The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

THE subjects which form the basis of our editorial in this number all serve to illustrate one point, to which we are constrained to attach special importance—the value of co-operation. One of the most pleasing features in the recently issued report of the National Physical Laboratory was the evidence of mutual help rendered to each other by the Engineering Standards Committee, the International Electrotechnical Commission, and the Laboratory. Equally satisfactory is the evidence of co-operation between the National Physical Laboratory and the laboratories of France, Germany, and the United States, with a view to the settlement of vexed questions in photometry.

We are convinced that very good results would follow from similar co-operation between different nations with respect to lighthouse administration and the hygienic aspects of illumination. In both these subjects there are many doubtful points on which further information is needed, and both may be said to be of international importance. We think that the time has now arrived when it must be realized that individual effort cannot be relied upon to definitely solve these great questions. Individual research will, of course, always be of great value in order to open up new pathways and lead to new suggestions. Even in the past, however, the existence of societies has been necessary in order to render such work readily available, and cause it to be appreciated.

Holding these views, we are naturally anxious to give this magazine a truly international character. In this way we shall learn from each other, and, no doubt, gradually solve many of the difficult problems in illumination with which we are faced at the present time.

THE NATIONAL PHYSICAL LABORATORY.

We need not make any apology for discussing the important points brought out by the recent commission on the future of the National Physical Laboratory. The work of this institution is rightly regarded as of national importance, and there is one section of its work—that relating to photometry and standards of light—which is attracting much attention at the present time, and is of special interest to us.

The National Physical Laboratory was formed partly with a view to carrying out valuable theoretical research work, but was also intended to act as a reference to whom recourse might be had in cases of dispute, for the purpose of verifying standards, or undertaking some special piece of industrial work which the appliances and experience at the service of the Laboratory enabled it to do better than could be done elsewhere.

It must be recognized that the National Physical Laboratory can only adequately fulfil the object for which it was created if it is properly supported. If the work of the Institution is to receive the respect which its position demands, the Institution ought certainly to be made as far as possible independent of the support of private individuals, and should possess such an equipment and staff as to cause its decisions to be accepted without cavil or dispute. It is clearly absurd to expect private firms and individuals to be content with contrary decisions when they feel that the facilities and experience at their own disposal are superior to anything at the Laboratory.

Above all, the laboratory ought to be definitely freed from the crippling necessity of undertaking work for the value of the remuneration. This necessity must tend to use up time which might preferably be devoted to research, and might tempt the laboratory to undertake work approaching the purely routine character. Indeed, for any laboratory to be really commercially successful, it must undertake a large proportion of such purely systematized and routine work. Hitherto the National Physical Laboratory has struggled heroically to carry out its functions, though crippled by want of the necessary funds. As we are in earnest in desiring to maintain in this country one institution capable of carrying out the beneficial work of the Reichsanstalt in Germany or the Bureau of Standards in the United States, for instance, let us at least endeavour to approach the support given to such institutions.

The work which the National Physical Laboratory is intended to carry out is shared between several separate institutions in Germany. In 1904 the cost of building and equipment of these institutions amounted in all to very nearly £400,000, and the combined annual grant to nearly £40,000. The staff contained upwards of 250 persons.

The cost of the newly installed equipment and building of the Bureau of Standards in the United States amounted to £115,000, and the annual grant is £19,000.

At the time to which these figures refer (see Report to British Assoc., Section A, 1904), the sum expended on the buildings of the National Physical Laboratory was given as £19,000, and the annual grant as £4,000, and the number of persons on the staff as 50. Since that date the annual grant has been increased, and for the years 1908 and 1909 to £7,000, while the capital grants and donations for building and equipment *from all sources*, amounts to about £46,000 (Minutes of Evidence before Commission, 1908, p. 95). The entire staff of the laboratory now amounts to about 95 persons.

The support given to the National Physical Laboratory, therefore, seems to us still far from sufficient. It must be remembered, too, that the German institutions are of much older date than our own institution, and have the advantages of accumulated experience. In our own case even greater expenditure might be necessary in order to secure that the equipment and staff, as compared with that of various private establishments, should be correspondingly adequate. This is a case in which the Treasury might profitably grant support more nearly approaching that given to corresponding institutions in other countries. Far greater sums than that required are constantly expended on improvements the value of which may only become evident in the course of a generation. In the present instance we firmly believe that further expenditure would be amply and immediately repaid. Even under the present disadvantages the National Physical Laboratory has fully justified its existence, and the value to the nation of such an adequately supported centre of industrial research is beyond dispute.

Lighthouse Administration.

An interesting report has recently been issued by the Royal Commission dealing with the above subject. The report is mainly concerned with the details of administration of the boards controlling the coast-illumination of the United Kingdom, though a large number of very important technical questions arose in the course of the evidence given before the Commission.

At present the lighting of this country is under the control of three separate boards—the Trinity House authorities, the Commissioners of Northern Lighthouses, and the Commissioners of Lights—who are responsible for the lighthouses, &c., in England and Wales, Scotland, and Ireland respectively. Having found that the present administration is on the whole satisfactory, the Commission does not propose to alter the existing arrangements materially, and has only varied certain details, in order to promote freer intercourse and co-operation between the various boards.

No doubt there are good reasons for not yet attempting to place all the arrangements under one central authority, though we are given to understand that such a course may be adopted in the future. To us the value of international co-operation on such a subject seems very clear, and we hope that an official attempt at such co-operation will be made.

In this case there need be no feeling of mutual distrust or rivalry. There can be little doubt that different countries might learn much from each other by mutual discussion and experiment. Certainly, bearing in mind the immense annual expenditure in this department, the need for constant experiment, with the object of producing more efficient results and reducing cost of maintenance, is evident. We regret to note that, according to some of the evidence, there is a disposition to grudge the money necessary for such experiments. Here, surely, is an instance in which co-operation, in the form of sharing the cost of such researches, of mutual value, might prove beneficial.

Then, again, there must surely be countless cases where simplicity and convenience would follow the adoption of some common basis of action. One of the witnesses, indeed, expressly stated that the method of rating lights in France was not the same as in this country, and it is quite possible that similar differences of method exist in other countries. We really think that 'The Illuminating Engineer' is unusually favourably placed from this point of view, partly because of its impartiality of outlook on different illuminants, and also because of the international character of the magazine.

The Hygienic Aspects of Lighting.

Our present number includes an interesting article from the pen of Dr. Rideal, in which the results of his recent investigations into the hygienic aspects of gas and electric lighting are summarized.

Valuable as such researches are, up to a certain point, we cannot but feel that the question which Dr. Rideal has attempted to solve is too wide to be adequately dealt with by a single individual. The views expressed on the subject by different authorities are in themselves frequently so conflicting, and the results of a series of experiments depend so much on the exact circumstances under which they are made, that even the impartial observer must remain in considerable doubt as to whether they are applicable to the particular conditions in which he is interested.

To meet with general recognition, therefore, any research of this nature ought to be backed by such a weight of impartial and authoritative evidence as to be absolutely convincing. It must also enter into the exact varieties of circumstances which actually occur under practical conditions, study the effect, and deal with all the many important factors included under the heading of "Hygienic Aspects of Illumination." We note that further experiments on the subject are now to be undertaken by Dr. Wade, who has received for that purpose a special grant from the Local Government Board. This is satisfactory, inasmuch as such experiments receive definite Government recognition; but to our mind this research can only be done satisfactorily by means of a Commission representing the different lighting interests, and assisted by the most eminent authorities, and in touch with a very extensive and prolonged series of tests; these tests will have to be conducted on certain definite lines to be agreed upon beforehand.

There are other important questions, such as the influence upon sight of colour and intrinsic brilliancy of illuminants now in use, on which no really authoritative data are available, and we hope that such an investigation will receive due consideration.

We desire, in short, a complete investigation into *all* the factors of importance from a hygienic point of view, undertaken by eminent authorities on the various aspects dealt with, and backed by the necessary Government support.

The Coming Municipal Exhibition.

The first Municipal and Public Health Exhibition is to be held at the Agricultural Hall from the 1st till the 12th of May in the present year. As will be seen from the notice printed elsewhere in this number, the subject of public lighting will receive special attention.

The opportunity of interesting those connected with municipal matters, seems to us an exceptionally good one. An immense sum of money is spent annually in public lighting, and it can scarcely be doubted that the results achieved might often be very materially improved.

It is therefore proposed to gather together illustrations of lighting by all the different illuminants, to exhibit photometrical apparatus of different kinds, and to explain their action by a series of short lectures by various authorities on the subject.

There is one feature in the exhibition to which we would direct special attention. The display will be conducted on an absolutely impartial basis. Opportunity will be granted to those who prefer to do so to exhibit their own apparatus, and such demonstrations of their action as are given will be carried out with the object of stimulating interest in the subject, and without any intention of comparing one instrument or system of illumination unfavourably against another.

This is, we believe, the first occasion on which an exhibition has been held devoted to illumination in general, and not merely to the display of any particular branch. We certainly hope that all who are in a position to do so will come forward and assist the honorary Advisory Committee in their enterprising effort.

Leon Gaster.

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.* 185.)

Theoretical Examples of Distribution.

By the means of the cosine law, and of the foregoing table, the illumination which will be produced by any given arrangement of lights may be determined. The principal object of my original paper was to attempt to enable engineers to predetermine, specify for, and provide a definite illumination. While it failed to be utilized in this way to any appreciable extent, other writers have from time to time calculated and published similar curves. Engineers may have considered these too laborious to apply in practical cases, and the illumination of streets, railway stations, &c., has been for the most part carried out either by adding to the number or to the power of the lights until the illumination was sufficient, or by trying experiments with lamps at various heights and distances. One excuse for this unscientific procedure was that in general nobody knew how much illumination was wanted.

The curve given on Fig. 9, and the table of values of cosine^3 θ, enable the curves for the combined effect of a number of lamps to be determined by the simple addition of ordinates. The curves given in Figs. 10 to 14 assume that the candle-power of each lamp is the same in all directions. They give the component and resultant curves for four different arrangements. The first, Fig. 10, represents the distribution of illumination on the ground due to a row of lamps at a distance apart equal to their height from the ground. The dotted lines are the cosine ^{3} curves, and the tails of the curves of the more remote lamps appear. The first full line shows the resultant illumination due to two lamps, and the next one above, a symmetrical portion being given, represents the illumination due to three lamps. The other lines similarly show the additional effect of more remote lamps. The horizontal scale is one of distances along the ground; the ordinates give illumination in an arbitrary unit, being the illumination which would be found below one lamp alone, if there were no shadow. It may be observed (but no one who is thinking of using the method should be alarmed by the statement) that the illumination at the maximum is 1 + twice the cubes of the cosines of the angles whose tangents are 1, 2, 3, 4, &c., and is 1·978 when there are four lamps on each side. The minimum illumination is equal to twice the cube of the cosines of the angles whose tangents are

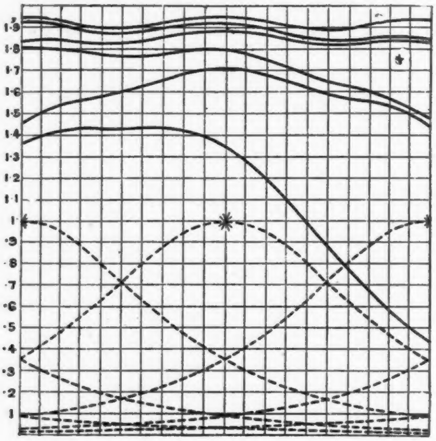


FIG. 10.—Resultant illumination due to lights at a distance apart equal to their height.

0·5, 1·5, 2·5, 3·5, &c., and is equal to 1·932 for five lamps. The resultant curve is practically symmetrical about a horizontal line, and the mean illumination may be taken as the arithmetical mean of the values. It is hardly necessary to point out that the eye could scarcely detect any variation in the illumination of the ground along the line of such a row of lamps, the difference being only 2¼ per cent.

The next arrangement, Fig. 11, is that of lamps placed at a distance apart equal to twice their height. The dottted lines, as before, are the curves of the separate lamps, and the full lines the resultants. The maximum illumination is 1·219, being twice the cubes of the cosines of angles whose tangents are 2, 4, 6, 8, and the minimum is 0·7836, being twice the cubes of the cosines of the angles whose tangents are 1, 3, 5, 7. The minimum is 35·8 per cent. less than the maximum. The mean is practically unity. In the next arrangement, Fig. 12, the distance is three times the height. The maximum is 1·073, and the minimum is

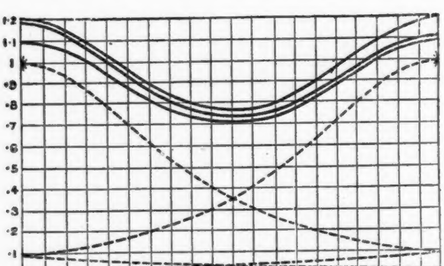


FIG. 11.—Resultant illumination due to lights at a distance apart equal to twice their height.

0.362, being 63.8 per cent. less than the maximum. This variation is, of course, very marked, but is not nearly so apparent to the eye as is indicated by the curves. The last example, Fig. 13, is a common arrangement in street lighting, the distance apart being six times the height of the lamps from the ground. The maximum is 1·01, and the minimum is 0·0632, and the variation 93·7 per cent. The additional effect of only one lamp on each side has been considered. It is somewhat doubtful whether the mean illumination in these last two cases is a quantity worth considering, since the effect of such an illumination produced by a considerable number of smaller lamps, closer together, and approximating to that mean, would be very different.

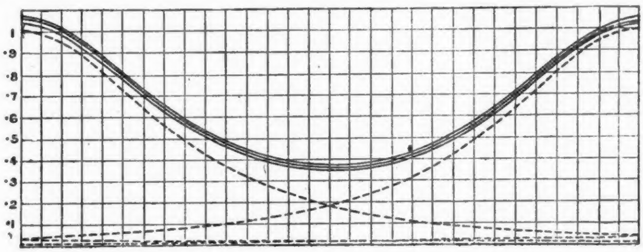


FIG. 12.—Resultant illumination due to lights at a distance apart equal to three times their height.

Two practical modifications must be considered with regard to these results: one is the non-uniformity of candle-power in different directions, due, in some cases, to the shadow of the gas burner or the frame of the lamp, or to the shadow of the lower carbon of an arc lamp; the other is the reflection of neighbouring walls.

The light of an ordinary continuous current arc lamp is emitted in a well-defined manner, and when used with a clear glass globe or lantern, may be taken as the worst case of non-uniform candle-power. Fig. 14 gives a curve showing the variation in candle-power, and the resultant illumination produced. With angles of incidence from 0° to about 55° the light is more or less obstructed by the lower carbon.* Beyond 55° the light follows a regular law, but not that of the cosine cubed, for the light is not emitted from a point or (in the case under consideration, that of the ordinary arc) from a flame, but from the horizontal tip or crater of the upper carbon. The projected area of this disc, as seen from any direction, varies as the cosine of the angle. The cosine being thus introduced for the fourth time, the illumination beyond 55° incidence varies as the fourth power of the cosine. The whole curve of $\cos^4 \theta$ is given in Fig. 14 as far as a point $2\frac{1}{2}$ times the height of the lamp. The part

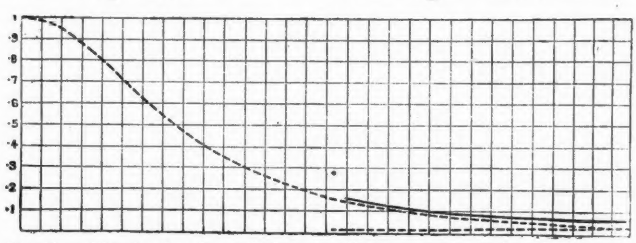


FIG. 13.—Resultant illumination due to lights at a distance apart equal to six times their height.

* See Trotter, *Journal Inst. Elec. Engrs.*, vol. xxi.

between 55° and 0° is dotted. The total light or flux is π, and a right-angled cone contains half the flux.

In the foregoing curves (Figs. 9 to 14) the height of the lamp and the maximum illumination have both been taken as unity. This is an arbitrary convention, and is useful mainly in enabling the curves to be compared. When, owing to non-uniform distribution of the light, the maximum illumination does not occur below the lamp, this convention fails ; but it is possible to retain the relation between the vertical and the horizontal scales by considering the illumination at some distance from the lamp. At angles of incidence greater than about 55 degrees, it has been already shown that the illumination from an arc lamp on a horizontal plane varies as the fourth power of the cosine. The fourth power of the cosine of 45 degrees is 0·25. If, then, the height of the lamp be set off on the same scale of feet as the horizontal measurements, and if it be assumed that the maximum illumination measured on a vertical scale be represented by a height equal to 0·25 of the height of the lamp, illumination curves of different kinds of lamps may be plotted together for comparison. Fig. 14 was constructed in this way. The flatness of this curve is rather a disadvantage.

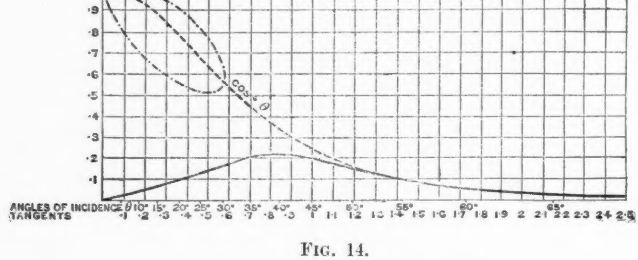


FIG. 14.

- · — · — · Candle-power curve of arc-lamp.
— — — — Curve of $\cos^4 \theta$.
———— Illumination curve for arc-lamp.

Distribution over a Plane.—The foregoing considerations relate only to the distribution of illumination along a straight line, and the typical curves (Figs. 10 to 14) show the results only in the line of the lamps. The next step is to consider the general distribution in plan. For this purpose lines or contours of equal illumination may be calculated. These correspond to the contour lines on maps, which show equal elevations. The calculation of these contours has been supposed to be laborious and intricate. There are generally difficult and tedious ways of performing any calculation, and certain people will delight in such methods. The following curves (Fig. 17) were drawn with no geometrical or even arithmetical calculations. A number of circles having as radii the tangent of the round numbers of the cubes of the cosines, taken from Táble I., were drawn with thick black lines. The length of the radii are the lengths of the horizontal lines in Fig. 9 intercepted between the curve and the zero ordinate, or the last vertical line on the left.

One set was drawn on ordinary paper and another on tracing paper. Each circle was boldly numbered along a radius, with a maximum at the centre, 100. One sheet was laid over each other, and was adjusted with the centres, that is the lamps, at the required distance apart, remembering that tangent 1 is equal to the height of the lamp above the ground, and a blank sheet of tracing paper was laid over all.

Fig. 15 shows, for the sake of clearness, portions only of two sets of circles. The lamps are at a distance apart equal to four times the height of each. The tangent of the angle of incidence at the point midway between the lamps is 2. The angle of incidence is 63 degrees 27 minutes, and the cube of the cosine is 0·0893. The intersection of the circles give a number of quadrilateral figures. Lines are drawn by free-hand from corner to corner through these quadrilaterals, and these are the contours required. Everywhere along the circle numbered 6 the illumination due to each lamp separately is 0·6 of the maximum illumination below the lamp. At the point when the two 6 circles cross the illumination will evidently be 12; and where circle 8 crosses circle 4 the illumination will be 12. Thus the values

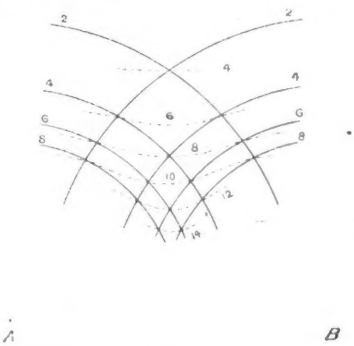


Fig. 15.

of the contours can be found. Where the circles do not intersect a little judgment is required, and this may be assisted by the following method.

Mark off two scales of radii along the edges of two strips of paper and pin them on to a sheet at points representing the lamps at the desired distance apart, as in Fig. 16, starting, say, with 6 set against 6, make a dot at the intersection. Move one strip clockwise and the other counterclockwise until the next pair of divisions meet, make another dot, and continue, observing from time to time that the

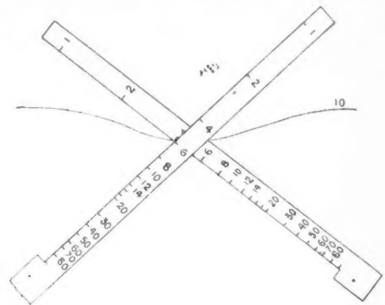


Fig. 16.

sum of the numbers remains constant. Only one quarter of the whole system need be drawn when two lamps are concerned, and this can be repeated four times by tracing. It is, in general, better to find the contours of two lamps first, and to combine a third by the first method. The contours for three lamps may be found by using three strips, but a good deal of mental arithmetic is needed to adjust them so that the sum may be constant. The illumination of a number of points regularly spaced or otherwise may be found by using three or four or more radial strips, and these may be prepared to represent lamps of different candle-power or placed at different heights. The strips are adjusted to intersect at any desired point, and the readings on the scales at this point are added together and written against the point. Contours may then be drawn by hand and eye, as in ordinary map work, and at any doubtful point the contour may be easily verified by bringing the scales to intersect.

(To be continued.)

The Globe Photometer in Practical Photometry.

By Dr. L. Bloch.

The Globe Photometer, a simple instrument intended for the measurement of mean spherical candle-power, was described by Prof. R. Ulbricht as long as eight years ago in a contribution to the *Electrotechnische Zeitschrift* (1900, p. 595).

However, it did not come into very general use until the year 1905, when the instrument was investigated simultaneously in several laboratories, and the favourable experiences of those undertaking the experiments were described in several subsequent contributions to the above-mentioned journal.* Since that time the use of the Globe Photometer has rapidly extended in Germany, especially since the Photometrical Commission of the German Institution of Electrical Engineers (Verband Deutscher Elektrotechniker) recommended its use for the photometry of arc lamps.

At the present time the Globe Photometer occurs in almost all German photometrical laboratories, and has proved itself of great value in the hands of capable workers. On the other hand, the instrument does not seem to have found very extended use in England or America. This is the more surprising, because it is in these very countries that a lively interest in illumination and questions of light measurement has recently been manifested, as is shown by the organization of a Society, and of a journal devoted solely to problems of this nature. Moreover, in England and America greater weight is attached to the value of the mean spherical candle-power than in Germany, and it is for the measurement of this particular quantity that the Globe Photometer is specially and pre-eminently adapted. It may, therefore, not be out of place in the present article to consider the Globe Photometer in the light of its application to practical photometry.

Besides the Ulbricht Globe Photometer mention may be made of the Lumenmeter of Blondel and the Matthews Integrating Photometer, which are also intended for the measurement of mean spherical candle-power. Both the latter instruments, however, only enable the mean candle-power in one meridian plane of the source of light investigated to be obtained by a single measurement. This value is only identical with the mean spherical candle-power when we have to do with a source of light which is perfectly symmetrical; that is to say, a source of light which yields the same intensity in all directions at a given angle to the vertical. Such a source of light is only approached by the Nernst lamp with a vertical glower, or a glow-lamp with a single vertical filament. Ordinary glow-lamps certainly cannot be regarded as perfectly symmetrical sources, and their intensity must either be measured in a series of different directions, or the lamps must be rotated during the experiment. Preferably, in order to obtain the mean spherical candle-power of glow-lamps with the Blondel or Matthews photometer we must rotate the lamps about the vertical axis by the aid of an apparatus similar to that employed for the determination of mean horizontal candle-power. Arc lamps also do not, as a rule, distribute their light uniformly,

* *Electrotechnische Zeitschrift*:—

Ulbricht	1905, p. 512.
	1906, p. 50 and 803.
Bloch	1905, pp. 1047 and 1074.
	1906, p. 63.
Consepius,	1906, p. 468.
Monasch	1906, p. 669, 695, 803.

and, therefore, their intensity must be measured in at least two perpendicular directions, if the above types of photometers are employed.

On the other hand the Globe Photometer enables the mean spherical candle-power of a source to be determined by means of a single measurement, even when the distribution of light from this source is very far from being symmetrical. In addition to this it is essentially simpler and cheaper to construct than the photometers of Blondel and Matthews. It is, moreover, easier to use than these instruments, and does not require the same expert manipulation on the part of the experimenter. In the two types of photometer referred to, for instance, it is essential that the sources of light to be tested should be situated exactly in the centre of the apparatus; in the case of the Globe Photometer, on the other hand, it is theoretically entirely immaterial, and, from a practical point of view, very nearly so, what the particular position of the source of light within the globe may be. Also the Globe Photometer enables the mean hemispherical candle-power to be obtained in a particularly simple fashion, and this quality is, of course, of considerable practical importance.

The proof of the correctness of the principle on which the Globe Photometer depends need not be repeated here. The correctness of this principle has been satisfactorily demonstrated both experimentally and theoretically in the contributions mentioned above, to which reference may be made if further details are required. For the present we will only consider the practical application of the results referred to.

Suppose that the source of light "L" is placed in any particular position in the interior of the hollow sphere, the inner surface of which is coated with a white diffusely reflecting varnish. Then the illumination of any particular point, "F," from the surface of the globe is proportional to the mean spherical candle-power of this source, if all the light radiating from this source remains, and is reflected to and fro within the globe. Thus the illumination at the point F is a measure of the intensity of this diffusely reflected light, it being understood that the direct rays from the source of light are screened from the point F by means of a suitable screen, B, as shown in Fig. 1.

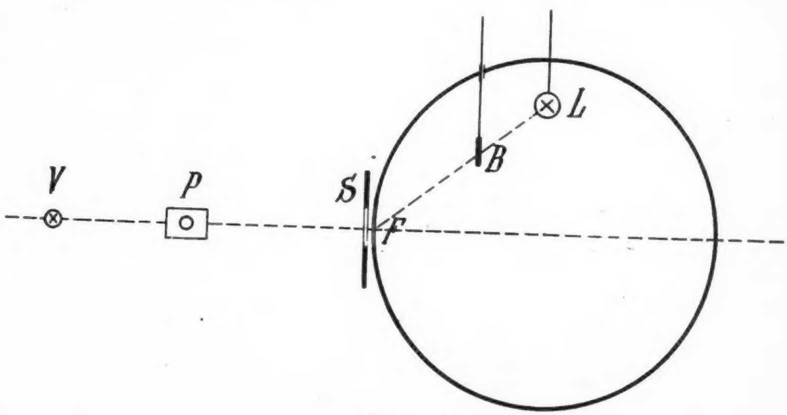


Fig. 1.

On the other hand, we may not use a complete globe, but one with an aperture at the top of the upper hemisphere, as shown in Fig. 2, the source of light being situated in the plane of the small circle of the sphere formed by this aperture. In this case all the light thrown in an upward direction does not illuminate the interior of the globe, and therefore the illumination of the inner surface of the globe is proportional to the mean lower hemispherical candle-power of the source. Here, again, the direct light is screened from the window F by means of the screen B.

In utilizing the Globe Photometer it is, therefore, only necessary to measure the illumination at a single point F, at the surface of the sphere. F may be situated at any desired point on the surface, but from considerations of convenience it is usual to select a point situated on the equator of the globe. Here a circular opening is made, the diameter of which varies, according to the size of the globe, from about 4 to 10 centimetres. If one utilizes the globe in conjunction with the ordinary photometrical bench, an opal glass screen is inserted into this orifice, and the brightness of this screen is compared with a suitable comparison lamp by means of the photometer P, as shown in Fig. 1. The value so obtained is proportional to the illumination at the point F of the inner surface of the sphere, and, therefore, also proportional to the mean spherical candle-power of the source of light under test. On the other hand, a photometer of a variety intended for measurements of illumination, as, for example, the Weber instrument, may be employed. In this case the photometer can be applied to the aperture in the globe, and the illumination measured direct without the necessity for a diffusing glass screen (see Fig. 2). In this way the apparatus assumes a very convenient and practical form.

Measurements of a source of light with a globe photometer naturally only afford relative values, and to obtain the mean spherical candle-power these results must be multiplied by a suitable constant obtained by calibrating the photometer. For this purpose it is usual to employ some source of low mean spherical candle-power, preferably a standardized glow-lamp yielding about 25 to 50 candle-power, which is only used for a short time at a stretch, in order that this candle-power may remain constant for as great a length of time as possible. The mean spherical candle-power of such a standard glow-lamp is obtained by means of point measurements in the usual way.

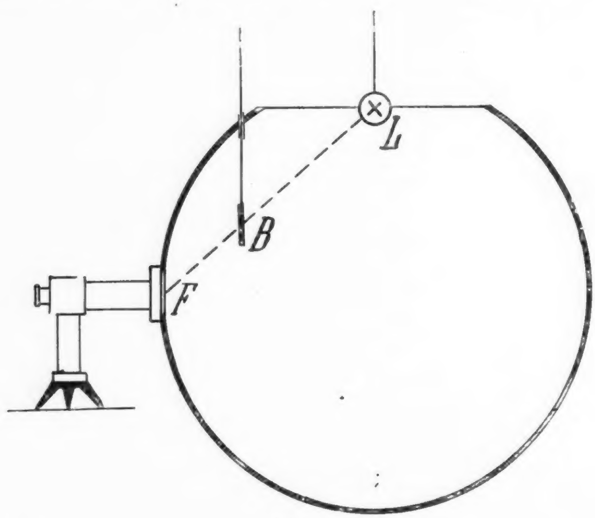


Fig. 2.

If, therefore, the source of light

under test in the Globe Photometer is replaced by a standard lamp, the comparison between its own mean spherical candle-power and the actual photometrical result enables us to calculate the desired constant. Instead of substituting a standard lamp for that under test we may adopt the proposal of Ulbricht, and place a standard lamp in the globe as well as the lamp under test, but in some other position, such as that shown in Fig. 3, the direct rays of the standard lamp being screened from the point F in the usual way.

method of measurement and the coefficient of reflection of the inner coating of the globe remain the same. It is, however, preferable not to assume that this is the case, but to repeat the calibration periodically, so as to avoid possible sources of error, at intervals of time depending upon the degree of use to which the photometer is put.

The constant of the globe so obtained, is, however, applicable to measurements of sources of all varieties and intensities, and it is not necessary to determine this value anew for each variety

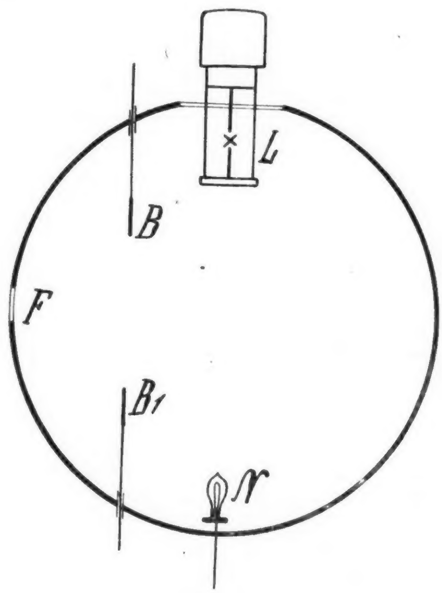


Fig. 3.

