TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

DRIVER VISION
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DRIVER VISION

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1. Advance direction signs and specular reflections, M. J. Gregsten. Traffic Engineering and Control 3: n 6, pp 347-349, October 1961.

In this article the association between specular reflection and the alignment of signs is discussed, and the results are given of experiments to determine the alignment required to avoid specular reflection from the smaller direction signs in use on all-purpose roads.

The legibility of advance direction signs can be seriously impaired at night by specular, that is, mirror-like reflection of the light from vehicle headlamps. In a recent survey of some 300 signs situated on major trunk roads, nearly half were found to exhibit some degree of specular reflection. Similar observations were made on the large signs on the Preston motorway in 1959, and in this case specular reflection was observed only on a sign on a left-hand bend. Measurements of the alignment of these signs, and of seven serious cases on route A 30, showed that whereas the motorway signs had flat surfaces and were aligned substantially at right angles to the roadway, those on the all-purpose road all showed some degree of surface irregularity and were turned towards the oncoming traffic by angles of up to 10 deg. It appears to be the general practice to align direction signs in this way.

It has been shown that specular reflection can occur if a sign of which the surface is not perfectly flat is either turned towards or at right angles to the road, and that the simplest method of avoiding this is to turn the sign slightly away from the oncoming driver. Two experiments to determine the necessary angle gave values of 4 deg and 5 deg, respectively. The probable reason for the difference is that whereas in the laboratory the tests were carried out over a finite observation distance, the calculations in the second experiment refer to the removal of specular reflection at all distances. The difference is so small, however, as are the angles involved, that it is reasonable to take the figure of 5 deg as being the required angle.

Recommendations: (a) All advance direction signs, whether illuminated or not, should be aligned in a vertical plane and turned away from oncoming traffic. (b) The angle of turn-out should be 3 deg $\pm$ 1 deg for motorway signs, and 5 deg $\pm$ 1 deg for signs on all-purpose roads. (c) On straight roads and right-hand bends the angle of turn-out should be measured from the normal to a chord of length equal to the legibility distance, reckoned at the rate of 50 ft per in. of letter height, drawn back from the sign.

2. Basis for judgments of relative brightness, R. M. Warren & R. P. Warren.
Journal, Optical Society of America 48: n 7, pp 445-450, 1958.
The hypothesis is offered that relative brightness judgments are based on experience with the way the amount of light reflected by objects changes with their distance from the light source. The experimental results support this hypothesis. One group of 40 subjects judged half-brightness, and another 40 estimated the change in luminance corresponding to moving a hidden point light-source to twice the distance from an illuminated standard field. Judgments of the two groups were equivalent. Under stimulus conditions designed to represent the common visual situation (stimuli subtending wide visual angles, adaptation approximating stimulus levels), one-quarter the standard luminance was correctly chosen for the effect of doubling distance from the source, and the same fraction was chosen for half-brightness' for all standard intensities (0.000867 millilamberts). Under less familiar conditions similar to those employed for the bril scale (small stimuli with black backgrounds, indeterminate levels of adaptation) half-brightness judgments were again equivalent to estimates of the effect of doubling distance from object to light source. These estimates were less than one-quarter standard luminance. The hypothesis is discussed in terms of sensory scaling in general, and the neutral-value and bril scales in particular.

3. Assessment of nighttime roadway visibility, D. M. Finch, and J.D. Palmer.
Nat'l Research Council--Highway Research Board Bulletin 163, 1957, p 1.
Approximately seven visibility meters have been described in the literature during the last 20 years. The salient features of each of these instruments along with their limitation and applications are briefly discussed. The U. C. Visibility Meter is discussed in detail.

The design equations of the U.C. Visibility Meter are given together with the criteria for a suitable visibility meter. Details of optical parts and calibration are included to show compliance with the design criteria.

The U.C. instrument has been used to evaluate the visibility conditions of two extremes of street lighting, that is, a uniform and an extremely non-uniform roadway brightness pattern. Under each condition a two-dimensional and a three dimensional target was used to gather information. Results of these roadway studies are presented.

