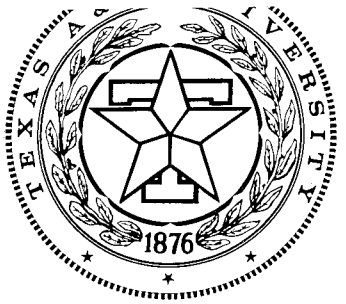

TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

ROAD LIGHTING
2-8-54-1

in cooperation with the
Department of Commerce
Bureau of Public Roads

BIBLIOGRAPHY (64-16)
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ROAD LIGHTING

Compiled by
Texas Transportation Institute
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1. Adams, E. and J. Baker, "Trends in street and highway lighting," Can Mun Utilities 101: n 9, Sept 1963, p 39-41.

   New developments and improvements in light sources in Canada, United States and Europe; contribution which road can make to visibility, possibilities of high mounting luminaires and some advantages of low mounting are considered.

2. Asmus, C., "Constant-current regulator loading for series lighting circuits," Illum Eng 58: n 7, July 1963, p 495-9.

   Series street lighting installations using constant-current regulator are being converted from incandescent to mercury lighting to utilize advantage of mercury lamp; street lighting engineer is faced with problem of how to use available equipment to its full potential; 3 limiting conditions which must be considered to determine number of mercury lamps on series circuit; example for operating conditions; determining factors are described for maximum load on series circuit, operating mercury lamps on moving-coil type, constant-current regulator; formula developed to find load for operating condition by calculation.

3. Asmussen, E. and J. B. de Boer, "Een luminantiemeter voor straatverlichting", Electro-Techniek 41: n 1, Jan 3, 1963, p 8-12.

   Luminance meter for street lighting; instrument described is intended for everyday use in public lighting installations; no special photometric training is needed for personnel using meter; instrument is designed for measurement of local and average luminance values; average measurements can be made quickly from moving cars.

4. Balch, C. R., "Street lighting control by daylight", Publ Ltg 28: n 122, 1963, p 170-1.

   A description is given of cadmium-sulphide cell equipment which automatically switches on street lighting when light falls below a predetermined level. The initial cost compares favourably with that of the time switch, it needs no adjustment after interruption of supply, and it

will control its load according to requirements. It is recommended that equipment chosen should fail to safety and should incorporate a time delay in order to avoid unnecessary switching due to transient light conditions.

5. Berry, G., "Lighting of traffic routes", Surveyor 116: n 3419 Nov 2 1957, p 1133-6.

   Technical, administrative and financial aspects of street lighting; if installation of adequate street lighting is not to be hampered, there should be no delay in reorganization of lighting administration; financial assistance must be given by British government comparative characteristics of different light sources; costs of various street lighting systems; capital and running costs per lighting point.

6. Boie, M. A. Szymanski and H. C. Zuellig, "Eine neue Strassen-und Brueckenbeleuchtung", Aluminium 36: n 1, Jan 1960, p 28-30.

   New kind of street and bridge lighting; illustrated description of lighting system (fixtures of extruded aluminum section, cold cathode ray tubes) installed in handrails of bridges to give more light, without glare, in interest of traffic safety.

7. Box, P.C., "Effect of highway lighting on night capacity", Traffic Eng 28: n 4, Jan 1958, p 9-15, 23.

   Study made of headways and speeds on 4-lane divided highway to determine effect of roadway lighting on basic capacity at night; highway lighting prevented 5% loss in night capacity of right lane; it had little effect on speeds.

8. Box, Paul C. and Warren Edman, "Roadway lighting, a new standard", Traffic Engineering 34: n 7, April 1964, p 11-14, 25.

   The 1963 edition of the Recommended Practice for Roadway Lighting (approved 7 November 1963, by the American Standards Assocation) represents some five years of major effort by the Roadway Lighting Committee of the Illuminating Engineering Society. The new Practice contains a significant revision from earlier editions in the method of luminaire classification. Other

important changes were made in the street classification system, recommended illumination values, illumination uniformity and method of mounting height specification.

9. Burghout, F., "Onderzoek naar de depreciatie van lantaarns voor openbare verlichting", Electro-Techniek 41: n 4, Feb 14, 1963, p 65-73.

   Deterioration of luminaires for public lighting; investigation conducted in different parts of Netherlands on reduction in light output expressed in terms of average horizontal illumination.

10. Bush, J. P. and J. A. Scott,"Extrusions + adhesives = versatile light poles", Modern Metals 17: n 2, Mar 1961, p 46, 48.

    Requirements of cost, appearance, versatility and durability in new light standards for New York City are met by unique design employing two C-shaped aluminum extrusions, adhesive-bonded together with epoxy; bonding process was developed by Olin Mathieson Chemical Corp; tests reported; two prototypes have been in successful service for more than year in metropolitan area that has corrosive marine and industrial environment.

11. Cataliotti, V., "Sull'alimentazione degli impianti di illuminazione serie con sampade HgFl," Engergia Elettrica 38: n 11, Nov 1961, p 1012-20.

    Operations of illumination with HgFl lamps in series; in Italy in street lighting; fluorescent lamps operate in series with use of self-controlling transformers having mobile coil and resonance acting static current regulators.

12. Chase, R. H., "Street-light surveys sell towns on code lighting", Elec World 156: n 20, Nov 20, 1961, p 60-2, 100.

    Street lighting system of 16 Connecticut towns based on traffic surveys according to Street Lighting Code of ASA and Illuminating Eng Soc, including pedestrian traffic.

13. Chauchereau, A., "Elements intervenant dans la perception visuelle en eclairage public", Societe Francaise des Electriciens--Bul 9: n 106, Oct 1959, p 610-20.

    Factors involved in visual perception of public lighting;

analysis of factors involved in design of highway lighting systems such as color of light, shadows of objects on roadway, and contrast creation; psychological factors, including perception, concentration of interest, memory and imagination.

