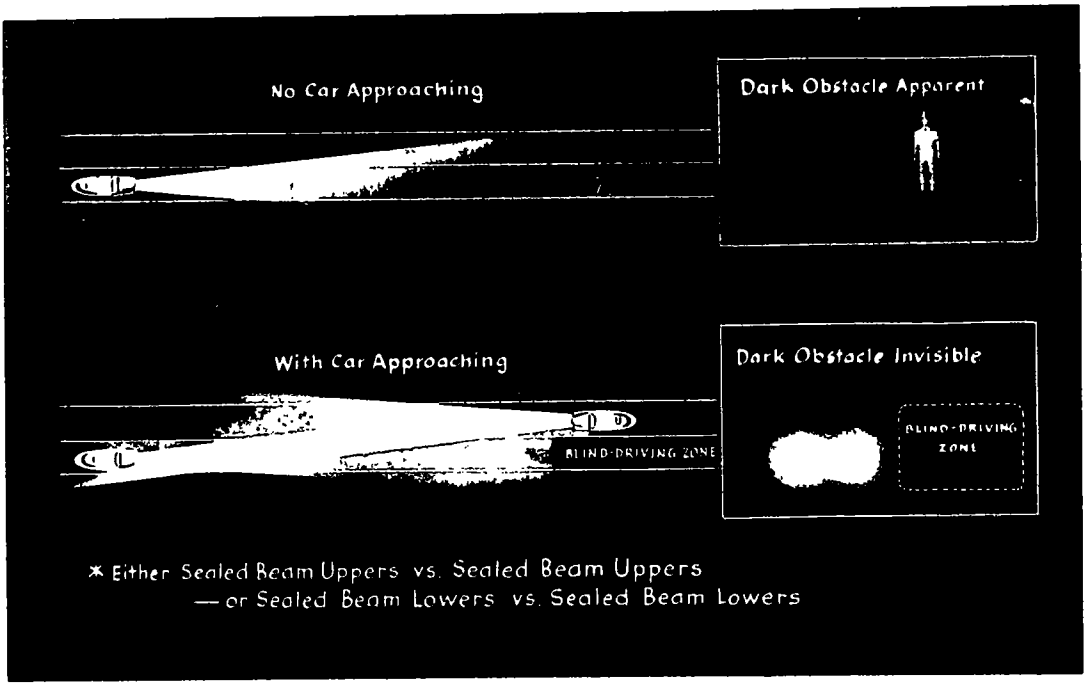

Figure 4. The Blind Driving Zone of Ordinary Headlighting

cannot see past them. You have the situation which we have diagrammed in Figure 4. The area to the right of the approaching headlights is, for you, a blind driving zone. In speaking of it, many drivers refer to it as the blind spot. All of us, as we drive at night, habitually drive into this zone on faith, hoping there is no obstacle in the road, but with a sense of hazard and insecurity. This sense is correct. If a man with a dark coat is standing in this zone, you cannot see him with your present headlights, even with the upper beams (used against upper beams) because you are blinded. There is frequently a similar blind driving zone for drivers who use their lower beams (against lower beams) because of inadequate illumination. This blind driving zone is a real thing. You are driving at 40 mph. into a zone on the road in which you cannot see a dark obstacle at sufficient distance to permit you to make an emergency stop.

You cannot see the pedestrian or any other dark object in this blind driving zone because your eye simply cannot record a very faint image when that image is close to the enormously brighter oncoming headlights.

With the Polaroid headlight system in use, there is no blind driving zone (Fig. 5). The pedestrian to the right of oncoming Polaroid headlights can be seen clearly. From the day Polaroid headlights are first introduced, there will be no blind driving zone for any meetings in which all cars are equipped with Polaroid headlight systems.

The Pedestrian Is Safer With Polaroid System Many a pedestrian confronted with glaring Sealed Beam headlamps feels instinctively that the driver behind the headlamps can see him clearly. In effect, the pedestrian relies on the driver for his security. Actually, the driver

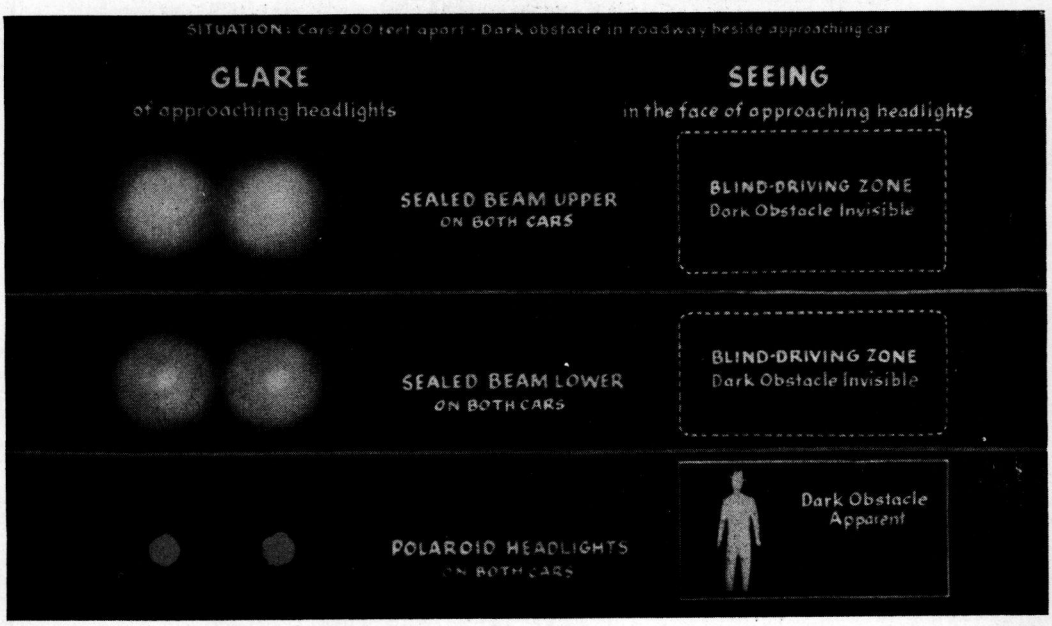

Figure 5. Polaroid System Eliminates Blind Driving Zone

cannot see at all the pedestrian walking in the blind driving zone. With the blind driving zone eliminated by the Polaroid system, the pedestrian will be sufficiently illuminated for the driver to see him in time to stop if necessary.