These results show a great variation in visibility under the non-uniform roadway brightness pattern and less variation in visibility under the uniform roadway brightness pattern. The peak visibility of the non-uniform condition is only slightly greater than the average visibility level of the uniform condition.

4. Analysis of certain variables related to sign legibility, H.W. Case, J. L. Michael, G. E. Mount, and R. Brenner. <u>Nat'l Research Council--Highway ResearchBoard Bulletin</u> 60, 1952, p 44-54.

The recent development of high-speed urban freeways has increased the need for destination signs of maximum legibility. One factor though to influence legibility is the letter-background arrangement, with the usual alternatives being black letters on a white background and white letters on a black background. A survey of the literature revealed nine published studies in which the legibilities of these two combinations were systematically compared. The results of these studies throw little light on the problem as it relates to highway destination signs.

All but one of the studies were conducted in the laboratory with illumination levels ranging from 1 to 100 foot-candles. Since outdoor daylight may range as high as 10,000 foot-candles, results obtained in lower illumination levels may not be directly applicable to the usual daylight situation. However, if the results are considered only in terms of the low levels of illumination, the problem still reamins unresolved because of the inconclusive and contradictory results obtained. Furthermore, the earlier experiments were, in general, based on the principle that all variables but one should be held constant. Therefore, it was assumed that the relationship between letter-background arrangement and legibility was independent of other factors. The failure to assume interaction between several relevant variables may be responsible in part for the contradictory nature of the findings.

As a result of the survey and analysis of the experimental literature related to the subject, it was decided that an investigation should be made in a field situation to attempt to determine whether or not outdoor, daylight letter legibility varies with letter-background arrangement, and in turn how this letter-background legibility is influenced by spacing between letters and rows.

5. Visual appraoch to highway planning and design, Louis B. Wetmore. <u>Nat'l Research Council--Highway Research Board Bulletin</u> 190, 1958, p29.

Visual design as used in this paper is intended to have a very broad meaning. One way of indicating the breadth of this meaning is to note the several kinds of concerns about visual aspects of highways which would all be dealt with within the general phrase "visual design." The areas of concern are as follows:

1. Pleasure and satisfaction.
2. Safety and convenience.
3. Economic values.

6. Relative effectiveness of some letter types designed for use on road traffic signs, A. W. Christie and K. S. Rutley. Roads and Road Construction 39: n 464, pp 239-244, August 1961.

Before the opening of Britain's first motorways only upper-case lettering was used on road signs, but for signs on the new motorways lower-case lettering was chosen. This choice led to discussions of the relative merits of upper and lower-case lettering in the press. In these discussions conflicting claims were advanced for the two kinds of lettering.

Clearly there was need for further experiment. The main need was for a comparison of upper and lower-case lettering on signs designed for maximum legibility and including complex as well as simple legends. The experiment described in this article was performed in an attempt to fulfill this need.

The results obtained from charts consisted of 6,336 reading distances, 1,584 on each of four different types of script. The mean values for the different scripts are shown. There was little difference between the mean distances for the three closely spaced scripts but the distance from the widely spaced lower-case script was distinctly less than the other three.

The results for all the observers were pooled to give one mean value for each sign element separately (that is, top names, bottom names, etc., were treated separately). The scripts were then tested in pairs. Using the 95 percent probability level the results of the tests were as follows:

1. There was no significant difference between the mean reading distance for the lower-case script with close spacing and that for the sans-serif upper-case script. The true value of the difference probably lies between -2 and +3 percent.

2. The mean reading distance for the serified upper-case script was significantly greater than that for the sans-serif upper-case script (by between 1 and 5 percent) and for the lower-case script with close spacing (by a similar amount).

3. The mean reading distance for the lower-case script with wide spacing was significantly less than the distances for the same script with close spacing (by between 10 and 14 percent) and for the two upper-case scripts, which were alos at close spacings (by roughly similar amounts).

When the results for individual types of sign were examined it was noted that there was a tendency for the lower-case lettering to be relatively less effective on signs with written messages such as "Stop" and"Ice," than on signs with place-names. Possibly people are more accustomed to seeing upper-case lettering used for warnings and instructions and on that account find them easier to read when in upper-case lettering.

