ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

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EDITORIAL.

The Annual Meeting of the Institution of Gas Engineers

AND

The International Acetylene Congress.

THE two recent gatherings of the Institute of Gas Engineers and the International Acetylene Congress, furnish gratifying evidence of the tendency towards international co-operation in technical and scientific matters, characteristic of the present century. At the conclusion of the meeting of the English Institution of Gas Engineers many of those present, having accepted the invitation of their German confrères, left London to pay a visit to Berlin. The Acetylene Congress was attended by delegates from all the chief European countries, many speeches being delivered in three languages. As Sir W. Ramsay said at the conclusion of his speech on the opening day, the real value of such meetings lies not so much in the receiving or giving of a certain amount of useful information, as in the opportunity provided to the representatives of different countries of forming friendships and getting to understand each other's point of view.

A number of papers of considerable technical interest were read at both meetings, but we feel that such important meetings as that of the Institution of Gas Engineers might with advantage deal not only with points of technical interest to the engineer, but that the standpoint of the consumer ought likewise to receive attention, and that it would present a favourable opportunity of organizing demonstrations of the most recent methods of gaslighting.

There were, on the other hand, several papers dealing more or less closely with lighting at the Acetylene Congress, notably that of the President, Mr. Bingham, contrasting the merits of acetylene with petrol-air gas. Mr. Bingham, however, dealt with his subject entirely from the acetylene standpoint, and to us it was a matter for regret that in the discussion which followed there was none present to state the case from the point of view of petrol-air gas. As we have repeatedly asserted in these columns, those interested in one system of lighting act unwisely in attempting to minimize the merits of another, and ought rather to take every opportunity of hearing what its exponents have to say, in order to learn where their own strength and weakness really lie. Many of the questions raised in Mr. Bingham's paper, which we abstract elsewhere, are of great interest, and we would gladly put our columns at the disposal of such authorities on both illuminants who would like to discuss the matter frankly.

The Effects of different Illuminants on Eyesight.

There was one point raised in Mr. Bingham's paper which seemed to us to illustrate very clearly the want of authoritative and impartial ruling on many vexed questions connected with illumination. We have often called attention to the hopeless discrepancies between the statements of those representing different systems of illumination on this point of eyesight, and insisted upon the need for a thoroughly scientific and impartially conducted investigation, having for its object an authoritative ruling on the disputed points. At present the conflicting statements which greet us on all sides are only ridiculous. We fear that very often the representatives of each system of lighting do not really attempt to discover what is physiologically good or bad in their respective systems of lighting. They merely lay hold of some favourable opinion, or even abstract a convenient passage from it, and proceed to argue that their system is the only one that is physiologically correct and that others are bad for the eyesight.

As an amusing illustration of such conflicting statements, we may mention a few of those which are deliberately put forward in connexion with the gas and electrical companies' exhibits in the Machinery Hall in the Franco-British Exhibition. A visitor passing the gas exhibit is greeted by the advice "save your eyes," in a notice which runs as follows:—

Save Your Eyes.

A WORD ABOUT EYESIGHT.

At the 1905 Congress of the Royal Institute of Public Health *Sir James Crichton Browne* said: "In two generations half the people will be blind and the other half wearing spectacles, unless something is done to check the injury to the eyes."

Dr. Allan Wilson said that "his experience had proved to him that electric light did a large amount of serious harm to the eyes."

The Lancet (Nov. 26, 1904) says: "For some not very clear reason, the incandescent electric lamp seems to be wearying, taxing the muscles of accommodation of the eye, and many people complain that reading by the electric light gives rise to headache."

If you desire to preserve your eyesight and that of your children, you will want the best diffused and softest light, and you will find it best as well as cheapest to *light by gas.*

A few yards further on he comes to the electrical exhibit, and he is then confronted with the following statement, purporting to be extracted from the recent report of the Education Committee of the L.C.C.:—

"With regard to the general efficiency of the two methods of lighting (gas and electricity), there can be no question that electric lighting is preferable to gas in every way. All who have had to do with the lighting of educational institutions are agreed in this matter."

We are also presented with the view of the medical officer to the L.C.C. that "handiness, simplicity, and ease in distributing points of light, complete absence of shadows below the lamp, the possibilities of perfect reflection, healthiness in freedom from consumption of air and production of fumes, and noiselessness, make lighting by the electric glow lamp the most perfect means now available for school use."

There are other equally conflicting statements put forward in connexion with the exhibits to which we refer. Let us, however, imagine the effect of the two quoted above on the average passer-by. It is quite certain that any reasonable person will immediately perceive that no illuminant can be at once notoriously bad for the eyesight and at the same time unquestionably the best for the illumination of educational buildings, in which good illumination, from the physiological point of view, is so essential. The most probable effect of such conflicting statements is to induce him to believe that there is something radically wrong in both. We think, in fact, that this is just one of those cases in which the public confidence is not gained, but lost, by putting forward sweeping general statements that are certainly not justifiable without further and more detailed explanations.

We can readily believe that brilliant unshaded sources of light, such as the naked metallic filament of an electric glow lamp, for instance, may do harm to the eyes if constantly stared at. But it is quite possible that an incandescent mantle, used in an equally careless way, would also be equally injurious.

It is necessary to distinguish between evils which arise from using sources of light in the wrong way, and evils arising from the quality of light itself. The question of the influence of the quality of light — its "colour" or "spectral composition"—on eyesight demands much careful study before any definite pronouncement can be made.

The Report on the City Lighting.

The report on this subject, and also the letter that Mr. Voysey, the electrical engineer to the City Corporation of London, has sent us for publication in this issue, are of exceptional interest. It is, we need hardly say, very gratifying to us to meet such strong advocacy of the principles for which we have been contending, namely, the desirability of mutual assistance on the part of those representing different systems of illumination, instead of the existing confused and needless hostility. Our views on this subject have been so frequently put forward in this journal as to render repetition unnecessary at the present juncture. We need only express our satisfaction at this new proof of the spread of the growing sympathy which these views are now exciting.

The manner in which this report has been received in the technical press is one more illustration of the necessity for some impartial tribunal to settle these important problems of street-lighting. For how has the publication of this report been regarded in the technical press?

We have before us an electrical journal in which the editorial comments approve Mr. Voysey's decisions, and gleefully point to the portions unfavourable to gas-lighting. We have also a gas journal, in which the contents of the report are subjected to severe criticism, and the decisions at which it arrives are regarded as biassed.

One of our contemporaries also proceeds to draw what seems to us a most unwarranted conclusion from this report when they declare their disbelief in photometrical tests of street-lighting entirely. The results of different observers, they point out, differ among themselves considerably. We ourselves have never been under any false impression as to the degree of accuracy with which such tests are at present carried out. No doubt the tests of different observers do vary; but we can hardly see how this could be otherwise in view of the short time during which serious attempts to measure the illumination in streets have been carried out. We know well enough the difficulty of making measurements at such low orders of illumination as occur under these circumstances, and we also fully admit that our present street-photometers are far from being perfect instruments. But this does not justify the contention that such measurements are useless. Even such as they are, they are vastly preferable to reliance upon mere ocular demonstration and upon the fancy of observers, whose impression as to what constitutes adequate illumination is swayed by many external influences, and is constantly varying.

The difficulties to which our contemporary alludes are inseparable from the origination of any new system of testing, and are in no small measure due to the fact that there has hitherto been no adequate opportunity for the discussion of the subject. It is for the *principle* of the measurement of illumination that we contend. Once this principle is established, there can be no question that the details of photometrical measurement will soon be settled.

A definite decision upon such important points as the comparative value of flame arcs and high-pressure incandescent gas lights would be extremely valuable. The problem dealt with by Mr. Voysey is one that will constantly recur, and it is safe to say that future tests, carried out under the prevailing conditions, will only lead to conflicting results.

This state of things will continue until a serious attempt is made to organize incontestably impartial tests. Such tests might be carried out *jointly* by representatives of the different systems interested under the superintendence of some impartial expert, who would be present, not for the purpose of prescribing the method employed, but in order to act as arbitrator on any disputed point.

We believe that if the matter was frankly discussed the questions in dispute would prove to be much less serious than is commonly supposed. The details of the method of testing being agreed upon, the experiments would be carried out in the presence of the arbitrator by the two representatives. Any vital difference in their results would soon reveal itself, and the source of uncertainty removed. Neither party could afterwards urge any just ground of complaint against the tests, and we should have gained some reliable knowledge well worth the trouble involved.

From the views expressed in his letter we feel confident that Mr. Voysey would be only too willing to promote the consideration of a scheme of this nature, and we think that our journal, being quite impartial in its outlook, might well be made the medium for a full discussion of the possibility of the plan on the broad lines laid down in this editorial.

There's many a true word—

There is many a true word spoken in jest. Another of our contemporaries has found ground for complaint in the decision of the City Board of Guardians to light the new Homerton workhouse and infirmary with electricity. In this connexion it is remarked, "This would seem to be a good case for the independent 'illuminating engineer,' if there is any field at all for such a specialist."

Now we welcome this paragraph as an illustration that the need for the illuminating engineer is becoming actually felt. Here is a case in which it is felt that an unfair result has been arrived at, but—there is no redress. There is no higher tribunal, whose impartiality is above all question, to whom the matter might be submitted for arbitration. If, as we desire, there were an impartial authority to whom such cases could be referred, all these disputes could be examined, and the prevailing uncertainty as to exactly under which conditions electricity and gas are desirable, and how far the claims put forward on behalf of both illuminants are justifiable, would gradually be removed, and the legitimate spheres of action of both systems of lighting would gradually become recognized. Such cases only emphasize the need of the illuminating expert, whose coming into existence is only a matter of time.

LEON GASTER.

Review of Contents of this Issue.

HAVING shown in the last number how examples of street illumination may be compared by reducing each to a single number representing the mean, **Mr. A. P. Trotter** proceeds to explain his method of expressing the GENERAL ILLUMINATION OVER AN AREA by a CHARACTERISTIC CURVE.

Prof. S. Ruzicka discusses the existing METHODS OF TESTING THE DAYLIGHT ILLUMINATION in educational buildings, and gives the results of his own researches on the connexion between the actual working illumination and the intensity of the brightness of the sky. The value of the ratio between these two quantities constitutes an index as to whether the window space provided under any special circumstances is adequate or no; the method of "relative photometry," which he advocates, consists in comparing the brightness of an artificial sky with the existing illumination due to it, in an exact model of the school-room to be studied. By practical experiment he has found that results so obtained are applicable to actual conditions, provided they are understood to refer to an approximately uniformly bright sky.

E. W. Weinbeer describes a method of very easily and quickly DETERMINING THE MEAN SPHERICAL OR MEAN HEMISPHERICAL CANDLE-POWER of a source from the polar curve of distribution of light. The method is based upon a principle recently described by Kenelly, and consists in the use of a series of movable graduated rules, by means of which the various terms making up the mean spherical c.-p. are automatically added up. The apparatus thus resembles a specially constructed slide-rule, and can be combined with a slide-rule of the ordinary variety for purposes of general calculation.

A report by **Mr. A. A. Voysey,** the engineer of the City Corporation, deals with the LIGHTING OF THE CITY OF LONDON, and describes a series of tests on the illumination of Holborn, Cannon Street, and Queen Street by means of flame arc-lamps and high pressure incandescent mantles. The report is fully illustrated by curves showing the distribution of illumination in the streets named, and contains tables giving exact data as to the conditions under which they were obtained. Mr. Voysey states that the illumination in main streets ought never to be allowed to fall below 0·1 candle-feet, and comes to the conclusion that lighting by flame arc-lamps costs about one fourth of that by gas. He also contributes a letter to our correspondence columns urging the DESIRABILITY OF CO-OPERATION BETWEEN REPRESENTATIVES OF GAS AND ELECTRIC LIGHTING.

Dr. C. V. Drysdale continues his scientific description of various methods of measuring the MECHANICAL EQUIVALENT OF LIGHT AND THE LUMINOUS EFFICIENCY OF ILLUMINANTS by calorimetric and spectrum integration methods.

Mr. W. R. Herring communicates the results of a few additional tests on the GAS LIGHTING AT THE NATIONAL SCOTTISH EXHIBITION which he was unable to include among those published in our last number.

In the SPECIAL SECTION of the present number **W. Biegon von Czudnochowski** contributes a complete description of the various exhibits at the RECENT AUGUR EXHIBITION IN BERLIN. The report includes a description of the methods of lighting and lamps exhibited, representative of both gas and electric lighting, and also discusses their application to shop-window lighting in accordance with the object of the exhibition. Tables of the costs of initial outlay and consumption of energy in the case of the exhibits are given, and the special circumstances to which the different methods are best suited discussed.

In this section some illustrations of the METHOD OF SHOP LIGHTING by gas adopted by MESSRS. EHRICH and GRAETZ and the PHAROSLICHT-GESELLSCHAFT are shown, and the two different methods of lighting briefly discussed. In the first case the use of concealed lights placed well above the goods in the window is advocated; in the second, the use of high candle-power lamps placed outside the shop window.

Some particulars are also given in this number of the proceedings at the recent meetings of the INSTITUTION OF GAS ENGINEERS and the INTERNATIONAL ACETYLENE CONGRESS. Reference is made to some of the interesting points raised in the speeches of **Sir George Livesey** and the President of the Institute of Gas Engineers, **Mr. Doig Gibb**, and the various papers read before the two societies dealing with matters connected with lighting are abstracted. In this connexion mention may be made of the paper by **Mr. C. Bingham**, who discusses the merits of acetylene and petrol air gas, as regards cost, health, and convenience, from the point of view of acetylene. Other papers before the Acetylene Congress dealt with IMPROVED FORMS OF ACETYLENE BURNERS, the MANUFACTURE OF INCANDESCENT MANTLES intended for use with incandescent acetylene burners and the STATISTICS OF THE RECENT GROWTH OF THE ACETYLENE INDUSTRY in France.

Among other articles of special interest in this number may be mentioned that dealing with the theory of the globe photometer. In a previous number of *The Illuminating Engineer* an article by Dr. L. Bloch described the practical use and applications of this instrument. In the present instance the theory of the photometer is considered in greater detail, the discussion being based upon the contributions of Prof. Ulbricht to the literature of the subject, in conjunction with information specially supplied by him for the purpose of this article.

Among other original articles may be noted those dealing with the PRACTICAL DEMONSTRATIONS OF INTERIOR-LIGHTING recently organized by the GAS LIGHT AND COKE Co., and the PRACTICAL PROBLEMS IN ILLUMINATION presented at meetings of the ILLUMINATING ENGINEERING SOCIETY in the United States.

Two lectures by **Prof. Trouton, F.R.S.**, recently delivered before the Royal Institution, dealt with the development of the theory of light, including the question of the exact nature of light vibrations and the medium in which they are executed. The lecturer dealt specially with the theory of polarization, and showed how light is shed upon the problems involved in the consideration of these phenomena by the analogous behaviour of electro-magnetic waves.

A recent paper by **Dr. Karl Sartori**, read before the Institution of Electrical Engineers in Vienna, deals with the vexed question of the nature of the RADIATION FROM THE NEW METALLIC FILAMENT LAMPS, and the problem of whether their improved radiation from the point of view of light-production is to be ascribed to a higher temperature of incandescence alone. The general impression both of the author and also of **Dr. F. Blau**, **Prof. A. Grau**, and others who participated in the discussion, favoured the view that the temperature of the metallic filament lamps was really higher than in the case of carbon filament lamps. Dr. Sartori, however, described an experiment which appeared to convey the reverse impression.

A paper was recently read by **Prof. H. Bohle** before the Cape Town Section of the Institution of Electrical Engineers on LIGHTING. The paper is divided into four sections, dealing with GENERAL PRINCIPLES, OUTDOOR AND INDOOR ILLUMINATION, AND ILLUMINATION - PHOTOMETERS respectively. The author discusses the methods of summing up the illumination due to two or more lamps, and discusses a number of practical problems in which the conditions best favouring a certain distribution are to be determined. He also gives a number of general rules governing the degree of illumination requisite for various purposes, winding up with a résumé of the different methods of types of photometers and the globe photometer.

At the end of this number are to be found the usual REVIEW OF CURRENT LITERATURE ON THE SUBJECT OF ILLUMINATION and the PATENT LIST.

TECHNICAL SECTION.

The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

BY A. P. TROTTER,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 450.)

Characteristic Curves.—The curves which have been illustrated and discussed are of two kinds. The first, which may be called illumination curves, are, as it were, vertical sections along a route, the ordinate being proportional to the illumination on a horizontal plane at any point, and the abscissa being the horizontal distance of that point from the point below the source of light. With the exception of Fig. 14, the candle-power has been assumed to be uniform in all directions. The second, which are sometimes called iso-lux curves, are contour lines of equal illumination, on a horizontal plane. For the simple case of a street or of an open space lighted by a number of similar and regularly spaced lamps, these curves give a good indication of the amount and of the character of the illumination. It is possible to sum up and express by one curve the general distribution of illumination over an area, taking into account lamps of different candle-power and of unsymmetrical or even irregular disposition. This form of curve which by analogy with those used in other branches of science and engineering may be called a characteristic curve, is related to the first of the two kinds which have been discussed. But while in the former case the distribution of illumination along a line, the abscissæ were lengths, the abscissæ of a characteristic curve are areas. A characteristic curve of illumination is a diagram which resembles a steam-indicator diagram in several respects, since the co-ordinates are the measures of an intensity and of an extension respectively, and the area of the diagram is the measure of a power. The maximum and minimum illuminations may be read off at a glance, the true mean may be found by taking the mean of the ordinates, like the mean pressure in a steam-indicator diagram; and the shape of the curve, as in the steam diagram, shows the quality or regularity of distribution. The departure of the curve from a horizontal line shows the want of uniformity of illumination. The portion of an area illuminated to any given degree may be easily found, just as an indicator diagram shows that portion of the stroke during which the steam pressure exceeds any given amount. Luminous flux or total light is (1) candle-power × solid angle, or (2) illumination × area. The area of this diagram is (2), and is a measure of power in an optical form. Such diagrams might be used for a number of other statistical purposes, such as the distribution of population.

Taking the simplest possible case, viz., a single lamp emitting uniformly in all directions light received on a horizontal plane, the illumination curve being of the type shown in Figs. 9 (p. 185) and 26 (p. 448); a minimum illumination or a circle of any given radius being chosen, the characteristic curve may be drawn by plotting areas as abscissæ, and the illumination in foot-candles or lux on those areas as ordinates. From Table 1, p. 185, it is seen that with unit illumination AB (Fig. 33) at the centre of the circle, an illumination of 0·9 is found at radius 0·270, that is, within a circle of area 0·228; an illumination of 0.8, at radius 0·401, or within a circle of area 0·505. Such illuminations and areas give the curve BC Fig. 33 as far as C, the last ordinate being 0·1, and the abscissa 11·4, being the area of a circle of radius 1·907. This curve differs from the cosine cubed curve Fig. 9 only in the horizontal scale, the former being the square of the latter, but reduced to a convenient length. The first part of the curve becomes, as it were, shrivelled up, and the flat top seen in Figs. 9 and 25 is imperceptible.*

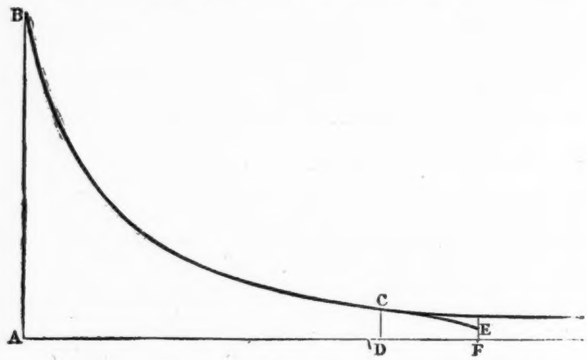


FIG. 33.

If instead of a circular area a square one be chosen, the extremity of the characteristic curve becomes modified. Let a square be circumscribed round the circular area, as in Fig. 34. The parts of the square beyond the circle diminish in illumination, but diminish more rapidly in area as their distance from the centre increases. The limiting illumination is found to be 0·04, and the remainder of the curve has been calculated, and is represented by CE, Fig. 33.

A characteristic curve is an illumination curve with a transformed scale of ordinates. The areas are conveniently represented as percentages on a decimally divided scale. Let BD, Fig. 35, be an illumination curve plotted to any scale on the radius AC, the maximum illumination, and at the distance AC, let AD be the minimum. Produce BA to E, making AE any convenient length. Draw CF parallel and equal to AE. Divide AC into any convenient number of equal parts, and CF into the same number of equal parts. Draw radial lines from A to each of the dividing points on CF. For example, AG. Through the corresponding point H in AC draw a perpendicular KH, and produce it to intersect AG. Through the intersection draw a horizontal line cutting AE at L and produce it to M, making ML equal to KH. The curve running through such points as M is the characteristic curve of the illumination curve BD, for a circular area of radius AC.

The intersections of the radial lines with the perpendiculars lie on a parabola or curve of squares, this being one of the well-known methods of draw-

* If the base of Fig. 9 is bent to fit a parabola and viewed from a distance, the curve would appear identical with Fig. 33.

ing a parabola. Lengths on AE are proportional to π times the squares of corresponding lengths on AC, since AE is a scale of areas of circles, and AC is a scale of radii of those circles. To find the mean ordinate of a curve, the usual procedure is to draw ten ordinates at 5, 15, 25, &c., up to 95 per cent. of the length of the base, to add

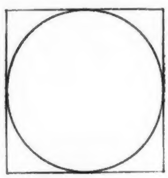


FIG. 34.

their lengths and divide by 10. These ordinates may be drawn directly on the illumination curve. Let the length of the base or extreme radius of the illumination curve Fig. 36 be R, then $r = \sqrt{\frac{R^2 \times d}{100}}$ when r is the radius or the abscissa on the illumination curve of an ordinate, and d the precentage of the total area. Thus the 5 per cent. ordinate is at 1·34, the 15 per cent. ordinate at 2·32, and so on, as in Fig. 36.

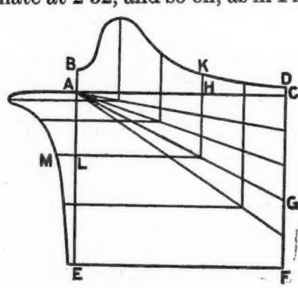


FIG. 35.

To carry out this calculation on a slide rule let R be 6, set the 10 on the C scale over 6 on the D scale, and below 5 and 15, &c., on the B scale, find 1·34 and 2·32, &c., on the D scale. This brings out a point of considerable practical interest, that the illumination near the lamp is of very little importance, for it is spread over a very small area.

The characteristic curves in Fig. 37 are derived from the curves in Figs. 10, 11, 12, and 13, both the maximum illumination and the minimum area being reduced to one hundred.

These characteristics do not strictly represent the distribution of illumination over a large area illuminated by lamps in rows, since there are several different ways in which such lamps

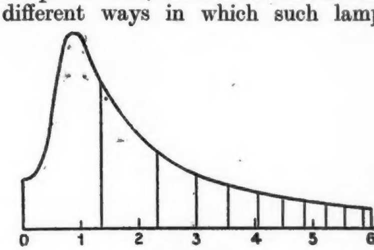


FIG. 36.

may be arranged, viz., quadrilaterally, as at the corners of the squares on a chess-board; quincuncially, as at the centres of squares of one colour on a chess-board; or hexagonally, as the cells of a honeycomb. The characteristic of a hexagon differs but little from that of a circle, the lamp in each

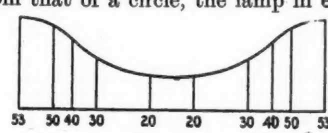


FIG. 39.

case being over the centre. The variations of illumination represented in Fig. 37 are simply those of the resultant curves in Figs. 10 to 13, and the areas are supposed to be circular.

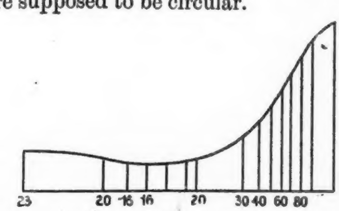


FIG. 40.

Fig. 38 is a portion of Fig. 19 (p. 360), and presents some of the features of lighting by lamps on alternate sides of a street. It differs from a practical case by the closeness of the lamps in proportion to the width of the street, and by the uniform candle-power of the lights in all directions.

This example is, perhaps, more suitable than a practical one for showing the difference between the true mean illumination and the average taken along a line, since the quantities may be easily calculated. The difference is much less than in the case of a single lamp, as already discussed (p. 449).

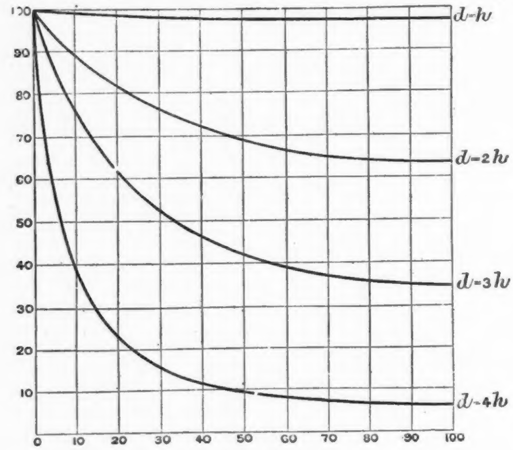


FIG. 37.

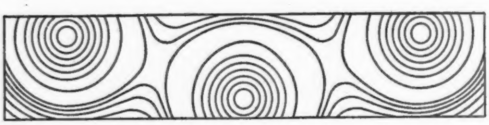


FIG. 38.

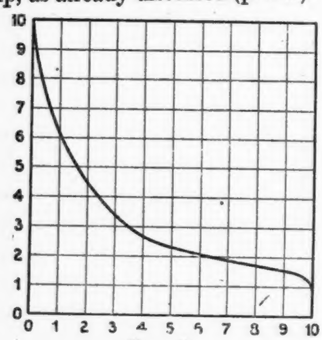


FIG. 41.

Fig. 39 is the illumination curve along the middle of the street, and Fig. 40 is the curve for a line parallel to this, passing through the alternate lamps. The former never reaches the maximum, and the latter is very different from the illumination curve due to two lamps at a distance apart equal to 7½ times their height (see Fig. 13) by reason of the light of the alternate lamp on the other side of the street.

The mean ordinate of Fig. 39 is 33; the mean of Fig. 40 is 34·15. The characteristic curve is given in Fig. 41. The areas of each contour were measured and plotted against the illumination. This is necessarily the method of finding the characteristic curve from a set of photometric tests forming a photometric survey of an area.

The mean ordinate of this diagram gives the true mean illumination 29·8. As might be expected, the mean taken along a line through the lamps is the highest. The difference would be greater if the lamps were more widely spaced. The droop of the curve towards the minimum appears here as in the portion CE of Fig. 33.

(*To be continued.*)

The Provision of Adequate Daylight Illumination in Schoolrooms.

By Dr. Stanislav Ruzicka,

Professor of Hygiene in the Bohemian University, Prague.

The problem of providing adequate daylight-illumination is one of the most difficult in school hygiene. There are so many different factors to be borne in mind, while even the source of light itself—the sky—varies very greatly in intensity from time to time.

I myself have made measurements of the brightness of the sky at zenith, extending over many months, and carried out between nine o'clock in the morning and three in the afternoon. As a result the brightness (leaving out of account times of exceptional darkness) was found to fluctuate between about 2,000 to 8,000 candle-metres.

As a result of a series of tests undertaken at Prague during these seasons, I have fixed the minimum sky-intensity at zenith likely to occur at 2,000 candle-metres. This excludes the month of December, the darkest month in the year, but during the greater part of this time schoolrooms will be unoccupied, owing to the Christmas vacation.

The problem with which we are confronted may now be stated as follows: namely, to design school-buildings in such a way that *even in the darkest part of the room a minimum permissible illumination of* 20 *lux, corresponding to a sky-intensity of* 2,000, *is available.* In fact, we may specify that the minimum available illumination is to be 1 per cent. of the "sky-intensity." This fraction may be looked upon as constant, and specially applicable to illumination from a roughly uniformly brilliant sky; this condition, moreover, is most nearly realized just on those dark and cloudy days with which we are concerned.

Let us now consider the various conditions on which the admission of daylight from the sky depends. The construction and position of windows, the distance away and height of adjacent buildings, and the amount of light they reflect, the position of the desks and tables in a schoolroom, the colour of the walls and ceilings, the number of students present—all these are very important factors, which I have recently considered in detail.*

One of the simplest attempts to secure conditions favourable to good daylight-illumination consists in specifying the *window-space required for a given floor-area.* This system, however, would evidently yield the same result for a room on the ground floor as for one at the top of the building; and similarly a schoolhouse situated in a narrow street would be specified, just as if it were as well illuminated as another standing in its own grounds. Then, again, the method takes no account of the nature of the interior, the position of the windows, the colour of the walls, &c.

The method of specifying of the *angle of opening* (Offnungswinkel) *of the window,* in conjunction with the *minimum angle at which light can enter a room,* is more complete in so far as it takes account of the height of the buildings opposite, the height of the windows, and the distance away of workers from these windows. On the other hand, it ignores such important factors as the *number* and *breadth* of the windows, and the reflecting power of the walls and ceilings within the room.

The specification of *the solid angle subtended by the visible sky-area* (the "Raumwinkel" of Weber) takes into account all the above factors, with the exception of effects of reflection from walls, ceilings, and other objects within the room.

How influential such reflection may be in promoting good illumination can be judged from the fact, to which I

* See 'Die relative Photometrie,' *Archiv. f. Hygiene*, 1907.

recently drew attention,* that it is possible sufficiently to illuminate a room *by reflection alone*, when the brightness of the sky is 2,000 units.

I am, however, convinced that it is impossible to devise a mathematical formula connecting working illumination and the brightness of the sky, taking account of all the factors influencing the access of light to a workroom, which would be of any rare practical value. It is, therefore, far preferable to study the connexion between these two quantities by means of actual measurement. On this principle is based my system of '*Relative Photometry*,' in which the brightness of the sky at zenith is compared with the actual existing illumination, and allowance for the influence of the many complex factors entering into the problem is rendered unnecessary by *observation of their total ultimate effect*.

The practical value of this relation,

$$\frac{\text{working illumination}}{\text{sky-intensity}}$$

lies in the fact that it at once enables us to calculate what the actual value of the illumination in a workroom will be under the most unfavourable daylight conditions, *i.e.*, a sky-intensity in the neighbourhood of 2,000.

The process of determining this relation is carried out as follows: a complete model, to scale, of the ground floor schoolroom to be studied is constructed, the benches, windows, &c., being shown in their actual positions; small pieces of white paper are attached to the benches in regions where the illumination is to be examined. The front wall of this schoolroom may take the form of a hinged board of convenient size.

This model is entirely enclosed within a second much larger box, the upper surface of which consists of a semi-transparent sheet of white paper placed between two glass plates; this, when illuminated, serves as an "artificial sky." The side of this box facing the model represents the front of a building supposed to be opposite the schoolroom windows, on the other side of the street. The bottom of the box represents the level of the street and ground floor. The inner surfaces of the two sides of the large box, on either side of the model, consist of mirrors, and have thus the optical effect of lengthening the artificial sky so as to reproduce the conditions occurring in a long street. The remaining side of the large box, that *behind* the model, is removed and replaced by a black cloth. The interior of the box is thus illuminated only by the light from the artificial horizon.

Before proceeding to make observations, the experimenter stands the whole arrangement on a table in some open place to which daylight has free access. He then puts his head and shoulders into the box, drawing the black cloth tight in order to keep out stray light, places the "relative photometer" on the ceiling of the model, and compares the illumination in the model schoolroom with the brightness of the artificial sky. In order to render this possible, apertures are made in the ceiling of the model just above the test-pieces of white paper on the benches, &c.