It is true that the pedestrian will be glared somewhat more by the Polaroid headlights than by Sealed Beams if he looks into them, but this increased brightness and the absence of glare in the eyes of the driver are the factors which operate to make him safer. What's more, the pedestrian frequently watches the roadway just in front of him as he walks. Thus the brighter Polaroid headlamps might even serve to improve visibility for him.

For the pedestrian who habitually walks on highways at night and who is inclined to look well down the road ahead of him, the Polaroid system provides an opportunity for glare relief in the form of a simple, inexpensive viewer, whereas today, he has no means of relief from the glare of Sealed Beam headlights.

Polaroid System Provides Greater Visibility Under conditions of proper use, the maximum apparent brightness of Polaroid headlights is about 1/250 of the maximum apparent brightness of the upper beam of the present-day Sealed Beam system. The extinguished Polaroid headlights, as I have said, are on the average one-seventh the brightness of the lower beam of present day Sealed Beam headlights.

The Polaroid system provides 400-ft. visibility distance with two approaching cars 200 ft. apart, while at the same distance, present day Sealed Beam uppers provide a visibility distance of 175 ft. and the Sealed Beam lowers provide a visibility distance of only a little more than 200 ft. (Fig. 6). Note that there is no blind driving zone in this situation with the Polaroid system, while the blind driving zone is present with the Sealed

Figure 6. The Polarized Headlight System Provides Greater Visibility

Beam system for both Sealed Beam uppers and Sealed Beam lowers.

Approaching Polaroid headlights seen through a viewer are completely free from glare (Fig. 7). When you drive a car with Polaroid headlights, and approach another car with Polaroid headlights, you do not glare the oncoming driver, yet, when the cars are 200 ft. apart, you are able to see about twice as far down the road.

Polaroid System Is Practicable Your next concern, I believe, will be the proper method of introducing the system. Granted that the Polaroid system closely approaches the ideal in safe headlighting, your immediate question should properly be: How do we get from where we are now, to the time when all cars on the road are Polaroid-equipped?

Since the invention of the automobile, there has been a series of transition periods during which cars with different types of headlights have been on the road at the same time; the transition period from oil to acetylene, acetylene to the early incandescent lamps and then a period when a number of different types of electric lamps were in use all at the same time and, finally, the transition period from those bulb-and-reflector type lamps to the Sealed Beam. During each of these transition periods the driver of the old car has been placed at somewhat of a disadvantage facing the lights of a new car.

We are still in the transition stage between the old bulb-and-reflector type headlights and the Sealed Beam.

Figure 8 shows the successive increases in beam candle power which have occurred at each of these transition periods. You will note that in the current transition period, Sealed Beam lights with a maximum of 60,000 beam candle power and the old bulb-and-reflector type lights with a maximum of between 5,000 and 40,000 beam candle power are on the road at the same time. You will recall that the maximum beam candle power of the pre-Sealed Beam lamps

Figure 7. The Polaroid Headlight System: No Glare - Greater Visibility

dropped off very rapidly due to deterioration of reflector and bulb. The introduction of the Polaroid system will bring about approximately the same relative step-up in maximum beam candle power that we have experienced since 1940 when the Sealed Beam was introduced. The Polaroid headlights, when you are not looking through a viewer, are bright - about 100,000 beam candle power compared with the 60,000 of the upper beam of the Sealed Beam lights. Moreover, as a matter of policy, the Polaroid lights are not aimed below the horizontal as are the Sealed Beams, so that you are likely to get the full brightness of the Polaroid beam more often than you would get the full brightness of the Sealed Beams. For this reason, those who have been involved in the Polaroid headlight development program have given attention to the possible effects of this increase in brightness.

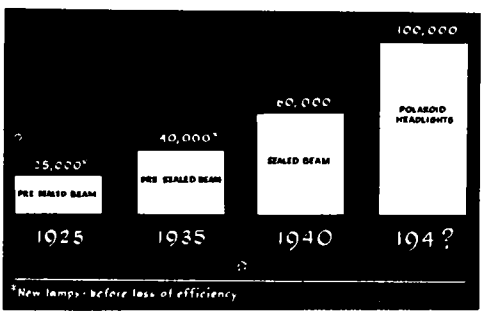

Figure 8. The Trend in Beam-Candle-Power

An increase in beam candle power of the upper, country driving beam has gone hand in hand with every major improvement in headlighting over the past twenty years. The reason is an obvious one: The need for more and better illumination for better clearer road seeing as finer highways and better cars have been provided. The adoption of the Polaroid headlighting suggests a further step in the trend toward better open road seeing, but with important differences.

