imental methods used and results obtained in an investigation of run-off from paved and turf surfaces. The project is a cooperative undertaking of the Public Roads Administration and the Soils Conservation Service to obtain data on the relationship of rainfall to run-off for use in designing drainage systems for flight strips.

A practical approach to the design of drainage for airports is covered in some detail with illustrative examples in Section III of "Principles of Highway Construction as Applied to Airports, Flight Strips and Other Landing Areas for Aircraft" published by the Public Roads Administration in June 1943. The section discusses amongst other items the design of surface and sub-surface drainage systems, size and spacing of drains and inlets, types of pipes, grating and gutters, as well as various methods commonly used in estimating rainfall and run-off. As the title indicates the principles involved and methods used should be of interest to both highway and airport designers.

It is hoped that Mr. Hicks' paper will be followed by discussion and additional papers on this important subject and its application to express highways in rural as well as urban areas.

CONTROLLED REFLECTION. A PLAN FOR GREATER SAFETY IN NIGHT DRIVING

By Eugene C. Bingham
Lafayette College

SYNOPSIS

Could it be demonstrated that our highway death-toll is unnecessary, we might after the war regard the present situation as unbearable. Lack of visibility, glare and the smooth condition of the pavements are all remediable. It is proposed that the surface of the pavement be given a fluted surface, with small nearly-vertical reflectors which will reflect the light of the headlights back to the driver to give visibility and not forward to produce glare. The roughness will not cause noticeable roughness or noise but will allow water to flow around the high points and prevent skidding. Visual observation, photographs or, better still, quantitative measurement of the light reflected with different surfaces prove conclusively the very great advantages to be obtained. The efficacy of the reflectors will depend upon their character and the care and expense spent upon their installation. The reflectors may first be tried out for the center strip or dividing line, or for curbs at the side of the road, but they should in time cover the entire pavement so that the entire highway will be highly illuminated several hundred feet ahead, without other source of light than the driver's own head-lights. Special treatment is suggested for crossings, curves and road-signs which will be described in detail. Questions as to methods of construction, durability and cost are to be considered. It is shown that the problem is one which is capable of exact scientific treatment. Controlled reflection may be applied to various types of roads, concrete, brick, asphalt.

Road safety may not be a hopeless problem. According to legend the Minotaur of Crete exacted a tribute of seven youths and seven maidens from Athens periodically. The important thing is that the Minotaur is no more, whereas the sacrifice of some 40,000 American lives to the labyrinth of our highways is a continuing and very real menace. Measured both in the loss of life and limb and in property as well, this is the equivalent of a great war, but one which is never won but ever growing in intensity with the years without any respite whatever. With the coming of the victory in arms bringing depletion of wealth and manpower in its wake, may we not resolve to remedy this unfortunate situation?

It is generally agreed that for an expanding economy after the war there are needed large new wealth-producing or wealth-saving projects. Would not serious study and experimentation on a broad scale be justified to determine what degree of safety can be obtained at a reasonable cost? Authorities will be found who will say that they are always studying, experimenting and improving but they will readily admit that the results are discouraging. They will say that with every new measure of safety the public "steps up the speed." That answer is not adequate. At one time the losses of life on the railways were excessive, the public became aroused and the losses were reduced; recent attempts to raise the speed have occurred with disastrous results, but the railway situation is not out of hand. Perhaps we need in our schools courses for drivers of cars, teaching not only the mechanics of driving but the rules for safe driving and of courtesy, followed by an examination as we have for pilots which will serve to exclude the unfit. Something more is needed than a first class condition of the machine. What is it?

Nobody knows all of the answers, but most drivers know some of them. They are not eager to commit suicide as some people assume. One who has driven in a dense fog when scarcely anything was visible, has searched at times almost in vain for a glimpse of the edge of the road or for an indication of the center of the road due to paint or tar. He may have had the experience when passing cars with glaring headlights, seeming to require him to be further to the right of the road than seemed safe, of seeing the backs of a nonchalant pair, apparently quite unconscious of danger, strolling on the right of way just ahead. Only a man's white collar or a girl's white hand revealed them, and averted a tragedy. Or, at another time, the air was turning cold and water standing on the pavement froze to glare ice which was quite invisible and threw the car into a skid or perhaps it was not ice at all but a smooth pavement which the authorities mark in a somewhat self-committal way, "Slippery, DANGEROUS when wet."

We may look on accidents either as due to carelessness or to an act of God, but a more realistic attitude is to assume that accidents happen due to a cause and if causes of accidents are removed, accidents will decrease. Lack of visibility was the cause of the near-accidents described above, for usually, if we see a danger long enough ahead, we can avoid it. The National Safety Council states that 60 per cent of all fatal accidents take place at night and that the death toll per million miles of travel is three times as great at night as during daylight. Moreover nearly 13,000, *i.e.* one-third of the fatalities are pedestrians, where it may be safely assumed that poor visibility is often at least a contributory cause. It is quite clear that the hazard derived from glare is in the lowered visibility. It may be less obvious why accidents by skidding are often due to lack of visibility—but of that, later.