14. Christie, A. W., "Road surface and lighting engineer", Instn Municipal Engrs--J 84: n 5, Nov 1957, p 153-60.

Problem of choosing suitable combinations of road surface and street lighting system are considered; discussion applies mainly to group A (main road) lighting.

15. Cleveland, D.E., "Driver tension and rural intersection illumination", Traffic Eng 32: n 1, Oct 1961, p 11-16.

Galvanic skin reflex is used to study effects of intersection illumination on driver tension; results show that method is also feasible for evaluation of signs, markings and signals.

16. Cleveland, D.E. and C. J. Keese, "Intersections at night", Traffic Quarterly 15: n 3, July 1961, p 480-98.

Study to determine effects of various types of intersectional illumination and signing on traffic safety and performance; scale model study of lighting at intersection; evaluation of field installations of highway illumination.

17. Cobin, D. R., "Glasgow tries out 300-Watt sodium integral discharge lamp", Traf Eng & Control 4: n 10, Feb 1963, p 571, 573, 575.

Introduction of 300-w lamp, by Phillips Electrical Ltd, having rated initial output of 34,000 lumens; tests of SOI/H 300-w lamp using 200-w sodium discharge lanterns to obtain information for lantern arrangement design.

18. "Colour, efficiency and economics in public lighting", Surveyor 120: n 3617, Sept 30, 1961, p 1189-92.

Discussion presented at Public Lighting Engineers conference at Scarborough, Oct 1961 deals with new types of tubular steel, aluminum alloy, "Zeta", and prestressed spun concrete lighting columns, also with sodium integral lamps, new amber lanterns, "Helion" post top lanterns, new wall mounted units, correction

capacitors, and lighting control gears; status of research on glare; new mobile workshops.

19. Conner, C. N., "Lighting on Florida turnpike sets example for expressway designers", Roads & Streets 100: n 5, May 1957, p 74-6, 80.

    High intensity lighting at all interchanges, terminals and service areas is part of design of 109 mi turnpike in southern Florida; mercury vapor luminaires generating 20,000 light lumens each were selected for bulk of installation.

20. Crandell, F.F., K. Freund, "Photoelectric telephotometer of high sensitivity and high angular selectivity", Illum Eng 52: n 6, June 1957, p 319-22.

    Instrument, developed specifically to facilitate work on problems related to night-time street lighting, is essentially Cassegrain reflecting telescope which can be focused over range from 70 ft to infinity by moving Cassegrain secondary mirror in and out along axis; circuit diagram of null-detecting system.

21. deBoer, J. B. "Concept 'Road Surface Luminance' and its application to public lighting", Illum Eng Soc--Monograph 4, Jan 1962, 11p.

    Method is outlined for calculating average value and uniformity of road surface luminence; additional data on road surface reflection characteristics and lantern light distributions are required for design of installations to given standard; difficulties of measurement of road surface luminance and details of luminance meter and its use for determinations of reflection characteristics of particular road surface.

22. deBoer, J. B., "Die anwendung des begriffes "Leuchtdichte der Strassendecke" in der Praxis der oeffentlichen Beleuchtung", Assn Suisse des Electriciens--Bul 51: n 12, June 18, 1960, p 585-95.

    Application of notion of "street surface illumination density" in practice of public illumination; simple graphical method for determination of density; transistorized photoelectric telephotometer.

23. Downey, J. C., "Street lighting", S African Inst Elec Engrs--Trans 47: pt 9, Sept 1956, p 277-301 (discussion) 301-3, further discussion pt 10 Oct p 277-315, v 48 pt 1 Jan 1957, p 36.

    History of street lighting; principle of seeing in street lighting; modern practice; sources of light; fixtures; planning and layout; maintenance; future development and costs; accidents and street lighting.

24. Eastman, A.A. and McNelis, J.F., "Evaluation of sodium, mercury and filament lighting for roadways", Illum Eng 58: n 1, Jan 1963, p 28-33.

    Series of laboratory investigations conducted to determine effect of spectral quality of light on contrast sensitivity and on visual comfort with wide variety of conditions, and to supplement these with subjective appraisals of experimental roadway lighting installations; summary of threshold contrast data, discomfort glare evaluations and field test evaluations; it is concluded that when only color of source is considered there is no clear-cut evidence that any of sources evaluated has any significant advantage over others.

25. EEI-NEMA Standards for physical and electrical interchangeability of light-sensitive control devices used in control of roadway lighting", Edison Elec Inst-Publ TDJ-146 July 1962, 5p., 4 plates.

    Standard covers locking type or meter socket type control units with their electric connections, exclusive in which they are normally mounted.

26. EEI-NEMA Standards for selection of filament lamps used in roadway lighting equipment," Edison Elec Inst--Publ TDJ-131, July 1962, 2p.

    List of EEI-NEMA and ASA standards covering sockets, supports, reflectors etc., for road lighting; ASA standard publications on lamps; tables for recommended series and multiple lamps.

27. Edman, W. H., "Development of new American Standard Practice for roadway lighting", Illum Eng 58: n 11, Nov 1963, p 687-94.

    New recommended practice is extension and expansion of previous 1953 ASA recommended practice and elaborates on basic recommendations of illumination levels, light distribution classifications, roadway classifications, and classifications with respect to glare control; cutoff classifications above maximum candlepower; international lighting practices.

28. Edman, W. H., "Analysis of visual elements in roadway lighting", AIEE--Trans 77: pt 2 (Applications & Industry) n 39, Nov 1958, p 447-52.

    Illumination intensity, background and object brightness, veiling and discomfort glare, and uniformity of illumination and brightness; analysis of their relation to fundamental principles of roadway lighting practice. Paper 58-549.

