

UNDER REVISION.

*Hooper*

No. 307—1931.

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Incorporated by Royal Charter  
FORMERLY  
British Engineering Standards Association.  
FORMED IN 1901 AS THE ENGINEERING STANDARDS COMMITTEE.

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BRITISH  
STANDARD SPECIFICATION  
FOR  
**STREET LIGHTING.**  
(REVISED, SEPTEMBER, 1931.)

LONDON:  
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*September, 1931.*

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The following Government Departments and Scientific and Industrial Organisations were officially represented upon the Committees entrusted with the preparation of this Specification :—

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Department of Scientific and Industrial Research.  
Home Office.  
General Post Office.  
Metropolitan Police (Traffic Department).  
Ministry of Transport.  
Office of Works.  
War Office.  
National Illumination Committee of Great Britain.  
National Gas Council.  
Institution of Electrical Engineers.  
Institution of Gas Engineers.  
Institution of Municipal and County Engineers.  
Institution of Public Lighting Engineers.  
Illuminating Engineering Society.  
Society of British Gas Industries.  
Society of Glass Technology.  
Automobile Association and Motor Union.  
British Electrical and Allied Manufacturers' Association.  
Electric Lamp Manufacturers' Association.  
Incorporated Municipal Electrical Association.  
Royal Automobile Club.  
Research Laboratories of the General Electric Company.

*This Specification was adopted by the Illumination Industry Committee at their meeting on 17th August, 1931, and published by the authority of the Council of the Association as a British Standard on 1st September, 1931.*

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#### NOTE.

*In order to keep abreast of progress in the Industries concerned, the British Standard Specifications are subjected to periodical review.*

*Suggestions for improvements, addressed to the Director, British Engineering Standards Association, 28, Victoria Street, London, S.W. 1, will be welcomed at all times. They will be recorded and in due course brought to the notice of the Committees charged with the revision of the Specifications to which they refer.*

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*Note* :—This Specification includes references to the following British Standards :—

No. 161. Tungsten Filament General Service Electric Lamps.

No. 230. Portable Photometers.

**PREFACE.**

This specification provides a basis upon which highway (street) lighting installations can be designed and compared, tenders invited, and installations tested, on an equitable basis. It furthermore specifies the technical conditions applying to the maintenance and testing of highway lighting installations under service or working conditions. 5

The local or statutory authority, the supply undertaking, the designer of the installation, and the manufacturer are interested in a highway-lighting specification in differing ways, which are liable to vary in different localities. The local authority may, for instance, decide to provide and maintain the highway lighting installation and for that purpose simply require tenders from manufacturers for the supply and possibly the design of the installation; or the local authority may invite quotations from the local gas or electricity-supply undertaking for the provision and maintenance of the installation at an inclusive annual charge. Again, any local authority owning a gas or electricity undertaking may be asked to give similar quotations to a neighbouring Council and in that case wish for designs and tenders from manufacturers for the necessary installation. It has not been possible to sectionalise the clauses of the specification to suit all conditions, and it has been left to the parties concerned to adopt such clauses as meet the needs of possible contracts. 10 15 20

The importance to the public of well-lighted highways cannot be over-estimated, and it is the opinion of many competent observers that the present standard and quality of illumination in many artificially lighted highways should not be accepted as good British Standard practice. It has therefore been felt that a British Standard Specification for Street Lighting must deliberately set a standard of highway lighting which is higher than that commonly existing at the present time. For this reason it has been decided to omit altogether from the categories in this specification a type of lighting—sometimes spoken of as “beacon” lighting—in which lamps are placed at such wide intervals that they indicate the edge of the roadway rather than illuminate the highway or the vehicles using it. Furthermore, even of the first seven classes of lighting installation given in Table I, that with the lowest illuminations (Class G) is still to be found in many relatively important highways in Great Britain, whilst such highways as Victoria Embankment, Whitehall, Strand, and Regent Street fall within the group of Classes B, C and D. The Class A highway has been inserted rather as a future category than as representative of any installations existing at the time of issue of this specification. 25 30 35 40

There is no doubt in the minds of those responsible for this specification that during the next few years the trend will, and should, be towards higher and better distributed highway illumination, and the standards have been set to anticipate the immediate future rather than to stereotype the past. 45

( 5 )

NOTE.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the design of a street lighting installation, but does not purport to comprise all the necessary provisions of a contract.*

**BRITISH  
STANDARD SPECIFICATION  
FOR  
STREET LIGHTING.  
(REVISED.)**

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NOTE.—This specification does not deal with those systems of Highway (street) Lighting at present often adopted for highways in which lights of relatively low candle-power are placed at great distances apart, so that the illumination over a considerable area is negligibly small. 10

**I. DEFINITIONS. 15**

**Highway.**

1. The term *highway* in this specification denotes the whole width of a street or road between the fences or boundaries of land used by public traffic.

**Carriageway. 20**

2. The term *carriageway* in this specification denotes that part of the road specially assigned for the use of animal or mechanical transport.

**Footway.**

3. The term *footway* in this specification denotes those portions of the highway between the carriageway and the boundaries, specially assigned for the use of pedestrians. 25

**Margin or Verge.**

4. The terms *margin* and/or *verge* in this specification denote those parts of the highway between the carriageway and the boundaries, not specially assigned for the use of pedestrians. 30

**Kerb.**

5. The term *kerb* in this specification denotes that portion of the highway composed of stone or other hard materials, bordering a raised footway, margin or verge and separating it from the carriage-way. 35

NOTE.—The use of the word “kerb” may also denote the line between the carriageway and the margin where no material kerb exists.

**Illumination.**

6. The term *illumination* in this specification denotes the illumination in foot-candles or in lumens per square foot of a surface situated at the ground level and parallel with the plane of the highway. Only light received directly from the installation is considered, light received by reflection from buildings and the like or that received from light sources not forming part of the installation being excluded. 5

**Unit of the System.**

7. The term *unit of the system* in this specification denotes a single unit of the repeat pattern. A highway lighting system is regarded as a series of sources forming a repeat pattern. 10

The light sources forming the unit of the system for typical installations are indicated in Appendix II.

**Test-point.**

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8. The term *test-point* in this specification denotes that point on the ground to be illuminated which is equidistant and as far as possible from the light sources which form one complete unit of the system. The test-points will be either on the carriageway or at the edge of the carriageway, and on the road margin or on the footway. The illumination at the test-point in the carriageway is generally the minimum for the carriageway and that at the test-point on the road-margin or footway is generally the minimum for the whole highway. See also Clause 19. 20

NOTE.—In order to avoid ambiguity, the position of each test-point is fixed definitely by Clause 16. For convenience the distances are measured from the points on the ground directly below the light sources. 25

**Illumination at a Test-point.**

9. The term *illumination at a test-point* in this specification denotes the illumination at one particular test-point as defined in Clauses 6 and 8. 30

**Mean Test-point Illumination.**

10. The term *mean test-point illumination* in this specification denotes the mean of the illuminations at the test-points in one class of installation or agreed section thereof (see Clauses 24 and 26), but in every case it must be specified whether it refers to the carriageway or the footway. 35

**Rated Illumination.**

11. The *rated illumination* is the illumination which would be produced if all the factors which govern the illumination were at their rated value. 40

**Service Illumination.**

12. The *service illumination* is the illumination which prevails at any time during the operation of an installation. See, however, Clause 23.