Visibility. With the development of steam locomotion the headlight was required to illuminate the right of way, but the motorist is conscious of the fact that visibility is not proportional to candle-power. As the candle-power goes up, glare appears until one sees the lights but not the objects which are supposed to be illuminated. The manufacturers of stationary lighting have worked on the problem but their solution is expensive, of problematical value and out of the question for secondary roads. The trouble is that road builders have tried to make the surface of the pavement as nearly a level plane as possible in order to give the maximum of riding comfort, yet apparently without inquiring whether or not this ideal is compatible with safety. Time of riding-comfort should not be counted as the sun-dial counts "only sunny hours." Our highways must be for fair and foul weather. If the tendency toward smooth pavements is not resisted, an optical surface would result at last and a beam of light would then not illuminate the roadway at all for the benefit of the driver of the car; all of the light would go on ahead as glare to the confusion of approaching motorists. This same smoothness of the pavement would inevitably bring about another disastrous feature, since the grip of the pavement on the tires would be thereby lessened, making the road slippery and therefore dangerous when wet. At high speed a film of water on a smooth pavement does not have time or opportunity to drain away and therefore acts as a lubricating film. Therefore it is well-recognized among highway experts that for safety the roadway surface must be somewhat rough, either a "sandpaper surface" or one with larger rough pieces of stone harder than the cement which will act as "islands" around which the water can easily drain away. From the writer's point of view, we need not only a slightly roughened surface but one which for the sake of high visibility is roughened methodically in a very definite manner, although the material of construction is less important.

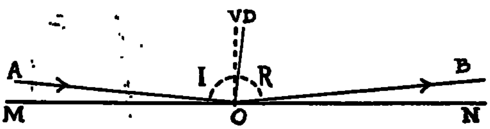


Figure 1. The ray *AO* is specularly reflected from a plane surface along the line *OB*, the angle of reflection, *R*, being equal to the angle of incidence *I*. For the ray to return to the same source *A* after reflection the reflecting plane would need to be perpendicular to the paper along *OD*. The angle of incidence shown in the figure is 85 deg. instead of 89.5 deg. which is used in the discussion, the line normal to the surface is *OV*.

speed, the driver should be able to see objects on the highway at a distance at least great enough to permit the complete stoppage of the car. For the sake of our argument, we shall assume this distance to be around 330 ft. or 100 m., and again assuming the height of the headlights above the pavement to be about 3 ft., we obtain a ratio of 0.0090 which is again roughly one per cent. This corresponds to an angle of 31 min. or about one-half of a degree. This is then the distance of highly effective illumination. We assume that if the entire pavement is well illuminated at 330 ft. there is no advantage whatever in wasting light on nearer distances which will be sufficiently illuminated anyway, and in any case there is no light to be wasted. We reach the conclusion therefore, that to be most effective, reflectors must be nearly vertical and facing the hypothetical source of light some 330 feet distant. One can most readily conceive of the appearance of such a highway being made by laying down, on a level base, bricks of trapezoidal longitudinal section, so designed as to expose at one end a narrow horizontal strip of reflecting surface sloped at the desired angle of 0.5 deg. with the vertical, as shown in Figure 2, in section. It is desired to make plain to

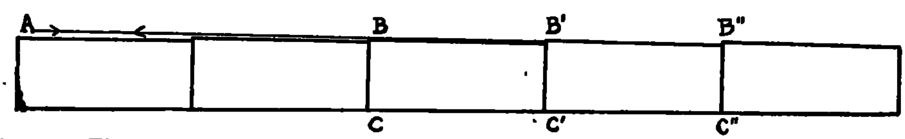


Figure 2. This shows in section five trapezoidal blocks resting on a horizontal plane, the distance *BC* being two per cent greater than *B'C'* which is twice the value suggested as a minimum.

When a ray of light *AO* is reflected from a plane surface *MN*, the angle of reflection *BOV* is equal to the angle of incidence *AOV* in Figure 1. Since the reflected ray continues on away from the observer, the riddle is insoluble of getting light back to the driver on a smooth surface but is readily soluble on a slightly roughened surface. All that is necessary is to make the two angles zero, then $R = I = 0$. Such a surface in the figure cuts the paper perpendicularly along the line *OD*; it will reflect back to the driver all of the light undiminished provided only that it is an optical surface. The height of this reflecting plane above the horizontal plane *MN* must now be decided upon and it is a matter of arbitrary albeit important selection. At full

the reader that light from *A* at the assumed angle not striking the reflector at *B* would just skim the surface BB′ and strike the reflector B′ etc. further on and be returned to the vicinity of the source; and thus there would be a brightly illuminated area or gleam traveling along at some distance ahead of the car on the level straight-away. The reader may here raise the question as to why it is desirable to illuminate the highway as well as objects on the highway. The reason is that all objects, light colored or dark, cast dark shadows on a brightly lighted highway, but black objects cannot be seen at all on a very dark background.