29. Finch, D. M., "Roadway guidance lights for driving in fog", Illum Eng 57: n 7, July 1962, p 464-6.

    Approach to "hazardous visibility" by using guidance, rather than area lighting, to mark traffic lanes; system is in operation in Oakland, Calif, consists of small, surface mounted lighting units, designed to develop lineal patterns of high brightness and contrast for use in poor visibility conditions or under general nighttime situations; system is arranged for multiple operation from 240-v mains; fixture design; cost analysis of half-mile test system, using lines on both sides, indicates cost of 1 dollar/lineal ft/line; guides for future design.

30. Finch, D. M., "Some factors influencing night visibility of roadway obstacles", Illum Eng 52: n 3, Mar 1957, p 120-9 (discussion) 129-30.

    Summary of report on street lighting and its evaluation in terms of visibility of objects under specified conditions; principle of operation of contrast threshold visibility instrument; visibility indices for two experimental roadway lighting systems developing uniform and non-uniform pavement brightness patterns; technique of measurements; outdoor street lighting laboratory.

31. Fowle, A. W. and R. L. Kaercher, "Light distributions for effective control of glare in roadway lighting", Illum Eng 57: n 5, May 1962, p 336-48.

    Since there is significant loss of vision due to disability veiling glare, trend toward use of larger light sources and higher illumination glare control; data presented show benefits of using precisely controlled low-angle distributions for reduction of disability and discomfort glare; trend toward use of shorter spacings presents more opportunities to use this type of light distribution.

32. Fowle, A. W. and R. L. Kaercher, "Roadway brightness and illumination as related to luminaire distributions", Illum Eng 56: n 4, Apr 1961, p 279-90.

    Instead of specifying only light/brightness values for roadway lighting, development of application charts is proposed to be derived from series of system data for pavement brightness, obstacle brightness, veiling brightness, illumination values, plotted vs varying street width and spacing conditions to enable overall quality of installation to be judged.

33. Fowle, A. W. and R. L. Kaercher, "Theoretical and practical light distributions for roadway lighting", Illum Eng 54: n 5, May 1959, p 277-85 (discussion) 285-90.

    Concept of "visibility distance" is suggested as criterion in calculating requirements of light distribution; level and uniformity of horizontal illumination are most important factors in overall aspect of visibility distance; both depend on system design factors, spacing, mounting height, street width, luminaire overhand and arrangement, and luminaire design factor of candlepower distribution; determining distribution.

34. Franklin, J. S., "Automated universal distribution photometer", Illum Eng 53: n 12, Dec 1958, p 667-75 (discussion) 675-8.

    Major requirements for Paudget (Photometer, Automated Universal Distribution Gonio Electric Type), designed by General Electric Co to meet present needs of luminaire testing; photometer is capable of operating all luminaires in their normal "in use" position, at any

required test distance, at standardized ambient temperature with minimum thermal drafts; construction details and design of controls; operation with respect to digital readout circuits and other features.

35. Franklin, J. S. and P. M. Garratt, "Distribution photometry and automation", Elec Eng 81: n7, July 1962, p 512-18.

Automation techniques utilized in photometric studies to determine accuracy, reliability, and repeatibility of outdoor lighting luminaire performance, and various testing procedures employed; considerable time savings can be realized as result of improvements--testing, calculating, and plotting methods.

36. Future design of luminaire head to receive external, locking type unit control used in street and highway lighting", Nat Elec Mfrs Assn--Publ SH 18-1959 Mar 1959 3p, 2 supp plates.

Means of control unit attachment to provide rigid weatherproof electric and physical junction of control unit and luminaire head.

37. Gebhardt, A. W., "New concept for integrating street lighting and residential underground distribution systems", Illum Eng 58: n 4, sec 2, Apr 1963, p 318-22.

Key to success of concept is to combine street lighting and distribution systems into single integrated system designed to achieve lowest cost and maximum customer benefits; no circuiting is required for majority of installations; distribution circuit is utilized and overhead distribution and lighting system are integrated into single system; problems involved when distribution system is placed underground; methods used and examples of single unit integrating distribution transformer, street lighting standard and luminaire; economic analysis.

38. Giovanelli, R. G., W. R. Blevin, and K. A. Wright, "Flood-lighting of pedestrian crossings", Illum Eng Soc--Trans 27: n 3, 1962, p 139-42.

It is proposed that pedestrian crossings which require supplementary lighting be flood lit from direction of oncoming traffic, so that motorists see pedestrians illumination directly; glare can be avoided by using light beam of sharp cutoff, and by shielding primary

light source; details of experimental installation on Pacific Highway in Sydney suburb of Wahroonga, Australia, which proved very effective, even under adverse weather conditions; crossing on 60 ft wide 2-way street can be lit acceptably using 2 500-w lamps.

39. Glanville, W., "Light and road safety", Illum Eng Soc--Trans 25: n 2, 1960, p 69-85.

Summary of research at Road Research Laboratory of Dept Scientific and Industrial Research in Great Britain; importance of improving seeing at night; road illumination problem, and visibility in lighted streets and effect of road surface; reflection characteristics of road surfaces, and relation between skidding and light reflecting properties of road surfaces; experimental low-cost street lighting system on main roads outside built-up areas; vehicle lighting.

40. Glenner, M. J. and J. Chaput, "Chicago's State Street has world's brightest street lighting", Elec Construction & Maintenance 58: n 1, Jan 1959, p 75-9.

Radio controlled lighting system; system consists of 70 tree-like standards, each holding four 7-ft, 6-lamp power groove fluorescent luminaires; other festures include air conditioning of luminaires and built-in receptacles; installation problems.

41. Grundy, J. T. and G. K. Lambert, "Colour technology applied to street lighting" Surveyor 120: n 3618, Oct 7, 1961, p 1213-15.