**Spacing-height Ratio.**

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13. The *spacing-height ratio* is the ratio of the distance between two adjacent light sources, measured along the centre-line of the roadway, to the height of the light source from the ground immediately beneath it.

**II. SPECIFICATION.**

10

**Classification of Installations.**

14. British Standard Highway-lighting Installations shall be grouped into eight classes, A, B, C, D, E, F, G and H, having rated mean test-point illuminations\* of not less than the figures given for each Class in Table I.

15

TABLE I.

Class.	Minimum Rated Mean Test-point Illumination.*	
	In Roadway (at points T or T' in Appendix II).	
A	2.0 foot candles and upwards.	
B	1.0 foot candle.	
C	0.5	„ „
D	0.2	„ „
E	0.1	„ „
F	0.05	„ „
G	0.02	„ „
H	0.01	„ „

*Note.*—Class H installation is not recommended for highways which are likely to be used appreciably for through traffic.

In a Class A Installation the value of the mean test-point illumination with which the installation is to comply shall be specially prescribed. The clauses of this Specification then apply to such specially prescribed values as if the latter had been inserted in this table.

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**These classes are only used for reference purposes in this Specification and do not necessarily represent the relative merits of the installations.**

35

\* See Definitions 9, 10 and 11.

**Footway Illumination.**

15. The rated mean test-point illumination of the footway as shown at "t" or "t'" in units of system I—V, Appendix II, shall not be less than 0.4 times the rated mean test-point illumination of the roadway. For the purpose of this requirement the illumination of the footway shall be calculated in accordance with the terms of Clauses 17 and 24. 5

In service, the test-point illumination of the footway shall not fall to less than 0.2 times the minimum rated mean test-point illumination of the carriageway for the appropriate class as given in Table I. For the purpose of this requirement the illumination of the footway shall be calculated in accordance with the terms of Clauses 18 and 26. 10

**Positions of Test-points.**

16. In the case of installations having the light sources arranged as shown in Appendix II, the test-points, except when otherwise agreed, shall be at the positions corresponding with the points marked T and t (or alternatively T' and t') in these diagrams. In other cases, and where the symmetry of an installation has to be materially disturbed to make provision for lighting the entrances to side streets, or for other reasons, the positions of any test-points shall be those at which the illumination due to the light sources under consideration would be a minimum, and these positions shall be agreed by the parties concerned. 15 20

The footway test-point shall be situated on a line at right-angles to the centre-line of the road and passing through T or T' (as shown in t or t' in Appendix II), 1½ feet from the boundary of the highway, but not in any case more than 12 feet from the edge of the kerb. 25

**Variation in Rated Illumination at Test-point.**

17. Unless otherwise specially prescribed the illumination at any test-point either on the carriageway or on the footway, under rated conditions, shall not be less than 0.5 times the rated mean test-point illumination obtained in the carriageway or on the footway respectively. 30

In the event of the illumination at any test-point exceeding 1.5 times the rated mean test-point illumination, the value to be taken in calculating the mean test-point illumination in accordance with Clause 24 shall, nevertheless, be only 1.5 times the rated mean value. 35

( 9 )

This clause applies to the minimum rated mean test-point illumination both on the carriageway and on the footway.

#### Service Illuminations.

18. In service the authority responsible for the maintenance of the installation shall not allow the mean test-point illuminations in any class of installation given in Table I and Clause 15 to fall below 0.5 times the minimum rated mean test-point illuminations specified in Table I and Clause 15 for that class. Unless otherwise specially prescribed, the illuminations at any of the test-points under service conditions shall not be less than 0.5 times the service mean test-point illuminations obtained on test. The service illumination at any individual test-point shall not in any circumstances fall below 0.25 times the rated mean test-point illuminations given in Table I and Clause 15.

In the event of the illuminations at any of the test-points being more than 1.5 times the service mean test-point illumination obtained on test, the value to be taken in calculating the mean test-point illumination in accordance with Clause 26 shall, nevertheless, be only 1.5 times the service mean value obtained.

NOTE.—The difference between the values of the rated and the service mean test-point illuminations is necessary in order to allow for the unavoidable variations in the spacing and to provide for decrease of the candle-power of the light sources, variation due to replacements or incorrect adjustment of the light source in the fittings, soiling of glass and reflecting surfaces of the fittings, changes in voltage or gas pressure and other factors which may cause the service illumination to fall below the rated illumination.

#### Distribution of Illumination on the Ground.

19. The illumination on the ground shall be so graded as to avoid an abrupt change at any point. The illumination at any part of the ground, including the footway, except within such shadows as shall be cast from the light sources or other equipment, shall not be less than the illumination prescribed for the test-points in the foregoing clauses.

#### Height of the Light Source above the Ground.

20. The height of the luminous centre of the light source above the ground, for highways lighted on one side only, shall be at least two-thirds of the width of the carriageway, and for highways lighted on both sides, not less than one-third of the width of the carriageway for each class of installation. In no case shall the height of the luminous centre of the light source above the ground be less than that shown in column 3 of Table II. Column 4 of the Table gives the lowest height that is recommended in each case.

TABLE II.

Class. I	Rated mean test-point illumination on carriageway. 2	Height of the luminous centre of the Light Source above the Ground.		
		Minimum. 3	Lowest recommended. 4	
A	2.0 foot candles and upwards.	30 feet.	30 feet.	5
B	1.0 foot candle	25 "	27 <sup>1</sup> / <sub>2</sub> "	10
C	0.5 " "	21 "	25 "	
D	0.2 " "	18 "	21 "	
E	0.1 " "	15 "	18 "	
F	0.05 " "	13 "	15 "	
G	0.02 " "	13 "	13 "	15
H	0.01 " "	Preferably 13 feet.	13 "	

NOTE.—The low values of the heights given in the above table have been specified because of the existing practice of using low posts. There are many cases, however, in which it would be advantageous to use mounting heights even greater than those recommended in Column 4, and wherever possible this should be done. 20

When the light sources are enclosed in large well-diffusing translucent envelopes, it is recognised that the minimum heights given in the above Table may not be essential and a minimum height should be agreed by the parties concerned.

**Maximum Spacing-height Ratio.**

21. This spacing-height ratio should be chosen to give the best distribution of illumination having regard to all the circumstances of the case in question. The following Table gives the maximum permissible spacing-height ratio also the values which it is undesirable to exceed :— 30

TABLE III.