It appears from careful studies that the transition from Sealed Beam to Polaroid headlights will be far safer than the transition between pre-Sealed Beam and Sealed Beam. (This assumes that pre-Sealed Beam cars will be off the roads at night by the time the Polaroid sys-

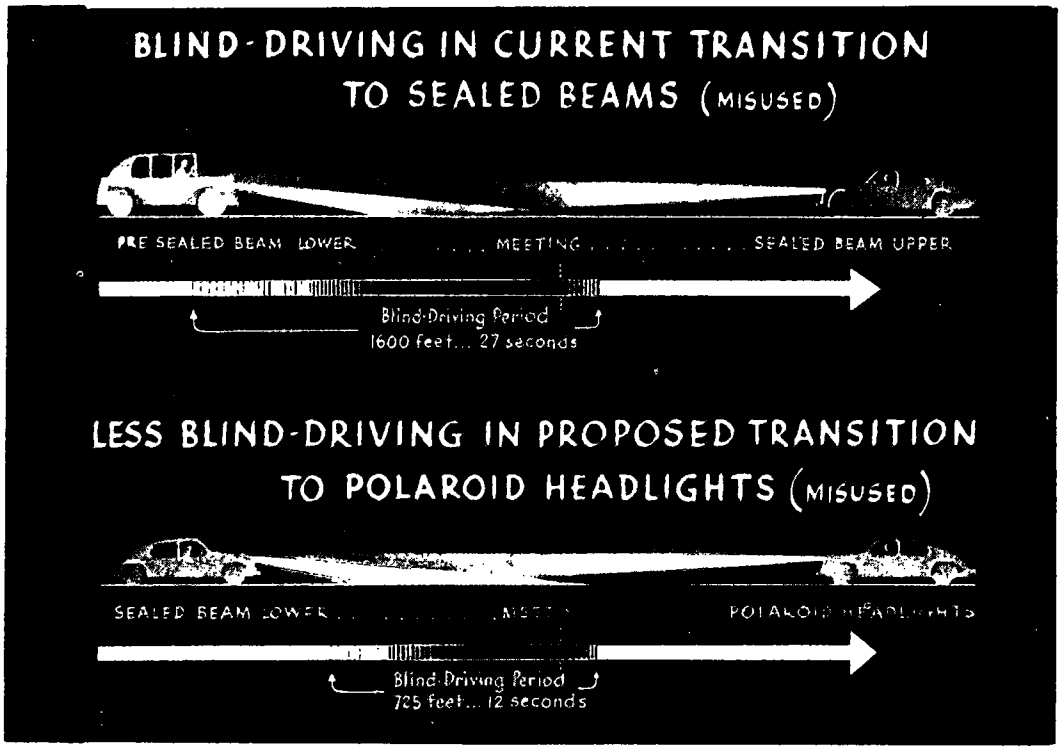

Figure 9

tem is introduced.)

Figure 9 shows the comparison under conditions of misuse of the blind-driving period for the pre-Sealed Beam driver facing a Sealed Beam car and for a Sealed Beam car facing a Polaroid-equipped car. You will see that the blind-driving period is over twice as long in the current transition to Sealed Beams, as it will be in the transition to come.

Proper Use of Polaroid System in Transition Period Is Easy to Learn With the introduction of the Polaroid headlight system, the rule of the road for headlights will be easy for all drivers to learn (Fig. 10). There need be only a single rule, "Depress for white light." You can have a rule as simple as this because Polaroid headlights have a characteristic blue color when you see them through a viewer. The rule is the same for all drivers.

If you are driving a present-day Sealed Beam car, all the lights approaching will be white, so you depress as usual. If you are driving a Polaroid-equipped car, the lights from Sealed Beam cars will be white and for these you depress too; the lights from Polaroid-equipped cars will be blue and for these you do nothing at all.

Groups of cars present no cause for confusion. An old car driver proceeds as at present; a new car driver does nothing at all if all cars ahead have blue lights, depresses if any have white lights.

During Transition Misuse of Polaroid Headlights No More Hazardous Than Misuse of Sealed Beams Now If the rule of the road is not observed,

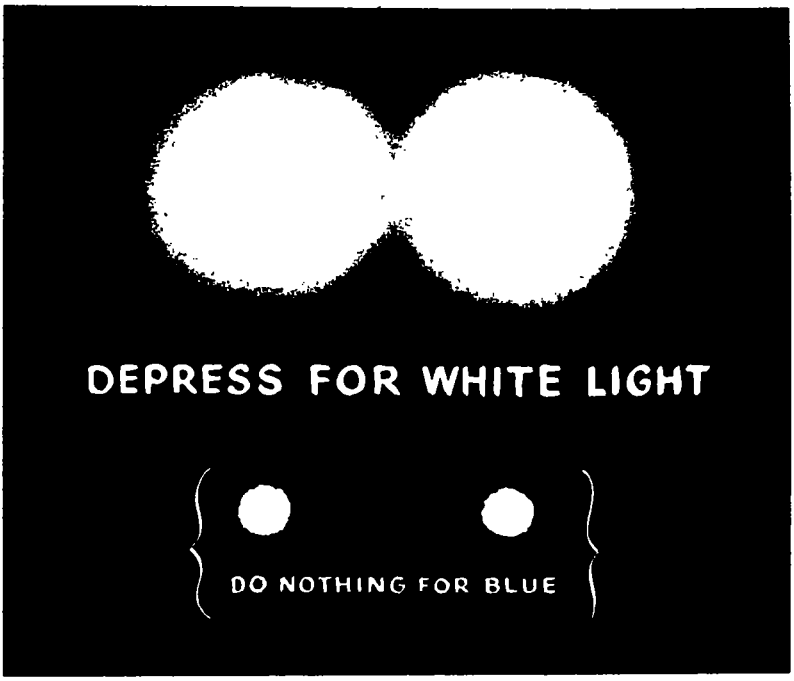

Figure 10. During the Transition Period the Single Rule of the Road

if the driver does not depress for white light, the blind driving period is no longer than it is now when drivers fail to depress their upper Sealed Beams and thus misuse the Sealed Beam system. Even under conditions of misuse, all possible meetings, once the Polaroid headlight system is introduced, will be at least as safe as (although sometimes less comfortable than) they are at the present time under conditions of misuse of the Sealed Beam system. The worst that can happen today with Sealed Beam headlights is the situation that arises when your car with Sealed Beam lowers approaches a car with Sealed Beam uppers. You are then temporarily in jeopardy: your own headlights fail to illuminate enough of the road for you, and the glare from the oncoming upper beams blinds you (Fig. 11). The result is that at 40 mph., for example, you go through a blind driving period of 725 ft. or 12 sec. This, of course, is a highly undesirable situation. Yet it occurs frequently, as we all know. People are inclined to overdrive their lights.

