Vision at Levels of Night Road Illumination

VIII. Literature 1962

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•CONTRIBUTIONS from the vision literature of interest to the Night Visibility Committee are selected, and as in previous years (82), no attempt is made for complete coverage. Of general interest are Fletcher (46), a new edition of Weston (99), the Duke-Elder series (41), a new set by Davson (34), and a review by Blair (23). Sneller (91) has written a small volume for the beginning driver with one chapter on rules for night driving. The reports of the National Committee in France summarize much of what is known about seeing at night driving luminances (18, 66, 67). Waldram's analyses are summarized (96) and there is an interesting attempt to evaluate the Smith-Cummings-Sherman driving-seeing system (20). The evaluations vary with the ratings of the individual judges, and there is an interesting discussion of accidents of professional drivers.

ILLUMINATION

Rex (81) appeals again for more light on highways, for at least as much as used in some European countries. DeBoer (35) states the essentials of road lighting and recommends 0.6 fL as a compromise between the desirable and reasonable cost. Connolly (32) summarizes some of the recent work on automobile lighting, including the new amber turning lights. Increased fixed lighting does reduce accidents (59). Harrington and Johnson (54) describe an improved instrument for measuring pavement reflectance.

Glare fatigue is explained in a British medical journal (1) as due to fatigue from the eyelid and associated muscles trying to hold the lid partially closed to reduce the dazzle. Meyer (73) discusses glare and the scattering of light within the eye. New measurements of the wavelength transmissions of the ocular media are available (103). A median of 10 to 20 ft reduces glare from low beams but must be 70 ft or more to reduce discomfort from high beams (62). Lighting arrangements for the reduction of glare are discussed by Foote and Kaercher (47). Hofer (56) advocates an aluminum glare screen. Contrast and seeing with poor lighting are discussed by Aulhorn (19). Finch (43) recommends flat luminaires to delineate the road edge.

The pupil regulates the light entering the eye and because of its own thickness shuts off light from wide angles (61). Weale (98) shows the role of the crystalline lens in the aging eye. The smaller pupil and increased lens absorption may account for the poorer vision of old age rather than changes in dark adaptation. From 2.5 to 3 times more light is needed for older people (97). Weale also suggests that the Stiles-Crawford effect can include the rods of the retina.

Meeting distance vision measured by Johansson (63) in Sweden reveals that symmetrical low-beam headlights are more efficient for seeing an object just off the road than are asymmetrical lights.

Motion pictures of different types of signs have been made on the road and shown to various groups to learn the relative seeability of different designs. This type of analysis by Burg and Hulpert (31) should be extended into night driving conditions. A warning is given against flashing and dazzling repetitive stimuli which cause fatigue, are disturbing, and may even have a hypnotic effect on some drivers (2). This is regarded as especially true at night when more effort is required because of the unusual contrasts. White posts, guardrails, broken lines, or other markers which flicker should be avoided.

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Elstad (42) reports on sign luminances and finds ambient levels of 0.1 fL in the country, 0.4 fL in suburban, and 4 fL in urban regions. High beams give 66 ft and low beams 58 ft visibility distance per inch of height of a standard letter. U.S. signs with place names were judged better than British or continental signs for simple junctions, but the continental diagram signs were preferred for complicated intersections (15).

ACUITY AND CONTRAST

Simmons (89) describes a visibility meter that reduces a 2^{0} field to threshold contrast without changing the level of adaptation of the eye. Boynton and Miller (27) consider the following mechanisms for dark adaptation: increase in photo pigment, neutral adaptation of single receptors, increase in retinal summation areas, increase in retinal summation times, and a decrease in the number of coincident quanta. Each shows a different effect on the curve for adaptation. A sudden change of luminance disturbs vision in accordance with the relative levels, and contrast must be increased to avoid loss of seeing.