Summary of knowledge on nature of light and characteristics and effects of colors; extent of visible waveband in relation to wavebands which are senses as radiant heat, radio waves, X-rays and ultraviolet; advantages of colors in street lighting; relation of brightness and colors; colored sodium lighting and color corrected mercury lighting; use of filament lamps; it is essential that light be mixed always within lantern itself.

42. Halperin, A., "Lighting upgrades shopping area", Elec Construction & Maintenance 61: n 3, Mar 1962, p 85-7.

New fluorescent street lighting system installed at Englewood shopping district, Chicago, Ill., to provide

average 16 ft-c for street area, and 11.3 ft-c for sidewalk area with no supplemental window lights.

43. Hamming, I, and J.F.T. van Heemskerck Veeckens, "Open-air laboratory for road lighting", Philips Tech Rev 19: n 6, 1957-58, p 202-5.

Description of open-air laboratory at Philips Lamp factory in Turnhout, Belgium, which includes road, 320 mi long and 14 m wide, provided with ten lighting-masts mounted on trolleys; road has different surfaces which are used both in dry and wet conditions; in addition to its use for fundamental research on road lighting, area is used for testing new lamps and fittings.

44. Hasler, E. F. and G. Spurr, "Light intensity meters for local and remote indication", Electronic Eng 30: n 370, Dec 1958, p 690-6.

Measurement of daylight illumination is necessary to electricity supply industry for prediction of demand for artificial lighting, instruments are described that utilize method of measurement based on photocell used as grid leak of blocking oscillator; emphasis is placed on simplicity, reliability and versatility.

45. Hasler, E.F. and G. Spurr, "Ways to measure light intensity at distance", Electronics 32: n 29, July 17, 1949, p 48-9.

Daylight intensity at remote location may be determined by simple illumination measuring device which provides output in form suitable for transmission over telephone lines; system can be used in industrial process control with visible light, infrared, or ultraviolet input; circuit is based on blocking oscillator whose pulse repetition frequency is controlled by photocell.

46. Herzig, M., "Das 'Isocandela' diagramm und seine Anwendung in der Strassen-beleuchtungstechnik", Assn Suisse des Electriciens--Bul 52: n 15, July 29, 1961, p 564-8.

Isocandle diagram and its application in street lighting technology; suitability of graphical representation of light distribution of lamps and luminaires, especially of radiators with nonrotational symmetrical light distribution.

47. High level street lighting," Light & Lighting 57: n 5, May 1964, p 162-164.

Under normal circumstances, conventional methods of street lighting with one or more rows of lighting columns parallel to the direction of the road, provide not only a satisfactory means of lighting the carriageway but also provide the motorist with a visual guide to the course of the road ahead. Where complex intersections have to be lighted, however, this conventional method is less successful because the large number of columns and light sources usually needed presents a confusing picture to the motorist approaching the intersection, and also tend to mar appearance by day.

Such intersections are becoming more frequent as more and more motorways are built and designers have already been developing for some time solutions to the problems they create. One solution which seems to have found particular favour in Germany has been to use a small number of lighting points mounted on very high poles. This has been made possible by new large light sources which would, of course, be intolerably glaring at conventional mounting heights.

48. Horton, G. A., R. C. Speck, P. S. Zaphyr, and R. E. Wandt, "Automatic photometer for street lighting and other luminaires", Illum Eng 53: n 11, Nov 1958, p 591-5 (discussion) 595-7.

Photometer consisting of equipment such as single mirror selector unit and microampere recorder; programming is accomplished by two tape readers, one to control lateral orientation of luminaire, and other to control vertical orientation of selector mirror; basic elements of programming system are timing cams; block diagram of data and control units; sequence of operations.

49. Horton, G. A. and P. A. Zaphyr, "Automatic processing of photometric test data for street lighting luminaires", Illum Eng 53: n 6, June 1958, p 341-9 (discussion) 349-51.

Reduction in time of computation from 30 hr to 13 min by means of internally programmed digital computer, IBM type 704; luminaire testing; luminaire 704 program

and computer method; calculation and printing of iso-footcandle lines; results are presented as recommended by Illuminating Eng Soc.

50. Jordan, J. H., "Street lighting systems", Instn Mun Engrs--J 84: n 3, Sept 3 1957, p 111-19.

Relative merits of various types of street lighting for traffic routes, residential streets and shopping areas are discussed in order to explain what makes system of lighting, and why different authorities favor different methods.

51. Karns, E. B., "New developments in light sources and optical systems for roadway lighting", Elec Eng 77: n 10, Oct 1958, p 903-7.

Combination of two basic elements of optical control in modern street lighting; main reflector and refractor; tubular fluorescent lamp units; luminaire; new developments in fluorescent lighting are liable to make it more economical; use of new materials.

52. Koehler, W., "Die Beleuchtung von Schnellverkehrsstrassen", Forschungsarbeiten aus dem Strassenwesen n 34, 1958, 43p.

Highway lighting; purpose, limits, and design aspects; effects of lights of various forms, intensity and distribution; examples of practical solution of highway lighting presented.

53. Lighting city street", Illum Eng 54: n 11, Nov 1959, p 705, 55: n 1, 7 Jan 1960, p 38, July p 385.

Nov 1959: Installation at Wauwatosa, Wis, is designed to provide good nighttime visibility on divided traffic artery having curb to curb distance which varies from 60 to 100 ft; 480-v multiple wiring system is used; average maintained level of illumination of 1.2 ft-c is provided by mercury street lighting luminaires; each luminaire is mounted at 30 ft above the roadway and equipped with one 20,000-lumen, 400-w mercury lamp.