Dimensions and materials. For our argument we have used a gentle slope for the cut or groove which is approximately one hundred times as long as the height of the abrupt reflector slope. This ratio is fixed within rather narrow limits, but if it is kept constant, the height of the reflectors may be varied at will. In fact, there is no objection to having a greater number of reflectors than the theoretical minimum, and that might conceivably be advantageous but experiment has not gone far enough yet to recommend it. In any case, the useful reflecting area is the same per mile regardless of the height of the reflectors. Thus if the reflectors are 0.1 in. high, the distance

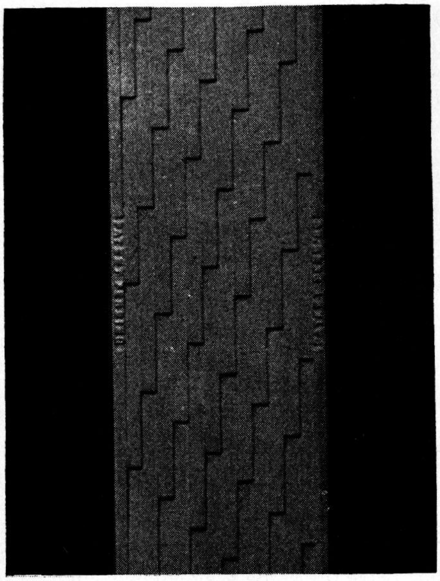


Figure 3. This photograph is intended to show the arrangement of the reflectors, which are here dark. Each reflector is ½ in. wide and 6 in. long. The entire block is painted with several coats of white paint.

between the reflectors will be 10 in. whereas if the reflectors are 0.2 in. high, the distance should be increased to 20 in., etc. Tolerance in construction requires that the reflectors be made slightly higher than theoretical. This may also increase their life. Secondary reflections take place at the distances less than 330 feet but that subject cannot be discussed here.

Bricks have been referred to for the simplest illustration. We have not experimented with them as yet. We have however made precast concrete blocks with multiple reflectors which were given several coats of white paint and enamel. We have also placed chromium plated brass strips in a mold and poured cement around or over them so that the strips were exposed in part but firmly imbedded. The Research Corporation has rendered us invaluable advice and material assistance in getting 20 blocks of reflectors in echelon, each 4 ft. long, made out of cast iron. These have

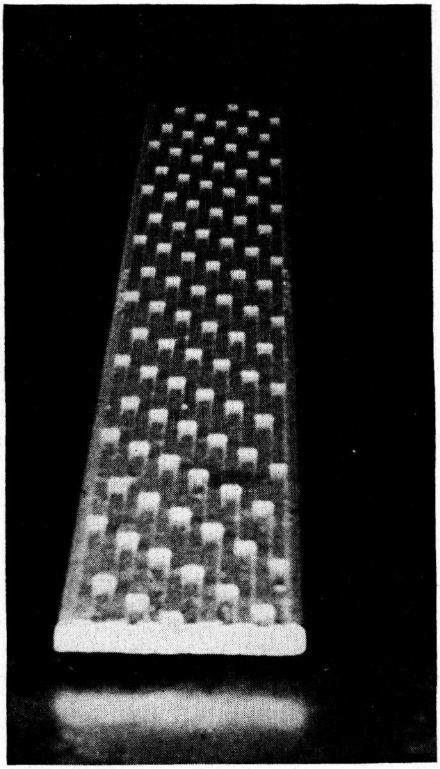


Figure 4. As soon as the illumination strikes the reflectors they light up, When one is near by, the individual reflectors are seen. The end of the block here shown would not be seen when the block was buried in the highway. When seen from a greater distance the reflectors merge together and produce simply the white surface seen in *B* or *D* of Figure 5.

also been made an integral part of one of the streets of the City of Easton where they are subject to traffic wear and conditions of both wet and dry weather. We are particularly indebted to Mayor Joseph Morrison for his cooperation in this probject. Views of these blocks are shown in Figures 3 and 4, the former revealing the reflectors in the shadow and the gentle slopes in the light. Each prong of the reflectors is 6 in. long and the reflectors are ¼ in. high. Figure 4 shows the individual reflectors as they light up when the light strikes them. When the block is viewed from a greater distance the light from the different reflectors makes them seem to merge together as shown in Figure 5, at *B* and *D*, referred to again later. In frankness we point out that Figure 5 does not refer to the same sample as