Now the worst that can happen, once the Polaroid system is introduced, is the situation I have just described as the worst for Sealed Beams. If you do not use a viewer and approach Polaroid headlights, you naturally experience a blind-driving period. Research data indicate that this blind-driving period with misuse of the Polaroid system, is no longer than the one resulting from misuse of the Sealed Beam system. However, let me point out what must be obvious. There is no remedy in sight for the misuse of the Sealed Beam system. There is no protection for you as a Sealed Beam driver who is confronted by a discourteous or thoughtless Sealed Beam driver who fails to depress. But there is a remedy for you if

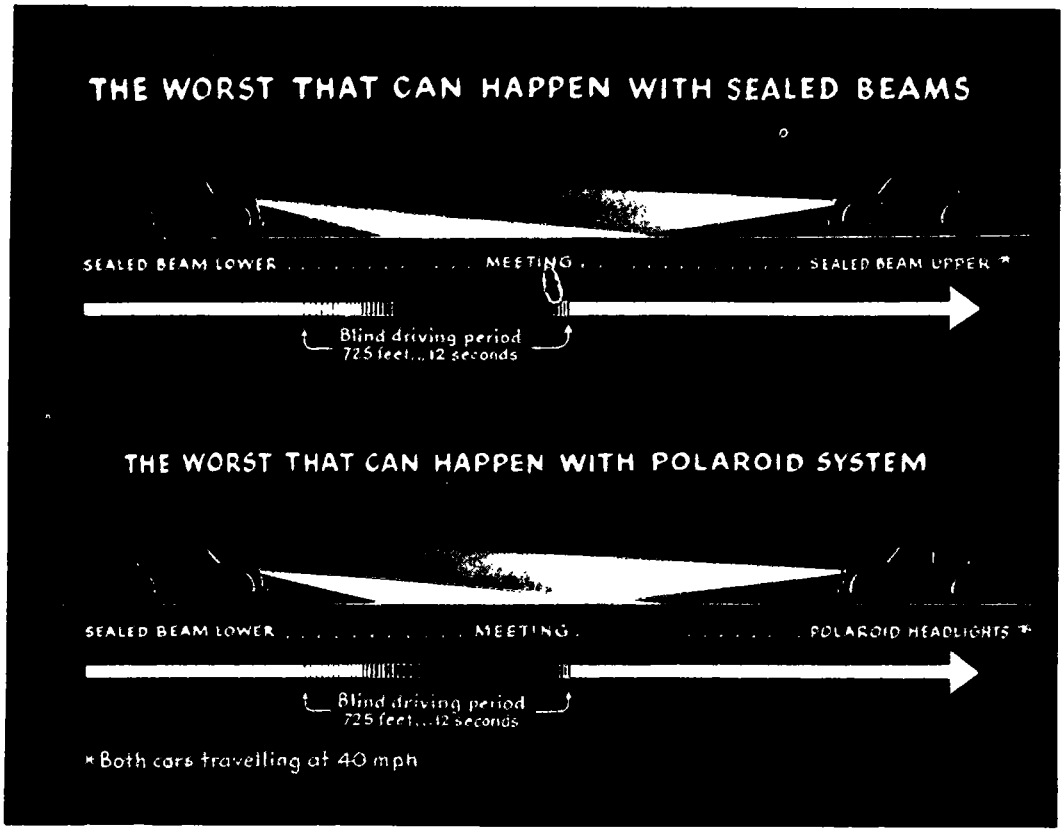

Figure 11

you are confronted during the transition period by a discourteous or thoughtless Polaroid driver (Fig. 12). You not only can reduce the glare of the oncoming Polaroid headlights, you can eliminate it completely, simply by using a viewer. All other situations involving misuse of Polaroid headlights appear to be more favorable than situations of misuse involving present-day Sealed Beam headlights.

Length of Transition Stage Statistitions point out that the length of the transition stage depends upon numerous variables and upon the numerous interpretations that can be made of these variables. For example: At what rate can we expect new cars to be built? At what rate can we expect old cars to become obsolete? How many car meetings at night are simple - that is, involve only two cars? What is the ratio of newer cars used for night driving against older ones? (See Appendix B). Since, as we have already seen, drivers of cars equipped with ordinary headlights are not affected adversely, should the data be interpreted from the point of view of the driver who has purchased Polaroid equipment? How much weight should be given to the possibility of providing conversion equipment for old cars?

Against the background of these and other unknowns, one known fact stands out. When all cars are finally equipped with the Polaroid system, headlight glare will be a thing of the past.