Jan 1960; Details of installation at Franklin Park, Ill, designed to provide good roadway illumination in city's business district to facilitate local pedestrian and vehicular traffic; street lighting luminaires, each equipped with four 72-in cool white high output fluorescent lamps, are used, mounted at height of 30 ft on American Concrete poles, have 2-ft bracket spans; illumination varies from 1.1 to 1.5 ft-c. July: Details of installation of Fourth South St, Salt Lake City, Utah, which is state highway with heavy traffic; spacing of posts is 108 ft on both sides for total of 14 posts for 2-block section; "T" luminaires consist of one unit containing four 72-in 1500-ma fluorescent lamps mounted on 2-ft bracket at right angles to curb and tipped upward 15° above horizontal; other two units, each containing two lamps, are mounted horizontally on 2-ft brackets parallel to curb, one on each side of post; lighting data sheet.

54. "Lighting traffic tunnels and underpasses", Illum Eng 52: n 6 June 1957 p 325-35.

Recommendations prepared by Subcommittee on Tunnel and Underpass Lighting of Street and Highway Committee of IES; tables on physical data on lighted tunnels; continuous burning and supplementary daytime entrance lighting; examples of existing tunnel lighting systems shown.

55. Lurkis, A. "Combating juvenile delinquency with light", Illum Eng 56: n 10, Oct 1961, p 606-10 (discussion) n 12, Dec p 713-14.

Outline of program carried out by Department of Water Supply, Gas and Electricity of City of New York for lighting all playgrounds in areas where juvenile delinquency problems existed; physical characteristics of playgrounds and general lighting considerations; factors considered in selection of lighting equipment for exterior and interior lighting; details of actual installations and lighting results.

56. Marsh, C. "Highway visibility", Illum Eng 52: n 12, Dec 1957, p 621-7 (discussion) 627-8.

Progress report of investigations at Pennsylvania State University on problem of fog on turnpikes with view to increasing visibility of light sources and

markings when viewed through fog; findings have applicability to public streets and highways, and rail, air, and marine travel; project is divided into four parts: vehicle mounted lamps; fixed lighting; fog detection and traffic control; and equipment.

57. Massart, P., "Les luminances en tant que criteres de qualite de l'eclairage public", Soc Royale Belge des Electriciens--Bul 77: n 1, Jan-Mar 1961, p 1-11.

Brightness as quality criteria of public lighting; relation of efficiency and economy of street lighting to brightness of road, lighting apparatus, background formed by sky and facades, and any obstacle that may be present; examination of correlations to obtain visibility and visual comfort; basic rules of calculation.

58. Morrison, J. H., "Lighting of motorways 'a necessity'," Surveyor 121: n 3668, Sept 22, 1962, p 1167-8.

Experiments with unidirectional lighting using 200-w linear sodium lamp on 35 ft columns are suggested; discussion of road safety, rates, research, road surfaces, and residential lighting. Before annual conference of Assn of Pub Lighting Engrs, Blackpool, Sept 1962.

59. Nagel, G.A., "Highway lighting test installation", Illum Eng 52: n 3, Mar 1957, p 155-65 (discussion) 165-71.

To evaluate various types of lighting for Connecticut Turnpike, 1-mi, 4-lane highway at Old Lyme, Conn, was selected to make comparison under actual highway driving conditions; 27 fluorescent and 22 mercury vapor luminaires, rated 21,000 lumen, were mounted on test strip; lighting evaluation; instrumentation used; results of photographic sequences; conclusions; tables.

60. Nellborn, Olov, "The use of dipped headlights in illuminated streets", (Om halvljusets anvandning pa belysta gator och vagar), Svenska Vagforeningens Tidskrift 51: n 1, February 1964, p 35-39. (Sweden)

English summary, p 54.

61. Night visibility," Nat'l Research Council--Highway Research Board--Bul n 163, 1957, 32p.

Assessment of night time roadway visibility, D. M. Finch, J. D. Palmer.
Some night views of highway lighting test installation, G. A. Nagel;
Device for establishing safe stopping distance at night, C. O. Swanson;
Visibility of reflectorized license plates, E. M. Larimer.

62. Nonneman, H. S., "Streetlighting by yard", Elec Light & Power 35: n 15, July 15, 1957, p 108-10.

Experimental 200 ft stretch of new street lighting system being tried out in Dayton, Ohio; system consists of continuous line of fluorescent luminaires suspended some 25 ft over road surface from ½ in. steel catenary messenger running over center of street; only every other lamp can be operated at time, or entire system can be lighted at once.

63. Ohnemus, H., "Die Berechnung mittlerer Beleuchtungsstaerken bei queraufgehaengten Leuchtstofflampenleuchten aus ihrer Haupt-Lichtverteilungskurue," Lichttechnik 14: n 6, June 1962, p 305-9.

Calculation of medium illumination values in street lighting with fluorescent lamps; method to determine medium illumination value when fluorescent lamps are installed transversely, longitudinally or at incline.

64. Old lamps new light," Can Mun Utilities 101: n 9, Sept 1963, p 42-3.

Mercury vapor post-type saturn luminaires were installed in Victoria, BC, to supplement weak glow of 5-branch clusters which are one of city's tourist attractions; modern luminaires are mounted 115 to 120 ft apart in staggered spacing on cluster street lights and total of 245 units were required to give average density of 2.64 ft-c; conversion of power poles to underground cable described.

65. Pahl, A., "Leuchtdichtestudien auf einer neuen Beleuchtungsuersuchsstrasse", Lichttechnik 15: n 3, Mar 1963, p 119-23.

    Luminance studies carried out on experimental road lighting; measurements carried out to determine light intensity and road surface luminance under various conditions, effects of various lighting installations and results obtained; evaluation of street lighting installations.

66. Piccione, N. E., "Butyrate street-lighting gloves resist breakage by vandals", Elec World 156: n 19, Nov 6 1961, p 66-7.