The relative photometer—shown diagrammatically in Fig. 1—consists essentially of a Lummer-Brodhun prism, the central mirror-field, m, of which reflects to the eye of the observer an image of the test-pieces of paper placed above the benches.

The outer portion of the field of view is illuminated by light from the artificial horizontal reflected, as shown, by means of the mirror M. The observer would therefore see the image of the test-paper as a central darker spot on the image of the artificial sky. Between M and m is placed a wedge of smoked glass W, consisting of two portions which may be slid over each other, thus varying the thickness of the wedge as a whole, and therefore obscuring to a greater or less degree the light passing through it.

By adjusting the thickness of this wedge the observer can render both portions of the field of view equally bright, and it is evident the value of the thickness that must be introduced furnishes an indication of the ratio

* Casopis lékaru ceskych, 1907. *Archiv. f. Hygiene*, vol. 63.

of the brightness of the two sources considered.

The question may be raised how far measurements executed in this way correspond to natural conditions. I have shown (*loc. cit.*) mathematically that the actual *height* of the "sky" or clouds, above the ground, did not influence the resultant intensity of illumination, provided the *brightness* remained constant. It was found further that the very much brighter natural sky might be substituted for the artificial one without materially affecting the results; the ratio,

$$\frac{\text{working illumination}}{\text{brightness of sky}}$$

remained the same, though naturally the absolute intensities were very much higher. Both, however, seemed to increase in the same proportion.

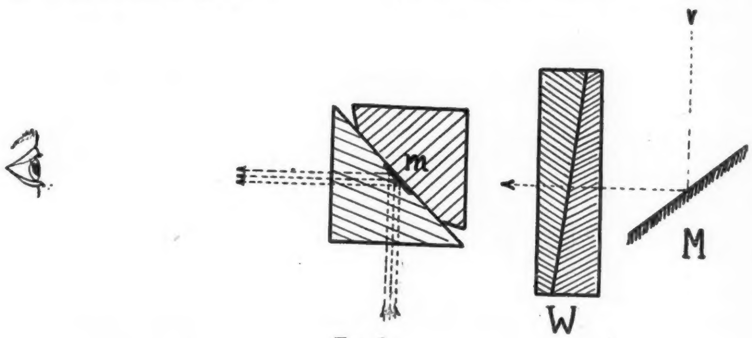


FIG. 1.

Yet it is not really advisable to use the natural sky for this purpose, because, as explained previously, its occasional lack of uniformity in brightness is prejudicial to the accuracy of this method of testing. Nevertheless, we are justified in basing our method on the *uniformly* bright sky for two reasons: firstly, because we obtain a better *average* result by so doing, and secondly, because we are mainly concerned with the least favourable conditions prevalent in the darkest season of the year. Under these conditions we usually observe that the sky presents a very nearly uniformly bright appearance all over. We are, therefore, utilizing just those conditions as are justified by our desire to secure a certain minimum illumination, *even on the darkest days that can occur.*

The method of "Relative Photometry," as outlined above, can be very advantageously and conveniently applied to the predetermination of the daylight-illumination in schools yet to be built. In such a case we construct a model of the proposed schoolroom, and, as a result, of our experiments, contrive such alterations in the window-space, the scheme of decoration in the interior, &c., as may be necessary to ensure the required conditions. The effect of altering all the factors involved can be studied in the model, and we can take measures to secure beforehand that the illuminator in the schoolroom, when erected, will be satisfactory.

Moreover, measurements can be carried out in a much more economical manner by the use of such models, because the study of the conditions of all the schools in a district can be put into the hands of a single expert, who can make the necessary experiments in his office, and decide on what alterations are required, without it being necessary for him to be continually travelling about to observe the effect of each small modification he introduces. And, lastly, such an expert would have at his command a means of trying experiments on a small scale, and actually observing the result, instead of being obliged to make costly alterations, which may, after all, afterwards fail to achieve exactly what was needed.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 462.)

Direct Measurement of the Mechanical Equivalent of Light.—The most direct mode of procedure is obviously to allow a beam of light of any required quality to full simultaneously on some form of radiometer and a photometer, and to compare the indication of the radiometer with that obtained from a known source of radiation at a given distance. As nearly all devices for measuring low intensities of radiation are liable to troublesome variations, it is of the greatest importance that the comparison between the radiation in the beam under test and the known radiation should be effected as quickly and easily as possible, and with the minimum of disturbance.

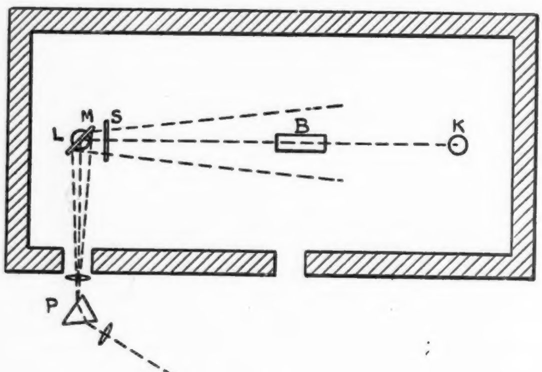


Fig. 5.

Figs. 5 and 6 show the arrangement of apparatus adopted after consideration of the above points. A small intense source of light, such as an arc or Nernst filament, was employed, in conjunction with a lens and carbon bisulphide prism P, to form an approximately pure spectrum at the photometer and radiometer box B. By using a narrow slit an approximately monochromatic light of any required wave-length could be projected on to the photometer, while by widening the slit a band of any width up to the entire limits of the visible spectrum could be employed, the integration being automatically performed without any other collecting device. The known source of radiation consisted of a glow-lamp, which will be referred to as the "comparison lamp" L, placed close to the prism (in some cases beneath it so that both were approximately on the axis of the bench). A standard glow-lamp K was kept continuously burning on the other side of the photometer box B. A fixed screen with an aperture served to block off all radiation but that from the prism P or comparison lamp L, while a sliding metal screen S, actuated by a cord, could be rapidly moved in front of one or the other. In taking the readings the light from the prism was allowed to fall on the radiometer, and the current through the comparison lamp varied until on moving the screen S in front of P or L alternately, no change could be noticed. In this way all disturbances due to external changes of temperature could be eliminated, and the observations were much more rapidly obtained than by waiting for slow deflections.

A glow-lamp was used as the standard source of radiation for the following reasons: (*a*) the total power is easily measured by the P.D. and current, and can be readily regulated; (*b*) the ratio of convection and conduction to radiation is very small. Since by the Stefan Boltzmann law the radiation is proportional to $(T^4 - T_0^4)$, while according to Dulong and Petit the convection is proportional to $(T - T_0)^{1\cdot235}$, it follows that the ratio of radiation to convection increases very rapidly with the temperature. It is also of advantage for the dominant wave length of the comparison source to approach as nearly as possible to that of the light tested, in order to eliminate the possibility of errors due to selective absorption in the radiometric device. Further, by enclosing the source in a vessel of relatively large size from which the air has been withdrawn, convection is still further reduced, owing to the low temperature of the walls of the vessel. These two conditions are well satisfied in the glow-lamp, and make it immeasurably superior to low temperature sources such as employed by Thomsen and others. On the other hand, the radiation is not uniformly distributed. But this difficulty can be overcome by remembering that the dominant wave-length is a function of the temperature, and that for a red-hot filament at a temperature of from 700 to 1000 degrees Centigrade we have by Wien's law $I_\lambda = C_1 \lambda^{-5} \epsilon^{-\frac{C_2}{\lambda T}}$, Paschen and Wanner find 14,440 as the value of C_2 in this expression, from which by differentiation the dominant wave length $\lambda \max = \frac{2888}{T}$.

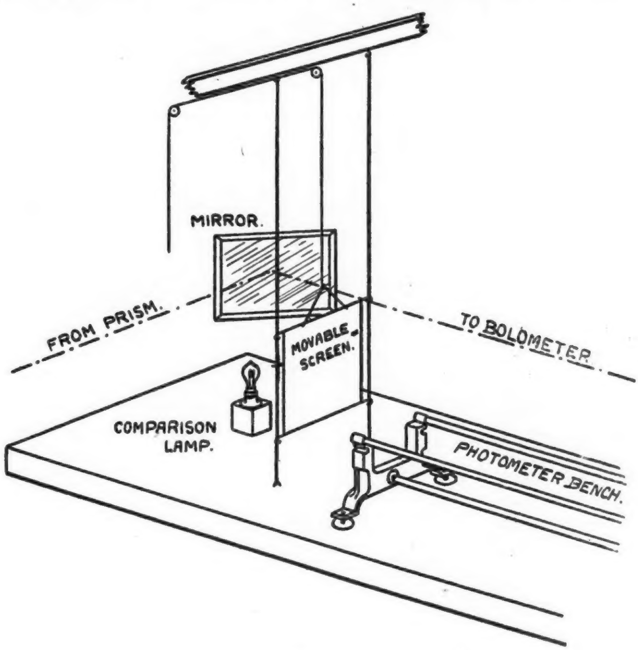


FIG. 6.

Hence for temperatures in the neighbourhood of 1,000 degrees absolute λ max is of the order of 3μ, which is negligible in comparison with the dimensions of the filament. We are

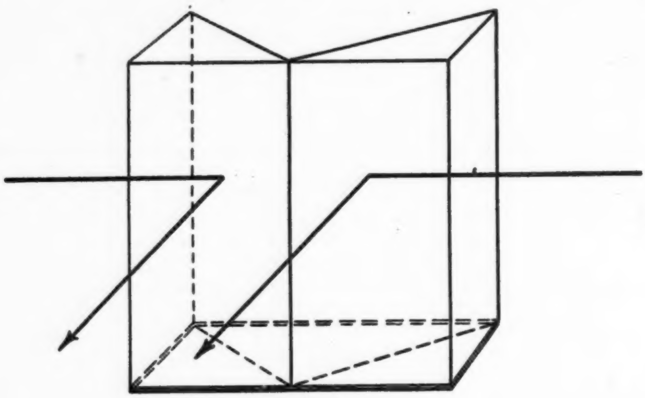


FIG. 7.

therefore justified in assuming that the distribution of radiation will be similar to that of light, and this can be determined once for all by the photometer, giving us the relation of the intensity in any given direction to the mean spherical emission.

The photometer employed was of a special form, devised by the writer

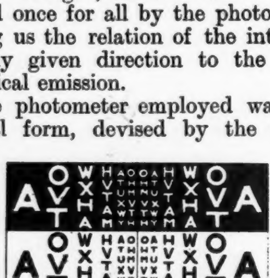


FIG. 8.

for ordinary and heterochromatic measurement. It consists simply of two totally reflecting right-angled prisms, mounted with their edges in contact, as shown in Fig. 7. When this combination is set up between two lamps, the light from each is reflected—as shown—and can be received on a screen placed in contact with the front face of the prism. This screen may be simply of translucent paper or opal glass, in which case the appearance is identical with that of the Joly paraffin block photometer; or in the form of a discrimination diagram, which serves for heterochromatic work. The diagram actually employed is shown in Fig. 8. The advantages of this arrangement are, briefly, that it serves either for isochromatic or heterochromatic photometry; it is absolutely symmetrical; it is not affected, as are the wedge photometers, by a slight inclination to the axis of the photometer bench; it forms a very sensitive cross staff for indicating whether the lamps and the photometer are in line, and whether there is any inclination to the axis; and, lastly, it permits any portion of a spectrum to be brought exactly to the dividing line, so that the comparison may be made with a fairly short spectrum on one side.

For the measurement of the energy a pair of thermo junctions on the lines employed by Prof. Fery was at first made up, but was found insufficiently sensitive. They were therefore replaced by a bolometer, which was made of 50 cm. of 2 mil copper wire wound backwards and forwards on a mica frame, and had a resistance of about 7·5 ohms. Two such bolometers were made and mounted in the same case with the photometer prisms, as shown in Fig. 9, the centre of the bolometer being carefully adjusted to be over the edge of the prisms, so as to be in the part of the spectrum under photometric examination. To protect the bolometers from draughts the two ends of the box and the observing window were covered with quarter-wave mica sheets.* The two bolometers were

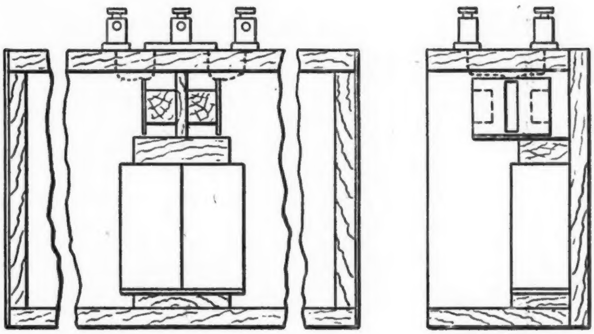


Fig. 9.

separated by an asbestos screen, and were connected to three terminals on the top of the box, whence three flexible conductors were taken to a Carey Foster bridge and connected, as in Fig. 10, thus enabling balance to be conveniently obtained. By having the two bolometers, changes of the air temperature are of less importance, and the whole photometric and radiometric arrangement is reversible. The ratio coils were of 10 ohms each, and a moving coil galvanometer, having a resistance of 7·5 ohms and a sensitiveness of 22mm. per microvolt, was employed. The current in each of the bolometer grids was from ·04 to ·1 ampere.

In taking the readings the photometer head was first fixed in the middle of the bench, and the spectrum moved until the required colour appeared at the dividing edge between the prisms. The standard lamp was then brought up and balance obtained at a distance d from the photometer. Next, the comparison lamp was regulated, as above indicated, until the heat balance was obtained, the comparison lamp being at a distance D, and supplied with power W watts. Then, on the assumption that the heat from the comparison lamp was radiated equally in all directions, we have :—

Intensity of radiation at bolometer

$P = \frac{W}{4\pi D^2}$ watts per square cm.

Intensity of illumination of beam

$I = \frac{K}{d^2}$, where K is the candle-power of the standard lamp.

Hence the mechanical equivalent of light $M = \frac{4\pi P}{I} = \frac{W}{K}\left(\frac{d}{D}\right)^2$, or if f is the ratio of the mean spherical candle-power to the candle-power in the working direction for the comparison lamp, and r the ratio of radiation to total power, $M = \frac{Wr}{Kf}\left(\frac{d}{D}\right)^2$, giving the mechanical equivalent in watts per candle.

A careful determination of the candle-power of the comparison lamp in various directions when kept at a constant P.D. was made by Mr. Jolley, resulting in a ratio of $\frac{\text{M.S.C.P.}}{\text{M.H.C.P.}}$ or

* Tests were afterwards made to see if these mica windows had any influence on the result, by interposing several such films, but no perceptible effect was noticeable.

spherical reduction factor of ·862, agreeing very well with the ·865 given by Paterson, and of a ratio of the M.S.C.-P. to the candle-power in the direction in which the radiation was taken, of ·78, which is accordingly the value of the factor f.

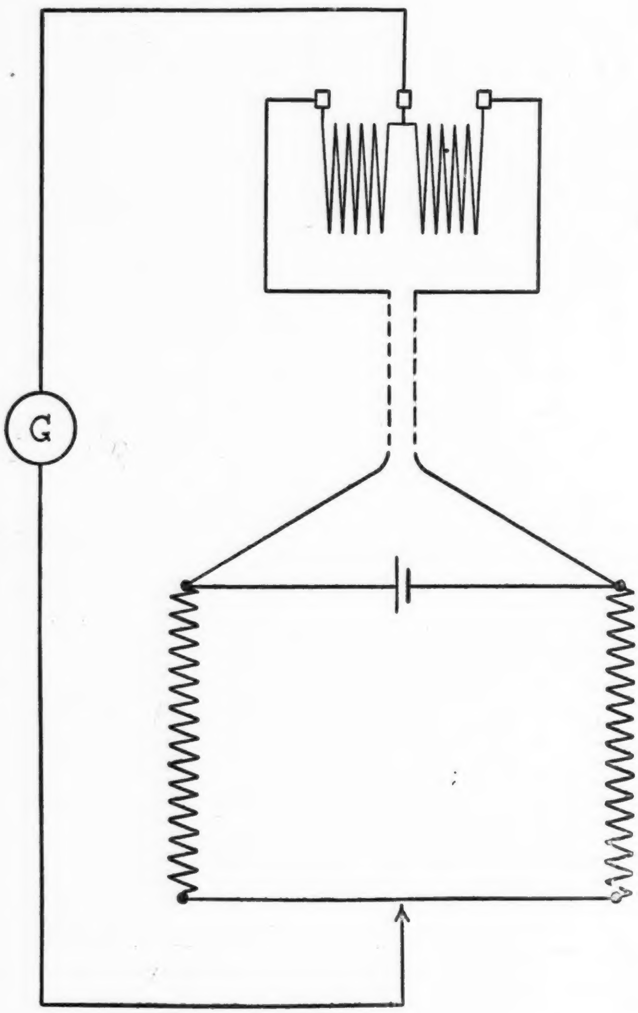


Fig. 10.

(To be continued.)

The Fifth International Acetylene Congress.

(With which is incorporated the Fourth Meeting of the International Committee for Acetylene and Calcium Carbide, and the Seventh Annual Meeting of the British Acetylene Association.)

THE FIFTH INTERNATIONAL ACETYLENE CONGRESS was held in London on May 28th, 29th, and 30th, and afforded an excellent example of the tendency towards internationalization in trade and science. Many foreign delegates were present, and the International Committee of Organization included representatives from Austria-Hungary, Belgium, Canada, Denmark, France, Germany, Great Britain, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United States.

The opening speech on the first day was given by **Sir Wm. Ramsay**, the technical portion of whose remarks dealt mainly with the chemistry of processes for the manufacture of calcium carbide, and their historical development. In conclusion Sir Wm. Ramsay extended a hearty welcome to the foreign delegates, and declared that, in his opinion, the chief value of such a congress lay in the formation of friendships and the social intercourse they rendered possible, rather than the mere receiving of certain items of information.

The remaining part of the day was occupied in the reading and discussion of papers, and in visits to various acetylene establishments in Victoria Street.

On Friday the annual meeting of the Acetylene Association took place. After the preliminary business had been settled an address was given by the President (**Mr. F. S. Thorne**), who referred in general terms to the progress that was still being made in the manufacture of acetylene for purposes of illumination. One direction in which he looked for still greater progress in the future was the design of incandescent acetylene burners.

On this and the third day of the Congress there were further papers and demonstrations, and a number of items of interest to the visitors were arranged. These included the official dinner at the Trocadero Restaurant, a motor-car trip to the residence of the President, and visits to the Crystal Palace and the Franco-British Exhibition. The next Congress is to take place in Vienna in 1910.

Among the various papers read at the meetings dealing with the "illuminating" side of the acetylene industry, mention must first be made of the paper by **Mr. Charles Bingham,** entitled 'Acetylene and Petrol-Air Gas.' These two illuminants must be regarded as rivals in those circumstances in which neither electricity nor gas-supply is available, and a self-contained plant is essential. Mr. Bingham attempted to demonstrate that "Acetylene is cheaper, safer, healthier, more convenient, and more ornamental than the petrol-vapour light."

The "cheapness" of a variety of illuminant, he said, calls for careful study. A light may appear cheap in the laboratory, or in the saleroom; but the only test on which reliance can be placed is actual experience in practice, in a country house or railway station, for instance. The cost of such system of lighting may be divided into—

(*a*) *Initial costs* of installation, including (1) The gas-making plant itself, (2) the piping, (3) the burners, (4) the fittings (wall-brackets, pendants, &c.), and (*b*) *Running cost.*

It was not, the author explained, easy to make absolutely accurate comparisons between the two systems, but he thought that the following details might be regarded as representative :—

PETROL GAS.

	20 Lights			40 Lights			80 Lights		
	£	s.	d.	£	s.	d.	£	s.	d.
Litz Co.	40	0	0	50	0	0	80	0	0
National Co. ...	45	0	0	60	0	0	110	0	0
	20 Lights			50 Lights			70 Lights		
Non-Explosive Gas Co.... ...	26	5	0	57	15	0	78	15	0
De Laitte... ...	48	10	0	70	0	0	90	0	0

ACETYLENE.

	20 Lights			40 Lights			80 Lights		
	£	s.	d.	£	s.	d.	£	s.	d.
Clapham	22	0	0	31	7	6	42	15	0
Manchester Acetylene Gas Co. ...	19	7	0	28	14	0	42	8	0
Standard Co. ...	23	0	0	40	0	0	65	0	0
Thorn & Hoddle...	21	5	0	25	0	0	32	0	0

As regards the cost for piping, the author claimed that, as petrol-gas had a much lower heating and illuminating power than acetylene, very much more of it must be burnt. This necessitated very much larger pipes, which not only cost more in themselves, but involved pulling about walls, floors, &c., to a greater extent. On the other hand, the pipes for acetylene were so small that it was often possible to place them on the wall of a finished house, without interfering with the wall-paper or wainscotting; this was rarely feasible with petrol-gas pipes, their large size rendering them unsightly.

The cost for petrol gas burners he stated to be as follows, including a single mantle: Litz, 3*s*. 2½*d*. to 4*s*. 1½*d*.; National, 4*s*. 3*d*. to 6*s*. 6*d*.; De Laitte, 2*s*. 8*d*. to 5*s*. 3*d*. The cost of the best acetylene burners was about 10*d*. to 1*s*. each.

Lastly, there was the question of the fittings (wall brackets, pendants, &c.) to be considered, and the author thought that this would come out about the same in both cases.

Finally, he suggested that the capital outlay for petrol gas is at least 50 per cent. more than for acetylene.

The author then proceeded to quote a number of cases in which it appeared that the running costs of acetylene-lighting had proved lower than petrol-air gas, assuming that mantles cost 6*d*. each, carbide 15*l*. a ton, and petrol 15*s*. a gallon.

He also proceeded to cite the instance of a British railway, a company working more than 2,000 miles of line, who for the last two years had made comparative tests at various stations; as a result, the engineer reported to his Board that in actual practice petrol gas was equivalent to coal gas at 3*s*. 6*d*. per 1,000 cubic feet, while acetylene was equivalent to coal gas at 2*s*. 6*d*. Thus the cost for petrol gas works out in actual practice at 40 per cent. more than acetylene.

In all the above comparisons the light given by ordinary open-flame acetylene burners was compared with incandescent petrol gas burners. If the acetylene incandescent burners now rapidly coming into use be taken as basis, the author stated that the comparison becomes infinitely more to the disadvantage of petrol gas.

SAFETY.

This part of the question may be divided into three heads, viz.: (*a*) safety in the dwelling; (*b*) safety in the gas house; and (*c*) storage of the raw material.

As regards (*a*); where the petrol is led into the house in the form of a very weak vapour there is practically no difference between petrol gas and acetylene. The author knew of no record in this or other countries of any explosion caused in a house by the escape of petrol-air gas or acetylene from the burners or from a leak in the piping.

Where, however, as is the case in some systems, the petrol itself passed into the house *in liquid form* in pipes, or was stored in a vessel near the light, there was always a very serious danger, and in this form petrol, or gasoline, as it is called in America, was, according to the statistics issued by the American Fire Insurance Companies, the most dangerous of all ordinary illuminants.

As regards the gas-generating plant

(the gas house), it sufficed to state that fire insurance companies would insure an acetylene gas house, but they would not insure a petrol gas house.

Lastly, there was the question of the raw material itself. Carbide in hundreds of cases, has been taken out of factories when these were burning, without any explosion occurring, and the author was not aware of any case on record of a fire being caused by the storage of carbide or the charging of an acetylene generator.

On the other hand, cases were on record of the vapour from a leaky petrol vessel being ignited at a distance of many feet by a chance light.

Reference may also be made to the French *Revue des Eclairages* (*Lighting Review*) of January 15th, 1908, in which a record is given of the accidents caused by the various systems of lighting in the single month of December, 1907, showing: caused by coal gas, 11 accidents; caused by petroleum, 19 accidents; caused by acetylene 2 accidents; caused by petrol 37 accidents; caused by alcohol, 8 accidents In spite, therefore, of the infinitely smaller number of lights in use, petrol caused almost as many accidents as all its rivals put together.

HEALTH.

This part of the subject might be divided into two chief heads: (*a*) effect on the eyesight; (*b*) effect on the atmosphere of the room.

As regards (*a*); the supposed candle-power of a light had little to do with its value because all lights are composed of rays of different colour. Some of these rays were useful; some useless; some, if anything, harmful. Now, the acetylene flame contained a far larger proportion of useful rays than the incandescent light used with petrol gas.

According to Vidal, the ordinary acetylene flat flame had more than three and a half times the actinic value —candle for candle—of the Welsbach incandescent light. In this connexion the author quoted the opinion of Mr. E. F. Robson, Consulting Architect to the Local Government Board, who had publicly stated that, after an experience of twenty years, he places acetylene at the head of all lights for schools, because it is the best light for the eyesight.

Turning to point (*b*); great stress is laid by air-gas advocates on the fact that their gas contains so much air that no additional oxygen is taken from the air of the room.

The author, however, considered that there was very little to choose between the two systems, as far as consumption of oxygen and production of carbonic acid are concerned. According to his experiments, a full-size petrol gas-burner removed about two feet of oxygen from the air per hour, and produced about 1¾ feet of carbon dioxide, while, for a three-quarter foot acetylene burner the figures were almost exactly the same. From the point of view of pollution of the atmosphere both systems were far and away ahead of petroleum lamps, candles, and flat-flame coal-gas burners, but from the point of view of the oculist acetylene was far ahead of all other artificial illuminants.

CONVENIENCE.

Here again acetylene outstripped its rival. Indeed, it might fairly be said that in one respect only does petrol gas excel; it was undoubtedly a little easier to fill a vessel with a liquid like petrol than to fill the trays of an acetylene generator with carbide and remove the sludge.

In point of time, however, the difference was not very great, and if the regulations now enforced in Germany (*i.e.*, that the petrol shall be pumped, not poured, into the apparatus, and that the apparatus shall be separated from the petrol tank by a wall) should come into use in this country also, this small advantage would disappear.

There were, however, many other disadvantages accompanying petrol gas which did not exist with acetylene.

For one thing, petrol gas not being a true gas (but merely air more or less saturated with petrol vapour), was liable to return to the liquid form just as easily as it vaporized.

Owing to the tendency of petrol gas to condense, it was not possible to carry pipes downwards; for instance, an underground pipe could not be carried from the house to an outhouse or stable unless the generating plant were placed on a lower level than the lowest point in the piping. In one case a petrol gas firm had proposed to put in three different generating plants, as being the only satisfactory way oi lighting a house with two blocks of stables. The order was, therefore, given to an acetylene firm. Again, if the length of piping were at all great, it would usually be found that the burners furthest away from the generator give a very poor light.

Nothing of this kind was experienced with acetylene. Being a true gas, atmospheric changes did not affect it, and it could be carried up and down, through flexible tubes, &c., with impunity.

One great drawback of petrol-gas was that unless the plant be a very small one, worked by weight, somebody had to be sent to start the engine, even if only a single light be required, and it often took ten minutes to obtain a light. With acetylene, on the other hand, it was simply a question of up turning a by-pass, as with coal-gas or, where one is more economically minded, of simply turning a tap and applying a match.

And it was just when there were only a few lights required (as was the case practically every day in every house) that petrol gas became so expensive, for the engine had to be kept running all the same. As acetylene required no engine or motor, the use of a single light did not cost more proportionately than the maximum number in the house.

The author had also met with cases of the lighting giving out through stoppage of the engine. Finally, there was one more inconvenience, viz., the obligatory use of mantles.

GENERAL APPEARANCE.

The author said that every one knew the colour of an incandescent burner, and the trouble experienced in giving a pleasant appearance to it, especially when it was desired to use it in connexion with silk and similar shades.

On the other hand, the acetylene light, the nearest to sunlight of all artificial illuminants, lent itself far better to artistic use, and showed persons and objects—and especially colours—in a far more favourable way than incandescent lights.

In the **discussion** that followed this paper several speakers referred to disadvantages of petrol-air gas plants; for instance, it was stated that the apparatus worked much better in summer than in winter.

Mr. Gaster, who was present at the Conference as editor of *The Illuminating Engineer*, regretted that there was not more opportunity of hearing what was to be said on the other side of the question. He also took exception to the assumption that acetylene was the best light from a physiological point of view, based on opinion only. This question demanded careful scientific consideration, and ought to be definitely settled by experiment, instead of being regarded as a matter of conjecture.

M. R. Granjon contributed an interesting and useful table of statistics relating to 10,000 installations in France, in the eight districts of Marseilles, Paris, Bordeaux, Lille, Nancy, Toulouse, Rouen, and Nantes. The table refers to the years 1897 to 1907, and is a wonderful record of the system of inspection undertaken by the Union of Owners of Acetylene Apparatus.

Full particulars are given of the number of instalments visited in each district, the profession of those owning them, the date of installation, the nature of the system and service, the number of burners in use, &c., and also the recorded opinion of the inspector as to whether the installation ought to be classed as excellent, satisfactory, or defective.

M. Louis Cadenel contributed a note on 'The Manufacture of Mantles used for Incandescent Lighting by

Means of Acetylene,' of which the following is a short abstract.

The process of manufacture of mantles destined to be used with incandescent acetylene burners differs in several essential points from that employed in connexion with mantles intended for use with coal-gas, petrol-air, &c., and a series of researches on this subject have recently been carried out by "l'Office Central de l'Acétylène."

In the first case it may be observed that the exceedingly hot flame utilized in the acetylene incandescent burner tends to tear and deform mantles of the ordinary variety, being much higher than that to which they were subjected in the ordinary process of manufacture.

The simple remedy consists in carrying the temperature of such mantles to a much higher point than usual in the process of manufacture, either by utilizing high-pressure gas, or by substituting acetylene for ordinary town gas.

It is now possible to manufacture mantles intended for use with acetylene capable of withstanding the deteriorating action of the acetylene flame, to the same extent as those employed with ordinary gas, provided the acetylene used is chemically pure. It is, however, necessary to make these mantles both smaller and more solid, and in other respects different from ordinary mantles, in order to withstand this high temperature.

One might imagine that it was easy to increase the solidity of a mantle by merely increasing its density. Were this the case, the problem of manufacturing an indestructible mantle would have been solved long ago. Unfortunately any increase in density is accompanied by a corresponding loss in illuminating power: indeed it may be said that the more fragile a mantle the greater its illuminating power. Naturally we have to strike a balance between these conflicting conditions in the case of the ordinary gas mantle.

But the problem in the case of mantles intended for use with acetylene is somewhat different. For, these mantles being so very much smaller than those of the ordinary kind, it is permissible to employ solutions of certain rare and expensive salts, not ordinarily employed without too greatly increasing the cost of manufacture. Thus an acetylene mantle weighs only a quarter of what an ordinary mantle does, and may therefore be made of materials four times as expensive.

The process of impregnation, however, is a very complex one, and it is only after prolonged experiment that we have obtained the desired results. For instance, the best composition and density of the solution employed are dependent both on the size of the mantle and the pressure to which it is subjected.

Practically this last consideration has not been troublesome because we nearly always utilize acetylene under a pressure of 10 to 12 cms. of water. If, however, we consider generators as being broadly divisible into two main classes, producing gas at pressures of 8 and 15 cms. respectively, it becomes necessary to alter the impregnating solution so as to produce the best mantle to meet both conditions.