As the exact position of a light-source within the globe is immaterial, this arrangement enables us to carry out the calibration immediately after the experiments on the source of light to be examined, without it being necessary to remove the latter from the globe. All that is necessary is for each to be lighted in turn, and the corresponding measurements obtained.

When the constant of the globe has been obtained once and for all it should not alter, so long as the

of light experimented upon. Only in the case of sources possessing very extended radiating surface or bulky accessory apparatus will accuracy of the measurement be influenced. When it is desired to test a large number of sources of the same kind it is a good plan to first obtain the mean spherical candle-power of the type by point-to-point measurements on a single lamp, and then to calibrate the photometer by using this particular lamp. A value of the constant is thus obtained, which holds good for all sources of light of this particular variety. But in the case of all ordinary photometrical measurements the requisite degree of accuracy is obtained by the use of a standard glow-lamp.

Fortunately the actual construction of the globe photometer is very simple. The apparatus consists essentially of a sphere constructed of zinc or iron plates, with several openings, and equipped with a suitable movable screen.

If the Globe Photometer is only intended for the measurement of glow-lamps, a diameter of the globe of 0·6 to 0·8 metres suffices. If intended for experiments on naked light arcs, or for those having but small globes, it is advisable to make use of a globe with a diameter of 1 to 1·5 metres. If, however, arc lamps having globes of all the sizes occurring in practice are to be tested, a diameter of 2 metres is necessary.

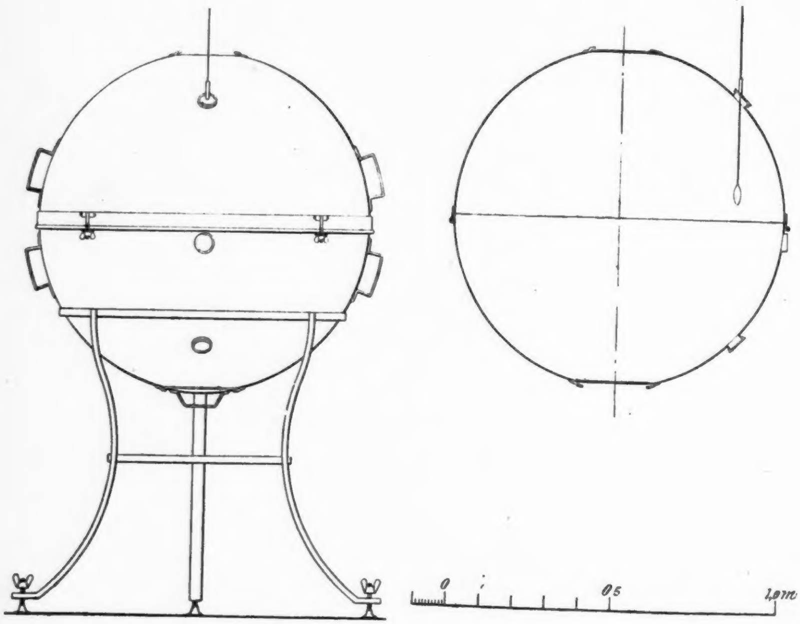


FIG. 4.

The upper aperture serves to enable sources of light to be lowered into the globe or to be removed from the apparatus to receive attention, and usually consists of a circular opening, which is 20 to 50 centimetres in diameter, according to the dimensions of the globe. As previously mentioned, there is also an opening at the side of the globe for the purpose of measuring the illumination, and there are also others which enable the observer to inspect the source of light while carrying out experiments upon it.

Globe photometers, having a diameter of even 2·5 and 3 metres, have also been constructed, and are in use at the present time. The choice of such great diameters arose from the desire to render the dimensions of the light source under test relatively small in comparison with those of the globe, and hence to reduce any sources of error due to the size of the lamp tested to a minimum. Yet it is doubtful whether there is any gain in accuracy by increasing the diameter beyond 2 metres. Certainly the original cost of the photometer, and also the amount of space occupied by it, is undesirably increased. It must also be noted that very large globes cannot conveniently be employed for the measurement of glow-lamps of comparatively small candle-power, because the illumination at the observation opening becomes inconveniently low; this illumination is inversely proportional to the square of the diameter of the globe.

The writer has employed a photometer one metre in diameter for several years with very satisfactory results, both as regards accuracy and convenience of measurement. Fig. 4 shows a sketch of this instrument as previously described in the *Electrotechnische Zeitschrift* (1905, p. 1050). This globe is made of zinc plate 2 millimeters in thickness, the two halves of the globe being built up by pressure on a model, and subsequently connected together by suitable screws and wingnuts. The upper and lower apertures of this globe are 20 to 25 centimetres respectively in diameter, both being provided with suitable covers fastening on the bayonet principle.

There are also three side apertures, each 5 centimetres in diameter, for the purpose of observation. The central aperture of these three serves for actual measurement of illumination, and the upper one enables the position of the screen within the globe to be adjusted; the lower aperture is used for this purpose in cases in which it is necessary to introduce a source of light from the base of the globe.

Fig. 5 shows a Globe Photometer 2 metres in diameter, previously described by Dr. Monasch (*E.T.Z.*, 1906, p. 670). This instrument is composed of 64 segments of sheet iron, which are bound together by flat strips. The globe is divisible into two sections. On the right hand we see the Weber photometer in position applied to the illuminated window.

The condition of the light-reflecting coating in the interior of the globe is of special importance. The more uniform and lasting is this coating, the greater will be the attainable accuracy, and the smaller any variation in the constant of the photometer in the course of time. In order that as great a percentage as possible of the light falling upon the interior of the globe may be reflected the coating must be composed of some pure white material. For this purpose barium sulphate or zinc-white may be used. By the use of either of these materials a coating can be obtained which reflects about 75 per cent. of the light falling upon it; but as the coefficient of barium sulphate is apt to alter under the influence of certain kinds of light, zinc-white seems to be best designed for this purpose. The coating so obtained must not only be white, but must present a dull, matt surface, without any sign of shininess. Otherwise, one does not obtain the true diffused reflection of the light which the theory of the instrument demands, and the coefficient of regular reflection enters into the problem. Moreover, the material employed for coating the interior of the globe should not contain too much of the fine glue solution, which is generally added in order to make the coating adhere. If the percentage of adhesive material added is too great the surface assumes a yellowish tinge.

The coating of the instrument gradually becomes darker with use, and this causes a corresponding alteration with the constant. So long as the darkness is uniformly distributed this has but little influence on the accuracy of measurement. If the darkness is very considerable, however, or is irregular, it is desirable to renew the light-reflecting coating. Under ordinary circumstances this will probably be necessary every six to eighteen months, according to the use to which the globe is put and the exact nature of the coating. The screen which serves to keep the direct rays of light from falling ~~from~~ on the illuminated window may be simply constructed out of white cardboard. Its exact dimensions naturally depend upon the dimensions of the source of light tested. In the case of ordinary glow-lamps, and arc-lamps without globes, a diameter of about 5 centimetres generally suffices. The screen is provided with a white rod by means of which it can be mani-

FIG. 5.

PHOTOGRAPH OF GLOBE PHOTOMETER, 2 METRES IN DIAMETER.

pulated or placed in any desired position from one of the aperture windows in the side of the globe. One can easily judge whether the correct position of this screen has been obtained by looking at the source of light through coloured glasses, and observing whether any direct rays from the source of light are visible. This method, however, is not to be recommended, at all events, in the case of the person who is going to carry out the photometrical measurements himself, because it would certainly disturb his eyes in the subsequent measurements. It is more convenient to place a slip of white cardboard in front of the illuminated window, and to judge by the brightness of the illumination upon it when the correct position of the screen has been obtained.

As mentioned before, it is theoretically quite immaterial what the exact position of the source of light within the globe may be. Practically, however, it is preferable not to place the source of light in the exact centre of the globe, because the various bits of apparatus attached to the lamp must also be introduced into the globe with it, and will interfere with the accuracy of measurement; it is, therefore, better to place the source of light nearer the wall of the globe, and perhaps 10 or 20 centimetres from the aperture at which it is introduced. By so doing the mechanism of the arc lamp and suchlike inconvenient apparatus can be kept outside the globe.

The majority of sources of light will be introduced into the globe from the upper opening, but in the case of petroleum and alcohol lights, and many gas lamps it is often convenient to introduce the light through the lower opening. To facilitate this process it is desirable to support the globe in some form of framework in such a way that its lower point is not nearer than half a metre to the floor.

In order to measure the mean spherical candle-power, the knowledge of which is especially valuable in the case of many arc lights, inverted gas-lights, &c., the source of light must be situated exactly in the plane of the aperture at the top of the globe. Under these conditions all the light in the lower hemisphere passes into the globe, while that in the upper hemisphere, on the other hand, passes outside and is not measured. In the case of naked arc lamps, &c., and in other cases in which very great accuracy is not essential, one can judge this position very correctly by observing the border line between the light and shadow on the wall of the photometer-room. If this shadow line is situated at the exact height of the aperture of the globe from the floor, the position of the light source is correct. It is very convenient to mark out this correct height by a strip running round the whole of the room.

In the case of sources in which the radiating surface is more extensive, *e.g.*, glow-lamps and incandescent mantles, one must endeavour to arrange so that the centre of radiation of this light-giving surface is situated on the plane of the aperture. Where very great accuracy is desired we may determine this centre of radiation by the method of Ulbricht (*E.T.Z.*, 1906, p. 50, and 1907, p. 777).

In the case of measurements of mean hemispherical candle-power the determination of another constant for the photometer is necessary, and this can be obtained in the same manner as that described previously for the mean spherical candle-power. It is approximately double the value of the constant in the latter case.

In measurements involving the determination of mean hemispherical candle-power appreciably greater care is necessary than when determining the mean spherical candle-power. In the latter case, as previously mentioned, the exact position of the source of light within the globe does not very much matter, but in the former case small inaccuracies in situation of the light source causes very appreciable errors in the result. In many cases it is preferable to determine the mean spherical candle-power in the photometer, and to determine the mean hemispherical candle-power therefrom by the use of a reduction factor, obtained once and for all for the variety of lamp under test. For instance, this factor approaches 1·85 to 1·95 in the case of the naked arc lamps, and 1·02 to 1·05 in the case of the majority of glow-lamps.

It may next be inquired for what kind of measurements is a Globe Photometer specially adapted. In this connexion, the measurement of light from arc lamps is worthy of special mention. The determination of polar curves of distribution of light and the deduction of mean spherical candle-power or mean hemispherical candle-power therefrom not only demands considerable expenditure of time, but also a very competent observer. But these quantities can be obtained direct by the use of the Globe Photometer by means of one or two single measurements. The influence of different currents or P.D.s, or certain varieties of carbons on the mean spherical candle-power of an arc lamp can be obtained in a very short time. Therefore the Globe Photometer is especially serviceable for the comparison of different kinds of carbons in the same lamp or different kinds of lamps with the same pair of carbons.

The necessity for this Photometer is not so striking in the case of measurements of the candle-power of glow-lamps, although it may be very serviceable in this connexion also. As yet measurements of the candle-power of glow-lamps are almost exclusively made in the horizontal direction. In such a case it is essential to measure the intensity in several different directions horizontally; otherwise irregularities in reflection and refraction from the glass bulb introduce very considerable errors into the results, even though the lamp itself may yield a very uniform distribution of light. Hence special mirror-appliances or arrangements for the purpose of rotating the glow-lamps have been devised in order to enable the mean horizontal candle-power to be obtained from a single measurement.

It is naturally desirable that when great numbers of glow-lamps are to be compared some standard method should be adopted, especially in order to be able to secure agreement between measurements from different sources. Therefore measurement by means of the Globe Photometer ought to receive precedence, because in this instrument the whole of the light given out by the lamp is taken account of. The mean spherical candle-power measured by the Globe Photometer can easily be converted into mean horizontal candle-power by the use of a suitable reduction factor. This factor can be obtained once and for all for the various types of lamps in question by measurement of the mean spherical candle-power in the Globe Photometer and the mean horizontal candle-power by one of the special types of apparatus previously referred to; both candle-powers can also be obtained by point-to-point measurement. The reduction factor is then the quotient of the mean spherical by the mean horizontal candle-power. In the case of the majority of glow-lamps this factor is intermediate in value between 0·76 and 0·82. When great accuracy is not essential we may take this reduction factor as 0·78.

As well as glow lamps and arc lamps other sources of light can be very quickly and easily tested in the Globe Photometer, and the dimensions of lamps capable of being so tested is only limited by the diameter of the globe. It need not be feared that the measurement of the light from lamps burning combustible substances will be prejudiced by alterations in the state of the atmosphere in the globe, because the various openings in the globe provide abundant ventilation. Experiments on this point are, however, being carried out by the Institution of Gas Engineers in Germany, and no doubt the results will be available very shortly.

Now that the practical value of the Globe Photometer is thoroughly appreciated in photometrical laboratories in Germany, it may confidently be predicted that this instrument will receive the attention it deserves in other countries.

A New Form of Photometer for the Comparison of Sources of Light which Differ in Colour.

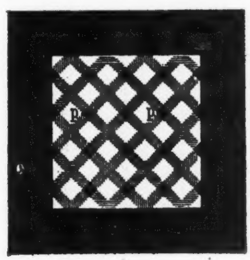
By W. Biegon von Czudnochowski.

One of the oldest and most simply constructed of photometrical instruments is the so-called "Lambert" or "Lambert-Rumford" photometer. This consists essentially of a simple vertical rod, shadows of which are thrown on a white ground by the two sources of light to be compared

The distances of these two lights are then adjusted so that the two shadows appear equally bright. It is, however, well known that it is very difficult to compare sources of light which differ in colour by a method depending upon the principle of "equality of brightness." In this case the different colours of the shadows renders this method difficult of application, and, as the author has shown elsewhere, the Lambert - Rumford photometer ought, strictly speaking, to be termed "A Contrast Photometer." because we really attempt to judge balance by the equality of contrast of the shadows against the white background of the screen. The sensitiveness of this simple photometer is not very great, even when a suitable transparent screen, enclosed in a box so as to avoid the possibilty of diffused light reaching the screen, is used. It seems possible, however, to develop this apparatus so as to obtain much better results.

Suppose that, instead of a single shadow, we utilize a number of equidistant shadows all vertical, parallel to one another, and in the same plane; then, if the two sources of light producing these are in the same horizontal plane, we can produce a series of equidistant shadow lines on the screen, of which those corresponding to the numbers 1, 3, 5, 7, &c., have the colour of the first of the two lights to be compared, and those corresponding to the numbers 2, 4, 6, 8, &c., the colour of the second; otherwise the conditions are unaltered.

We have, however, an entirely different result if we use two separate gratings composed of parallel wires and crossing at angles of 45 degrees to the horizon. In this case two intersecting shadows are formed on the screen, and the points of intersection of the patterns, being illuminated by neither of the two sources, appears much darker than the rest, as is shown in Fig. 1.



SHADOW FROM L_1

SHADOW FROM L_2

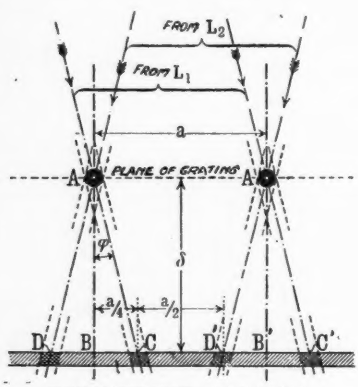
Fig. 1.

By this means a new system of comparison is available; we form our judgment not only by the contrast between the shadow pattern and the white background, but also between the shadow pattern and the dark points of intersection; but the method may be further developed.

When we project the image of a solid object on to a semi-transparent screen, the image appears sharply defined when our direction of vision is perpendicular to the screen, but becomes indistinct when viewed obliquely; this is a natural consequence of the semi-transparency of the screen. We can now arrange that the direction of the rays coming from the *left* hand light source coincides with the direction of vision of the *right* eye, and vice versâ. Thus an image formed by the left hand sources appears sharp to the right eye, while, conversely, an image formed by the right hand source only appears distinct to the left eye. This gives rise to a stereoscopic effect, and one observes a system of black points, apparently free, against a background formed by the pattern.

In order that these considerations may hold good certain conditions must be realized.

Fig. 2 represents a horizontal sectional view of the arrangement.



SEMI-TRANSPARENT GLASS PLATE.

FIG. 2.

Let " a " be the distance AA between the two wires of the grating, *i.e.*, the diagonal of the mesh formed by crossing the two patterns. Let " d " be the distance AB between the grating and the diffusing glass plate. Then if the light sources be placed symmetrically, the distance between two adjacent shadow-lines DC, CD', C'D', is $\frac{a}{2}$, and similarly $BC=\frac{a}{4}$.

Hence if ϕ be the angle of incidence of the ray forming the extreme edge of the shadow, we have :—

$$\tan. \phi = \frac{BC}{AB} = \frac{a}{4d} \ldots\ldots\ldots (1)$$

A must be distant from the eye of the observer the smallest distance of distinct vision (*i.e.*, about 25 centimetres) = " n," say. Then taking the distance between a normal pair of eyes as a_o = 6·5 centimetres, we have also :—

$$\tan. \phi = \frac{a_o}{2n} \ldots\ldots\ldots\ldots (2)$$

From (1) and (2) we obtain $a = d . \frac{2a_o}{n}$ (3)

Thus, given " d," " a_o," and " n," we can determine " a." Also, as the angle of intersection of the two gratings is in this case 45 degrees, the distance between two wires on the grating becomes $\frac{a}{\sqrt{2}}$.

Hence, if we select the value 1 centimetre, for " d," the above distance becomes 3·68 millimetres. Actually, in the experiments of the author, " k " was 2·25 mm., and hence the exact value of " d " worked out to 6·12 mm.

One difficulty experienced in these investigations was the construction of a suitable form of grating. The ordinary variety of wire-gauze is not satisfactory for the purpose in view, because of the wavy character of the wire. The individual strands cross and recross, first underneath and then over each other. Hence, if the diameter of the individual wires is 0·5 mm., the grating as a whole has a thickness of 1 millimetre, which is too great compared with " d." The grating is prefer ably made by a method similar to that employed in the manufacture of lead plates for accumulators; it might, with advantage, be stamped out of thin sheet.

It is well known that, in accordance with the " Purkinje effect," our eyes are incapable of perceiving colour, if the intensity of the coloured light is too low. Under these circumstances all objects appear of a ghostly grey. This can be explained by the physiological structure of the eye, and is due to the fact that certain organs on the retina, with which are connected the functions of perceiving colour, are insensitive at these low illuminations. When the introduction of the arc light drew attention to the difficulty of comparing sources of light differing in colour, Allard and Gladstone, in 1881, were led to suggest that sources of light might be compared at such distances from the photometer, as to cause the illumination of the photometric surfaces to fall below that value at which the colour-sense disappears.

The author is not aware of this method having actually found practical application. The process dealt with in this article, however, seems to admit of the production of a colourless field,

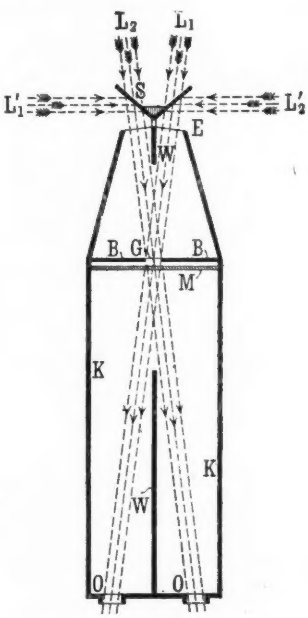


FIG. 3.

without the necessity for utilising a low order of illumination. Instead of two fields on the photometer we have now the two shadow patterns appearing grey on a white background with black intersections, but if either of the light sources is moved very sensibly out of balance one of the patterns becomes coloured.

The utilization of the stereoscopic effect is of great consequence, the method being somewhat similar to that utilized in the "Anaglyphs" invented by Duros du Hauron. According to this method, two stereo-photographs of an object are taken, and the corresponding positives are prepared, which are reproduced, say, in red and blue. These are viewed by the observer through a pair of spectacles, one lens being coloured red and the other blue, so that one eye sees only the blue image and the other only the red image, exactly as in the stereoscope, and thus the two superimposed images give rise to a single impression.

We have thus a stereoscopic effect analogous to that utilised in the photometer described in this article.

Finally, the general nature of the optical system of the shadow-grating-photometer is shown in Fig. 3.

KK is a light-tight box, blackened on the inside, with two circular openings, O, O. BB is a diaphram into the centre of which is let the small grating G. Slightly in front of B is situated the diffusing glass plate M; the screen WW serves to divide the box into the left and right portions.

L1, L2 are the light sources to be compared. In order that the apparatus may be used on the ordinary type of photometer bench two mirrors, shown at S in the diagram, can be utilized; then, if the lights are placed at L_1, L_2, the two beams of light converge as before.

The advantages of the form of photometer described in this article consist in its simplicity, its great sensitiveness, and its value for the comparison of the various modern illuminants, such as the flame arcs, enclosed arcs, &c., which differ very considerably among themselves in spectral composition.

The necessity for some such photometer is certainly much greater than in the past when the illuminants in existence resembled each other very closely in colour, and the difficulties referred to did not arise in practical photometry.

The Chicago Electrical Trades Exhibition.

An exhibition under the above title was held at Chicago from January 15th to 25th of the present year. The electrical lighting of the exhibits and of the whole exhibition generally was of a special character, and, through the courtesy of the *Electrical Review* of New York, we are enabled to include some illustrations of the most interesting features of the arrangements referred to.

It is stated that during this exhibition light was used on a more lavish scale than had ever been the case under similar circumstances before. Judging from the effects of such lavish lighting in some displays in this country, one would be inclined to exercise caution in regarding this as an advantage. It is common knowledge that in many such instances a great deal of light is spent, with the result that the building as a whole becomes a blaze of light, which, so far from producing artistic effects, is wearisome to a degree.

It is, however, satisfactory to learn that in the present instance the general scheme of illumination was devised by a firm of architects in co-operation with illuminating engineers with special reference to the production of effects pleasing from the æsthetic standpoint. The chief features of the general scheme of illumination seem to have involved the use of festoons of lamps and chandeliers carrying 275 lights apiece. Some of these occur in Figs. 1 and 2.

The illumination of the various stalls demanded special arrangements, but, in general, efforts were made to tone down the great brightness of individual sources of light by the use of suitable shades, &c. Special mention may be made of the exhibit of the National Electric Lamp Association, where a series of 40 and 60 watt tungsten lamps, including 300 40 watt tungsten lamps equipped with special holophane reflectors, were shown; the pleasing effect of the combination should induce other lamp-makers to follow suit. Fig. 1 shows a stall illuminated by various forms of holophane globes and reflectors. The main sources of light are placed within holophane globes, while 132 of the new bowl-type reflectors are mounted round the sides of the stall.

Naturally illuminated signs were in evidence, and there were also some attempts to bring home special points in illumination. For instance, arrangements were made to show the difference between the appearance of coloured materials when illuminated by the carbon filament and the osram lamps respectively. For this purpose a stall, which could be illuminated by both systems, was equipped with pictures rich in bluish and greenish tints, and also specially decorated with materials in delicate shades of colour. Each variety of light was switched on in turn, and the improvement in colours under the osram light, which, of course, represents a closer resemblance to daylight, was demonstrated.

One company arranged to fit up an "electric home," where actual furnished rooms illuminated by various types of holophane and other types of shades and reflectors, and the newest fixture designs were exhibited.

An exhibition presents an excellent opportunity of exhibiting special lighting effects, and educating the public to appreciate the difference between bad and good illumination.

Certainly the advantage to be gained by the company that studies the needs of the consumer in this respect, and is willing to take some trouble to lead him to appreciate this distinction, are well worth consideration.

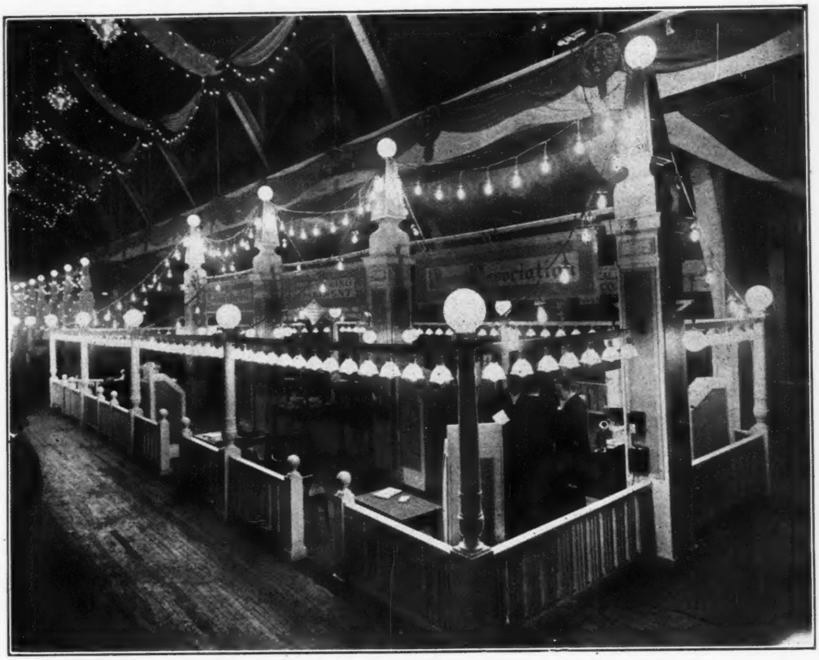


FIG. 1.

FIG. 2.

EXHIBITS AT THE RECENT CHICAGO ELECTRICAL EXHIBITION.

Electrically Lighted Signs at the Olympia Motor Exhibition.

THE CLEMENT-TALBOT STAND.

(From a Correspondent.)

THE question of the best methods of illuminating notices, &c., is attracting no little attention at the present moment, and a description of the electrically illuminated sign shown in the illustration, one of the many tastefully illuminated devices at a recent Olympia motor exhibition, should therefore be of interest.

The framework of the stand was constructed of wrought iron and copper hand work throughout.

On this frame were mounted one large central shield and four smaller similar shields at top and bottom of the two pillars.

The lighting of these shields was carried out as follows :—

The large central shield was illuminated by thirty internally placed 16 C.P., 220 volt lamps, while the two top shields and the two lower shields received ten and fifteen 16 C.P. lamps respectively.

On each pillar four brackets arranged to carry four illuminated lanterns were arranged, each lantern containing four Osram 50 C.P., 110 volt lamps, wired two in series. The rest of the illumination of the stand was carried out by means of 8 C.P. 44 volt lamps connected 5 in series.

Other arrangements were necessary in order to illuminate the various trophies. In all 44 distinct circuits controlling the different lamps were utilized.

It is interesting to note that as much as half a mile of 3/25 wire was used for the wiring of the small series lamps, and 2½ miles for all purposes. Yet all this wire was completely concealed.

Modern Methods of Illuminating Display Windows.

A Critical Description of the Recent "Augur" Exhibition in Berlin.

By Dr. Karl Stockhausen.

One of the most interesting of the special exhibits at the recent "Augur" (Ausstellung Umfassend Gesellschafts-austattung und Reklame) Exhibition, which has been held in Berlin under the auspices of the society of special industries from the 12th to the 14th of February, was certainly that devoted to illumination. This exhibit was confined exclusively to the illumination of display windows, the arrangements being designed to answer the question, *What is the best way of illuminating a modern show window in at once. the cheapest and most effective manner?*

Seldom—one might say never—has a similar opportunity been afforded, both to business people and illuminating engineers, of witnessing the different varieties of illumination and the many possible devices that can be applied to window-lighting. The display was rendered specially valuable by the ingenious arrangement of the exhibits. Eighteen exactly similarly built shop-windows, each equipped with plate glass in the usual way, were grouped round the four sides of a great square, so that the observer, standing inside the square, could examine several windows at the same time, and critically compare the illuminating effects with one another. Each window was equipped with tastefully displayed wares exactly as would be the case in the street; and the firms exhibiting were able to select different sources of light and different arrangements of wares in the windows in order to show their methods to the best advantage. The whole display was specially interesting to illuminating engineers for the reason that examples of exceedingly tasteful and effective methods of lighting were ranged side by side with others which demonstrated most emphatically how a display window ought *not* to be illuminated.

Let us next consider the purposes which the illumination of display windows can really be said to serve. A show window is one of the best methods of display for any business man—if not the best. Any other method of advertising, whether by placards, illuminated signs, or any other device, is only suitable for the purpose of drawing attention to his goods. A display window, on the other hand, shows these goods to the passer-by, as they actually are, in all their attractive elegance; it both attracts attention and stimulates the desire to buy. In the daytime this is effected solely by tasteful methods of decoration and display; but in the evening the salesman can derive powerful assistance from the possibility of controlling and arranging the illumination of his window so as to be specially adapted to the effect he wishes to produce. Not every striking method of illumination can be said to be effective, and just in the same way effective illumination is not necessarily striking; in the happy combination of both these intentions lies the great art of window illumination.

If two shops flood their wares with light in an extravagant manner, the shop between them appears by contrast to represent moderate but yet striking illumination, while, of course, the converse is equally true. Yet one must always take account of the prevailing taste in these matters, which at the present time finds expression less in the adoption of any striking system, but rather in adequate illumination in sympathy with the wares it is intended to display.

At the present time six distinct methods of window illumination can be distinguished, as follows :—

1. Row-illumination. 2. Ceiling-illumination. 3. Side-illumination. 4. Exterior-illumination.. 5. Illumination by means of diffused lighting; and, finally, 6, mixed illumination, in which several methods of illumination can be employed in order to produce a given effect.

Row-illumination consists essentially in the placing of a row of sources situated at a given height above the ground, as, for instance, gas-jets placed along a gas pipe or glow lamps mounted at regular intervals. This method is not a satisfactory one, and cannot easily lead to really tasteful illumination. It is chiefly used in small concerns and shops.

Very pleasing effects can be achieved by means of *ceiling-illumination*. In this method the lamps are either mounted on the ceiling or are partially let into it.

Side-illumination is of special value in the cases in which a general effect is to be produced. Any danger of dazzling the eyes of the onlooker can be avoided by hiding the individual lamps in suitable reflectors, so that no direct rays pass out through the window. For the display of carpets, drapery materials, furniture, and so on, this method is very effective.

By placing lamps outside the shop very serviceable illumination can be obtained if the sources are correctly arranged, but as a rule these lamps are so carelessly hung that the observer is either dazzled by the direct rays from them or by the reflection of their illuminated surface in the plate glass windows or other shining surfaces in the window. The public illumination of streets and open spaces, and especially the illumination of display windows by means of unshaded lamps, has become an actual nuisance. In most large towns one can scarcely take a step without encountering cases in which dazzling of the eyes takes place.

Diffused lighting presents a sharp contrast to these external methods of illumination. By the latter method the light streams from the outside into the window, so that passers-by are chiefly attracted by the amount of light displayed in the window and thrown upon the wares contained therein.

In the case of diffused illumination, on the other hand, the lamps are arranged high above the window behind a frosted or opalescent glass roof. By this method the rays are diffusely distributed, and the contents of the window and the pavement are flooded with a bright and uniform illumination. All danger of dazzling is avoided, yet the smallest object is perfectly visible; both to the salesman and the customer this method of illumination, which produces an excellent impression, is very convenient. Indeed, it may be said that there is no modern system of illumination so well adapted to window-lighting as these diffusing methods. They are applicable to almost all conditions, but are especially effective in the case of sweet shops, linen draperies, jewellers, shops devoted to needlework and the like.