    New gloves, installed by Long Island Lighting Co., are blow molded from extruded butyrate cylinders, their specifications calling for minimum but uniform gage of 5/32 in. in wall thickness; complete street lighting unit, consisting of butyrate glove, spun aluminum canopy, and injection molded plastic finial, or handle, costs somewhat less than replaced glass equipment.

67. Putnam, R. C. and W. F. Gilimore, Jr., "Discomfort glare at low adaptation levels--off-axis sources", Illum Eng 52: n 4, Apr 1957, p 226-9 (discussion) 229-32.

    Paper reports work on BCD (borderline between comfort and discomfort) technique applied to study of light sources of visual sizes applicable to street lighting conditions; results of investigation based on 1000 readings taken by ten observers; chief factors influencing discomfort glare; test and compariosn sources used; tables.

68. Putnam, R. C. and K. D. Bower, "Discomfort glare at low adaptation levels. Pt III--Multiple Sources", Illum Eng 53: n 4, Apr 1958, p 174-80 (discussion) 180-4.

    Street lighting study consists of four parts; BCD measurements of circular source; single source above line of vision for background brightness of from 0.001 to 1.0 ft-L; simulated incandescent and fluorescent sources and effect of multiple sources; results and data.

69. Rand, J. A., "Powerbeam lighting", Am Assn State Highway Officials--Committee on Electronics--Regional Conf on Improved Highway Eng Productivity, San Francisco, Calif, Mar 2-3 1962 pt 3, p 98-103.

Discussion of European and American developments in use of low-mounted linear fluorescent sources for highway lighting; 4-ft extruded aluminum fixture using Powerbeam lamp and special reflector shape designed and produced by Sylvania Electric Products, is described.

70. Reid, J. A., "Some measurements of brightness of road signs at night", Surveyor 121: n 3637, Feb 17 1962, p 189-92.

Survey on nighttime brightness of more than 100 different self-illuminated road signs and signs illuminated only by street lamps; luminance measurements were made by usual telephotometer mounted on tripod in car; types of lighting units surveyed; results indicate conventional lighting system will not meet requirements of British Standard 873 on illumination of road signs.

71. Rex, C. H., "Computation of relative comfort and relative visibility factor ratings for roadway lighting", Illum Eng 54: n 5, May 1959, p 291-301 (discussion) 310-14.

Importance of good rating evolves from correlation with effectiveness ratings in terms of traffic produced; seeing benefit of roadway lighting is presented in dual ratings; example computations, conditions and factors involved; graphs, tables and curves.

72. Rex, C. H., "Effectiveness ratings for roadway lighting", Illum Eng 58: n 7, July 1963, p 501-20.

Efforts made by 47 state highway departments to improve roadway lighting and need for effectiveness ratings; IES's opportunity for progress impels following report on measurements of several roadway lighting systems in relative visibility and factors; double illumination for equivalent visibility on medium reflectiveness pavement surfaces; computed lightings in similar and preferable

to test ratings; double illumination in brightness for 1/6 sec simulation of dynamics; implementation and use of available seeing factor data; measurements made and data obtained.

73. Rex, C. H., "New developments in field of roadway lighting", Traffic Eng 30: n 6, May 1960, p 15-25, 28.

Aids available for improvement of night motor vehicle transportation, classified as follows: products efficient and effective in producing good seeing; improved roadway lighting practice essential for improvement of night transportation; ratings for evaluation of visual seeing effectiveness of roadway lighting systems; instrumentation developed for field measurement of seeing factors; report on foreign achievements.

74. Rex, C. H. and J. S. Franklin, "Relative visual comfort evaluations of roadway lighting", Illum Eng 55: n 3, Mar 1960, p 162-72 (discussion) 173-4.

Relative visual comfort studies were conducted at Outdoor Lighting Dept, General Electric Co, Hendersonville, NC, using Guth Evaluator and outdoor fullscale roadway lighting laboratory; details of evaluation and computed rating method; BCD (borderline-comfort-discomfort) evaluation; observer data by means of indoor laboratory BCD population study involving 50 people are in agreement with work by previous researchers.

75. Roberts, G. J. "Relighting of side streets", Chartered Mun Engr 89: n 2, 3 Feb 1962, p 43-6, Mar p 87-91.

Economics of obsolete lighting; advantages and disadvantages of simple conversions; typical gas conversion scheme described; problems in exchange of new lamps for old ones; side street lighting and aesthetics.

76. Rumar, Kare, "Night driving visibility", Traffic Engineering & Control 5: n 10, Feb 1964, p 611, 613, 615.

Visibility distances; available braking distance; silhouette visibility; re-adaptation time; smcking.

77. Secord, W. A., "Practical street layouts", Can Mun Utilities 101: n 9, Sept 1963, p 46-7.

General formula producing lamp lumens is recommended for problem of lighting new subdivisions when pole positions are fixed by requirements of distribution system; cost comparison table for chosen sources which fulfill technical requirements is presented; hints are given for approach to problem when pole positions can be selected to suit most economical street lighting layout.

78. Schmidt, W., "Beleuchtung von Schnellstrassen und Autobahnen", Lichttechnik 15: n 1, Jan 1963, p 15-23.

Lighting of high speed expressways and highways; traffic conditions in Europe; lighting installations and practice in United States; traffic accidents and lighting requirements; examples of installations in West Germany; cost factors.

79. Schmidt, K. P. R., "Die Bedeutung der Strassenbeleuchtung im Hinblick auf die Verkehrssicherheit und der Stand der Normung", Technik 12: n 11, Nov 1957, p 748-50.

Significance of street lighting with respect to traffic safety and present status of German DIN standard specifications.

80. Schreiber, W., "Neuzeitliche Strassenbeleuchtung", Strasse u Autobahn 7: n 12, Dec 1956, p 417-21.

Modern street lighting; explanations and suggestions in connection with introduction of regulations DIN 5044 concerning maintenance duties with respect to street lighting.