Another question of interest is the exact form that should be given to mantles intended for acetylene. The best shape proved to be a cylindrical mantle, the diameter of which was about two-thirds of its height, and slightly conical towards the upper end and aperture. This form has the advantage of not distorting the flame, and permits the use of very low pressures. The shape is so contrived that, in the event of the flame smoking, owing to the injector becoming choked or a sudden fall in the pressure, the soot is not allowed to soil the mantle.

The construction of the head of the mantle also demands attention. In the ordinary process of manufacture, the web of the mantle is plaited together and soaked in a solution of "fixcine" in order to give the necessary solidity. This, however, is only attained with a certain loss in illuminating power. This matters but little in the relatively large mantles used in gas lighting, but is more serious in the case of the small acetylene ones.

We have altered the usual system somewhat, in order to secure a homogeneous mantle, and to avoid this loss in illuminating power, by utilizing very fine strands to effect the junction at the head of the mantle, and also by employing an exceptionally dilute solution, which does not injure the illuminating power.

In conclusion it may be said that the manufacture of mantles of such small dimensions demands special care in every phase of its construction.

Dr. Letang, of Paris, contributed a note on 'An Improved Manchester Burner.' This type of burner, he explained, is characterized by the use of two separate jets, which are projected against one another, with the result that a flame shaped somewhat like a butterfly is obtained.

It would, he thought, be of interest to see if any of the earlier forms of this burner did not utilize a combined supply of gas and air. This system is eminently suitable for promoting the combustion of gases rich in carbon, such as acetylene; it is also useful in preventing the choking up of the orifices by which the gas escapes. The burner invented by Legris half a century ago seemed to fulfill the conditions.

In the construction of acetylene burners it is necessary to confine oneself to the use of refractory materials for portions with which the heated gas comes in contact, because most metals tend to create polymeric forms of acetylene which rapidly obstruct the burner. Steatite is a material that yields excellent results.

The efficiency of such burners depends on the amount of gas consumed. Thus a 10 litre burner will give 1 carcel at 8·2 litres per hour, while the 21 litre burner gives the same result at 7·1 litres. These results are effected by the angle between the two jets; the best conditions are obtained, not by the 90° commonly adopted, but by an inclination of about 65°. The distance between the two orifices may be fixed at 10 mm., the base of the "butterfly" being then 3 mm. above the burner, and no deposit of soot formed.

In conclusion, the author considers that the Legris burner, though invented in 1860, may justly be considered not only the first as regards date, but embodying the essential principle of all modern acetylene burners.

A paper dealing with 'A New Form of "O.C.A." Burner' was also read by **M. Eberhard Held,** of Paris.

This incandescent burner was stated to be exceedingly simple in construction, and devised on lines intended to reduce all danger of obstruction to a minimum, and to facilitate the clearing of the orifice without subsequently interfering with the shape of the jet of gas, as is liable to occur.

One essential characteristic of the burner was the use of a special spiral spring which replaces the gauze usually employed, and serves the double purpose of promoting the mixture of gas and air, and preventing the gas from lighting back. All parts of the burner are easily removed and replaced.

M. Pierre Rosemberg contributed a short note on the value of statistical data on acetylene lighting, and explained how proposals had already been put before various associations that a uniform system of tabulation should be adopted, and that data relating to the number of consumers and lamps in use in different towns, &c., should be compiled and systematized by the International Committee, who would afterwards publish the collected results for the benefit of all participating.

Other papers presented before the Congress included :—

J. W. Gatehouse, Chemist to the British Acetylene Association, 'A Method for the Estimation of Certain Subjects Produced during the Combustion of Acetylene, &c.'

Dr. A. Fraenkel, Vienna, 'The Phenomena of Haze in Acetylene Combustion.'

Maricheau Beaupre, Paris, 'On the Impurities of Acetylene, their Determination and their Elimination.'

Pitaval, Paris, 'Acetylene Lighting in Mines in France.'

Dr. E. Schumacher-Kopp, Lucerne, 'The Illumination by Acetylene of the Locomotives of the Gothard Railway.'

On the Theory of the Globe Photometer.

SEVERAL articles bearing on the practical application of the globe-photometer to practical photometry have already appeared in *The Illuminating Engineer* (see Vol. i. No. 3, p. 230, and No. 4, p. 274). It may, therefore, be of interest to consider in greater detail the theory of an instrument which enables the mean spherical candle-power of any source, whatever be the nature of the distribution of light from it, to be obtained by means of a single measurement. In doing so, we rely mainly upon the recent contributions of Prof. Ulbricht on the subject, and also upon information specially furnished by him for the purpose of this article.

As a starting point to these considerations we may quote the following statement, which occurs in the first of the series of articles mentioned above (*Elektrotech. Zeitschr.*, 1900, p. 595) :—

"Any diffusely reflecting surface, such as that obtained by means of a suitable coating of chalk, &c., when uniformly illuminated by means of an external source, behaves very similarly to a surface which is itself generating and emitting light in a uniformly distributed manner. Could we, instead of close resemblance, obtain *exact* similarity, the following relation would be rigidly true :—

"The unit element of surface, illuminated by means of a flux of light, B, would present the exact surface-brightness

$$H_1 = (1 - a)\frac{B}{\pi}$$

whatever be the direction in which it is viewed ; here a represents the fraction of the light striking the surface which undergoes absorption in consequence.

"In reality, however, diffuse reflection is invariably accompanied by a certain amount of regular reflection, and minute shadows are also formed owing to the small irregularities of the surface. Nevertheless the conditions of pure diffuse reflection can be sufficiently nearly approached for us to be able to lay the basis of a process by means of which the mean spherical intensities even of sources yielding very diverse polar curves of distribution of light, can be obtained. Assuming, however, that the relation

$$H_1 = (1 - a)\frac{B}{\pi}$$

is rigidly true, any surface element, forming part of a hollow sphere of radius 2r, and illuminated by means of the flux of light B, will transmit to each other unit of surface the same flux of light,

$$\frac{(1 - a)B}{4r^2\pi}.$$

This arises from the fact that the effect of surface-elements being unequally inclined to the rays striking them, is neutralized by the relations between their various distances.

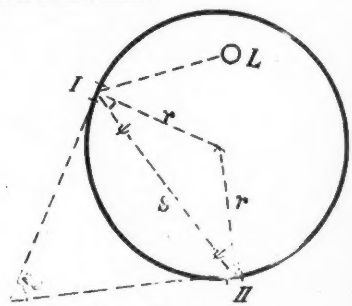


FIG. 1.

"A completely uniform illumination of the interior of the globe thus results. Moreover, since each illuminated surface element taken by itself illuminates all others in a uniform manner, we see that *the illumination due to diffusely reflected light is the same in every portion of the interior of the globe, however unevenly distributed the direct illumination of the interior of the globe may be.*"

The condition of things can be represented by the behaviour of the two surfaces I and II in Fig. 1.

The two surfaces in question form part of the inner surface of a sphere, and reflect light in a rigidly diffused manner according to the cosine law. They are at distances from one another, and inclined at an angle 2ψ. Both surfaces have unit dimensions. Surface I is illuminated by a source L, receives as a result the flux B, and attains to the surface-brightness H_1. As seen from the surface II it appears to possess a magnitude cos ψ and an intensity $H_1 \cos \psi$. The rays emitted from it strike the surface II at the angle $\frac{\pi}{2} - \psi$, and thus give rise to the intensity of illumination $\frac{H_1 \cos \psi . \cos \psi}{S^2}$

Hence the illumination of II, obtained from I, becomes $\frac{H_1 \cos^2 \psi}{4r^2 \cos^2 \psi} = \frac{H_1}{4r^2}$, and is therefore independent of ψ, and the same for all portions of the globe. What is true of the behaviour of a small portion of the illuminated surface of the globe must also naturally hold good for the total illuminated system. Since, however, the light striking any point in this surface is once more

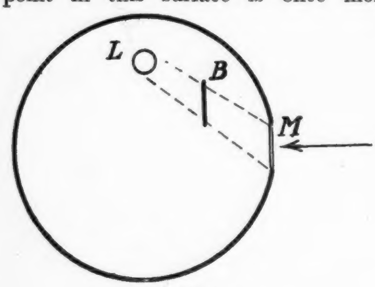


FIG. 2.

reflected with an intensity diminished by absorption, we see that a series of consecutive reflections of ever-weakening intensity will occur, with the ultimate result that the entire inner surface of the globe becomes evenly illuminated.

Let Φ represent the entire flux of light enclosed within the globe, and let a be the absorption-fraction of the inner coating, which is usually about 0·2. A flux of light, reflected to and fro within the globe of the magnitude $\Phi (1-a) + \Phi (1-a)^2 + \Phi (1-a)^3 + ...$ $= \Phi \frac{1-a}{a}$, is thus formed. The reflected light falling upon any surface-element in the globe thus becomes $\frac{\Phi (1-a)}{4 \pi r^2 a}$.

It is therefore only necessary to creen some point in the surface from all the *direct* light to obtain an intensity of illumination at that point which is a measure of the total flux of light Φ.

This is equally true whether the source of light is placed at the centre of the globe or eccentrically—the result following immediately from the fundamental principles previously explained.

The photometer, therefore, as shown in Fig. 2, consists essentially of a hollow sphere, the inner surface of which is coated with a white diffusely-reflecting material; a small opening M, provided with an opal glass screen, is made in the side of the globe, and is protected from the direct rays of the source of light to be studied, by means of the screen B. The brightness of illumination of this window M can be obtained by the application of a photometrical-bench outside in the usual way. Or the diffusing glass screen may form at once a portion of the inner surface of the globe, and also a portion of a small portable photometer of the Weber type. In any case, the intensity of illumination thus determined is directly proportional to the flux of light Φ, and therefore also a measure of the mean spherical candle-power J_o, of the source to be investigated. Thus if H_M denote the intensity of illumination of the window M, we have :—

$$J_o = \frac{\Phi}{4\pi} = K_o H_M.$$

In order to determine the constant of calibration K_o a comparison lamp, for which Φ_o or J_o has been previously measured by means of its polar curves of distribution of light, is introduced into the globe. When a series of measurements are to be made it is preferable, as Prof. Ulbricht, in his second contribution (*Elektrotech. Zeitschr.*, 1905, p. 512), suggests, to place both the source of light to be studied, L, and the comparison lamp L_1 together with their respective screens B and B_1, simultaneously inside the globe. By extinguishing L and lighting up L_1 instead, the constant of calibration K_o can be determined.

The value of this constant depends upon the coefficient of reflection of the inner coating of the globe, which, of course, is subject to alteration with age, and also depends, to some extent, upon the foreign bodies within the globe. Prof. Ulbricht has shown that the influence of these "foreign bodies" such as screens, parts of lamps, &c., can be reduced to negligible dimensions. He has, however, determined the magnitude of the error that can be caused by the absorption and obstruction of light on the part of the screens used in this work, and found that it is a minimum when the distance of the screen from the lamp is about 0·4 times the distance of the latter from the measuring aperture.

Prof. Ulbricht has also developed a method for the measurement of mean hemispherical candle-power, in which the diffused reflection of only a portion of a spere is utilized. In this case also a uniform illumination of the surface exposed is obtainable; it is only necessary to guard against the possibility of light entering by the opening so produced.

The use of the globe for this purpose is shown in Fig. 4. It will be seen that the cap of the sphere has been removed, the source of light being placed in the plane of section. Under these conditions the globe only receives the light in the lower hemisphere, and its internal illumination therefore serves to measure the mean hemispherical candle-power, in precisely the same manner as was previously described. The determination of the constant of calibration is accomplished by the use of a comparison lamp, which is screened by the use of a small cap in such a way that no light from it crosses the plane of section of the globe. The mean spherical candle-power of this lamp can be determined by previous comparison with an unscreened standard lamp. We thus determine the mean hemispherical flux of light $\Phi_{\cup}$, which is connected with the mean hemispherical candle-power $J_{\cup}$ by means of the relation, $J_{\cup} = \frac{\Phi_{\cup}}{2\pi}$. Instead of actually removing a portion of the globe altogether we can replace it by a similar portion, the inner surface of which is of a dead black non-reflecting character.

In order to measure the mean hemispherical candle-power of sources of light which cannot be considered "point-sources," we must know the exact position in which they should be placed as regards the plane of section—in other words, we must determine their centres of radiation. This question forms the subject of

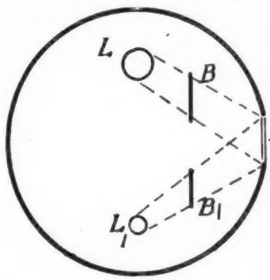


Fig. 3.

Prof. Ulbricht's third contribution (*Elektrotech. Zeitschr.*, 1906, p. 50). He explains that if a source of light is placed at a certain specified distance from a thin horizontal plane plate, for instance, an ordinary paper grease-spot disc, and if this source be raised and lowered until the upper and lower surfaces of such a plate appear equally brightly illuminated, then the centre

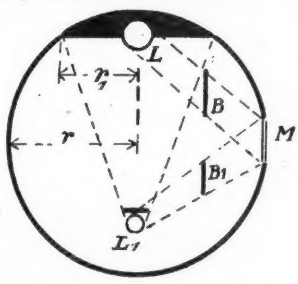


Fig. 4.

of radiation must lie in the plane of the paper in question. If we denote the radius of the circle produced by the cutting of the sphere for the purpose of hemispherical measurement, by r_1, the correct distance of the grease-spot paper from the source of light must be $r_1\sqrt{3}$.

In a fourth contribution (*Elektrotech. Zeitschr.*, 1907, p. 777), Prof. Ulbricht deals with the influence of screens and its elimination. He also considers the photometry of lamps in clear glass globes, and describes a form of apparatus, in which an arrangement of mirrors enables the observer to inspect the upper and lower surface of the grease-spot disc simultaneously. We are able to show the most recent modification of this apparatus in Fig. 5.

The grease-spot disc F is placed within a blackened tube, at the further end O, of which is situated the eye of the observer. By means of the mirrors SS the observer is able to see both the upper and the lower sides of disc simultaneously. The corresponding images are brought into juxtaposition by means of the two prisms PP, when the lamp, placed at a distance $r_1\sqrt{3}$ from the tube is so adjusted as to cause the appearance of the upper and lower surfaces to be the same, the eye is applied to either the upper or lower aperture O_1. By looking through the opening between the mirrors the observer is now able to determine which point in the light-giving surface coincides with the extension of the plane of the grease-spot disc, which is visible in section as a thin line. This point must be situated in the plane of section of the globe.

From theoretical considerations Prof. Ulbricht derives the following rules, which must be applied to the apparatus shown in Figs. 3 and 4. The surface F of the screens B must not be larger than $\frac{1}{20}$ of the sectional area of the globe. The screen B, as observed through the measuring aperture in the globe, must completely cover :—

(*a*) The actual source itself and its reflectors, in the case of naked lamps.

(*b*) The whole globe, in the case of lamps equipped with a diffusing globe.

(*c*) The source itself, the reflector, and any reflected images of the source of light,* in the case of lamps equipped with clear glass globes.

In any case the dimensions of the screens B, B_1 must suffice to prevent the possibility of even the outer edges of the window of observation being exposed to the direct rays from the source. The extent of the error caused by the screens B and B_1, having surfaces F and F_1 respectively may be computed to be about

$$\frac{80F - 100F_1}{\pi r^2} \%$$

in the case of measurements of spherical intensity, and about

$$\frac{50F - 100F_1}{\pi r^2} \%$$

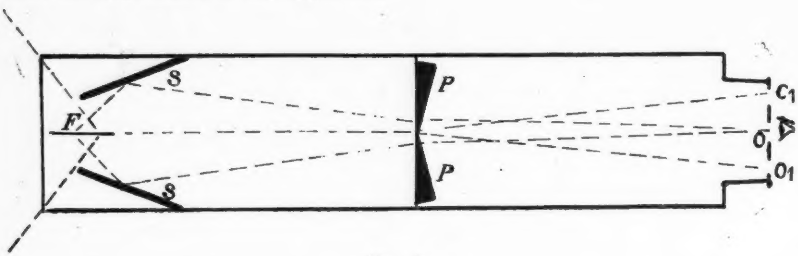


Fig. 5.

in the case of measurements of hemispherical intensity. In what has just been said the radius of the circle formed by the plane of section has been assumed to be about 0·4r. In any case it should not be smaller than the diameter of the luminous source, and not greater than $\frac{r}{2}$. In the case of measurements of spherical intensity L and L_1, as seen from the measuring aperture, should subtend an angle of ± 30 degrees. In the case of measurements of hemispherical intensity the lamp must be so situated with respect to the globe that its centre of radiation lies in the plane of section.

Practical forms of the globe photometer, of which three (shown on pp. 230,

* Such images, formed by reflection in spherical or elliptical glass globes, are a marked feature of most arc lamps.

278, and 280 respectively), have been recently depicted in *The Illuminating Engineer*, range from 0·5 to 3 metres in diameter. The larger instruments, upwards of 1·5 metres in diameter, give the best results. A globe of this description, built in the works of H. Stieberitz of Dresden, is shown in Fig. 6. The larger sizes of globes possess the advantage that the errors of measurement are greatly reduced; they become, indeed, so small as to be negligible in comparison with the ordinary errors of photometrical observation.

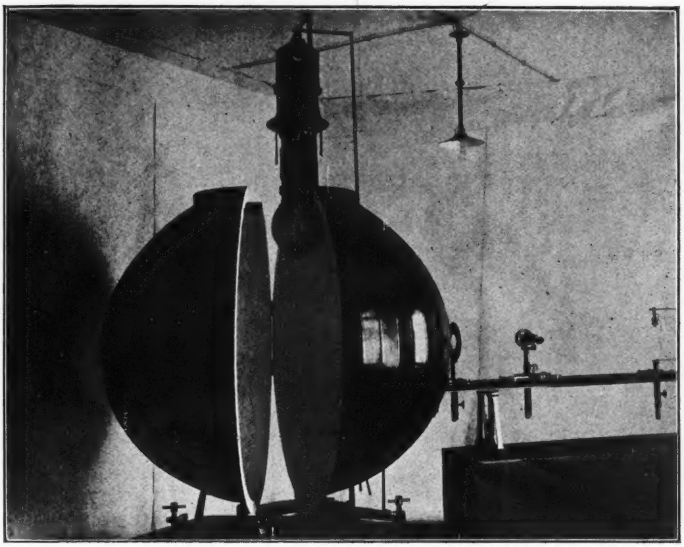
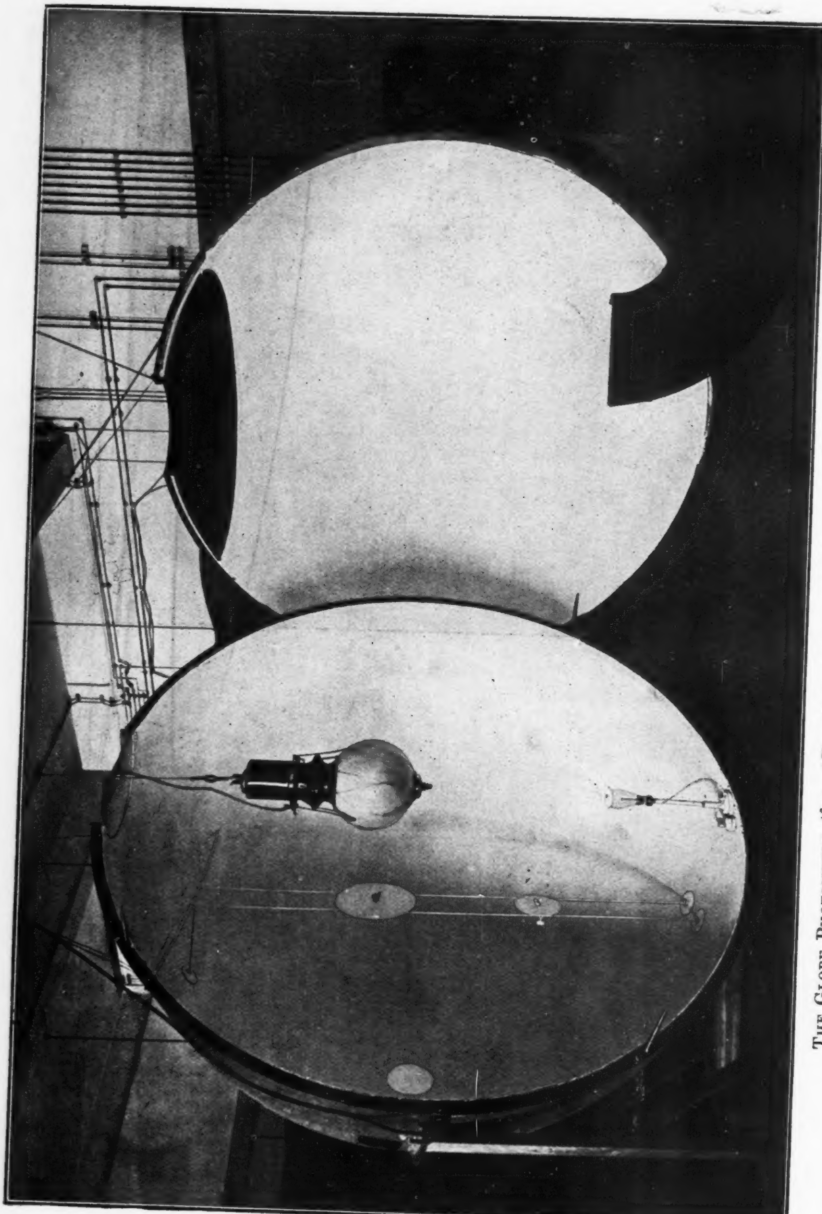


FIG. 6.

On the next page will be found an interesting illustration of a Globe Photometer, which occurs in Dr. Stockhausen's book on the enclosed arc, and to which the author has kindly drawn our attention. This globe was designed for use at the Dresden Technische Hochschule. It is built out of 1 mm. thick pieces of sheet-iron, and is divisible into two halves in order to facilitate access to the interior of the globe.

The illustration shows very clearly the arrangement of the arc lamp to be tested, the various screens and the window, and the position of the comparison lamp within the globe.

This globe, designed by Dr. Stockhausen for the purpose of his experiments, is, we understand, the design on which that of Messrs. Körting & Matthiesen, shown on p. 230 of the March number of *The Illuminating Engineer*, was constructed.



THE GLOBE PHOTOMETER (from 'Der eingeschlossene Lichtbogen,' by Dr. K. Stockhausen, p. 155).

A Simple Method of Determining the Mean Spherical Intensity of a Source of Light.

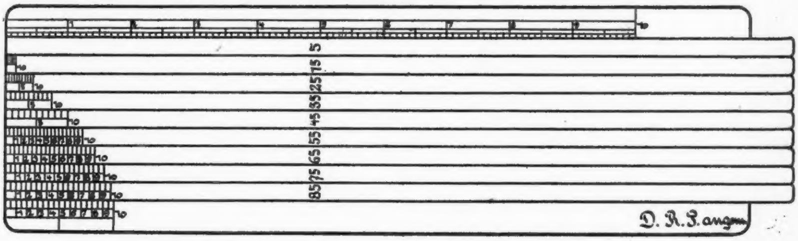
By E. W. Weinbeer.

Hitherto the graphical determination of the mean spherical intensity of sources from the polar curve of distribution of light has been invariably carried out by means of the Rousseau construction. This method, however, involves the use of a planimeter in order to ascertain the area of the diagram in question.

Kenelly (*Elec. World*, No. 13, 1908) has recently described a new method involving purely linear measurements, by the aid of which the mean spherical candle-power can be determined by the use of a rule and a pair of compasses only. This method is based upon the fact that a given source of light yielding a mean spherical candle-power I, over the region embraced between the two angles ϕ_1 and ϕ_2, measured with respect to a vertical base line, emits a flux of light $2 \pi I (\cos. \phi_1 - \cos. \phi_2)$ within these limits. Kenelly's method thus gives us the total flux of light over any desired region—in the lower hemisphere, for instance — expressed as the sum of the individual fluxes of light of which this quantity is made up, and this is obtained by purely linear measurements. The flux of light over the lower hemisphere being $2 \pi I$ ☋, this linear measurement will also give us the mean hemispherical candle-power to the same scale as the polar curve of light-distribution.

The formula $2 \pi I (\cos. \phi_1 - \cos. \phi_2)$ forms the basis of design of a piece of apparatus, for which a patent has recently been demanded, and which enables the mean hemispherical candle-power of a source to be determined directly from the polar curve without any calculation. This apparatus is shown in the figure accompanying this article, and its action may be briefly described as follows :—

Suppose that the individual fluxes of the source of light to be investigated have been photometrically determined for the angles 85°, 75°, 65°, &c., to the vertical. Now the contribution of these fluxes to the total flux over the hemisphere are $2 \pi I_{85} (\cos. 80° - \cos. 90°)$, $2 \pi I_{75} (\cos. 70° - \cos. 80°)$, &c., in accordance with the formula referred to above. The actual values of the trigonometrical expressions occurring in this series are as follows :—



cos. 80°	– cos.	90°	=0·1736
„ 70°	– „	80°	=0·1684
„ 60°	– „	70°	=0·1580
„ 50°	– „	60°	=0·1428
„ 40°	– „	50°	=0·1232
„ 30°	– „	40°	=0·1000
„ 20°	– „	30°	=0·0737
„ 10°	– „	20°	=0·0451
„ 0°	– „	10°	=0·0152

the sum of which is equal to unity.

These figures enable the individual fluxes of light—or, leaving out of account the constant quantity 2π — the values of the individual intensities corresponding to the various angles, to be determined. The author has utilized this principle in the device shown in the figure, which resembles an ordinary slide-rule. The upper edge of this is provided with a convenient scale ranging from 0 to 10 or 0 to 100, &c.

The lowest scale in the figure is exactly similar, except that it is reduced in the ratio 0·1736 to 1. It will be seen that there are in all 9 successive movable rules, the first of which needs no scale at all, and the second receives the same scale as the upper one, but reduced in the ratio 0·0152 ;1, while the remaining scales are similarly reduced in the ratios 0·0451, :1, 0·0737 :1, &c.

In order to obtain the results following the application of the above formula we proceed as follows : the zero of the lowest movable rule (marked on the figure 85) is adjusted so as to be opposite to the value of I_{85} on the scale below it. Next the second movable rule from the bottom (marked 75 in the figure) is adjusted in exactly the same way, so that its zero is opposite the value of I_{75} as read on the rule 85, and so on, until eventually we can read the summation of all the terms in the series by the reading of the end of the movable rule 5 on the top fixed edge.

The apparatus may be provided with a greater or smaller number of movable rules at will ; naturally the accuracy increases with the number adopted. The fundamental fixed scale on the fixed upper edge may also be constructed to any desired value of luminous intensity—to 32 candle-power lamps, for example—or an ordinary slide-rule may be added to the apparatus, thus enabling the final results to be reduced in any desired ratio.

In any case the essential features of the device are the same, namely, a number of movable scales graduated according to the system outlined above. A very cheap and simple modification of the arrangement may be obtained by merely printing the various scales required upon a single fixed rule. In this case it would be necessary to prick off the various lengths on a straight line with a pair of dividers, and then to measure the resulting length by the fundamental non-reduced scale at the top of the figure. The length so obtained gives the mean hemispherical candle-power.

In order to obtain mean spherical candle-powers all that is necessary is to repeat the process for both hemispheres, and to take the arithmetic mean.

Recent Developments in Electric Lighting.

THIS formed the title of a series of three lectures delivered by Prof. J. T. Morris, M.I.E.E., on June 15th, 22nd, and 29th, at the East London Technical College. The lectures were extremely well attended, and the evident appreciation of those present was both a tribute to Prof. Morris and an illustration of the interest which is invariably aroused by a series of lectures dealing with progress in lighting and illumination.

In his first lecture, at which Sir Wm. White, K.C.B., F.R.S., presided, Prof. Morris dealt mainly with the arc light and recent developments in arc lamps, his remarks being illustrated by exhibition of many of the most recent types, including the Excello, the Oriflamme, the Jandus Enclosed, &c., and also exhibited one of the latest Keith gas lamps. On the following Monday this branch of the subject was again dealt with, special attention being paid to the use of flame and impregnated carbons, and the influence of the nature of these carbons on the colour of the light. Subsequently the lecturer dealt briefly with street illumination and photometry, and referred to the report of Mr. A. A. Voysey on the City lighting.

We write this before the third lecture of the series has been delivered, but we understand that this will deal with glow lamps, and include a comparison of the costs of gas and electric lighting.

Report on the Public Lighting of the City of London.

By A. A. Voysey,

Electrical Engineer to the Streets Committee of the Corporation of London.

PUBLIC HEALTH DEPARTMENT.

To the Worshipful the Streets Committee.

Gentlemen,—It is now my duty to report on the subject of the Public Lighting of the City, having regard to recent experiments which have been made with a view to improve and cheapen it.

In the first place, I propose briefly to refer to what is called the science of photometry, of which I have made some use for the purpose of this investigation.

Many people even to-day, in dealing with questions of artificial light, are content with a statement of the candle-power of the source of light—a statement frequently as false as it is vague—taking no account of the directions in which light is given, of the globe, lantern, reflector, position and surroundings of the lamp, all factors of the utmost importance in determining the useful lighting effect. However important the study of the source of light may be, the study of the actual illumination in the street under working conditions is far more essential. In 1892, the work of Mr. A. P. Trotter, now the Electrical Adviser to the Board of Trade, showed the lines on which such an examination might proceed, and at the same time provided an excellent illumination photometer for the purpose. I worked a great deal with this instrument in the City in 1896, taking measurements of the illumination on a horizontal surface six inches from the ground and formed the opinion that the illumination measured on a horizontal surface may be taken as a sufficient indication of the effective lighting of a street. I am now again led to the same conclusion. But as the tendency is to measure illumination at a height of 4 ft. from the ground, my recent tests have been made at this level. The photometer used is an improvement on the one used in 1896, and was sent to the National Physical Laboratory for verification.

The unit of illumination is that produced by 1 candle-power at a distance of 1 ft. and is called 1 candle-foot.

Attached hereto will be found some curves showing the illumination given in Holborn, Cannon Street, and Queen Street by the experimental lamps. The length of the street in feet is plotted along a horizontal scale and the vertical scale is marked in candle-feet and fractions thereof, so that the curves show the variation in illumination along the street.

Curves A show the illumination along the curb line given by flame-arc-lamps in Holborn Viaduct and Cannon Street and by gas in Queen Street.

Curves B are similar, but are taken along the centre of the road.

Curves C show the difference in illumination along the curb in Cannon Street, between the central suspension of lamps at a height of 28 ft. and lamps on posts at a height of 20½ ft.

Curves D are similar, but along the centre of the road. There is also shown the effect of turning out one of the centrally-hung arc-lamps.

Curves E show the effect of suspending the lamps in Cannon Street at 26 ft. instead of 28 ft.

Curves F show the effect of lighting Tower Royal with the centrally-suspended flame arc-lamp in Cannon Street, with a flame arc on a post and with two incandescent gas lamps.

The arc-light curves marked A and B are each taken as the mean of several curves, and the atmospheric conditions, when the tests were made, were clear and favourable.

The curves C, D, E, and F were taken with a view to make specific comparisons, and they each represent a single set of observations. The atmospheric conditions prevailing when curves E were taken were distinctly inclined to be foggy.

It is now necessary to consider what conclusions can be drawn from the curves. I have already stated that I think the illumination given on a horizontal surface can be taken as a sufficient indication of the value of the lighting in a street.

Next, I have formed the opinion from observation and testing that the minimum illumination is the most important factor in good lighting, and I have come to the conclusion that about one-tenth of 1 candle-foot is the minimum below which it is not desirable to go in the main streets of the City. If that figure is adopted and maintained, then I think that the main streets of the City will be very well lighted. If the curves for Holborn Viaduct are studied, it will be seen that, although Holborn Viaduct is a very wide thoroughfare, the lighting is not very far from complying with the minimum value, which I think necessary.