And even during the transition

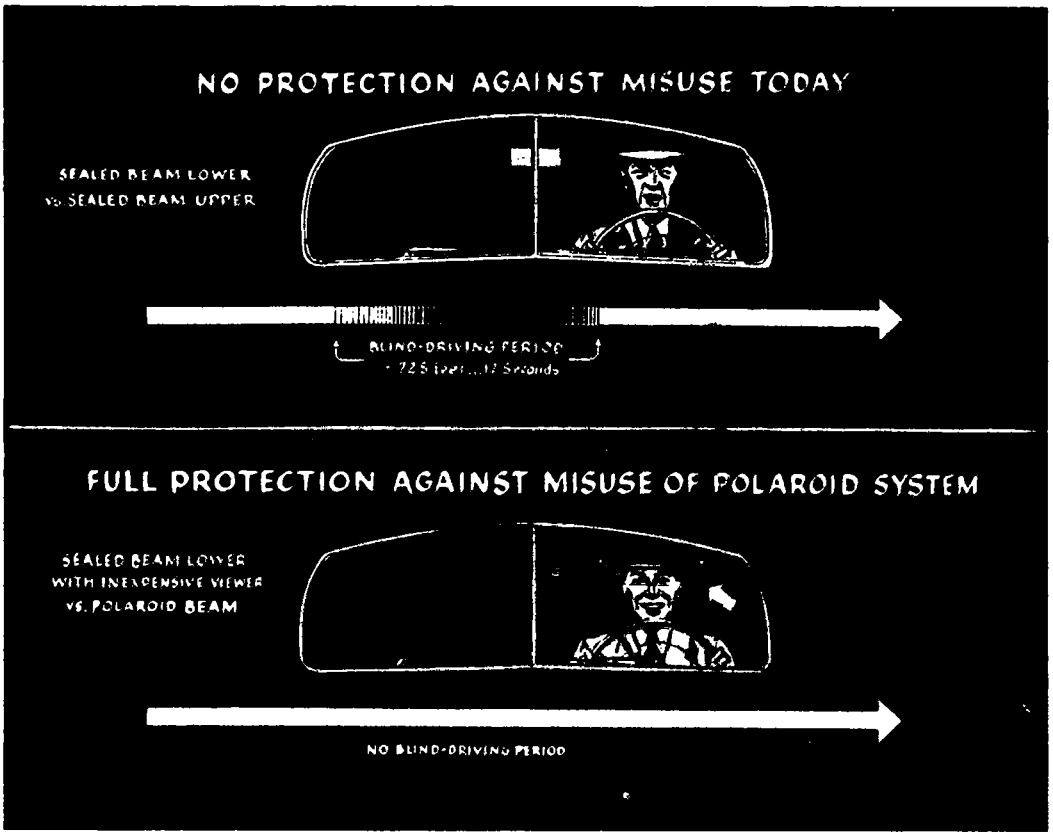

Figure 12

stage, the system will eliminate the blind driving zone for drivers of any two Polaroid-equipped cars involved in simple meetings. Since a certain number of accidents is attributable to the blind driving zone, it is to be expected that the number of such accidents will be reduced as soon as Polaroid-equipped cars start simple meetings, and that the reduction will accelerate as additional simple meetings of Polaroid-equipped cars take place.

In situations covered by proper usage where they meet Sealed Beam cars, Polaroid-equipped drivers will be able to see somewhat better with their new equipment than they would if they were using Sealed Beam equipment.

And on the open road, Polaroid-equipped drivers will have better light than ever before.

COST NOT OUT OF LINE

One further consideration is the cost of the system and its effect on the price of cars. On the largest item, the more powerful generator, I should like to point out that, since 1934, the industry has increased the capacity of generators substantially on two occasions; once, I am told, by about 50 percent in 1934, and again by about 25 percent in 1940. The increase to take care of Polaroid headlights is not much greater than these two which have already been made.

The polarizers are relatively cheap. It is estimated that a pair of polarizing filters for the headlamps, together with a Polaroid

visor for the driver, will have a cost to the manufacturer of less than $2.00. With a simpler viewer, the price would be less. Moreover, we have entered into an agreement with the Automobile Manufacturers Association under which Polaroid materials can be made available to the industry from several sources of supply at competitive prices.

In general, we believe the cost of the Polaroid system in new cars, even assuming that it turns out to correspond with the present estimates, will not be a cause for surprise, one way or another. It seems to be about what one would expect to pay for an improvement of this magnitude, a cost completely justifiable as compared with the costs of such improvements as safety glass and four-wheel brakes.

Certainly the cost of the Polaroid system does not appear to be out of line if you compare it with the cost of a number of popular automobile accessories (Fig. 13), such as an outside sun visor, a heater, or a radio.

Furthermore, we at Polaroid believe that the industry can be counted upon to reduce the cost of the system to a point well below the current estimates through the economies resulting from mass production.

SUMMARY OF SOME OF THE ADVANTAGES OF THE POLAROID SYSTEM

Let me attempt to sum up for you some of the justifications for the prompt introduction of the Polaroid system.

1. It is the only system which makes it possible to increase the down-the-road illumination and at the same time decrease the risk involved when cars meet and pass each other.

2. It is the only system which provides an opportunity for complete protection against glare, even for the driver who does not have Polaroid headlights on his own car.

3. Short of illuminating all the roads of the nation with overhead lights, or making all streets one-way, at an astronomical cost, the Polaroid system is the only system which can bring an end to the regulation and enforcement problems of beam depression - and it can do so at a cost which is not considered an insuperable obstacle.

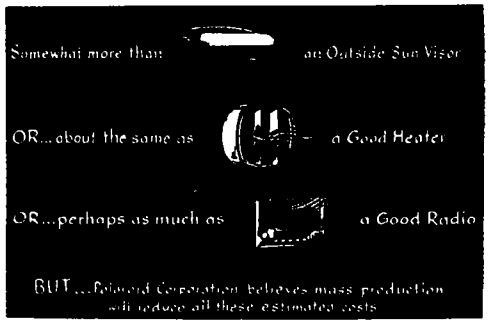

Figure 13. How Much Is the Polaroid System Likely to Cost?