81. Schwanhausser, W. E.,Jr., "Highway lighting--feature of modern roadway design", Traffic Eng 29: n 3, Dec p 14-17, 38.

Illumination level requirements for access roads and acceleration lanes, straight sections--continuous lighting, rural four-lane design; urban four, six and eight-lane design, at-grad intersections and interchanges.

82. Schwanhausser, W.E. Jr., "Where lights are needed to get drivers out of dark", Eng News-Rec 161: n 2, July 10, 1958, p 54-6, 58.

Lighting at danger spots on highways; lighting for open road, urban multilanes, intersections and interchanges, acceleration and deceleration lanes, underpasses and tunnels, bridges and viaducts; use of illuminated signs.

83. Siegel, E.F., "Urban by-pass highway lighting", Elec Construction & Maintenance 58: n 3, Mar 1959, p 89-91; see also Consulting Engr (St. Joseph, Mich) 11: n 4, Apr 1959, p 128-32.

Features of lighting system of roadway, approaches, and interchanges of controlled-access Baltimore Harbor Tunnel project; approaches to Baltimore tunnel are lighted to maintained illumination level of 0.6 ft-c, illumination being provided by total of 845 4-lamp 6-ft fluorescent luminaires; 4-lamp luminaires selected make it possible to feed two lamps in each luminaire from separate circuit.

84. Smith, R. L., "Some fundamental facts on highway lighting", Roads & Streets 102: n 2, Feb 1959, p 122-4, 129.

Planning of adequate lighting of highways; basic equipment required is lamp, luminaire, bracket and pole and distribution of energy; cost of producing light based on lamp efficiency, cost of electricity and lamp replacement cost; application of lighting to seven critical elements of highway; it is shown that cost of lighting extensive arterial mileage is more than compensated for by reduction of nighttime accidents.

85. Spencer, D. E., "Fog on turnpikes", Illum Eng 56: n 67, July 1961, p 443-7.

Several effects which fog produces on turnpikes are enumerated; lighting of six-lane turnpike in fog is studied; effect can be minimized if luminaires illuminate road surface and lower part vehicles and

obstacles, while all of their light is confined to region close to road surface.

86. Sullivan, D.D., "New approach to residential street lighting...four-way luminaire design," Illum Eng 57: n 5, May 1962, p 349-52.

Examination of residential intersections and lighting problems involved; development of luminaire design which formed solution to problem; basic lamp selected is clear mercury 175w; for compatibility with bidirectional Type II luminaire to which this is companion, lamp is horizontal burning and mouth openings of reflector and refractor are ovate; newly designed reflector and refractor function with lamp as complete optical system with offset 4-way distribution.

87. Summers, T., Jr., "Estimating cost of roadway lighting system", Illum Eng 53: n 5, May 1958, p 269-77 (disuussion) 278-83.

Advantages and disadvantages of series and multiple street lighting distribution circuit; constant current transformer and distribution transformer loading; cost study comparing incandescent, fluorescent and mercury luminaires shows that type of circuit makes little difference in either initial or annual operating cost; tables.

88. Swetland, R. M. and K. D. Tobin,"Demonstration laboratory for roadway lighting", Illum Eng 54: n 5, May 1959, p 265-71 (discussion) 271-2.

Details of "Crossroad of Light" demonstration and research facility, at Hendersonville, NC: street layout, and pavement types, luminaires and lamps, etc, under full scale realistic conditions; examples of experimental projects such as continuous line parallel-to-curb lighting; low mounted parapet sources, highway sign illumination, automobile parking area lighting, etc.

89. Swetland, R. M.,"Effective roadway lighting practice", Pub Works 88: n 4, Apr 1957, p 107-11.

Review of status of roadway lighting in United

States with particular emphasis on need for and benefits from adequate roadway illumination, basic objectives in building and applying roadway lighting equipment, available roadway lighting tools, examples of well lighted roadways.

90. Symons, R. H., "Trends in street lighting and the new street lighting code of practice", Public Lighting 29: 124, March 1964, p 32-37.

The first literature I can find dealing with the specification of street lighting is a document called "Standard Clauses for Street Lighting Specifications," and it appears in the Journal of the Institution of Electrical Engineers. Published in 1917, it is the work of a committee appointed in 1910, and it seems rather a small document for seven years' work. Perhaps the reason for this was a dispute involving the Gas Engineers who objected to the appraisal of street lighting in terms of horizontal illumination, since, as they said, the illumination at any point on the road is affected by a number of lanterns. They were in favour of specifying the candlepower at two or three defined angles, and issued a minority report to this effect. This document served as the basis of the 1927 code which one might have expected to be a rather primitive affair, in view of its early date. However, the contrary is true and in some ways it is more ambitious than the present one. The two main points it dealt with were glare and illumination levels. The glare part was based on the work of Holladay and Stiles, and Walsh contributed a graphical method of using their data.

Whilst I have not tried using it, it appears to be quite simple. You make an adjustment to the polar curve to allow for the mounting height of the lantern above eye level, and then you place the resulting curve over the graphs given in the code. Where the adjusted polar curve cuts the curves given in the code gives you the degree of glare. The permissible limits for the various classes of road were given. Apparently this system broke down because insufficient was known about the reflection properties of road surfaces and the adaptation level was taken to be toolow with the results that the installations were calculated to be more glaring than they really were.

As regards illumination levels, certain test points were given where illumination readings were to be taken, and it was stipulated that the level at no point was to be lower than half the mean. Also a table of lower limits for mean values was given for each class of road. These vary from 2.0 lumens per square foot for a Class A road to 0.01 lumens per sq. ft. for a Class H road, and are much higher than those in the Institution of Electrical Engineers 1917 document.