In order to meet any possible objection to unpleasant colour, the Holborn

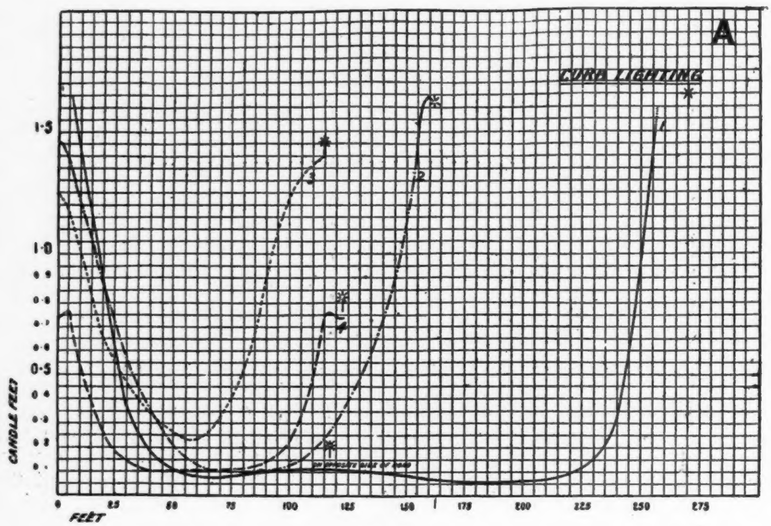


TABLE A.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft. in.				ft. in.	
1	Holborn Viaduct	Flame Arc	10·6	20 5 post	2·0	0·41	0·05	77 5	118
2	Cannon Street	Do.	11 0	28 0 central	1·6	0·56	0·1	50 0	100
3	Do.	Do.	11·0	Do.	1·4	0·12	0·23	50 0	139
4	Queen Street	High pressure gas two mantle	...	13 0	0·76	0·29	0·1	50 0	196

Viaduct lamps are trimmed with carbons giving a pleasantly-toned light, but the illumination is thereby reduced. If 7 m/m and 6·35 m/m (cores $\frac{3}{32}$ in. and $\frac{1}{16}$ in. respectively) carbons are used in Holborn Viaduct, giving a yellower light, the minimum illumination would be increased so as not to fall far short of the necessary value, and it could be regarded as approximately fulfilling what I think are the reasonable requirements for the sufficient lighting of a City main street. I do not think that Holborn Viaduct can properly be compared with Cannon Street, because, in addition to other reasons, the width of the Viaduct is about 50 per cent. greater than the width of Cannon Street.

Therefore I determined to make another test in Cannon Street, first with the centrally-hung lamps as used at present, and then with identical lamps on posts on the footway, keeping the conditions of current and carbons the same for both. The arrangements for this test were kindly made for me by the City of London Electric Lighting Co., and the results shown in curves C and D indicate the advantage obtained by central hanging in a street such as Cannon Street, which is fairly typical.

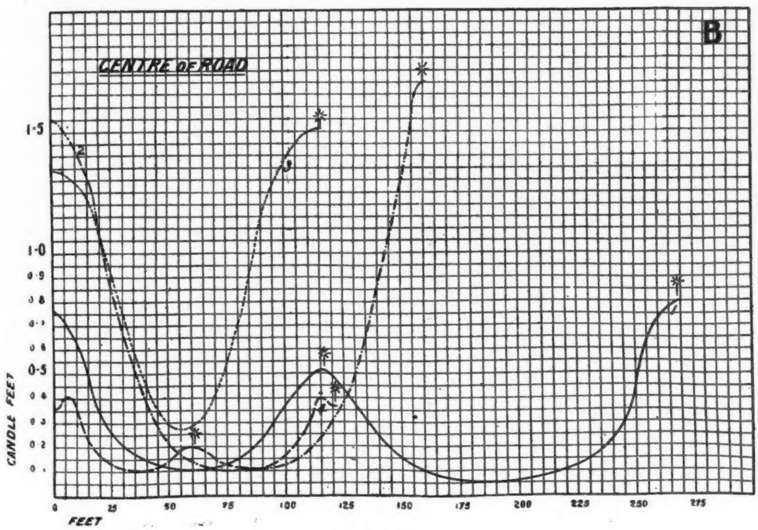


TABLE B.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft. in.				ft. in.	
1	Holborn Viaduct	Flame Arc	10·6	20 5 post	0·8	0·28	0·06	77 5	118
2	Cannon Street	Do.	11·0	28 0 central	1·7	0·66	0·10	50 0	100
3	Do.	Do.	11·0	Do.	1·5	0·88	0·28	50 0	139
4	Queen Street	High pressure gas two mantle	...	15 0 post	0·4	0·21	0·10	50 0	196

The illumination curves of the centrally-hung lamps in Cannon Street show that the lighting also fulfils the suggested condition that the minimum should not be less than one-tenth of

1 candle-foot, and I think the curves are very good ones, and indicate what is obvious from an examination of the street, namely, that the lighting is very good and, if we study the curves, the advantages of the central suspension and the extra height of the lamps are evident. From the central suspension there is, however, an additional gain for side streets and at the junctions of streets, owing to the fact that the light of one lamp can be used over a greater area. For instance, 45 per cent. of the cost of lighting in Cannon Street is saved on gas in the side streets. This economy could, to some extent, be obtained by placing posts at the corners of streets, but I do not think it could be obtained to the same extent as is possible with the higher centrally-hung lamp.

An experiments was made in Cannon Street at the suggestion of the late Chairman, Mr. Stopher, some of the lamps being hung at 26 ft. instead of 28 ft. The result is given in curves E, which, I think, show that the higher position is slightly better than the lower one.

Curves F show the illumination in Tower Royal, a turning off Cannon Street, lighted by the centrally-hung arc-lamp, and by the arc-lamp on a standard in Cannon Street, and by the two incandescent gas lamps on brackets in Tower Royal. The curves show the advantage of the central suspension.

Attention should be drawn to curve D, No. 3, which shows the effect of extinguishing alternate lamps in Cannon Street. The curve does not fulfil

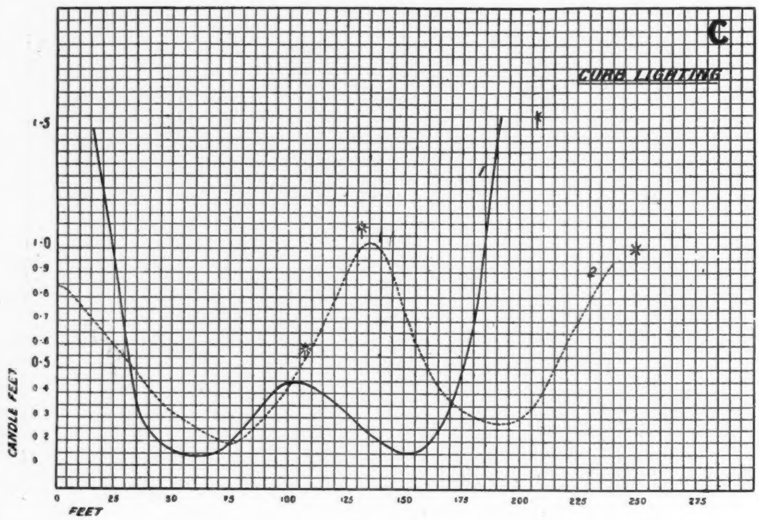


TABLE C.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination.			Width of Street.	Relative Cost.
					Max.	Avg.	Min.		
				ft. in.				ft.	
1	Cannon Street	Flame Arc	11·0	20 5 post	2·0	0·68	0·14	50	155
2	Do.	Do.	11·0	28 0 central	1·02	0·56	0·19	50	127

the requirements of a well-lighted main street, but it shows a better result than Queen Victoria Street, and the lighting is very fair. If it were not for the fact that the cleansing of the streets is an operation which may be greatly assisted by good lighting, I should be inclined to recommend the turning out of half the lights in main streets at midnight, and I think the matter is worth consideration. This is, perhaps, an opportune place to discuss the question of lighting hours. In my opinion the fixing of lighting hours between sunset and sunrise is a mistake, and I think the lighting might be curtailed on an average of about one hour per day, half in the morning and half in the evening, if a reasonable reduction were made in the annual charges. It is now desirable to consider the question of comparative cost, and this is bound up with the question of spacing.

The average distance between the centrally-hung lamps in Cannon Street is approximately the same as that of the standards in Holborn, though Holborn is 50 per cent. wider than Cannon Street. The average spacing of the centrally hung lamps in Cannon Street is a little closer than the spacing of the old standards in that street, there being eleven of the suspended to ten of the lamps on standards. The extra lamp results really from the consideration of the side streets rather than from any need in Cannon Street

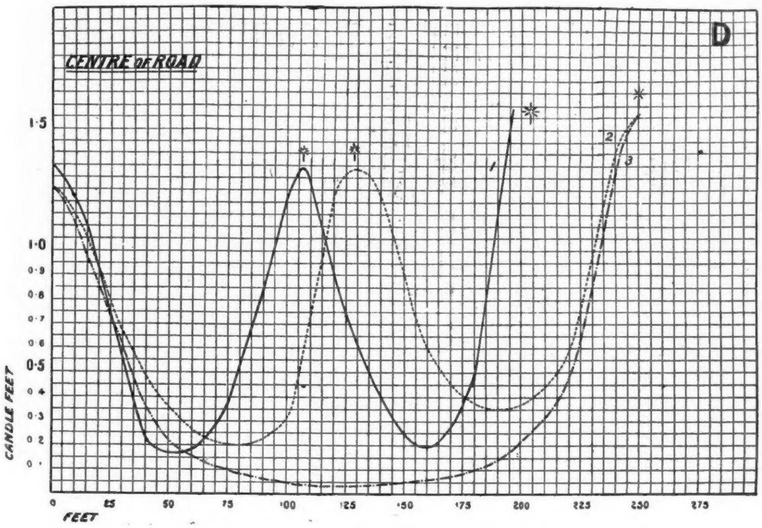


TABLE D.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumiuation. Max.	Avg.	Min.	Width of Street.	Relative cost.
				ft. in.				ft.	
1	Cannon Street	Flame Arc	11·0	20 5 post	2·0	0·7	0·17	50	155
2	Do.	Do.	11·0	28 0 central	1·56	0·72	0·2	50	127
3	Do.	Do.	11·0	28 0 central	1·56	0·4	0·04	50	64

itself. With regard to spacing, a regular distance should be followed as closely as possible, but due consideration must be paid to side streets and cross streets in order to obtain the most economical results. As will be seen from the curves, the distance between the lamps in Cannon Street varies from 112 ft. to 165 ft. I think the latter distance may be regarded as the extreme, beyond which it is not desirable to go; whereas the former is closer than is necessary, and can only be justified by a consideration of the side streets.

For the purpose of comparing the effect of gas with electric lighting I made a test in Queen Victoria Street, but I found a large portion of this street with a very low illumination, and neither from observation nor test did it appear to me at all comparable with Cannon Street. I therefore sought out a piece of good gas lighting, and I found this in a portion of Queen Street. It was interesting to find that the piece of street I picked fulfilled the condition which I had fixed as essential for a well-lighted street, namely, that the illumination on a horizontal surface 4 ft. from the ground should in no place be less than one-tenth of 1 candle-foot. The average illumination of the picked piece of gas-lighting in Queen Street, which is, fortunately, just the same width as Cannon Street, is only about half that in Cannon Street, though it is about

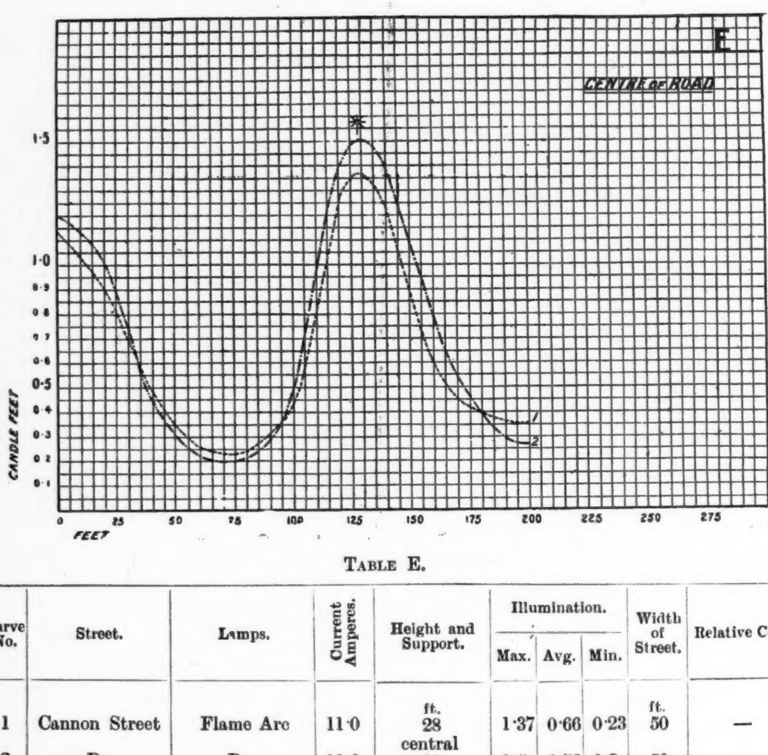


TABLE E.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft.				ft.	
1	Cannon Street	Flame Arc	11·0	28 central	1·37	0·66	0·23	50	—
2	Do.	Do.	11·0	26 central	1·5	0·72	0·2	50	—

double the cost. This confirms what I reported three years ago as the result of some photometric tests, namely, that, light for light, high pressure incandescent gas-light costs four times as much as the flame arc-light. It may here be observed that Departments of the Corporation, other than the Public Health Department, are now saving at the rate of about 3,000*l.* a year, partly by changing from gas to electricity and partly by bringing electric lighting up to date, and I have good reason for saying that this sum could be considerably added to.

On the whole I think it may be fairly assumed that about 500 eleven-ampere flame arc-lamps will light the main

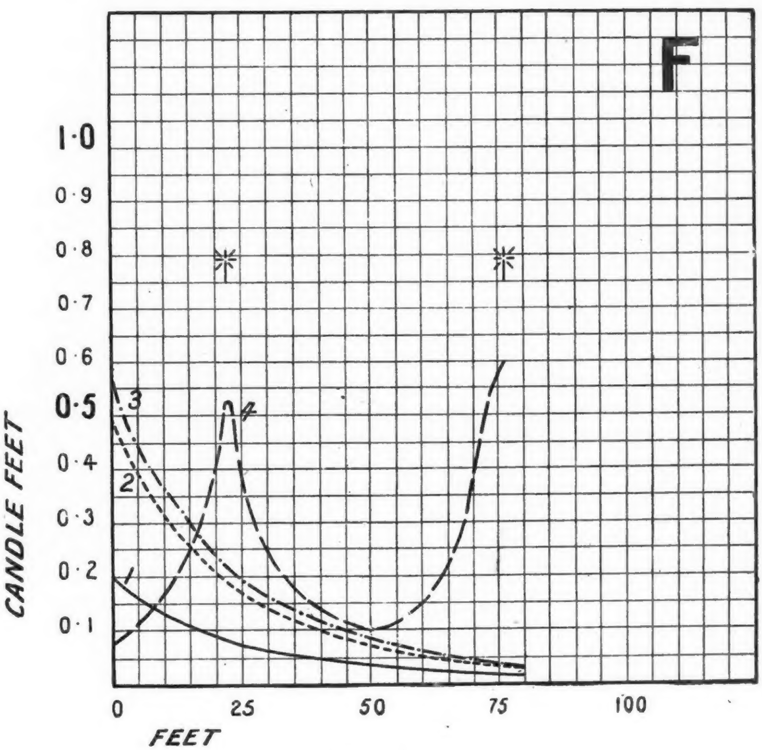


TABLE F.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft. in.					
1	Tower Royal	Flame Arc	11·0	20 5 on post	0·2	0·08	0·025	...	Nil
2	Do.	Do.	11·0	28 0 central	0·48	0·16	0·04	...	Nil
3	Do.	Do.	11·0	26 0 central	0·56	0·19	0·04	...	Nil
4	Do.	Low pressure gas single mantle	...	11 6 bracket	0·6	0·25	0·08	...	£6 14 4 per annum

streets well, whether centrally hung or on standards. The cost of these at 17*l*. 10*s*. each would be 8,750*l*. The present cost of lighting the whole City is about 22,000*l*. a year, about half the cost being for electric light and the other half for gas. In addition to this a sum of about 17,000*l*. appears to have been spent in the last nine years on providing and maintaining apparatus for gas-lighting. The side streets can be very much better lighted by centrally-hung arc-lamps than they are at present for a sum which I estimate approximately at 5,000*l*. to 6,000*l*. per annum. It is very important in my opinion that the main-street lighting should not be arranged independently of the side streets. Economical effective lighting of both is bound up one with the other. A few lamps arranged in the side streets off Cannon Street would quickly show what can be done. I have very little doubt that the average illumination throughout the whole of the City streets can be at least doubled, and a saving of about 6,000*l*. a year effected.

On the subject of lamp supports, I think it may be remarked, with regard to the central suspension, that the plan followed in Cannon Street of making them as invisible as possible is a good one. Attachments would have to be securely made and the supporting wires carefully examined, and, no doubt, the existence of a large number of such supports in the City would necessitate some extra cost to the Corporation in the supervision of overhead wires. But if reasonable care is used in the matter, there should be no danger whatever attaching to the central suspension of lamps.

In the main streets the plan of trimming the lamps in position during the early hours of the morning is a sound one. No doubt some small occupation of the roadway space during busy hours would take place when a lamp went wrong at such a time; but it must be remembered that a standard on the footway remains for several thousands of hours each year as an obstruction to traffic, and must necessarily be a much greater cause of inconvenience than the very occasional visit for a few moments necessitated by a fault in a centrally-hung lamp.

In narrow streets it would be advisable to arrange for bringing the lamps down to the footways for trimming, because otherwise a serious obstruction to traffic would occur. In some very wide streets, like Holborn and Farringdon Street, it might be advisable to use standards placed in the centre of the road, and in any case a certain number of standards may be required.

While I recognize the importance of economy and the consequent need to use existing material as much as possible, I think I ought to point out the unsatisfactory condition of London in the matter of lamp standards, and especially electric lamp standards. The design is usually left to an iron-founder's draughtsman. Mr. Norman Shaw has very kindly given his gratuitous aid in matters affecting the appearance of London, and I think his help might very well be asked. If new posts are found to be necessary, I think some endeavour should be made to redeem the reputation of London in this matter.

I will re-state my main conclusions :

1. That the illumination on a horizontal surface 4 ft. from the ground is a sufficient indication of the useful light in a street.

2. That the minimum value of such illumination is the most important factor in good lighting.

3. That such minimum should not be less than one-tenth of 1 candle-foot.

4. That this illumination can be approximately obtained by eleven-ampère flame arc-lamps with yellow flame carbons, spaced approximately as at present, either on standards at 20½ ft, as in Holborn Viaduct, or centrally hung, as in Cannon Street, at 28 ft. from the ground.

5. That a more even distribution of light and a more economical result can be secured by the centrally-suspended lamp at 28 ft. than by the lamp at 20½ ft. on a standard.

6. That economy and efficiency require the treatemnt of main streets and side streets together.

7. That a demonstration should be made in the side streets of centrally-hung arc-lamps as soon as possible.

8. That about 6,000*l.* a year may be saved and a doubling of the average illumination throughout the City streets effected by flame arc lighting assisted by a few metallic filament lamps where arc-lamps have not a sufficient area for economical lighting.

9. That where central suspension is used, it should be without lowering gear in broad streets and with lowering gear in narrow streets.

10. That any new standards which may be required should be designed according to the advice of some reliable guide, such as Mr. Norman Shaw.

11. That the lighting hours can be reconsidered with a view to economy, without prejudice to lighting efficiency.

12. That the question of reducing the lighting in the main streets at midnight should be considered.

In order to obtain as soon as possible the great advantages in economy and better lighting that I showed to be possible, I think a small demonstration should be invited from both Companies in the side streets, and some of the streets adjoining Cannon Street would be very suitable for the purpose. I also think it would be a great advantage if a provisional decision were come to as to whether the lighting is to be divided between the two Companies, and if so, in what proportions. If that is done, and the side-street demonstration of lighting found satisfactory, then the way will be clear for the preparation of complete plans and specifications for lighting the whole of the City, and instructions might be given accordingly.

I ought to acknowledge the assistance kindly given me by the police, by Mr. Engineer in the lighting and extinguishing of gas-lamps for testing purposes and in supplying me with details of gas costs; also the assistance given by those in my office, which entailed night work. Both the Electric Supply Companies afforded me every facility to measure the current given to the lamps during test, and at their own expense made the temporary arrangements which were required in Cannon Street for testing purposes.

I have the honour to remain,
Gentlemen,
Your obedient Servant,
A. A. Voysey.
Electrical Engineer.

The Annual Meeting of the Institution of Gas Engineers.

The annual meeting of the Institution of Gas Engineers took place from June 16th to June 18th. From the standpoint of the gas engineer the meeting seems to have been a complete success, and the papers, though none of them dealt with the lighting side of gas technics, reached a high order of merit.

The address of the President, Mr. Doig Gibb, M.I.C.E., covered a wide range of subjects, but contained several references to matters of interest to the illuminating engineer. We appreciate Mr. Doig Gibb's comments upon the value of competition between gas and electricity in having educated the public to demand a more liberal standard of illumination, and especially his testimony that he regards misleading statements on the part of his rivals as less frequent. We feel that any one who had been impartially following the progress in both sections of lighting would admit that there has been misrepresentation on both sides, and we are glad to believe that the folly of such misunderstandings is becoming realized by those in both camps.

As the President said, companies relying on such tactics can hope to gain no real success by them. It is pleasant, too, to have his recognition that all systems of lighting have their own sphere of activity. "There is a field for electrical supply companies, and I have no doubt that they will increase and prosper, as gas undertakings have done, and will do." In this connexion it is interesting to note that in Newcastle recourse was had to electrical driven fans supplied by two 30-kilowatt dynamos, in order to maintain the pressure at the requisite high level. In his address the President also referred to the spread of methods of automatic street lighting by "pressure waves," and stated that about 500 such installations were now in use in Newcastle with satisfactory results.

An extremely interesting paper was read by Sir George Livesay on 'Copartnership.' In co-partnership Sir George Livesay saw the only sure and certain settlement of the relations between capital and labour. He testified to its value in promoting a spirit of co-operation between employer and employee, as a result of nineteen years' practical experience. Many, the President remarked, might urge that the present conditions worked well enough, and ask why we could not "leave well alone." But did any man believe that the present conditions of labour and capital could be regarded as entirely satisfactory or could be expected to endure indefinitely ?

What was really necessary, however, was not profit-sharing—the mere payment of an annual bonus in cash—but actual shareholding, involving partnership in responsibility.

During the discussion that followed the general aims of the paper, and the spirit between workers and employers for which Sir George was working were generally approved, though there was some criticism of points of detail. Some seemed to fear that in future years the success of the movement might be jeopardized when, eventually, Sir George Livesay's support would no longer be available.

An amusing story was told by Mr. Berridge of a town councillor who had proposed that gas should be replaced by electricity for the public lighting. As a result he was approached by several of the workmen at the local gas works, who explained that if the scheme was not abandoned they would buy no more tobacco at his shop. The matter was dropped.

Among the other papers read before the Institution may be mentioned that by Prof. W. A. Bone, whose recent appointment to the Chair of Fuel at the University of Leeds is an illustration of the attention that is now being devoted to the scientific aspects of gas engineering. Prof. Bone's lecture was entitled 'The Combustion and Thermal Decomposition of Hydrocarbons.' Among other points the lecturer dealt with the theories which have been put forward to explain the chemical basis of the luminosity of flames, and the effect of temperature upon the decomposition of the hydro-carbons participating in these reactions.

Another valuable paper, which also illustrated the scientific spirit in which problems connected with gas engineering are now attacked, was that by Mr. Bywater dealing with refractory materials.

On Thursday, June 18th, the meeting took place at the Franco-British Exhibition, where the various gas exhibits received attention.

The meeting of the German Institution of Gas and Water Engineers took place from June 15th to the 19th, which was attended by many English gas engineers, and at which representatives from all the chief European countries were present. Amongst the items on the programme of the meeting may be mentioned a visit to the works of Messrs. Ehrich & Graetz, and an address by Prof. Drehschmidt on the public lighting of Berlin.

The following papers were also read :—

'Continuous Carbonization in Vertical Retorts,' by H. W. Woodall, of Bournemouth; 'Recent Experience with the Dessau Vertical Retorts,' by A. F. P. Hayman, of Berlin; 'Description of the New Gasworks at Valby, Copenhagen,' by J. Irminger, of Copenhagen; 'The Extraction of Cyanides and the Manufacture of Yellow Prussiate by the Davis-Neill Process at the Linacre Gasworks, Liverpool,' by Edward Allen, of Liverpool,

Practical Demonstrations of Interior Lighting.

THE recent article by Dr. Stockhausen, describing the display of shop-window lighting at the "Augur" Exhibition in Berlin* served to illustrate a method of exhibiting the capabilities of sources of light which is coming more and more to the fore. In this exhibition a number of similar shop-windows were illuminated by various methods; the various illuminants, in fact, were exhibited doing exactly what they would be called upon to do under practical conditions, namely, illuminating certain specified objects. Many other displays, on somewhat similar lines, have, of course, been carried out in the past.

FIG. 1.—KITCHEN.

At the recent Chicago Electrical Trades Exhibition,* for instance, an "electric home" was fitted up, and a number of different rooms were shown actually illuminated by electric lights, surrounded by suitable shades and reflectors, and exhibits both of gas and electric lighting of this nature are now being shown at the Franco-British Exhibition.

It is becoming generally understood how very much better it is to show off an illuminant in actual use and to the best advantage rather than to merely exhibit *as* a light and no more. If the public are able to see any system of lighting used in an

* See *Illuminating Engineer*, April, 1908.

interesting way, employed, for instance, to illuminate a tastefully got up living room, they go away with a very much clearer conception of the value of such lights in their own homes than if they are merely shown a row of brilliant sources, arranged like soldiers. At the same time the salesman has an opportunity of educating the consumer to appreciate what he may not previously have had a chance of understanding, the really essential characteristics of efficient and yet tasteful illumination as opposed to mere glare.

This method of procedure seems to have much greater possibilities than are generally realized; it might be extended to many practical problems in illumination, besides house- and shop-lighting, and there are endless possibilities in the way of bringing out the merits of certain types of lamps and fittings, intended to produce special artistic effects.

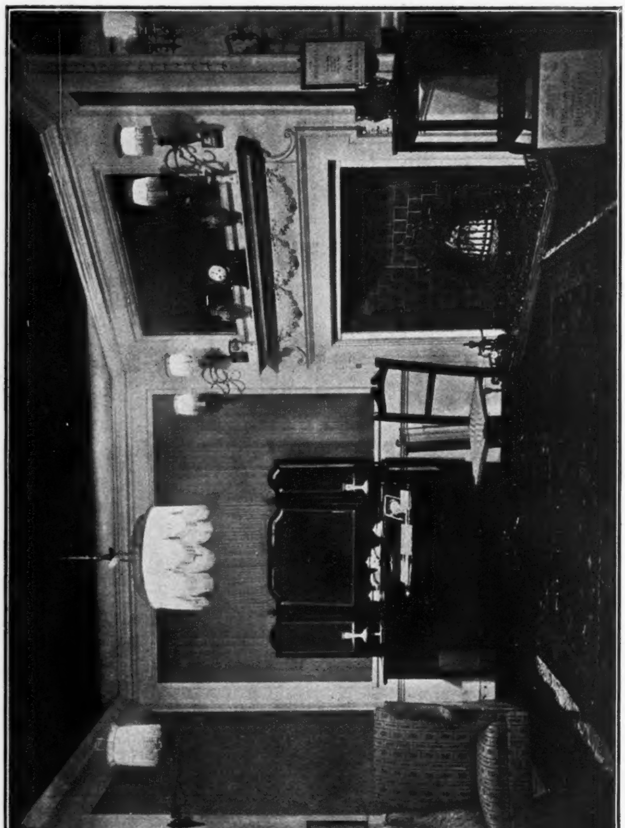


Fig. 2.—Bedroom.

A specially instructive exhibit might take the form of two identical rooms, side by side, furnished in exactly the same way and lighted by the same illuminant, the illumination being in the one case as efficient and pleasing as care could render it, and all rules of good lighting being deliberately disregarded in the other.

It need hardly be pointed out that these considerations are especially important in the case of shop-lighting. The mere production of "glare" has of lamps. The attention of passers by is much more likely to be attracted by some novel and interesting method of arranging the contents of the window.

In this connexion the arrangement adopted at the premises of the Gas,

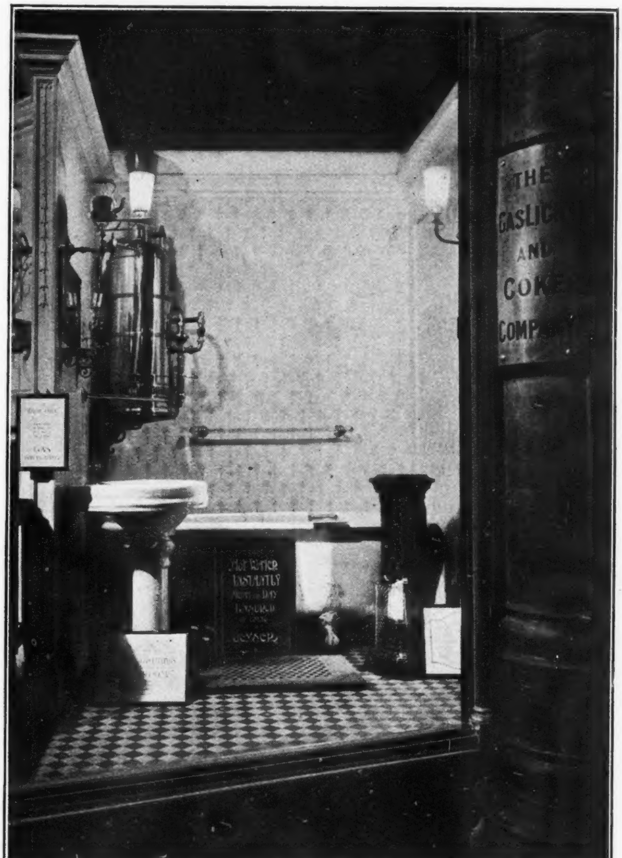


FIG. 3.—BATHROOM.

become so usual as to fail in its object of attracting and holding general attention. Moreover, the effort to increase local brilliancy, which was, to some extent, justifiable in the case of our older, comparatively feeble illuminants, becomes tiresome and painful in the case of the most modern types Light & Coke Co., Ltd.—to the courtesy of whom we are indebted for the use of the blocks accompanying this article—in the High Street, Kensington, deserves attention. In these five illustrations an attempt is made to display the actual illumination of five typical interiors, a dining-room, drawing-room, bedroom, bathroom, and kitchen.

It will be seen that the opportunity is utilized to show a number of different types of fixtures are utilized in the various rooms. Distinct schemes of decoration in the three first rooms named are employed, and in addition the furniture is changed periodically. The lights in the rooms are controlled by pneumatic switches fixed on the back of the partition. Table lamps, equipped with flexible tubes, are also displayed.

Gas fires are installed throughout, and the merits of gas for heating and cooking receive practical demonstration in the bathroom and kitchen.