If you will look back over the history of important new improvements that we now take for granted in our day-to-day life, you will find, I believe, that each was introduced for obvious and overwhelming reasons, but that at the same time each of these improvements presented a number of minor disadvantages which may have seemed significant at the time the change was proposed but which we have now come to disregard. You will also find that the minor disadvantages have been balanced by a number of minor advantages to which little attention was given when the improvement was introduced. If pressed, I am sure we could all point out a number of minor disadvantages of such overwhelming improvements as the telephone, the electric light, or even the automobile. All of us could at the same time point out a great many minor advantages of these improve-

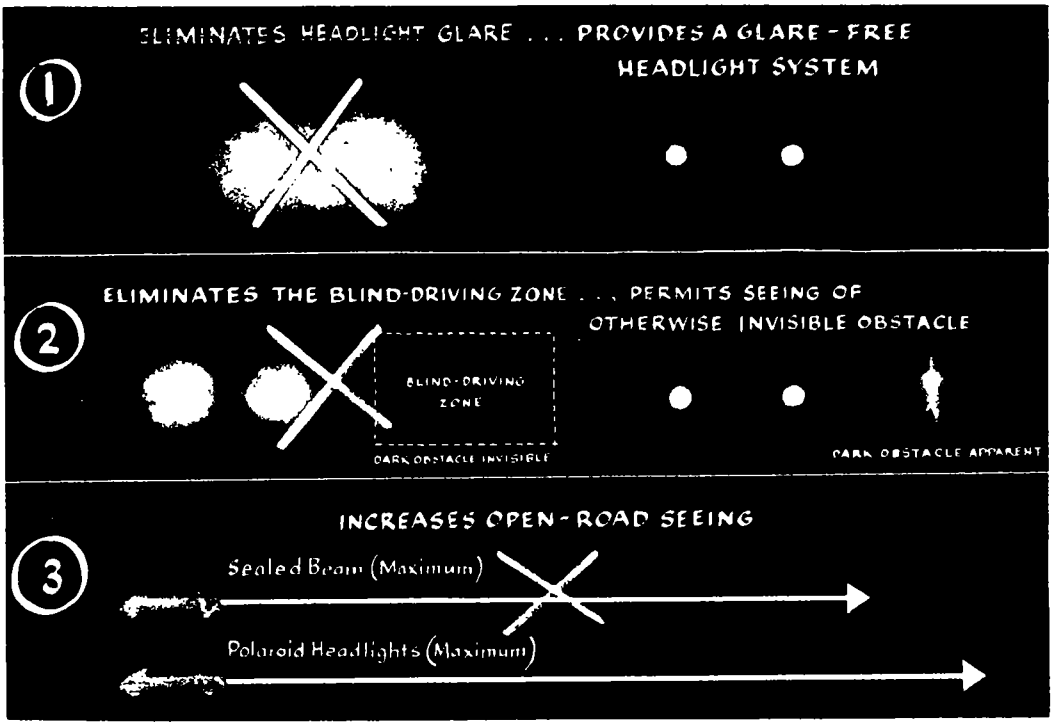

Figure 14. Chief Benefits of Polaroid Headlight System

ments beyond the obvious ones. This, I believe, will prove true of the Polaroid headlight system.

For example, through the Polaroid viewer you cannot see the haze which ordinarily warns of the approach of a car over a hill. On the other hand, if you now depend on this hilltop haze and would like to continue to use it, you will find that by looking around the edge of the viewer, you will get the warning haze at least twice as bright, and more reliably, because of the above-the-horizontal aiming of the Polaroid lights. And there are engineering methods for retaining the haze by affixing plastic pieces to the viewer.

What effect, if any, does the Polaroid system have upon your judgment of the distance of approaching cars? For some people the dim lights of Polaroid-equipped cars appear to be somewhat farther away than the hotter lights of Sealed Beam cars, which are actually at the same distance. These subjective impressions are difficult to measure, and neither our own tests nor those of the industry provide any scientific basis for anticipating additional hazards from this source. Yet you may predict that distance judgments will prove to be more precise when the Polaroid system is in universal use; because all approaching cars will be using the same driving beam, you will be able to use the apparent brightness of the approaching lights as a reliable indication of distance - something you cannot do now because you often do not know whether the approaching car is close at hand on his lower beam or at a greater distance on his upper beam.

That leaves us with the essential reasons for introducing the system which we all have had in our minds.

Figure 14 sums them up: The system eliminates headlight glare, it removes the blind driving zone, and it improves open road seeing.

Again, you may feel that the Polaroid lights are uncomfortably bright when you accidentally see them without a viewer. But against this disadvantage you may very well balance the greatly improved visibility on the open road, when traffic is light and you choose to raise the viewer.

It is possible to continue at some length reciting minor disadvantages of the Polaroid system and setting them off against minor advantages. It may be worth mentioning, for example, that the viewer appears to clear up a dirty windshield. When it rains, the viewer removes the scintillation from the drops on the windshield. On wet pavements, the system eliminates most of the glaring reflections from the oncoming car's lights - reflection which is today a source of considerable glare even from the depressed beam. There is a real possibility that the Polaroid system can reduce over-congestion of highways. Drivers hate highway congestion by day, and they fear blinding headlights by night. Of the two evils, they choose congested highways and leave the highways relatively empty at night. With Polaroid headlights, motorists may be encouraged to drive much more at night and may so relieve the increasingly widespread daytime highway congestion.

We believe that the minor advantages and disadvantages of the system will balance out more or less evenly. In any event, the study of these advantages and disadvantages has proceeded to a point where we believe it can be stated that there are no unacceptable disadvantages of a fundamental nature in the Polaroid headlight system.

As you have seen, all of the research and engineering data support the immediate adoption of the system. The technical evolution of the Polaroid headlight system is essentially complete. We have now entered what might be called "the phase of political evolution" - a phase in which the Highway Research Board may, I believe, take an important part.