Class. I	Maximum. 2	Recommended. 3	
A	5	Not more than 3	35
B	6	" " " 4	
C	8	" " " 5	
D	9	" " " 6	
E	10	" " " 7	
F	12	" " " 8	
G	12	" " " 10	
H	12	" " " 10	

## ( II )

NOTE.—In calculating the spacing-height ratio, the distance “*i*,” as shown in Appendix II, between adjacent light sources shall be taken.

**Glare.**

22. The Installation should be as free as practicable from Glare. Glare can be reduced by decreasing the spacing and increasing the height of the light sources. 5

NOTE.—The Appendix which appeared in the 1927 issue of this specification and which indicated a method of evaluating glare is omitted from this issue but will probably be re-introduced in a modified form in a later edition. 10

**III. TESTS.****Climatic Conditions during Tests.**

23. Illumination tests taken in the highway shall be made only on nights when the climatic conditions are agreed to be satisfactory by the parties concerned, agreement being not unreasonably withheld. 15

**Illumination Tests of an Installation under Rated Conditions.**

24. When testing an installation, or part of an installation, for initial conformity with this specification under rated conditions, the mean test-point illumination of the carriageway and of the footway shall be determined by taking the average of the illuminations at one of the test-points (on the carriageway and footway respectively), in each of five or more units of the system as nearly consecutive as possible. In cases where, owing to disturbance in the symmetry of the installation, the positions of the test-points have been agreed in accordance with Clause 16, agreement shall also be reached as to the number of test-points to be taken. 20 25

The tests shall be carried out in accordance with Appendix I, and appropriate corrections shall be applied to the results if the tests are carried out under other than rated conditions. Measured values in excess of 1.5 times the rated mean test-point illumination given shall be reduced in accordance with Clause 17 in order to determine the average value. The lamps, lanterns, glassware, burners and mantles shall be clean and adjusted in position in accordance with the manufacturer's instructions. 30 35

**Laboratory Test for Conformity of the Apparatus with the Rated Conditions.**

25. In cases where it is found to be impracticable to carry out the highway tests described in Clause 24, the following test shall be used to determine, by calculation, the rated mean test-point illuminations, due attention being paid to the illumination which 40

would be received at a test-point from both the adjacent lamps and others which materially contribute to the illumination.

The number of samples of the complete fitting to be selected shall be agreed between the parties concerned. These samples shall be selected at random by the purchaser and tested at the maker's works, or at an agreed testing laboratory, for consumption and for conformity with the light distribution necessary to provide the specified mean test-point illumination under rated conditions. The fitting shall be equipped with a light source of the type and rating prescribed by the manufacturer. In the case of electric lamps the luminous output of the light source shall be equivalent to the mean figure given in Col. 8 or 11 of Table II of the appropriate Schedule of British Standard Specification No. 161-1930; in the case of gas lamps the lantern, reflector, burner and mantle shall be fixed and adjusted to suit the declared calorific value and the pressure of the gas.

#### **Illumination Tests of an Installation under Service Conditions.**

26. When testing an installation, or part of an installation, for conformity with this specification under service conditions, the mean test-point illumination of the carriageway and of the footway shall be determined by taking the average of the illuminations at one of the test-points (on the carriageway and footway respectively), in each of five or more units of the system as nearly consecutive as possible. In cases where, owing to disturbance in the symmetry of the installation, the positions of the test-points have been agreed in accordance with Clause 16, agreement shall also be reached as to the number of test-points to be taken. Measured values in excess of 1.5 times the rated mean test-point illumination shall be reduced in accordance with Clause 18 in order to determine the average values.

The time and locality of the test shall be at the discretion of the local lighting authority. The conditions of supply of gas or electricity shall not vary from the normal when the test is made (see Appendix I).

#### **Information to be Supplied with Enquiry.**

27. In addition to the general information as to the highways to be lighted the party inviting the tender shall state where applicable:—

- (a) The class of highway installation desired (see Table I).
- (b) For a gas installation, the normal pressure and calorific value for which the burners are to be supplied.
- (c) For an electric installation, the declared voltage and nature of the supply.
- (d) For the purpose of the rating test, if the voltage at the lamp terminals cannot be given, the nearest point shall be stated at which the voltage can be measured, together with particulars as to the connecting-wires, so that the average voltage on lamp terminals can be calculated.

- (e) Any preference as to positions of light sources.
- (f) Particulars as to the average width of the carriageway, or, where necessary, drawings.
- (g) Particulars as to the average width of the margin and footway, or where necessary drawings.

5

**Information to be Supplied with the Tender.**

28. In addition to the general information as to the character of the apparatus it is proposed to supply, the following particulars shall be given for information only :—

- (a) Such light distribution curves of the fittings proposed as will enable an estimation to be made of the distribution of the light on the carriageway and on the footway. 10
- (b) Value of the maximum and average illumination on the carriageway. The average illumination to be calculated by a method to be agreed by the purchaser. One method for calculating average illumination is shown in Appendix IV. 15
- (c) The luminous output of the light sources necessary to provide the illumination required.
- (d) The type, rating and total number of gas burners or electric lamps to be used. 20
- (e) For a gas installation, the consumption of gas per hour for the complete installation, (i) for burner, (ii) with by-pass, if any.
- (f) For an electric installation, the consumption of electricity per hour for the complete installation. 25
- (g) In cases falling within the exceptions dealt with in Clause 16, the positions at which the illumination test on the equipment is to be carried out.

**Arbitration.**

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29. In case any dispute shall arise between the parties to any contract in which this specification is in whole or part incorporated, then such dispute shall be referred to the arbitration of a person to be agreed upon between the parties, agreement being not unreasonably withheld, or, failing agreement, to be appointed at the request of either party to the said dispute, by the Chairman for the time being of the British Engineering Standards Association, provided always that if such dispute is within the terms of any other agreement to refer or submit to arbitration this Clause shall be of no effect.