Luria and Kinney (69) have measured some effects on adaptation from short exposures to increased light, although at much lower levels of illumination than usually prevail on highways. Fry (48) reports a device for measuring transient adaptation. The question of recovery from glaring effects from oncoming automobile lights remains unanswered. Hallet et al. (53) describe the sensitivity of different retinal areas to brief flash stimulation, and the variation that they found questions the validity of some of the intensity-area laws. Roper (84) stresses the need for more information on acuity and contrast as seen at night driving luminances. Marimont (72) proposes a model to explain the apparent greater contrast from increased luminance.

Wolf (101) finds that both central and peripheral flicker fusion decrease with age, and Domey (39) reports improved predictability of age and dark adaptation when flicker measurements are included in the equation. The Biophotometer has been modified by the addition of a fixation control (70).

The size constancy question is being investigated by Anstis (17) through the effects of the position of the eye and movements of shadows on a screen. The problem is related to night driving and further work could be useful. Speaking of perception problems, Bloomer (24) indicates that increasing stress and stimuli can increase vigilance and reduce accidents—a consideration for planning design and education.

Variations of depth of focus of the eye and spherical aberration with pupil size need to be considered when prescribing spectacles and discussing acuity (3, 16). The out-of-focus blurring of retinal images and two-point contrast thresholds are measured by Ogle (77).

DYNAMIC AND SPACE VISION

Fiorentini (45) has summarized the dynamic characteristics of the vision process. Brownstein and White (28) show that at a forward acceleration of 1g, about twice as much contrast is needed for seeing from 1 to 0.03 fL. Vision does not black out during movement of the eyes (95). Latour (65) demonstrates wide variations in thresholds for perceiving flashes of light from eye movements. Vertical stripes must be brighter to be seen by the laterally moving eye, and horizontal stripes are seen under these circumstances better than vertical stripes. Vibrations of 3 to 4 cps adversely affect reading dial instruments. Vibration rates from 2 to 7 cps should be minimized, and at frequencies of 5 cps, higher contrasts are required for seeing (40). Low frequency vibrations are reported to decrease contrast thresholds and high frequency movements to increase thresholds (64). The frequency response of compensating eye movements fixating a static target is higher than the frequency response of pursuit movements by still subjects fixating a moving target. This is believed due to otolithic stimuli added to the visual sensation (52).

A uniform visual field free from cues fails to maintain the focusing mechanism of the eye. The restricted fields at night increase nearsightedness of some eyes. Heath (55) has measured night myopia with both objective and subjective methods for periods of 4 hr and finds the myopia due to a general breakdown of the focusing mechanism; as large fluctuations (0.75 Diopter), changes in level (1D) and drifts (1.5D) occur continuously and irregularly. Fincham (44) reports that accommodation and convergence relations also breakdown under similar conditions of view. Both researches question the correcting of vision for night myopia. However, an individual may have a mean focusing amplitude and correcting for this amount of myopia does help those drivers. The French (18) report recommends that glasses large enough to cover the peripheral fields be used when correcting night myopia.

COLOR

The French (18, 67) study also recommends adding shape differences to color differences to make signals less misunderstandable. Undue amounts of noise affect the visual fields and the color fields are first affected according to Benkö (22).

R.G. Fry (50) states that yellow glasses are scarcely useful for motorists because of the small amount of blue and blue-gray contrast on roads. Verriest et al. (94) discuss the visual loss from withdrawal of the short wavelength light by use of colored glasses. This may explain why wearing yellow glasses during the day does not help night driving vision. A Russian experiment with colored asphalt roads is reported (93). So far, no results seem to have been reported from this use of colors under adverse conditions of dense fog, heavy rain, or snow on moonless nights.

Davids (33) tells how color-deficient men see a green traffic light as white, ask why the amber is so like the red light, why not change the red to a scary blue seen by all men, why there is a program to replace easy-to-see black-on-yellow signs with less visible white on red and why some car makers now use rear lights which look as big as front lights. Fortunately only a few men are so handicapped, yet these pleas should be considered when color-coding roads and signs. Breckenridge (29) considers U.S. signal lights and standardization. Huber (57) discusses the use of colors on the ramps of the experimentally color-coded exchange in Minnesota.