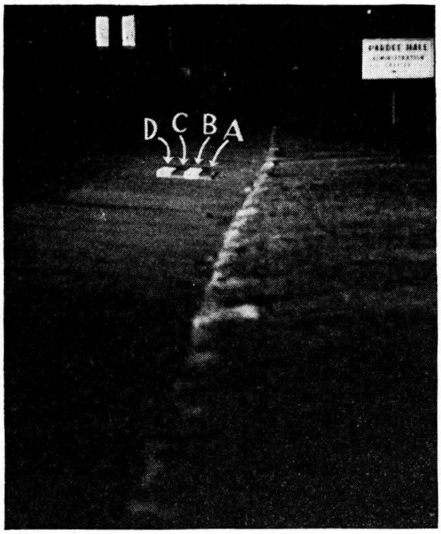


Figure 5. A board *A*, 4 ft. long, 6 in. wide was painted with several coats of white enamel and laid on an asphalt road and photographed. Under the light of a car 50 ft. away it appeared darker than the roadway as did another similar board coated with aluminum paint, *C*. Two similar concrete blocks with reflectors 1⅛ in. high, running across the surface, were coated, the one with white enamel, *B* and the other with aluminum paint *D*. Both appear brightly illuminated as is the road sign at the right. The two vertical rectangles at the left are the windows of the College Library illuminated from the inside.

shown in Figures 3 and 4 but the result would be the same.

The nature of the reflectors to be used must depend upon the conditions, such as the density of the traffic, the material of the road etc. It may be practicable to emboss a reflecting pattern on asphalt roads under certain conditions which will be of some value. Such a roller has been described. Mr. R. H. Baldock of the Oregon State Highway Department has also proved quite conclusively that transverse brushing or brooming of cement before setting appreciably improves the visibility in use. Our own experiments with metallic reflection suggest that improvements in design with the possible greater durability make desirable further investigation of the utilization of much greater reflection on a considerable scale. Baked lacquers or enamels may be a possibility or even stainless steel. Between the use of brushing the cement and the use of stainless steel reflectors set in the concrete there would be a wide difference in cost as well as in efficiency. Our remarks thus far have referred to the entire width of the highway. Many experiments must be made and ours have been going for a few years only and on a very small scale. Fortunately, experiments can be made in a variety of ways still on a small scale which will now be suggested.

The center line. There is now a considerable expenditure of money for the painting of the center and division lines. This paint is subject to wear and has to be done more than once a year to be effective. A means for obtaining a center line of much higher visibility which would require painting less frequently, if at all, would be an advantage. It would also be worth trying for marking the edges of the pavement, and would have the merit that it would in no way hamper drivers from crossing and driving off the pavement for parking or for minor repairs. Thus, it would not obstruct a portion of the highway and therefore become a potential danger in driving, as may be said of some of the high curbs.

Controlled reflection at the center line requires somewhat special treatment. Since the reflectors face one way only it is necessary to divide the center strip into two equal halves, each three inches wide, the one for the right lane and the other for the left lane; moreover since the driver always sees the center line at his left, the reflectors are set at an angle of nearly four degrees from the transverse line in order that the light from the car will return to the driver from a point about 80 ft. away. In fog and traffic, the gleam of the center line needs to be much nearer than the distant gleam on the main highway. The reflectors have to be tilted backward from the vertical away from the driver by about 2½ deg., which means a twist at the central line of 5 deg.

We are now testing stainless steel reflectors which are the crossbars in grids, 10 ft. long.

Three carbon steel bars form the longitudinal members of the grid; they are notched at every 8 in. and engage snugly with the reflectors which are notched to correspond, and then welded. The construction can be readily understood from Figures 6, 7, 8 and 9. The grids are made by the Hendricks Manufacturing Co., of Carbondale, Pa. to whom we are indebted as well as to the Republic Steel Co. for the necessary stainless steel. By having the pieces stamped out correctly, it is simple to obtain the same focussing for all of the reflectors; it is only then necessary for the engineers to determine their proper location on the pavement. The cells of the grid are filled with cement and the surface leveled off so as to expose the reflectors. Arrangements have been made for placing a test specimen of this on a street subject to very heavy traffic conditions.