The question of aesthetics may enter more strongly into the choice of the spacing to be used on signs. The most economic solution is to use close spacing and this has the advantage of keeping the signs as small as possible (although there is alower limit set by the fact that signs must be sufficiently conspicuous to attract a driver's attention in good time).

7. A method of illuminating direction signs on motoways, V. J. Jehu.
<u>Light and Lighting</u> 52: n 11, pp 338-40, November 1959.

This article describes a system for the floodlighting of large direction signs. The system is being tried out on some of the signs on the Preston Bypass (England).

It has been shown that, for good legibility at night, the luminance of the white parts of direction signs should be within the range 5 to 30 ft-L. Luminances of this order should be achieved over the whole area of the sign without causing undue glare to drivers traveling in the opposite direction--who will see the reverse side of the sign and will face the lighting installation.

Basically, the floodlighting system consists of fluorescent lamps inside reflectors arranged across the width of the sign, the lamps being positioned a short distance in front of the sign and just below its lower edge. Mounting the lamps close to the sign ensures that their light output is used efficiently; it also simplifies the screening of the lamps from the view of drivers traveling in the opposite direction, the floodlights, the screening boards and the sign itself forming a compact unit. The closer the lamps are to the sign, however, the more difficult it becomes to maintain uniformity of luminance over the height of the sign. The shape of the reflector used with the fluorescent lamps has been designed to help offset the fall off in luminance in a vertical direction for a wide range of sign heights.

In practice, the size and shape of a motorway direction sign will depend upon the length of the message it carries and upon its method of presentation. Measurements were therefore made on the lower half only of the test sign, i.e., on an area 8 ft.

high by 16 ft wide, to determine the minimum number of floodlights and their optimum arrangement for such signs. It was found that 2 floodlight, stepped-in about 8 in. from the edges of the sign, were adequate, the maximum and minimum luminances being 15.5 ft-L. and 7.6 ft-L respectively. The following set of rules should enable the best arrangement of floodlights to be found for a particular size of sign:

1. All floodlights should be mounted so that the distance from the light source to the sign is 6 ft.

2. For signs up to 9 ft in height, 2 floodlights will satisfactorily illuminate a sign up to 16 ft wide, the outer edges of the floodlights being stepped-in about 8 in. from the sides of the sign.

3. For signs between 9 and 12 ft in height, the floodlights must span the full width of the sign.

4. For signs more than 12 ft in height, the floodlights must span the full width of the sign, and a top reflector with an overhang of 9 to 12 in. should be fitted to the top of the design.

Floodlights made commercially to the Laboratory's design have been installed to illuminate 4 signs on the motorway. The largest illuminated sign is 18 ft 6 in. high and 14 ft wide. The maximum variation in luminance of the white parts of the sign is 4.5/1. The maximum luminance variation on another sign 15 ft 6 in. high by 14 ft wide is 3/1. Three floodlights are used on each of these signs together with a flat reflector at the top of the signs.

8. Headlight design, R. L. Moore,
<u>Ergonomics</u> 1: n 2, pp 163-176, February 1958.

A brief survey is given of the historical development of motor vehicle headlights. The principles underlying the design of the block lens headlamp used in American and Great Britain and the sharp cut-off lens used on the Continent are described and a comparison is made of the two systems.

An outline is given of the polarized headlamp system that is beirg investigated by the Laboratory.

The main conclusions reached during the course of research are:

A very substantial improvement in visibility and dazzle is possible with equipment now on the road if means can be found to improve aim and restore or replace damaged lamps.

No great improvement is possible by a change of lamp design using ordinary light.

The most hopeful field of inquiry is the use of a polarized headlamp system.

9. New traffic signs to make debut on bridge.
Michigan Roads and Construction 52: n 42, p 2, October 17, 1957.

Motorists will get a preview of a major new advance in traffic engineering developed by the state highway department when internally illuminated traffic speed and lane control signing is installed on the Mackinac Straits Bridge.