The illustrations, however, convey a better impression than any description can do as to the advantages of this method of displaying fixtures and lamps, as compared with the mere exhibition of groups of isolated lamps shown burning without reference to their surroundings. In this case it will be seen that somewhat elaborately furnished rooms have been selected, but of course the method is equally applicable to those of a more humble character.

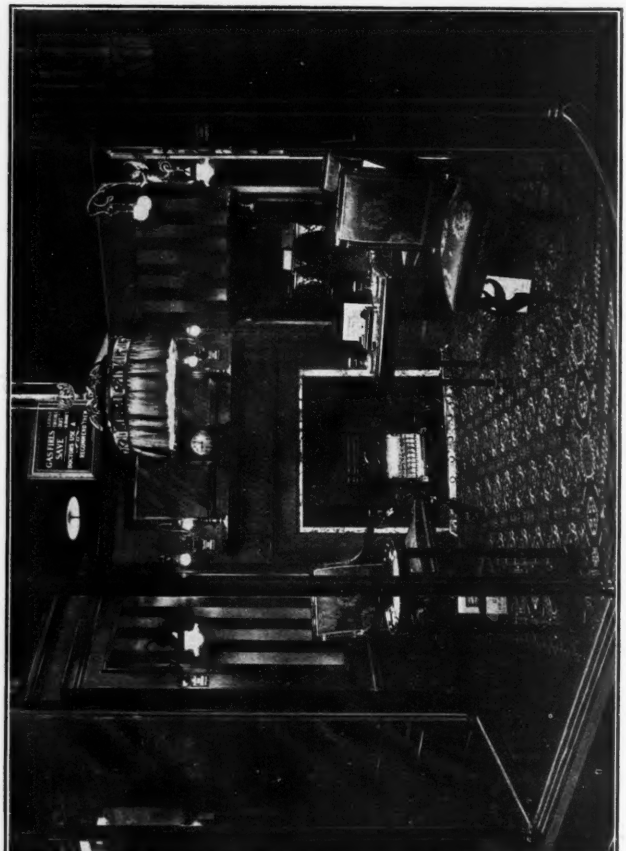


Fig. 4.—Dining-Room.

There is indeed a danger that, if too

elaborate schemes of decoration and costly furniture are employed, the attractiveness of the latter may overshadow that of the lights employed and so obscure the real intention of the exhibit.

We have in mind one exhibition of the kind in which it is said to have been found necessary actually to remove some of the furniture originally installed, in order to prevent any possible mistake as to the object of the display. What is really necessary is to show the sources of light in actual use under favourable conditions, but at the same time to make the method of illumination the central point of interest.

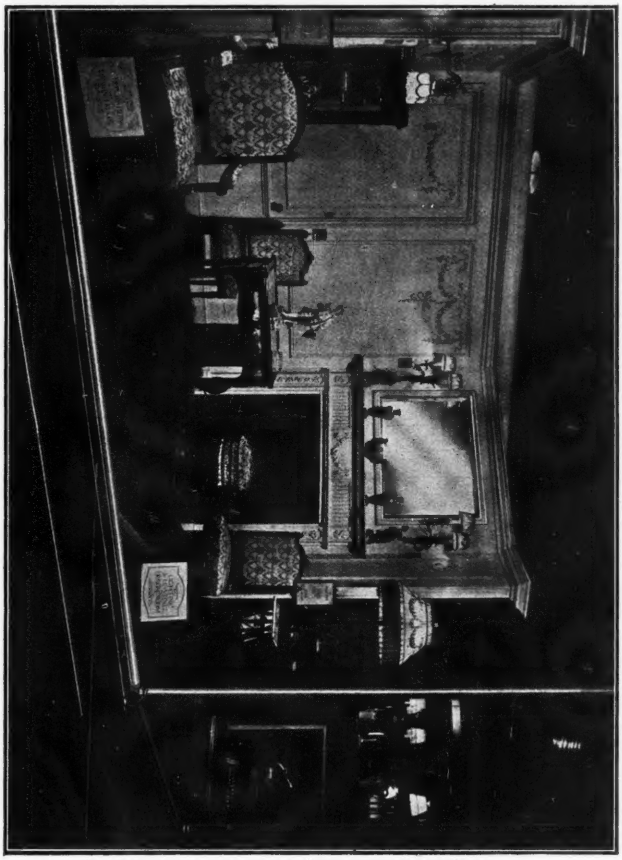


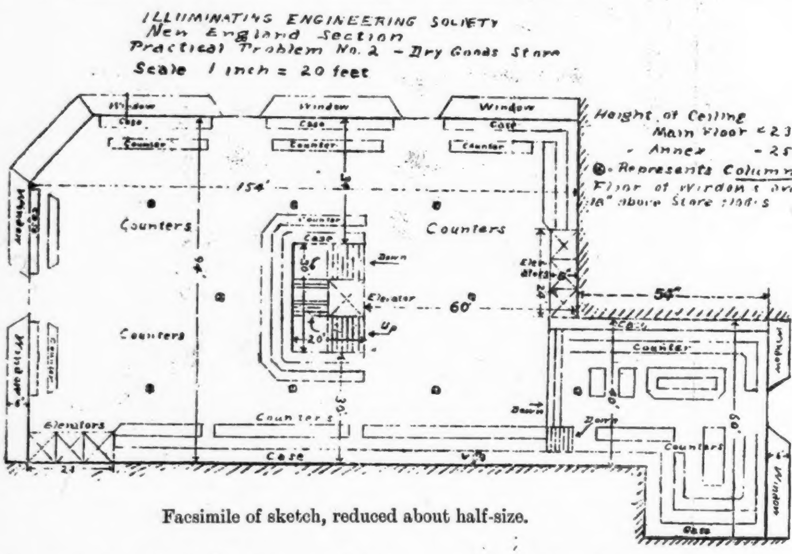
Fig. 5.—Drawing-Room.

Practical Problems in Illuminating Engineering.

We have received a copy of one of the "problem programmes" set by the Illuminating Engineering Society (New England section), which seems to us an admirable illustration of the useful and practical nature of the work now being carried on in the United States.

These problems consist in the circulation of a plan of some interior, which is to be illuminated in compliance with practical requirements, among each method of illumination must stand upon its merits; its advocates may present its advantages, but any misrepresentation must recoil on the heads of those responsible. And those interested have every opportunity of hearing both sides of the question and forming their own conclusions.

We append a facsimile of one of the most recent of these problems, and a copy of the letter by which it was accompanied:—



Facsimile of sketch, reduced about half-size.

the members of the society, and the matter is then thoroughly discussed at a subsequent meeting.

It is quite certain that a discussion of this nature can only result in a better general appreciation of what constitutes good illumination, and, what is equally important, a more perfect understanding as to what the cost of such illumination ought to be. In particular, we should like to draw the attention of our readers to the fact that these problems are discussed by representatives *both of gas and electric lighting*. We have often urged the value of such free discussion in this country. Under these conditions

Illuminating Engineering Society,
New England Section,
May 18, 1908.

Dear Sir,—The May meeting of the New England Section of the Illuminating Engineering Society will be held at the Auditorium of the Edison Building, 39, Boylston Street, at 7.30 on Wednesday, May 27.

The problem presented for solution at the last meeting proved very interesting, and a second problem has accordingly been arranged for the May meeting. A plan is enclosed of a dry goods store to be lighted. The solutions will be worked out and presented as at the last meeting, by representatives of gas and electric interests.

Very truly yours,
R. C. Ware, Secretary.

Gas-Lighting at the Scottish National Exhibition, Edinburgh.

By W. R. Herring,
Chief Engineer to the Edinburgh and Leith Corporation's Gas Commissioners.

(*Continued from p.* 484.)

When the statement of tests of various lamps used at the Edinburgh Exhibition were published a few weeks ago, I was not able to include amongst them the tests of the Vesta-Graetzin high-pressure inverted lamp, which, through the instrumentality of Messrs. Falk, Stadelmann & Co., London, I had arranged to erect at the Exhibition, owing to their not having come to hand in time.

The lamps in question are, I understand, exactly the same as those at present being largely put up in the streets of Berlin. The lamp itself appears to be a simple adaptation of the Graetzin lamp to high pressure purposes, and differs in this respect from the Keith-Blackman lamp, which takes the fullest advantage of the pre-heating of the gas and air prior to combustion by abstracting from the products of combustion some of their escaping heat. The lamps to be installed consist of two two-mantle lamps and one three-mantle lamp. The effective size of the mantle when inflated with the flame is 3½ in. by 1¾ in.

Over 5,000 candles of illumination from a single lamp in size no larger than an electric arc-lamp is certainly a high degree of illumination to disperse from one centre, and without discussing the question as to whether high-power light centres are the best for general illuminating purposes, it does certainly appear as though we were approaching the time when workshops and warehouses would be as brilliantly or even more brilliantly lighted by artificial means than they are at present with ordinary daylight. It will be observed that the candle-efficiency per foot of gas is not so great in these lamps as in the Keith-Blackman lamp, and I attribute this entirely to the fact that the pre-heating of the gas and air supplies in these lamps is accomplished only in its passage through the pipes

Photometrical Tests on Messrs. Falk, Stadelmann & Co.'s New High Pressure Inverted Lamp—3 Mantle Light, Mantle 3½ inches long by 1¾ inches diameter, slight cone shape.

The normal quality of the gas would be 20 to 21 candles when burned in a No. 2 Metropolitan Argand Burner, and the calorific power of the gas at the testing station 526·4 net.

The test was taken by a Simmance & Abady's Street Photometer, which had been previously verified by testing a given lamp simultaneously on a 100-inch Bar Photometer and the Portable Photometer in the same room and under like conditions.

13th May, 1908.

Pressure Inches.	Height of lamp from floor.	Distance of lamp from Photometer Disc.	Angle.	Feet Candles at Photometer disc.	Consumpt feet per hour.	Candle-Power.	C.-Pr. per feet.
	ft. in.	ft. in.	°				
61	4 8	49 5	4	1·7	89·4	4,154	46·5
61	16 0	50 8	16	1·8	89·4	4,666	52·2
61	20 0	52 1	21	1·9	89·4	5,174	57·9
61	28 0	47 6	34	2·1	89·4	4,716	52·7

Remarks.—Clear globe. The first test (viz., at angle of 4°) is as nearly horizontal as possible without cutting off light with shade. The last test (viz., as near angle of 45° as possible).

leading to the burners, whereas in the Keith-Blackman lamp this is a special feature of the construction of the lamp, and is brought about by causing a momentary pause or delay in the flow of the gas and air in a large chamber immediately in the full way of the exit flue from the lamps.

Another point of importance to note is that on the horizontal line the three-light lamp gives a lower efficiency per foot of gas than the two-light lamp. This can only be accounted for by the fact that the third mantle is partially shadowed or shielded by the other two.

In view of the visit of the Institution of Gas Engineers to Berlin, where I understand some of these lamps will be seen lighting the highways, it will be interesting to add these tests to those already published.

PHOTOMETRICAL TESTS ON MESSRS. FALK, STADELMANN & CO.'S NEW HIGH PRESSURE INVERTED LAMP—2 MANTLE LIGHT, MANTLE $3\frac{1}{2}$ INCHES LONG BY $1\frac{3}{4}$ INCHES DIAMETER, SLIGHT CONE SHAPE.

The normal quality of the gas would be 20 to 21 candles when burned in a No. 2 Metropolitan Argand Burner, and the calorific power of the gas at the testing station 545·9 net.

The test was taken by a Simmance & Abady's Street Photometer, which had been previously verified by testing a given lamp simultaneously on a 100-inch Bar Photometer and the Portable Photometer in the same room and under like conditions.

14th May, 1908.

Pressure Inches.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Feet Candles at Photometer Disc.	Consumpt Feet per Hour.	Candle-power.	Candle-power per Feet.
	ft. in.	ft. in.	°				
61	4 0	40 4	4	1·75	53·0	2,829	53·3
61	16 0	42 3	20	1·70	53·0	3,037	57·3
61	20 0	43 6	25	1·65	53·0	3,117	58·8
61	28 0	37 6	43	1·87	53·0	2,658	50·1

Remarks.—Clear globe. The first test (viz., at angle of 4°) is as nearly horizontal as possible without cutting off light with shade. The last test (viz., as near angle of 45° as possible).

Publications Received.

WE have received a bound copy of *Traité théorique et pratique de la Fabrication du Gaz*, by E. Borias (Paris, Librairie Polytechnique Ch. Beranger), a scientific treatise on the production of gas, to which we mean to refer in greater detail in a subsequent number.

Also *Les Nouveaux Modes d'Éclairage Électrique*, by A. Berthier (Paris, H. Dunod et E. Pinet). This volume, detailed examination of which we likewise postpone to a subsequent issue, discusses the different modern methods of electric lighting, including arc, electric, and mercury vapour lamps.

We have also to acknowledge the receipt of the beautifully illustrated number, (Vol. II.) of the *Annals of the Astrophysical Observatory*, issued from the Smithsonian Institute, U.S.A.

SPECIAL SECTION.

The Recent Augur Exhibition of Display-Window Lighting in Berlin.

A Description of some modern sources of light and their application to show-window lighting.

By W. Biegon von Czudnochowski.

At the present time we observe everywhere the prevailing tendency to make things beautiful. This tendency is well illustrated by modern methods of arranging display-windows; on the taste and ingenuity expended upon the arrangement and lighting of the goods in a window depend their general attractiveness to the passing customer.

This question of shop-window illumination formed the subject of special study at the recent "Augur" Exhibition in Berlin.* For this purpose a number of windows were erected all of exactly the same dimensions: 3 metres wide, 1·5 metres deep, and 3·5 metres high, as shown in Fig. 1.

Those taking part in the display were required to illuminate the window at a cost of 500 mk.; the variety of lighting adopted was optional, it being, however, stipulated that only one system should be used in the same window. The nature of the goods displayed was also left to the choice of exhibitors, who were therefore in a position to adopt the variety of goods best suited to the type of illuminant they proposed to utilize. In calculations of the running costs of installations, the price of electricity was assumed to be 0·4 mk. per unit and the price of gas 0·13 mk. per 1,000 litres. It was further enacted that the general scheme of illumination must be of a thoroughly up-to-date, practical nature, and that data as to the costs of maintenance should be exhibited in each window, the firm exhibiting being, of course, responsible for the correctness of these figures. It must be added, however, that, the authorities having eventually

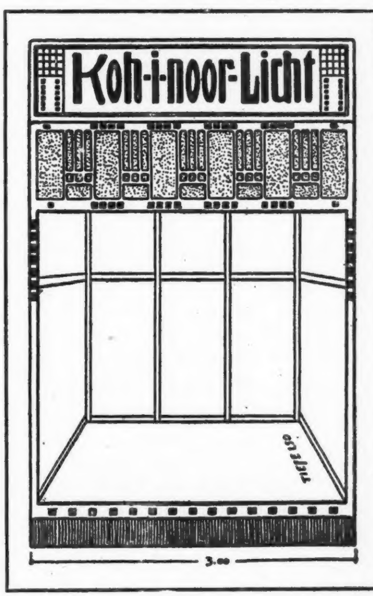


Fig. 1.

decided not to award any prize in connexion with the display, the regulation insisting upon the exhibition of data as regards, costs, &c., was afterwards relaxed. Eighteen such windows were erected, and illuminated by the following firms:—

* See *The Illuminating Engineer*, April, p. 289.

The Allgemeine Elektricitäts Gesellschaft (Berlin), the Bayerische Glühfaden Fabrik, Lechhausen, the Carbone-Licht Ges. (Berlin), Ehrich & Graetz (Berlin), Frister & Co. (Niederschöneweide, Berlin), J. Hirschhorn (Berlin), Klatte & Co. (Hamburg), Lion & Tugendhat (Berlin), the Regina Bogenlampenfabrik (Cöln-Sülz), the Siemens-Schuckert-Werke (Berlin), the Stark Licht Ges. (Berlin), the Viel-Licht-Ges. (Berlin).

Among other firms who exhibited, but who did not take any direct part in this competition may be mentioned the Beck Bogenlampen Ges. (Frankfurt a-Main), the Deutsche Gas-Glühlicht Ges. (Berlin), Körting & Mathiesen (Leutsch, Leipzig), A. Meenen (Berlin), K. Weinert (Berlin).

The methods of lighting adopted may be considered separately under the headings of gas lighting, lighting by electric glow-lamps, and lighting by arc-lamps.

I. Systems of Gas Lighting.

(*a*) Practically all modern methods of gas lighting involve the use of mantles; the most recent forms of lamps utilize inverted burners, of which the *Graetzin-Light*, manufactured by Ehrich & Graetz according to the *Mannesmann* patents (D.R.P. 126,135) is a well-known example.

A number of these lamps have recently been installed in the streets of Berlin. The system can be employed in conjunction with either high or low pressure of the order of 23 to 75 mm. The admission of gas and air is under

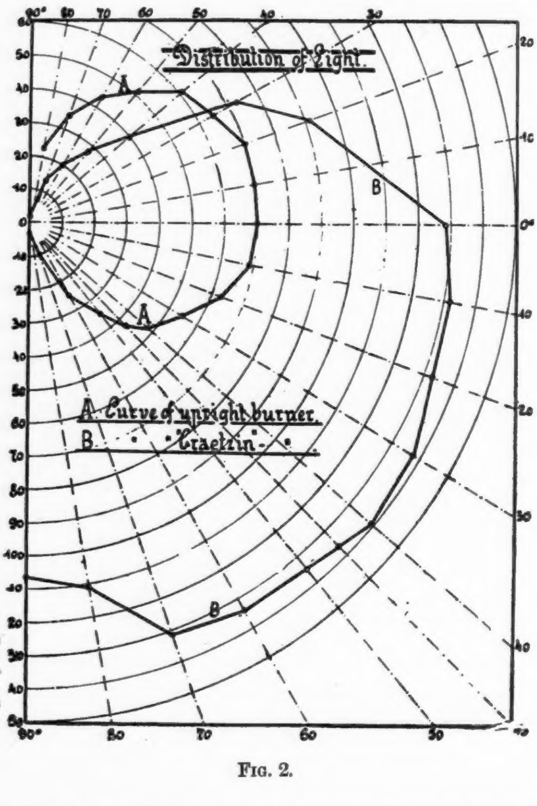


Fig. 2.

full control, while special precautions are also taken to prevent the possibility of the flame lighting back. Such a lamp, yielding about 110 H.K. in a horizontal direction, will consume 87–90 litres of gas. The nature of the distribution of light will be understood from Fig. 2.

the *Eros*, the *Saerular*, and the *New Auer Light*. The *Eros* light of J. HIRSCHHORN burns at a pressure of 23 mm., and the lamps can be arranged to include 1 to 5 mantles. The chief characteristics of the *Saerular* light are the horizontal outlet pipes, and the absence of any chimney, very

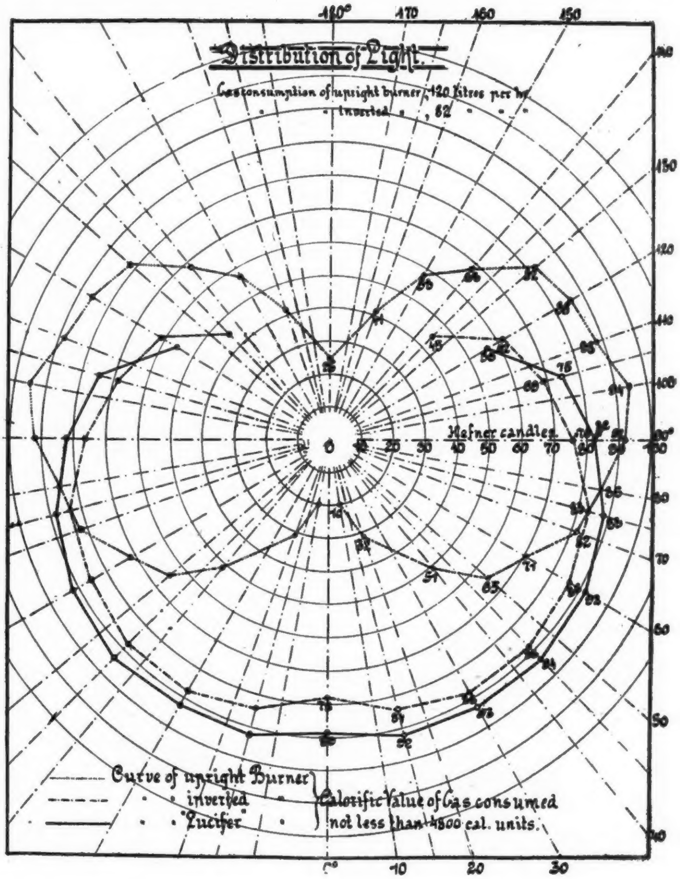


FIG. 3.

A similar form of lamp is the *Lucifer* type of R. FRISTER A. G., in which the absence of any chimney is worthy of note. This lamp yields an intensity of 90–120 H.K., with a consumption of 80 litres per hour. The nature of the distribution of light is shown in Fig. 3.

Other inverted lamps exhibited were complete combustion, at a pressure of 15 mm. being guaranteed. A single mantle yields about 120 H.K., with a consumption of 85–90 litres per hour. As many as 9 mantles, however, are placed in a single lamp, yielding in all 1,140 H.K. at a consumption of 800 litres of gas per hour.

Several varieties of the *New Auer Light* for indoor illumination are available, all utilizing a single mantle. The number of mantles may be increased for out-door lighting. The minimum pressure is in this case 28 mm.

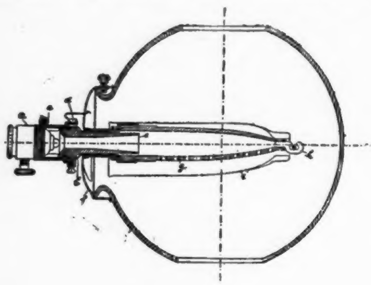


FIG. 4.

The mantles are comparatively small in size. The gases coming from the mantle pass out through two special chimneys, the lighting of the burner being carried out automatically by means of the special *Harras* device. Lamps intended for external illumination are made specially rain- and wind-proof, to guard gainst possible extinction of the pilot-flames utilized with them. When a single glass chimney is utilized with several mantles, a single pilot-flame can serve to light up all the group. According to the tests of the Reichsanstalt these lamps yield an intensity of about 110 H.K. with a consumption of 91 litres of gas per hour.

An entirely new type of lamp of exceptional interest is the *Tubus* burner of R. FRISTER, in which a horizontally placed mantle, arranged as shown in Fig. 4 is utilized.

Here *a* is the entrance gas-pipe terminating in the mixing tube *b*; *e* serves to regulate the air-supply. The globe *k* is held in position by *f*; *g* is the porcelain burner—the "tubus," with the small magnesia-hook *h*, and the mantle *i*. The flame is so arranged as to heat the horizontal mantle over its entire length, though naturally all portions do not appear equally bright. Instead of a clear or obscured globe, a special reflector is commonly utilized. The arrangement shown in Fig. 5 is specially intended for shop lighting, where the distinctive characteristic of a horizontal mantle is specially valuable.

The nature of the curves of distribution of light will be understood from Figs. 6 and 7.

In this interesting new system both the primary stream of sucked-in air, and the secondary air admission, are greater than in the case of the inverted burner. This is accomplished both by the absence of any marked upward draught and by the position of the mantle with respect to the air-inlet. As a result such lamps burn without a trace of smoking on a pressure of about 20 mm.

(*b*) In gas-lighting, as in other branches of illumination, there is very general tendency to demand "more light," and consequently a tendency to concentrate a great intensity in a single source of light.

This was formerly accomplished by mounting several mantles in the same globe, but the same end may be attained in another way, namely by increasing the dimensions of the mantle, and at the same time using correspondingly greater flames to bring them to incandescence. Apart from this we can also secure better results by making the flame-temperature higher.

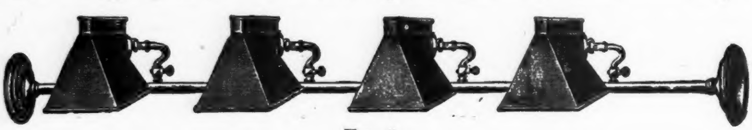


FIG. 5.

P. Lucas, ten years ago, had already discovered that the most perfect mixture of gas and air for this purpose was in proportion of one (by volume) of gas to six of air. In order to reach this condition the plan has been adopted of driving gas into the burner under pressure, and thus sucking in a correspondingly higher proportion of air; this method is exemplified in the *Graetzin* light, of the VIEL-LICHT GES.

Another method of obtaining the same result involves the admission of a supply of compressed air to the lamps, as occurs in the *Pharos* light of KLATTE & Co. of Hamburg. The *Pharos* system, it may be remarked, really makes use of *both* methods, utilizing both compressed air and gas at a pressure of 1,300 to 1,400 mm. of water. Both methods, however, demand special apparatus and arrangements, the latter even requiring a separate system of pipes for the conveyance of the compressed air. The most perfect solution of the problem would entail the design of a lamp which could be used on the existing pipes only, and generally would not require any further complication beyond the ordinary gas supply. This has been attained in the *Lucas Compressor* light of the STARK-LICHT GES.

The general nature of this ingeniously constructed lamp will be gathered from Fig. 8.

In order to obtain the desired proportions of gas and air, Lucas originally had recourse to long chimneys placed above the lamp. It was found, however, that the intensity could not be increased above about 500 H.K. without making the chimneys supplying the forced draught unduly long. He therefore constructed lamps in which the suction-effect was obtained from small hot-air motors fixed above the mantle. But these motors, unfortunately, were found to deteriorate with use.

Finally the construction shown is Fig. 8 was adopted. The gas enters through the regulator at *r*, passes through the cock *h* into the mixing

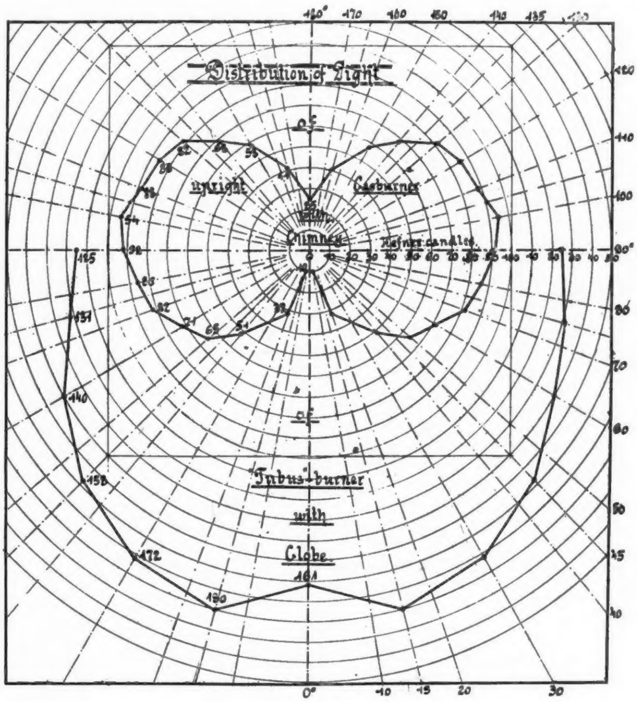


FIG. 6.

chamber *m*, and finally through the burner at *n*, and so, after heating the mantle, up the chimney. In this is fixed the thermopile *t*, the current generated in which is carried by the wires p_1, p_2, p_3, p_4, to *m*, a small electromotor, rotating about a vertical axis at a speed of 2,000 revolutions a minute. This motor is coupled directly on to a small fan, which creates the required draught. It is interesting to note that the lamp is an example of two great rivals, gas and electricity, acting in harmony. The height of the entire lamp is about 1 metre, and the diameters of the globe and reflector 0·4 and 0·65 metre respectively.

The lamps are rain- and wind-proof, and yield about 1,250 H.K. at a consumption of 1,000 litres of gas per hour.

Table I. gives some figures as to the relative costs of the various installations: the absence of any complete data as to the actual illumination of the display as a whole must, however, be regarded as an unfortunate omission on the part of exhibitors. Gas lighting was employed for the illumination of windows containing goods of very diverse character—for instance, hardware, linen, and silk goods, flowers, jewellery, &c.

The colour of the light emitted was practically the same in the case of all

TABLE I.

	Specifications.	"Eros." T. Hirschhorn.	"Pharos." Klatte & Co.	"Lucas." Stark Licht. G.m.b.H.	"Graetzin." Viel Licht. G.m.b.H.	"Graetzin." Ehrich & Graetz.
I. Initial Cost.	(*a*) A one-burner lamp for interior lighting ...	8·0[1]	70·0	...	6·0[4]	6·0[4]
	One lamp for external lighting	40·0	80·0	250·0	57·0	57·0
	One ceiling lamp	...	...	...	50·0	...
	One lamp mounted on wall of interior	70·0	...[3]	...	...	86·0
	(*b*) The whole installation ...	300·0	(2 + 1)230·0	(2)500·0	514·0	914·0
II. Wording Expenses.	(*a*) Consumption of 1 lamp or burner	90 lit.	0·065 & 0·12	0·13	90 lit.	90 lit.
	(*b*) Consumption of all inside lamps	1·71m.[3]	0·25 (b and c)	0·26 (b and c)	0·12	0·12
	(*c*) Consumption of all outside lamps	0·6m.[3]			0·06	0·06
III. Costs of supply per 1,000 burning hours.	(*a*) For 1 lamp inside window	1 mantle	0·05	0·14	0·30	0·30
	For 1 lamp outside window...	...	0·12			
	(*b*) For the whole installation	1 mantle	0·22	0·28	4·20	5·0
IV. Method of lighting-up.	(*a*) System	electric[2]	electric	by pilot flames	...	electric also for automatic extinction
	(*b*) Costs for 1 lamp... ...	5·50[2]	20·0			
	(*c*) Costs of the whole installation	104·50[2]	60·0			

[1] Complete with surrounding hanging glass rods for the dispersion of light.
[2] Without costs of installation and battery.
[3] Additional costs of complete apparatus for air compression, electrically driven, with motor, 1,100 marks.
[4] Small burners are also supplied for this type, complete, price 5 marks.
All prices are given in marks.

the lamps to which reference has been made, and though, as explained above, many different classes of goods were illuminated, the colours could, apparently, always be distinguished satisfactorily.

arranged in straight lines parallel to the window-front, in others lamps were mounted at intervals on the walls of the shop. In yet other cases a few powerful lamps were placed outside the window.

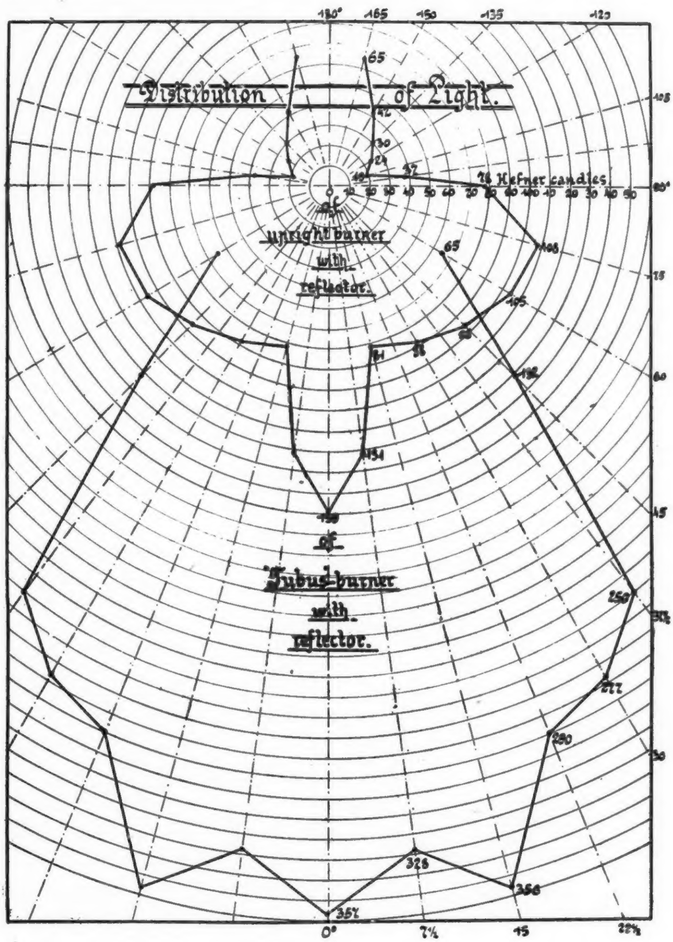


FIG. 7.