In *mixed-illumination* a combination of several of the previous methods of illumination are employed. In this way quite startling effects can sometimes be produced, especially when it is desired to bring into prominence special objects within the window. It is also possible to illuminate furniture, &c., in a tasteful manner that can hardly be arrived at by any other method.

Let us now consider critically some of the actual exhibits detailed for the purpose of comparison; we may divide these into excellent, good, moderate, and bad.

Excellent effects were produced by some methods of purely diffused arc lamp illumination, to which, in one instance, an ingenious colour change arrangement was added, so that the shop could be flooded at intervals with a mild white, red, yellow, or blue light. Yet one may entertain some doubt as to the value of this method in the case of linen-drapers and other shops where coloured goods are displayed. Other excellent systems of illumination were effected by ceiling-illumination with Nernst lamps, side-illumination with Tantalum lamps, Just-Wolfrom lamps, &c. In all these cases bright illumination was obtained, and yet any danger of dazzling the eye was avoided by the careful use of frosted shades or reflectors. Window illumination that might be described as "good" was obtained in several cases by the use of enclosed arc lamps. In one case two lamps were hung close to the ceiling inside the show window, while two others were employed for exterior lighting. Here, however, the dazzling of the eyes was not entirely avoided, although the effect was not very serious, partly because the lamps were hung fairly high up, and partly because of the comparatively small surface brightness of the globes. It was surely not without an object that this method was applied to gentlemen's clothing and linen. In other cases, where objects presenting very extended and stationary surfaces were to be illuminated, the use of the somewhat unsteady light from enclosed arc lamps might prove unsatisfactory.

Those windows which were illuminated with inverted incandescent mantles might also have been ranked not only as good, but as excellent examples of window illumination, had it not been that the inconvenient arrangement of the lamps outside the window were apt to dazzle the observer, either through his receiving the direct rays from the source itself, or of the bright image of it by reflection from the show window. Moreover, in these cases, adequate—and therefore effective—illumination might well have been obtained without the use of any outside lamps at all. Again, in one exhibit, where excellent diffused interior illumination was employed, exterior flame-arc lamps, having insufficiently large globes, and provided with no screen in the direction of the pavement, were added. So marked is the dazzling produced in such cases, that this method of window-lighting constitutes, as previously remarked, an actual nuisance, and it cannot be sufficiently condemned.

The utilization of miniature arc lamps for the illumination of a richly decorated table must also be ranked as only moderately good, because in this case a very steady source of light is desirable. This defect was emphasized by the streakiness of the globes employed, which caused light and dark patches to appear upon the table-cloth.

As an example of what an illuminated window ought not to be we may mention several cases in which unshaded incandescent mantles were used, and no attempt was made to screen the eye of the observer; the naked and intensely brilliant mantle was allowed to play direct upon the eye. In another case, a lamp of this kind had, indeed, been equipped with a diffusing surface on the street side of the lamp, but the unshaded incandescent mantle, only slightly reduced in brilliance, could be seen by reflection in the shop window. In general far too little attention is paid to the possibility of directly dazzling the observer in this way; the image of the source of light thus seen by reflection from the window is almost as trying to the eye as the source of light itself.

There were also several other illuminated windows which likewise exemplified some pitfalls which must be avoided in lighting with glow-lamps. For instance, the shop was, in one case, illuminated with metallic filament lamps, but only about half of each lamp was obscured by means of a holophane shade, so that the eye could easily perceive and suffer from the exceeding great intrinsic brilliancy of the naked filament. The same thing might be said with even greater force of the exhibit of metallic filament lamps by another firm, in which only the lower half of each lamp was frosted over. In this case the lamps were enclosed in small lanterns, the sides of which were made up of clear glass, the upper portion consisting of a silver glass surface. Different opinions might be formed as to the merits of this arrangement according to individual taste, but probably few people would have considered it a really artistic method of decoration.

The first portion of the inquiry, "How can a modern display-window be illuminated in the most effective and cheapest way"? may therefore be solved in a variety of ways. But which is also the cheapest method of illumination? In almost every case the illuminated window was provided with a placard giving complete details of the cost of installation, the cost of energy taken by lamps, and the cost of renewals per 1,000 hours, so that those present were able to make a note of the probable relative costs of the different systems.

Though this was extremely convenient for those interested in the matter, it may fairly be said that the question of cost does not enter very materially into the problem of really effective display-window lighting. The far-sighted salesman will not shrink from the naturally increased cost of a really effective advertisement in comparison with one of lesser merit. *In short, the most effective system of display-window lighting is at the same time the cheapest.*

It is naturally not aways easy for the merchant to weigh the merits of all the many methods of illumination and varieties of illuminants at his service, and decide which are best adapted for the illumination of his special display of goods. Moreover, it is often desirable to be able to alter the kind of illumination of a window at will so as to continually produce new and charming effects of light, and rivet the attention of the passer-by. This intention calls for the services of a capable illuminating engineer, and can be satisfactorily met in most cases by arranging for the simultaneous provision of several alternative methods of illumination. For instance, we may design the installation in such a way that either diffusing arc lamp illumination, or ceiling-illumination by means of glow-lamps, or side-illumination, can be used as desired. The method of illumination giving rise to the most effective results in special circumstances can thus be secured at will. Of course, this necessity is mainly experienced by large establishments, in which not one variety of goods only is shown, but many different varieties, such as furniture, confectionery, gentlemen's clothing and linen, &c.

Finally, we may lay down the following rules, which may be said to form the basis for effective shop-illumination:—

1. The window must always be so illuminated that even the smallest object is clearly distinguishable.
2. The attention of the passer-by is attracted not merely by an extravagant and dazzling expenditure of light, but by the effectiveness of the illumination.
3. The more original and striking the form of illumination employed, the greater its ability to attract attention.
4. The choice of the varieties of illuminants and methods of illumination adopted must be determined by the nature of the goods to be exhibited.

Shop-Window Lighting.

In commenting upon the March number of *The Illuminating Engineer, The Builder* remarks:—

"The current issue has a special-section on 'Illumination and the Architect,' in which a plea is advanced for greater co-operation between the architect and the illuminating engineer. The journal contains several articles of interest to photometrists. We hope the influence of this periodical will be used to put a stop to the display of batteries of powerful arc lamps outside shop-windows. The Corporation of London introduced a short time ago a regulation prohibiting the use of unshaded high power lamps outside shops in City streets, but they appear to lack either the power or the courage to enforce the regulation, for some of the most dreadful examples of vulgar and garish shop-lighting are still allowed to dazzle and annoy City pedestrians."

The Economical Illumination of Display Windows.

BY J. D. MACKENZIE.

(*Continued from p.* 119.)

THE following table gives watts expended and candle-power per cubic foot of window space, which may serve as a basis for further comparison.

From the foregoing table it will be noticed that the nominal candle-power per cubic foot of window spaces varies from 1·53 to 2·42, excluding the effect of the outside lamps, and it may safely be assumed that for modern requirements in well-lighted streets 2 candle-power per cubic foot of window space is practically essential. Consequently this figure may be used to give an approximate pre-determination of the light required in any given case. When outside lamps are in use the interior candle-power may be considerably reduced, especially if the exterior lamps are fitted with reflectors arranged to throw a proportion of the light toward the windows.

In some lines of business, where goods are dressed close up to glass, or where they are of such a nature as to reflect most of the light falling on them, it is possible to obtain a thoroughly satisfactory illumination without any interior window lights. For this purpose electric or gas arc lamps are absolutely essential (except in the case of the very smallest class of windows where clusters of the metallic filament lamps may advantageously be employed), if the most economical results are desired, and special care is required in placing lamps so as to obtain the best effect. A knowledge of the polar curve of the particular lamp installed is of use in determining the best position. Besides this, however, careful consideration should be given to the consumption of the individual lamps and a judicious use made of the smaller types wherever possible. Reflectors should also be fitted to direct the light in the required direction. Of course, as previously indicated, the lighting of the thoroughfare has a good deal of influence on the size of lamps necessary.

Perhaps one of the most difficult classes of window to light is that of a clothing warehouse. Generally speaking the windows are large, the goods comparatively dark, and the only way in which the lighting effect may be enhanced is by a liberal use of mirrors. This, however, is not always possible, and even when possible is not always advisable. To fit up the back or inner side of the window with mirrors would undoubtedly greatly assist in reducing the expenditure of energy required in lighting the window, but against that must be placed the fact that so doing renders the interior of the shop dark, making it necessary to use artificial lighting inside the shop all day long. Such a method does not tend towards economy in illumination, and hence a balance should be struck between the window lighting and the interior lighting of the shop.

From an analysis of various shops of this nature the writer finds that the expenditure of energy required to give a satisfactory illumination varies from 1·5 watts per cubic foot of window space (using enclosed arc lamps with white enamelled reflectors) to 3 watts per cubic foot, using open type arc lamps without reflectors. Flame arc lamps, except those giving a white light, are unsuitable for this class of work.

In concluding this short article the writer must deplore the fact that there is so very little reliable data to be had regarding the illumination necessary for various purposes, and hopes that the interest now being taken in the subject will result in the accumulation of information from which reliable data could be obtained. During the last year or two a great improvement has taken place in shop window lighting, particularly in the matter of concealing the lamps and yet obtaining the lighting effect, but a great deal remains yet to be done. In the meantime the illuminating engineer can only form his opinions more by intuition than by scientific data.

Errata:—TABLE I.

Tobacconists A and A_1	Watts	Burning cost per hour.	Relative Costs for Equivalent Light.
Instead of	300	1·050*d.*	4·991
Read	400	1·400*d.*	7·347

TABLE II.

Shop.	Cubic feet of window space.	Watts, or cubic feet of gas.	Nominal candle-power.	Watts per cubic foot.	C.P. per cubic foot.
Hatter and Hosier ...	112 cubic feet	240 watts (without arcs)	172	2·14 watts	1·53
,, ,,	112 ,,	990 watts (with arcs)	972	*5·5 ,,	*5·1
Jeweller ...	71 ,,	330 watts	172	4·65 ,,	2·42
Tobacconist...	71 ,,	160 watts (without 100 c.p. outside Osrams)	120	2·25 ,,	1·7
,,	71 ,,	400 watts (with 100 c.p. outside Osrams)	320	*4·0 ,,	*3·0
Stationer ...	160 ,,	21 cubic feet gas per hour	†370	0·13 cu. ft.	2·3
Confectioner...	160 ,,	17·5 cubic feet gas per hour.	†310	0·11 ,,	1·94

* In these cases the consumption of one outside lamp only is debited against the window, the other lamp being in each case used to light up the doorway; similarly, the C.P. of only one lamp is taken into account in the "C.P. per cubic foot" column.

† Candle-power reckoned on the basis of approximately 18 c.p. per cubic foot of gas.

Artificial Illumination, Historical and Practical.

THE above formed the title of an interesting lecture by Mr. A. E. Battle before the Institute of Marine Engineers on March 9th.

Mr. Battle traced the evolution of lighting from the days of the camp-fire, the torch, and the very earliest forms of oil-lamps, up to the newest forms of electric glow-lamps and the incandescent mantles of the present time. At this point the subject was taken up by Mr. Holmes, of the West Ham Electrical Supply, who briefly dealt with the development of metallic filament and the newer arc lamps and their relation to the consumer and the electric lighting industry. His remarks were illustrated by an exhibition of tantalum, Osram, flame-arc, and enclosed arc lamps, and also various electrical heating devices.

A brisk discussion followed, in which a keen interest in the subject of illumination was displayed, Mr. Holmes being called upon to reply to many questions dealing with the value of the newer forms of illuminants to the consumer.

The Production and Utilization of Light.

A Brief History of Artificial Lighting.

By Dr. C. V. Drysdale.

(*Continued from p.* 200.)

Glow Lamps.—The earliest attempts at practical electric lighting by incandescence were made by employing a bad contact between carbon pencils and discs. De Moleyns of Cheltenham in 1845 produced the first lamp of this kind, and Varley in 1876 and Reynier in 1877 produced lamps in which a fine carbon pencil made contact with a rotating carbon disc. The incandescence in this case was accompanied by combustion. Werdermann and Joel employed the same principle.

In 1841, however, the first purely incandescent lamp was produced by De Moleyns using platinum wire. Iridium and its alloys were used by Petrie in 1849. In 1845 a patent was taken out by King (probably acting for Starr, of Cincinnati), for a carbon filament in an exhausted bulb and an electrolier of electric lamps was shown by Starr and Faraday. In Starr's lamp the carbon was probably in the form of a pencil or slip of gas retort carbon, which being fairly solid could be rendered incandescent in a comparatively poor vacuum without rapidly burning away. It seems, however, that by the same year Mr. (now Sir Joseph) Swan had succeeded in producing thin carbon filaments by employing paper or thin card and slowly carbonizing it in a pottery furnace, the process of carbonization almost identical with that now employed. These filaments being much thinner required a higher vacuum, and it was not until the introduction of the Sprengel Pump into this country about 1875 that a durable lamp could be produced. Heinrich Göbel, of New York, appears to have produced a carbon filament lamp in 1854, first using wood charcoal and afterwards carbonized bamboo. But these early inventions seem to have been lost sight of, and the subject appears to have been revived by the physicist Lodyguine in 1873, who wrote an essay pointing out the importance of high specific resistance and high melting point in materials for the filament, and that carbon best fulfilled these conditions. Edison, after experimenting with platinum spirals, commenced in 1877 to attempt the production of carbon threads. He also realized the importance of high resistance, and engaged a mathematician, a former student of Helmholtz, who came to the conclusion that the filament must have a resistance of at least a hundred ohms to permit economy in the leads.

In 1879 a lamp was made with a horseshoe carbon filament 5 to 6 cm. long, of carbonized brown paper, in a bulb exhausted to $\frac{1}{100,000}$th atmosphere, and in 1880 he employed carbonized bamboo. In May, 1880, a lighting installation was arranged on the steamship "Columbia"; and at the Paris exhibition in 1881, 1,000 glow lamps were shown running from a large Edison dynamo. In the same year Swan produced filaments by parchmentizing cotton in a mixture of one part sulphuric acid to two of water, which gave more uniform filaments.

Lane Fox employed the process of flashing the filaments originally suggested by Sawyer, thus further improving the uniformity of the filaments. Since then the squirting process of producing filaments from a solution of cellulose in zinc chloride was introduced by Swan, and the flashing process of mounting the filaments. Great improvements have been made in constructive processes by Weston, Swinburne, and many others; while recently a considerable advance has been made by the General Electric Co. of America in the graphitized or metallicized carbon filament, prepared by subjecting an ordinary filament to the heat of the electric arc. By this means the efficiency of the carbon lamp has been increased to 2 or 2½ watts per candle.

Metallic Filament Lamps.—Most of the pioneers of incandescent electric lighting endeavoured to employ metallic wires. Davy in 1810 brilliantly incandesced a platinum wire $\frac{1}{30}$th inch thick and 18 inches long; and unsuccessful attempts were made by nearly all the early workers to make platinum filament lamps, the difficulties lying in the low melting point and the low specific resistance of platinum. Edison, indeed, noticed later that when platinum was heated and cooled repeatedly, driving off all occluded gases, it became much harder, and could then be raised to seven or eight times the ordinary safe degree of incandescence. Iridium was suggested by Petrie and tried by Staite, Starr, Molt, Edison, and others; and De Lodyguine, besides giving attention to carbon filaments, experimented in the United States from 1892 to 1894 with filaments of molybdenum, tungsten, rhodium, iridium, ruthenium, osmium, chromium, &c., depositing these metals upon a carbon core or "fillet." The first commercial metallic filament lamp was that of Osmium devised by Dr. Auer von Welsbach, and this has been succeeded by the tantalum lamp of Bolton and Siemens, and the many various forms of tungsten lamps in which the filaments are prepared by the different processes of Just and Hanaman, Kuzel, and others. Zirconium, titanium, and selicon carbon have also been employed, and at the present time almost every month sees some new form of lamp, having efficiencies of about 1 watt per candle, and gradually increasing voltages from the 25 volts of the early Osmium lamps to the 200-240 volts of the zircon wolfram and other lamps at present.

Non-Conducting Filaments.—As far back as 1877 Jablochkoff observed that several non-conducting substances, such as kaolin and magnesia, became conductors when hot, and succeeded in maintaining a kaolin strip incandescent by an electric current. Although this was experimented with by others, it was left for Dr. Walther Nernst in 1897, working under the auspices of von Welsbach, to produce a commercial lamp, using filaments of the rare earths used in the Welsbach mantles, such as Thoria, Yttria, &c. Many difficulties had to be surmounted, notably those of automatic lighting, and of overcoming the high negative temperature co-efficient, which led to unstability and increase of current to the breaking point, but these were successfully overcome by the use of a heating coil and relay, and by "bolstering" resistances having a large positive temperature co-efficient. The Nernst lamp so made gave a light of from 1·5 to 2 watts per candle efficiency, and has been found very satisfactory on high voltage circuits.

Vacuum Tube Lamps.—The light produced by passing a high potential discharge through gas at low pressure was employed in France for a miner's lamp, using an ordinary Ruhmkorff coil. Recently, however, it has been developed on the large scale by McFarlane Moore, using tubes about 1¾ in. diameter and up to 200 ft. long, with a high voltage transformer and using a special valve to admit a small quantity of air at intervals. This light is fairly efficient and well diffused, as well as being of pleasant colour if nitrogen or carbon dioxide is used, and will probably come into considerable use.

Luminescence.—In 1879 Sir Wm. Crookes found that when a tube was very highly exhausted streams of what he termed radiant matter were discharged from the negative pole or cathode, and that the surface of the glass where these rays impinged glowed with a green light. Other solid substances also gave off light of characteristic colours. The term luminescence was given to this phenomenon by E. Wiedemann, and several investigators have given attention to it. No commercial form of luminescent lamp has yet been devised, but it is generally recognized that the method has great possibilities, and special mention will be made of it later.

(*To be continued.*)

The Development of the Electrical Metal Filament Glow-Lamp.

By Dr. H. Weber.

There is one point in connexion with the history of incandescent glow-lamps which must strike every one as somewhat remarkable, namely, the fact that attention was paid to the use of metals for the very earliest filaments, that subsequently these filaments were abandoned in favour of those made of carbon, but that at last it has been found desirable to come back to metallic filaments again. One is inclined to wonder how it could be possible that the excellent qualities of the metals used in the filaments of the most recently developed electrical lamps were not recognized earlier, and that so great a lapse of time followed before any practical results with these metals were obtained.

We must, however, remember that previous to the years 1868 to 1875, when the first really practical incandescent lamps were produced, the properties of the materials employed therein were not so well known as they are to-day, and that, in addition, we had not at our disposal the same well-developed processes of manufacture that are now common. Whenever any investigation proved abortive it was always concluded that the material employed was of no value, and the fact was not recognized that it was very often only the method of manufacture of the glow-lamp filament which was unsatisfactory. How otherwise could it have been possible for the, to-day, so generally used metal tungsten to have remained unnoticed, after being made use of in the year 1889 by Lodiguine and Tibbits, though certainly without any practical result?

Tibbits soaked cotton and silk threads in a solution of tunstic acid, and subsequently rendered the threads incandescent in an atmosphere of hydrogen, the temperature being 1,800 degrees Centigrade. By this process tunstic acid was reduced, and the tungsten separated out on the surface and interior of the threads as a hard shining metallic deposit; filaments so prepared were mounted in lamps by Tibbits, but proved to be of no practical value; but, had the inventor possessed the knowledge of the physical and chemical properties of the metal that are to-day at the service of the glow-lamp industry, he would have known that the reason of this failure lay in the now fully recognized fact that the tungsten is unserviceable if it contains appreciable quantities of carbon, either free or in a combined form. By the aid of our present knowledge and better methods of manufacture it might, perhaps, have been possible to have produced a 1 watt per candle-power lamp by the year 1889, though such a lamp was actually publicly exhibited for the first time in the year 1906. The author now proposes to outline the principles underlying the most recent developments of metallic filament lamps, though it will naturally be advisable to refer occasionally to carbon lamps in so doing.

The glow-lamps of the present day may be said to have arisen from the original discovery that a fine metal wire can be brought to incandescence so as to give out light by the passage of a suitable current. The first metallic filament lamp may be said to have been devised in the year 1802, when Humphrey Davy succeeded in bringing a fine platinum wire to incandescence. For a long time after nothing further occurred as a result of these experiments, but in 1841 F. Moleyns, of Cheltenham, took out a patent having for its object the improvement in the output of light of the filament by a deposit of fine carbon on a suitable metallic wire, preferably platinum. In the year 1845 Starr & Grove exhibited an exhausted incandescent lamp, which consisted essentially of a platinum wire of suitable resistance, into which a current was led by means of thick copper strips. By the use of a suitable battery Grove was able to produce a serviceable light lasting several hours. Subsequently, in 1847, J. W. Draper, of New York, described some investigations in Stillman's *Journal* (second series), in the course of which platinum wires were heated in an electrical current, while Petrie, in 1849, proposed to employ the refractory metal iridium in the place of platinum. (This very metal iridium has been recently employed for low-voltage lamps by Gülcher.)

Yet all these researches led to little practical result, and this can be readily understood at the present day, for just those metals were employed which are least well adapted to serve as an incandescent filament. Even Edison, who is often incorrectly regarded as the actual inventor of the carbon filament lamp, had some difficulty in freeing himself from the supposition that platinum would make good filament, and, in the year 1880, actually took out a patent, according to which 30 ft. of platinum wire, 0·005 inches in diameter, were wound upon a cylinder of lime and brought to incandescence. Although by this arrangement the fairly high resistance of about 750 ohms was obtained, the lamp did not find any practical application. Yet Edison himself seems to have been so firmly convinced of the results of this discovery, that he had some fear lest the entire output of platinum of the world might not suffice for the desired number of lamps. This led to the humorous picture of Edison sending out a small army of prospectors and chemists into the world in order to search out new sources of platinum.

However, soon afterwards Edison seems to have realized that satisfactory filaments could only be composed of materials having a high resistance, such as carbon, and from this date onwards efforts were made to construct, incandescent filaments out of pure carbon, and to produce these filaments in the necessary homogeneous and elastic state. Space does not allow the author to deal with these attempts in detail, and readers who desire further details are referred to his recently published book on the subject (' Die Kohlenglühfäden für elektrische Glühlampen ').

It need only be mentioned that when the efforts to make serviceable carbon filaments had proved successful, it was still necessary to construct filaments capable of standing a higher temperature in order to secure the higher output of light. In order to attain this object carbon filaments were first impregnated with metallic solution, or by other methods coated with a fine surface of metal or metallic mixtures. These experiments, however, all led to but little result, for the simple reason previously mentioned, that so long as carbon is present in any considerable quantity in such a filament, it becomes impossible to increase the efficiency of the lamp very greatly without the bulb soon showing signs of blackening. It seemed, therefore, impossible to secure any great gain in efficiency so long as carbon was employed. Attempts were subsequently made to employ other materials such as boron and silicon, &c., until eventually the pure metals were employed once again.

It is interesting to observe that just as platinum was originally very universally employed, so the metal osmium formed the basis of the first practical result in the metallic lamp industry, and for many years formed the single example of a serviceable metallic lamp. Auer von Welsbach was attracted to the use of the osmium by the fact that it is the most refractory metal of the platinum group, having a melting point near 2,600 degrees Centigrade, and succeeded in producing lamps which could be run at an efficiency of 1·5 to 1·6 watts per candle-power. Osmium consists of a grey-black powder with a specific gravity of 22·48, and is prepared from osmiridium. This metal, one of the heaviest of this group, was at first deposited upon fine metallic wires composed of some substance having a low melting point; this easily melted metal was then vapourized by heating the filament to incandescence by the passage of an electric current, leaving the osmium behind.

But the osmium filaments obtained in this way proved to possess very inferior qualities, and their great brittleness proved very inconvenient in the manufacture. Subsequently the metal was reduced into a fine powder, mixed with a certain oxide of osmium, and worked into a soft paste with sugar solution, the paste being forced under high pressure through diamond apertures. These filaments were next dried and were "formed," that is to say, converted into a metallic state, by heating with an electric current in a certain gaseous atmosphere. The oxygen accompanying the metallic osmium combined with the carbonaceous material of the sugar, the oxide was completely reduced, and filaments of pure metallic osmium resulted.

The filaments prepared in this way were, however, still extremely brittle, and could only be produced of a certain diameter, with the result that it was found impossible to produce lamps for pressures higher than about 73 volts. Further difficulties in their manufacture lay in the fact that the rare metal osmium naturally exists in certain limited quantities, so that the Auer Company were put to some difficulties to obtain a sufficient quantity. For this reason lamps were not sold outright, but only loaned, so that the company might utilize the osmium in the used-up lamps, *de novo*. Finally, it should be mentioned that the lamps could only be burned in a vertical hanging position on account of the softening of the incandescent filament, which might otherwise lead to a short circuit, and so destroy the lamp. The lamps, however, proved very successful, for they could be burned at an expenditure of 1·6 watts per candle, with a life of about 800 to 900 burning-hours.

It only remained to discover other materials which did not possess the drawbacks of osmium—brittleness and high conductibility. After many failures the firm of Siemens and Halske succeeded in manufacturing a lamp with a filament of the rare metal tantalum, derived from the compound Ta_2O_5. This occurs in the minerals tantalite and columbite which are obtained from Grönland, North Carolina, Sweden, &c.; these minerals generally contain not only tantalum, but also compounds of the very similar metal niobium, which accentuates the weak points in the metal tantalum. It was thus necessary to devise a chemical method for the separation of the two metals, and this was achieved by utilizing the tantalum-potassium and niobium-potassium fluorides. The pure tantalic acid so obtained was reduced to the metallic form by means of sodium or potassium. The metal prepared in this way is a black powder, and was formed into a paste containing a suitable binding material, which was pressed into rods, and heated by means of an electrical current in vacuo. As a result the particles of tantalum sintered together into shining metallic strips, which were, however, too thick to be of any practical use. As the author for several years acted as assistant to Dr. von Bolton, the inventor of the tantalum lamp, and has had the opportunity of watching its development from the earliest beginnings, he is in a position to give some details which may be of interest as to the development of this lamp.

It was found desirable to melt together a considerable quantity of pure tantalum for the purpose of certain experiments. For this purpose the thick rods previously mentioned were heated by the passage of an electrical current in a vacuum until the metal was brought into a molten condition. During the experiment the metal mass broke and separated, with the result that an arc was created between the two portions, and small molten globules of the metal were formed. These globules were subsequently examined more closely, and hammered on the anvil with a view to testing their hardness, when the ductibility of the metal was accidentally discovered, and the method of manufacturing glow-lamp filaments by simply drawing out wire tantalum suggested. For the purpose of further experiments on the metal in this state a thick rod was allowed to break up while heated by the electrical current in the method described, and molten globules of the metal obtained. These globules were pressed out into very fine sheets, strips were cut out of the sheets and mounted, and the first tantalum lamp, which had a life of 70 to 80 burning-hours and ran at a pressure of 10 volts, was produced.

It was subsequently found that the ductibility could be very considerably improved if the metal was prepared absolutely free from impurities, especially traces of oxygen and hydrogen. In order to attain this result the metal is heated several times in vacuo, the arc formed as before, and a metallic regulus obtained which could be drawn out into wires as fine as 0·03 mm. in diameter. From wire of this description lamps yielding 50 candle-power can be obtained for a supply pressure as high as 220 volts. Unfortunately, however, the tantalum lamp cannot be said to have quite fulfilled the expectations aroused by its arrival, for, apart from the successful production of sufficiently strong filaments, capable of standing transport without breakage, and suitable for use on 200 volt circuits, there still remains the drawback that the lamps can only be prepared with difficulty in a form suitable for use with an alternating current, and that the mean consumption of power is on the average not less than 1·8 watts per H.K. A type has recently been put on the market in which the consumption is 2·3 watts per H.K. One would suppose, however, that even the 1·8 watts per H.K. lamp hardly satisfied present requirements, for it was found necessary to counteract this comparatively high consumption per candle-power by a corresponding reduction in the price of the lamp. Actually the tantalum lamp of to-day amounts to one-third of the earlier price, and may be said to be richly rewarded thereby, for it does not appear to possess any very great advantage over the new metallized carbon lamps having a consumption of 2·5 watts per H.K.

More recently the attention of the glow-lamp industry has been turned to an entirely different group of metals which, however, were known a long time ago, namely, tungsten, molybdenum, &c. As was mentioned before, it may seem peculiar that the wonderful properties of the members of the chromium group of metals should now be realized for the first time, in spite of the fact that the metals in question were discovered and studied as early as 1783 and 1797 by Klaproth and the Brothers d'Eljuhar. It was explained above that the application of tungsten to glow-lamp filaments was tested nineteen years ago, and that the experiments of Lodiguine and Tibbits at that date led to no result.

The processes of manufacture of the new filaments differ very greatly, and can only be described very briefly here. The majority of them involve the reduction of the metal into a finely powdered form, the subsequent mixture with some binding material into a pasty mass, and the forcing of this paste through fine dies into filaments. The chief detail to which attention must be paid is the absolute necessity for the resulting filament being entirely free from carbonaceous constituents. In the so-called "paste-process" a metal containing an acid constituent is employed mixed with an organic paste, which becomes carbonized when heated. The materials are intimately mixed together, and forced through fine diamond dies. The resulting filaments are dried, and eventually brought to a high temperature in vacuo, in order to render them conductive. During this process the organic paste becomes carbonized, and eventually combines with the acid constituent to form carbonic acid. Thus the filament is completely freed from the carbonaceous material and the injurious acid constituent, and should now consist of pure metal.

Naturally, however, this chemical reaction does not follow its exact theoretical course, and small traces of carbonaceous material generally remain in the filament. In order to remove these traces completely additional processes are commonly employed.

For instance, the Auer Co. secure a complete removal of the carbon by treating the filament in an atmosphere of hydrogen. As the results were not entirely satisfactory this method was soon modified. The vessel in which the treatment of the filament took place was completely evacuated, washed out several times with pure dry hydrogen, and eventually filled with a certain quantity of pure, dry, acid-free nitrogen. When the filament was heated to a high temperature in this atmosphere the carbon was completely removed by the combination of the carbonaceous material with the nitrogen to form cyanogen. As regards the name "osram" it may be remarked that this word is a combination of osmium and wolfram (another name for tungsten); as a matter of fact, however, the filament does not contain a mixture of osmium and wolfram, as is frequently erroneously supposed, but only pure wolfram.

Another process by which tungsten metallic filaments are obtained absolutely free from carbon is that devised by Dr. Kuzel of Vienna, who, by a special chemical process, converts the metal into a gelatinous or "colloidal" condition, such that it can be easily pressed out into filaments. The filaments are then dried and sintered together in a high vacuum The method is such that no further treatment is needed to remove carbonaceous impurities. Yet another method adopted by the General Electrical Co. in Austria-Hungary is as follows: perfectly pure tungstic acid is mixed with a binding material, forced into filaments, and the filaments brought to a temperature of 600 to 700 degrees Centigrade in a stream of hydrogen. By this means tungstic acid is reduced to metallic tungsten, and a metal filament results, which contains but slight traces of carbon; in order to remove these traces either of the special treatments previously mentioned may be used.