The overhead signs, being developed for use on Michigan's urban expressway system, will tell traffic which lanes are open and which are closed to traffic, as well as indicate safe travel speed.

The bridge installation consists of an illuminated "SPEED" sign with letters 16 inches in height, with illuminated speed listings below of 15, 30 and 45 mph. Only one speed indicator will be illuminated at any one time, to clearly indicate a safe speed. Green illuminated arrows will indicate lanes open for use and a large deep orange illuminated "X" will indicate lanes closed to traffic.

The installations will be made at some seven locations on the bridge and will be remotely controlled from the St. Ignace toll gate office. They are normally visible at 1,000 ft, but are more apparent at night. In case of an accident, the lane control signs can be switched to direct traffic to free lanes. The speed controls can be changed for icy weather conditions or in case of other emergencies on the bridge.

Huge overhead aluminum truss structures will support the internally illuminated signing. The design specifications and requirements for the signing were developed this year by the State Highway Department Traffic Division under the direction of Ed Gervais. They were being developed for use on Detroit and Grand Rapids urban expressways, and installations on the expressways will probably start sometime in 1958.

10. Method of assessing the suitability of reflecting materials for use in traffic signs, P Jainski.
Strasse u. Autobahn 2: n 1, 1951, p 9-12; n 2, p 45-7. (In German).

The reflecting properties of about 80 materials were compared under illumination from a motor headlight at various angles of incidence and positions of observation. The loss of reflecting power caused by the accumulation of dirt in exposure periods up to 310 days was also studied. Reflectivity values for three white, four silvered, four red and four yellow materials, the method of calculation being explained, were plotted on a logarithmic scale against actual values of the angles of incidence and of observation. Some of the conclusions:

1. In all cases reflectivity decreased with increasing angles of incidence; in each color group the decrease was gradual in some cases and abrupt in others, the former type being obviously preferable for use in traffic signs.
2. As the angle of observation increased from 0.5 deg. to 2.5 deg., the reflectivity decreased in all cases, the white materials showing the greatest constancy.
3. Generally speaking, the materials whose reflecting powers were least influenced by the angle of incidence showed least diminution in reflectivity at increasing angles of observation.
4. In selecting reflecting materials, a balance must be struck between reflectivity at different angles of incidence, constancy of color by day and night, and liability to obscuration on exposure.

11. The effect of specular reflection on visibility, Pt. I. Physical Measurements for the Determination of Brightness and Contrast, D. M. Finch.
<u>Illuminating Engineering</u> 54: n 8, pp 474-481, 1959.
Brightness (luminance) of letters written in ink and pencil was measured with a microphotometer at various angles under various systems of illumination, and compared with brightness of the paper background. Curves of "brightness factor" are given for several samples measured at different angles relative to the incidence of light from a small-area bright source. It is shown how to derive average brightness factor for a given situation from the curves, and hence the contrast under different systems of illumination. The calculated contrast values are compared with those actually measured.

12. Relation between scotopic vision as measured by the night sight meter, daylight vision and age, A. R. Lauer.
<u>Nat'l Research Council--Highway Research Board Bulletin</u> 191, 1958, p 53.
The high frequency of nighttime traffic accidents and the frequent complaints about glare blindness calls attention to a very important phase of highway safety investigation. Up-to-date this phase has received only meager attention by students of highway safety.

There are several aspects to the night vision problem and it might be well to consider them in order. The hypothesis to be investigated may be stated as a question, "What relationship exists between vision measured in daylight and vision measured in very low illumination?"

The Night Sight Meter is an instrument designed to give three types of scores on phases of night vision which are commonly mentioned as important to motorists traveling the highway at night. The visual measurements for daylight vision were made with the regular Sight Screener made by the American Optical Company.