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( 15 )

**APPENDIX I.**  
**NOTES ON TESTING.**  
**Gas Burners.**

(a) In the case of gas burners, when carrying out tests for the rated mean test-point illuminations, the lamps shall be operated with properly adjusted burners, new mantles, and with gas at the normal pressure and declared calorific value specified in Clause 27 (b). 5

**Electric Lamps.**

(b) In the case of electric lamps, when carrying out tests in the highway for the rated mean test-point illuminations, it is necessary to ascertain the voltage supply at the lamp terminals at the time of the test. For this purpose the voltage shall be measured at the nearest available position. The voltage at the lamp terminals and the voltage which should have been available shall be calculated from the particulars supplied by the purchaser. The luminous output of the source and the measured illuminations shall be corrected for any difference between the voltage at the terminals and the voltage which should have been available. The rated candle-power of the lamp shall be taken as the mean value calculated from Col. 8 or 11 of Table II of the appropriate Schedule in British Standard Specification No. 161—1930, and corrections shall be applied for any departure at the time of test from this mean value. 10 15 20

For tests under service conditions it is necessary to ascertain that the voltage is not in excess of the rated voltage, or declared voltage of the system. If the voltage is above this amount, the necessary correction to the value of the minimum illuminations can be ascertained from the curve or table in Appendix III. 25

**Illumination Tests.**

(c) The test-point shall be determined by direct linear measurement. Where there are cross-roads, open spaces, etc., it is only necessary to see that the mean test-point illuminations are not less than the specified values. Where there is difficulty in deciding how to determine the positions of the test-points, agreement should be reached between the contracting parties before the design is approved as to which positions shall be taken as the test-points (see Clause 28 (g)). 30 35

The photometer used and the methods of employing it shall conform with the British Standard Specification for Portable Photometers No. 230—1925. The test-surface shall be as near the ground as possible, and in no case more than 12 inches above. 40

If the photometer cannot conveniently be used for the measurement of illumination at the carriageway level and in any case if the illumination is less than 0.05 foot-candle, or the light from the

principal sources under consideration reaches the test surface at an angle exceeding 75 degrees, the test shall be carried out by means of a test-surface arranged normal to the light rays, the direct illumination in foot-candles due to each light source contributing to the illumination at the test-points being measured. For this purpose 5 the test-surface shall be supported on a suitable stand placed at a convenient distance from each light source in turn in such a position as to intercept directly on its surface the light which would otherwise illuminate the test-points. The illumination at the test-points may then be ascertained by calculation. The correction factor  $K$ , by 10 which these readings must be multiplied in order to determine the corresponding illumination at the test-points, may be obtained from the chart in Fig. 1 if the height of the test-surface is 3 feet above the ground.

In carrying out the illumination tests care must be taken to 15 prevent shadows from the photometer, from the complete lighting units, from the operators, or from any temporary obstruction, falling on the test-surface when making the measurements. Similarly, care should be taken to avoid any abnormal reflections, and to ensure that only direct light from the highway lighting system reaches the 20 point of test. Care should be taken especially to avoid reflections from the road surface when making measurements normally to the incident light.

*Example.*

A carriageway 50 ft. wide is illuminated by standards centrally 25 mounted at a height of 21 ft. and spaced at 126 ft. (see Unit of System III). In this case the distance  $d$  from the source to the test point is 67.8 ft.

Set up a vertical from the point 67.8 to intersect the curve corresponding to a mounting height of 21 ft. The corresponding 30 correction factor indicated on the scale of  $K$  will be seen to be 0.225. Assume the readings on the test-surface 3 ft. high and normal to the incident light from the two sources are 0.50 and 0.58 foot-candle respectively, then the illumination at the test-point will be 0.225 (0.50 + 0.58) = 0.243 foot-candle. 35

The position of the test-surface may be checked by noting its shadow or by any other convenient method.

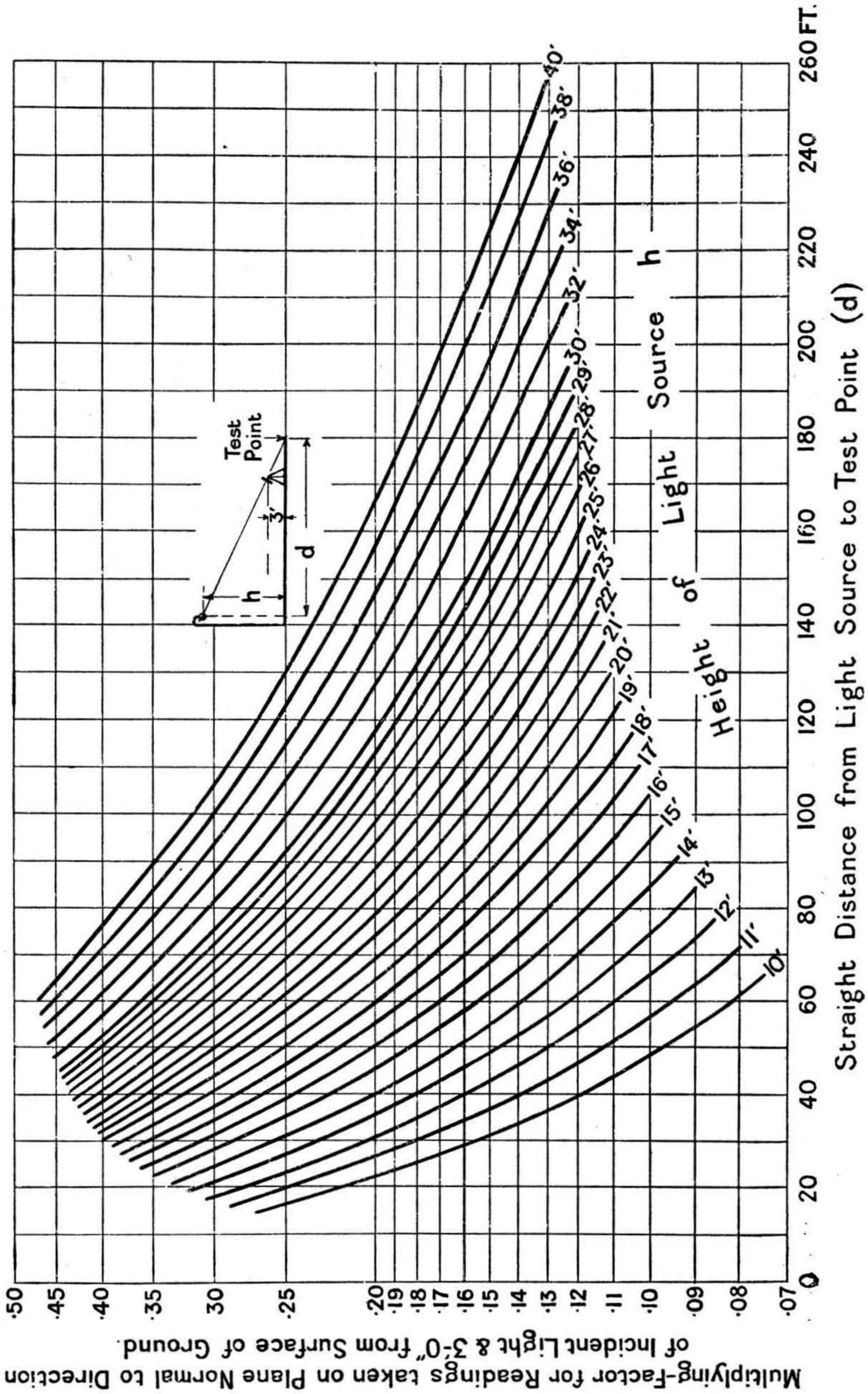


Fig. 1.