The ordinary normal course for a development in the automotive field would be for the company which has invented and developed a new improvement (safety glass, for example, or an automatic transmission) to sell the improvement to one of the automobile companies. This company would go to the trouble and expense of building the improvement into its cars. One of the basic and most reliable motives of our free enterprise economy would have been at work - a desire for profit on the part of the company inventing and developing the improvement, and a desire for competitive advantage and profit on the part of the company adopting it. This has been the history of most of the great improvements which have occurred in the American automobile. The competitive profit-making motive has been the driving force which has brought them from the laboratory, through the troubles and expenses of introduction, to final use by the public.

As you have seen, there is an obstacle which prevents the Polaroid headlight system from following this well-worn path. If the system is introduced on only one make of automobile, it will be fully effective only in meetings between cars of that particular make. Introduced on one make of car, after obtaining the necessary permissive legislation, it cannot offer a strikingly effective competitive advantage. To be fully effective, it should be built into new cars of all makes at the same time. But if this is done the competitive advantage is again removed.

Who, then, does have a driving incentive to bring about the adoption of this system? The public is clearly interested.

Polaroid has an obvious incentive in addition to its belief in this system as a major safety contribution.

The Motor Vehicle Administrators function as regulatory or enforcement officers. Their efforts in proposing and studying the system, undertaken as representatives of the public, are an extra burden which they have voluntarily added to their already heavy administrative and legislative load. They have an important role in the program, covering regulations and permissive legislation, and I am sure we can count on their cooperation. Individually they all have a fundamental interest in safety measures, but many lack facilities for implementing such a program.

I have already touched on the lack of competitive incentive to the automobile manufacturers. I feel that under the circumstances they have spent a surprising amount of time and energy on the program and it is understandable, if regrettable, that they should feel that they have now gone as far as they can on the system until they know the public wants it badly enough to insist on its installation. The introduction of Polaroid headlighting is a major program requiring responsible handling. We have the industry's assurance that they will cooperate under what they consider appropriate conditions.

Where then can an effective driving force be found? We believe that the public must supply the force and that your organization, the Highway Research Board, is the type of organization which could help to work out means for introducing the system. Dedicated to the improvement of public welfare through the products of research, your only bias is the bias of public interest. You can find facilities for making an accurate estimate of the value of polarized headlights in improving highway safety and comfort. You have the organization and the channels of communication necessary for bringing the facts to the attention of the public and for finding the response of the public to these facts. You are in close association with other organizations, private and governmental, who share your interest in public safety. It appears to me that you are one of the key organizations, in a position not simply to cooperate, but also to help organize and lead the cooperative effort the public must make to obtain adoption of the system.

APPENDIX A

EARLY HISTORY OF THE POLAROID HEADLIGHT SYSTEM[1]

Early in the twenties, polarized light was recognized, particularly by Dr. Lewis Chubb, as the best escape from the headlight glare dilemma. In 1925, the present engineering secretary of the AMA told a meeting of the Illuminating Engineering Society that a "proper and universally satisfactory solution of the headlighting problem is one of the most important needs of the automobile industry," that "it would seem that the headlighting problem should be solved with the proper polarizing materials." He had to go on to say, however, that "the schemes which have been mentioned will undoubtedly seem very wild to the average engineer" since, as he had already explained, "no substance of the properties for a windshield plate is yet known, while analyzing prisms for goggles is quite out of the question commercially."

He had in mind the polarizing prisms used in physics laboratories at that time, cut from natural calcite and the fragile plates of herapathite, the only synthetic polarizing device then known. That was the situation up to 1932.

In that year, I brought to Detroit a polarizer in sheet form. Some time earlier, I had set down the requirements of a polarizer suitable for automobile use, conceived of it as a plastic film of some kind, and, after some effort, succeeded in synthesizing what we came to call Polaroid J Film. This material promised to be quite satisfactory for the headlights then in use, and we proceeded at once with the developments necessary for putting it to work - the building of a production machine capable of turning out some thousands of square feet of material per day, the designing of the special adhesives for bonding the material between glass, etc.

Meanwhile, however, the industry had become dissatisfied with even the best headlights of that time and had started on the program that ended with the adoption of the Sealed Beam. This introduced an entirely new concept; that of a complete, self-contained polarizing light source. That, in turn, called for an entirely new polarizer; one that would be capable of withstanding the 400-degree temperatures of the face of a Sealed Beam lamp in still air, the destructive exposure in sunlight, and the wear and tear of continuous use for the entire life of the lamp.

We set to work all over again, against the assurance of our friends in the plastics industry that there were no plastics capable of standing that range of temperature, and against our own certainty that there were no polarizing crystals that would stand that abuse, even if we found a plastic to embed them in. It took many months to arrive at a solution; a polarizer containing no crystals, made up of a plastic of a new kind.

With this new polarizer perfected we proceeded with the materials and devices for using it; the development of an adhesive for bonding it to the front of the lamp, the de-

[1] Excerpts from "Progress Report on the Polaroid Headlight System" read July 16, 1947 by Edwin H. Land, President, Polaroid Corporation, at the meeting of the Engineering Committee of the AAMVA and the Engineering Liaison Committee of the AMA at the General Motors Proving Grounds in Detroit.

velopment of a coverglass that would project the film without depolarizing the light; the design and testing of dozens of different viewers; and the combining of these developments into a matched system, adjusted for the slope of windshields and the use of safety glass. We had a great number of inventions to make and a new mass production process to perfect.