13. Ratings for visual benefits of roadway lighting, Charles H. Rex.
<u>Nat'l Research Council--Highway Research Board Bulletin</u> 226, 1959, p 27.
The increasing extent to which roadway lighting is being used to improve night automotive transportation is of great social and economic significance. Many people desire, or may be required, to drive after dark. Motorists and truckers involved pay for a large percentage of the over-all multi-billion dollar investment in streets, highways, autos, trucks, and buses. More efficient night operation, higher dividends from the public investment, and more pleasant and attractive night driving conditions result from the use of good roadway lighting.
Seeing is obviously a basic requirement for night driving, as well as day driving. The rapidly increasing recognition and knowledge of the benefits of good roadway lighting may be expressed in terms of the improvement in (a) visual seeing and (b) traffic operations.
As shown in the upper portion of Figure 1, seeing and traffic benefit are interrelated; the traffic benefit is generally contingent upon the seeing benefit provided by the lighting. Evaluation studies are under way for rating both the traffic and visual benefits. The traffic benefit studies should specify the visual seeing factor effectiveness of the roadway lighting provided.

14. Retinal sensitivity and night visibility, R. H. Peckham and William M. Hart.
<u>Nat'l Research Council--Highway Research Board Bulletin</u> 226, 1959, p 1.
A previous report (HRB Bull. 56, p 17) indicated a correlation between retinal sensitivity and visibility during night driving. A new method for estimating retinal sensitivity by determining critical flicker frequency has been completed. A large field of view is kept at a constant and high level of brightness, so that retinal adaptation is consistent throughout measurement of sensitivity. A small area within this field alternates above and below the background brightness for a measured contrast, and at levels such that the "average" of the extremes equals the background. The contrast is controlled by a unique beam-splitting device within an optical relay, at any chosen

contrast from 0 to 50 percent with respect to background. The frequency of alternation of the two beams is accomplished by a synchronous motor operated by an audio-generator and amplifier, from 30 to 70 cycles per second, at will.

Random order presentation of the stimuli yields data which can be reduced to psychometric estimates of threshold by probit analysis. Subjects chosen from a large ophthalmic practice, ranging from 8 years up to 80 years of age, have been studied.

It has been found that the measure of retinal sensitivity, by means of flicker rate, indicates a superiority in young adults (21-31 yr) of five or more times above the average of the median adult population (32-50 yr). A comparable depression to one-fifth or less in the sensitivity of older adults (51-80 yr) is also demonstrable. This amounts to a superiority of 25 to 1 or better for young vs old adults. Teenagers (8-20 yr) are comparable to the young adult group, but show greater individual variance, depending in part upon immediately preceding out-of-door activity before their testing.

It is concluded that older drivers (50 yr and more) should be cautioned, and perhaps examined. Elderly drivers should be persuaded not to drive at night, if at all avoidable. Potential protection of elderly retinas by the use of sunglasses or out-of-doors avoidance is suggested. Support of further research is greatly needed, as this degree of retinal dysfunction is a significantly potential cause of accidents due to poor night visibility.

15. Dynamic visual fields, Barry G. Kind and Peter J. Sutro. Nat'l Research Council--Highway Research Board Bulletin 152, 1956, p 3.

It is estimated that an obstruction to vision contributed to one out of every eight motor vehicle accidents. In these, vision was obscured by objects on the car in 40 percent of the cases and stationary objects such as trees and buildings in 30 percent of the cases; the remainder were other cases--some moving, some parking, and a few instances of glare. To these must be added an undetermined number of cases where, through inattention, distraction, or other cause, the visual stimulus which fell upon the eye failed to "register;" that is, it failed to be perceived and interpreted. Knowledge of man's capability for viewing in terms of extent when operating a moving vehicle, his viewing habits or patterns, and his response behavior, is essential as the basis for specifying and providing for human requirements for vehicle design, highway planning, and driver training.

16. Photometric tests for reflective materials, B. W. Pocock and C. C. Rhodes.
<u>Nat'l Research Council--Highway Research Board Bulletin</u> 34, 1951, p 40-54.

Photometric tests developed and now in use by the Michigan State Highway Department for reflectivity measurements and color determinations on reflex reflectors and diffuse reflecting materials are described. Detailed accounts of equipment and procedures used in both tests are accompanied by examples of data obtained and methods of computations.