DRUGS

Sloan (90) has revised and indexed his previous paper on drug effects on vision, and a summary (4) of the possible effects of drugs on driving is now available. Dix (38) has re-examined the question of improving dark adaptation with large amounts of vitamin A and finds that there is little improvement. On the other hand, Masci (73) reports improved ability to perceive targets after small doses of caffeine. Long treatments with chloroquine can result in degeneration of the retina (79). The uncontrolled use of many drugs could very well lead to visual distrubances that could trigger an accident. Many of the commonly-used stimulants are followed by irritability, fatigue, and decreased ability to concentrate, and many of the various sedatives and tranquilizers can also produce drowsiness and mental confusion. Unless large amounts have been taken, it may not be obvious that the individual in an accident was suffering from an undue amount of the drug. Nevertheless, here is a field that should be more thoroughly studied. (Also pertinent are 104 and 105.)

Alcohol decreases eye movement frequency, more so when the subject is being vibrated (52). Schmidt (85) states that clinically-identified alcoholic drivers are involved in proportionally more accidents than the general driving public. Accidents involving the drinking driver are partly a problem of alcoholism, rather than the effects of alcohol on the casual drinker.

VISION AND TESTING

Long (68 A) discusses, the intangibles of driving seeing and particularly the danger of complying with only a minimum of legal standards. Whether the driver with a visual deficiency is dangerous may well depend on how well he can compensate for that deficiency. Others offer useful comments in the general field (9, 16, 36, 78). The physical impairments of the problem drivers are tabulated by Sneller (92). Bateman (21) discusses the aspects of binocular vision and accident proneness. Some colors are, he believes, more useful in locking stereovision than others, and diplopia must be avoided by proper correction of phoria at distance to provide fused binocular vision.

As might be expected, the new British law makes a £50 fine a possibility when glasses are required and not worn by drivers. At any time a driver can be checked as to whether he can read a British auto license at 75 yd. Much of the comment has concerned the fact that, though some drivers could read part of a driving license, they might not be able to read a six-letter plate (5) and as the illumination is not specified, the visibility could be determined by the more or less light available. Not all number combinations provide equal acuity targets (3, 5 through 11). Others criticize that, though this law is a good start, other tests (fields, phorias, color, etc.) may be as important as reading a license plate at 75 yd. Weale is quoted (7): "Eyes ought to be tested under the conditions under which they are alleged to have failed."

A program for testing driver's vision is given by Humphriss (58). The medical viewpoint on screening vision procedures is given by Lippmann (68). The need for carrying a second pair of glasses by those whose sight is inadequate without glasses is again stressed (10, 11). Nearsighted individuals should have full correction (102).

Contact lenses have limitations for air crew personnel (37) and some of the limitations apply also to automobile driving. Tinted contact lenses, other than the very palest shades, should not be worn when driving at night (83). Blyford (25) describes a contact lens photoelectric, eye movement recorder.

Schober (86) states that the average night driving luminance in Germany is 0.1 fL; the variable-focus French "Verilux" lens must be adjusted carefully to avoid difficulties in seeing while driving and that this lens is not too satisfactory after strong presbyopia has developed. Bryan's (30) "Nite-Site" antiglare lens and its proper use is described. Vision specialists have an opportunity in some cases and an obligation in others to provide proper occupational glasses for motorists, which should be lightweight, have small nonobscuring frames large enough for adequate peripheral view, with good nonslip ear pieces, fit comfortably (even with vibration), and come with a strong case for protection when not worn. Metal frames are recommended (8, 10, 11, 16). For night driving, the curves of the lenses should be selected for best vision and least distortion, and be antireflective-coated when reflections of lights are annoying or obscure vision.