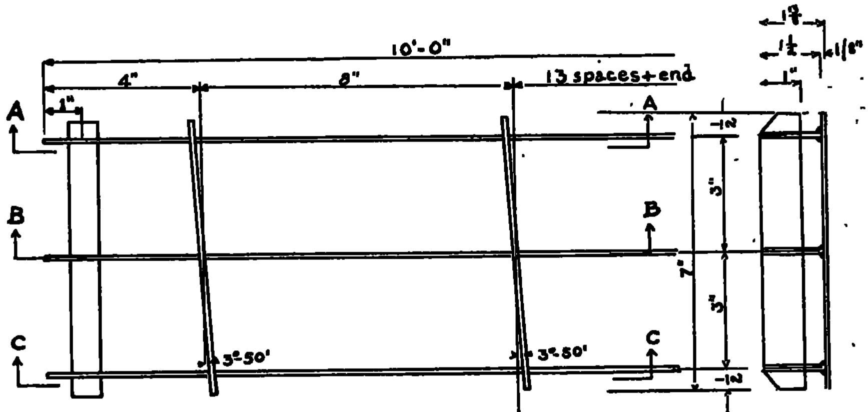
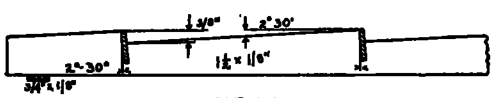
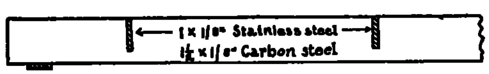


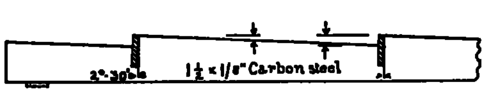
Figure 6. Plan and End View



SECT. A-A
Figure 7



SECT. B-B
Figure 8



SECT. C-C
Figure 9

Crossings. The application of controlled reflection at highway crossings should be very different from that on the ordinary road and on account of its importance deserves special consideration. On the ordinary road the motorist can give his undivided attention to the road ahead but as he approaches a crossing his mind is suddenly concerned with road signs of various sorts intended for his aid, with vehicles approaching from either side; and since his vision at a given moment may be obstructed, he finds it necessary to shift his vision from side to side. The necessary slowing down at the crossings causes congestion and all of these changes contribute to produce nervous reaction in both driver and passengers. Alertness is necessary but psychological bewilderment is dangerous and should be obviated if possible. Of course the driver should obtain under all conditions the necessary directions well in advance of reaching the crossing, but that is not always practicable at night or in a fog when it is most important. Postponing for the moment the discussion of road signs, it is absolutely essential that the approach of vehicles on either side be known, so this subject will be given first consideration. By leaving portions of the highway C, C′, C″ and C‴ without reflectors, Figure 10, those areas will appear to be black and give warning of the crossing and be the cause for slowing down. To enable the driver to gain information of the approach of cars from either side-direction it is only necessary to omit the transverse reflectors on all of the other areas and substitute in their place reflectors which will reflect light from cars coming from the left or right successively, as shown in Figure 10. For a right angle crossing these reflectors would be set at 45 deg. facing in either direction. The sequence of events is as follows: A driver (41) sees two dark squares C and C′ and slows down. If the areas 36 and 34 remain dark, he proceeds on through; if 36 is bright, a car is approaching from the left but if 34 is clear he may proceed with caution. The pattern of 36 is that

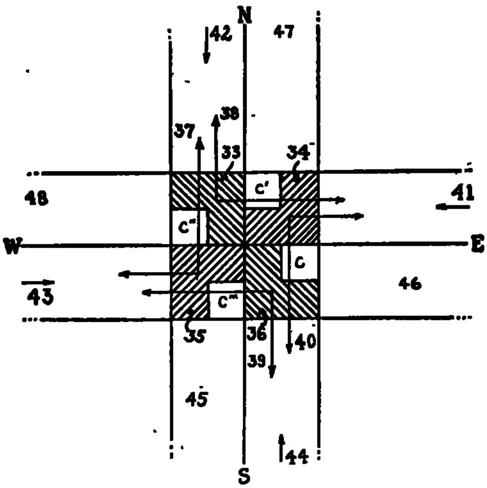


Figure 10. Road crossing. The diagonal lines indicate the location and direction of reflectors on the crossing. The transverse reflectors are not indicated on the lanes near the crossing.

of a capital letter L, the lower limb of the letter indicating the direction of travel of the approaching car. If 34 is lighted up by car 41 approaching from the right, it is necessary to stop before reaching the area 36 and wait until it is obviously safe to pass on through. We note that area 34 as seen by driver 41 resembles a reversed L indicating the direction of right to left. It is important to observe that the patterns are the same from whatever direction they are approached. Controlled reflection should not alter the etiquette at the crossing but it does make it possible to perceive the approach of cars which would otherwise remain invisible for an appreciable time behind buildings, bushes etc.