Some fundamental physical concepts and the significance of measurements are discussed briefly, and several useful and interesting applications of the data are pointed out.

Included also are photographs illustrating the apparatus now in use by the Department.

17. An acrylic reflecting material which offers new and unique applications for traffic signs, R. F. Hibbert.
<u>Nat'l Research Council--Highway Research Board Bulletin</u> 34, 1951, p 1.

Molded acrylic lens sheet is a retro-reflecting product which has many effective applications for traffic signs and signals and for automotive signs and signals as used on cars, trucks and trailers.

This acrylic plastic, sometimes known as Methacrylate, has been in good service and continuous exposure for over ten years.

Acrylic lens reflector sheet is made up of minute spherical lens sections which are an integral part of it. The lenses are arranged in honeycomb patterns and are correctly spaced to provide 2900 accurately molded lens sections per square inch of surface. The smooth back surface of the reflecting sheet is in the focal plane of the front surface lenses and only the area of greatest retro-reflecting efficiency is used in each lens section.

A reflecting medium usually aluminum flake in a vehicle of acrylic lacquer is applied to the back surface of the sheet. The reflecting system then consists of a multiplicity of minute spherical lenses on the front surface and a reflecting material on the back surface. The lenses, acting in unison, give the whole reflecting pattern an even, bright appearance, when illuminated and viewed from a normal distance.

If a highly concentrated beam of light is desired for long range, narrow divergence is achieved by precise molding to the focal length of the lens, a thickness of .070 in.; conversely, if wide divergence is desired, the plastic is molded off-focus to provide a reflector of lower intensity with a wider divergence angle at a nominal molding thickness of .055 in.

18. Field and laboratory evaluation of roadside sign surfacing materials, James H. Havens, Allie C. Peed, Jr.
Nat'l Research Council--Highway Research Board Bulletin 43, 1951, p 32.
Physical and optical characteristics of sign materials and design and application of a reflectometer devised by the Kentucky Department of Highways are discussed. Accelerated weathering procedures and specification standards are described.
Field studies paralleling laboratory work and a possible correlation between the two are described. The field work included several thousand individual observations covering 30 different sign-surface types under actual conditions on a night-visibility driving-course. Most of the major types of surfaces avaialble were represented.
In addition to using ordinary sealed-beam headlamps, field observations were made using polarized headlamps and viewers.

19. Spherical lens optics applied to retrodirective reflection, James H. Havens and Allie C. Peed, Jr.
Nat'l Research Council--Highway Research Board Bulletin 56, 1952, p 66.
This paper describes some expedient applications of elementary optical principles to the evaluation of glass-bead reflectorizing systems for highways signs and markers. The optical function of spherical lenses in achieving reflex reflection is illustrated both photographically and diagrammatically. Various optical designs are discussed and analyzed. By simple geometric optics, the efficiency of these systems is correlated with the practical performance criteria for retrodirective reflectorization.

20. Perceptual and field factors causing lateral displacement, R. M. Michaels and L. W. Cozan.
Nat'l Research Council--Highway Research Board Preprint, January 1963.

21. Implications of mid-air visual collision avoidance research for highway safety, Theodore H. Projector, K. G. Cook and Robert B. Sleight.
Nat'l Research Council--Highway Research Board Preprint, January 1963.

22. Research on traffic signs, R. L. Moore and A. W. Christie. Road Research Laboratory, Engineering for Traffic Conference, July 1963, p 113-122.

If one undertakes an unfamiliar journey, the best method of making sure of reaching one's destination is to take someone who knows both the way and the proper time to impart fresh information about each stage of the journey. An ideal system of traffic signs should do exactly this too, in all weathers both night and day, yet, except possibly on motorways, such ideal signs do not exist. If one might summarize the complaints one hears, they are that signs are frequently badly sited and place-names often too small to read without slowing down; sometimes at night they cannot be read at all, even when illuminated, and often side turnings are difficult to locate.