The different arrangements of the lights adopted illustrates the range of intensities now available, and the general flexibility of this system of lighting. Lamps varying in candle-power from 50 up to 1,500 were exhibited. In some cases lamps were

Special interest attaches to the systems of automatic lighting up exhibited, for, in the case of large establishments the lighting up of all the individual lamps in succession, one at a time, is distinctly inconvenient. On the other hand the increased cost of installation involved is not very great, considering the advantage to be derived as a result.

It may be remarked that the use of electrical ignition devices is another example of the two rivals—gas and electricity—working together to accomplish a desired result.

In what follows, therefore, we can afford to pass over the carbon lamps, and refer mainly to more recent types exhibited.

Mention may first be made of the forms of Nernst lamps exhibited by the A. E. G. Three distinct types of these lamps are now manufactured,

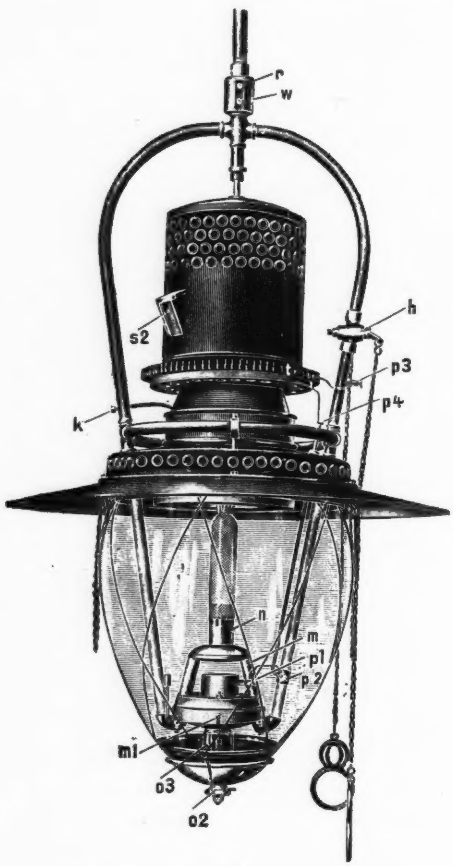


Fig. 8.

II. Electric Glow-lamps.

When walking in the streets one cannot but be impressed with the fact that the carbon filament lamp has all but disappeared; they have either been replaced by metallic filament glow-lamps or the small arc-lamps of recent introduction.

the B lamps, with horizontal glowers taking 0·25 to 0·5 ampères, and yielding 16 to 35 H.K., the larger A type, with vertical glowers, taking 1 to 2 ampères, and yielding 68 to 250 H.K., and the *Intensivlampe*, in which a set of carbon filament lamps are mounted in addition to the Nernst filament. These light up immediately the lamp is switched on, and are afterwards cut out of circuit when the Nernst filament lights up. The Nernst lamp consumes about 1·5 watts per H.K. The D.C. Nernst lamps must always be placed in the holder in such a way as to preserve the correct polarity; otherwise electrolysis results in the deposition of metallic magnesium on the kathode, which is subsequently oxidized, and results in the heaping up of material, and, ultimately, the destruction of the filament.

The *Osmium* lamp of AUER VON WELSBACH now consumes about 1 watt per H.K.; this lamp has already been described by Dr. H. Weber (*Illuminating Engineer*, No. 4, p. 297–301).

The consumption of the well-known and ingenious *Tantalum* lamp of MESSRS. SIEMENS & HALSKE, varies from 1·5. watts per H.K. to the higher value of 2·3. watts per H.K., in the case of the more recent type referred to by Dr. Weber (*ref. cit.*). These lamps are manufactured for pressures up to 120 volts, with a life of 800 to 1,000 hours. They are, however, subject to the drawback of not burning well on an alternating current circuit. Some of these lamps, equipped with a new type of fixture, are shown in Fig. 9. A similar arrangement, specially intended for shop lighting, is shown in Fig. 10. These lamps are made in three forms, A and B, yielding 12–25 and 32–50 H.K. respectively, and consuming 1·5–1·7 watts per H.K., and C, yielding 8, 10, or 16 H.K., and running at 2·1–2·3 watts per H.K.

The *Osram* and *Osmin* lamps, introduced in Germany and Austria respectively by the AUER COMPANIES, both involve the use of filaments of tungsten. The osram lamp (according to the tests of the Reichsanstalt) consumes 1 watt per H.K., and has a life of more than 1,000 hours, on the average, accompanied by a loss in candle-power of only 4 per cent. Three distinct forms of these lamps are also made: (1) For burning in parallel on 100–130 volts, yielding 25, 32, 50, and 100 H.K. respectively. (2) For series burning on 100–130 volts per lamp, and yielding 24, 26, 28, 30, 34, 36, 48, 52, and 54 H.K. (3) Low voltage lamps for use with accumulators on motor cars, railway carriages, &c.

As an illustration of the economies that may be achieved by the use of osram lamps, the company quote the following example:—

Assume the price of a kilowatt-hour to be 0·5 mk., and the carbon filament lamp and the osram lamp to take 3·5 and 1 watt per H.K. respectively. The watts consumed by a 32 c.-p. lamp will be 112 and 32 respectively. Therefore, during a single year, which corresponds roughly to 1,000 burning hours, 30 lamps would consume 3,360 and 960 K.W. hours respectively. The number of lamps required will be 48 and 30 respectively, and the cost of a lamp being 0·5 mk. and 3 mk. respectively, the total cost during the year will amount to 1,704 mks. and 570 mks. in the two cases. We should therefore save 1,134 mks. during the

FIG. 9.

year. The interest on the original price of 3 mks. would thus be paid off in the first 75 burning hours.

Unlike the tantalum and osmium lamps, the tungsten lamps could at first only be burned in a vertical position, for the adoption of the method of supporting the filament by winding it on a frame, was excluded by the patent of SIEMENS & HALSKE. More recently, however, lamps up to

FIG. 10.

50 H.K., capable of burning in any position, have been manufactured, and sold at an additional cost of 20 pfennigs each.

Another metallic filament lamp is manufactured according to the patents of Drs. Just and Hanaman of Vienna, and is made by the BAYERISCHE GLÜHFÄDEN FABRIK of Lechhausen (Bavaria). This, too, consumes about 1 watt per H.K.

Similar lamps to those already described are sold by the A. E. G. and the BERGMANN ELEKTS. GES., both of Berlin.

Among other metallic filament lamps now in practical use may be mentioned those of J. PINTSCH in Berlin and KREMENEZKY in Vienna, who work the patents of DR. KUZEL covering the use of rare metals in a colloidal condition.

GÜLCHER, of Berlin (D.R.P. 145,456, 145,457), also makes low-voltage iridium lamps intended for use on accumulators, and consuming 1·0 to 1·5 watts per H.K.

Zirkon lamps utilizing zirconium carbide, have also been constructed by HOLLEFREUND & Co., of Berlin, according to the German patents 133,701, 137,568, and 137,569, (Sander) and 140,323, 140,378, 141,353, 146,555, 147,233, and 147,316. According to

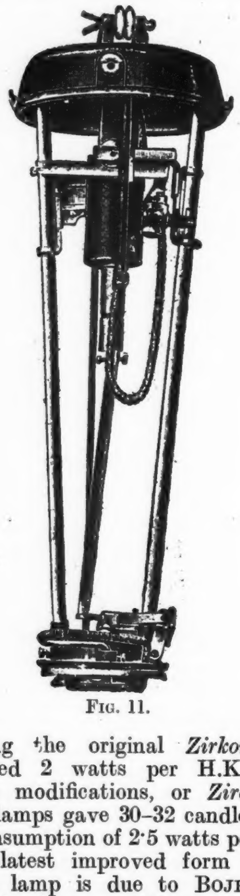


FIG. 11.

Wedding the original *Zirkon-lampe* consumed 2 watts per H.K. Subsequent modifications, or *Zirconium-carbon* lamps gave 30–32 candle-power at a consumption of 2·5 watts per H.K.

The latest improved form of zirconium lamp is due to BOJE, who, under the best conditions, secured a consumption of 0·3 watts per H.K., while a life of 1,000 hours was found possible coupled with a consumption of

1·0 watt per H.K.; during the first 500 hours the candle-power remained practically constant. Allowing a diameter of 0·6 mm., filaments so manufactured must be 55 cms. long for 110 volts, and lamps for this pressure require three single loop-filaments mounted in series.

Table II. shows the relative costs of the lamps which were exhibited at the Augur Exhibition.

Here again one feels that the absence of any complete data as to the actual illumination of the windows as a whole is unsatisfactory. Electric lighting by means of glow-lamps was utilized for 5 show-windows, and these again contained a very varied selection of goods. The illuminated windows contained leather work, boots and shoes — especially *white* shoes — linen goods, electric heating and ventilating apparatus, &c.

The whiter light yielded by the new glow-lamps, as compared with the old carbon filament ones, is a distinct advantage for shop lighting, where the ability of a light to bring out delicate shades of colour is often of paramount importance. The colour of the light yielded by them does not differ very greatly from that of the modern incandescent mantle, so that both can be utilized for the conditions, as far as the display of colour is concerned.

Here again, as in the case of gas lamps, we have only recently succeeded in producing lamps which can be burnt in any position. The older gas mantles were necessarily burnt in a vertical position. To-day we have the inverted burner, in which the position of the mantle is reversed, and the *Tubus* burner, which even burns in a horizontal position. With the exception of the tantalum lamp, the earlier metallic filament lamps likewise suffered under the disadvantage that they could only be utilized vertically, but this difficulty may now be said to have been overcome.

Naturally, for shop lighting this last quality is very essential, for in order to secure the most perfect effects we wish to be able to place our sources wherever they may be desired and in a vertical, horizontal, or slanting

TABLE II.

		Siemens & Halske Tantalum lamps.	Siemens & Halske Tantalum lamps.	A. E. G. Nernst lamps B	Bayer. Glühfaden Fabrik Just-Wolfram lamps.	A. E. G. Metallic Filament lamps.	Lion & Tugendhat. Bergmann metall. filament lamps.
I. Initial cost of Installation.	(*a*) For one lamp	Marks. 2·5	Marks. 3·0	Marks. 13·65	Marks. 5·00[4]	Marks. 3·00	Marks. 3·00
	(*b*) For the whole installation	45·00	80·00	111·80	30·00[5] 60·00[6]	279·0	240·00
II. Cost of energy per hour.	(*a*) For one lamp	0·0102	0·032	0·088	0·024	0·022	0·01
	(*b*) For the whole installation	0·12	0·256	0·704	0·480	0·040	0·24
III. Costs of Renewal for 1000 hours.	(*a*) For one lamp	2·5	3·00	4·00[3]	5·00	3·00	3·00
	(*b*) For the whole installation	30·00	24·00	32·00	100·00	54·00	72·00

[1] Two brackets carrying 12 lamps and fixtures.
[2] Ceiling illumination, 8 lamps, total intensity, 400 H.K.
[3] For 1 burner only: as is well known the *burner* only is replacable in these lamps, exactly as are the carbons in the case of arc lamps.
[4] Intensity of each lamp, 50 H.K.
[5] Two boxes carrying 5 lamps each, placed vertically on sides.
[6] Two boxes each carrying 5 lamps, placed horizontally on top, all costs reckoned in marks.

position as circumstances may require.

In these cases lamps hanging from the ceiling or mounted on wall-brackets, or arranged in cascade as shown in Fig. 9, were utilized. Some of the best effects, however, were secured by mounting the lamps in the manner of footlights in a theatre, either at the base, top, or sides of the window. Indeed a shop window may be said actually to represent a miniature stage, the people out on the pavement being the spectators, and it is natural that the methods which have proved most effective in the theatre should prove of value in this case also.

Electric Arc-Lamps.

The introduction of the differential arc-lamp only occurred in 1879, but the simple electric arc between two carbons was known long before, as far back as the experiments of Davy, and of Deleuil, who for the first time undertook public illumination by this method in 1844. In all such cases two vertical and co-linear carbons were employed; many other varieties and shapes of carbons were, of course, attempted — cylinders, plates, discs, &c.—but none found their way into practical use.

In 1898, however, Bremer began his experiments on this subject, experimenting in a comparatively new field, and using carbons of a variety which have since proved of the greatest practical use, and which I have classified as "electrodes of the second order."* These form the basis of the so-called "flame" or "chemical" carbons of to-day. Bremer's success was due to the fact that he not only applied the results obtained by earlier workers in this field, but added devices of his own contrivance. As a result he eventually brought out carbons yielding light of some special spectral composition, and at a vastly more efficient rate than previously. His carbons were distinguished both by the characteristic yellow light they gave and the unusual length of arc adopted.

A special company, the Deutsche Gesellschaft für Bremerlicht, was formed to exploit his inventions, and other German firms were soon forced to co-operate. In a short time a number of flame-arcs came into use, all, however, possessing the same radical characteristics as the Bremer arc. This revolution in methods of arc-lighting may be said to have commenced at the beginning of the new century in 1900. The old system of vertical carbons is now being completely replaced by carbons of the inclined variety, both for flame carbons and for the ordinary kind. The new system of inclined carbons has not only enabled a higher P.D. to be employed across the arc—a distinct advantage when the loss of pressure in additional resistance on many circuits is borne in mind—but has also resulted in improved efficiency, due to the avoidance of the loss of light occasioned by the lower negative carbon and a greatly improved distribution of light.

Another kind of improvement in arc-lamps followed the Bremer type of arc-lamp. In 1894 to 1895 Niewerth of Berlin tried to manufacture arc-lamps intended for small currents of 1 to 2 amperes. However, he met with but small success, partly because, in the case of an open arc-lamp such as he employed, the area of cooling surface was too great in proportion to the small currents employed. Steadiness in an arc-lamp is only attainable when a comparatively high temperature can be maintained especially in the neighbourhood of the crater.

The problem of the small-current arc-lamp was finally solved by A. Rignon in 1902, and subsequently by Siemens & Halske, who introduced the *Lilliput* arc in 1903. These two lamps were followed by a succession of others of the same general nature, the *Mignon, Miniatur, Perkeo, Piccolo, Luna, Regina, Baby*, &c., lamps, as they were termed according to the nomenclature of the countries in which they were brought out. All these

* 'Verhandl. deutsch. physikal. Gesellsch.' 5, 157 to 176, 1903; 'Das elektr. Bogenlicht s. Entwickelung u. s. physikal. Grundlagen,' p. 468, &c., 1904-1905.

lamps employed currents in the neighbourhood of 2 to 3 amperes. The explanation of this success lay in the reversion to a form of small arc-lamp, of such dimensions as to avoid the excessive cooling of the electrodes that had proved detrimental in the case of the earlier lamps. In these lamps the old form of vertical and co-linear carbons has been universally adopted.

Another type of lamp, intended to be intermediate between the ordinary open and enclosed arcs, was the so-called *Economy* lamp (Sparlampe). In these lamps the admission of air to the electrodes was limited, and carbons of relatively small diameter were employed. As a result the advantages of both open and enclosed lamps were obtained in some measure. The range of current for which they are made is in the neighbourhood of 4 to 5 amperes; lamps of this kind are built by most important modern firms of the present day.

Having dealt briefly with the recent history of the arc-lamps, let us now turn to the exhibits at the Augur exhibition :—

(*a*) SIEMENS & HALSKE equipped a window with flame arcs yielding a yellow light. Flame-arcs were also utilized by the CARBONE - LICHT-GESELLSCHAFT. The mechanism of these lamps resembles that of the high-voltage flame arcs, to which reference will be made later. KÖRTING & MATHIESEN, whose well-known *Excello* lamps utilize the Bremer patents, also exhibited, but not in the display of shop-window lighting. These lamps are made for direct currents of 6, 8, 10, 12 amperes, and 44, 45, 46, and 47 volts respectively. WEINERT of Berlin likewise exhibited intense flame arcs intended for currents of 6 to 15 amperes, and 45 to 47 volts.

A singular form of lamp was exhibited by the BECK BOGENLAMPEN GESEL. of Frankfürt, which was supposed to solve the problem of the arc-lamp mechanism, by dispensing with it entirely. A mechanism of this kind is usually regarded as necessary in order to correct for the slow burning away of the electrodes and the variations of pressure of the circuit; in my opinion a lamp without some such arrangement would be an impossibility.

The general nature of this lamp, however, will be gathered from Fig. 11. A series coil is caused to attract an iron core, and so, by a special lever arrangement, to actuate two inclined carbons. It can be seen at once, therefore, that this cannot really be described as a lamp without mechanism, though it is true that the mechanism is of a simple nature. It might, perhaps, be described as a "lamp without clockwork."

The length of the arc being maintained rigidly constant no compensation can be made for small variations in current due to want of homogeneity of the carbons, and therefore fluctuations in the light given by the lamp would occur, were it not for the balancing metallic resistance in series with the arc, acting on similar lines to that utilized in the Nernst lamp. A diminution in the resistance of the arc tends to increase the current, but this is checked by a corresponding increase in the compensating resistance.

The lamp is intended for series-burning, the length of arc being rigidly regulated so that the P.D. maintained constant. The lamps are made for currents of 8 to 12 amperes, and pressures of 42 to 47 volts. According to the results of Wedding they run at a consumption of 0·163 watts per H.K. Special combination lamps are built for very high intensities up to as much as, perhaps, 30,000 H.K., utilizing four distinct lamps within a single case.

(*b*) The next group of arc-lamps exhibited which claim attention are the *High - Voltage Open - type* lamps. The problem of producing a satisfactory high-voltage arc has often been attempted, but until recently without any satisfactory solution. The question has been again taken up, however, and this time with better result, in the development of the *Excello* arc. These lamps are specially well adapted to show-window illumination because of their strong intensity in a downward direction, which allows the lamps to be placed, out of sight at the top of the window behind a screen of diffusing glass. This plan was adopted as early as 1877 in the Grands Magasins de Louvre in Paris. The colour of the light, however, was regarded as a disadvantage, and in 1905 KÖRTING & MATHIESEN introduced their "Ideal Form of Show-

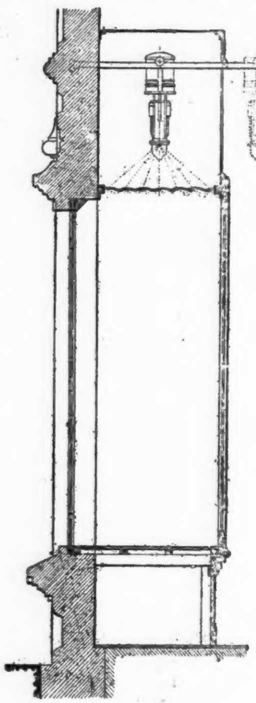


FIG. 12.

Window Illumination," in which lamps of the same character were utilized, but carbons yielding as far as possible a *pure white light* were employed. A special modification of the deflecting magnet was also introduced which blew out the arc into a globular form, instead of the crescent-shaped form previously employed, the new lamp being termed the *Excello-Globe-Flame* arc-lamp. The same device had been previously adopted by F. L. CARBONE in 1901 (German Patents, 141,675, 147,764, 148,878, 150,736).

The exhibit of KÖRTING & MATHIESEN, which is shown diagrammatically in Fig. 12 and 13, was an excellent example of this method of shop-window lighting. The window was filled with metal-ware. In Fig. 12 the arcs are shown suspended above the diffusing sheets of glass in the manner previously explained. It will be seen that they are completely screened from the eyes of the customer, throw the light where it is wanted, on the goods themselves, and produce a very satisfactory diffusion of the light. The lamps are suspended on rollers of the kind shown in Fig. 13, and can easily be withdrawn for recarboning, &c., without interfering with the contents of the window in any way. A lamp removed for this purpose is shown dotted in Fig. 12.

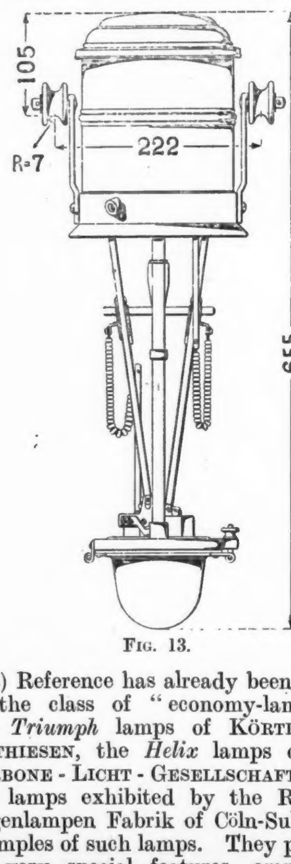


FIG. 13.

(*c*) Reference has already been made to the class of "economy-lamps": the *Triumph* lamps of KÖRTING & MATHIESEN, the *Helix* lamps of the CARBONE - LICHT - GESELLSCHAFT, and the lamps exhibited by the Regina-Bogenlampen Fabrik of Cöln-Sulz, are examples of such lamps. They present no very special features, employing vertical co-linear carbons, mechanisms of the ordinary variety, and running at about 3 to 5 amperes and 84 volts.

(*d*) Finally, we may mention the miniature arc-lamps, which were represented by the *Miniatur* of KÖRTING & MATHIESEN, and the *Reginula* of the REGINA BOGENLAMPEN FABRIK.

Some particulars of the cost of the various exhibits are given in Table III., exactly as was done in the case of the earlier sections, I. and II.

The CARBONE-LICHT-GESELLSCHAFT exhibited two windows. The first of these could be illuminated by either of two systems or by both conjointly. In this case high-voltage open lamps were erected on the ceiling inside the shop, and two *Radiante* lamps without. In the second window flame arcs were employed.

In all six windows were illuminated by means of arc-lamps. Among the classes of goods illuminated mention may be made of a dinner-table completely equipped with cloth, dishes, and the usual paraphernalia, boots and shoes, silken goods, &c.

When designing to illuminate shop windows with arc-lamps we must, of course, consider whether the variety of light yielded by them will be agreeable or the reverse. The yellow character of the light yielded by many flame lamps, for example, is generally considered to be unsatisfactory when any very delicate shades of colour are to be illuminated. In such a case a high-voltage open lamp specially designed to this end should be used.

On the other hand, when we are dealing with very striking and pronounced colours the colour of the flame-arc is less objectionable—may, indeed, even be of advantage in cases in which it is desired to bring out certain colours. The majority of enclosed arc-lamps and miniature lamps give light of a more or less blue tinge, and therefore tend to accentuate this shade of colour. One would, there-

TABLE III.

		Regina Bogen Lamp Fabrik. 4 "Heller" Lamps.	Regina Bogen Lamp Fabrik. 4 "Reginula."	Siemens & Halske. Flame Arc Lamps (yellow).	Carbone Licht Ges. High voltage open arc lamps (2).	Carbone Licht Ges. 2 "Radiante."	Carbone Licht Ges. Flame arc lamp (yellow).
I. Initial costs of Installation.	(*a*) Of one lamp	60	46	88	80[2]	47[2]	82[2]
	(*b*₁) Of the whole installation, inside illumination...	120	200	188[1]	160[3]	94·0[3]	164[3]
	(*b*₂) Ditto, outside illumination... ...	160					
II. Cost of energy for one hour.	(*a*) For one lamp	0·22	0·11	0·176	0·35	0·22	0·22
	(*b*₁) For the whole, inside illumination	0·44	0·44	0·352	0·70	4	0·44
	(*b*₂) Ditto, outside illumination... ...	0·44					
III. Renewal expenses for 1,000 burning-hours.	(*a*₁) Glass ware and accessories ...	2·00	2·00	28·0	10·0	1·2	23 0
	(*a*₂) Electrodes	2·50	2·40				
	(*b*₁) Installation glass ware, &c. ...	8·00	8·00	—	20·0	2·4	46·0
	(*b*₂) Electrodes	10·00	9·00	—			

[1] Inclusive of resistance.
[2] Intensities of respective lamps, 1,600, 800, and 3,000 H.K.
[3] Total intensities of respective entire installations, 3,200, 1,600, and 6,000 H.K. respectively.
All costs are reckoned in marks.

fore, also exclude the use of these lamps in cases where very delicate shades are to be distinguished. They may, however, be used very successfully for the illumination of a window containing only white goods.

A new and interesting colour-device was shown by the A.E.G., in which the colour of the light coming from above was changed in some manner invisible to the customer on the pavement, the window being flooded with light of any character at will. I understand that the effect was not, in this case, produced by the use of coloured glass, but by reflection from coloured surfaces, driven by an electromotor.

gas lights have also placed gas in a very much more favourable position as regards general convenience in comparison to electricity than was formerly the case, and at a very slightly increased cost.

In short we are in a position to produce any special effect that may be desired by either illuminant. The difference in colour between modern mantles and metallic filament lamps is also not great enough to give either illuminant any very decided advantage. On the whole, therefore, it appears that when the choice is limited to these illuminants, the matter will be settled mainly by the actual

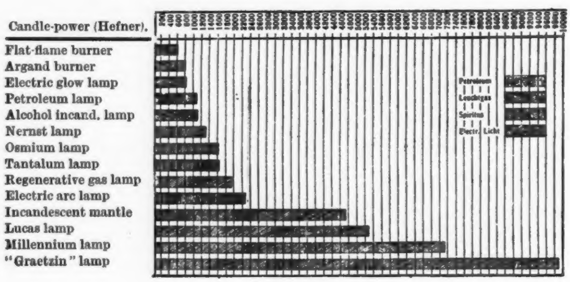


FIG. 14.

costs in the two cases. Naturally it is impossible to lay down any very definite rule as regards this point; the relative economy of the two systems; depending on the costs of gas, and electric energy, the P.D. of supply, and other local circumstances.

In the case of arc-lamps the same general observations apply, except that the cost of light-production is, in general, considerably lower, and that the question of colour becomes of greater importance.

In Fig. 14 is shown the relative economy of a variety of illuminants, as stated by the Viel-Licht-Gesellschaft, on the basis of the intensity of light available, for one hour at a cost of 1 mark.

CONCLUSION.

In the case of both electric and gas incandescent lamps, it may be said that there is ample choice for the purpose of shop-lighting, and that both systems of lighting present sufficiently diverse types of lamps to meet any requirements that are likely to occur. In both cases fixtures and lamps are available which can be burnt hanging from the ceiling, mounted on the walls, or as concealed lamps in the foreground of the shop, and in both cases lights giving the desired range of intensity and form of polar curve of distribution of light.

The improvements in methods of automatic lighting up and extinguishing

Some Examples of Shop Lighting by Gas.

RECENT numbers of the *Journal für Gasbeleuchtung*, &c., contained some description of the gas-lighting exhibits of Messrs. Ehrich & Graetz and the Pharos Licht-Gesellschaft at the Berlin Augur Exhibition, and we are indebted to these two firms for the illustrations accompanying our reference to this section of the exhibition.

We have already laid stress upon the desirability, in lighting shop windows, of separating the purely advertising functions of the sources of light placed outside the shops and the qualities which enable them to effectively illuminate the goods in the window. For this latter purpose it is essential that the sources themselves should be either concealed from view or, as far as possible, placed in such positions as not to interfere with the vision of the customer on the pavement. Other critics besides Dr. Stockhausen seem to have been struck by the fact that many of the exhibitors in the Augur display indulged in needless extravagance in the amount of light used, and, moreover, utilized this light in such a way as to dazzle the eyes of the customer. The method adopted by Messrs. Ehrich & Graetz is intended to attain the desired results by concealing the lights actually intended to illuminate the goods behind some ornamental and semi-transparent device such as that shown in Fig. 1. In this connexion they give the following table illustrating the relative costs of energy of gas of various types of lighting exhibited.

In a recent article dealing with the Pharos-Licht exhibit, however, it is explained that the figure given for the Pharos system in the above table ought by rights to be divided by two, for it is calcuated on the assumption that two lights are employed to illuminate the window, whereas one single amp suffices.

In the article to which we are now referring (*J. f. G.*, April 11th, 1908) the main points to be attended to in an effectively illuminated shop window are stated as follows :—

1. The goods themselves must not be injured by the sources of light by means of which they are illuminated (*e.g.*, their colour must not be caused to fade or the material injured by noxious fumes given off by the illuminant, &c.).

2. The goods must be so lighted that every object must appear to the observer completely illuminated by light striking it from the front.

TABLE I.

Name of Lamp.	System of Lighting.	Cost of Gas or Electricity per Hour.
Graetzin Light	Inverted incandescent mantles	15 pfennigs.
"	Inverted incandescent mantles	17 "
	Electric glow lamps I.	24 "
Pharos Light ..	High-pressure incand. gas lamps	25 "
Tantalum Lamp	Electric metallic fil. glow lamp	25·6 "
Lucas Light ..	High-pressure incand. gas lamps	26 "
Eros	Inverted incandescent mantles	29 "
Carbone ..	Electric arc lamps ..	44 "
Reginula ..	Electric arc lamps ..	44 "
	Electric glow lamps ..	48 "
Nernst Lamp ..	Electric glow lamps ..	70·4 "
Regina	Electric arc lamps ..	88 "

3. The method of lighting must not give rise to much heat within the window, otherwise a deposit of moisture will be formed on the panes in winter, which will prevent the contents of the window from being clearly seen.

Although these conditions were not actually specified by the authorities at the Augur exhibition, the author claims that they are nevertheless essential when very fine and easily damaged goods are to be illuminated. Moreover, in many such cases it is even desirable to enclose the precious goods within an air-tight and dust-tight enclosure.

In view of these considerations the Pharos Co. adopt either an external system of lighting by a single lamp, or interior lighting by two lamps. But in either case, as will be seen from the alternative methods shown in Fig. 2, precautions are taken to secure that actual productions of combustion, &c., cannot injure the goods, by keeping the actual sources of light outside the enclosure containing them. The first method of illuminating the shop window from the front by a single 2,000 H.K. lamp, costing about 12 pf.

