ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

PUBLISHING OFFICES:—ATHENÆUM PRESS, 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.

EDITORIAL OFFICES:—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Westminster.

EDITORIAL.

WE take this opportunity of expressing our acknowledgment of the invariable kindness with which the first two numbers of 'THE ILLUMINATING ENGINEER' have been greeted. This shows that our conviction of the necessity for a journal dealing solely with matters of illumination was well-founded. We think that the present number should be found of equal interest.

The article by Dr. Hubert Biss on the preservation of the eyesight of school-children will be read with interest by those who have followed the discussion of eyesight and illumination which formed the subject of the special section in our first number. Dr. Biss's remarks should serve to show that the importance which we have attached to the improvement of lighting conditions in the schools is fully shared by the medical profession, and that we have not over-emphasized the gravity of the whole question.

M. Pihan's description of the method of testing coloured glasses intended for signal-lamps is also of exceptional interest, as an illustration of a case in which colour-phenomena become of very great consequence. For the appearance of distant coloured signals is necessarily controlled by physiological effects. The exact point at which a signal becomes indistinguishable is dependent on the behaviour of the retina of the eye on which the image of these coloured objects is received.

Also the classification and selection of glasses intended for such purposes should, as M. Pihan truly points out, be subjected to careful and scientific study, and this, again, involves a knowledge of the scientific sides of the subject.

The varied nature of the other interesting articles in this number will serve to convey some impression of the wideness of the field covered by the work of the illuminating engineer, and do not require special mention.

Illuminating Engineering and the Architect.

In a previous number we dealt with the influence of good and bad illumination on eyesight—a matter of the greatest moment to oculists.

There is, however, another aspect of illumination on which we lay stress in our present number, which must also be recognized as worthy of special study.

The æsthetic aspects of illumination, with which the architect is very closely concerned, have certainly not received the attention they deserve. It is unquestionably true that the intentions of the architect are frequently defeated by the adoption of some tasteless and defective system of illumination, which quite fails to bring out the æsthetic and architectural features of a room or building to the best advantage.

When we take the broad standpoint that it is only by means of light that we are able to see surrounding objects at all, the importance of the careful utilization of this light is evident.

The general scheme of decoration of an interior being left to the architect, he is, naturally, concerned with the nature of the illumination employed to display it. Conversely, the scheme of decoration has a very marked influence on the order of illumination which the lighting engineer can expect to secure from a certain choice of lights. Dark-coloured wall-papers and surroundings, for instance, reflect but a fraction of the light falling upon them, and necessitate a corresponding increase in the intensity of the sources employed.

There is, therefore, every reason to advocate the co-operation of those who are chiefly concerned with the satisfactory use of light from a utilitarian point of view, and those who are interested in securing illumination which is pleasing æsthetically.

Nor is there any real reason why these two aims should clash. It is true that many decorative devices and fittings in use at the present time would be rightly condemned by the expert in illumination as inefficient, because they absorb a considerable amount of light, or distribute it in directions where it is not needed. Yet it should certainly be possible by judicious design to secure lighting conditions which are both efficient and artistic.

At present, however, the data available as to what really constitutes effective artistic lighting are very meagre, especially when we bear in mind the varying nature of the requirements of different types of buildings.

International Notation.

The letter from M. Laporte on this question in our present number shows how readily different conceptions as to the meaning of photometrical terms—even those which have been the subject of careful deliberation and definition—may prevail in different countries. Briefly, M. Laporte's contention is that the "lux," as understood in France, is defined in terms of the French standard, and is therefore understood in a different sense from that advocated by Dr. Monasch, who has naturally been guided by the German standpoint in suggesting the adoption of "lux" as synonymous with Hefner-metre.

All these are questions on which general agreement is now recognized to be essential, but there is a great need of a tribunal sufficiently exalted and appreciated to impose conditions which will meet with general recognition.

Satisfactory conclusions on these points can only be arrived at by conference, not only between those representing the different aspects of illumination in the same country, but also those representing different nationalities.

The excellent work accomplished by the International Commission on photometry is largely due to its essentially international character. Yet, as Dr. Monasch has succeeded in showing, its recommendations are very frequently not carried out at present even by competent and responsible writers.