In seeking to design a system of signs which will remedy these defects, one must first of all state more exactly what is required of a traffic sign. The act of driving depends upon the continual use of vision and if, in critical moments, it has to be diverted from guiding the car to reading the sign there is a danger of overloading the perceptual mechanism. Furthermore, as the driver may need to take some action as a result of seeing the sign, it must be presented to him at the correct time.

23. The perception of light signals: the effect of mixing flashing and steady irrelevant lights, A. Crawford. Ergonomics 6: n 3, July 1963, p 288-294.

A previous experiment has shown the danger of increasing the number of irrelevant lights in a driver's field of view and that the signal most easily seen is one which flashes while the irrelevant lights are steady. However, a flashing light which may be an important signal to one driver may be irrelevant to other drivers in the vicinity.

A second experiment with the same general conditions as before has been carried out to find the effect of a mixture of flashing and steady irrelevant lights as a background to an essential signal.

It was found that the advantage gained by the use of a flashing light as a signal was lost if even one other light in the background was flashing. It was a definite disadvantage to have the signal flashing if three of ten irrelevant lights flashed, and when the number flashing was more than four, the ability to perceive flashing signals was seriously impaired.

24. Surfaces, seeing and driving; some recent studies, J. M. Waldram.
<u>Pub. Ltg</u> 25: n 111, 1960, p 249-60, Discussion 260-5.
Part I of the paper briefly discusses the reflection (properties of surfacings constructed before the 1939-45 war and the non-cut-off type of lighting installation designed to make use of these properties. Reference is then made to the work after the war of the Road Research Laboratory, Harmondsworth, which showed that improvements to the skid-resistance of road surfaces generally imply a more matt surface, which requires changes in lighting systems to maintain the previous levels of reflection. The luminances obtained on various present-day road surfacings (shown graphically) indicate that the angle at which the light is directed at the road surface should not exceed 82° to produce effective reflection. A modification of the width-height and spacing-height ratios may also be necessary. Part II of the paper reviews recent studies in visibility and accidents.

25. Vision and eye movements of motor drivers, J. M. Waldram.
<u>New Scientist</u> 8: n 208, 1960, p 1264-7.
This article describes some methods used in recording the visual observations of vehicle drivers to assess the adequacy of the information provided by street lighting of various types. In the first part of the study comments were made by drivers on a tape recorder during day and night trips in different lighting conditions to find which elements are well or badly revealed in different conditions, and why and in what respects night conditions are inferior to day conditions. In the second part of the study observations were made, by N. H. Mackworth's television camera method (see following Abstract), of the eye movements of two subjects who were watching a film depicting various road, traffic and lighting conditions. The two viewers produced the same kinds of eye movements and seemed to observe the scene in the same way, especially if the traffic conditions were awkward. It is though that (1) the experianced dirver "reads" the scene at a glance by recognizing typical traffic patterns learned by experience and discarding the irrelevant; he watches in particular for the run of the track ahead of him, the position and movements of other vehicles and the space available for manoeuvre; (2) the driver's attention tends to centre on objects or situations that call for special action or are difficult to recognize; (3) peripheral or parafoveal vision is of special importance; objects are perceived not in detail

but as comparatively vague shapes, and the eye in these regions is sensitive mainly to motion; therefore, the great amount of detail and colour which can be seen by day is not so important as the clear contrast of an object against its background; (4) it is important that information obtained peripherally should not be misleading.

26. Recording of eye movements by the television eye marker, E. Llewellyn-Thomas and N. H. Mackworth.
<u>J Instn Elect Engrs</u> 6: n 66, 1960, p 331-4.
This method of studying eye movements, which was developed at the Medical Research Council, Applied Psychology Research Unit, Cambridge, makes use of one television camera to view the reflection from the front surface of the eye (the corneal reflection), while a second camera views the subject's field; the composite picture appears with a white spot of light (the eye marker) superimposed on it, which indicates the position of the gaze at each instant. This white spot can be used to activate photocells which can operate a machine for recording eye movements or a circuit to control the visual input to the subject.