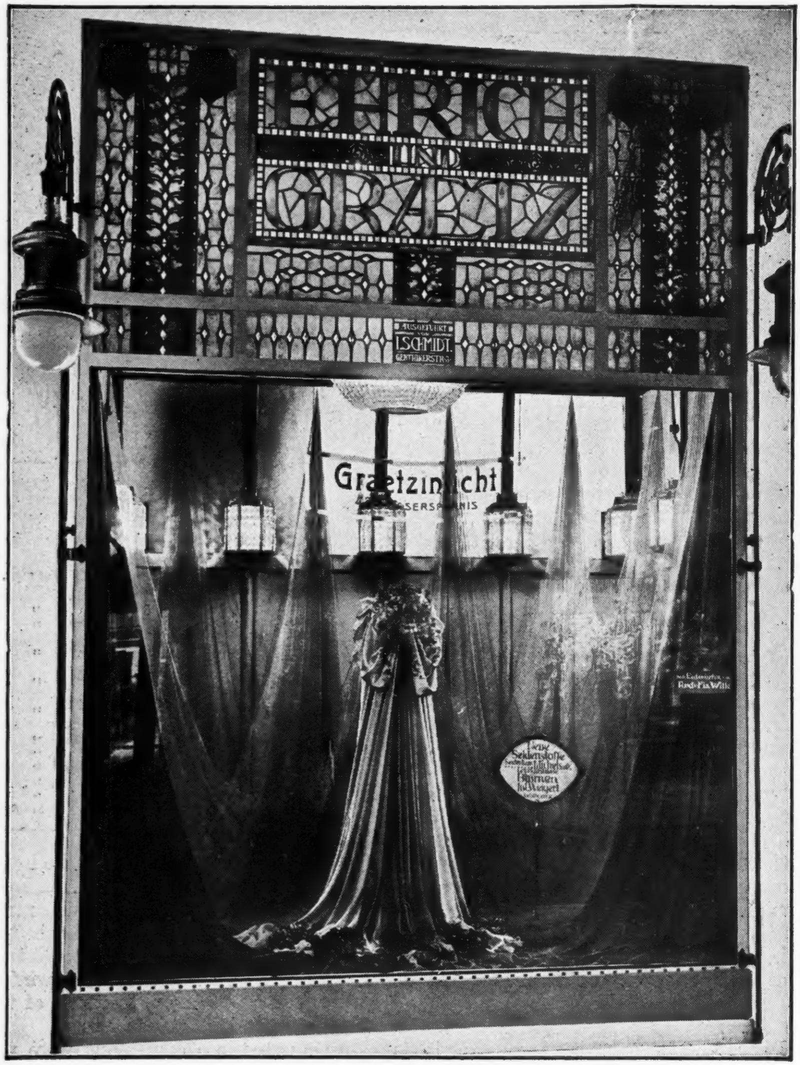


FIG. 1.

per hour is, however, almost invariably adopted. Other examples of shops so lighted are shown in Fig. 3.

In this way, it is claimed, the required conditions are complied with. The Pharos Licht Co. also claim that the method of illuminating goods from the front is advantageous, because it avoids the possibility of the goods themselves throwing shadows, and so interfering with the appearance of the window. In order to secure that lights placed outside the shop in this way should not dazzle the eyes it is customary to provide them with globes which are partially obscured on the side facing the street, but clear on the side facing the window.

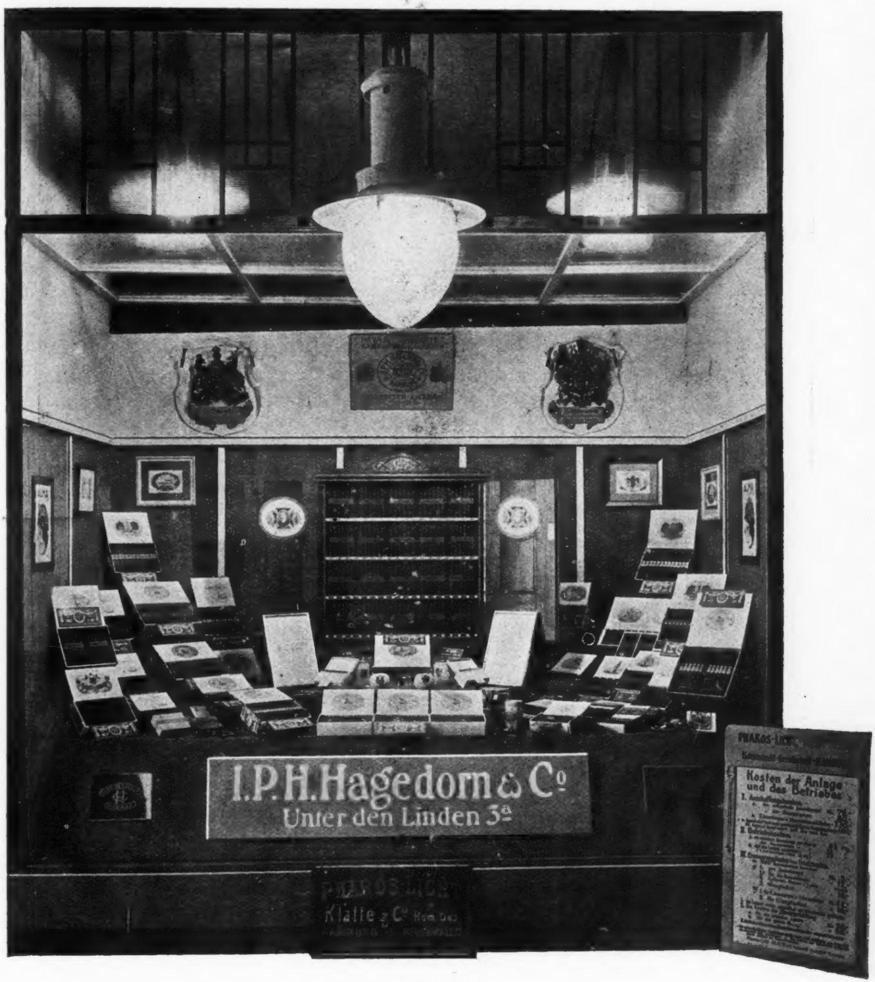


Fig. 2.

Fig. 3.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Why Light is Believed to be a Vibration, and what it is that Vibrates.

(Two Lectures delivered by PROF. TROUTON, M.A. D.Sc. F.R.S., at the Royal Institution, May 12th and 19th.)

IN these two lectures Prof. Trouton traced the gradual development in the theory of light. It was, he said, peculiar that this development originally started on what are now considered to be correct lines, and yet afterwards wandered off, for a century, into what now seem impossible directions.

Strange to say, it was the overwhelming authority of Newton that was responsible for these incorrect conceptions. Newton adopted the view that light was due to luminous particles being continually projected from the light-giving surface. Previously Huyghens had put forward the wave-theory of light, and we to-day rely on a theory of this description. But the waves suggested by Hughens differed materially from those we now recognize. He believed that these waves vibrated longitudinally, in the actual direction of transmission. Nowadays it is believed that light-waves act *transversely, i.e.*, at right angles to the direction of propagation.

Assuming, therefore, that light vibrates in this way, what differences must be looked for in ordinary waves of light? They may, firstly, succeed each other at longer or shorter intervals, and secondly, they may vary in amplitude. The first of these qualities settles the "pitch" or colour of the light, the second determines its intensity. Two kinds of light would therefore appear to be identical, if they possess exactly the same colour and exactly the same brightness.

There is, nevertheless, yet another quality of light-waves which must be taken into account. This new property is *direction of vibration*. We have stated that light consists of vibrations in a direction at right angles to that in which they are travelling, but there are many such directions. We have not as yet mentioned whether the vibrations all take place parallel to each other in a certain plane, or whether they may take any direction provided only that they are perpendicular to the ray. Both varieties of vibration may exist. Meantime we may note that on this fact depend certain properties of the ray of light, for which Newton, reasoning from the idea of longitudinal waves, was quite unable to account, and therefore turned to his emission theory.

Huyghens applied his theory to explain the double-refracting properties of many crystals, but could not explain why the rays should travel faster in one case than the other. The explanation of this effect was only realized when the idea of transverse waves was introduced.

An important link in the chain of evidence to prove that light consists of transverse vibrations, demonstrated by Young, lies in the fact that waves can be timed so to arrive at a given surface as to reinforce their mutual action in some regions, and to neutralize it in others. Thus, when light of a given wave-length is reflected from a film of oil spread over water, there are certain places where the light appears to be reflected, and others where it does not. The location of these regions depends upon the thickness of the layer of oil. If the thickness at any point happens to be just enough to enable the light-waves reflected from its upper and lower surfaces to arrive in time, and to reinforce each other, we get light. If, on the other hand, they arrive in exact opposition, the crest of the one wave over the hollow of the other and vice versa, we get darkness. And the calculated thickness of the film resulting in these patches of light and darkness can be verified by exact measurement.

Another class of phenomena which afford no little insight into the mechanism of light-propagation is that of light-shadows. One of Newton's arguments against the wave-theory rested on the assumption that if light were of this nature, there ought to be no shadows; and that light ought to be able to turn corners, just as occurs in the case of sound. Yet we know from common observation that light travels in apparently straight lines, and does not seem to be able to turn corners to any appreciable extent.

Actually, however, if the action of light passing over a very sharp edge is studied scientifically, we find that there *is* a small amount of bending possible, but only to a degree commensurable with the extreme smallness of the wave-length of light. This ability of light to turn corners is so completely explicable on the basis of the wave-theory as to afford another excellent means of measuring the wave-length of light.

In a second lecture Prof. Trouton returned to the discussion of the exact nature of the transverse vibrations of which light-waves consist. Such vibrations may be confined to one plane, and we can prepare crystals, which allow such a beam of "plane-polarized" light to pass through in one position, but completely obstructs its passages in a position at right angles. The specially constructed "Nicol-prism" serves this purpose.

Such a beam of light has also the peculiar property that it fails to be reflected when striking a reflecting surface at a certain angle. A number of slides were shown by the lecturer illustrating the behaviour of polarized light passing through selenite and other crystalline media. Glass, when subjected to strain by being squeezed, shows similar effects.

All these phenomena can be so completely explained on the basis of the wave-theory as to justify our belief in the transverse vibration of light. The question remains what exactly is it that vibrates?

It has been conjectured that light-vibrations are transmitted by the aid of an absolutely all-pervading substance known as the "ether." Much information has been obtained as to the properties of such an "ether" by the study of electrical phenomena, which being, like light, transmissible through space, demand the assumption of the existence of some such peculiar transmitting medium.

At one time it was supposed that there were five distinct ethers, but Maxwell was able to show that it was only needful to suppose the existence of one single ether, equally capable of transmitting light and electricity. Subsequently the practical work of Hertz fully confirmed Maxwell's suggestions. Hertz was able to produce electric waves, of the same nature as those used to-day in wireless telegraphy, and to show that these waves could be reflected and refracted, polarized, &c., just as in the case of light. They were, in fact, merely light-waves of very great wave-length.

The analogy between electric- and light-waves also enables us to settle one point as regards the vibration of the latter, on which some doubt was previously felt to exist.

When a beam of plane-polarized light refuses to be reflected, is this because the vibrations are parallel to the reflecting surface, or because they are perpendicular to it?

Now in the case of electric waves we have no difficulty in deciding the direction of vibration from the line of the discharging apparatus radiating waves. And, in the case of such waves, we find that the direction of vibration must be parallel to the surface in order to secure the best reflection, and conversely perpendicular to the surface in order that the light reflected may be a minimum.

Finally, therefore, we arrive at the conclusion that light is a vibration propagated in the same medium as that in which electric phenomena arise. Electricity, it is becoming increasingly evident, plays a very important part in natural phenomena. It may be that matter, and even the ether itself, may ultimately prove to be but a manifestation of it.

On the Temperature of Incandescence of Glow-Lamps.

By K. Sartori.

(From *Elektrotechnik und Maschinenbau,* March 22nd, 1908.)

Although we have succeeded in producing satisfactory metallic filament glow-lamps running at a much higher efficiency than the carbon filament lamps used to do, yet the exact explanation of this improvement is far from clear.

In considering this subject we must first understand the nature of the physiological perception of light on which our impressions of brightness are based. The human eye is most sensitive to the central region of the spectrum, in the neighbourhood of the green-yellow, corresponding to the lines D and E. This appears to be a consequence of the fact that the eye has developed in such a way as to use daylight to the best advantage. At the enormous temperature of the sun—estimated at about 6000 degrees—the maximum amount of energy is situated in a region of the spectrum very closely approaching that for which the maximum sensitiveness of the eye occurs. The high efficiency of many flame-lamps may be ascribed to the fact that a line-spectrum is super-imposed over the main radiation, so that several very bright lines are added in this favourable region of the spectrum. This method of improving the efficiency of radiation of a source is, however, excluded in the case of glow-lamps, for incandescent solids which do not yield line-spectra.

In Fig. 1 is exhibited the distribution of brightness in the solar spectrum as determined by Frauenhofer. In this curve the abscissæ represent the wave-lengths of the spectrum and the ordinates the intensity. The maximum sensitiveness occurs, as previously stated, in the yellow-green.

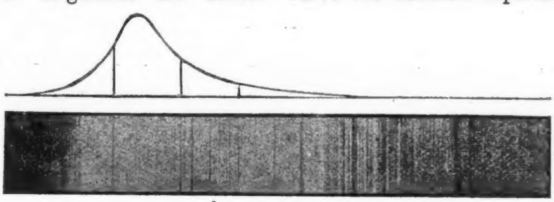


Fig. 1.

Fig. 2 represents the energy-curve of the prismatic solar spectrum, as determined by Langley. In this case the values of the intensity of the energy of radiation measured by means of a bolometer, are taken as ordinates.

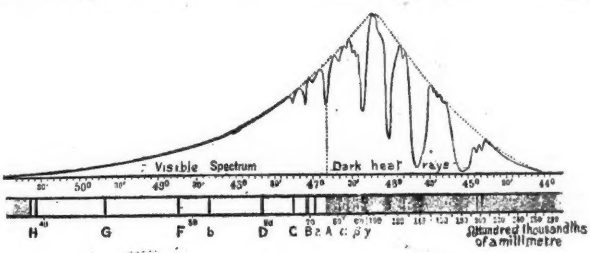


Fig. 2.

The corresponding curve for a grating-spectrum is shown in Fig. 3. Although referring to the same source of light as Fig. 2, namely the sun, it will be seen that the shape of this curve is very different.

This arises from the fact that a prism

does not refract all rays according to the same law, but disperses those rays more effectually, which lie towards the blue-violet end of the spectrum. In consequence of this property of the prism, which is termed anomalous dispersion, the less easily refracted rays are crowded together, and the energy-maximum does not occur at the correct point. The grating, however, is quite free from this peculiarity, and hence the different nature of the curves in the two cases.

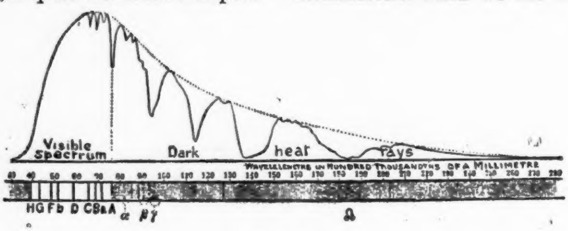


FIG. 3.

In the case of the sun, then, the energy-maximum and the position of maximum sensitiveness of the eye coincide. But the temperature of ordinary sources of light is far too low for this to occur. By increasing the temperature we bring the position of the energy-maximum nearer to the visible range of radiation, but even at such a temperature as that of molten platinum the maximum still falls far without the visible range. How great is the difference in the behaviour of this radiation and that of the sun is shown in Fig. 4. Fig. 4 represents the distribution of energy in the spectrum of the sun and the Violle standard respectively, the visible range of radiation being left blank, and the other invisible portion of the spectrum shaded.

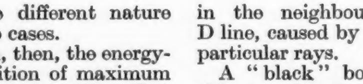


FIG. 4.

According to the law of Kirchoff, a heated body is in a position to radiate just those rays which it can also absorb. For this reason a bunsen-flame appears non-luminous. It is transparent to visible rays, and therefore it cannot radiate them. If, however, we place a little common salt in the flame it becomes coloured with the characteristic yellow tinge of the sodium flame. In virtue of this fact the flame is now opaque to rays of this colour. If, therefore, we place a sodium flame between the slit of a spectroscope and a brightly incandescent solid we see a dark band in the neighbourhood of the sodium D line, caused by the obstruction of these particular rays.

A "black" body is a body which is able to absorb all radiation impinging upon it, and is, therefore, also able to give out all these varieties of radiation. Such a body must tend to be uneconomical from the point of view of light-production, because it will give out many varieties of radiation which are invisible.

On the other hand, bodies which radiate "selectively," *i.e.*, show a marked preference for giving out certain kinds of radiation, may be more efficient light-producers than black bodies, if they happen to prefer to radiate energy lying within the visible spectrum.

In general, a brightly polished metal will, at a given temperature, glow more brightly than one with a dull black surface. (This was illustrated by an experiment with black and brightly polished platinum. When the strip was brought to incandescence by means of an electric current it became evident that the brightly polished portion glowed the brighter.) Herr Sartori then proceeds to describe an experiment of Melloni's, in which it was shown that a brightly polished metal surface had to be heated to a temperature of 800 degrees in order that it might give out the same total radiation as that yielded by a corresponding blackened surface at a temperature of only 100 degrees. Magnus has also found that the selective radiation of an object is affected by the quality of the surface.

One very important law of radiation is that of Wien, which is essentially as follows:—

$$\lambda_m \cdot T = \text{Constant}.$$

Where λ_m is the wave-length corresponding to the maximum of the energy-curve, and T the absolute temperature. The constant varies but little in the case of different substances. Lummer has found the values 2940 and 2630 for a black body and bright platinum respectively. According to Wien's relation the temperature of the sun should be—

$$T = \frac{3000}{0 \cdot 5} = 6000 \text{ degrees (abs.)}$$

By the aid of this law it is possible to form a fairly correct idea of the temperature of a body from the nature of its radiation, but for this purpose it is essential, for the reason mentioned above, that a grating-spectrum should be utilized.

The author has undertaken some experiments with the object of comparing the temperature of incandescence of carbon and metallic filament lamps. For these experiments he at first used a Zeiss grating having 14,400 lines to the inch. The dispersion of the grating for the visible portion of the spectrum was about 13 degrees, and sufficed both to clearly separate the two sodium D lines, and to enable other fine lines to be perceived between them. In spite of the excellent optical properties of the grating, however, it proved to be unsatisfactory for the purpose in view, because the energy which could be focussed upon the bolometer was too small to enable reliable readings to be obtained. Eventually, therefore, the author decided to return to the less satisfactory prism apparatus. A Cook spectrometer was utilized, the flint glass prism employed in this apparatus being, however, exchanged for one of crown glass, giving less dispersion but greater energy. In place of the eyepiece of the telescope a bolometer was fitted, and by this means it was at length found possible to obtain reliable results; the apparatus is shown in Fig. 5.

The energy curves of a 3·5 watt per H.K carbon filament lamp, and a metallic filament one taking 1 watt per H.K., were then studied, and it was found that the maximum was distinctly nearer to the violet end of the spectrum in the case of the carbon filament lamp. Applying the law of Wien, therefore, it would seem that the temperature of incandescence of the carbon filament lamp was the higher of the two.

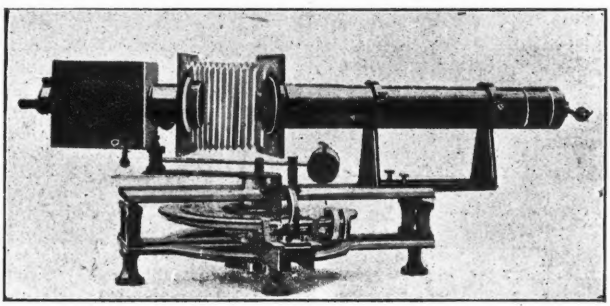


FIG. 5.

Nevertheless, one would certainly exercise caution in concluding that this is the case, because there are many other facts which suggest that the great efficiency of these lamps is to be ascribed to their high temperature. On the other hand, the researches of Melloni make it evident how greatly the radiation of metallic surfaces differs from that of carbon. Dr. Blau has also maintained that the metallic filament lamp, together with a lower energy-consumption, has a greater radiating surface than a carbon lamp, and that a lower temperature is thereby automatically reached in the former case. Dr. Grau, it is true, has arrived at the result that the temperature of metallic filament lamps is the higher, but it must be noted that he utilized an optical pyrometer for his measurements. The result he arrived at is, therefore, hardly surprising—is, indeed, the only one possible—because this method of measurement assumes that a higher intensity of radiation of any specified portion of the spectrum is a criterion of higher temperature ; this, of course, is the acutal question, the solution of which is being attempted.

In the discussion of the paper Prof. Grau inquired whether Herr Sartori was able to estimate the supposed difference of temperature between the two lamps. Herr Sartori replied that he was not in a position to say exactly to how a great difference of temperature the actual angular difference of thirty minutes on the spectrometer corresponded, because, for the reason previously mentioned, the prism apparatus utilized by him was not adapted to the measurement of absolute temperature.

Prof. Grau remarked further that Lummer's researches had placed the temperature of the carbon filament lamp near 2100 degrees. On the other hand, the bolometric measurements of Kurlbaum and Pringsheim suggested a value nearer 1600 to 1800, and therefore it seemed that the law of Wien could not be rigidly applied. As regards the question whether the temperature of the metallic filament lamps was really lower than that of carbon filament ones, the extremely interesting results of Auer, with a platinum-osmium composition, suggested a contrary result, for in this case a temperature of 2000 was reached, which is higher than the temperature ascribed to the carbon lamp by the work of Kurlbaum and Pringsheim. Blau and Lombardi have both been led to suggest that the temperature of the osmium lamp is in the neighbourhood of 1460 degrees. There are, however, researches of Burgess, and also those of Morris and Ellis, who estimated the temperature by noting the expansion of the hoop of a filament, which are opposed to this view.

Herr Sartori replied that no actual method of measuring temperature exists. We can only base our impressions upon phenomena which occur at various temperatures, and hence our so-called methods of measuring temperature are really based upon convention. And even the study of the expansion of a heated body as a means of estimating its temperature rests upon a purely conventional basis

A Correction.

Dr. F. Blau writes to us to explain that he does not hold the opinion, attributed to him in the journal from which this paper is abstracted, that the osmium filament radiates at a temperature of 1460° C. On the contrary, he believes that this cannot be the case, and that the temperature in question is much too low.

We notice that a similar letter on this subject from Dr. Blau appears in *Elektrotechnik und Maschinenbau*, in which he states that the responsibility for this suggestion rests not with him, but only with Dr. Lombardi.

Dr. Sartori has also written to explain that he did not attribute the opinion referred to to Dr. Blau, nor does he himself believe that the temperature of incandescence of an osmium filament can be as low as 1450°.

Prof. Grau, too, writes that in quoting Dr. Blau he did not connect him with the work of Lombardi yielding such low values.

CORRESPONDENCE.

Co-Operation between those representing Gas and Electric Lighting.

To the Editor of 'The Illuminating Engineer.'

SIR,—The publication of the results of some of our work on the City lighting makes me wonder whether it will be the occasion of more antagonism between those who are interested in gas and those who are interested in electricity. Personally I am a greater advocate of going to bed when it is dark than of either gas or electric light, and as I desire above all to promote unity among men rather than discord, I will ask you to allow me to say a word to both parties in this discussion. When one observes the terrible waste of human life and material that is taking place, a waste that does not arise so much from the want of technical knowledge as from its neglect; when one looks upon the terrible farce that is proceeding once more before a Committee of Parliament, and when one carefully examines the cause of these dreadful things, one is led irresistibly to the conclusion that they arise from want of unity among men. Instead of adding one to one and making two, we are everlastingly subtracting one from one and making worse than nothing. This madness has proceeded so far that recovery is probably a difficult matter—we are like people bound by some magic spell. Yet delivery from this spell must come sooner or later, and when trade is bad is the best time to stop and think, for when trade is good few of us will ever think of what we are really doing.

Now, both gas and electric light people are public servants fulfilling the same task in different ways. It is quite easily ascertainable as a matter of fact, and not as an opinion, that electricity can be under most circumstances cheaper for lighting and gas cheaper for heating; but even supposing this were not so, and that the fact were quite different, why should not both unite to do that which is best, and find some reasonable basis of agreement by which both should get a fair return for the services they render?

Of course, the suggestion of a combination between the gas and electric light people is enough to make the hair of the average trader stand on end, and justly so, if a superficial view of the case is taken. As buyers we all know the apparent advantages of price cutting; but try and trace out the whole system of trade competition, and we shall find that we gain 1*d*. in one pocket and lose 2*d*. out of the other, and that the whole thing is madness, which is bringing us to destruction. If we are going to admit that one man will not properly serve another man unless a third man is waiting to eat him up if he does not, then disaster is already complete. But I will not believe it, and I say the time is now ripe for men to take a more serious and simple view of what is proceeding, and endeavour to stop the madness that is now destroying us.

The unity that I ask for among all parties interested in the electric supply of London I would like to see extended to those interested in gas, and as a practical man having the good of all the people of London at heart I do not believe that there would be a great deal of difficulty in preparing a scheme which would satisfy Parliament if we all tried to be reasonable.

I am, &c.,

A. A. VOYSEY.

Dorking, June 6th.

P.S.—It may be thought that there is an argument against what I have urged in the fact that the gas mantle, the metal filament lamp, and the flame arc-lamp have possibly been developed as the result of competition between gas and electricity, but it is no argument against me. Do we not all know that the great discoveries which have advanced the consciousness of man have been made for the love of truth and not for the love of self? Is not my own experience like that of all men, that the less I think of the size of my salary the better my work becomes? If we were not madly trying to eat each other up we might now be considering a scheme for the partial conversion of gas works to join with the electric light works in endeavouring to give London the cheapest possible light with a reasonable profit, instead of wasting our money over propositions for further waste and chaos.

The Temperature of Incandescence of Metallic Filament Lamps.

Naples, June 21, 1908.

DEAR MR. GASTER,—In reply to your kind inquiry, I have much pleasure in sending you a copy of the paper delivered before our Associazione Elettrotecnica in 1903, which was subsequently abstracted in the *E.T.Z.*

My results, according to which the osmium lamp appeared to have a lower temperature of incandescence than that of the carbon filament lamps, have been contested in several quarters, mainly on the ground that they were derived from the Weber theory of glow-lamp filaments, the principles of which are not in accordance with the more modern theories. In this connexion I may remark that the metallic filaments of the modern glow lamps are not truly black bodies, and that measurements which are carried out with the ordinary pyrometers are more or less influenced by the errors and uncertainties involved in the calibration of such instruments.

I therefore proposed to undertake a further research on the metallic filaments of the glow-lamps of to-day, and to verify the consequences of the Weber theory directly, but unfortunately I have lacked the time as yet. In the event of my being in a position to collect some new material bearing on these interesting questions, I should be very glad to send your journal a short contribution on the subject.

I am, yours sincerely,

L. LOMBARDI,
Professor at the Technische Hochschule, Naples.

Neapel, 21 Juni, 1908.

LIEBER HERR GASTER!—Bezug nehmend auf Ihre freundliche Anfrage, beehre ich mich Ihnen ein Exemplar eines Vortrages zu senden, welchen ich vor unserer Associazione Elettrotecnica im Jahre 1903 gehalten, und in der *E.T.Z.* abzugsweise erscheinen liess.

Meine Resultate, welche für die Osmiumlampe eine niedrigere Temparatur wie diejenige der Kohlenfaden ergaben, sind von verschiedenen Seiten bestritten worden, hauptsächlich aus dem Grunde, dass dieselben aus der Weber'schen Theorie der Glühfaden stammen, deren Grundlagen nicht in Ubereinstimmung mit der modernen Theorie der Glühkorper steht. Darüber möchte ich nur bemerken, dass die Metallfaden der modernen Glühlampen keine schwarzen Körper sind und die Messungen, welche mit gewöhnlichen Pyrometern aufgestellt wurden mehr oder weniger mit den Fehlern und der Unsicherheit der Kalibrierung der Instrumente behaftet sind.

Ich hatte daher im Sinne, eine weitere Untersuchung der Metallfaden der modernen Glühlampen zu unternehmen und die Folgerungen der Weber'schen Theorie direkt zu prüfen. Dafür fehlte mir aber leider bis jetzt die Zeit. Im Falle, dass ich nächstens im Stande ware, neues Material über diese interessante Frage zu sammeln, wäre ich gerne bereit eine kurze Mitteilung darüber an Ihre Zeitschrift zu senden.

Hochachtungsvoll:

L. LOMBARDI,
Prof. an der Techn. Hochschule Neapel.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

ONE of the most important recent papers on matters connected with illumination is that of E. L. Nichols (*T.I.E.S.*, May), who contrasts the qualities of various types of artificial illuminants with those of daylight. Both the nature and intensity of daylight illumination differ very considerably under different conditions and at different periods of the same day. This is illustrated by the numerous curves given by Dr. Nichols, who, however, accepts diffused daylight as the normal stimulus to which the eye is exposed. Sunlight is almost invariably less blue than diffused daylight. Therefore we may take it as a principle that artificial illuminants ought to yield light as nearly approaching diffused daylight as possible. The numerous curves given in this paper show how rarely this is the case. As a general rule incandescent carbon and metals yield the nearest approach to it, incandescent oxides coming next, while incandescent vapours, such as are utilized in the mercury arc, deviate very widely indeed—so widely as to be only with difficulty comparable.

J. Sorber (*T.I.E.S.*, May) discusses the bearing of such natural phenomena as the position of the sun with respect to the earth on human development. He argues that the fact that the sun is overhead, and not on the horizon, during the greater part of the day has induced the human species to gradually assume an upright attitude, and suggests that the natural imitation of nature's method of illumination would entail the production of a source of very great candle-power suspended at a great height above the earth, so that its rays reached us from above just as the light from the sun does.

N. M. Black (*Optical Journal*, U.S.A., June 11th) raises the question, What is the best variety of artificial light to be used by opticians in illuminated test-screens ? and also whether it is better to illuminate such screens by reflected or transmitted light. The author circulated a number of inquiries on these points, but the replies seemed to have varied among themselves very greatly, and it is difficult to deduce any definite result.

E. W. Weinbeer writes to *The Electrical World* (May 23rd) criticizing a recent article by Wohlauer, on the ground that the polar-curve of distribution of light adopted by the latter could not actually be obtained in practice. A. A. Wohlauer, however, replies that such a curve can be obtained by the use of suitable reflectors (*Elec. World*, May 30th).

An article by J. H. Hart (*Elec. Rev.*, N.Y., May 23rd) discusses the trend of modern types of photometers. He remarks that these instruments may now be divided into two classes, those intended for rapid work and ascertaining the actual illumination on the spot, and those meant for accurate use in the laboratory. He remaks that the former class are proving to have a great field of usefulness, though still imperfect in detail. He also seems to suggest that the limit of utility of the more accurate instruments as a means of research has been reached—a conclusion, one would think, that would be doubted by very many illuminating engineers of the present day.

A. E. Kenelly and S. E. Whiting describe some experiments on the sensitiveness of several types of Lummer-Brodhun and grease-spot photometers, carried out both with lights of the same colour and with slightly heterochromatic sources of light. The former conditions were represented by two carbon filament lamps run at the same efficiency and yielding exactly the same quality of light. The heterochromatic conditions were represented by the comparison of a carbon filament lamp taking 4·5 watts per c.-p. with a tantalum lamp taking 1.25 watts per c.-p.

With lights of the same colour all the observers found the contrast Lummer-Brodhun photometer to be the most sensitive. In the second case they reached very different conclusions ; the mean error also proved to be about 2·6 times that obtained under the homochromatic conditions.

Lautsch (*Elek. Anz.*, June 11th) describes a new form of Rumford photometer, in which the lamps to be compared are kept stationary and the rod, producing the shadow, is moved along a graduated scale. The photometer, however, is only intended for the comparison of sources of light, which do not differ more than about 25 per cent in intensity.

C. Paulus (*Z.f.B.*, June 20th) undertakes a systematic comparison of the three chief methods of obtaining the mean horizontal c.-p. of glow lamps as applied to metallic filaments. These methods include (*a*) the method of point to point individual measurements, (*b*) the angle-mirror method, and (*c*) rotation methods either by rotating the lamp about a vertical axis, or rotating the mirrors about a stationary and screened lamp.