Increasing efforts are being made to put professional and national bias aside and consider these problems in a scientific and impartial manner. We have already referred to the work of the International Photometrical Commission. We note, too, that in Germany the recommendations of this commission receive the united consideration of the Verband Deutscher Elektrotechniker, the Vereinigung der Elektricitätswerke, and the Verein der Gas- und Wasserfachmänner—a very pleasing illustration of the truth of our contention that there is no real obstacle in the way of those representing the gas and electric interests coming together to discuss matters of mutual interest. Similar efforts are being made in the United States. We have been informed by Mr. Marks, who last year was the first President of the Illuminating Engineering Society, and whose letter we reproduce elsewhere, that the American Institution of Electrical Engineers and the American Gas Institute have both appointed committees to meet the Committee on Nomenclature and Standards of the Illuminating Engineering Society, with a view to agreement on a suitable standard of light.

It appears to us desirable for the efforts of the various committees at work on the subject to be subjected to yet further concentration. This is rendered the more essential by the fact that there also exists the very fully representative International Electrotechnical Commission, which is considering the possibility of extending its work to questions of light measurement. From the point of view of national representation, this commission is probably unique, in that executive committees have already been formed or are in process of formation by no less than eighteen nationalities and colonies, including the United States, Canada, South Africa, Australia, Japan, and the chief European countries.

The machinery available is therefore, in one sense, excellent for the purpose in view, but it would be unfortunate if a fresh effort at standardization were to be made which did not utilize the deliberations of other existing commissions.

In this connexion it may be mentioned that the sub-committee dealing with symbols, &c., is bearing in mind the recommendations of the International Photometrical Commission.

A comprehensive system of symbols covering the various appliances used in wiring and plumbing, which ought to find a place in suitable plans before installation, is also badly needed. The list of symbols recommended by the American Illuminating Engineering Society, which we reproduce in this number, is therefore well worthy of study.

The services which the International Electrotechnical Commission is rendering to the electrical industry are exceedingly great. We see no reason why the existing organization should not be applied to the standardization of the quantities and symbols to which we have referred, and which we consider to be of the very greatest interest not only to the illuminating engineer, but to the contractor and, indeed, all concerned with the improvement of existing methods of illumination.

The Application of the Thermopile to Photometry.

The question raised by the recent article by W. Voege abstracted in our present number—the problem, that is, of the application of so-called "Physical Methods" of measuring light to photometry—is of considerable interest. Such methods are usually dismissed by the photometric expert with the declaration that they are merely devices for the measurement of radiant energy, and that, even when they do distinguish between radiant energy of different wave lengths, they do not do so in the same manner as the eye, which, of course, must always be the ultimate reference in photometrical measurement.

At the same time we need not consider this an insuperable obstacle. It is desirable that we should presently succeed in producing a physical photometer resembling an artificial eye in its treatment of light-energy. Voege has himself gone a little way in this direction by the use of suitable glasses in front of the thermopile. Such photometrical arrangements, if sufficiently accurate, would undoubtedly render possible a great saving in labour, and the thermopile arrangement here described seems very convenient in its application to one of the most tedious varieties of work with which photometric experts have to deal.

Yet we must own that we ourselves are impressed by the difficulties to which the author himself makes reference. Unless a thermopile can be used under conditions which preclude the possibility of undue preference being given to the heat rays, the method must be occasionally inaccurate. The curves given by the author for various illuminants certainly resemble those which are obtained by the usual photometric process: we note, however, what seems rather a surprising omission in an attempt to show the practical value of the method. The author does not actually show, side by side, curves of distribution of light obtained by a thermopile and also by a purely photometrical method. Such curves would be of great interest, and might go far to reassure those who are disposed to doubt the practical utility of the method.

One application of the method dealt with by the author seems to us of special value, and that is the study of the "steadiness" of different sources of light. The author says truly that there has hitherto been no really satisfactory method of observing fluctuations in the light from a source on account of the time necessary to carry out a photometric observation and the labour of taking a series of readings.