27. Visual problems on motorways, J. M. Waldram.
<u>Trans Illum. Engng Soc., Lond</u> 26: n 2, 1961, p 66-75; Discussion 75-8.
<u>Autocar</u> 113: n 3385, 1960, p 1122-3, 1125.
The visual problems ot drivers on the motorway have been studied by new techniques and compared with the problems on traffic routes, with special reference to the possible need for fixed lighting. By day the visual problems are generally much less severe on the motorways, but the vehicle and the driver have less in hand to cope with emergencies and consequences of an accident are often more grave. By night the information presented to the driver by headlights, reflector studs, rear lights and signals are found to be inadequate and often confusing. Fixed lighting of good quality has been shown to be capable of giving the driver all the information he needs, and it is concluded that a technical case for its installation can be made out. The accident rate on motorways is low at present traffic density, but on motorways abroad where the density is greater high accident rates occurred which have been substantially lowered by the installation of fixed lighting. Technical characteristics for fixed lighting on the motorway are derived from the observed requirements. The paper does not discuss questions of engineering, economics or policy. Some suggestions for guidance and visual signalling on the motorway are discussed in an appendix.

28. Visibility at intersections, A. E. J. Nap.
Internat. Rd Saf. Traff Rev 5: n 3, 1957, p 37-8, 40-3.
This extract from a lecture given to the International Study Week in Traffic Engineering, Stresa describes research carried out by the Netherlands State Road Department on visibility problems encountered by drivers at intersections and technical measures to improve traffic safety at these places. The paper discusses the blind angle formed by the pillar of the windscreen of a vehicle, the hazards presented by "open" intersections, and at triangular and Y-junctions; these junctions are thought to be out of date. The following are some of the recommendations; (1) at intersections and unguarded level crossings backgrounds should be varied; (2) roads should meet at right angles; (3) the use of triangular junctions should be avoided, but existing ones should be improved by the provision of drop-shaped islands (illustrated).

29. Industrial vision, H. W. Hofstetter.
Philadelphia, 1956 (Chilton Company), 189p+.
This textbook for students of optometry treats the subject under the following headings: 1. Industrial eye hazards and protection. 2. Visual testing in industry. 3. Vision and industrial efficiency. 4. Industrial compensation for loss of vision. 5. Visual tests for driving ability. 6. The relation of vision and visual testing to driving ability. In each of the last two chapters, the particular subject is discussed with reference to glare, poor vision in dim light, poor central acuity, poor peripheral vision, poor colour vision, diplopia, lack of ability to judge distance and depth accurately, difficulty in adaptation to changes in fixation distances, and inadequate ability to recognize briefly seen objects. Each chapter is provided with a list of references.

30. Safety glass for windscreens. A survey of the type available their characteristics, and accident and injury potentialities, R. D. Lister.
Auto Engr 51: n 9, 1961, p 341-7.
Glas Technol 2: n 5, 1961, p 186-91.
Aspects tech. Securite routiere n 9, 1962, 2.1-2.22 (in English, with French, Flemish and German summaries).
In this paper, prepared at the Road Research Laboratory, Harmondsworth, the characteristics of laminated and toughened windscreens are described with reference to their strength, the patterns they produce on fracture and the character of the edges of the fragments of glass. The problem of the visibility through toughened glass after

fracture is considered in detail. Results are given of tests on specimens of toughened glass with particle counts of 40, 20 and 10/sq. in. to assess the effect of particle count, slope of windscreen, and degree of contrast of the target being viewed on the facility with which drivers can recognize objects and shapes. The causes of the shattering of toughened glass windscreens of vehicles on the road are discussed; although this shattering can be alarming to the driver, statistics suggest that it is rarely responsible for accidents. Examples of the screen's being shattered while the car is travelling at high speed are given and comments are made on the special screens which contain barrier zones giving a clear view to the driver after shattering of the remainder of the windscreen. An analysis of the incidence is given for the two types of safety glass. Although the ratio of laminated to toughened glass windscreens in use for cars in Great Britain is about 1:8, there are more head and facial injuries involving laminated glass windscreens. Therefore it is concluded that there is a strong case for preferring toughened glass. The risk of injuries due to cutting could be reduced if safety harnesses came into general use.