Curved windshields are criticized (12), and vision in rear view mirrors has been investigated (60, 76). Convex mirrors are used more in Great Britain than in the United States, and difficulties from their use are cited, particularly for older people who cannot accommodate enough to see the image from the convex mirror. Distances of mirrors from the eyes of the driver and the relative positioning are reported, and for useful aid the mirror should be within 30° of the forward road view. When convex mirrors are used, curvatures of about 27 in. and a field of view of 15° are recommended; although a larger mirror with a field of 30° would be better. Problems of seeing when backing are discussed by Gernet (51). The proposed California project to test static and dynamic visual acuity, field size, glare resistance, and recovery should give useful information (13, 14).

REFERENCES

1. "Glare: A Query." Optician, 143:579 (1962).
2. "Highway Markers Can Be Dangerous." J. Am. Med. Assoc., 180(13):31 (1962).
3. "Significance of Visual Acuity Variations." Optician, 143:27 (1962).
4. "Drugs and Driving." Health, Education and Welfare, FDA Pub. 15 (1962).
5. "The Driver's Eyesight Test." Optician, 144:100 (1962).
6. "Motor Drivers' Vision." Optician, 144:33 (1962).
7. "Motor Drivers' Vision." Optician, 144:128 (1962).
8. "Suggestions for Motorists' Glasses." Optician, 144:79 (1962).
9. "Driving Vision: A Note." Optician, 144:83 (1962).
10. "Drivers' Sight: A Note." Optician, 144:224 (1962).
11. "Glasses for the Motorist." Optician, 144:422 (1962).
12. "Windscreens a Visual Hazard." Optician, 144:204 (1962).
13. "Plan Better Vision Tests for Motorists." Sci. Newsletter, 81:147 (1962).
14. "Calif. Drives for Motor Vision Tests." Optom. Weekly, 53:808 (1962).
15. "New Research on the Driving Task: Sign Visibility v. Interpretation." Optician, 144:162 (1962).