The application of the thermopile to this problem may be of great practical utility. Moreover, this seems to be a case in which the fundamental difficulties of the method are of less consequence, for it would seem that rapid fluctuations in the radiation from a source must co-exist with variation in the light emitted. Even here, however, errors and misconceptions might easily be introduced by the unscientific observer who was not on the look-out for possible abnormalities. It may be suggested, therefore, that such methods may be found chiefly useful by the skilled worker, well acquainted with the subjects of radiation and photometry.

The Legal Aspects of Gas-testing.

The recent judgment against the Brentford Gas Co., to which we make reference elsewhere, affords an interesting case of the incongruous results which may arise from the legal insistence upon the letter of an obsolete form of testing. Whatever be the purely technical aspects of such a case, one cannot help being struck by the anomaly presented by a law which insists that gas must be tested by a form of burner that is admitted to be obsolete and, judged by modern standards, defective in addition.

Mr. Grafton, in his recent contribution to our columns, was evidently impressed with the inconveniences of such a system, and contended that all that was necessary was the use of a burner that really yielded the maximum light from the gas tested. These, of course, are important points for the expert to settle.

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.* 97.)

ALTHOUGH cosines and their powers will often be mentioned, no trigonometrical work will be employed here. The practical application of this will be seen at once. In Fig. 8 a ray from a lamp at A on a pole AB, casting light

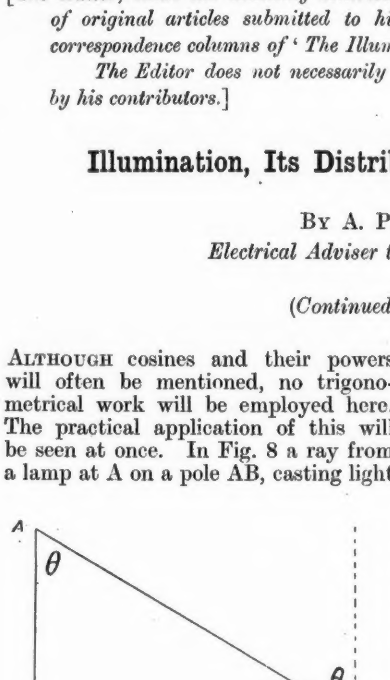

FIG. 8.

on the point C, makes the angle θ, the angle of incidence being the angle between the ray AC and the dotted perpendicular at the point C, or, what is the same thing, the angle between the ray and the perpendicular AB. The cosine is in this case the ratio of AB to the slant height AC. So long as the distance AC remains the same, the illumination at C will be in proportion to, or will vary as the cosine.

MEAN SPHERICAL CANDLE-POWER.

Conceive a source of light to be surrounded by an imaginary sphere, and many points to be taken uniformly distributed over the surface of the sphere, and the candle-power to be measured in the direction of each of these points, then the average of all the measurements is the mean spherical candle-power. So long as the candle-power is sensibly the same in all *useful* directions, there is no advantage in considering the mean spherical candle-power. When the candle-power is widely different in different directions, as in the case of a continuous current open arc, the mean spherical candle-power gives very little useful information. It is like trying to describe the performance of a steam-engine by giving the mean pressure in the cylinder. On the other hand, for those who know the kind of distribution of light, as in the special case mentioned, the M.S.C.P. as it is called, is better than giving the maximum candle-power, as was the custom in the old arc-lamp days of the early eighties. Since such an arc gives practically no light at all in the upper hemisphere, the mean hemispherical candle-power is sometimes used. The horizontal candle-power of ordinary electric glow-lamps does not differ more than about 15 per cent. from the M.S.C.P.

FLUX OF LIGHT OR TOTAL LIGHT.

There are three ways in which rainfall may be measured. The average annual rainfall on Great Britain may be described as 115,200 cubic feet, or 3,200 tons per acre; or as standing with a vertical section of 2·65 square feet on each lineal foot. (The flow of a river in cubic feet per second is found by multiplying the area of the vertical section in square feet by the average velocity in feet per second.) Or it may be simply stated as 32 inches. The first way employs three dimensions of water and two of land; the second suppresses one of each of these dimensions, and leaves two of water and one of land; the third way again suppresses one of each of the dimensions, and leaves one of water and none of land. The last is of the nature of an intensity.