An entirely different method of constructing tungsten filaments is that by which filaments of carbon or some other metal are heated in an atmosphere of tungsten chlorides and hydrogen, with the result that the deposit of tungsten gradually permeates the carbon or metal throughout.

Finally, there have been unsuccessful efforts to draw tungsten into wire, in the same way as tantalum. By one such method tungsten is mixed with some easily volatalized metals, drawn into wire, and then the foreign metals expelled in vacuo. Unfortunately filaments so produced are too fragile to be of any practical value.

On the whole, it may be said that of all these methods the first-mentioned paste method, after the removal of certain difficulties, has yielded excellent results; at first it was not possible to attain a strong and completely uniform filament; yet we have eventually learnt to manufacture even the finest varieties successfully. When one bears in mind that such filaments are actually composed of isolated metallic particles built together, one cannot but wonder at the elasticity which even the finest of them exhibits. It is already possible to manufacture filaments in large quantities, having an ultimate diameter of only 0·03 mm. These can be utilized in lamps giving 18 H.K. at 100 volts or 36 H.K. with 220 volts, which is certainly an excellent result. In this connexion it may be mentioned that the entire length of the filament of a single lamp intended for 110 volts and yielding 18 H.K. is as much as 42 centimetres long.

In conclusion it may be remarked that the actual mounting of filaments in lamps at first presented very great difficulties.

For instance, difficulty was experienced in designing the lamps to burn in any position. In order to render this possible small light supports are provided, which take up the shortening and lengthening of the filament in its hot and cold state. When the lamp is switched off and the filament becomes cold, this support gives way with the shortening of the filament, so that the latter is not subjected to a strain, and does not tear away or break. These lamps can also be burned in a horizontal position, for the support possesses sufficient strength to keep the glowing and pliable filaments stretched, and prevent them sinking downwards.

The Relative Hygienic Values of Gas and Electric Lighting.

By Dr. Samuel Rideal.

(A more detailed account of the researches of Dr. Rideal described in this article will be found in the Journal of the Royal Sanitary Institute for March of the present year, vol. xxix., No. 2.)

Object of Investigation.—The purpose of this inquiry has been to determine and compare the hygienic effects of gas and electricity as used for ordinary domestic lighting.

Three parallel lines of research were indicated as desirable, firstly, into the direct hygienic effect of the two lights; secondly, into the indirect effects of their products; and, thirdly, into the nature, amount, and distribution of these products. The three lines of research were conducted simultaneously.

The investigation being essentially a medical one, priority was given to the physiological work; the chemical and physical part mainly consisted in arranging and recording the conditions under which the medical observations were made.

Rooms and Mode of Lighting.—The experiments were carried on in a room in the basement of No. 28, Victoria Street, which was, for the purpose of the second series of experiments, divided by a tight wooden partition into two chambers numbered 4 and 6, each having two windows with S.S.E. aspect, a fire-place and doorway, a wooden floor bedded on concrete, and brick walls 1 ft. 9 in. and 2 ft. thick.

Each room could be lighted from the centre with gas or electricity as desired. As far as possible the candle-power of each illuminant was made the same; but the photometric tests revealed the fact that the illumination of the table was greater with the inverted incandescent gas-burners, owing to the difference in the arrangement of the light-emitting surfaces.

As a rule the rooms were not heated, except by the lamps and the warmth derived from the inmates themselves; but during the latter part of January the weather became so cold that a non-luminous electric heater was installed, an open fire being inadmissible on account of the extra ventilating effect it would have produced.

Chemical and Physical Observations.—Estimations of the amount of carbonic acid produced by inmates in the room and burners were carried out every quarter of an hour. Similar observations of the amount of organic matter in the air were periodically carried out by testing with a solution of potassium permanganate.

The physical observations comprised a record of the temperature and humidity of the room by means of wet and dry bulb thermometers.

Changes produced in the Air of the Room by the Illuminating Agents.—These may be classified as follows:—

Gas.

1. Heating effects.
2. Drying effect due to heat, modified by water vapour produced.
3. Production of carbonic acid.
4. Sterilizing action.
5. Ventilating effect.

Electricity.

1. Heating effects.
2. Drying effect due to heat.
3. None.
4. Sterilizing action.
5. Ventilating effect.

The changes in the air of the room, brought about by the occupants themselves should also be taken into account. They include:—

1. Heating effect.
2. Addition of moisture.
3. Production of carbonic acid.
4. Vitiation of air by other respiratory products.

Heating effects.—Theoretically the gas lamp gives out more heat than an electric lamp in the same candle-power. In these experiments two 25 candle-power electric lamps were found to give about half the heat of two gas lamps of the same intensity. Actually, however, observations of the temperature in the room showed very similar results in the two cases, even when the rooms were vacant, while the presence of people in the rooms gave rise to an amount of heat in comparison with which that given out by illuminating agents was of minor importance.

The Production of Water Vapour.—Naturally no water vapour is produced by the electric lamp. The amount of gas consumed in each room is about $2\frac{1}{2}$ cubic feet per hour; this gave rise to about a quarter of the hourly weight of water exhaled by the six inmates of the room.

The Production of Carbonic Acid.—With the amount of gas burned mentioned above, the ratio of carbonic acid produced by gas to that produced by the occupants in the room is about one to three; hence at least three-quarters of any injurious effect produced by carbonic acid must be ascribed to the latter.

This substance, however, is a normal constituent of air, and now recognized to be harmless, even in much larger quantities than could result from any reasonable consumption of gas. In an adequately lighted and unoccupied room an amount of carbonic acid greater than 11 parts per 1,000 could not well be obtained, while in these experiments 50 parts per 1,000 were exceeded without any bad physiological effects resulting.

Sterilizing Action.—The sterilizing action—the power to destroy germs in the atmosphere—of an illuminant arises chiefly through the organisms coming in contact with heated surfaces such as are presented by gas flames and the bulbs of glow-lamps, the effect of sulphur acids created by gas burners, and increased ventilation due to heated air from the illuminants. The sulphur acids, which have marked germicidal properties, are, however, partially "fixed" by the whitewash coating of the ceiling and walls of a room. In these experiments gas-lighting appeared to possess greater sterilizing properties than electric, as was shown by the number of organisms per cubic centimetre in the air, or in water deposited from the air on cool surfaces in the room. This is partially to be ascribed to the greater temperature of the heating surface in the case of gas and the larger volume of air operated on.

Vitiation of the Air by other Products.—It has been believed that the injurious influence of ill-ventilated rooms is due to certain volatile organic materials given off by the lungs. The presence of such products was tested by the action of potassium permanganate solution, but these experiments do not seem to have confirmed the injurious nature of such organic matter. It was, however, noticed that the air of the gas-lighted room was invariably purer by this test than that in the room lighted by electricity, presumably because of the partial destruction of this organic matter by the burning gas, and also by reason of the better ventilation in the case of the illuminant.

Effects of Ventilation.—The ordinary room is not a stagnant mass of air, but is constantly receiving influxes from without. In these experiments at least one-third of the air was found to be changed per hour; this result was confirmed by studying the rate of disappearance of a large quantity of carbon dioxide added to the atmosphere. The ventilation was examined at the beginning and end of the evening's work, and it appeared that the heated column of air from gas-burners had a marked effect on the ventilation of the room; the air rising from the electric lamps was also effective, but to a less extent.

Medical Observations.—As mentioned at the commencement of this article, the conditions imposed, namely, that the experiments should be carried out under as natural conditions as possible, prevent the possibility of any strictly conducted physiological investigations. Though in some cases conditions more extreme than those generally met with have been aimed at, they still lie within the limits of the human power of accommodation, and therefore do not produce any marked deleterious effects.

A large mass of data has, however, been collected under the following heads :—

1. Frequency of pulse and its character.
2. Frequency of respiration.
3. Arterial blood pressures.
4. Richness of blood in coloured corpuscles.
5. Body temperature.
6. Body weight.
7. Mental fatigue.
8. Time reactions of mind and muscle.
9. Eye fatigues (differentiated).
10. Impressions on senses.
11. A special experiment on three subjects as to the poisonous effects of coal-gas when present in large quantities.

The rate of the pulse depends primarily upon the frequency of the heart's contraction, which is affected by a variety of outside causes, and respiration also serves the purpose of ridding the system of an excess of carbonic acid, moisture, and heat. Therefore, the study of the alterations in these two quantities often serves to indicate a change in the conditions of environment.

As a rule the pulse rate was found to be high at the beginning of the evening, but, under the uniform conditions maintained in the room, dropped gradually, the average final frequency being practically constant, and the same with both systems of illumination.

The average frequency of respiration decreased under both systems of lighting in a very similar manner, and it is significant that the increase in the number of inmates in the room was more effective in producing this decrease than varying the illuminant.

The progressive change in body temperature and loss of body weight during the evening also proved to be very much the same in the case of both illuminants, and an examination of the blood corpuscles also gave negative results.

No very appreciable difference in the physiological effects of the two illuminants could therefore be traced, and an endeavour was made to ascertain whether there was any difference in their effects upon mental conditions. The test of mental fitness applied consisted in setting a long addition sum, and noting the length of time required to execute the same and the number of errors made. In the case of both lights there was a gain in speed but a loss in accuracy. But this gain in speed is presumably due not to the light, but to the rest after the day's work, and was very nearly the same in the case of both methods of lighting. The subjects were also tested for alertness by measuring the interval between the hearing of a signal and the response thereto, this period being indicated on a revolving drum. Again, there was no perceptible difference between the result of gas and electricity. As regards action on the eyes, the sensitiveness of the eye to light appeared to be appreciably diminished during exposure to electric light, an effect not to be noticed in the case of gas.

On the whole, the results of these experiments show fairly conclusively that under ordinary conditions either light can be used without the least prejudicial influence on health.

Finally a test was devised to study the effect of leakage of gas into the room. Ordinary gas contains poisonous constituents, including carbon monoxide, and has been known to give rise to poisoning through inhalation. In the course of these experiments three individuals were placed in a room—the door, windows, and fireplace of the same being blocked in such a way as to prevent ingress of air. Yet, although an amount of gas equivalent to three times the ordinary consumption of the burners—as much, in fact, as could only occur through breakage or some accident—was allowed to pass into the room, the subjects experienced no ill effects during the four hours and twenty minutes they were in the gas-laden atmosphere. When we bear in mind how easily an ordinary leakage of gas is detected by the smell we can see how difficult it is for a condition of affairs to be set up which would be really prejudicial to health.

General Conclusions.—The results of this inquiry may be summed up as follows :—

1. Owing to the better ventilation obtained by gas the products of combustion are not found in the air in anything like the proportion which might be expected, the temperature and humidity in an occupied room being no greater than when the room is lit with electric light.

2. Carbonic acid has not the injurious effect which was formerly attributed to it; but considerable rises in the temperature and moisture content of a room, from whatever source, do have a prejudicial effect upon the well-being of the occupants. Even under adverse conditions of ventilation purposely created for this inquiry, neither the temperature nor percentages of moisture in the room reached a point at which any such effect could be detected by any of the recognized physiological tests.

3. It has been established that the products, viz., heat, carbonic acid, and moisture, which might modify the health of the occupants of a room, are derived from the inmates to a far greater extent than from the illuminant, and that a room of moderate size can be efficiently lighted by gas without sensibly affecting the amount of these three factors.

4. Whilst undoubtedly it is important to ensure adequate ventilation in domestic rooms, this, with present methods of construction, is ensured better the smaller the room. The problem of securing sufficient ventilation has only to be considered in public rooms of a larger size, which have been outside the scope of this inquiry.

5. The medical conclusions are in accord with those arrived at from the chemical and physical data, and prove conclusively that the choice between the two systems of lighting does not depend upon hygienic considerations.

The Lighting of Streets and Public Buildings.

DEMONSTRATIONS OF ILLUMINATION MEASUREMENT.

(*Special Notice issued by the Honorary Advisory Council.*)

THE question of public lighting is one of the problems of the day, not only in regard to the comparative merits of different illuminants, but also in regard to the amount of illumination required for different purposes. The latter aspect of the subject is of great importance, as it involves the question of necessary or superfluous consumption, which again resolves itself into a matter of finance affecting the ratepayers of the district.

In order to contribute something towards the solution of this difficulty, and to endeavour to obtain some authoritative data on the question, the Hon. Advisory Council of the Municipal Exhibition have specially arranged with Mr. Leon Gaster, the Editor of *The Illuminating Engineer*, whose well-known views are sufficient to ensure impartiality and absence of prejudice, to superintend and direct a series of demonstrations at the Royal Agricultural Hall during the Exhibition, with the latest apparatus available, for the measurement of the illuminating power of different illuminants now in use.

The appliances used will consist of the most recent types introduced in this country, and, it is hoped, of those in use in America and the Continent. As the subject is one of the utmost importance and interest to all users of illuminants, the demonstrations will be of considerable value to all municipal authorities and others engaged in the lighting of streets and public buildings.

Electricity v. Gas for Illuminating Purposes.

By a Correspondent.

A discussion on the subject covered by the above title took place at the Municipal School of Technology, Manchester, on February 25th. This meeting was organized by the Manchester Students' Section of the Institution of Electrical Engineers, whose members championed the electrical cause, and had as guests the members of the Manchester and District Junior Gas Association to defend the gas interests. Prof. Harold B. Dixon, M.A., F.R.S., F.C.S., was in the chair, and a gathering of youthful enthusiasts followed the points brought out by their various spokesmen, an earnest and entertaining debate resulting, a number of lantern-slides being shown by those taking part in the discussion.

After the general rules of the debate had been explained, these including costs on a rough basis of 3*d.* per B.O.T. unit for electricity, 2*s.* 6*d.* per 1,000 cubic feet for gas and the use of British candle-power, the case for the electrical men was opened by Mr. D. L. Sands.

He realized his responsibility in undertaking to open a debate of the nature, and did not propose to indulge in unreserved slander of the gas side. There were the two important sources of light energy for the consideration of the engineers present, and in each system only a small portion of the energy supplier was delivered in visible rays, the maximum proportion with a gas-flame being about 20 per cent.; whilst it was within the range of possibility to obtain as much as 60 per cent. by the use of electricity. About two-thirds of the energy supplied to an incandescent gas-burner was used in heating the nitrogen of the air alone. Diagrams were thrown on the screen, plotted from the recently obtained results of experiments by an eminent authority, showing the light efficiency of our common sources of energy, which proved that the flame-arc was the best in this respect, being followed by the mercury vapour lamp and other electric types, the various forms of gas-lighting being well in the rear, close to petroleum. The new metallic filament lamps would do as much for electricity as the incandescent burner had done for gas, and from actual results in ordinary domestic use proved cheaper than the best gas-lighting. Mr. Sands quoted figures showing that flame arc lighting was far superior to and cheaper than gas. Altogether the electrical prospects in the lighting world were very promising.

Mr. Franklin Thorp followed with the gas arguments, and claimed that the advantages, for cleanliness, safety, and convenience of "our trusted friend gas" were greater than of that "dazzling though fickle" electricity. A slide was shown giving the challenge thrown out by a leading firm of gas-mantle makers to the metal filament lamp people, a challenge, he said, unaccepted, for reasons with which they were quite willing to agree. Comparing the costs of the two systems, he stated that for 1,000 hours equal illumination, including replacements, electricity would total 14*s.* and gas 3*s.* Another slide portrayed the instructions issued by the electric filament lamp makers, such as "do not burn lamps at angles from the vertical, or in vibratory positions without spring holders; do not clean while burning or switch on immediately after cleaning;" and concluded with his own advice: "Do not bother, use gas." On high voltage circuits Osram lamps could only be used in series, needing careful pairing, whilst the series depended on the behaviour of a single lamp. He reckoned the cost of new Osram lamps at 4*s.*, and gas-mantles at 6*d.* each., The cost of installing he calculated at

8*s.* per point for electricity, and 3*s.* 6*d.* per point for gas. On the points of distribution and intrinsic brilliancy of light gas had the advantage.

Mr. John Roberts renewed the electrical arguments, and gave figures showing the costs of the respective systems in which the electrical compared quite favourably with the gas. Some recent results, instanced by Mr. Seabrook of West Ham, and obtained from reliable and independent sources, showed that electrical was quite as cheap as gas-lighting in cost of energy alone. Combating the figures of previous speakers, Mr. Roberts claimed that a number of the figures put forward by gas advocates were exaggerated, and pointed out that lamps were intended for illumination, and not for staring at. From an hygienic point of view electricity was much preferable, as incandescent lamps did not emit noxious fumes or consume oxygen, as all gas-lamps undoubtedly did. The deleterious effects of the use of gas-lighting were especially noticeable in shops, causing discolouration and perishing of goods, whilst efficient lighting of air-tight show-cases, so necessary in some businesses, was only possible with electric light. The damage to decorations and the cost of cleaning were faults to be laid to the gas side, and should be reckoned with in making comparisons. For up-to-date efficient lighting in new buildings electricity was always chosen, as witness the magnificent institute in which the meeting was held.

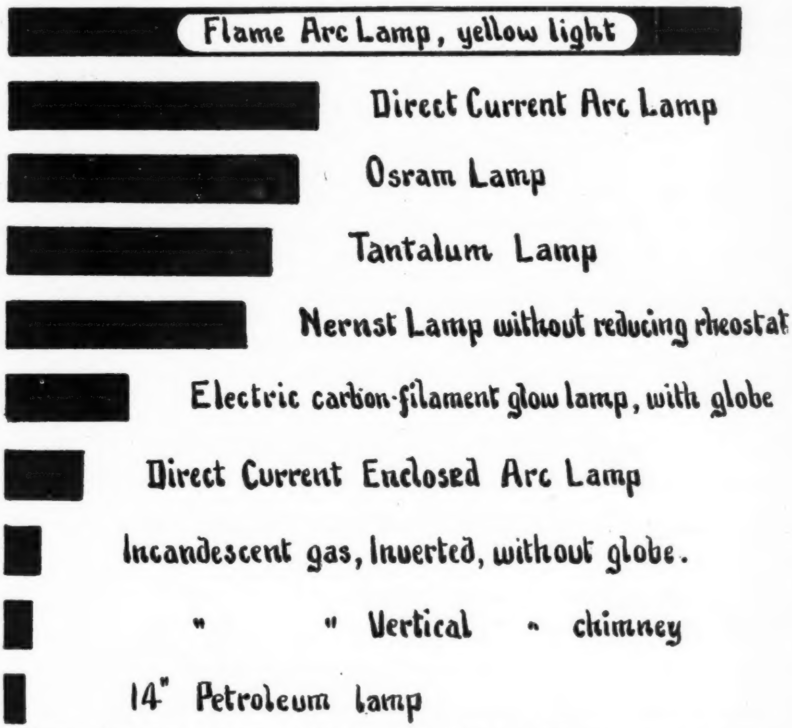


Diagram showing relative amount of light energy evolved from different sources for a unit supply of fuel.

Mr. J. Alsop continued for the gas interests, and gave a number of figures for mill and street lighting, all showing gas to be the cheaper. In one case, totalling up the capital cost, and including the cost of the generator on the electrical side, gas had an advantage of 279*l.*, and 110*l.* in annual expenditure. An all-sufficient light was obtained from incandescent mantles, and these were being largely adopted. Many of the new mills being erected in Lancashire were adopting gas, and as heat was required in cotton-mills to enable the operatives to satisfactorily perform their duties, gas, which gave heat as well as light, was here advantageous. In one case where metallic filament lamps had been installed their use had been discontinued on account of breakages, and gas used instead. For street lighting he claimed that gas was cheaper, and in proof of this he quoted a number of costs of the different systems obtained from various towns. In Queen Victoria Street the cost of electric lighting was 825*l.*, against 540*l.* for gas, per annum, whilst the costs at Victoria Station and in other places were in favour of gas illumination.

Another electrician followed, in the person of Mr. L. H. A. Carr, B.Sc.Tech., who pointed out that the figures given by the previous speaker were quite meaningless without details of the basis on which the two systems were contrasted, on which no information was given or apparently considered. In comparing mill-lighting and similar cost the expense of cleaning and redecorating had to be included, and also the results of the injurious effects on the health of workpeople, on which points electricity scored. In street lighting commonsense and economy were on the side of electricity, and the expense of replacing the easily broken mantles, and the inconvenience of loss of light in the meantime, were great points against gas. In private houses gas caused much more work and annoyance, whilst in shops electricity gave better results without the damage to and loss of stock caused by the heating and fumes of gas. Electricity was safer inasmuch as no evil after effects were possible, as when taps were accidentally left on after a temporary failure of the gas supply. The flickering light noticed with gas burners also had an injurious effect upon the sight, especially after enforced continuous use.

Further championship of gas came from Mr. D. V. Hollingworth, who stated that the alleged fouling of the atmosphere by gas burners was of small account, and that the heat given off had a ventilating action, carrying away any impurities created. No CO or acetylene was formed; CO_2 was not poisonous, and was permitted by the Board of Trade, as their regulations stipulating the amount allowable showed. These arguments against gas-lighting should be used equally against an ordinary coal fire. All SH_2 was removed in process of manufacture, being an important and profitable by-product. Gas-lighting had been adopted at the Birmingham Art Gallery on the advice of Prof. Frankland. Electrical generating stations were far greater sinners in the matter of injurious exhalations than gas-burners or than gasworks; whilst flame-arc lamps give off hydrofluoric and hydrochloric acids and nitrogen oxides, which render them unemployable in enclosed spaces.

Mr. A. E. Jepson pointed out other advantages of electric light. Reverting to the previous speaker's remarks on the gas lamps adopted in the Birmingham Art Gallery, he quoted a letter from the City Electrical Engineer of Birmingham, showing that these lamps were only used in a case where there was a domed roof and it was possible to fit direct ventilating shafts, and that in other cases in this gallery the valuable pictures were directly illuminated by electric lamps.

Dealing with the question of reliability, Mr. C. E. Teasdale said that an accident to a gas main could be patched up temporarily or a by-pass used and the supply be continued, whereas an electrical misfortune needed immediate attention, and could be easily caused, the dropping of a spanner across two terminals in a station being sufficient to throw a town into darkness. He also claimed that the owners of every building, when installing electric light, put in gas fittings as a standby, a remark followed by a mock and unsuccessful search on the part of the electrical men for the gas-fittings in the room of meeting. Electrical meters, too, were more unreliable than those of the gas type, and were not subject to official certification as were gas meters, though he gave figures to show the proportion of incorrect electricity meters discovered in a series of tests by the L.C.C.

On the other hand Mr. W. Browning considered that electricity was more reliable than gas, especially in theatres and similar locations, and after a stoppage the supply could be resumed without the trouble and ill-effects consequent upon a like gas failure.

Where lights were left burning in bedrooms this might be a serious matter, resulting in suffocation and explosions. As against Mr. Thorp's list of "don'ts" for electric lamps, he gave a number for gas mantles, and concluded with "Don't forget your matches."

Mr. James Taylor, in speaking of the dangers of either system, pointed out that gas did give warning of any escape by its odour, whereas electricity was not noticeable. the danger of electricity being admitted, and regulations for its control provided by the Institution of Electrical Engineers and the Fire Offices, which precautions were not considered necessary with gas.

Replying to Mr. Hollingworth's remarks *re* the Board of Trade limit for CO_2, Mr. J. L. Lovell claimed that as there was no help for it, they just had to allow as little as possible, and quoted the Home Office regulations for workrooms, &c., where artificial illumination was employed, which call for 400 cubic feet of space for each person, unless electric light was used, when only 250 feet was considered necessary. Electricity was the only lighting medium possible in many of the modern industries where naked lights would be dangerous. With reference to Mr. Thorp's figures for relative costs of fitting and subsequent claim that with the use of the new gas switches convenience equal to that of electricity was obtained, he quoted the makers' advertised price of "from 6*s*. 6*d*. each," which put up the cost of gas-fitting to 10*s*. per point, as against the claimed 8*s*. for electricity.

Mr. H. D. Symons, Mr. A. H. Holton and Mr. W. Hanna also spoke, and then the Chairman brought the meeting to a close.

He congratulated himself upon being present at such an "illuminating debate," and whilst not attempting to follow all the figures put forth, thought they had been given with not more than usual exaggeration. From a point of oratory he thought the gas speakers, perhaps naturally, had the better, whilst in "abuse" honours were even. Both systems had advantages, and their adoption depended upon local conditions. Shopkeepers did and would use electric light, which was certainly a boon in decorated rooms. Although arc lamps did emit impurities, gas vitiated the atmosphere more than electric light, but the heat could and should be used for ventilating purposes. In his own house he used both systems, in the best rooms electricity being installed, which he thought better for ordinary lighting, whilst in the bedrooms, for convenience, and the billiard-room, where light, heat, and ventilation were wanted, he used gas. He had not been moved by any of the arguments for cost, and considered that although gas might be somewhat cheaper, electricity had certainly compensating advantages. In conclusion, he quoted a parody on Dryden's well-known lines :

> "Let gas and glow-lamp share the prize
> And both divide the crown.
> This raised a fossil to the skies,
> That drew the lightnings down."

A hearty vote of thanks was accorded to Prof. Dixon for his services as chairman, and the meeting closed.

Owing to the late hour, and to disperse the combatants at the conclusion, the school authorities cut off the light, when accumulator pocket-lamps carried by some of the electrical men had an opportunity of proving their worth, and came gallantly to the rescue.

The Jandus Regenerative Arc Lamp.

By A. Denman Jones.

This is the first commercial lamp to use chemically treated carbons burning in an airtight enclosure. It is well known that the ordinary enclosed arc has almost displaced the open type pure carbon arc lamp, on account of the saving due to the long burning hours of the enclosed lamp, despite the fact that the light efficiency of the enclosed lamp is less than that of a similar open type lamp.

On attempting to solve the problem of the enclosed flame or chemical arc several main difficulties occurred.

Flame carbons, if burning in an ordinary enclosure, give a dense white deposit upon the sides of the glass enclosure, sufficient to entirely cut off the light after a few hours' burning.

The ordinary chemically treated carbon would also only give its efficiency if exposed freely to atmospheric air.

It was also realized that little economy would be effected in the cost of the carbons unless the chemicals necessary for operation were greatly reduced in amount, as the open type flame lamp will burn several ounces of chemically treated carbon per hour.

The problem was eventually solved by enclosing the arc in a cylindrical glass vessel, with side tubes giving free communication between the top and the bottom, this system of chambers being arranged as an airtight enclosure. The carbons of the lamp are placed in the inner cylinder. The chemically treated carbon is positive, and placed at the bottom, and consists of a high grade carbon core of star-shaped section, the inter-spaces between the rays of the star being filled with a special chemical composition, consisting of a mixture of calcium tungstate and calcium fluoride, together with steadying salts of sodium and potassium.

The inner glass cylinder is surrounded by an outer opalescent glass globe, to ensure good distribution of the light.

The heat of the arc in the glass cylinder produces a strong upward draught of heated gases, which descend downwards through the side tubes, and pass up again through the central glass cylinder. The passages are so arranged that the walls of the glass cylinder are swept by a rapid current of hot gases. Under these conditions it is found that the fumes are not deposited upon the glass walls, but the deposit mainly occurs in the chamber above the glass cylinder, from which it may be easily removed when recarboning the lamp.

The rapid circulation has also the effect of carrying the majority of the chemical vapours given off again and again through the arc, serving to regenerate the chemical vapours therein. The success of this regeneration may be gauged from the fact that less than 15 grains of chemicals are consumed per hour, the carbons giving off only sufficient fresh chemicals to compensate for such chemical vapours as are condensed in the chambers.

It will be seen from the sectional illustration of the lamp that arrangements are made by means of a coned block at the bottom of the lamp to withdraw the inner cylinder and carbon for recarboning without disturbing any other part of the lamp. The cone is clamped tight by the winged nut at the bottom.

Under usual conditions 70 hours' life is obtained from one pair of carbons. The lamp operates at a current of 5 amperes with 100 volts on the lamp terminals, including resistance, and may be burned any number in series at 100 volts apiece per lamp.

The upper electrode is a plain carbon.

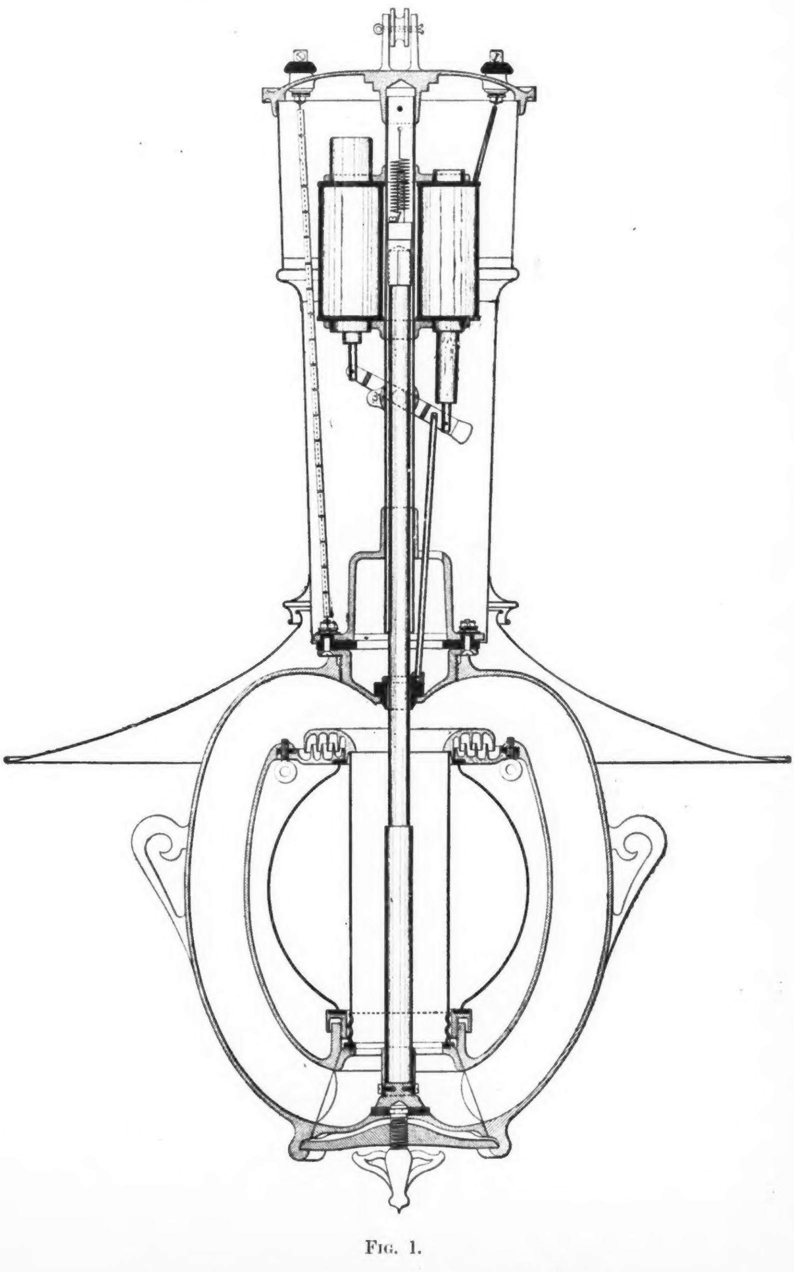


FIG. 1.