16. "Correction Tolerances." Optician, 144:106 (1962).
17. Anstis, S.M., Shopland, C.D., and Gregory, R.L., "Measuring Visual Constancy for Stationary or Moving Objects." Nature, 191:416-417 (1961).
18. Arnulf, A., et al., "Les Performances Visuelles et la Conduite des Vehicules Routiers." Comm. Nat. de la Vision, Sec. d'Etudes Theoriques (n.d.).
19. Aulhorn, E., "Über die Sehschärfe bei herabgesetzter Beleuchtung." Ber. Deutsch. Ophth. Ges., 64:555-560 (1961).
20. Barmack, J.E., et al., "A Field Evaluation of the Smith-Cummings-Sherman Driver Performance Rating Scale." Traffic Safety, 6(2): 25-30 (1962).
21. Bateman, E., "Aspects of Binocular Vision and Their Effect on Accident Proneness." Optom. Weekly, 53:2019-2023 (1962).
22. Benkö, E., "Weitere Angaben über die durch lärmschäden bedingte Gesichtfeldeinengung." Ophthalmologia, 143:76-80 (1962) from Bi. Absts., 39:6280 (1962).
23. Blair, H.L, and Martens, T.G., "Refraction and Visual Physiology." Arch. Ophth., 68:107-138 (1962). (A review with 268 references.)
24. Bloomer, R.H., "Perceptual Defence, Vigilence and Driving Safety." Traffic Quart., 16:549-558 (1962).
25. Byford, G.H., "A Sensitive Contact Lens Photoelectric Eye Movement Recorder." IRE Trans. Bio-Med. Electr., 9(4):236-243 (1962).
26. Bouman, M.A., and Ten Doesschate, J., "The Mechanism of Dark Adaptation." Vis. Res., 1:386-403 (1962).
27. Boynton, R.M., and Miller, N.D., "Visual Performance Under Conditions of Transient Adaptation." IE (in press).
28. Brounstein, M.L., and White, W.J., "Effects of Acceleration on Brightness Descrimination." J. Opt. Soc. Am., 52:931-933 (1962).
29. Breckenridge, F.C., "U.S. Standard for the Color of Signal Lights." HRB Bull. 336, 102-103 (1962).
30. Bryan, W.E., "Lenses for Night Driving." HRB Bull. 336, 104 (1962).
31. Burg, A., and Hulburt, S.F., "Predicting the Effectiveness of Highway Signs." HRB Bull. 324 1-11 (1962).
32. Connolly, P.L., "Recent Developments in Automotive Lighting." Am. J. Optom., 39:401-422.
33. Davids, R.C., "A Case of Daltonism." Optometric Weekly, 53:2453-2455 (1962).
34. Davson, H. (Ed.), "The Eye: 1. Vegetative Physiology and Biochemistry; 2. The Visual Process; 3. Muscular Movements; 4. Visual Optics and the Optical Space Sense." Academic Press, New York. (1962).
35. deBoer, J.B., "Lighting of Traffic Routes." Philips Tech. Rev., 23:258-272 (1962).
36. Dennett, J., "Driving and Drivers' Vision." Optician, 143:140-142 (1962).
37. Diamond, S., "Contact Lenses in Aviation." Aerospace Med., 33:334, 1361-1366 (1962).
38. Dix, U., " A Contribution to the Problem of Improvement of Night Vision." Cologne and Opladen Westdeut. Verlag (1962). From Am. J. Ophth., 54:151-152 (1962).
39. Domey, R.G., "Flicker Fusion, Dark Adaptation and Age as Predictors of Night Vision." HRB Bull. 336, 22-25 (1962).
40. Drazin, D.H., "Factors Affecting Vision During Vibration." Res. Appl. Ind., 15:275-280 (1962).
41. Duke-Elder, S., "System of Ophthalmology: No. VII. Foundation of Ophthalmology." (1962). "II. Anatomy of the Visual System." Kimpton, London (1961).
42. Elstad, J.O., et al., "Requisite Luminance Characteristics for Reflective Signs." HRB Bull. 336, 51-60 (1962).
43. Finch, D.M., "Roadway Delineation with Curbmarker Lights." HRB Bull. 336, 105-109 (1962).
44. Fincham, E.F., "Accommodation and Convergence in the Absence of Retinal Images." Vis. Res., 1:425-440 (1962).
45. Fiorentini, A., "Dynamic Characteristics of Visual Processes." Pp. 253-288 of Wolf, E. (Ed.), "Progress in Optics. I." Interscience, New York (1961).