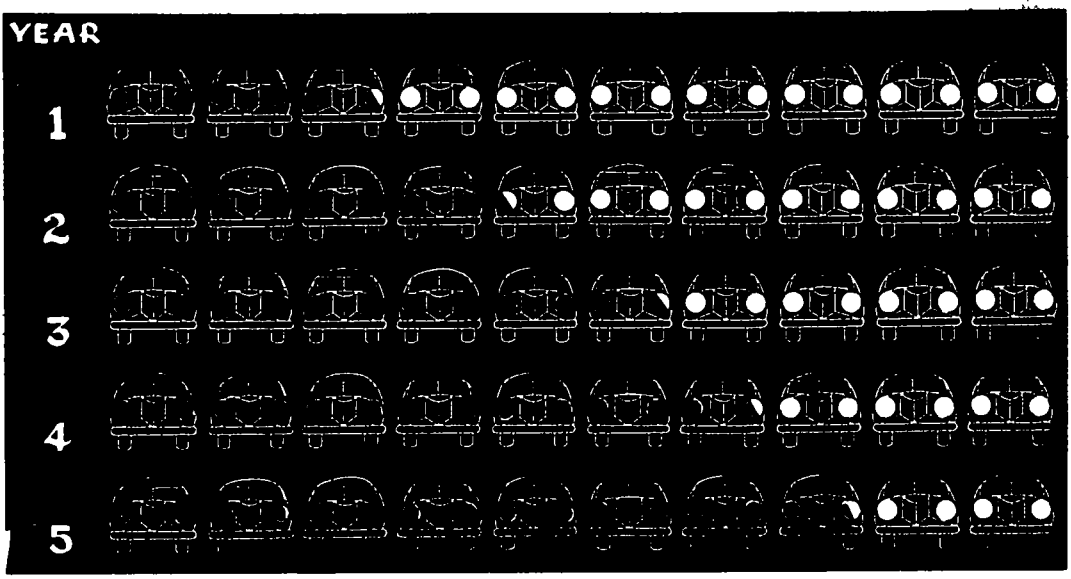

Figure A. Transition Period Without Conversion

APPENDIX B

TRANSITION CAN BE SHORT

How long will the transition stage last?

We have done some counting on the intercity highways, 10 to 30 miles out of town, in six different parts of the country - near Seattle, Los Angeles, Detroit, Dallas, Savannah and Boston - only about 3,500 cars, but probably an indicative sample. We find that the ratio of post-war cars to pre-war cars met at night is over three times as great as the number of post-war cars to pre-war cars registered. One might predict a result something like this on the common-sense grounds that a large proportion of night driving is done by those who are driving for pleasure, and who want to have a new car, and by salesmen and others who run up a high yearly mileage and who, therefore, have to have new cars. The ratio may not hold after the age-distribution of cars is restored more nearly to normal. Assuming this ratio, however, for want of any better, and assuming also a continuation of the normal 10 percent retirement of old cars each year, we can make a rough calculation of how long the transition period is likely to last. We have the situation shown in Figure A. In the

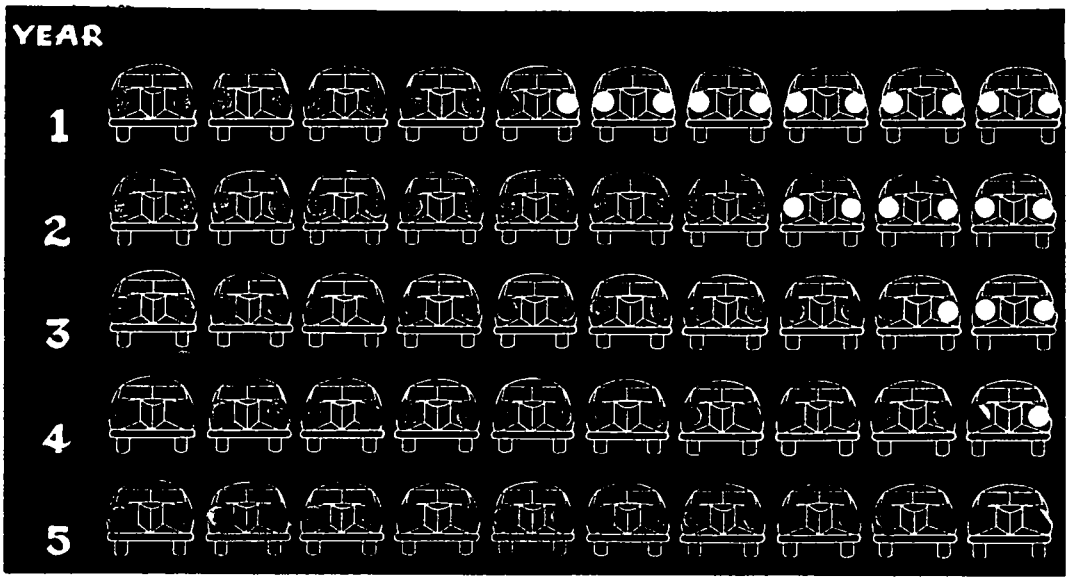

Figure B. Transition Period With Conversion

fifth year, if all passings were single passings, over three out of four of the cars you would meet on the road at night would be glareless. By the eighth year, over 95 percent of them would be glareless, and the transition period would be substantially ended.

If we assume a really attractive conversion system can be offered to the old-car drivers, and assume a very successful sale of this system accounting for the conversion of 25 percent of the old cars the first year, 20 percent the second, 20 percent the third, 10 percent the fourth, and 5 percent the fifth, we would have the situation shown in Figure B. After the second year, 70 percent of all cars on the road at night would be equipped; after five years, 95 percent. I present this as perhaps the most optimistic view, to be weighed against the very conservative view set forth in Figure A which assumed no conversion system at all.

In short, the Polaroid system can be working at a high degree of effectiveness in meetings in possibly five, certainly in less than eight years after it is introduced. Its immediate contribution to open-road seeing and occasional meetings has already been pointed out.