91. Taragin, A. and B. M. Rudy, "Traffic operations as related to highway illumination and delineation", Pub Roads 31: n 3, Aug 1960, p 59-66, 71

Study to evaluate effectiveness of roadside delineation, pavement markings and combination of delineation and markings under conditions of full, partial and no highway lighting; results showed no significant differences with respect to average vehicle speeds, lateral placements, and clearances between vehicles, under various conditions of illumination and delineation.

92. Tobin, K. D., "Latest street-lighting trends", Elec Light & Power 36: n 14, July 1, 1958, p 34-6.

Since 1949 lighting installed on multiple circuits has increased from 10% to 20-25% of total, due to use of vaporsource lamps, fluorescent luminaires and photoelectric control; discussion of relative merits and demerits of series and multiple developments, and problems of choice posed to lighting engineer; mercury and fluorescent luminaires.

93. Waldbauer, W. M., "Highway lighting withoutglare--new lighting technique", Illum Eng 54:,n 1, Jan 1959, p53-60 (discussion) 60-4. see also Westinghouse Engr 19: n 2, Mar 1959, p 42-5.

Review of major types of systems; paper deals with unidirection system, aimed in direction of traffic flow; consideration of associated photometric, luminaire and application requirements; calculation of disability veiling brightness (DVB) and DVB comparison of various systems; possible criteria for evaluating system; development of highway luminaire; luminaire distribution; optical system.

94. Waldram, J. M., "Cine photography in study of drivers' visual problems", Brit Kinematography 39: n 6, Dec 1961, p 166-72.

    Method of using camera, and also microphone, in automobile to determine light requirements for safe driving; comparisons were made for daytime and night driving to determine illumination given by, and required of, street lighting.

95. Waldram, J. M., "Lighting and visibility in approaches to underpasses", G.E.C. J Science & Technology 29: n 3, 1962, p 119-29.

    Successful solution by low-level lighting for transition from conventional street lighting to conventional tunnel lighting; 2 different means adopted in 2 underpasses in England discussed; in neither case was artificial lighting used to facilitate transition stage during day.

96. Waldram, J. M., "Road surfaces, seeing and driving", Engineer 210: n 5463, 5464, Oct 7, 1960, p 594-6, Oct 14, p 632-4.

    Review of some recent studies on road surfaces and their effect on seeing and driving. Oct 7: Pre-war concepts of mechanism of street lighting and modifications required in design to match present day changes in properties of road surfaces. Oct 14: Studies on visibility and accidents; general conclusions on existing installations, and on methods for improving street lighting.

97. Waldram, J. M., "Visual problems in street and motorways", Illum Eng 57: n 5, May 1962, p 361-75.

    Experiments made on English urban highways and motorways to determine ways in which driver uses his eyes when driving, and means by which information is conveyed to him in various lighting systems, including daylight; mechanism of seeing in empty roads, medium and heavy traffic, and effectiveness of daylight, twilight and street lighting; it was found that vehicle lights were not capable of providing information necessary for safe driving on motorway if emergency occurs, but that fixed lighting was capable of doing so; characteristics of fixed lighting.

98. Wojcik, Henry L., "Highway lighting: design dilemma", Consulting Engineer XXII: n III, March 1964, p 100-104.

Author refers to the present basis for design of lighting systems for highways. Publication is by AASHO and is entitled An Informational Guide for Lighting Controlled Access Highways. It is the opinion of the writer, however, that there are many more actual and potential variables that effect not only the illumination level but also the quality of a lighting system and the installation and maintenance costs. He lists some of the considerations as follows: luminaire and lamp. He says both the reflector shape and finish are important; refractor characteristics; reflector and refractor assembly; lamp position whether vertical or horizontal; lamp type; and tolerances in terms of light output and operating voltages. He includes several photographs with both the daytime and after dark pictures of the same area, and has several charts. Included in the charts are figures indicating mounting height, coefficient utilization and lamp operating voltage tolerances. At the end of the article there is a glossary of terms taken from American Standard Practice for Roadway Lighting. The article also contains a short bibliography.

99. Wotton, E., "Humpty-Dumpty and stand practice", Illum Eng 57: n 5, May 1962, p 376-8.

Uniformity of illumination is one of criteria used in Standard Practice to determine effectiveness of street lighting installation; design of luminaire is examined with discernment; it is shown that uniform illumination without overlapping beams results in bad street lighting and that high angle distribution and nonskid road surfaces do not go well together, yet installations presumably complying with Standard Practice, but satisfactory in operation, were made on above basis.

100. Yeager, J. C. and H. A. Van Dusen, Jr., "Factors affecting efficiency of street lighting systems", Illum Eng 56: n 4, Apr 1961, p 262-70.

Compilation and discussion of all factors likely to

reduce output of lighting systems; comparison of efficiencies of incandescent, mercury, and fluorescent systems, sole criteria of which is incident ft-c level on roadway; "figure of merit" defined and data presented are intended to show that improvements in equipment design and circuit planning are needed if full potentials of these sources are to be used.

101. Young, J. W., "Application experience with mercury vapor lamps in street lighting service", Illum Eng 53: n 5, May 1958, p 253-61 (discussion) 261-6.

Tabulation of lamps recommended and offered for street lighting; development of phosphor coated lamp; essential lamp performance characteristics; ballast consideration; luminaire operating cost comparisons; application practice; particular reference is made to lighting design of residential areas.

102. Young, J. W., "Europe's streets and highways", Illum Eng 56: n 4, Apr 1961, p 253-61.

Different approach is noted with reference to "luminous environment" in street lighting plan; supplementary lighting includes high intensity lighting of plazas and squares, and floodlighting of building facades, distinguished architecture and monuments; use of mercury, fluorescent, sodium and xenon sources; installation practice and methods; examples of arrangements; poles or columns; concepts that govern provision of lighting intensity level, distribution on roadways and, control of glare.