46. Fletcher, R.J., "Ophthalmics in Industry." Hatton Press, London (1961).
47. Fowle, A.W., and Kaercher, R.L., "Light Distributions for Effective Control of Glare in Roadway Lighting." I E, 57:336-348 (1962).
48. Fry, G.A., "Transient Adaptation of the Eyes of a Motorist." HRB Bull. 336, 110 (1962).
49. Fry, G.A., "Assessment of Visual Performance." I E, 57:426-437 (1962).
50. Frey, R.G., "Zur Frage der Sichtverbesserung durch eine Blendschutzbrille." Wein Klin. Woch., 73:526 (1961).
51. Gernet, H., "Das Umblick-Wahrnehmungsfeld des rückwartsfahrenden Kraftfahrers." Klin. Mbl. Augenhk., 140:879-884 (1962).
52. Guignard, J.D., and Irving, A., "Measurement of Eye Movements During Low Frequency Vibrations." Aerospace Med., 33:1230-1238 (1962).
53. Hallett, P.E., Marriott, F.H.C., and Rodger, F.C., "The Relationship of Visual Threshold to Retinal Position and Area." J. Physiol., 160:364-373 (1962).
54. Harrington, T.L., and Johnson, McR. D., "An Improved Instrument for Measurement of Pavement Marking Reflecting Performance." HRB Bull. 336, 111-113 (1962).
55. Heath, G.G., "The Time Course of Night and Space Myopia." Wright-Patterson Air Force Base, Ohio, Rept. AMRL-TDR 62-80 (1962).
56. Hofer, R., "Glare Screen for Divided Highways." HRB Bull. 336, 95-101 (1962).
57. Huber, M.J., "Traffic Operations and Driver Performance as Related to Various Conditions of Nighttime Visibility." HRB Bull. 336, 37-50 (1962).
58. Humphriss, D., "A Programme for Checking Drivers' Vision." Optician, 144:159-161 (1962).
59. Ives, H.G., "Does Highway Illumination Affect Accident Occurrence?" Traffic Quart., 16:229-241 (1962).
60. Jani, S.N., and Menezes, D.F., "A Comparison of Seeing Times Using Plane and Convex Mirrors." Brit. J. Physiol. Opt., 19:103-109 (1962).
61. Jay, B.S., "The Effective Pupillary Area at Varying Perimetric Angles." Vis. Res., 1:418-424 (1962).
62. Jehu, V.J., and Hirst, G., "Problems of Headlight Glare: Effect of Lateral Separation of Beams of Opposing Vehicles on Seeing with Headlights." Traffic Eng. Cont., 3 (9):545-547, 552 (1962). From HR Absts., 32(5):20-21 (1962).
63. Johansson, G., "Visible Distances During Night Driving." Rept. Psych. Lab. Un. Upsalla (1961).
64. Krauskopf, J. "Effect of Target Oscillation on Contrast Resolution." J. Opt. Soc. Am., 52:1306 (1962).
65. Latour, P.L., "Visual Threshold During Eye Movements." Vis. Res., 2:261-262 (1962).
66. LeGrand, Y., et al., "Problemes Visuels Relatifs a la Conduite des Vehicules." Ann. Ocul., 195:160-165 (1962).
67. LeGrand, Y., et al., "Synthese des Rapports Presentes par les Experts sur les Problemes Visuels Relatifs a la Conduite des Vehicules." Comite Natl. de la Vision, Sec. d'Etudes Theoriques (n.d.) (A reprint of 66).
68. Lippmann, O., "Eye Screening." Arch. Ophth., 68:692-706 (1962).
68A. Long, H., "Vision for Motor Driving." Optician, 144:269-270 (1962).
69. Lauria, S.M., and Kinney, J.A., "The Interruption of Dark Adaptation." Med. Res. Lab., U.S. Sub. Base, New London, No. 347 (1961).
70. Lyle, W., and Hofstetter, H.W., "A Modification of the Bio-Photometer for Alterocular Fixation Control." HRB Bull. 336, 33-36 (1962).
71. Mackworth, N.H., and Kaplan, I.T., "Visual Acuity When Eyes Are Pursuing Moving Targets." Science, 136:387-388 (1962).
72. Marimont, R.B., "Model for Visual Response to Contrast." J. Opt. Soc. Am., 52:800-806 (1962).
73. Masci, E., "Influenza della Caffeina sulla 'Performance' Dinamica Visiva Rilevata Mediante Campimetria Tachistoscopica." Atti Fond. G. Ronchi, 17:340-346 (1962).
74. Mercier, A. (Ed.), "Visual Problems in Aviation Medicine." Macmillan (1962).