SECTIONAL VIEW OF JANDUS ARC LAMP.

The core of the bottom electrode being also of carbon, and the current of the lamp low, the voltage drop across the carbons is less than 1 volt. Variations of light due to varying carbon resistance do not therefore occur.

The combination of chemicals mentioned above gives a light of very great efficiency, of a brilliant but pale yellow colour, somewhat similar to sunlight or incandescent electric lamps. The spectrum of the light shows bands throughout all the colours, from deep red to violet. This polychromatic light therefore gives good colour values in tinted fabrics; the distorted effects sometimes seen from monochromatic illuminants do not occur.

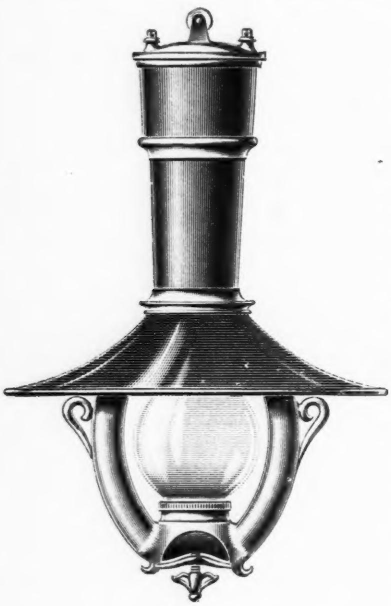


Fig. 2.
General View of Jandus Arc Lamp.

The mean hemispherical candle-power for a 500 watt lamp is 2,500.

The globes and reflectors are so arranged that the diffusion is sufficiently good to prevent any shadow, even at a distance of 1 ft. directly under the lamp.

The arrangement of the carbons gives a long vertical arc; almost the ideal shape for efficient distribution of light over a wide area.

The maximum candle-power occurs at an angle slightly below the horizontal. The candle-power vertically below the lamp is considerably less. This tends to distribute the amount of illumination over a very large space without the lamp being hung at an excessive height.

The most interesting feature of the lamp is, perhaps, the method of preventing the deposit upon the inner glass cylinder. This method, as outlined above, consists essentially of producing an even flow of gaseous vapours through the glass cylinder, sweeping the walls of the cylinder with a rapid current, and without the production of eddies within the cylinder. Should eddy currents be produced, rapid deposition of the chemical products would occur. If, for instance, the inner cylinder is omitted, and only the outer globe used, although the surface of the outer globe is considerably greater, it would rapidly become covered with deposit, due to the production of local eddy currents within the globe. It will be seen that the chamber above the inner cylinder tends towards the production of eddy currents therein, and it is at this point that the fumes are deposited.

Junior Institution of Engineers.

Sir William Huggins, K.C.B. O.M. D.C.L. LL.D. F.R.S., has been elected Vice-President of the Junior Institution of Engineers, in succession to the late Lord Kelvin; also Sir Archibald Geikie, K.C.B., F.R.S., and Prof. J. J. Thomson, F.R.S., have been elected.

The first Local Section in connexion with the Institution, now numbering over a thousand members, has been established at Birmingham, with Mr. F. S. Pilling as Chairman, and Mr. R. B. A. Ellis, of 67, Wordsworth Road, Small Heath, Birmingham, as Hon. Secretary.

SPECIAL SECTION.

Lighting from the Architect's Point of View.

By G. A. T. Middleton, A.R.I.B.A.

It is unquestionable that a period of exceedingly brilliant illumination of the interiors of buildings is with us now, and is certain to remain, beside which no previous period in the world's history is comparable. The architect, whose art is historical, dating back to the earliest times, and whose modern work is based upon tradition thus handed down to him, is consequently bound to reconsider his position in designing his interiors.

On the other hand, he claims that the illuminating engineer should respect the traditions of his craft, and, while providing the degree of light which modern requirements demand, that he should do this in such a way as not to interfere with systems of enrichment which have become stereotyped. Both architect and engineer are right, and consequently there must be a certain amount of give and take between them. Speaking generally, the architect demands that light should be diffused rather than concentrated, so that there may be no harsh and unnecessary shadows where they are not desired. This demand is unquestionably due to tradition, for, from the earliest ages onwards, the lighting of interiors has hitherto been dim, and their decoration has been evolved upon this basis. Traditional forms of decoration are slow to change, and consequently it is reasonable to expect the architect of the present day, when confronted by an entirely new conditions of affairs, to ask that he shall be let down gently, and allowed plenty of time in which to conform to the new state of things.

The architect learns his business by studying the old, the engineer his by studying the new, and the two professions are thus in sharp conflict; but when the problem is that of lighting an old building, the new must surely give place to the old. Most old buildings in England are of the character of churches, erected in the great Norman and Gothic times lying between the Conquest and the Reformation.

The buildings of those days were, internally, at any rate, designed with little idea of brilliant illumination. Certainly, towards the later period, a great deal of light entered in the daytime through the large windows, but these were intended for the display of stained glass rather than for the admission of daylight. The general internal effect was sombre, and it was deliberately so, and this in spite of the fact that night-time services were frequently held, for which the only illumination consisted in a few candles near the altar, the effect of which was but to intensify the gloom. Yet how beautiful the result must have been can well be comprehended by any one who has attended a twilight or night service in a great continental cathedral such as that of Cologne, where a silent congregation stands in the huge nave listening to, though not taking part in, the music and the prayers.

No wonder, therefore, that the cry in respect to the Gothic churches is for a system of lighting which shall respect an architecture designed under such conditions. Glaring electric lights or incandescent gas lamps, centrally suspended along the nave or placed on stands, are exactly what are not required. They may give ample light to enable members of the congregation to read hymns printed in small type, but even so, they are generally irritating to the eyesight. In some way or other the source of light should be concealed. The lamps are preferably more numerous and of lower power, placed, for instance, above the capitals of the shafts or suspended with a dish below them, to reflect the light upwards instead of downwards, and so allow it to spread evenly.

Of course, more illuminating power is required if this sort of thing is done, and where economy is a great consideration, as it often is, the more obvious plan of exposing the light may have to be resorted to, but even this might be subject to a great deal more care and discrimination than is usual. The light above the pulpit, for instance, need not necessarily blind the preacher or throw his face entirely into shadow, and in no case is there any reason why the filaments of incandescent lights should be visible through clear glass.

In the case of new buildings the positions are somewhat reversed. The architect can then, at any rate, consider his method of artificial illumination at the same time that he is preparing his plans and provide accordingly; in fact, all careful architects do so. The style in which they are working may be controlled by other circumstances, yet it is undoubtedly recognized that places which are to be brilliantly lighted, such, for instance, as theatres and restaurants, ought to be designed in brilliant colour, trusting to surface decoration in polychromy and gilt rather than to moulding and carving. This follows tradition, being according to the rule which allowed this sort of thing to be done in the Byzantine, Moorish, and Indian work executed in countries where the sunshine is most brilliant.

Under such circumstances, too, it is unquestionable that classic forms are more suitable than Gothic, and for the same reason, that the classic styles developed in the brilliantly lighted lands of Greece and Italy, while the Gothic arose in the duller countries of the north. We may even go so far as to say that the highly refined work of Greece was only possible in a land where the sunshine was extremely bright, and that, given similar artificial conditions of high illumination, we should do well to use the same extreme precision of workmanship and delicacy of form as did the Greeks, combining with these the use of that beautiful material which so largely assisted them. For this reason low relief work in highly polished marble, or even in plaster, looks exceedingly well in an electrically lighted hall, while much elaboration in high relief appears vulgar and gaudy.

To the great majority of us it is, however, domestic work which is of the greatest interest and importance, for while we may occasionally spend a few hours in large buildings, we most of us live our lives in offices or homes. Here, again, the tendency of the moment is towards too obvious lighting, placing high candle-power lamps, for instance, over the centre of the dining table, when several of lower power placed round the room would enable everything to be seen quite as distinctly and with much less strain upon the eyesight.

It is certainly no essential part of one's comfort to be dazzled during meal-times, while the central light is one of the most inconvenient if the room be used for other purposes, such as for reading or for working. Whatever be the employment, and perhaps most of us use our dining-rooms for general purposes, the great need is that the lamp shall not be placed in front of the eye. On a winter's evening one naturally turns to the fire, and the lamp should then be arranged in such a position as to throw light upon the printed page or the piece of needlework, and from behind the shoulder yet not behind the head.

Similarly in a drawing-room it is necessary to select the position of the lamps to suit the furniture, the piano in particular requiring attention. A central light is obviously absurd, for if such be the only means of illumination, the piano has to be placed with its back against the wall, while the singer interposes his person between the light and the music. Wherever music is really loved, as it is in most families, it is well recognized that the singer should face the room. This to a large extent controls the position of the piano, which has also to be regulated by such essential matters as keeping it out of a draught and in a position where the temperature will be uniform. An architect, in planning a room like this, will always, if he is wise, obtain information as to whether a cottage or grand piano is to be used, and will arrange a place for it, thinking last of all of the source of artificial illumination, which must be chosen to suit the piano and the other features of the room.

The common mistake made in bedrooms is again that of not recognizing where the light is required in relation to the furniture, particularly when electric lights are used. The dressing-table in particular requires attention, and is best lit by several small lights or a diffused light, which will give a good reflection from the looking-glass, both of the front of the face and of the back when a hand-glass is used. With regard to the bed, the light is commonly suspended over the centre of it, where it is most trying in case of sickness. The right position is against the wall at the back, so as to throw the light upon any book which the invalid may wish to read, and not into his eyes.

Throughout the house the same rule applies, that many low-power lamps are preferable to a few of high-power, and that diffused is generally better than concentrated lighting. This is more particularly the case with regard to the decorative effects, giving much more opportunity for the architect to display his skill as well as for the owner to arrange his furniture and hangings with good results.

A clever designer can, however, utilize modern artificial lights to enhance the beauty of his work. He can show his light or hide his light just as best suits his design, or throw it by means of shades and reflectors in any direction which he may desire. The effects produced may perhaps be a trifle theatrical, but there is no real necessity why they should be so if the architect really possesses the artistic instinct. All of us, though often unconsciously, recognize the difference between a room which is artistically lighted and one which is not, and we all appreciate the value of gradation. This it is that the artist must seek, combined with occasional sharp contrast, if he is to succeed in properly lighting an interior. Uniform monotony, even the monotony of brilliance, is scarcely ever satisfactory. There is always a temptation to an amateur in the matter to so arrange his lights that there is no shadow or shade or difference of tone, but while doing this he is destroying all delicacy of effect and everything that goes to produce a perfect picture.

Reverting once more to the case of great churches already alluded to, how much more peaceful, how much more solemn they are when certain parts are thrown into gloom, than when all are brilliantly lighted! Shadows give a sense of mystery, and tend to restfulness. It is only very occasionally that uniformly brilliant light is needed, as in a ballroom or a opera-house on a gala night; and even in the ballroom there is no reason why, in regard to the gallery, if there be one, the space beneath it should not be allowed to rest in its normal shadow, and the gallery above more dimly lighted than the rest of the room.

If something of this sort be done the beauty of the scene, instead of being detracted from, is enhanced by emphasis. On all points, therefore, it is well that an architect who designs a building should control its lighting also; but he must do so with knowledge and understanding, and in full consultation with those who know best the peculiarities of the system of lighting which it is intended to adopt.

The Relation of Illuminating Engineering to Architecture, from the Engineer's Standpoint.

By E. L. Elliott.

(Abstract of Paper read before the Illuminating Engineering Society, the 12th of March, 1908.)

The dwellings of our remote ancestors were probably of the very simplest description; they were merely huts or caves, intended for the individual dweller, and requiring only individual effort. With the development of such rude shelters into more elaborate dwellings the co-operation of a number of individuals was needed. Co-operation invariably requires leadership. Where the work of more than one individual is directed to a common end, there must be a director. Thus, in the development of building, there came a time in its very early stages of development when a master-builder was a necessity. The word "architect" is merely the Greek equivalent of master-builder.

The fundamental purpose of the architect is thus disclosed, namely, to plan and direct the construction of a building so that as a whole it shall fulfil all the purposes for which it is intended. Herbert Spencer has shown that the æsthetic instinct takes precedence of the desire for protection in the evolution of dress; and while the same order can probably not be shown in the evolution of building, it is certainly true that the desire to decorate was very nearly contemporaneous with the ability to build. Thus, almost from the beginning, building involved two theoretically distinct elements, namely, Utility and Beauty. These two elements, however, were practically connected; and thus the architect became not only the mere director of labour, but the originator and arbiter of art as applied to building.

In the advance of civilization it came about that structures were frequently erected in which the artistic or æsthetic elements predominated. Such buildings were intimately connected with the religion of the time, or with the government, or with both, which were generally closely allied. The æsthetic effect served an important purpose in impressing the people with the authority of their government and religious institutions. Some of the few remaining portions of early structures of this kind, in point of grandeur and beauty of conception, and even in skill of execution, have never been surpassed. They were wonderful embodiments of the highest degree of artistic taste and originality, coupled with the lowest form of human labour. Massive blocks of stone were quarried and hauled comparatively long distances, and fitted into their prescribed places with consummate skill, so far as the actual results were concerned; but this was accomplished with a total disregard of human life....The substitution of the forces of nature for the mere brute force of the human muscles is an entirely modern development. The utilization of natural forces to accomplish what had hitherto required the muscular power of human beings, is the foundation of modern engineering....Strictly speaking, there are no remnants of any ancient structures which show the application of true engineering principles; for engineering implies not only the achievement of results with the minimum of material and labour, but a degree of classified knowledge which enables the engineer to predetermine accurately the exact amount of any given material, and the form necessary for it to take in order to secure these results. Such knowledge belongs only to modern civilization.

What we term "modern civilization" is characterized by its extreme complexity as compared with ancient civilization; and this complexity is largely the result of a vastly greater knowledge of natural phenomena. In a single century we have learned more of the workings of nature than had been found out in the entire previous existence of mankind. The result of this has been to transform the large majority of human beings from mere engines of force into sentient creatures, who are thereby free to develop those mental powers which lift them above the animals. As a direct consequence of this emancipation, the human family is on a vastly higher plane of intelligence and general happiness....

Even admitting that we have less commanding geniuses in the field of art than may have existed in the palmiest days of Greece and Rome, it is indisputable that the total amount of artistic appreciation among the masses of people is incomparably greater; and it is the scientist, the engineer, that has brought this about.....

Ancient and modern civilizations have scarcely a single important element in common, barring the elemental human passions, which never change. There is scarcely a phase of life which is not essentially different to-day from what it was in ancient and mediæval times: and this radical difference is, and by rights ought to be, exemplified in modern building. In Greece a philosopher gathered such people as had the time and disposition to hear him beneath the shade of a tree, and expounded his doctrines. The modern counterpart of this is the University, with its millions of dollars' worth of buildings and equipment, its thousands of students, and its hundred of instructors and professors. In place of the parchment scroll we have the daily newspaper, produced at the rate of several thousand complete copies an hour. These two instances give a fair measure of the all but infinite space between the old and the new. And yet the modern architect seems to have but one anchorage in which he has implicit faith, and that is veneration for antiquity: when he casts loose from his he drifts and tosses about, and knows not whither to direct his course. He dare not discard the parchment scroll, but would have it printed on a rotary press. Appreciating the simple beauty of the monolithic column, he strives to attain it with steel beams, hollow brick, and cement. Inspired by the majesty of the Gothic arch, he reproduces it in lath and plaster.

The habit of clinging to past forms of architectural expression is not infrequently carried to the point where it becomes ludicrous. The wind-swept island of Great Britain naturally developed a type of cottage having long stretches of sloping roof, designed to keep the whole structure as near to the ground as possible. As this developed in the very early period of the art of glass-making, the windows of necessity were divided into a large number of small panes. Incredible as it may seem, one of the first so-called "sky-scrapers" to be erected in New York was modelled after this type of cottage. The building is still standing at No. 1, Broadway, and has the distinction of being the only "Queen Anne" office building in the metropolis. On the other hand, the pointed arch, the succession of long vertical lines, and the versatility of adornment, which are the basis of Gothic architecture, and which would lend themselves to modern building with comparatively little violence to the original spirit of conception, have been only recently attempted, and then only in a timid and half-hearted manner....Eliminate the evidences of ancient and mediæval architectural features, and what have we left to represent modern civilization?....

The simple truth is that modern civilization has not yet expressed itself in architecture. Were our nation to be suddenly blotted out-to-day, the structures which would most adequately portray its habits of life and planets of thought would be our engineering works—our bridges and tunnels, our railways, mills, and factories. In point of beauty some of our modern bridges may be put along with any architectural structure of antiquity. True, the beauty is of quite a different type; but so was beauty of person of a different type in ancient times.

Reduced to its lowest terms, the business of the engineer is to produce a given physical result with the minimum of material and labour; and the justification for his vocation must be found in the extent to which he can accomplish this end. Emerson has defined beauty, taken, of course, in its physical and material sense, as "that which has no superfluous parts, which exactly fulfils its purpose." In following this definition the work of the engineer is beautiful to exactly the degree that it is efficiently done. Broadly speaking, the modern building is simply an aggregation of utilities. With very few exceptions it is simply a part of a vast machine—a machine being properly defined as any device which enables a man to accomplish more or better work than he could do without it. Apply this at random and see how well it fits. The factory building exists because it enables work to be done that could not be done at all in the dwelling, or that can be done to better advantage; and it is as much a fundamental part of the apparatus for producing the particular articles made as is the engine or machinery. So the office building is merely a device by which the various operations of accounting and commnuication can be efficiently carried on; and so with the store, the school-house, and, to a large extent, even the dwelling. Almost the single exception is the church; and this, from being almost the only form of public building, has become a comparatively infrequent and inconspicuous structure.

Building to-day has, therefore, become almost entirely an engineering problem; and with the vast increase in the complexity of life which characterize modern civilization has arisen the necessity of subdividing the general problem of construction into a number of distinct branches. Among these are the purely mechanical construction, which has given rise to structural engineering; the methods of heating and ventilating, with its special engineering; electrical equipment, with its electrical engineering; provisions for sanitation, with its sanitary engineering; and, lastly, the necessities for artificial illumination, demanding illuminating engineering. All but the last mentioned of these special branches of engineering have gradually been necessitated in the evolution of building, and have been accepted by both architect and client. It is only the last that is still to some extent in the undeveloped state.

Accepting the formula already given as to the general field of engineering, we arrive at the fundamental proposition that the business of the illuminating engineer is to produce a given or required result of illumination at the minimum outlay for the original installation, and subsequent maintenance cost. This leaves one highly important question still to be settled, namely, Who shall determine what the required illumination shall be? Evidently this question must be decided jointly or separately by the three parties to the contract, namely, the owner or client, the architect, and the illuminating engineer. It may be stated without fear of serious contradiction that the owner has fully met his responsibility in the premises when he has clearly set forth the exact uses for which the various parts of the structure are to be put. It then lies between the architect and the illuminating engineer to determine what the best illumination for each and every particular case may be. As between these two parties, the greater economy of thought and labour will be secured by placing the responsibility upon the illuminating engineer. To determine just what manner of illumination is best for all the numerous and widely varying conditions of modern life requires an extent of technical knowledge, and a breadth of experience which the architect may very appropriately and wisely avoid, providing the results can be obtained from other sources. It is simply a matter of division of labour and economy of human effort. Modern civilization demands that the individual shall be able to do some one thing completely and well, and shall not spend his time in doing things which he can only do indifferently, and which others can do more efficiently.

Benjamin Franklin used to set his own writings in type, put them in the press, and take a hand in running off the printed sheets; and even Horace Greeley was in the habit of going to the cases and setting up his own editorial in his early days; but this was not true economy of human effort. There was many a one who would have been glad of the job of setting the type, whose written productions would have been of infinitesimal value. Surely the architect of to-day has a sufficiently wide and dignified field for his labour in the legitimate work of unifying and harmonizing all the diversified elements that enter into a building, without bothering his head about the infinite details of these different elements.

The advent of the illuminating engineer as a specialist should be hailed with greater delight and relief by the architect than by any other member of the community. Having satisfied himself of the competency of the illuminating engineer, just as he would satisfy himself of the competency of the electrical or construction engineer, the architect can turn over the plans of the building, with the specifications of the use or uses to which it is to be put, and probably also a statement of the illuminant to be used, and leave the entire technical problem to the illuminating engineer. On the other hand, the illuminating engineer must have authority commensurate with his responsibility. The architect would not think of arbitrarily changing the specifications of a structural engineer without his full consent, and for the same reason the plans of the illuminating engineer should be equally respected.

There is one difference, however, between these two branches of engineering as connected with building; the skeleton of a building, which is the work of the structural engineer, is hidden when the work is completed; but the apparatus especially connected with the illumination is not only in plain view, but so conspicuously in sight as to form one of the necessary elements in the artistic whole. This phase of the problem of illuminaton, therefore, falls within the legitimate province of the architect. There is clearly but one solution of this apparent clash of authority, and that is co-operation between the architect and the engineer. The engineer demands a certain physical result; the architect demands certain structural features or conditions in order to produce the general harmony of result which it is his business to secure: how shall these two demands be reconciled? Evidently there will be a large number of cases in which no reconciliation will be necessary; all that is required will be such a versatility on the part of the engineer that he can design the physical part of the installation so that it will produce both the physical and artisic results demanded. It is conceivable, however, that cases may arise in which the artistic conditions required by the architect can be secured only at a greater or less sacrifice in economy: the decision then very clearly rests with the client. The possibility also still remains of the architect specifying certain conditions which he considers essential from the artistic standpoint, but which the engineer deems not only uneconomical, but positively detrimental in point of the resulting illumination: who then shall decide? In this, as in all other cases, the client is the court of last resort, on the generally accepted theory that he who buys an article has a right to dictate as to its character. If a man chooses to work by light which is dangerous to his eyes, or is ill-suited to the purpose for which the illumination is required, for the sake of the supposed artistic effect, he can hardly be denied his right to such a course, however foolish it may seem to the engineer. Such cases, however, are hardly likely to occur under proper conditions. There are few persons who would willingly subject their eyes to a dangerous strain, or handicap the efforts of themselves or their employes by bad light after having been duly warned.

Since the larger proportion of buildings at the present time are predominantly utilitarian, there is extremely little opportunity for any disagreement between the illuminating engineer and the architect. In all this large majority of buildings the general artistic talent of the illumination engineer should be sufficient to avoid such breaches of taste as would be objectionable. This class of building includes factories of every description, office buildings, school-houses, and the larger portions of hotels and public buildings. In the case of a large number of residences the illuminating engineer should also be competent to lay out, or pass upon every feature of the installation. There remain then only the more pretentious class of dwelling-houses. churches, theatres, and, to a partial extent, libraries and public buildings, in which co-operation of engineer and architect is essential. In these cases the artistic features of the lighting installation are of such importance as properly and justly to demand the attention of the architect. However, while the architect is properly the arbiter in such cases as to the artistic side of the problem, the services of the illuminating engineer are no less valuable than in the other cases. Let it be clearly understood that art as applied to architecture does not exist for its own sake, but is only directed to the embellishment of the necessary and essential physical features of the building. Good decorative art is not only compatible with an efficient physical result, but can be considered of the highest order only when it conforms to good mechanics—in fact, decorative art rests upon a purely scientific basis.

A careful analysis of the respective provinces of the illuminating engineer and the architect, therefore, disclose no more ground for mutual disagreement and distrust than between the architect and any other engineering specialist. The passive or active antipathy which has thus far existed to a greater or less extent on the part of the architect toward illuminating engineering, appears to be wholly unjustifiable; and it may be worth while to seek the reasons for this apparently groundless opposition. The most obvious cause of this feeling may undoubtedly be found in the fact that the illuminating engineer has thus far been to a large extent a reformer; in fact, the very existence of his profession may be directly traced to the prevalence of bad practice in the use of light. The faults of illuminating installations as designed under past conditions at last become so numerous and so obvious, that there arose a demand for reform.... The work of the illuminating engineer thus far has, therefore, been necessarily directed to a large extent toward pointing out the faults of the prevailing practice. Such a course is by no means the most agreeable of tasks, but is a necessary preliminary to better work in the future; and the illuminating engineer must not shrink from this task until the absolute soundness of his contention has been universally recognized.

In most cases the sins of the architect have been rather of omission than commission. With the increasing demands upon his attention from the growing complexity of building, he has given less and less attention to details, and seemingly the least attention of all to the extremely important matter of artificial illumination. Lighting systems have been put in either without the slightest regard to the scientific principles involved, or at best with the aid of a few rule-of-thumb formulas which were as apt to produce faults as anything else. Only the greater ignorance of the client has prevented an earlier upheaval. Were proportionately serious mistakes made in other points of construction, there is scarcely one building out of ten that would be accepted by the owner when completed. What would one say, for example, on learning that the heating apparatus in his building was wasting 25 per cent. or even 50 per cent. of the fuel? And yet such losses in light are by no means uncommon.

Perhaps from a natural inclination to avoid details, the architect has very frequently delegated his duties to the fixure manufacturer, with the result always to be expected when the blind leads the blind, namely, that they have both fallen. The sins of omission committed by the architect were even surpassed by the sins of commission committed by the fixture maker. Where the architect specified a number of light-sources, figuring in a vague way on the illumination which they would produce if unobstructed, the fixture manufacturer has, perhaps, reduced the illumination to one-half by the accessories and construction used. It is quite to be expected, therefore, that the fixture manufacturer should not welcome the illuminating engineer with open arms. It is bad enough to have one's faults badly pointed out; but when such faults have been an important source of revenue, the sting is so much the keener. There is no denying the fact that a very considerable part of the faults of lighting fixtures are directly traceable to a desire for profit.

....Look at any fixture you please, and judge for yourself how much of the metal work is essential, and how much is a mere excrescence hanging on in the name of art, but having its true motive in the pocket-book. It is the existence of this condition of affairs that has made it necessary for the illuminating engineer to give a greater consideration of the artistic side of their subject than ideal conditions would require or justify, and so long as the condition prevails their efforts must continue....

The principal point in dispute thus far between the illuminating engineer and the architect seems to be a question of jurisdiction. The architect has been comparatively ready to admit the authority of the illuminating engineer in regard to the purely physical and economical aspects of the question, but has denied his authority in matters pertaining to the æsthetic or decorative features involved. The engineer, on the other hand, has contended that under this ruling the architect can practically overthrow the results of his labour by setting up the claim of æsthetic requirements....

Since illuminating engineering involves questions of decorative art, there is no reason why the illuminating engineer should not make a sufficient study of this side of his profession to become an adept. The principles of art as applied to architecture are within the grasp of any intelligent person having a reasonable amount of native appreciation, and there is no more reason why the illuminating engineer should not master these principles, at least, so far as they affect his profession, than there is for the architect not acquiring the general principles of structural engineering.

Whatever his incompetency may be in regard to the purely artistic side of the question, there is one invaluable result that is sure to follow the agitation that has been set up, and that is a greater amount of attention on the part of both professional and layman to the subject of illumination. The results in this regard are already apparent. The very first essential to reform is to discover the need of it, and until this discovery is made and accepted by a sufficient number of the people it is useless to look for improvement. The fact that the former prevailing practice in lighting had numerous and grievous faults is becoming pretty generally known, and as a direct result of this knowledge a demand for better methods is making itself felt.

Papers of Interest before the Illuminating Engineering Society.

AMONG other papers of special value before the American Illuminating Engineering Society we note those of Dr. H. Seabrook and Mr. Leland Hunter on 'The Effects of Light on the Eye,' and 'Light and Colour in Decoration.' With these papers we mean to deal shortly. Among papers of interest which are to be read before the Society in the course of the next two months we note that of Dr. E. L. Nichols on 'Daylight and Artificial Light.'

The Electric Lighting Installation of a Berlin Theatre.

By Dr. Alfred Gradenwitz.

A great development has taken place in architecture of late years, especially in the art of interior decoration both of dwelling houses and buildings intended for use mainly by night, such as theatres, music-halls, and restaurants. In the latter case, one naturally avails oneself of the recent improvements of electric lighting, so that the artistic features of the interior may show to the best advantage; incandescent lamps have been found well adapted to cases of this nature.

A typical instance of an up-to-date lighting plant of this kind is that of the Neues Schauspielhaus on the Nollendorf Platz, Berlin, which was opened last year. This enormous block, constructed by well-known Berlin architects, comprises, in addition to the theatre proper, a large music-hall (the Mozart Hall), an extensive restaurant, and a manager's office.

The electric lighting installation installed in this extensive set of buildings was designed to meet many special conditions of the case, both from an artistic and decorative standpoint. Also, with a view to the great crowds frequently assembling in these rooms, the risk of danger from fire must be reduced to a minimum.

The installation was designed throughout on the three-wire system, continuous current, at 2×220 volts; the source of supply being the Motzstrasse sub-station of the Municipal Electricity Works of South-Western Berlin. Two distinct special circuits leading to the theatre and terminating at the main switch board are laid from two self-contained feeding points of this sub-station. Each of these circuits in turn comprises two independent sets of mains, allowing the electrical energy to be supplied in four different ways, thus ensuring the greatest degree of safety and reducing the possibility of breakdown, to a minimum, in the event of one cable or other being disabled.

From the main switch-board in the basement below the stage there are feeders leading to four centres of distribution, set apart for the supply of current to the theatre, the Mozart Hall, the restaurant, and manager's office respectively. In connecting the main switching rooms with the feeding points for the theatre and Mozart Hall, a high degree of safety has been secured by providing for two entirely distinct, self-contained, sets of conductors. While only one set leading to the restaurant and manager's building feeding points is in use, the safety of the supply is secured by the arrangement of additional connexions with the general municipal mains, which are situated below the street in the immediate neighbourhood.

Branch conductors are led from the distribution points to the various rooms in each building, the whole system being sub-divided into four main groups corresponding to the four main buildings, which enables inspection and supervision to be easily carried out, and the highest possible convenience in operation. The dimensions and capacity of the lighting-system will be best gauged from the fact that as many as 5,150 incandescent lamps of 16 to 32 normal candle-power and 36 arc lamps for 3 to 20 amp. have been provided, these lamps being distributed over the various buildings in the following manner:—

The theatre and auditorium contain 2,880 incandescent lamps and 2 arc lamps.

The Mozart Hall and accessory rooms contain 590 incandescent lamps and 14 arc lamps.

The restaurant contains 1,210 incandescent lamps and 10 arc lamps.