APPENDIX II.

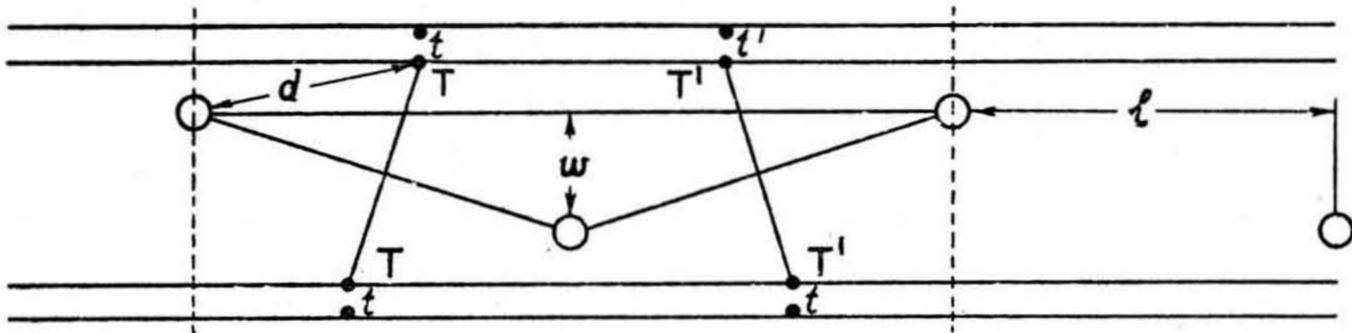
PLANS AND DIAGRAMMS ILLUSTRATING THE POSITIONS OF TYPICAL TEST-POINTS AND A SECTION OF THE CARRIAGEWAY SHOWING THE LIGHT SOURCES FORMING THE UNIT OF THE SYSTEM.

UNIT OF SYSTEM I.

5

NOTE.—When the intersection of the straight lines TT and T'T' occurs in the carriageway, there will normally be only one test point which will be taken at that intersection. In the special case where this intersection occurs on the kerb line there may be three test points per unit of system.

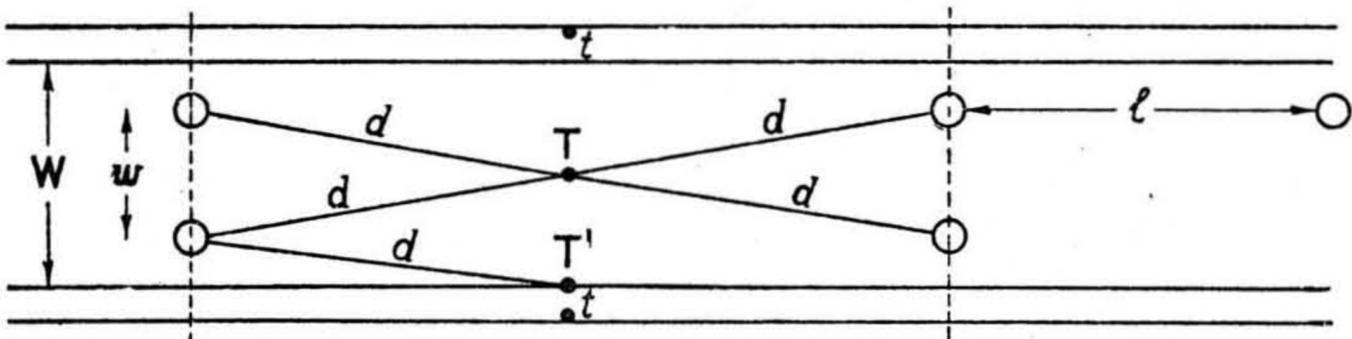
10



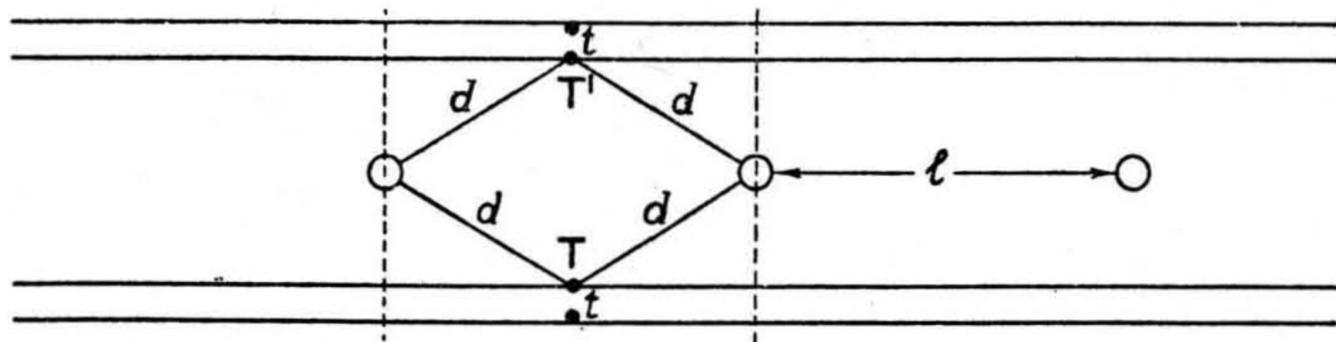
UNIT OF SYSTEM II.

Normally the test point will be situated at point T ; but in cases where the transverse distance between light sources  $w$  is less than one half the width of the carriageway  $W$ , the point T' shall be the test point.

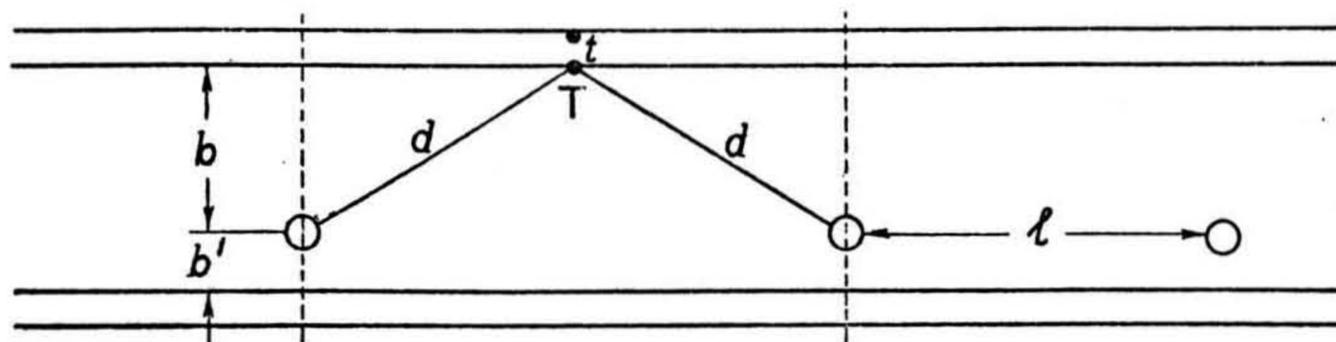
15



UNIT OF SYSTEM III.