75. Meyner, M., "Vorschlag zur Untersuchung des Adaptationsvermögens bei Kraftfahrern." Ber. Deutsch. Ophth. Ges., 64:547-550 (1961).
76. Morrow, I. R. V., and Salik, G., "Vision in Rear View Mirrors." Optician, 144: 314-318, 340-344 (1962).
77. Ogle, K. N., "Blurring of Retinal Image and Foveal Contrast Thresholds of Separated Point Light Sources." J. Opt. Soc. Am., 52:1035-1039 (1962).
78. Payne, C. G., "New Look on Car Drivers' Vision." Optician, 144:483 (1962).
79. Penner, R., and Somers, K., "Bilateral Macular Degeneration Associated with Chloroquine Therapy." Am. J. Ophth., 54:381-385 (1962).
80. Peters, H. B., "Safety in Sight." Optom. Weekly, 53:2175-2178 (1962).
81. Rex, C. H., "Visual Data on Roadway Lighting." HRB Bull. 336, 61-75 (1962).
82. Richards, O. W., "Vision at Levels of Night Road Illumination: VII. Literature 1961." HRB Bull. 336, 12-21 (1962).
83. Richards, O. W., and Grolman, B., "Avoid Tinted Contact Lenses when Driving at Night." J. Am. Optom. Assoc. 34, 53-55 (1962).
84. Roper, V. J., "Relation of Visual Acuity and Contrast Sensitivity Under Nighttime Driving Conditions." HRB Bull. 336, 114 (1962).
85. Schmidt, W., et al., "The Role of Alcoholism in Motor Vehicle Accidents." Traffic Safety, 6(4):21-27 (1962).
86. Schober, H., "Die Brille des Verkehrsteilnehmers." Ber. Deutsch Ophth. Ges., 64:560-563 (1961).
87. Sherman, R. A., "Seeing Habits in Vision, a Neglected Area in Traffic Safety." Optom. Weekly, 53:439-443 (1962).
88. Silvernale, L. R., "How Home and School Can Help Prevent Development of Problem Drivers." Optom. Weekly, 53:18-19 (1962).
89. Simmons, A. E., "An Instrument for the Assessment of Visibility Under Highway Lighting Conditions." HRB Bull. 336, 76-94 (1962).
90. Sloan, P. G., "Ocular Side Effects of Systemic Medication." Am. J. Optom., 39:459-470 (1962).
91. Sneller, R. C., "Vision and Driving." Am. Optometric Association, St. Louis (1962).
92. Sneller, R. C., "Physical Impairments of the Problem Driver." Optom. Weekly, 55:15-17 (1962).
93. Syun'i, G. K., and Marchenko, N. I., "Colored Asphalt in Road Construction." Avtom Dorogi (Moscow) 24(8):24-25 (1961). (In Russian) From HR Abstracts, 32(8):3 (1962).
94. Verriest, G., et al., "Etude Quantitative de l'Effect qu'Exerce sur la Discrimination Chromatique une Absorption Selective de la Partie Froide du Spectre Visible." Rev. Opt., 41:109-118 (1962).
95. Volkmann, F. C., "Vision During Voluntary Saccadic Eye Movements." J. Opt. Soc. Am., 52:571-578 (1962).
96. Waldram, J. M., "Visual Problems in Streets and Motor Ways." I E, 57:361-375 (1962).
97. Weale, R. A., "Retinal Illumination and Age." Trans. Illum. Eng. Soc. (London), 26:95-100 (1961).
98. Weale, R. A., "Notes on Photometric Significance of the Human Crystalline Lens." Vis. Res., 1:183-191 (1961).
99. Weston, H. C., "Sight, Light and Work." H. K. Lewis and Co., London (1962).
100. Whitcomb, M. A. (Ed.), "Visual Problems of the Armed Forces." Natl. Acad. of Sci. —Natl. Res. Council, Washington, D. C. (1962).
101. Wolf, E., "Effects of Age on Peripheral Vision." HRB Bull. 336, 26-32 (1962).
102. Alphen, G. W. H. M. van, "On Emmetropia and Ametropia." Ophthalmologica, Vol. 142 (Supplement) (1961).
103. Boettner, E. A., and Wolter, J. R., "Transmission of the Ocular Media." Inv. Ophth. 1:776-783 (1962).
104. Nash, H., "Psychologic Effects of Amphetamines and Barbiturates." J. Nerv. Mental Dis., 134:203-217 (1962). From Aerospace Med., 33:1404 (1962).
105. Weiner, H., and Ross, S., "Effects of D-Amphetamine Sulfate on Time and Brightness Perception in Human Subjects." Psychopharmacologia, 3(1):44-50 (1962). From Aerospace Med., 33:1405 (1962).