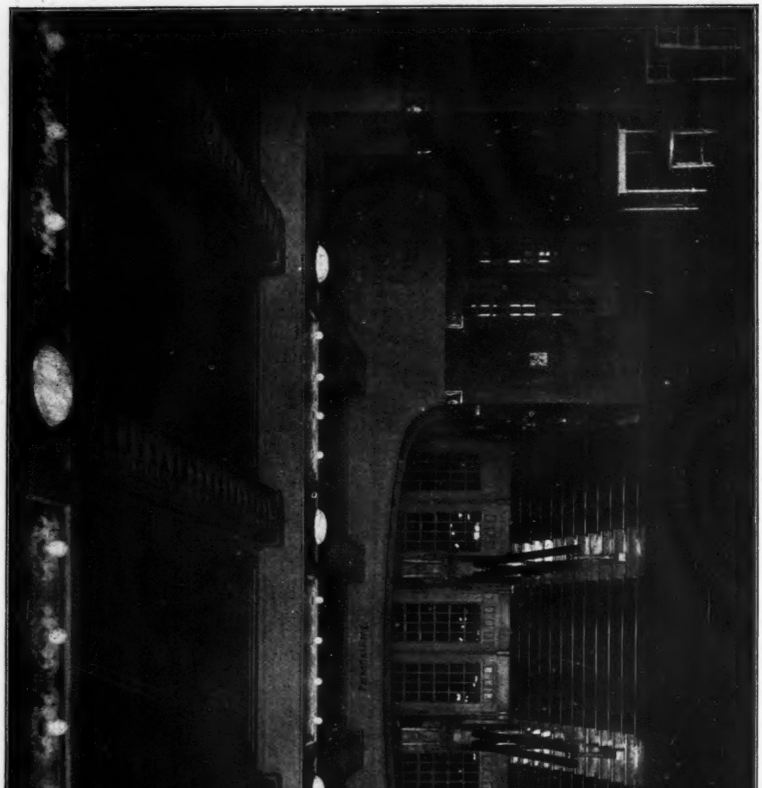


FIG. 1.—Illumination of Main Entrance to Auditorium.

The manager's offices contain 470 incandescent lamps and 10 arc lamps.

In what follows the arrangement of the lamps employed in connexion with the remaining three centres of distribution will, therefore, be dealt with in detail, and also the lighting of the theatre vestibule, in which the distribution of light and general effects of illumination are similar to that occurring in music-halls and modern restaurants.

In order to meet the requirements of interior decoration, every facility had to be given both to the architects and artists in regard to the arrangement of conductors. These had accordingly to be carried, according to their orders, to any point on the walls and ceilings at which any lamps were to be fitted, and yet to be invisible, in order not to interfere with the decorative arrangements. The conductors had also to be permanently accessible in order to facilitate any repair work. These conditions are complied with most satisfactorily by the Peschel steel pipes, which are slashed steel pipes without any inside insulating lining, intended for receiving insulated strand conductors. Instead of cutting threads, as in the case of steel-armoured tubes, and laboriously tightening the muffles as in the case of insulating pipes with inside lining, all that is necessary in this case is to slip the resilient tubes into the smooth muffles and the fittings of the connecting pieces. Owing to the large inside dimensions of the pipes the arrangement and accessibility of the conductors are extremely satisfactory.

The artistic and decorative arrangements are of an extremely varied kind, each of the rooms having a character of its own, to which the electric lighting had to be strictly adapted. Thus the main staircase leading to the first gallery contains chandeliers in which 16 incandescent lamps are mounted together in a polished crystal bowl.

Within the main entrance to the auditorium, the ceiling has been divided into rectangles formed by beams, and over which single lamps are distributed (Fig. 1).

The lobby of the first gallery (Fig. 2) is equipped with exceptionally rich inside decoration. There are two wide entrances equipped with two arcs overhead, situated opposite one another. A number of incandescent lamps are arranged in cavities in the central part of the ceiling, the whole forming an illuminated cupola. The latter in turn is provided with a great number of rosettes, each of which contains an incandescent lamp. Other lighting fittings of more simple design, each carrying 6 incandescent lamps, are used for the illumination of the ceilings of the walks beside the first gallery (Fig. 3).

A combination of incandescent and arc lamps is used for the illumination of the Mozart Hall (Fig. 4). This extends over a length of 29 m. by 16 m. width and 15 m. height, immediately behind the frontage of the main building. To the ceiling are attached 8 arc lamps of 20 amp. and 4 clusters for 44 incandescent lamps each. Below are provided 30 additional lamps of the same kind, giving an average of 200 incandescent lamps used, apart from the 8 large arc lamps for the lighting of this extensive hall.

The incandescent lamps used for lighting this part of the building are exclusively tantalum lamps, of which an aggregate number of 2,000 has been used. The restaurant rooms likewise contain exclusively this type of lamp.

The tantalum lamps are intended for a pressure of 110 volts, being arranged two in series. This arrangement has given excellent results in rooms of this kind, this type of lamp, owing to its brilliant white light and efficiency, having found a wide scope as a competitor to carbon-filament glow lamps.

The large courtyard situated between the buildings has been arranged as a summer garden, and is equipped with 400 tantalum lamps arranged on chandeliers.

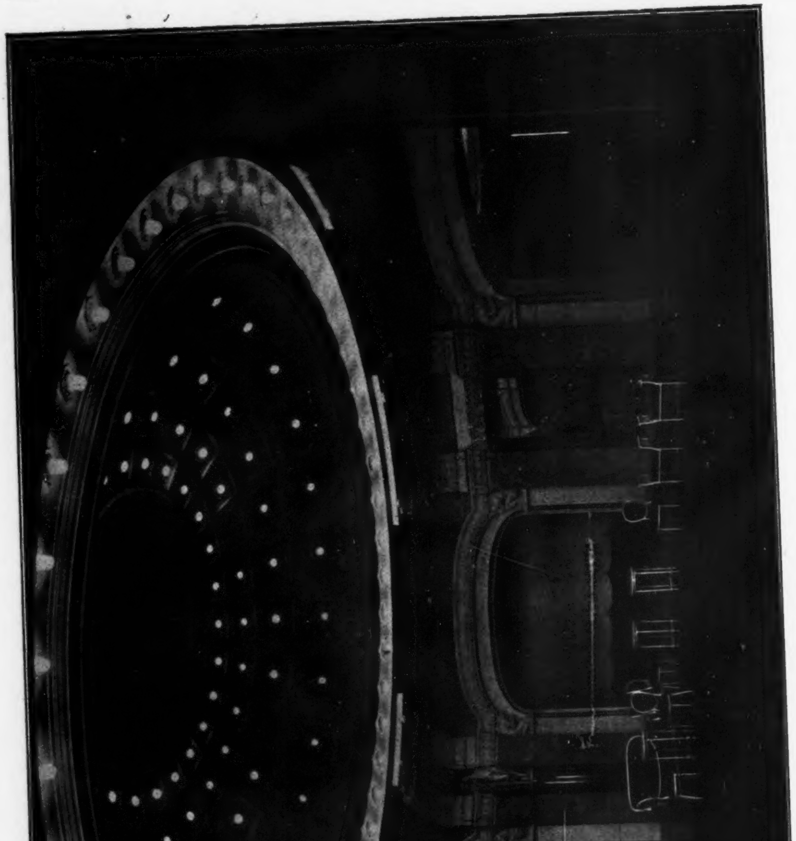


Fig. 2.—Illumination of Lobby of First Gallery.

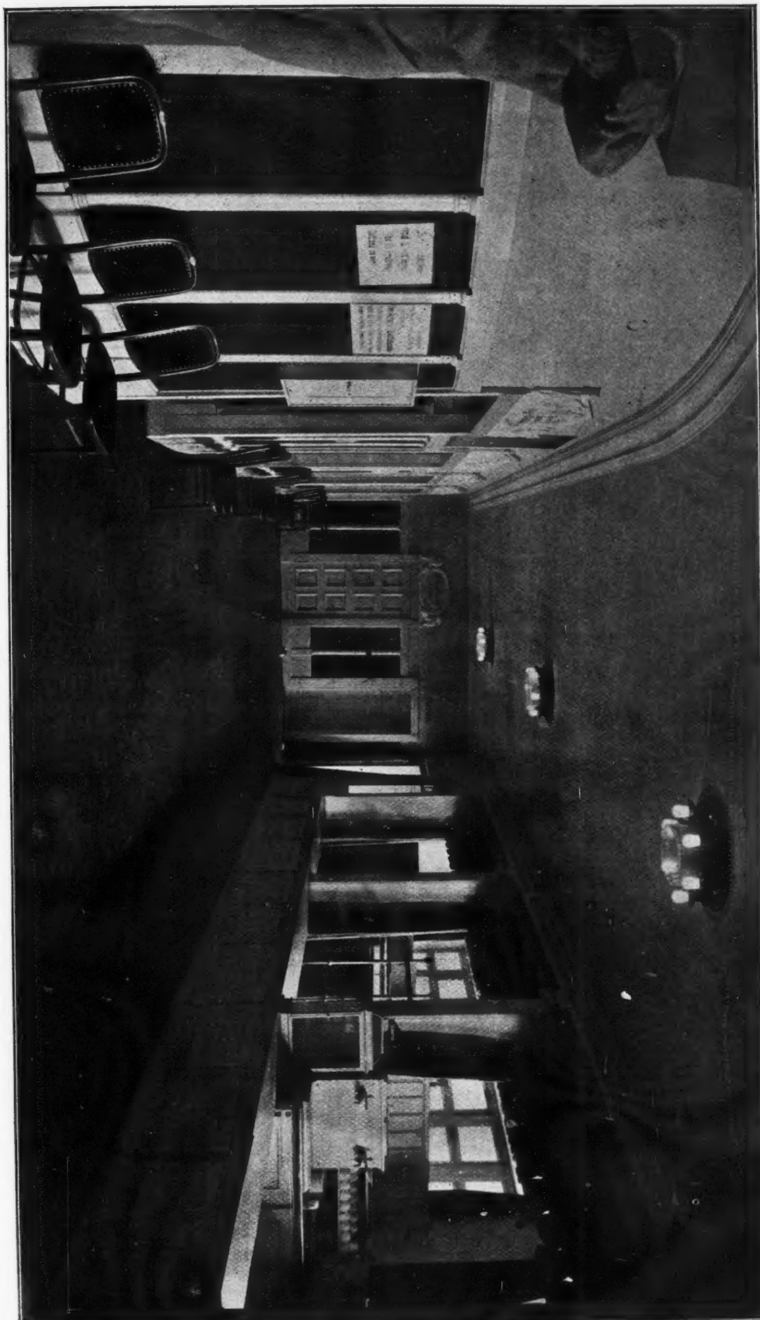


FIG. 3.—Illumination of Passages Adjoining First Gallery.

FIG. 4.—Illumination of Mozart Hall.

The Illumination of London's New County Hall.

By a Correspondent.

The municipal building which the London County Council now appears to be seriously contemplating must necessarily form a most interesting topic for discussion and meditation from the point of view of illumination.

As our readers are aware, the design of Mr. Ralph Knott has been selected out of some 150 competing designs sent in from architects practising in all parts of the world. Mr. Knott's ground plan, which was published in a recent number of *The Builder*, scales about 730 ft. long by 240 ft. wide, or covers an area of, say, rather more than four acres. Readers of *The Illuminating Engineer*, who happen to carry in their mind's eye the size of a four-acre field, and are able to imagine such field covered by a building having a ground floor and five floors above this, with a basement, sub-basement, and attics, will be able to form an idea of the magnitude of the proposed building.

The west, or river side, is the more attractive part of the site, and the spacious committee-rooms are arranged along this frontage. Each room is provided with three or four large windows, opening on to the uninterrupted view, so that these rooms will all be well lighted during the daytime. Four large courtyards serve to give light and air access to the rooms situated in the interior of the building. The Council chamber on the first floor and the hall on the ground floor—forming, perhaps, the most striking feature in Mr. Knott's conception—which is to be used as required for public entertainment, are both provided with glazed domes through which (in the absence of fog) ample provision can be made for daylight illumination.

Perspective of the Selected Design for the London County Hall.
Ralph Knott, *Architect.*

It is in some of the long corridors, particularly those running across the building—a matter of 240 ft.—to which direct rays of daylight can obtain access only through single end windows, that a deficiency is chiefly to be anticipated. This will be more especially the case should these windows, as is more than probable, be devoted primarily to decorative purposes, and to that end be fitted with stained glass, showing some ornamental, allegorical, historical, or figurative sketch, instead of being turned to the best possible account for the access of the external light. The longitudinal corridors are provided with four windows looking out on each of the four courtyards, and are, therefore, not likely to normally fall below a fair standard of illumination; but the crescent-shaped corridor on the east, or Belvedere Road side will receive only a small share of direct illumination with some addition derived from the main and subsidiary stairways leading to and away from it.

Interesting, however, as these considerations may be, it is rather to the artificial side of the illumination of the building that the attention of readers will turn. Central station engineers, cable manufacturers, manufacturers of switch-boards, fittings, &c., and contractors generally, will be eagerly watching for some indication of what share of the ensuing business—and big business, though still many months far ahead—will fall to their lot. For the electricity supply people there is a fair prospect that high efficiency lamps will be used throughout, unless something yet more efficient shall have made its appearance. By that date the extra efficiency of the metallic filament lamp will have so far leavened the lot of the supply authority that he will be looking back upon 1908 as an age during which it was marvellous that it was possible to make both ends meet on the small load then obtaining, and still more marvellous that it was possible to persuade the poor consumers that they were not being actually robbed by those wicked old black-bulbed carbon lamps.

It is impossible to enter into the maze of calculation which must be put on paper in connexion with a big scheme of this kind before it can be predicted what the annual bill is likely to be, especially under circumstances which will exist in the nebulous future. There are many short cuts, however, whereby an approximate idea may be formed. For example, the chamber in which the Council now meets has a superficial area of about 2,500 square feet, and is illuminated by eleven six-light electroliers and some forty other lamps. These are apparently all tantalum lamps of about 20 candle-power, or, say, a total of 2,120 candle-power. The effect is a soft pleasing light, such as could not be much improved upon in the new building. For the committee-rooms and offices, corridors and basements, store-rooms, &c., such a high rate of lighting would not be desired, as there would be greater facility in bringing the work to the illuminating source, whereas in the Council Chamber the members are frequently obliged to retain one definite position, and hence the light must be ample for all possible positions. Such values, however, as 0·5 candle-power per square foot for the committee-rooms, 0·4 to 0·3 candle-power per square foot for the offices, 0·2 for corridors, basements, &c., with a 10 per cent. margin over all, would indicate that something like 17,000 lamps of 20 candle-power will be required, or the equivalent in inverted arc lamps or other methods of illumination. The annual consumption would be rather more than 200,000 units, or perhaps nearly 250,000 units for lighting only, apart from the energy required by electric radiators, lifts, ventilating fans, &c. Enough has been said to indicate that the illuminating engineer and his satellites will be required, and that there will be room for much display of experience and wisdom in planning this vast scheme.

In conclusion it may be urged that no stone be left unturned to make every detail of the plan and execution, essential to the proper illumination of such a building as this, as perfect as human intelligence can devise.

The Physiological Basis of Illumination.

BY DR. LOUIS BELL.

(From the *Proceedings* of the American Academy of Arts and Sciences, September, 1907, Vol. XLIII. No. 4.)

THE purpose of this paper is to point out that with the existing knowledge of physiological optics artificial illumination can be removed from the domain of empiricism and can be made to rest upon constants which have a definite physiological basis, and which can be, and have been, predetermined with reasonable precision. For obvious reasons data which relate to the sensation of sight cannot rank with exact physical measurements, but they can nevertheless be evaluated closely enough to give a reliable basis of judgment in planning illumination to meet any given requirements.

Except for the aid received from accommodation and in binocular vision from convergence, we see things in virtue of their differences of colour and of luminosity. Of these two the latter is by far the more important, particularly in distant vision. Objects of similar luminosity, but differing considerably in colour, blend into the general view in a most astonishing fashion when at any considerable distance. Objects of similar colour but of different luminosity also fuse into the general field, and if colour and luminosity are both similar, things disappear in a way that is positively amazing. Small coloured areas of moderate luminosity blend even at relatively short range, a fact which the impressionists have turned to extremely good use: albeit they often transfer to canvas the colour vagaries of the tired eye, and the effects of simultaneous contrast rather than the fleeting impressions which they hold so precious. One of Monet's landscapes, however, is wonderfully interesting from the standpoint of physiological optics, and especially in the existence of a critical distance, within which the picture loses its magic.

Practically, therefore, vision depends very largely upon the power of distinguishing differences of luminosity. And since objects in general are luminous only in virtue of light reflected from them, their visibility depends in turn upon their coefficients of reflection. So far, at least, as problems of artificial illumination are concerned, objects seen do not range over a long scale of values of luminosity. Whatever the absolute values of the light reflected, the relative values expressed by the coefficients of reflection range from about 0·80 to about ·01, very few substances returning more than the former or less than ten latter percentage of the incident light.

The fundamental fact at the basis of vision is that the eye can perceive, within a very wide range of absolute intensity, a substantially constant fractional difference of luminosity. This is the purport of Fechner's law, and the fractional difference mentioned is well-known as Fechner's fraction. Its numerical value for normal eyes and ordinary intensities of illumination is from ·02 to ·0055. The importance of this law in practical seeing is enormous, for in a room well lighted by diffuse daylight the illumination may vary from 100 meter-candles down to 10 or 2 in different parts of the room or at different times; and if power of discriminating difference of luminosity changed much with the illumination, one would be purblind most of the time. In some abnormal eyes Fechner's fraction, with vision otherwise normal, is considerably increased, with serious results. A case is cited by Krenchel in which a patient was unable to get about in full daylight without stumbling over things. His condition was most puzzling, until a test showed Fechner's fraction at a value of 0·1. At this value one could not distinguish between dark and light shades of brown and grey, having coefficients of diffuse reflection of, say, ·15 and ·25 respectively, and ordinary shadows on neutral surfaces would therefore disappear entirely. With Fechner's fraction at 0·5 no contrast less than that between white and very dark pigments would be easily distinguished.

Now while Fechner's fraction is fairly constant over a wide range of intensities, one easily realizes that as twilight deepens his power of discriminating shades is seriously impaired. It is this variation of Fechner's fraction with the illumination which determines the minimum amount of artificial (or natural) light which is effective in enabling one to see things *en masse* in their natural relations. For general vision any illumination above that required to bring Fechner's fraction for the normal eye up to its steady value is needless, and, as we shall presently see, may be injurious.

Human vision, however, is frequently concerned with the observation of fine details both far and near, and the power of seeing these is within wide limits independent of the capacity of the eye for distinguishing small differences of luminosity. In the case mentioned by Krenchel this *visual acuity* was normal, in spite of the extraordinary lack of sensitiveness to variations of light and shade. Acuity seems to depend on the structure of the retina and the quality of the eye as an optical instrument rather than on the direct or secondary sensitiveness of the nerve endings to stimulation by light. Great acuity is possibly commoner among savage peoples than in civilized races. König * has noted it among the Zulus, whose colour vision, by the way, was normal. It has been found in unusual degree among the Kalmucks, and Johnson† noted it in the Congo peoples, in every case associated with slight hypermetropia. Some observations of Johnson (*loc. cit.*) would suggest that the extremely dark hue of the *fundus oculi*, and consequent diminution of choroidal reflection found among the dark-skinned races, may improve the definition, although, perhaps, at the expense of sensitiveness. It is of course, well known that in the last resort the ability to separate objects like neighbouring points and lines depends on the minute structure of the retina, and is greatest in the *fovea centralis*, where the cones are most closely packed. The *fovea*, too, is well known to be somewhat less light sensitive than the retina in general. Using a wedge photometer, I find for my own eye that there is a difference somewhat exceeding one stellar magnitude between the foveal visibility and that outside.

Following out this line of investigation, it is not difficult to project the fovea as a dull spot in the field of view. Using a wedge photometer, and fixing the eye at any point on a large sheet of white paper, one finds, on rather quickly cutting down the light by sliding the wedge, a roundish dark spot exactly in the axis, and corresponding in diameter with the projection of the fovea. It is not easy to hold vision of this phenomenon, since the axis of the eye inevitably tends to wander.

By drawing five rather faint crosses at the centre and corners of a square, say a decimeter on a side, one can, by careful manipulation of the wedge, make the central cross disappear in the foveal blind spot, while the corner crosses remain visible. The facts regarding the independence and acuity and sensitiveness lend weight to the theory of our confrère Prof. Lowell regarding the bearing of this matter on astronomical observations. Extreme acuity and extreme sensitiveness, being both rather rare, any considerable degree of independence must render the coexistence of both in the same individual unusual in a very much higher degree.

The failure of acuity in a dim light is familiar, and its variation with intensity affords an independent criterion of the necessary requirements in artificial illumination. Enough light must be provided to bring the eye to its normal acuity, as well as to its normal value

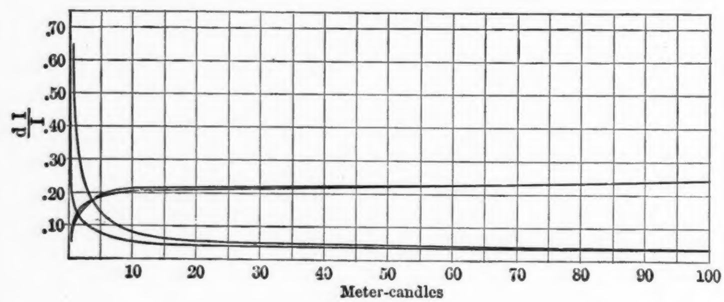


Figure 1.

* *Nature*, 31, 476.
† *Phil. Trans.*, 191, B. 61.

of Fechner's fraction. Fortunately the researches of Dr. Uhthoff* and of Drs. König and Brodhun † on acuity and Fechner's fraction respectively, give us safe ground on which to travel in these respects.

In Figure 1 are shown the acuity curves and the shade-perception curves of the normal eye for intensities up to 100 meter-candles. Curves *a* and *b* give the values of Fechner's fraction for white light and deep crimson light ($\lambda = 670\mu\mu$) respectively), while *c* and *d* give the acuity curves for light orange ($\lambda = 605\mu\mu$) and yellowish-green ($\lambda = 575\mu\mu$) respectively. The ordinates in the first case are $\frac{dI}{I}$, and in the latter case are in arbitrary units. The most important feature of these curves for the purpose in hand is that they are already becoming asymptotic at low values of the illumination, and except for strong colours at about the same point. At about 10 meter-candles they have turned well towards the axis, and beyond 20 meter-candles the gain in shade-perception and acuity is very slow with further increase. Hence, when the light reaching the eye has risen from 10 to 20 meter-candles, further increase does very little in the way of assisting practical vision.

Artificial illumination can be safely based on this amount as a working intensity. Visual acuity is the controlling factor in most indoor lighting. It varies noticeably with colour, but for practical reasons, which will appear later, the actual visibility of coloured objects depends not on the differences here shown so much as upon their general light-reflecting power, which for dark hues is always low.

At great intensities both shade-perception and visual acuity considerably decrease, the former at roughly 25,000 to 50,000 meter-candles, the latter at much lower intensity. Neither function is likely to fail at any intensity reached in the ordinary course of artificial lighting, though acuity may be seriously interfered with by dazzling and consequent rapid retinal exhaustion at intensities of a few hundred meter-candles, and the same secondary cause also impairs shade-perception long before its final decline.

It must be clearly understood that in specifying 10 or 20 meter-candles as the intensity physiologically necessary to bring the eye into its normal working condition, these intensities are those which become visible to the eye, and not merely those that reach the objects under observation.

The light reflected from any object is *Ik* where *I* is the incident illumination and *k* the coefficient of reflection. Then, if *a* is the normal illumination just indi-

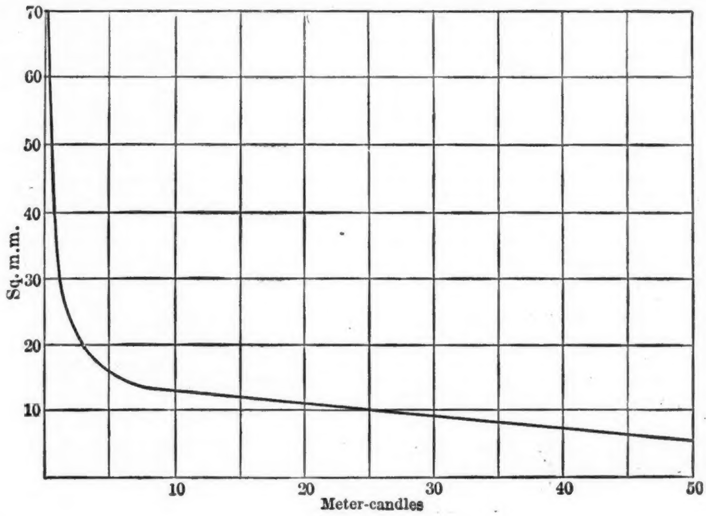


FIGURE 2.

* Graefe's 'Arch.,' 32, 171; 36, 33.

† Sitz. Akad., Berlin, 1888.

cated, the required incident illumination is

$$I=\frac{a}{k}.$$

Taking, for example, $a=15$ meter-candles, and assuming that one is observing white or very light coloured backgrounds, for which k would have a mean value in the vicinity of 0·6, the value of I should be about 25 meter-candles. If the background is dark fabric, for which k would not exceed 0.2, I would rise to 75 meter-candles, and for black fabrics one could hardly get too much light. A typical application of the principle may be taken in a draughting-room where tracing has to be done, and the drawing must be well seen through the tracing cloth. k for tracing cloth is about ·35, and the illumination which makes the drawing visible is reflected from the drawing paper behind and passed back through the tracing cloth. The drawing paper probably reflects, if slightly off white, as is common, about 60 per cent. of the incident light, and the final coefficient of the combination falls to about 0·25. Taking the same value of a as before, $I=60$ meter-candles. Ordinary draughting-rooms are found to be well lighted at this intensity. It should be noted that draughtmen generally use hard pencils, which make marks contrasting rather weakly with the paper, so that strong illumination is needed at all times.

In illumination out of doors, as upon the street, where no weak contrasts or fine details need to be made out, a may be taken very much lower, but k is also low, and the minimum of about ·25 or ·30 meter-candle often allowed between lamps is, as the curves show, considerably too small for good seeing.

Effect of Pupillary Aperture.—The iris serves as an automatic stop behind the cornea, adjusting itself so as to protect the retina from too violent changes of brilliancy. It may vary in diameter of aperture from less than 1 mm. up to the full diameter of the visible iris, which in the darkness may retreat even within the rim of the cornea, as Du Bois-Reymond* has shown. The eye therefore works over an aperture range varying from f20 or more down to f2·5 or f2. Incidentally the iris, acting as a stop behind the strongly refracting cornea, produces a certain amount of typical "pincushion distortion," which is evident in some optical illusions.

Data on the actual relation between intensity of incident light and pupillary aperture are scarce and imperfect. So much depends on the state of adaptation of the eye, individual sensitiveness, and probably also upon the intrinsic brightness of the source, that reliable values of the relation are difficult to obtain. From a reduction of Lambert's data, however, I have plotted the curve of Fig. 2, giving as abscissæ the illumination in meter-candles, and as ordinates the area of the pupil in square millimeters. The striking fact is at once in evidence that this curve, like those of Fig. 1, is rapidly becoming asymptotic in the neighbourhood of 10 meter-candles. In other words, the contraction and expansion of the iris is less to protect the eye at high intensities than to strengthen the retinal image at low intensities, even at the expense of considerably impaired definition.

* 'Centralbl. f. prakt. Augenheilkunde,' 1888.

(*To be continued.*)

Incandescent Gas Lighting.

A Word of Caution.

Mr. Thomas Newbigging read a short paper under the above title at the recent meeting of the Manchester District Institution of Gas Engineers.

He drew attention to the fact that, in spite of the value of the incandescent mantle to the gas industry, it had, for various reasons, not yet been adopted by the majority of consumers. Therefore it seemed premature to begin already to devote attention solely to the needs of the incandescent mantle, and, in consequence, immediately produce gas of lower illuminating power.

Moreover, in order to secure the most perfect results in incandescence-lighting, an increase in pressure beyond that utilized for flat-flame burners was necessary. If this point did not receive adequate attention, the consumer would inevitably be disappointed, and raise the cry of "bad gas."

The day might come when a non-illuminating gas and illumination by incandescence would become universal. But that day had not dawned yet, and any premature effort to force the adoption to these conditions might prove unfortunate for the gas industry.

The Gas World, March 7th, 1908.

Inverted Gas Lighting.

By M. C. Whitaker.

(From the *Transactions* of the Illuminating Engineering Society, Dec., 1907.)

The most important step in the improvement of illuminating devices embodying the use of the Welsbach mantle is now being made in the commercial introduction of the inverted incandescent gas lamp. Large numbers and varieties of these lamps have appeared in the American market within the last few years, and the activity shown by manufacturers and promoters of this type of lighting device must naturally suggest to the minds of those interested in gas lighting that there are some basic reasons for this development.

It is the purpose of this paper to indicate these reasons and to review the problems encountered in the development and introduction of this system of lighting. Its commercial outlook is exceedingly promising, and it behoves those interested in the use of gas illumination to familiarize themselves with the problems involved and the present trend of developments.

The primary reasons which tend to explain the interest in the inverted incandescent gas lamp may be indicated as follows:—

1. Improved efficiency and economy.
2. Better direct downward distribution of the light.
3. Superior decorative possibilities.
4. Greater durability and longer candle-power life of the mantle.
5. Units naturally adapting themselves to all conditions and uses.

In addition to these primary reasons, many minor advantages may be cited which place the inverted gas lamp on the highest plane for economical general illumination.

The accompanying tables will serve to show the comparative cost of operating the various lighting systems now in

TABLE I.

GAS.

LIGHT.	Rate per M. Cu. Ft.	Cu. Ft. per Hr.	Mean S. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.S.C.P.	
Acetylene Gas ...	$15.00	·5	12·7	$·0075	·66	16·9	Average of 20 towns. Brown's Directory, 1907. Practical Illumination, p. 97.
Open Tip Burner	1.00	5·0	21·0	·005	10·	42·0	Practical Illumination, p. 79.
Gas Arc Clear Globe... ...	1 00	18·8	228·7	·0188	10·	121·6	Welsbach Testing Laboratory.
Upright Mantle, Clear Chimney	1.00	3·7	63·0	·0037	10·	170·0	Practical Illumination, p. 82.
Inverted Mantle, Clear Chimney	1.00	3·0	54·0	·003	10·	180·0	Practical Illumination, p. 90.

TABLE I.—*Continued.*

ELECTRICITY.

LIGHT.	Rate per Kilo Watt.	Watts per Hr.	Mean S. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.S.C.P.	
Cooper Hewitt...	$.10	192	238·96	$·0192	100	124·4	Illuminating Engineer, Vol. I., p. 449.
Enclosed Arc ...	.10	600	213·0	·060	100	35·5	Practical Illumination, p. 121.
Gem, Clear Bulb	.10	125	40·7	·0125	100	32·56	Practical Illumination, p. 42.
Nernst, Clear Globe, 3-glower	.10	264	81·0	·0264	100	30·7	Practical Illumination, p. 115.
16 C. P. Edison	.10	55	13·2	·0055	100	24·0	Practical Illumination, p. 26.