Road signs and other road information. Both the time and the manner of impartation of road information are important. If items of information are given one at a time and long enough before the appropriate action to enable the driver to consider them some bewilderment may be avoided. They should be placed on the pavement itself which is not only well-lighted but has the driver's constant attention. It should not be necessary to slow down in order to get all of the desired information. Letters must be large enough so that they can be read at say 200 ft. away and the length of the letters needs to be nearly 20 times the width in order to have the right perspective

Figure 11. The above letters appear erect and with proper perspective when viewed from a low angle from a distance of about eight times the height of the letters.

when viewed at a very low angle. This is illustrated by examples of both letters, Figure 11, and signs, Figure 12. Where much information needs to be given in regard to places and mileage, several lines of words may be necessary and they will of course appear to read upward as the road unrolls like a scroll and not downward as we read a printed page. It would be a convenience to have each mile simply noted and occasionally the compass direction. If then a direction sign designated an action to be taken at some point ahead, the driver could identify that point very exactly by means of his odometer. The placing of signs on the pavement, in case the entire pavement is illuminated by controlled reflection, is done very simply by omitting the reflectors from those portions of the pavement where the letters are desired, which would cause black letters to stand out on a white background; however, if only the center line were illuminated by controlled reflection, then reflectors should be placed where bright letters are desired on the black background.

Curves. We have assumed that on a straight road the reflectors would be on straight lines transverse to the highway but it must be clear that the lines would be circular, with a radius of 330 ft. This would cause a deviation of ½ in. at the ends of a 10-ft. pavement. At the curves the maximum speed is lower so that the radius of curvature is smaller.

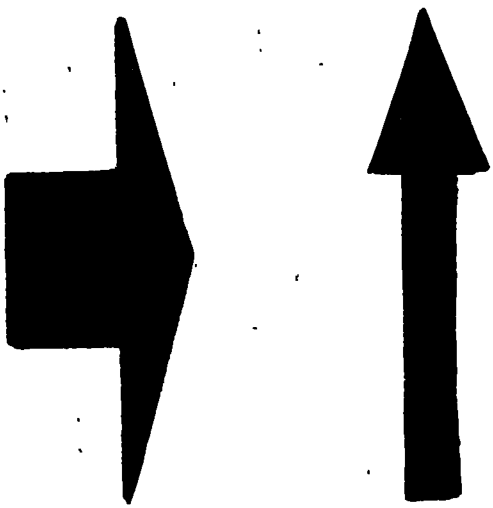


Figure 12. The above arrows look alike when viewed from the proper low angle.

The reflectors must still be set at angles which will return the light to the driver, which are quite different from that on the straight road. In Figure 13, the direction of travel is indicated by the arrow and the lines of the reflectors are shown crossing the pavement. Curb reflectors are also indicated, but not described for lack of space.

Efficacy of controlled reflection. A smooth horizontal surface coated with several coats of white paint and enamel when placed in a horizontal position and "illuminated" with automobile headlights some 50 feet or more away appears very dark, darker in fact than a black asphalt highway, similarly illuminated. This is shown in Figure 5 at *A*. A surface of concrete with reflectors similarly painted and illuminated appears very bright. Such a purely qualitative term is unsatisfactory. The photograph made by our colleague, Dr. Harold C. Downes is more satisfactory since we are able to compare the surface with the horizontal white surface, with the black road surface, with the surface of a neighboring road sign and with two brightly lighted windows of the College Library in the background. The camera may be "candid" enough but we desire exact information as to the amount of light which is reflected back at each angle. That reflected light is a measure of the visibility at each angle and therefore an analysis of the light magnitudes at different angles enables one to determine the efficiency of the reflectors.

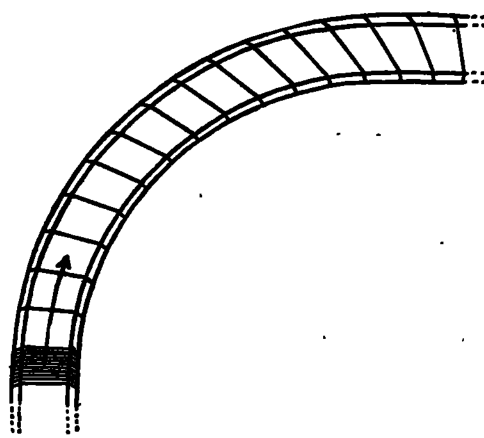


Figure 13

The theory of visual efficiency is simply to reflect back as much of the light as possible to those angles where it can be of possible use.

We have measured the light reflected from two samples, the one with the plain white surface and the other with the particular white surface already described, Figures 3 and 4. A Weston photoelectric cell loaned to us by C. K. Williams & Co. produced the fluctuating current which was measured on a delicate galvanometer. A narrow beam of light from a lamp was directed at a constant small angle of about 2.5 deg. at a certain point on the sample in a dark room. The photometric measurements were made as far as practicable through the entire 180 deg. at every 5 deg. interval. The measurements are plotted in Figures 14 and 15, *LO* representing the constant direction of the light beam, striking the surface around the point O. The small circles are placed at distances from O corresponding to the measurement at the indicated angle. The curve in Figure 14 for the plain white surface shows that very much more light is reflected away from the source than is reflected toward it. If the light were perfectly diffused, this curve should be the arc of a circle. On the other hand, if the light were nearly entirely specularly reflected, there should be a curve increasing to a maximum at 177.5 deg. and returning sharply to zero. Our equipment was not capable of getting readings at very small or very large angles, nevertheless it is clear that our observed curve shows high specular reflection. The second surface with the same coating and illumination but with reflectors arranged in echelon, Figure 15, is fundamentally different. For all angles up to 90 deg., more light is reflected back by the surface with controlled reflection than with the plain surface, and the lower the angle of observation the more noticeable this becomes. Furthermore, beyond 90 deg. the reflected light falls to a very small value, thus completing the proof of optical efficiency. The evidence should be much clearer if the angle of the beam could be reduced from 2.5 to 0.5 deg.