He points out the main drawbacks and advantages of these three, or rather four, systems, when used with lamps having metallic filaments proceeding to calculate the mean deviation of individual results from the determined average in each case. In the instalment of the article that has appeared he finds that the mirror methods are not superior in point of accuracy to the point by point ones. The article is to be continued.

ELECTRIC LIGHTING.

Several recent editorials in the American electrical papers have dealt with the metallic filament lamps industry. *The Electrical World*, for instance (June 6th), refers to two recently delivered papers on the introduction of the tungsten lamps. It is pointed out that the high efficiency of these lamps is so often dwelt upon that the exceedingly high life of the lamps, and the small fall in c.-p., which, under the best conditions, accompanies it, are allowed to pass unnoticed. The writer states that in his experience a life of 1,350 hours at 1·25 watts per c.-p. is not usual. It is also pointed out that the introduction of these lamps is really taking place very gradually. The writer calculates that the present manufacturers in the States would be unable to supply more than about 2½ per cent of the actual demand for incandescent lamps in that country.

J. B. Taylor (*Elec. World*, May 23rd) contributes some additional information on the subject of the initial rise in candle above the normal steady value which he finds to occur in the case of the tungsten lamps, suddenly switched into circuit—the "overshooting" as it is termed. The existence of the effect is demonstrated by a series of photographs.

A recent illustrated article in *l'Electricien* deals with the application of electric light to churches. The writer explains that there is a prejudice against the introduction of modern methods of illumination into churches of historic interest. Yet the greater convenience of good illumination had in some cases led to the claims for the traditional dim methods of lighting being relinquished. Metallic filament lamps are here at less disadvantage owing to the fact that they cannot be made for low candle-powers, because in large interiors, such as churches, big units are essential. The article is illustrated by examples of the application of electric light to ancient church-lighting, but, as far as can be judged from the inspection of these illustrations, the representatives of the æsthetic aspects of the problem might be justified in occasional stubbornness.

J. D. Mackenzie (*Electrical Review*, June 12th and 19th) considers the merits of gas and electric lighting from the standpoint of the small consumer. He remarks that in recent discussions of tariffs it has been assumed that it did not pay supply authorities to lay themselves out for the small consumers. Mr. Mackenzie, however, suggests that such consumers are now worth catering for *en masse*, and proceeds to show how electric light can be proved to be acceptable on the basis of cost—the fundamental consideration in cases of this nature. He admits, however, the great difficulty of the initial cost of installation. In the course of his comparison of the relative cheapness of gas mantles and osram electric lamps he comes to the conclusion that the running costs are about equal when electricity costs 3¼*d*. a unit.

A. A. Wohlauer contributes to *The Electrical World* (May 16th) a study of the running cost of various electrical illuminants, ranging from the carbon filament glow-lamp to the new quartz tube mercury vapour lamp. The latter he finds to be the most economical of all, at least on the basis of the figures at present published. A curve is given connecting the running costs with the cost per unit of energy.

A number of technical articles embodying recent patents, &c., bearing on the subject of glow-lamps have appeared of late in the German electrical papers. The most recent instalments of that occurring in the *Zeitschrift für Beleuchtungswesen* (May 30th and June 10th) deal mainly with the existing methods of winding metallic filaments so as to reduce the possibility of breakage to a minimum. Vogel (*Z. f. B.*, May 30th and June 10th) continues his comparison of vapour lamps with lamps utilizing incandescent filaments. In the present article he attempts to forecast the lines on which the development of vapour lamps may be expected to proceed.

A report of the Committee of the National Electric Convention has just been issued dealing with the specification of electrically illuminated streets (*Elec. World*, May 30th).

GAS AND ACETYLENE LIGHTING.

Although the annual meeting of the Institution of Gas Engineers took place during the present month there are no very novel papers on the subject of gas lighting to report.

Several translations of articles or papers recently published in Germany have appeared in the English press, notably that of Drs. Bunte, Mayer, and Teichel, on combustion in incandescent gas lamps, and that of Dr. Lux on the relative merits of compressed air and compressed gas. The latter question again receives ventilation in the *Journal für Gasbeleuchtung* (June 13th).

Anzbock (*J. f. G.*, May 30th) contributes a comparison of the costs of gas and electric lights. He makes the admission that there are certain cases—the lighting of theatres and mines for example—in which electric lighting is essential, but contends that the majority of cases are settled mainly upon the base of cost. It is interesting to find that his figures differ considerably from those given by Mr. Voysey in his report on the City lighting, though the latter were, of course, based on actual measurement in the streets, and not upon the performances of individual lamps. In this case the author finds that the cost of flame arc-lamps works out to about the same as high-pressure gas lamps when electricity costs 3*d*. a unit.

A new variety of illuminating and heating gas has been invented by Dr. Blau (*G. W.*, June 20th). This gas is obtained by distillation at a comparatively low temperature of 600 to 700 degrees, when the heavier and more easily liquified hydrocarbons are obtained. These are then stored in the liquid form in cylinders, each of which is capable of supplying 50 c.-p. for about 480 hours. The gas is said to have a high calorific value, and appears to yield the exceedingly high intensity of nearly 100 H.K. per cubic foot per hour.

Several of the contributions at the International Acetylene Congress were of considerable interest. Chief among these may be mentioned the paper by the President, Mr. Charles Bingham, on the relative merits of petrol-air gas and acetylene. These two illuminants may be said to be rivals, both filling the place of gas and electric lighting in remote districts with success. Mr. Bingham attempted to demonstrate that acetylene is not only cheaper, but more convenient and safer than petrol-air gas, justifying his statements by quotations from the estimates of various firms supplying installations of the latter, and also from the statistics relating to the accidents caused by the various systems of illumination in France. It would be exceedingly interesting to hear the same subject dealt with from the standpoint of the petrol-air gas.

Among other communications of interest may be mentioned that of M. Cadenel on the manufacture of mantles for use with incandescent acetylene burners. The manufacture of these mantles presented peculiar difficulties, partly owing to the great heat of combustion of the mixture of acetylene and air used in these burners. It was also found that the small size led to special difficulties which had to be overcome by special design in a manner made clear by M. Cadenel in his paper. There were also papers dealing with recent types of acetylene burners, and statistical data relating to the acetylene industry in France.

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Wohlauer, A. A. Economical Aspects of various Illuminants (*Elec. World*, May 16).
Fortschritte in der Glühlampen-Industrie (*Z. f. B.*, May 30 and June 10).
Glühlampen-Messinstrument (*Oesterr.-Ungar Installateur*, May 23).

GAS LIGHTING,

Anzbock, J. Okonomische Vergleiche zwischen dem elektrischen Lichte und dem Gaslichte (*J. f. G.*, May 30).
Bunte, Meyer, and Teichel. Combustion in incandescent gaslamps (*G. W.*, translated from the *J. f. G.*).
McPherson, H. H. An oft-neglected Asset: The Old Consumer (*Am. Gaslight Journal*, May 18).
Lux. Compressed Gas or Compressed Air (*G. W.*, May 30, from the *Z. f. B.*).
Blau Gas: a New Gas for Illuminating, Heating, and Power Purposes (*G. W.*, June 20).
Einige Winke aus der Praxis über hochintensive Invertbeleuchtung (*J. f. G.*, June 13).
Gasfernzünden (*Oesterr.-Ungar Installateur*, June 6).

ACETYLENE LIGHTING.

Some papers read before the International Acetylene Congress.

Bingham, C. Acetylene or Petrol-Air Gas.
Cadenel. On the Manufacture of Mantles for Incandescent Lighting by Acetylene.
Granjon, R. Statistics on 10,000 Plants inspected by the Union of Owners of Acetylene Appliances in France.
Letang. Note on an Improved Manchester Burner.
Pitavel. Acetylene Lighting in Mines in France.
Schumacher-Kopp. The Illumination of the Locomotives on the St. Gothard Railway by Means of Acetylene.

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. Bel.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

On Lighting.

(Paper read by Prof. H. Bohle before the Cape Town Local Section of the Institution of Electrical Engineers, February 10th, 1908.)

THE masterly paper recently read by Prof. H. Bohle, of the South African College, Cape Town, on this subject, suggests that the ever-growing interest in the subject of illumination in this country is shared by many in South Africa. The demands on our space prevent us from reproducing Prof. Bohle's paper, of which he has kindly sent us a copy, as fully as we should like to do. In what follows we append a short abstract, chiefly omitting those points which have recently been dealt with in *The Illuminating Engineer*. For further details we refer our readers to the original paper.

The subject of the paper is divided into four parts, entitled :—

I. Fundamental Conceptions.
II. Illumination of Buildings.
III. Outdoor Illumination.
IV. Illumination Photometers.

I. *General Considerations.*—The author commences by establishing the fundamental relation for the illumination, E, of a surface at a distance R from a source of intensity I, $E=\frac{I \cos \theta}{R^2}$, from which we may proceed to the well-known expression $E=\frac{I\,h}{(a^2+h^2)^{3/2}}$, for the illumination of a horizontal surface, at a distance *a* from a post of height *h*, at the top of which is placed the source of intensity I.

As an illustration of the use of this formula the author considers the illumination of a circular table of radius *a*, illuminated by a single source at a height *h* above it. In order to determine the height of the lamp giving the best illumination at the circumference of the table, we put $\frac{d\,E}{d\,h}=0$, and obtain the relation $a=\sqrt{2}\,h$. The actual illumination at the edge of the table is $0{\cdot}382\,\frac{I}{a^2}$, and at the centre it is $2\,\frac{I}{a^2}$.

The illumination from centre to circumference varies considerably, but can be made more uniform by the use of shades and reflectors. Evidently the ideal polar curve of illumination thus obtained from the source of light should approach the form $I=E\frac{(a^2+h^2)^{3/2}}{h}$.

Theoretically there need be no difficulty in securing a perfectly uniform illumination from a single source. The area that can be effectively illuminated by a single light depends upon the intensity of the source, its height from the ground, and the degree of illumination specified. As a rule $\frac{a}{h}$ is limited to 1·5 in the case of glow lamps, and to 3·0 for arc lamps.

Actually we usually utilize the effective illumination of several lamps, and we may study their combined illumination at various points by means of "contour-lines," in the manner suggested by Mr. A. P. Trotter and others. Prof. Bohle points out that the illumination midway between two lamps is either a maximum or minimum, according as 2a $<$ or $>$ hh.

The contour lines of a single symmetrical source are circles. For two or more lamps they are more complicated. The best results, as regards uniform illumination, are to be secured by arranging the lamps at the corners of a series of equilateral triangles.

After discussing a number of other problems in illumination, the author concludes that, though *perfectly* uniform illumination is very difficult to obtain, there is no doubt that by standardizing the term $\frac{a}{h}$, and by the introduction of more symmetrically designed shades and reflectors, the present conditions might be very materially improved.

Very few sources yield a completely symmetrical distribution of light, but this does not very greatly interfere with the production of uniform illumination A more important factor is the effect of reflection from surrounding surfaces, walls of buildings, &c.

II. *The Illumination of Buildings.*—For the purpose of reading, an illumination of 50 lux suffices, while it should never be allowed to fall below 10 lux. For general illumination, however, 7 to 10 lux are enough. As a rule, the most important illumination is that in a horizontal plane, about table-height from the floor. But in special cases, such as picture galleries, provision must be made for the illumination of surrounding objects.

In general we secure a good diffused illumination by employing a large number of scattered small units, and we may also utilize inverted arcs, which, however, entails a loss of 20 to 30 per cent. of the light in reflection. In calculating the effect of clusters of lamps we may assume the cluster to yield the sum of the mean hemispherical candle-powers of the individual lamps, minus a certain percentage to allow for the fact that each lamp tends partially to screen the light from the others. In the case of 2, 3, and 4 lights, we may deduct 12, 16, and 20 per cent respectively to allow for this. But, actually, such clusters are usually partially surrounded by shades and reflectors, and the resulting polar-curve of the combination must, therefore, be determined.

In shops, factories, and workshops, two kinds of illumination—that required for general purposes and that concentrated on the actual work—are usually necessary. This latter local illumination is best obtained by the aid of glow lamps.

The accurate predetermination of illumination in a building is necessarily interfered with to some extent by the influence of reflection from the walls of the room and the scheme of decoration adopted. In cases where the exact effects cannot be foreseen and allowed for, the author suggests that the best plan is to work out the results for a *black* room. The actual illumination will then be higher than intended, but this will be partially counterbalanced by the deterioration in lamps and reflecting surfaces with age. On the other hand, provided glow lamps are equipped with suitable diffusing shades and reflectors, the illumination cannot easily be made injurously great.

As a rough guide to the illumination required under various circumstances the author quotes the following figures, recommended by the A.E.G :—

	C.P. per sq. metre, floor space.
Private Houses.	
Drawing-room	4 to 5
Dining-room	3 to 3·5
Bedroom	1·5 to 2
Kitchen-room	1 to 2
Shops.	
Counter	4 to 7
Stores	3 to 3·5
Offices	5 to 6
Hotel.	
Concert Halls	9 to 13
Private Rooms	2 to 4
Meeting Rooms	5 to 7

The height of lamps in rooms less than 4 metres high is usually 2 to 2·5 metres. For rooms more than 7 metres high, a convenient height for the lamps is 0·4 times that of the room.

In factory yards we may likewise allow 0·3 to 0·5 candle-power per square metre floor space; in railway stations, market halls, and factories 0·5 to 1 candle-power, 1·5 to 2·5 candle-power, and 2·3 candle-power respectively.

III. *Outdoor Illumination.*—A great deal of doubt seems to exist in the minds of engineers with regard to the manner in which outdoor lighting is to be judged. Streets and squares are illuminated so as to enable people to recognize one another, to distinguish objects on the ground, and to read an address in, at least, some parts of the illuminated area. From this it might appear that a vertical plane would be best for testing the illumination. Against this stands the fact that a vertical plane may have different positions with regard to the incident rays, in some of which it might receive light only from one source, or from none at all, even though several sources take part in the illumination of the region into which the plane has been place d These disadvantages obtain more or less also for inclined planes, so that the horizontal alone is left, in which street lighting can be properly tested, and in which it should be judged.

As it is inconvenient to test the illumination of the ground, since one would have to kneel down with some photometers, the author proposes to determine the illumination of a plane one metre from the ground.

The illumination of a street or square is usually judged by that of the darkest part, *i.e.*, by its minimum.

This appears to be hardly correct for avenues which contains rows of trees, and would be unfair to the contractor. At the same time, we must not judge the lighting by the maximum illumination, as this would be unfair to the public, since, with a satisfactory maximum illumination, some parts of the illuminated area may be in comparative darkness.

To appease both parties the illumination should be judged by the average value, and then it is also possible to get an idea of the cost of outdoor illumination, which could be stated per lux per 100 square metres road surface. The uniformity of the lighting is expressed by

$$\frac{\text{maximum illumination}}{\text{mean illumination}}$$

and

$$\frac{\text{minimum.}}{\text{mean.}}$$

The more these two factors approach unity the greater is the uniformity of the illumination. Under (I) it has been shown how this result can be obtained.

Large squares and wide streets are best illuminated by arc lamps fixed about 15 metres above the ground. The best height would be 0·7 times the distance between adjacent lamps, but in this case we should get poles 30 and more metres high. In squares the lamps are best arranged at the corners of equilateral triangles, for streets above the middle of the road, if possible. The average illumination for main thoroughfares should not be less than 1 lux for side streets—it is often less than a tenth of this.

The determination of the average illumination may be accomplished by plotting illumination curves in various directions, and taking the mean value. Such a method is, however, extremely laborious. It is simplified by the assumption that the lights are symmetrical, and as most arc lamps are surrounded by diffusing globes, and as glow lamps are usually covered with shades, the error thereby introduced is not so very great, especially as, in any case, approximate results can be expected only.

The method is further simplified by dividing the street or square into a number of small squares. For the centre of each we determine with the aid of the polar curves the resultant illumination of all lamps taking part in its illumination, and afterwards take the mean. The method is not as laborious as it appears at first sight, especially if all the lamps are equally spaced, of the same type, and erected on poles of similar height. It is, at least, useful to check results of completed installations.

Dr. Bloch advocates a further simplification.* The street is divided into a number of equal squares, such that each one includes one lamp. or bracket, placed in the centre. The area of each square is then changed into an equal circular one, and it is assumed that no other lamp takes part in its illumination. This introduces two errors. By changing the rectangle into a circle and calculating the average illumination for the latter we obtain a value slightly too large. On the other hand, by neglecting the light from other sources, we obtain an average value somewhat too small. Both errors partly neutralize one another; the remainder may be expressed by a factor K, with which the calculated average value has to be multiplied in order to obtain the actual average illumination. For K Dr. Bloch gives the value (for street lighting) $K = 1{\cdot}2 - 0{\cdot}1\lambda$ where

$$\lambda = \frac{\text{distance between lamps}}{\text{width of street}}.$$

The distance between the lamps is measured in the direction of the street, even if the lamps are staggered.

The author then proceeds to deduce a number of mathematical expressions for the calculation of the mean illumination over a given area, and gives a number of practical examples illustrating their application to street lighting. Finally, he remarks that in these determinations, the reflection of light from adjacent buildings, &c., has not been taken into account. The effect of such reflection in different towns differs very greatly. Reflection from the buildings found in towns in South Africa, for instance, assists the general illumination considerably; in larger and dirty cities, on the other hand, the effect is comparatively trifling.

IV. *Illumination Photometers.*—In this section of his paper the author briefly summarizes the essential qualities of illuminometers, dividing these instruments into "diffused reflective" and "diffused transmission" photometers. He then proceeds to describe the well-known instruments of Weber, Brodhun, Martens, and Trotter. Finally, he describes the principles and use of the Ulbricht globe photometer, and makes brief reference to the integrating instruments of Blondel and Matthews.

* *Elektrotechnische Zeitschrift*, 1906, p. 493.

Middlesbrough Meeting of the Iron and Steel Institute.

THE annual meeting of the Iron and Steel Institute will be held at Middlesbrough on September 28th, 29th, and 30th, and October 1st.

A number of papers will be read, and other items on the programme will include a visit to the official opening of Smith's dry dock on the Tees; members will also be invited to luncheon by the Cleveland Institution of Engineers, and a garden party will be given by Sir Hugh and Lady Bell.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

10,590. Incandescent lamp filaments. May 15. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,690. Incandescence lamps. May 16. E. A. Gimingham, Birkbeck Bank Chambers, London.
10,760. Luminous radiators. May 18. The British Prometheus Co., Ltd., G. Cooper and F. C. Sharp, 77, Colmore Row, Birmingham.
10,773. Lamp holders. May 18. A. F. Rock, 77, Chancery Lane, London.
10,808. Metallic filaments for incandescent lamps. May 19. C. H. Dorman, 82, Duckett Road, Harringay, London.
10,885. Filaments for incandescent lamps (C.S.). May 19. (I.C. Nov. 27, 1907, Germany.) Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
10,889. Carbon holders for arc lamps (C.S.). May 19. (I.C. Nov. 29, 1907, Belgium.) R. Chaudet, 1, Queen Victoria Street, London.
10,891. Filaments for incandescent lamps (C.S.). May 19. (I.C. Oct. 7, 1907, Germany.) Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
11,460. Incandescent lamps. May 26. The British Thomson-Houston Co., Ltd., and T. E. Robertson, 83, Cannon Street, London.
11,564. Carbon steadier for arc lamps. May 28. E. Cunningham, 31, North Terrace, Tarbrax, Cobbinshaw, Scotland.
11,600. Filaments of Chinese ink for incandescent lamps (C.S.). May 28. (I.C. Oct. 30, 1907, Germany.) K. Rittersberg and H. Rubert, 67, Knesebeckstrasse, Charlottenburg, Germany.
11,607. Illuminating billiard and operating tables, &c. May 28. E. R. Crook, 5, Carnaby Street, Regent Street, London.
12,194. Method of supporting lamp filaments. June 5. D. Murray, 3, Lombard Court, London.
12,225. Luminous lighting and bell switches. June 5. E. S. Conradi, 19, Ebbsfleet Rd., Cricklewood.
12,398. Metal filament lamp installations. June 9. W. Dierman, 18, Southampton Buildings, London.
12,470. Adaptor for incandescent lamps. June 10. F. L. Wright, 9, Warwick Court, Gray's Inn, London.
12,556. Arc lamp carbons (C.S.). June 11. Siemens Bros. Dynamo Works, Ltd., Queen Anne's Chambers, Westminster. (From Siemens Schuckert-Werke G. m. b. H., Germany.)
12,592. Push-switch lamp-holder. June 12. G. H. Ide, 152, Sherlock Street, Birmingham.
12,630. Pocket lamp (C.S.). June 12. P. M. E. Bourgeois and C. H. Bourgeois, 65, Chancery Lane, London.
12,644. Arc lamps (C.S.). June 12. J. O. Girdlestone and C. F. G. Thorkelin, 37, Warwick Rd., Ealing.
12,651. Arc lamps. June 12. Johnson & Phillips, Ltd., and S. Paterson, Birkbeck Bank Chambers, London.
12,654. Lamps. June 12. The London Import Co., Ltd., and B. Pordes, 28, New Bridge St., London.
12,656. Arc lamps (C.S.). June 12. (I.C. July 8, Germany.) D. Timar and C. von Dreger, 7, Southampton Buildings, London.
12,682. Arc lamps (C.S.). June 12. (I.C. July 15, Germany.) Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

II.—GAS LIGHTING.

10,595. Anti-vibrators for incandescent burners. May 15. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
10,613. Fittings of inverted incandescent lamps. May 15. J. Webber, 18, Southampton Buildings, London.
10,650. Gas and like burners. May 16. T. Westgarth and L. Taylor, Hartlepool Engine Works, Hartlepool.
10,688. Inverted incandescent lamps (C.S.). May 16. Actien-Ges. Schaeffer & Walcker and W. Schultze, 231, Strand, London.
10,856. Igniting street lamps (inverted incandescent) electrically (C.S.). May 19. F. T. Cotton, 8, Quality Court, Chancery Lane, London.
10,932. Inverted incandescent lamps. May 20. C. W. Harrison, 96, Middlesex Street, London.
11,034. Incandescent mantles. May 21. N. Gödelmann, 19, Farringdon Street, London.
11,122. Incandescent burners (C.S.). May 22. H. W. Lake, 7, Southampton Buildings, London. (From Neue Kramerlicht-Ges. m.b. H., Germany).
11,152. Incandescent mantles (machines for tying) (C.S.). May 22. S. Cohn, 11, Southampton Buildings, London.
11.349 Inverted incandescent burners. May 25. W. B. Smith, 66, College Street, Chelsea, London.
11.635. Inverted incandescent burner. May 28. A. S. Francis, 77, Chancery Lane, London.
11,942 Inverted incandescent burners (C.S.). June 2. A. L. Dunphy and J. Tysoe, 163, Queen Victoria Street, London. (Addition to 20/07.)
12,146. Incandescent lamps. June 4. A. C. Noad, 18, Louvaine Road, St. John's Hill, Clapham Junction, London.

12,154. Reflector for inverted lamps. June 4. E. Hendrichs, 345, St. John's Street, London.
12,193. Inverted incandescent burners. June 5. G. Hands, 71, Farringdon Road, London.
12,278. Fittings for incandescent burners. June 5. J. Booth, trading as Samuel Booth & Co., and R. J. Simpson, 35, Temple Row, Birmingham.
12,331. Inverted incandescent lamp. June 6. H. O. Klauser, 116, High Holborn, London. (From Automatic Screw Works, Holland).
12,377. Incandescent burners. June 9. J. Cronin, 100, Wellington Street, Glasgow.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

10,662. Burners of reading lamps (C.S.). May 16. G. Baker, King Edward Street, Whitland, Carmarthenshire.
10,682. Acetylene lamps. May 16. H. Cole, 77, Colmore Row, Birmingham.
10,696. Lamp. May 16. J. S. Burns and the Sylverlyte Electric Lamp Co., Ltd., 173, Fleet Street, London.
10,707. Lamp globe (C.S.). May 16. O. A. Mygatt, 322, High Holborn, London.
10,708. Reflector (C.S.). May 16. O. A. Mygatt, 322, High Holborn, London.
10,715. Automatic igniters and extinguishers (C.S.). May 16. M. W. Bröndum, 345, St. John's Street, London.
11,054. Lenses for motor and other lamps (C.S.). May 21. A. R. Cosgrove, 19, Holborn Viaduct, London.
11,126. Globes for inverted lamps. May 22. J. Webber, 18, Southampton Buildings, London.
11,237. Petroleum lamps (C.S.). May 23. C. Schmölcke, 231, Strand, London.
11,301. Incandescent light economizer. May 25. E. C. Felstead, F. C. Finney, and R. C. Lamond, 39, Chatham Avenue, Murray Street, Hoxton.
11.772. Flash advertising signs. May 30. G. Sweetser, 11, Southampton Buildings, London.
12,210. Oil lamps. June 5. J. McNair, 154, St. Vincent Street, Glasgow.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

11,979. Arc lamp electrodes (C.S.). I.C. Jan. 29, 1907, Germany. Accepted May 20, 1808. Deutsche Beck-Bogenlampen G. m. b. H. and H. Beck. Thanet House, Temple Bar, London.
12,369. Arc lamps. May 28, 1907. Accepted June 3, 1908. A. H. Brzeski and A. Strauss-Collin, 27, Chancery Lane, London.
12,902. Enclosed arc lamps. June 4, 1907. Accepted June 3, 1908. B. A. Quint, "Maybury," Audley Road, Hendon.
15,798. Incandescent lamp with metal filament (C.S.). I.C. May 31, 1907, Germany. H. Kuzel, 322, High Holborn, London.
18,742. Arc lamps (C.S.). Aug. 20, 1907. Accepted May 20, 1908. W. G. Heys, 51, Deansgate Arcade, Manchester. (From the Scott Electrical Co., U.S.A.)
19,734. Arc lamps. Sept. 4, 1907. Accepted June 11, 1908. O. Gross, 5, John Dalton Street, Manchester.
23,585. Metal filaments (C.S.). Oct. 30, 1907. Accepted May 27, 1908. Glühlampenwerk Anker G. m. b. H., 65, Chancery Lane, London.
27,739. Arc lamp (C.S.). I.C. Dec. 20, 1906, Germany. Accepted May 20, 1908. F. Janecek, 27 Chancery Lane, London.
28,451. Lengthening life of incandescent lamps (C.S.). Dec 27, 1907. Accepted May 20, 1908. W. Herrmann, 40, Chancery Lane, London.
66. Arc lamp electrodes (C.S.). I.C. Jan. 5, 1907, U.S.A. Accepted June 3, 1908. G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.
2,481. Holders for incandescent lamps (C.S.). Feb. 4, 1908. Accepted May 27, 1908. Siemens Bros. Dynamo Works, Ltd., and H. C. Wheat, 139, Queen Victoria Street, London.
2,569. Incandescent lamps, and shades or reflectors (C.S.). Feb. 5, 1908. Accepted May 20, 1908. J. J. Rawlings and R. T. Smith, 34, High Holborn, London. (Addition to 8,151/07.)
5,225. Arc lamp electrodes (C.S.). I.C. July 5, 1907, Germany. Accepted June 11, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
5,610. Incandescent lamps (C.S.). I.C. March 14, 1907, Germany. Accepted June 11, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
8,421. Filaments for incandescent lamps (C.S.). I.C. May 13, 1907, Germany. Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.

II.—GAS LIGHTING.

10,975. High pressure lighting apparatus. May 10, 1907. Accepted May 20, 1908. W. Edgar, 173, Fleet Street, London.
12,354. Incandescent burners. May 28, 1907. Accepted June 3, 1908. F. Turner and G. Hands, trading as G. Hands & Co., 77, Chancery Lane, London.
14,158. Incandescent burners. June 19, 1907. Accepted May 20, 1908. S. Holman, 27, Chancery Lane, London.
19,811. Incandescent lamps. Sept. 4, 1907. Accepted June 3, 1908. C. W. Harrison and A. C. Noad, 7, Southampton Buildings, London.
23,267. Inverted incandescent burners. Oct. 22, 1907. Accepted May 20, 1908. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.
27,490. Inverted incandescent burner (C.S.). I.C. Dec. 12, 1906, France. Accepted June 3, 1908. M.-A. Robert, 18, Southampton Buildings, London.

27,939. Incandescent mantles (C.S.). I.C. Dec. 18, 1906, Germany. Accepted May 20, 1908. W. Huber, 72, Cannon Street, London.

1,074. Incandescent burners (C.S.). Jan. 16, 1908. Accepted May 20, 1908. A. Pöschl, Thanet House, Temple Bar, London.

2,973. Inverted incandescent pressure lamps (C.S.). I.C. Feb. 26, 1907, Germany. Accepted June 11, 1908. M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.

4,451. Nozzles for inverted incandescent burners (C.S.). Feb. 27, 1908. Accepted June 3, 1908. M. Graetz, 18, Southampton Buildings, London.

5,031. Incandescent lamps. March 5, 1908. Accepted May 27, 1908. E. H. Still, 46, Lincoln's Inn Fields, London.

5,273. Supporting incandescent mantles in vertical lamps (C.S.). March 9, 1908. Accepted June 11, 1908. B. A. Manning, "Montrose," South End Road, Hampstead.

10,782. Nozzle for inverted lamps (C.S.). I.C. May 17, 1907, Germany. T. Eberhard, 56, Myddelton Square, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

13,477. Combined upright and pendant incandescent vapour and gas burners (C.S.). June 11, 1907 Accepted May 27, 1908. M. W. Pitner, 615 F Street, N.W., Washington, D.C., U.S.A.

15,029. Lamp shades and lenses. June 29, 1907. Accepted June 11, 1908. T. Ward and M. Cooper, 173, Fleet Street, London.

15,851. Street lamp post and fittings. July 10, 1907. Accepted May 20, 1908. H. Hallows, 3, Gore Street, Greenheys, Manchester.

19,986. Wax-burning lamps. Sept. 7, 1907. Accepted May 20, 1908. C. E. Baxter, Victoria Chambers, Martineau Street, Birmingham.

3,163. Acetylene lamps (C.S.). Feb. 12, 1908. Accepted June 11, 1908. L. Jouvenet, Birkbeck Bank Chambers, London.

8,746. Incandescent filaments (C.S.). April 21, 1908. Accepted May 20, 1908. G. Auger, 18, Southampton Buildings, London.

8,960. Lanterns (C.S.). April 24, 1908. Accepted June 3, 1908. J. B. Brantingham and W. P. Brantingham, trading as Brantingham Bros., 4, South Street, Finsbury.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d.*

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s.*

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

The Lighting Department of the G. E. C. have sent us an illustrated pamphlet describing the new "*tungsten economy diffusers*" manufactured by the company specially for use in diffusing the light from tungsten incandescent lamps and softening their intrinsic brilliancy. The shades are also claimed to be effectual in distributing the light in the desired directions, and can be made to include groups of five or six lamps.

The "METALLINDUSTRIELLE RUNDSCHAU," of Berlin, draw our attention to an illustrated list of the complete series of glass chimneys of various shapes manufactured by Jacques Goldberg. The pamphlet contains exact measurements and illustrations of upwards of 240 different models, and serves to show the variety of globes and chimneys available for use with different oil-lamps, and the care necessary in order to make the best selection.

We have received a booklet describing the "*Chlorophylle*" tinted glasses, in which an attempt is made to give to eye-protectors, spectacles, &c., a greenish-yellow tinge of colour which is claimed to be advantageous from the hygienic standpoint. It is asserted that by this means a sensation of restfulness when observing bright lights coupled with sufficient luminosity and remarkable clearness of vision is obtained. The makers are J. B. JACQUEMIN BROS., LTD., 65, Hatton Garden, London.