UNIT OF SYSTEM IV.

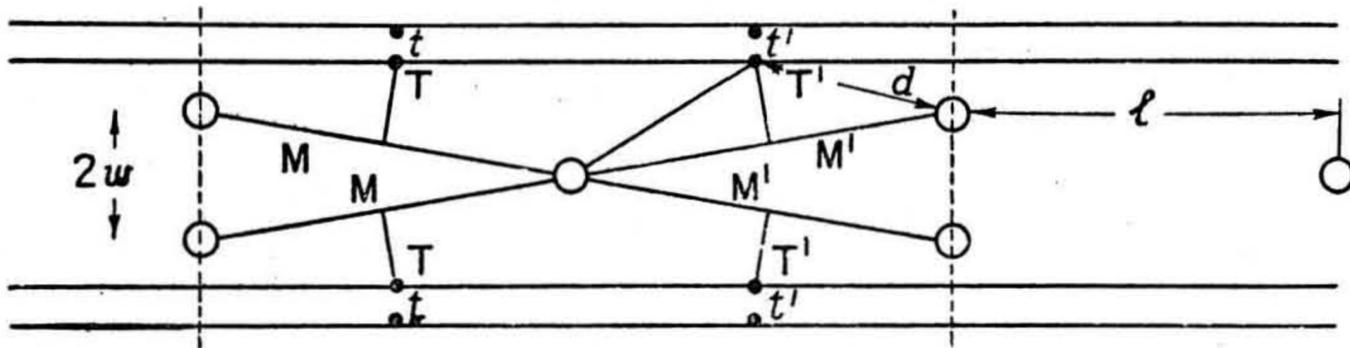


UNIT OF SYSTEM V.

Unit of System V can be treated in a similar way to Unit of System I: the distance  $w$  (the distance between the posts measured transversely across the road) is multiplied by two. Normally there will be four test points per unit of system.

5

When the intersection of the lines  $MT$  and  $M'T'$  falls within the carriageway, there will be only two test points per unit of system, and in the special case where the intersection lies on the kerb line there will also be two test points per unit of system.



NOTE.—In all of the units of system, light sources placed on the kerb constitute special cases of the above general distributions of posts, and in no way affect the positions of the test points.

10

In each case the unit of system is between the vertical dotted lines.

**APPENDIX III.  
CURVE AND TABLE SHOWING THE PERCENTAGE VARIATION IN  
CANDLE-POWER WITH VARIATION IN VOLTAGE OF METAL FILA-  
MENT VACUUM OR GASFILLED LAMPS.**

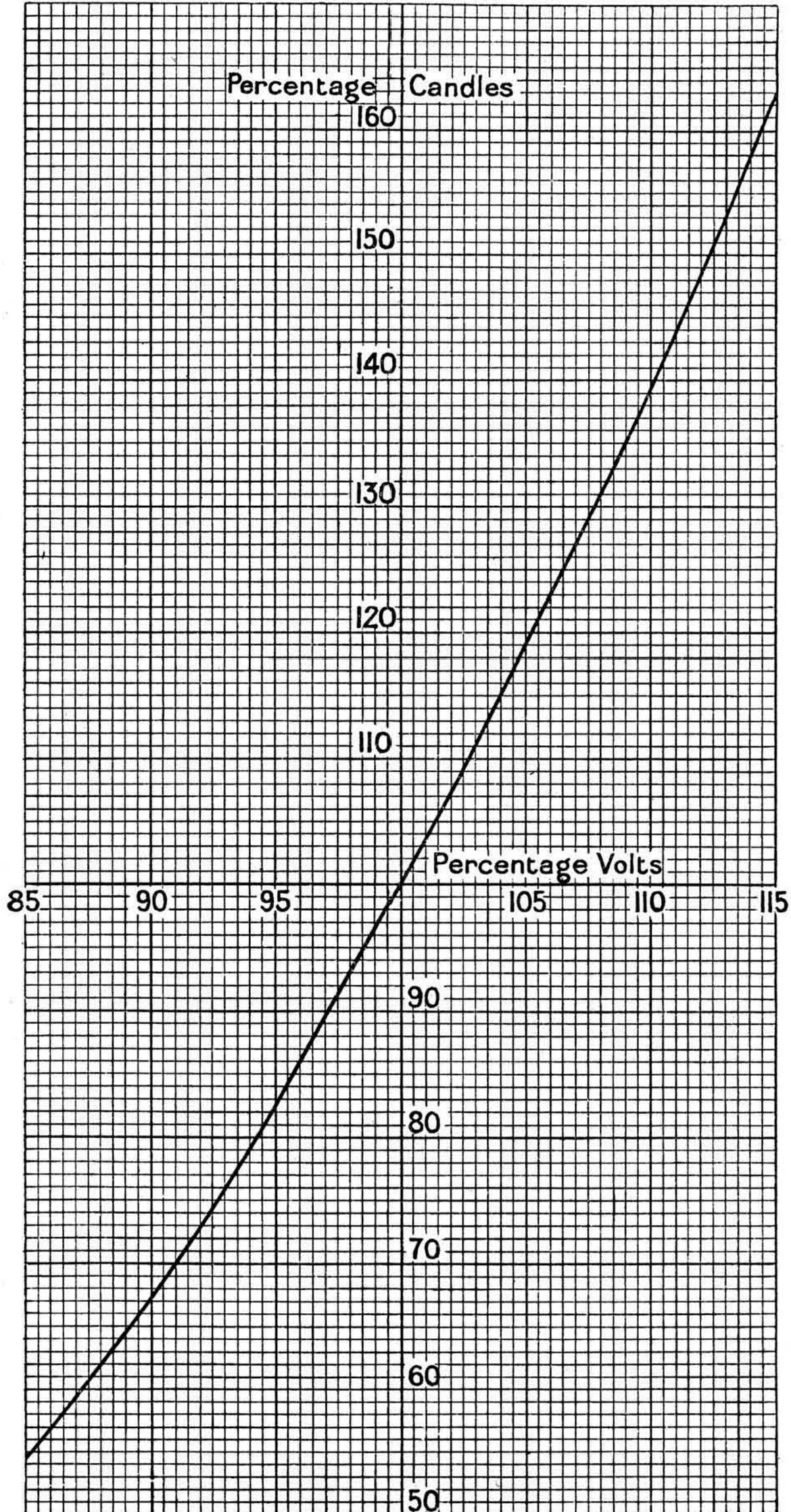


Fig. 2.

TABLE IV.