Desiring to gain further confirmation of these results and to perfect the method of measurement, Mr. Samuel G. Hibben of the Westinghouse Electric Co. was interviewed and he very kindly offered to make measurements with the very superior equipment available at Bloomfield. The results have been received but not in time to incorporate in this paper.

Factors other than efficiency. To be practically useful the method used for obtaining visibility must not only be effective it must not be too expensive to maintain, the results obtained must be capable of use for a number of years, the original expense must not be too great and there must not be serious drawbacks entailed. Such drawbacks would be strongly on the debit side, while the saving in overhead structures and in charges for electricity for lighting would be on the credit side along with the diminution of glare and decrease of skidding provided that they were connected. The main item would be the saving of life and property.

The first question that comes to mind is as to whether dirt on the highway will accumulate in front of the reflectors and make them useless. Experience over 3 years indicates that little dirt remains in the middle of a concrete or asphalt highway where drainage is maintained. Suction of the tires and air-currents cause the dirt to go to one side. The reflectors have not been covered with dirt except where water from the side drains over the pavement. Painted reflectors require repainting but not as frequently as they would in the ordinary center line where they are subject to wear.

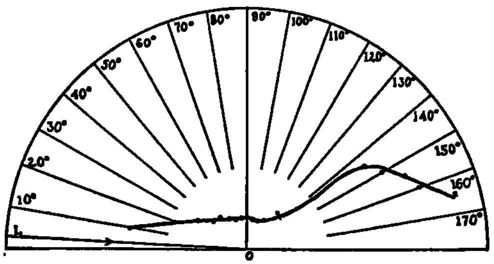


Figure 14. Reflection from Plane White Enamel Surface

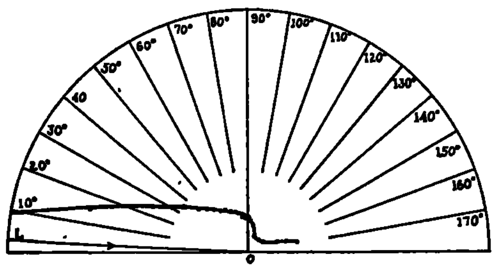


Figure 15. Controlled Reflection

If water accumulates as a pool so as to drown the reflectors, the area covered by the water will appear dark. That is as we would wish it to be since it reveals the danger. The same thing would be true if the water were frozen to glare ice.

Tests as to the occurrence of noise or vibration have been made with two strips of reflectors 40 ft. long so arranged that all four wheels of the car would be on the reflectors at the same time. No increase in sound or sensation could be detected and with the aid of assistants the speed of the car was increased to 20 m.p.h. and instruments were employed. We were embarrassed by the fact that the asphalt highway which appeared to be very smooth nevertheless contained undulations which could be readily detected with a straight edge which amounted to a half-inch or more. They affected the instrument. The castings had no such undulations and they seemed to give smoother riding. However, the test length was too short and the speed too low for an adequate test.

By laying a piece of carbon paper on the pavement with the carbon facing a white sheet of paper and then causing the well-worn tire on a car to run over them, a print of the highway

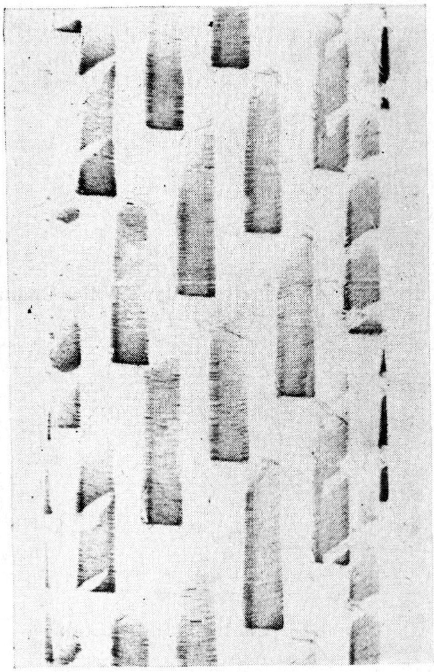


Figure 16. Road Print

was obtained which is reproduced in Figure 16. It is observed that the car rests on several of the files of reflectors at the same time so that there is little chance for vibration. One can also observe that the pressure is relatively very great upon the prong points and that water can readily flow off from these points and away, giving excellent traction.