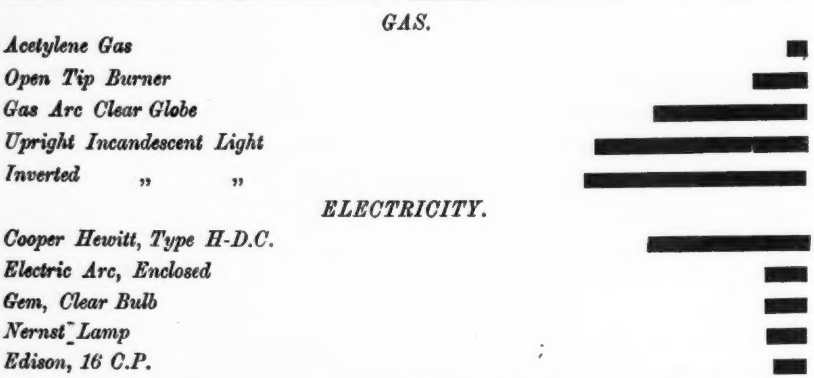


DIAGRAM SHOWING COMPARATIVE AMOUNTS OF CANDLE-POWER HOURS OBTAINED FOR ONE CENT; SPHERICAL READINGS.

common use for indoor illumination. The candle-power and consumption figures quoted in these tables are taken from actual tests made by expert observers and quoted from standard authorities. The rates are based upon the average quoted prices in our largest cities.

The full meaning of the figures given in the table may be made clearer by reference to the diagram, which represents the comparative amount of candle-power obtained for 1 cent. cost for the different systems of lighting.

Table I. is based upon the mean spherical candle-power obtained by taking the average of the candle-power readings at points ten degrees apart in a vertical plane through the centre of illumination. (See Fig. 1.) This comparison shows a larger candle-power yield per unit of cost for the inverted incandescent gas lamp; but calculations based upon the spherical candle-power are very misleading, and a further study of the direction of distribution is interesting.

Inasmuch as the source of illumination in the standard installations is usually overhead, it is apparent that the light distributed above the horizontal plane through the source is largely wasted, unless some medium of reflection be installed to divert the light into the lower portion of the room. It, therefore, follows that a source of light which gives its main distribution below the horizontal plane, without the necessity of using a reflector, occupies a position of great advantage and economy.

serve the purpose for which they are intended without loss. It seems fair, therefore, in considering the value of a source of light for illuminating purposes, that the factor of lower hemispherical candle-power, rather than the total spherical candle-power, should be regarded as of principal importance.

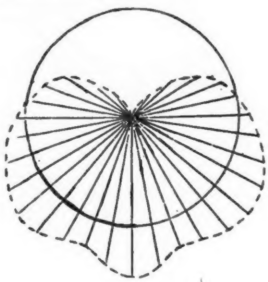


FIG. 1.

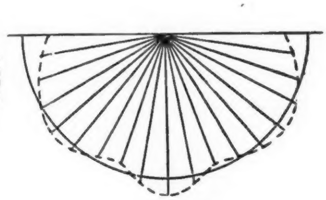


FIG. 2.

Where the greater percentage of direct light falls above the horizontal plane it is necessary to use reflectors to divert it into the lower portion of the room. Its reflection cannot be accomplished without a certain loss—this loss depending entirely upon the efficiency of the reflecting medium. On the other hand, the direct rays of light naturally distributed in the field below the horizontal plane

Table II., with its accompanying diagrams, shows the comparative amount of light obtained for 1 cent., based on readings of the lower hemispherical candle-power. (See Fig. 2.) The tests are based upon burner equipments without any reflecting glassware, it being assumed that a reflector can be used with equally effective results in any or all of the cases cited.

TABLE II.

GAS.

LIGHT.	Rate per M. Cu. Ft.	Cu. Ft. per Hr.	Mean L. H. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.L.H.C.P.	
Acetylene Gas ...	$15.00	·5	11·6	$·0075	6·66	15·5	Average of 20 towns. Brown's Directory, 1907. Practical Illumination, p. 97.
Open Tip Burner	1.00	5·0	20·0	·005	10·	40·0	Practical Illumination, p. 79.
Gas Arc, Clear Globe ...	.100	18·7	244·0	·0188	10·	129·8	Welsbach Testing Laboratory.
Upright Mantle, Clear Chimney	.100	3·7	51·27	·0037	10·	138·5	Practical Illumination, p. 82.
Inverted Mantle, Clear Chimney	.100	3·0	70·6	·003	10·	235·33	Practical Illumination p. 90.

TABLE II.—*Continued.*

ELECTRICITY.

LIGHT.	Rate per per Kilo Watt.	Watts per Hr.	Mean L. H. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.L.H.C.P.	
Cooper Hewitt ...	$.10	192	238·96	$·0192	100	124·4	Illuminating Engineer, Vol. I., p. 449.
Enclosed Arc ...	.10	600	329·05	·060	100	54 84	Practical Illumination, p. 121.
Gem, Clear Bulb	.10	125	36·96	·0125	100	29·56	Practical Illumination, p. 42.
Nernst, Clear Globe, 3-glower	.10	264	144·26	·0264	100	54·6	Practical Illumination, p. 115.
16 C. P. Edison	.10	55	11·68	·0055	100	21·78	Practical Illumination, p. 26.

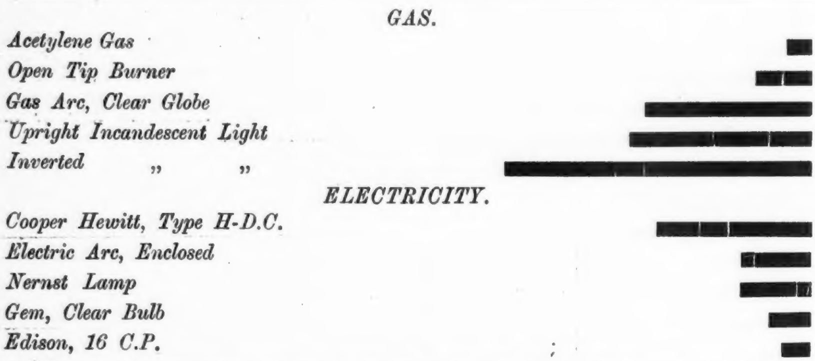


DIAGRAM SHOWING COMPARATIVE AMOUNTS OF CANDLE-POWER HOURS OBTAINED FOR ONE CENT; LOWER HEMISPHERICAL READINGS.

It will be noted from Table II. that an enormous advantage obtains in favour of the inverted incandescent gas lamp. Considering the various lighting systems now in use with special reference to production of illumination at minimum cost this advantage is so pronounced that it cannot be overlooked. This fact alone offers a very convincing reason for the prevailing interest and activity in the development and application of the inverted system of incandescent gas lighting.

The inverted gas lamp combines useful illumination with artistic and decorative effects not attainable in any other system. The lighting unit is of such a size that its direct downward distribution meets the requirements of ordinary illumination while the light distributed in the upper hemisphere is available for utilization in producing beautiful and decorative colour effects with various designs of globes and shades. Chandeliers, brackets, pendants, and dining-room fixtures, especially designed in both metal and glass equipment, have been provided in infinite variety to meet the favourable decorative possibilities offered by inverted lamps.

The inverted gas lamp naturally gives a free downward distribution of light, with a resultant illuminating effect which cannot be obtained by the upright incandescent system, from the fact that the greater portion of the candle-power yield of the upright burner is in the upper hemisphere, thus necessitating the use of reflecting shades more or less inefficient in operation. Moreover, notwithstanding the use of these reflectors, it is not possible to overcome entirely the loss due to shadows caused by interposition of the metal parts of the burner, chandelier, &c., directly in the path of the downward distribution of the light.

The inverted lamp has no structural parts interposed in the path of illumination; without the use of reflectors, it gives the greater percentage of its candle-power distribution directly into the portion of the room which requires illumination; and from these essential features it follows that by the use of special reflectors, designed for concentrating and directing the rays of light, results embodying unusually high economy may be obtained.

Mantle renewals of the inverted lamp must be considered a factor in estimating the cost of operation. Whether or not this is a greater factor than the various renewal items entering into the maintenance of the other forms of illuminating devices does not appear from any figures available. The experience so far obtained is that renewal cost for mantles for the inverted lamp is very materially less than for the upright burner. The construction and size of the mantle is such as to give it a greater physical strength.

Several designs of mantles are now in use, and, unfortunately, there are several standard fittings for attaching these mantles to the burner. The best quality mantles are mounted on magnesia rings with projecting fingers to hold the mantle in position on the burner. Metal rings have been used to some extent, but have not proved desirable on account of the corrosive action of the flame.

A lighting unit furnishing from 50 to 100 candle-power is found by experience to be better suited for general use than the smaller units, as furnished by individual incandescent electric lamps, or the larger units, as furnished by arc lamps. In gas lighting the demand for larger units is met by cluster lamps, but for lighting machines, office desks, reading tables, residences, &c., a unit of less than 50 candle-power would not be sufficient to meet general requirements.

The development of the inverted incandescent gas lamp divides itself into two distinct epochs.

The first inverted incandescent lamps were made by Clamond and exhibited in 1882–3 at the Crystal Palace Exposition in Paris. Considerable activity was subsequently shown by inventors, and numerous forms were exploited without commercial success. This was prior to the successful development of the thorium-cerium mantle by Dr. Auer, and the incandescing devices used in these early lamps were in the form of magnesia baskets, platinum cones, &c. Furthermore, the burners used in these demonstrations were successful only when compressed air or compressed gas, or both, were utilized. Their construction at that time did not overcome the problem of producing combustion with the burner inverted, except by the use of an abnormal pressure. With the advent of the Welsbach upright mantle, this line of research was abandoned, and no developments of any consequence were made for eight years.

The interest in the inverted incandescent gas light was renewed by the development of a burner for the utilization of a thorium-cerium mantle, which was shown abroad about 1900. These inverted lamps did not meet with marked commercial application in this country, because their designers failed to take into account the principles which modern inverted burner builders recognize as basic.

The early burners served, however, to acquaint illuminating engineers with the many points of superiority to be obtained by the use of the inverted light, and experimental activity was greatly increased, with a view to overcoming the many difficult problems in design, construction, and operation in this type of lamp.

(*To be continued.*)

The Luminous Properties of Conducting Helium.

By P. G. Nutting.

(Bull. Bureau of Standards, abstracted *Elec. World*, Feb. 22, 1908.)

The author describes some experiments having for their object the testing of the qualities of luminescent helium gas as a standard of light. Luminescent gases represent extremely efficient sources of light, and attention has recently been drawn to the possibility of reproducing the exact conditions under which such a gas yields a certain definite candle-power very closely, and hence also the possibility of producing a standard of light by this means.

Conducting helium emits a yellowish-white light, which is very convenient for photometric comparisons with glow-lamps. Carbon dioxide yields a much whiter light, but decomposes and disappears very rapidly, even with moderate current-densities.

In this connexion it is interesting to observe that Mr. Moore recently advocated the use of the carbon-dioxide Moore tube, as a standard, both on the grounds of its being easily reproduceable, and yielding a spectrum closely resembling that of daylight. (See Discussion of paper by C. E. Stickney, reprinted in The Illuminating Engineer for February, p. 161.)

Sulphur vapour emits a bluish-white light, but its density is difficult to measure and control. Helium, however, is easily controlled, and has the advantage of not becoming decomposed and disappearing rapidly, as the other gases do when carrying a relatively heavy current. Thus the life of a helium tube is about fifty hours, as compared with half an hour on the part of similar tubes filled with hydrogen and nitrogen.

The author next proceeds to describe the precautions which are needful in preparing tubes of helium for standard purposes. Naturally a mercury pump cannot be used for the purpose of exhausting the tube, on account of contamination by mercury vapour, and special measures are necessary to get rid of all traces of hydrogen and other impurities. The tubes utilized have been about 1-3 mm. in diameter and 10-50 mm. long, and were supplied with current from a 5,000 volt transformer. The intensity of the light produced was compared with that of a small 4 volt glow-lamp, by means of Lummer-Brodhun photometer, and the probable errors of observation are estimated at under 1 per cent.

The general nature of the variation in candle-power of the tube with current is shown in Fig. 1, while the corresponding fall in potential is shown in Fig. 2. In this connexion it may be mentioned

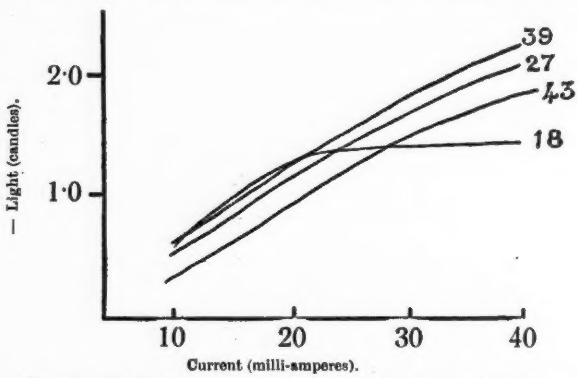


Fig. 1.—Variation of Light with Current in Different Tubes.

that a variation of 5-10 per cent. in the fall of P.D. could be produced by directing a flame or blast of cold air on the tube: the diminution, however, did not cause a corresponding change in the light emitted, as long as the current was kept constant.

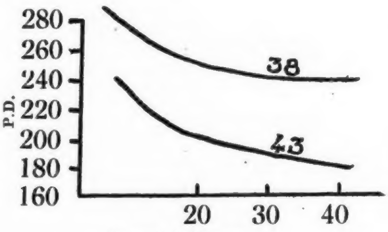


FIG. 2.—Variation of P.D. with Current in Different Tubes.

The luminous efficiency of helium is a maximum for a current density of about 6 milli-amperes per square millimetre; it is, in any case, exceptionally low for a gas, owing to the presence of three strong infra-red lines in the spectrum at 728, 1,117, and 2,040 $\mu\mu$, representing, at least, 90 per cent. of the total energy, and yet adding nothing to the luminous output of the gas.

The effect of gaseous-pressure upon the light from the tube is shown in Fig. 3. It will be seen that in the case of the 2 millimetre tube, the light is very slightly affected by a wide range of pressure.

Reference may also be made to the possible influence on the light of the tube of the variety of current utilized. The results of some experiments on this point are shown in the table below.

It is very interesting to observe that the light seems to vary only with the current, and to be practically independent of the nature of the discharge.

The effect of another factor influencing the result, namely, the bore of the tube, is shown below.

It will be seen that the relation between diameter of tube and light emitted is practically a linear one, as was found to be approximately the case for the other important influential factor, the current (see Fig. 1).

In order to test the possibility of reproducing tubes giving as near as possible exactly the same candle-power, a set of six duplicate tubes were prepared. As a result the greatest deviation from the mean was only 1 per cent., while the average is probably under $\frac{1}{3}$ per cent.

Many other tests were carried out with a view to testing the reproducability of the standard. Thus, after a long series of experiments with varying currents and positions of the tube, the initial conditions would be restored, and in every case identical results were obtained. In a few instances an apparent discrepancy was observed, but this invariably proved to be due to some obvious defect, such as a crack in the glass, &c.

These experiments may therefore be said to be distinctly favourable to the use of the helium tube as a standard.

EFFECT ON LIGHT EMITTED OF CHANGING THE NATURE OF THE CURRENT.

Nature of Current.	Light Emitted.	
	22·5 milli-amperes.	23·7 milli-amperes.
Direct, 1,000 volts	1·21	1·30
Alt., 60 cycles, 2,000 volts ...	1·22	1·28
,, 60 ,, , 5,000 ,, ...	1·22	1·29
,, 900 ,, , 5,000 ,, ...	1·21	1·29

EFFECT OF BORE OF TUBE ON LIGHT EMITTED.

Diameter of Tube mm.	1·029	1·949	2·168	3·120
M.H.C.P., per cm. of tube at 25 milli-amperes	0·365	0·325	0·311	0·259

In this connexion the three chief points requiring further investigation are :—

1. Differences between separate determinations of the same observer on the same tube. These are probably not serious, and of the same order as uncertainties occurring in ordinary work.

2. Uncertainties due to using different tubes. Reproducability will require further investigation with tubes of different diameter and composed of different kinds of glass. Experiments so far suggest that this uncertainty will not be serious.

3. Uncertainties due to varying the observer, on account of colour-difficulties. These are, perhaps, the most serious, and will require careful study by many different observers.

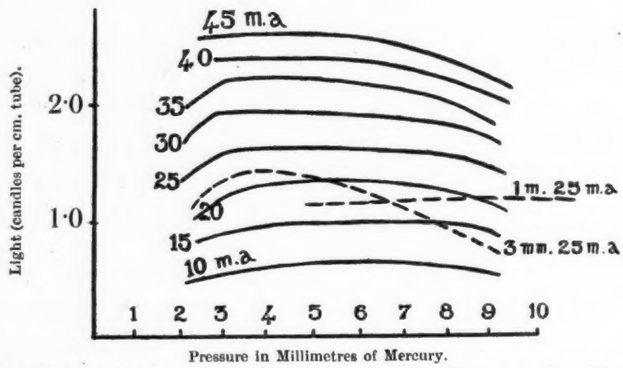


Fig. 3.—Variation of Light with Gas Pressure at Different Currents. The full line curves refer to a 2 mm. tube.

The Metallic Filament Lamps and the Arc Lamp.

The Electrical World has recently remarked upon one especially interesting aspect of the metallic lamp situation, which has doubtless also occurred to many of those connected with the electric lighting industry.

It seems likely that the usefulness of the ordinary carbon arc lamp will be considerably reduced by the advent of metallic filament lamps of high candle-power, running at an efficiency of only 1 watt per candle-power. The arc lamp has previously found favour partly on account of its high efficiency, but also on account of its value in cases where a high candle-power is desirable. Previous to the introduction of metallic filament lamps, the necessity for some source of light intermediate between the arc lamp and the ordinary carbon filament glow-lamp had led to the design of miniature arc lamps of various patterns; but with the advent of the metallic filament lamp the necessity for such lamps may be said to have very greatly diminished, except in cases where a very high concentrated candle-power is essential, and where a very large area is to be illuminated. Under these conditions the great brilliancy and efficiency of the flame lamp may enable it to hold its own. We gather, however, from *The Electrical World* that the flame arc has not come into very general use for street illumination in the United States, its use being chiefly restricted to purposes of advertisement, bill-board illumination, and so forth.

REVIEWS OF BOOKS.

DIE BELEUCHTUNGSARTEN DER GEGENWART.

By Dr. W. Brüsch.

(*B. G. Teubner, Leipzig.*)

This little book deals briefly with all kinds of illuminants, gas, electricity, oil, acetylene, &c., in a popular manner. In the 161 small pages at his disposal the author is naturally constrained to treat the subject in a very condensed manner, but, nevertheless, manages to impart a considerable amount of useful information, which will doubtless be of value to those requiring a brief summary of the subject. He, however, confines himself mainly to the actual processes and apparatus for the production of light without attempting to enter deeply into its utilization. Thus the book deals with illuminants rather than illumination, though the first chapter touches upon the principles of light-measurement.

The author is aided in his task by a liberal use of illustrations.

DIE ELEKTRISCHEN KOHLENFÄDENLAMPEN, IHRE HERSTELLUNG UND PRUFUNG.

By Heinrich Weber.

(*Max Janecke, Hannover, Germany.*)

Though the author of this book deals mainly with the carbon filament lamps, much of the information conveyed therein is of general application to lamp-manufacture, and will be read with interest at the present time, when the properties of metallic filament glow lamps have come to be regarded as of paramount importance.

He traces the gradual development of the entire lamp, and describes many processes, the details of which have hitherto not been generally known, the text being accompanied by many excellent photographs and illustrations.

There is no doubt that Dr. Weber's practical acquaintance with the subject enables him to deal with the matter with unusual explicitness, and we feel sure that his book will be found of value by those interested in glow-lamp manufacture.

THE MODERN GLOW-LAMPS FROM THE CONTRACTOR'S STANDPOINT.

At a meeting of the London section of the Contractors' Association, held at Frascati's Restaurant on Friday, March 12th, Mr. Leon Gaster dealt with the new metallic and other glow-lamps from the contractor's point of view. He referred to the value of standard specification for making of glow-lamps in enabling the contractor to readily recognize those which were not satisfactory. He also described the recent progress in the manufacture of metallic filament lamps and their advantages and drawbacks, urging the contractor to exercise caution in considering the exact circumstances under which they were of value, and to refrain from recommending them indiscriminately.

The exceptionally full attendance at this meeting and the discussion which followed, showed that contractors are fully alive to the importance of the subject.

THE REPORT OF THE NATIONAL PHYSICAL LABORATORY.

The report of the National Physical Laboratory for the past year has now been issued. During the last year a number of investigations, designed to trace the small variations existing between different pentane lamps, were carried out. Many tests on glow lamps were also undertaken in co-operation with the Engineering Standards Committee.

In July Mr. Patterson represented the Laboratory at the International Photometrical Commission at Zürich. As a result of the meeting of the Commission the important relations existing between the Hefner, the Vernon-Harcourt, and the Carcel standards of light were definitely determined.

It is now proposed to establish a set of sub-standards intended for use in testing metallic filament lamps, which will be run at 2·8 and 2 watts per candle. It is also hoped that investigations into the Violle standard will be carried out in accordance with the recommendation of the International Commission.

CORRESPONDENCE.

International Photometrical Nomenclature.

Sehr verehter Herr Gaster,—Die Ausfuhrungen von Herrn Laporte auf Seite 253 sind insofern ein wertvoller Beitrag zu meiner Arbeit über 'Die Unzuträglichkeit der gegenwärtigen internationalen Bezeichungsweise fur Beleuchtungswerte,' als sie gezeigt haben, dass es heute ein französisches Lux und ein deutsches Lux gibt. Es gab auch, wie ich erwähnte, ein englisches Lux, das von Preece, das aber ganz aus dem Gebrauch gekommen ist. Meine Anregungen, die Einheit der Beleuchtung auf eine Internationale Basis zu erheben sind also um so notwendiger geworden.

Die strikte Befolgung der Beschlüsse des Genfes Kongresses von 1896 liess nicht direkt, wie Herr Laporte es angibt, ein französisches und ein deutsches Lux entstehen. Denn damals im Jahr 1896 war als Name der Lichteinheit zwar die bougie decimale (definiert als $\frac{1}{20}$ Violle) angenommen worden, da "bougie decimale" jedoch nur ein Wort und keine reelle Lichtquelle ist, war in Genf 1896 beschlossen worden, die bougie decimale "vorlaufig praktisch durch die Hefner-lampe darzustellen." Man war nach dem Stande der Messungen von 1896 Beziehung ausgegangen, dass die Lichtstärke der bougie decimale und die der Hefnerlampe auf 2 % ubereinstimmen (1 H.K. = 1,02 bougies dec.), eine für die praktische Photometrie gewiss genügende Genauigkeit.

Erst später war es Herr Laporte, der nachwies, auf Grund der neugefundenen Beziehung :—

1 Carcel = 10,9 H.K.

und der früheren als feststehend von Violle ubernommenen Beziehung :—

1 Carcel = 9,6 bougies dec.

dass ein Hefnerkerze nicht mehr gleich 1,02 bougies dec. ist, sondern dass :—

1 H.K. = 0,885 bougie dec. also eine Abweichung von 11,5 % gegen früher.

Dear Mr. Gaster,—The remarks of M. Laporte on page 253 constitute a valuable addition to my article on 'The Incongruities of the Present International System of Denoting Values of Intensity of Illumination,' in so far as they make it clear that today both a French and German Lux exist.

At one time, as I mentioned, there was also an English Lux—that suggested by Mr. Preece (now Sir W. Preece,—but this term has fallen completely into disuse.

The establishment of the unit of intensity of illumination on an international basis, which I have advocated, is therefore all the more essential.

But the simultaneous existence of a French and German Lux is not, as M. Laporte suggests, a direct consequence of the decisions of the Geneva Congress of 1896. In that year the "Bougie decimale" (defined as $\frac{1}{20}$ of the violle) was indeed adopted as the name of a unit of light, but as this term only represented a value and not an actual source of light, it was also decided "that a bougie decimale" should "meantime be defined practically in terms of the Hefner lamp."

Owing to the state of photometrical measurements in 1896, people were under the impression that the intensity of the bougie decimale and the Hefner lamp agreed within 2 % (1 H.K. = 1·02 bougies decimales)—an exactitude which certainly suffices in practical photometry.

It was only afterwards that M. Laporte pointed out that, on the basis of the newly determined relation :—

1 Carcel = 10·9 H.K.

and the relation previously adopted as derived from the Violle standard :—

1 Carcel = 9·6 bougies decimales,

one Hefnerkerze could no longer be assumed to be 1·02 bougies, but that

Nachdem nun durch die Internationale Lichtmesskommission im Juli 1907 festgesetzt worden war, dass fernerhin 1 carcel nicht mehr 10,9 H.K. sondern nur 10,75 H.K. ist, ergibt sich der Wert,

1 H.K. = 0,895 bougies dec. der heute gültige Wert, den Herr Laporte auch auf Seite 254 angibt.

Der Entwicklungsgang des französischen und deutschen Lux ist also der, dass beide im Jahre 1896 zur Zeit der Genfer Beschlüsse praktisch gleich sind.

1896 1 deutsches Lux = 1,02 Französisches Lux (Fehler 2 %).

1907 1 deutsches Lux = 0,895 Französisches Lux (Fehler 10,5 %).

In dem letzten Absatz des Briefes von Herrn Laporte auf Seite 254 möchte ich bemerken, dass die praktische Gleichheit der bougie decimale, der 1 Kerzen Pentanlampe, und der spermaceti candle für die Beleuchtungsmessungen, auf die sich lediglich meine Ausfuhrungen bezogen, nicht so sehr eine " glücklicher Vereinfachung in jeder Hinsicht " bedeuten, so lange England und Amerika in die Beleuchtungsberechnungen nicht das meter, sondern den foot einfuhren. Und die Angaben in " candle-feet " oder " foot-candles " sind in englischen Arbeiten uberwiegend.

Mit vorzüglicher Hochachtung Ihr sehr ergebener,

DR. BERTHOLD MONASCH,

Oberingenieur der allgemeinen Elektrizitäts Gesellschaft, Berlin.

1 H.K. = 0·885 bougie dec., *i.e.*, a deviation of 11·5 % as compared with the former value.

After the decision of the International Photometrical Commission of July, 1907, that 1 Carcel must be taken not as 10.7, but as 10·75 H.K., this relation becomes—

1 H.K. = 0·895 bougie dec., the value which must be regarded as correct at the present time, and which M. Laporte quotes on page 254.

The development of the French and German values of the Lux thus arose from the fact that in 1896, at the time of the Geneva Congress, the two were regarded as practically identical.

In 1896 1 German Lux = 1·02 French Lux (Error 2 %).

In 1907 1 German Lux = 0·895 French Lux (Error 10·5 %).

With reference to the last paragraph in M. Laporte's letter on page 254, it may be remarked that the practical equality of the bougie decimale, the 1 c.-p. (Pentane lamp), and the spermaceti candle, on which my whole contentions are based, cannot be regarded as a " fortunate simplification in every respect " as long as England and America continue to use the foot and not the metre in measurements of illumination ; such expressions as " candle-feet " and " foot-candles " certainly predominate in English literature on the subject. I am,

Yours very sincerely,

DR. BERTHOLD MONASCH,

Chief Engineer of the General Electric Company, Berlin.

The Thermopile in Practical Photometry.

SEHR GEEHRTER HERR,—Für das gefl. Schreiben vom 6. d. M. so wie für die liebenswürdige Ubersendung des 3ten Heftes des *Illuminating Engineer* sage ich Ihnen meinen besten Dank.

Ihre Bemerkungen zur meiner Arbeit auf S. 179 habe ich mit grossem Interesse gelesen und stimme Ihnen darin vollkommen bei, dass bei der Verwendung der Thermosaule zur photometrischen Zwecken ein gewisses Mass von optischen und strahlungs-

DEAR SIR,—I beg to thank you for your letter of March 6th, and also for kindly sending me the third number of *The Illuminating Engineer.*

I have read with interest your remarks on my work on p. 179, and quite agree that, when applying the thermopile to photometrical purposes, a certain knowledge of optics and the theory of radiation is necessary ; but I also believe that this is particularly desirable in the case of the photometry of arc lamps.

theoretischen Kenntnissen vorhanden sein muss, glaube aber dass man dies bei der Photometrie von Bogenlampen um vor allen Umstanden verlangen muss.

Für übrigen ist wohl zu unterscheiden zwischen der Anwendung meiner Methode bei el. Glühlampen, Gasglühlicht, und ähnlichen auf der einem und bei Bogenlampen insbesonders Flammenbogenlampen auf der anderen Seite. Bei el. Glühlampen muss die Untersuchung mit der Thermosaule immer richtige Resultate geben, wenn man nur den Abstand von Thermosaule und Lampe gross genug wählt. Und dies kann man immer, weil hier uns ein dunnes Glas vor der Thermosaule erforderlich ist, welches die dunklen von den ausseren Teilen der Lampe ausgesendeten Wirkungwahlen zuruckhalt. Bei diesen Lampen ist das Enthaltens vom Licht zur Gesamtstralung konstant; die Energiekurve entspricht also genau der Lichtkurve. Bei Bogenlampen ist wie gesagt eine gewisse Vorsicht am Platze. Jedenfalls kann man sich aber auch hier die Arbeit wesentlich erleichtern, auch wenn man jeder Kontrolle die optische Messung unter 2 bis 3 verschiedenen Winkeln ausfuhrt.

Bemerken möchte ich bei dieser Gelegenheit, dass bei der Prüfung von Bogenlampen mit Glocken, Sammeltrichter der Thermosaule eine so weite Offnung besitzen muss, dass dieser offenungswinkel die gesamt Lampenglocke umfasst, da in diesem Falle die ganze Glocke an der Beleuchtung einer Flachenelementes teilnimmt.

Besonders wertvoll und einwandfrei scheint auch mir das Verfahren zur Aufsuchung der Lichtschwankungen der Bogenlampen, da eine Methode diese ungemein wichtige Eigenschaft der Lampen zu prüfen bisher nicht existiert.

Mit vorzuglicher Hochachtung,

Dr. W. Voege.

It is necessary to distinguish between the application of my method to such sources as glow-lamps, incandescent mantles, &c., on the one hand, and arc lamps—and especially flame arc lamps—on the other. In the case of glow-lamps experiments with the thermopile must always give correct results, if only a sufficiently great distance is selected between the thermopile and the lamp. This is rendered possible by the use of the requisite thin sheet of glass, which is placed in front of the face of the thermopile, and retains the "dark" invisible radiation from the lamp. In the case of this lamp the relation between the luminous and total energy of radiation is constant; hence the polar curve of energy exactly corresponds to the curve of distribution of light. But, in any case, the work can be considerably simplified by checking the results, at several angles, by means of optical measurements.

I may take this opportunity of remarking that in testing glow-lamps surrounded by globes, the angle of entrance of the collecting apparatus attached to the thermopile should include the entire radiating surface of the source, for in such a case the whole globe contributes to the illumination of a surface-element.

The apparatus seems to me especially useful and free from objection when applied to the study of the fluctuation in light from arc lamps, for there has previously been no satisfactory method of testing this exceedingly important quality. I am,

Yours very sincerely,

Dr. W. Voege.

Review of the Technical Press.

ILLUMINATION.

SOME papers of exceptional interest have again been read before the Illuminating Engineering Society in the United States on questions connected with the architect's view of illumination, and the æsthetic aspects of the problem generally.