Percentage Variation of Voltage.	Multiply Illumination by the appropriate figure in this column to obtain the corrected Illumination.
Percentage above. <ul style="list-style-type: none"> <li>15</li> <li>14</li> <li>13</li> <li>12</li> <li>11</li> <li>10</li> <li>9</li> <li>8</li> <li>7</li> <li>6</li> <li>5</li> <li>4</li> <li>3</li> <li>2</li> <li>1</li> </ul>	<ul style="list-style-type: none"> <li>.61</li> <li>.63</li> <li>.65</li> <li>.67</li> <li>.70</li> <li>.72</li> <li>.74</li> <li>.76</li> <li>.79</li> <li>.81</li> <li>.84</li> <li>.87</li> <li>.90</li> <li>.93</li> <li>.97</li> </ul>
Correct <ul style="list-style-type: none"> <li>1</li> <li>2</li> <li>3</li> <li>4</li> <li>5</li> <li>6</li> <li>7</li> <li>8</li> <li>9</li> <li>10</li> <li>11</li> <li>12</li> <li>13</li> <li>14</li> <li>15</li> </ul> Percentage below.	<ul style="list-style-type: none"> <li>1.00</li> <li>1.04</li> <li>1.08</li> <li>1.12</li> <li>1.16</li> <li>1.21</li> <li>1.27</li> <li>1.32</li> <li>1.37</li> <li>1.43</li> <li>1.49</li> <li>1.55</li> <li>1.61</li> <li>1.68</li> <li>1.76</li> <li>1.84</li> </ul>

## APPENDIX IV.

METHOD OF CALCULATING AVERAGE ILLUMINATION USING  
SINUSOIDAL ISOCANDLE DIAGRAM.

## Isocandle Diagram.

A sinusoidal diagram is a representation of the space around a lighting unit by means of angular coordinates similar to lines of latitude and longitude. It is so drawn that equal solid angles are shown by equal areas on the diagram. The distribution of luminous intensity of a source can be portrayed on such a diagram by lines known as isocandle lines indicating equal values of luminous intensity. The luminous flux in any zone, such as the zone bounded by two isocandle lines, is equal to the product of the area of the zone as shown on the diagram, the average intensity of the source over the zone, and a constant.\*

Such a diagram is shown in Figure 3, which portrays the intensity distribution of a particular asymmetric unit.

Two such diagrams are required to portray the whole of the space around the unit. But only one need be drawn unless the distributions on the two sides are different. The diagrams should show the distributions of luminous intensity on either side of a plane at right angles to the direction of the road.

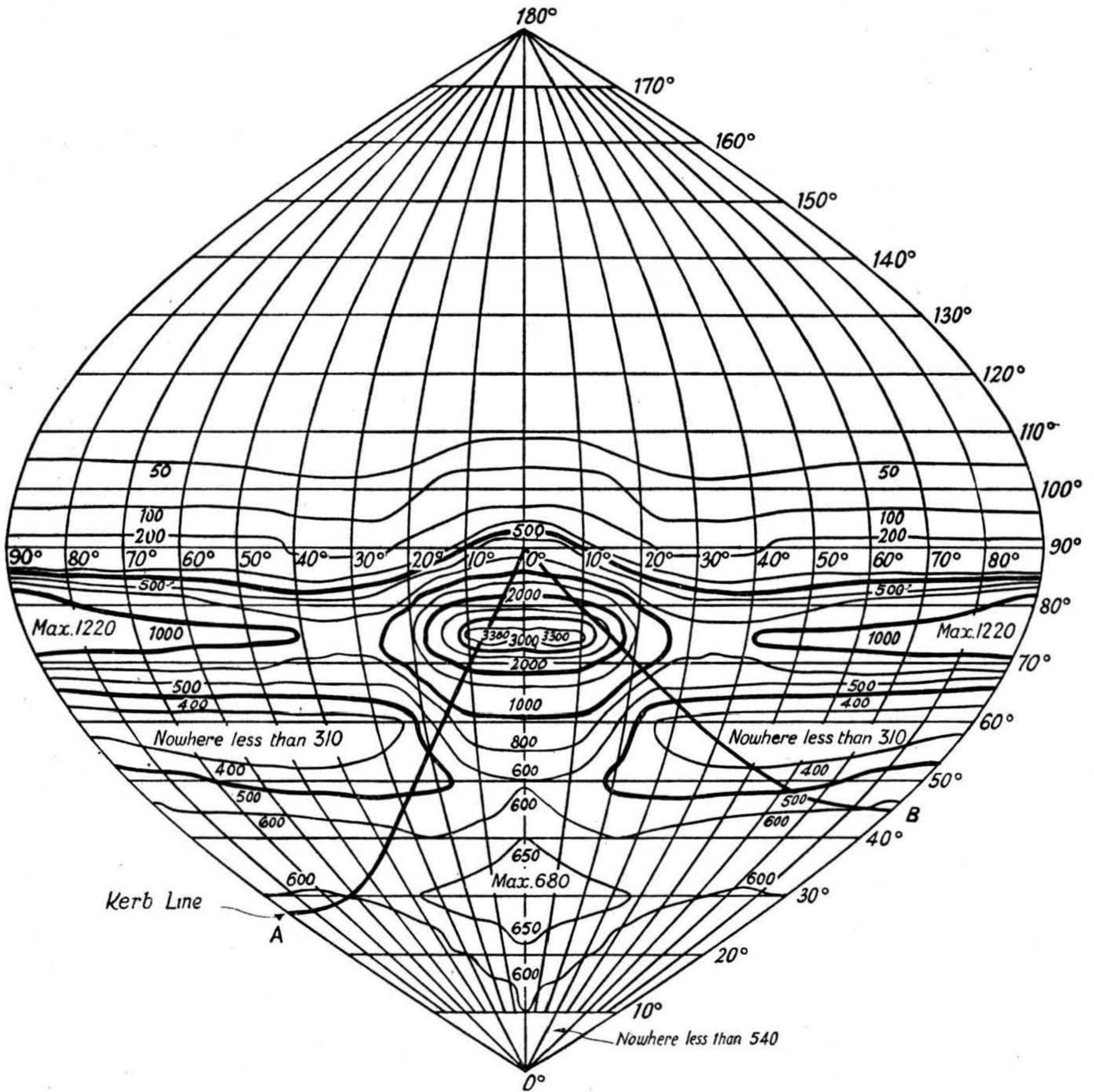
In order to determine the amount of luminous flux reaching the surface of the carriageway, it is necessary to project the boundaries of the road surface on to the diagram and to determine the amount of flux emitted within the boundaries. For this purpose it is convenient to specify the width of the road in terms of the height of the post, and a series of lines has been drawn on the diagram in Fig. 4, representing the boundary lines for various values of  $\frac{b}{h}$  where  $b$  is the width of the road from the source to the boundary, as shown in Fig. 4, and  $h$  is the height from which any particular case can be interpolated. This fraction will, in general, have a different value for the two sides of the street.