Conclusion. Light is like rain, which comes down from Heaven free to all to use as they choose. We consume a little in seeing, we are better off for bathing in it, and our gardens and fields use more, but of all the vast flood of light that comes to us we yet know how to use but a small fraction. Nature has stored some of this energy for us in coal as we store water in reservoirs and thus we get the precious gift of artificial light. Glare has been defined by some-one as simply "wasted light" and this paper might have been entitled "the utilization of glare." It is difficult for the mind to appreciate the possibilities of salvage in light.

Starting from the headlight as a source 1 sq. in. in area spreading out in a cone of light to a diameter of 20 ft., the light would be diminished to 0.5 per cent of its intensity. If each point of the highway receiving that light, reflected all of it diffusely in all directions, the brightness would be reduced in 330 ft. to 0.003 per cent of the remaining light, *i.e.* to 0.000,015 per cent. However a black highway reflects far from all of the light striking it and even a white cement highway would not reflect equally in all directions, hence the above figure is worthless except as a rough maximum; it makes it clear however that, in the attempt to salvage wasted light, it is not impossible to increase the illumination with our present headlights several hundred fold.

The improvement will not come from the manufacturers of lighting equipment for they have already done their part. It will not come from the State highway departments which are the servants of the people; the demand must come from the public, aroused to insist that a remedy be found for a situation which promises soon to become intolerable.

Summary. 1. A method is proposed for the deliberate roughening of highway surfaces in order to increase their safety in four different ways: (a) by the introduction of minute reflecting surfaces in a manner calculated to reflect light from the headlights of a car back to the vicinity of the driver of that car according to well-known laws; (b) by the use of light now wasted, to reduce the glare on the highways; (c) by providing "islands" from which water can drain off to decrease slipperiness and the danger of skidding when driving at high speed; and (d) by affording, on the road surface, a means for communicating all sorts of road information at night as well as day while traveling at full speed.

2. It is suggested that the reflecting surfaces may be made by grooving or embossing concrete in the period between the initial and final set or they may be obtained by casting in either concrete, porcelain or metal. Ce-

ment may also be poured into a grid, having metallic crossbars which would act as reflectors. Metallic reflectors would have the advantages of high reflectivity, great strength and low maintenance charges; cement would cost less but would require painting to secure high reflectivity.

3. The idea is put forward that roads can be built which will insure high visibility at selected points. One of these points, which constitute the "gleam points," is situtated several hundred feet ahead of the driver, where he should first note danger. A second gleam point should be much nearer at the left of the driver at the center line. The light for the gleams is obtained through the suppression and utilization of glare. Other gleams may be used to make the edges of the highway more strikingly visible.

4. Studies have already been made in an echelon formation of reflectors in order to enhance the anti-skidding characteristics of the highways. This naturally complements the researches already made by the rubber companies on how best to roughen the tire treads in order to secure the best grip to the road and to avoid noise and vibration. Some preliminary results of these studies are reported.

5. The reflectors may be arranged in patterns representing letters or road signs so that they can be easily read by the driver while the car is moving without shifting the eyes from the road.

6. In carrying out the use of signs on the surface of the pavement, it is suggested that good psychology should be used in imparting road information to drivers and passengers as well. The driver needs his information long enough before the appropriate action so that he can consider it in his mind and there will be no indecision when the time for action arrives.

7. Special treatments are briefly considered for crossings, curves, center lines.

REPORT OF COMMITTEE ON ROADSIDE DEVELOPMENT

By H. J. Neale, *Chairman, Landscape Engineer, Virginia Department of Highways*

SYNOPSIS

We must keep in sight the true objectives of complete highway design. The roadbed and the roadside are inter-dependent factors in a single problem. Streamlined grading, adequate drainage, positive slope protection, and provision for waysides, safety turn-outs, and other essential driver services, must be combined with safe and effective traffic services and structures.

A separate report on War Memorials is sponsored by the Committee as a guide in selection of sites and in design of appropriate memorials on highways and roadside areas. Lasting beauty, traffic service, and easy maintenance must be combined in a good memorial.

The value of aerial photographs for "complete highway" development is also covered in a special report on "Aerial Surveys for New Highways and Roadsides."

Those landscape items considered most essential for complete highway service are listed for inclusion in post-war construction.

The process of developing turf on stabilized soils on airfields in Florida is briefly described. Field tests for establishment of turf on a stabilized base of granular materials on highway shoulders in Indiana are also cited. Such treatment of soil areas has possibilities for widespread use on airfields, flight strips, and road shoulders and other areas subject to occasional traffic use and emergency parking of vehicles.

A "Clearing House" of timely information on roadside development was initiated in 1943. Among others, the need for more efficient equipment for distributing and anchoring mulches to control dust and erosion is pointed out.