That by Mr. Elliott, which comes as an interesting contrast to the previous paper by Mr. Basset Jones, deals with the feeling of the engineer for these aspects. He realizes that there is much in the illumination of a building which cannot be satisfied by mere good illumination from the purely utilitarian aspect of a certain general illumination of so many candle-feet. On the other hand he raises the question how far, after all, architects are justified in imposing conditions mainly associated with the architecture of the past, which naturally came into being when science and illumination were in a very different state from what they are now. Strictly speaking the conditions of the present scientific age have yet to evolve an architecture of their own, and it seems rather arbitrary on the architect's part to insist on imitating the dim illumination and ancient sources of light of the past ages. In certain cases where religious and historical associations are of paramount importance this may be desirable; but this is by no means invariably the case.

Another interesting contribution was that of Mr. G. L. Hunter, who dealt with light and colour in decoration. One point specially emphasized by him was that light which is allowed to fall on the walls and ceilings of a room is frequently very far from being wasted. As a rule it is bad policy to concentrate all the light upon the reading table and allow the rest of the room to remain in obscurity, for the eyes are troubled by the constant changing from light to darkness and their consequent efforts after accommodation. But apart from this, we must also remember that the walls of a building may themselves possess a certain decorative value, and are therefore deserving of illumination in order to show off their attractive qualities. Indeed, artificial light, wisely used, enables us to do this more effectually than by daylight, being more under control.

Mr. Hunter also dealt with the effects of various types of diffusing and coloured shades, and supplied a number of hints regarding their tasteful and effective use for decorative purposes.

Mr. W. H. Y. Webber contributes a few remarks on the subject of the comparison of lighting effects in street-illumination. He refers briefly to the part played by the polar curve of distribution of a source in affecting the evenness of illumination secured from it, and also alludes to the difficulty of adequately gauging the usefulness of this illumination by the existing methods of testing. A considerable amount of discussion has been recently raging round this point in the technical press, chiefly referring to the question of whether or no the illumination should be measured in a horizontal plane. Mr. Webber emphasizes the view that in any case mere measurements of "candle-feet" can only be regarded as an index, and by no means finally settle the question of whether the illumination is all that can be desired.

An article in the *Elektrotechnischer Anzeiger* (March 12th) discusses the relative merits of direct and indirect illumination. The main advantages of both methods are summarized, and a numerical example is given. The writer concludes that indirect illumination may answer best in cases in which the height of the room is not more than 4 metres; otherwise direct illumination is preferable.

Several exceptionally interesting reports of commissions have recently been published, notably those referring to lighthouse administration and the future work of the National Physical Laboratory.

The former deals mainly with the question of whether or no it is desirable to amalgamate or refer to a single central authority the separate authorities at present responsible for the coast-illumination of England and Wales, Scotland and Ireland. Apart from the main object of the inquiry, the evidence given before the commission serves to illustrate the wideness of the problems occurring in lighthouse illumination. A coast-light may have many and various functions to perform—may, for instance, be merely intended to be seen a great way off or may actually serve to illuminate the waterway or entrance to harbours, &c. In each case distinct qualities and a different order of brilliancy on the part of the illuminants may be required. Again, the whole question of the system of rating the illuminating power of these lights calls for careful study, and there seems to be some confusion about the point at present.

The report on the National Physical Laboratory is concerned primarily with the exact variety of work which the institution may be encouraged to carry out without entering into competition with private testing concerns.

Much of the evidence given before the commission relates to the desirability of adopting standard methods of rating glow lamps, it being suggested that such tests should be carried out at the National Physical Laboratory. The important nature of the work of the Laboratory relating to the preservation of standards of light, &c., renders the question under discussion of special import. The report of the Laboratory is also available and contains a record of the photometrical work of the past year. The suggested programme for the early part of the present year is also touched upon, and includes experiments with the Violle standard in accordance with the recommendations of the International Photometrical Commission at Zürich of last July. The report also contains an illustrated description of some of the photometric arrangements at the laboratory.

Paulus (*E.T.Z.*, Feb. 20th) describes the efficiency meter of Hyde and Brooks and also the watt photometer of the Everett and Edgcumbe type. He also gives the results of some of his own tests on the latter, in which the actual readings on the instrument are compared with the actual values of the illumination tested by "precision photometry."

P. G. Nutting (Bull. Bureau of Standards, *Elec. World*) describes some experiments designed to test the value of tubes containing helium gas, as standards of light. His experiments include investigation into the relation between current-density and light, the effect of internal pressure, diameter of tube, &c. As a result it seems to have been found that such tubes possess great possibilities as standards, for the conditions under which the gas is stimulated electrically and caused to give out light can be reproduced with great exactness. Therefore the tubes might serve as a standard of reference, though their life is at present only about 50 hours or so. The colour of the light yielded by the Helium-tube is yellowish-white in character which renders it very convenient for comparison with glow lamps, &c.

Electric Lighting.

A paper of great scientific interest was recently read by Dr. Karl Sartori in Vienna (*Elektrot. u. Masch.*, March 22nd) which discussed the oft-raised question as to how far the better efficiency of the metallic filament lamps can be ascribed to higher temperature — whether, indeed, the temperature of the carbon lamps is actually higher than that of the metallic filament lamp at all.

Dr. Sartori prefaced the subject proper of his paper by a general description of the nature of solid radiation. In particular he drew attention to the fact that the eye is most sensitive to the yellow-green region of the spectrum lying between the D and E lines, and that this seems to be a natural consequence of the fact that the energy maximum of sunlight, rightly studied, proves to occur in this region also. We must, therefore, try to increase the temperature of radiation of our sources of light so as to bring the energy-maximum nearer to this point. Actually to reach this point would require a temperature of approximately 6,000 degrees. In the case of glow lamps we are naturally unable to improve the efficiency by adding a linear spectrum, for this variety of luminous radiation is not characteristic of incandescing solids.

In general the energy maximum of a solid incandescent body which can be regarded as "black" can be predicted when once we know the temperature of incandescence by means of the law of Wien. This states that, $\lambda_m \times T = \text{Constant.}$, where λ_m is the wave length corresponding to the position of the energy maximum and T the absolute temperature of incandescence. It is, however, possible for a solid body to deviate from the black-body law and prefer to radiate certain kinds of energy. In that case it is said to exercise "selective radiation" and does not obey the law of Wien. Thus it is possible for the temperature of a filament to be lower than the position of its energy maximum would suggest.

Dr. Sartori then goes on to describe some experiments of his own on this point. He studied the position of the energy maximum of the grating spectra both of a metallic filament lamp running at 1 watt per c.-p. and a carbon filament lamp taking 3·5 watts per c.-p., and found that the maximum was situated nearer the violet end of the spectrum in the case of the carbon lamp. This would lead one to suppose that the temperature of the latter was the higher in spite of its lower efficiency.

Much difference of opinion on this point evidently still exists. Prof. Grau mentioned that Dr. Lummer had estimated the temperature of the carbon lamp to be about 2,100 degrees Centigrade, but actually bolometric measurements of Pringsheim and Kurlbaum had placed the value nearer 1,600 to 1,800 degrees Centigrade, and the law of Wien probably does not rigidly hold. Nevertheless it is still generally supposed that the higher efficiency of the metallic filament lamp is merely ascribable to higher temperature: there are, however, others who have been led to the same result as Dr. Sartori. Drs. Blau and Lombardi, for instance, assigned a temperature of about 1,460 degrees Centigrade to the Osmium lamp.

An informal address on the subject of incandescent lamps was also recently delivered to the Electrical Contractors' Association in London by Mr. Leon Gaster. He discussed the merits and disadvantages of the new lamps, and described the recent progress in their manufacture. The value of small step-down transformers at the supply mains also came in for mention, Mr. Gaster urging the contractors to consider each case brought before them on its merits, and not to run any risk of doing harm to the industry by recommending the metallic filament lamps indiscriminately. Small transformers for metallic filament lamps also form the subject of a recent article in *Electrical Engineering*, a number of the chief makes being described with illustrations.

A very complete history of recent progress in all the details of glow-lamp manufacture occurs in recent numbers of the *Zeitschrift für Beleuchtungswesen* (Feb. 29th, March 10th and 20th); references to the most important patents on the subject are given.

A new form of enclosed flame arc lamp has recently been brought out in England by the Jandus Arc Lamp Co. One of the chief points in the lamp is the specially designed system of ventilation, by means of which, it is claimed, the deposition of fumes on the interior of the globe mechanism is entirely avoided.

Auerbacher (*Electrical World*, Feb. 29th) contributes a short note on the lighting of Berlin. It is stated that the ordinary carbon filament lamp has practically disappeared, and that nearly all the commercial lighting of the city is carried out by means of flame-arc lamps. Some firms make a speciality of attending to the maintenance of these lamps for customers, and, as many blocks employ 50 or more arcs in all, the business is worth cultivating. An editorial on the same subject suggests that the ordinary arc lamp is bound to give way to the high candle-power metallic filament glow-lamps in the United States, though flame-arcs may be retained where high candle-power is very essential.

Gas, Oil, and Acetylene Lighting.

Mention may next be made of some recent lectures by Prof. Vivian Lewes. The first of these dealt with the theory of the incandescent mantle (see *J.G.L.*, March 3rd). The lecturer summarized the history of the incandescent mantle in a popular manner, prefacing his lecture with a few remarks on the development of gas-burners in general, as illustrated by the work of Wenham, Sugg, and others. Naturally the possibility of the incandescent mantle demanded a convenient form of high-temperature flame, and no progress could be made until the arrival of the Bunsen burner about 1852. Previously a genuine incandescent light had existed in the limelight, which dates from 1826. A basket of magnesium rods, rendered incandescent in the bunsen flame was brought out in 1882, but nothing great was done until the eventual solution of the difficulties of the mantle by Welsbach's mixture of 1 per cent. of cerium with 99 per cent. of thorium.

It is, however, still a mystery exactly why this particular proportion of these two substances should be essential. The lecturer mentioned a few of the various theories still in the field—the catalytic theory, the theory of luminescence, &c. One fact against the theory of high temperature pure and simple was the fact that the mantle would continue to glow a short time after the flame was turned out. This was illustrated by experiment. Finally, some details were given of the various methods of forming the mesh of the mantle, mention being made of the recent Plaissety process.

Prof. Lewes has also been delivering the Cantor Lectures before the Society of Arts. While mainly dealing with the question of fuel, these lectures contain many points of great interest in the generation of illuminating gas. One recent lecture, for instance, brought out the difference in the nature of the products obtained by distillation at high and low temperatures. In the latter case a smaller yield of gas is obtained, but it is of a higher illuminating power and calorific value. The bye-products are also such as to lead the lecturer to suggest that it might pay the gas-producer to adopt a lower temperature distillation in preference to the present system.

Mr. Thos. Newbigging has recently spoken on the question of illuminating values. Now that the incandescent mantle is becoming more and more universally employed, gas-engineers are anxious to obtain a calorific basis of testing as soon as possible, and, meanwhile, are tempted to reduce the illuminating power, especially in fortunate circumstances, where the great majority of consumers have been converted to the incandescent system. He intimated that the time was not yet ripe for any violent changes. The vast majority of consumers were still chiefly interested in the illuminating power of the gas they bought, and any attempt to hurry matters might prove of doubtful benefit to the industry as a whole.

Dr. Rideal has published the results of a series of investigations into the hygienic value of electricity and gas as illuminants. In these experiments a room is divided into two similar sections, illuminated by gas and electricity respectively. An attempt was then made to compare the various phenomena which might be expected to be injurious to health in these two cases. Among such effects we may mention the effect of carbon-dioxide and other gaseous substances given off by gas. The main conclusion drawn by Dr. Rideal from these experiments seems to be that neither illuminants could be said to show any very distinct signs of prejudicial action. The conditions under which the experiments were undertaken, however, precluded the intentional production of very adverse circumstances.

A discussion between the junior members of the institutions of Gas and Electrical Engineers took place in Manchester last month on the merits of gas and electricity. While the discussion did not, perhaps, elucidate any very novel points, it was at least notable as an instance of a growing feeling of toleration between the representatives of the different systems of illumination.

Stephenson (*J.G.L.*, March 10th) describes a system of automatic control of street-lighting; this system involves the lighting and extinguishing of street lamps by means of regulated waves of pressure in the town mains. The lighting up and extinguishing of the street lamps is accomplished by a temporary increase in the gas pressure of about 1 to 1½ in., maintained for about half a minute to a minute and a quarter. The wave of pressure is stated to travel very quickly, acting practically instantaneously at a distance of two miles. The method is said to have worked very satisfactorily and to have led to a considerable annual saving both in attendance and in reduction of breakages of mantles, &c. No irregularities of the mechanism have been experienced. Some interesting figures as regards the saving in mantles, rods, and glasses are also given in the Table. The great saving in the year 1907, when the system first came into general use, is very marked.

Year.	Mantles.	Rods.	Glasses.
1903	6,445	968	4,099
1904	6,806	858	2,891
1905	7,195	689	4,255
1907	4,508	333	2,248

Altogether the saving in gas, labour, and maintenance may amount to 300*l.* per annum. The cost of installing the apparatus comes to about 1*l.* per lamp. The only possibility of trouble has been the occasional extinguishing of pilot-flames by wind, against which, of course, every system of automatic control has to contend. This merely calls for the use of suitably designed lanterns.

An interesting anticipated difficulty was that street-lamps might have to be lighted slightly earlier in the evening than was really necessary. Otherwise, all the consumers would light up at the same time as the street-lighting began, and cause such a draught in the mains that the lighting wave of pressure would fail to operate. Actually, however, this difficulty did not occur. The apparatus invariably worked satisfactorily, and pressure charts, taken at various lamps distributed over the district, showed the same rise in pressure as that indicated on the chart at the works.

It had been suggested that consumers might resent the temporary change in the light in the one and a half minute during which the wave of pressure was in use; actually, however, no complaints were received. Indeed, in some instances we are told that this involuntary intimation that midnight had arrived was regarded as a convenience.

Recent numbers of the *Zeitschrift fur Beleuchtungswesen* have contained an exhaustive description of newer forms of burners for inverted incandescent mantles, which is accompanied by references to the recent patents on the subject.

MISCELLANEOUS.

Grau and Russ (*Physikalische Zeitschrift*, Feb.) describe some experiments on arcs formed between cooled metallic electrodes. Their object was to ascertain how far Mrs. Ayrton's results are applicable to metallic arcs. This had been already done by Guye and Zebrikoff, but their experiments were confined to short arcs; the authors extend their investigations to arcs of 40 to 50 millimetres in length, with the result that they, too, find that Mrs. Ayrton's results apply.

PHOTOMETRY AND ILLUMINATION.

Elliott, E. L. The Relation of Illuminating Engineering to Architecture from the Engineer's Standpoint (read before the Illuminating Engineering Society, March 12).
Hunter, G. L. Light and Colour in Decoration.
Nutting, P. G. Bull. Bureau of Standards (*Elec. World*, Feb. 22).
Paulus, C. Ein neues Photometer (E.T.Z., Feb. 20).
Vredenburgh, R. T. Spectacular Lighting (*Ill. Engineer*, New York, Feb).
Webber, W. H. Y. On the Comparison of Street-Lighting Effects (G.W., March 21).
Annual Report of the National Physical Laboratory.
Report of Treasury Committee on National Physical Laboratory.
Report of Royal Commission on Lighthouse Administration.
Direkte oder indirekte Beleuchtung? (Elek. Anz., March 12).

ELECTRIC LIGHTING.

Auerbacher, L. J. High-Efficiency Lighting in Berlin (*Elec. World*, Feb. 29; see also Editorial).
Gaster, L. Electric Incandescent Lamps (address delivered to Electrical Contractors' Association, March 12).
Sartori, K. Uber die Temperatur mit welcher Glühlampen Strahlen (*Elektrot. u. Masch.*, March 22).
The Jandus Regenerative Flame Lamp (*Elec. Engineer*, Feb. 28; *Elec. Engineering*, Feb. 27, &c.).
Small Transformers for Use with Metallic Filament Lamps (*Elec. Engineering*, March 5).
Emergency Lights for Residences (*Elec. World*, March 7).
Fortschritte in der Glühlampen-industrie (Z. f. Bel., Feb. 29, March 10 and 20).

GAS, OIL, ACETYLENE, &c., LIGHTING.

Günther. Schwimmenbadenbeleuchtung mit Gas (J. f. G., Feb. 29).
Lewes, Prof. Vivian. The Theory of the Incandescent Mantle (J. G. L., March 17; G. W., March 14).
Fuel and its Future (Cantor Lectures before the Society of Arts).
Newbigging, T. Incandescent Gas Lighting: a Word of Caution (J. G. L., March 3; G. W., March 7).
Rideal, S. The Relative Hygienic Values of Gas and Electricity (J. G. L., March 10; G. W., March 14).
Stephenson, S. O. The Automatic Control of Street-Lighting at Tipton (J. G. L., March 10).
Wedding, W. Uber hängendes Gasglühlicht (J. f. G., March 7).
Neue Invertbrenner (Z. f. Bel., Feb. 20 and 29, March 10 and 20).
Gas and Electricity as Illuminants (discussion held between members of Junior Institutions of Gas and Electrical Engineers in Manchester).
The Bijou Inverted Burner in Westminster Abbey (J. G. L., March 10; G. W., March 14).
Some further Remarks upon Gaslighting in the United States (J. G. L., March 10).

MISCELLANEOUS.

Grau and Russ. A Study of the Continuous Current Arc between Cooled Metallic Electrodes (*Phys. Zeitschrift*, Feb. 1).

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 fur Gasbeleuchtung und Wasserversorgung.*
Z. f. Bel.—*Zeitschrift fur Beleuchtungswesen.*

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

3,388. Incandescent lamps (C.S.). Feb. 14. (I.C., Aug. 7, 1907, U.S.A.) J. W. Howell, 83, Cannon Street, London.
3,715. Electroliers. Feb. 19. R. S. Woods, 4, St. Ann's Square, Manchester.
4,174. Mineralized carbons. Feb. 25. H. E. Moul, 18, Kensington Court Place, London.
4,212. Arc lamps. Feb. 25. H. Baggett, Norfolk House, Norfolk Street, Strand, London.
4,350. Locking incandescent lamps in their holders. Feb. 26. B. H. Morphy, Queen Anne's Chambers, Westminster.
4,568. Arc lamps (C.S.). Feb. 28. C. A. Taylor and E. R. A. Broom, trading as The New Century Arc Light Co., Norfolk House, Norfolk Street, Strand, London.
4,608. Holders for electric lamps. Feb. 29. F. W. Suter, Chancery Lane Station Chambers, London.
4,668. Arc lamps. March 2. A. Holman, 44, West George Street, Glasgow.
4,760. Conducting connection for use in incandescent lamps (C.S.). March 2. H. W. Lake, 7, Southampton Buildings, London. (From Elektrische Glublampenfabrik Watt, Scharf, Loti & Latzko, Austria.)
4,774. Key switch lamp holder. March 3. G. H. Ide, 152, Sherlock Street, Birmingham.
4,922. Electric lamps and their circuits. March 4. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
4,956. Incandescent bodies for lamps (C.S.). March 4. F. J. Planchon, 40, Chancery Lane, London.
4,957. Enclosed arc lamps. March 4. W. J. Davy, 40, Chancery Lane, London.
4,977. Arc lamps. March 5. A. D. Jones, Hartham Works, Hartham Road, Holloway. London.
5,029. Arc lamps. March 5. Johnson & Phillips, Ltd., and S. Paterson, Birkbeck Bank Chambers, Southampton Buildings, London.
5,040. Metallic filaments or rods for incandescent lamps (C.S.). March 5. (I.C., Nov. 9, 1907, France.) F. J. Planchon, 40, Chancery Lane, London.
5,225. Electrodes for arc lamps (C.S.). March 7. (I.C., July 5, 1907, Germany.) Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
5,231. Arc lamps. March 9. Verity's Ltd., and C. B. Walker, 11, Burlington Chambers, New Street, Birmingham.
5,372. Reflectors for electric lamps. March 10. J. Bein, 205A, Pentonville Road, London.
5,387. Incandescent lamps (C.S.). March 10. A. G. Bloxam, Birkbeck Bank Chambers, Southampton Buildings, London. (From Siemens and Halske, Akt.-Ges., Germany.)
5,415. Incandescing bodies containing zirconium. March 10. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
5,416. Filaments for incandescent lamps. March 10. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
5,560. Incandescent lamps. March 12. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
5,596. Mercury or metallic vapour lamps. March 12. H. A. Kent, H. G. Lacell, and The Silica Syndicate, Ltd., 47, Lincoln's Inn Fields, London.
5,681. Electric light fittings. March 13. F. M. Long, 77, Chancery Lane, London.

II.—GAS LIGHTING.

3,450. Inverted incandescent gas fittings. Feb. 15. M. Slomnitzkie, 37, West Nile Street, Glasgow.
3,593. Bunsen burners for incandescent light. Feb. 17. P. Wigley, G. N. Arculus, and J. Warry, trading as A. Arculus & Co., 128, Colmore Row, Birmingham.
3,785. Filaments for incandescent mantles (C.S.). Feb. 19. (I.C., Oct. 11, 1907, France.) R. Laigle, 6, Lord Street, Liverpool.
3,814. Holding globes of inverted burners. Feb. 20. G. N. Arculus and J. Warry, 128, Colmore Row, Birmingham.
4,073. Pressure regulators for use with gas burners. Feb. 24. C. C. Broad, 24, Temple Row, Birmingham.
4,415. Gas lamps and burners. Feb. 27. G. Helps, 1, Izon's Croft, Ansley, near Atherstone.
4,451. Inverted incandescent burners (C.S.). Feb. 27. M. Graetz, 18, Southampton Bldgs., London.
4,520. Supports for upright incandescent mantles. Feb. 28. G. Sunnucks, 19, Farringdon St., London
4,549. Inverted incandescent lamps (C.S.). Feb. 28. (I.C., May 1, 1907, Germany.) M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
4,550. Electrically igniting gas burners. Feb. 28. A. J. Hill and F. C. D. Mann, 60, Queen Victoria Street, London.
4,636. Gas burners (C.S.). Feb. 29. A. Felchlin, 33, Cannon Street, London.
4,652. Inverted incandescent burners. Feb. 29. G. H. Barber and S. R. Barrett, 18, Southampton Buildings, London.
4,659. Incandescent burners. March 2. H. Nehmer, 36, Clifford Street, Finsbury Square, London.
4,661. Incandescent lamps. March 2. H. R. Prosser, 5, Corporation Street, Birmingham.
4,885. Electrically controlled gas lighting devices. March 4. J. C. A. Maddick, 34, Castle Street, Liverpool.

4,986. Inverted incandescent burners. March 5. R. T. Grocott, Whitehall Works, Longport, Stoke-on-Trent.
5,031. Incandescent lamps. March 5. E. H. Still, 46, Lincoln's Inn Fields, London.
5,273. Supporting mantles of incandescent lamps (C.S.). March 9. B. A. Manning, "Montrose," South End Road, Hampstead.
5,356. Gas burners and incandescent lamps. March 10. J. W. Bowley, Aintree Villa, Court Oak Road, Harborne, Worcester.
5,381. Gas lanterns. March 10. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
5,474. Incandescent lighting. March 11. A. W. Norris and W. G. Clinch, 91, Beechdale Road, Brixton Hill, London.
6,626. Incandescent burners. March 13. H. Darwin, 24, Temple Row, Birmingham.

III.—MISCELLANEOUS.

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

3,899. Incandescent gas and oil lamps. Feb. 21. J. Royle and J. Darbyshire, 139, Dale Street, Liverpool.
4,208. Oil or gas lamps. Feb. 25. F. A. Lewis and R. S. Pike, 41, Earlsfield Road, Wandsworth, London
4,260. Lamps. Feb. 25. H. Salsbury and T. Whitaker, 18, Southampton Buildings, London.
4,461. Filaments for illuminating and heating (C.S.). Feb. 27. (I.C., June 10, 1907, France.) G. Michaud and E. Delasson, 7, Southampton Buildings, London.
4,856. Lamps. March 3. G. Epstein, 54, Willow Road, Hampstead, Middlesex.
5,209. Acetylene flare lights (C.S.). March 7. C. C. Wakefield, 111, Hatton Garden, London. (Addition to 11,758/05.)

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

28,600. Arc lamps. Dec. 14, 1906. Accepted Feb. 26, 1908. H. Beck & Deutsche Beck-Bogenlampen Ges. m. b. H., Thanet House, Temple Bar, London.
28,601. Arc lamps. Dec. 14, 1906. Accepted Feb. 26, 1908. H. Beck & Deutsche Beck-Bogenlampen Ges. m. b. H., Thanet House, Temple Bar, London.
2,587. Arc lamps. Feb. 1, 1907. Accepted March 11, 1908. A. Howard, 6, Lord Street, Liverpool.
9,172. Arc lamps. April 19, 1907. Accepted Feb. 19, 1908. E. R. Ingram and H. Hunt, 40, Chancery Lane, London.
9,572. Lamps with metallic incandescing bodies. April 24, 1907. Accepted Feb. 19, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.).
9,591. Supporting carbons in arc lamps. April 25, 1907. Accepted Feb. 26, 1908. O. Gross, 5, John Dalton Street, Manchester.
13,354. Attaching filaments to leads in incandescent lamps. June 8, 1907. Accepted March 4, 1908. F. P. Driver, 55, Gordar Gardens, West Hampstead, London.
18,243. Arc lamps (C.S.). Aug. 12, 1907. Accepted March 11, 1908. S. Szubert, Thanet House, Temple Bar, London.
18,681. Arc lamps for search lights. Aug. 19, 1907. Accepted March 4, 1908. Siemens Bros. Dynamo Works, Ltd., and E. A. Holmes, 139, Queen Victoria Street, London.
3,283. Electrodes for arc lamps (C.S.). I.C., Feb. 16, 1907, Germany. Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
3,464. Arc lamp (C.S.). I.C. Feb. 18, 1907, Sweden. L. S. Andersson, 65, Chancery Lane, London.
3,465. Carbon holder for arc lamps (C.S.). I.C. Feb. 18, 1907, Sweden. L. S. Anderson, 65, Chancery Lane, London.
4,762. Electrodes for arc lamps (C.S.). I.C. March 1, 1907, Germany. Allegemeine Elektricitäts Ges., 83, Cannon Street, London.
5,318. Sockets for incandescent lamps (C.S.). I.C. March 15, 1907, U.S.A. F. A. Swan, 72, Cannon Street, London.
5,610. Incandescent lamps (C.S.). I.C. March 14, 1907, Germany. Allgemeine Elektricitäts Ges. 83, Cannon Street, London.

II.—GAS LIGHTING.

2,563. Inverted incandescent lamps. Feb. 1, 1907. Accepted March 11, 1908. P. Wigley and G. N. Arculus, trading as Alfred Arculus and Co., 128, Colmore Row, Birmingham.
3,706. Inverted incandescent lamps (C.S.). Feb. 14, 1907. Accepted Feb. 19, 1908. A. Pöschl, 40, Chancery Lane, London.
5,135. Incandescent burners. March 2, 1907. Accepted March 11, 1908. J. Galilé, 53, Chancery Lane, London.
5,171. Flashlight apparatus (C.S.). March 4, 1907. Accepted Feb. 26, 1908. E. Wagmüller, 3, Stubenrauchplatz, Steglitz, Berlin.
6,323. Incandescent lamp. March 15, 1907. Accepted Feb. 26, 1908. W. C. Fairweather, 65, Chancery Lane, London (From the firm of Julius Hardt, Germany).
7,367. Gas lighting apparatus. March 27, 1907. Accepted Feb. 26, 1908. A. E. Broadberry, 173, Fleet Street, London.
13,343. Anti-vibration device for mantles. June 8, 1907. Accepted March 4, 1908. E. Wills and F. Knott, 56, Oldham Road, Ashton-under-Lyne.

14,161. Incandescent burners. June 19, 1907. Accepted Feb. 26, 1908. H. Wakefield, 24, Temple Row, Birmingham.
14,884. Gas pendants. June 29, 1907. Accepted Feb. 26, 1908. W. Beal, 128, Colmore Row, Birmingham.
16,292. Inverted burners. July 16, 1907. Accepted March 4, 1908. W. D. Marshall and W. Denholm, 104, Spottiswoode Road, Edinburgh.
18,415. Gas lamps (C.S.). I.C., May 15, 1907, U.S.A. Accepted Feb. 19, 1908. A. H. Humphrey, 6, Lord Street, Liverpool.
22,822. Inverted burners (C.S.). I.C., July 3, 1907, Germany. Accepted Feb. 19, 1908. Firm of Ehrich and Graetz, 1, Broad Street Buildings, Liverpool Street, London.
796. Electrically controlled apparatus for igniting and extinguishing lamps (C.S.). Jan. 13, 1908. Accepted March 4, 1908. A. M. Aubert and J. M. Aubert, Birkbeck Bank Chambers, Southampton Buildings, London.
1,881. Inverted incandescent burners (C.S.). Jan. 28, 1908. Accepted March 4, 1908. G. Cranmer and H. Cheshire, trading as Cranmer & Cheshire, Carlton Buildings, Paradise Street, Birmingham.
2,384. Burners for lighting and heating (C.S.). I.C., Feb. 6, 1907, France. A. Mouneyrat, 111, Hatton Garden, London. (Addition to 18,701/06.)
2,973. Inverted incandescent pressure lamps (C.S.). I.C., Feb. 26, 1907, Germany. M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.

III.—MISCELLANEOUS

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

5,400. Illuminant appliances. March 6, 1907. Accepted March 11, 1908. G. Calvert, Birkbeck Bank Chambers, Southampton Buildings, London.
13,241. Valves for hydrocarbon lighting fixtures (C.S.). June 12, 1907. Accepted March 4, 1908. M. W. Pitner, 615, F Street, N.W., Washington, D.C., U.S.A.
14,522. Acetylene burner tips (C.S.). June 24, 1907. Accepted March 11, 1908. E. J. Dolan and M. J. Tracy, 111, Hatton Garden, London.
20,514. Producing intermittent light (C.S.). Sept. 14, 1907. Accepted Feb. 26, 1908. J. C. F. Jürgens and F. R. W. Schroeter, 7, Southampton Buildings, London.
25,277. Lamps (C.S.). Nov. 14, 1907. Accepted Feb. 26, 1908. F. W. Kearsey, 111, Hatton Garden, London.
26,804. Illuminated glove and hosiery holders (C.S.). Dec. 4, 1907. Accepted Feb. 26, 1908. A. P. Graupner, 20, High Holborn, London.

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 Jandus Regenerative Flame Lamp.

We have received particulars of a new form of flame arc lamp, the invention of Mr. A. Denman Jones, the manager of the Jandus Arc Lamp Co.'s Works. This lamp is manufactured at the Jandus works in Holloway, and put upon the market by Messrs. Drake & Gorham, of Victoria Street.

Transformers for Use with Metallic Filament Lamps.

A leaflet has been issued by Messrs. Johnson & Phillips dealing with small transformers for house-service conditions. These transformers are listed in three sizes for reduction from 200 to 25, 50, or 100 volts respectively. With a reduction to 25 or 50 volts and an output of ¼-kilowatt the full lead efficiency is stated to be 86·5 per cent., while in the case of higher outputs greater efficiency is attained.

Excello Arc Lamps.

This attractive leaflet, issued by the Union Electric Co., gives a complete and interesting account of the Excello lamps, including the results of tests and advice as to maintenance. The leaflet concludes with a series of photographs illustrating the installation of Excello lamps in the Albert Hall and other buildings.