## Number of Contours required on Diagram.

A reasonable degree of accuracy can be secured provided that contours have been drawn at sufficiently close intervals. To ensure that this is the case, the areas between contours should be multiplied first by the intensity value of the upper contour and then of the lower, and the mean of the sums of the two sets of values so found used, provided that the two sums do not differ by more than 20 per cent from the mean.

---

\* The Constant is equal to  $\frac{2\pi}{A}$  when  $A$  is the total area of the sinusoidal diagram.



Contour Figures are in Candles.

Sinusoidal Diagram portraying Intensity Distribution of a particular asymmetric unit.

Maximum Intensity in peak = 3370 Candles.

Fig. 3.

**Calculation of Average Illumination.**

It can be shown that the flux enclosed between the appropriate boundaries multiplied by two (to account for the other side of the unit) and divided by the area of carriageway in one unit of system gives the average illumination for a long straight street. For a short installation there is a small error which can be safely neglected in cases of more than one span in length. 5

It will be found possible to perform this calculation for a given unit for a series of values of  $\frac{b}{h}$  once for all, and to obtain curves connecting average illumination and the ratio  $b/h$ . The solution of any problem for this unit can then be read rapidly from the curves. 10

*Example.*

INSTALLATION.—Unit of system IV mounting height 20 ft., overhang over kerb 10 ft., spacing 150 ft., road width 30 ft. Axial type asymmetric units having the light distribution shown in Fig. 3. The average illumination on the carriageway is required. 15

First draw on the diagram the projection of the two kerb lines with reference to one of the lighting units. In this example the two values of  $\frac{b}{h}$  are 1.0 and 0.5, and are shown by lines AO and BO.

Next, by means of planimetry, obtain the area between each pair of contour lines within the kerb lines and multiply each area in turn by (a) the intensity value of the upper contour surrounding it and (b) the intensity value of the lower contour surrounding it. Add together all the products resulting from the use of the values (a) above and all those resulting from the use of the values (b). Multiply each sum by the constant  $\frac{2\pi}{A}$ , where A is the total area of the hemispherical diagram. 20 25

In the example the following values are obtained :—

(a) 1025

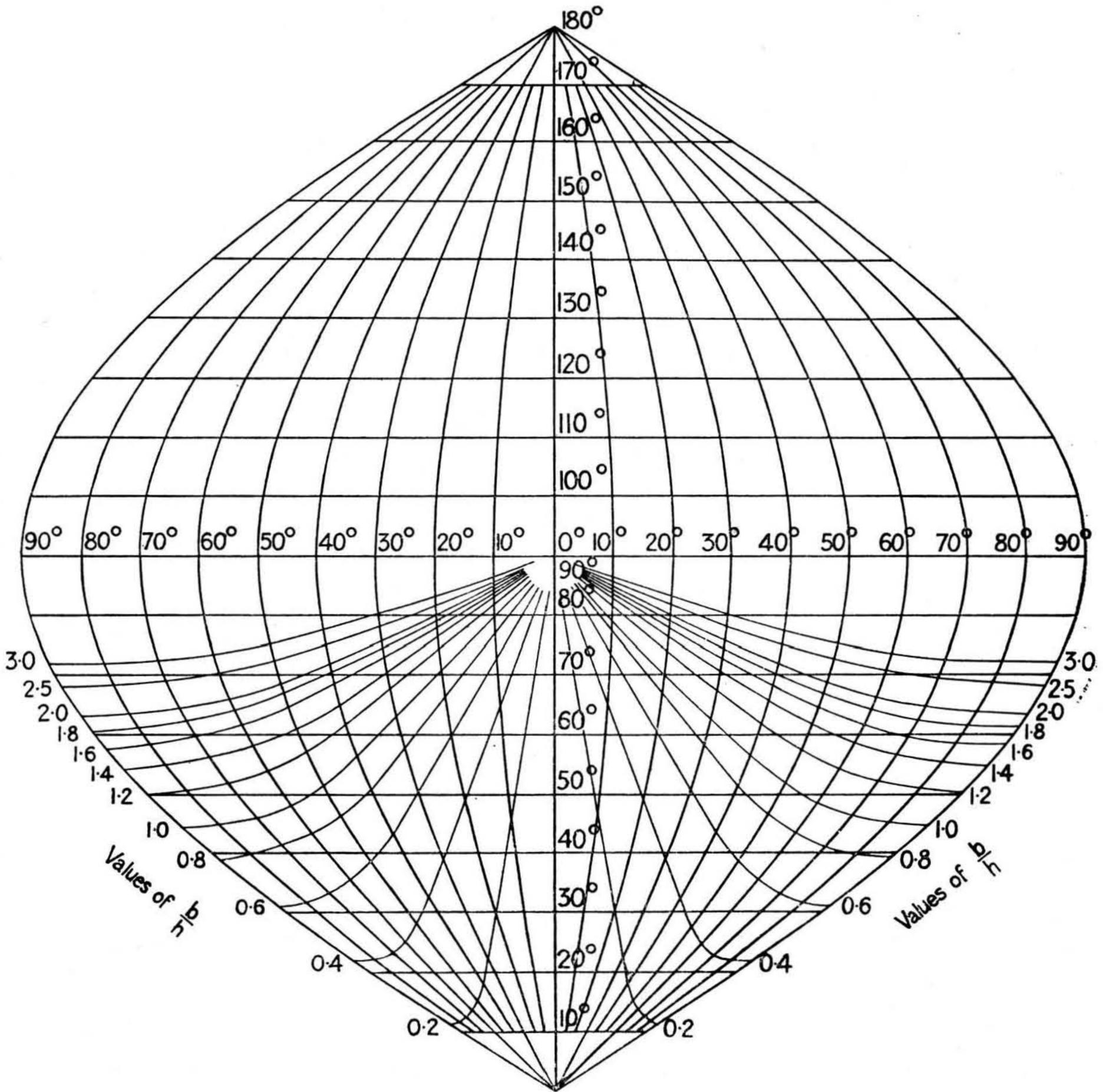
(b) 870

Twice the mean of these two values gives the mean value of the light flux from one unit falling on a long straight street. 30

Mean (c) = 947.5

Flux = 1895 lumens.

Providing that the values (a) and (b) do not differ from (c) by more than 20 per cent, the mean can be accepted. If a greater difference is obtained, sufficient contours have not been given on the isocandle diagram, and a more precise diagram must be used. 35



Web for Sinusoidal Isocandle Diagram,  
with lines showing kerbs.

Fig. 4.

The value of the average illumination is obtained by dividing the total light flux falling on the street surface from the units in one unit of system by the area of one unit of system. The area is 150 ft.  $\times$  30 ft., and therefore the average illumination is

$$\begin{aligned} E &= \frac{1895}{150 \times 30} \\ &= 0.42 \text{ foot-candles.} \end{aligned}$$

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