It may be argued that the first is the true way, for it alone deals with a real quantity of water; and the other ways are abstractions. Similarly, it has been suggested that the true way to measure light is as a flow of luminous energy. But the difference is one of suppressed dimensions.

M. André Blondel, who has written so lucidly on photometric magnitudes and units,* cites an American story to show that the flux of light is instinctively felt to be the fundamental quantity in photometry, and that it is misunderstood simply because no name for a unit of it has been recognized. "An expert, called in to interpret a clause in an electric lighting contract between a town near New York and the local electrical company, with regard to some 2,000 nominal candle-power arcs, expressed his opinion as follows: 'The arc lamps are suspended at the cross roads, and each one, therefore, sends its light out in four directions; one cannot, therefore, expect to get 2,000 candles in each direction. The 2,000 candle arc arranged for in the agreement was one sending 500 candles down each road.' We do not wish to make fun of this expert," adds M. Blondel, "for in truth he is a very sensible man."*

A source of light capable of giving 1 candle-power in every direction, placed in the centre of a sphere of 1 ft. radius, will give an illumination of 1 foot-candle over the whole surface. That surface is 4π, or 12·56 square feet. Some writers have wrought great confusion by saying that the light of such a source is 4π candles, or 12·56 candles. No such photometric quantity as a "candle" exists. Their reasoning is generally in a circle, and they come back to ordinary candle-power again after a mess of unnecessary mathematics.

No enterprising lamp manufacturers could excuse themselves for offering lamps as "201 candles," by explaining that they give $4\pi \times 16$ candle-power. If we say that the flux is 4π times the candle-power we make no advance, and if we say that the "total light" is 4π candles we are likely to be misunderstood. We should, if possible, avoid introducing unnecessary dimensions if they have to disappear in the final result.†

In the case of electric arc lamps the candle-power varies in different directions in any vertical plane, but, except for accidental irregularities, it is the same in each such plane. If the candle-power at various angles with the horizon is measured, the mean spherical candle-power may be calculated by certain methods which will

* *The Electrician*, vol. xxxiii. p. 633, Sept. 28, 1894.

* I told this story to a very intelligent lady, and, by request, repeated it three times. She said, "I give it up; I don't see anything funny in it."

† "The standard candle, which ought to give a light of 4π, is about as absurd as the horse-power. The candle and the horse are about equally obsolete, and the candle is about as likely to give a candle-power—or 4π units of British light—as a horse to give a horse-power. The horse has one advantage over the candle: he is not inextricably mixed up with the 4π controversy, and well-meaning people do not try to rationalize him as a unit."—Mr. J. Swinburne's Presidential Address, *Journal Inst. Elec. Engrs.*, vol. xxxii. p. 39.

be described. These involve the consideration of 4π and the solid angle; we have to hamper ourselves with dimensions, but get rid of them in the result. Mean spherical candle-power, so far as candle-power is concerned, is nothing more than the average candle-power in all directions, and has nothing to do with flux.

The quantity 4π, multiplied by the luminous intensity or candle-power, has been called by M. Blondel a lumen. It may perhaps deserve a name. Meanwhile "mean-spherical-candle-power" must serve for both. The flame of a candle pours out energy, partly luminous, and partly non-luminous. The total light may be measured as a rate of emission of luminous energy. This is an instantaneous value. The product of this by time would give a quantity in terms of energy.

This product of candle-power into solid angle has an application in connexion with distribution of illumination, and another in connexion with the diffused reflecting power of a dead or matt surface, or with the analogous case of the transmission of light through opal glass or paper. The elementary geometry of this will be dealt with in a later section.

Brightness or Intrinsic Brilliancy.

There is no essential difference between brightness and illumination. Brightness or intrinsic brilliancy is generally applied to a surface which emits light, and illumination or luminosity to one on which light is received. The hole in the screen which Methven placed in front of his Argand burner, burning non-carburetted gas, was 0·233 square inch in area. This gave a standard of 2 candle-power. The brightness of this part of the flame was, therefore, 8·6 candle-power per square inch. The projected area of the flame of a standard candle, as viewed horizontally, is about 0·56 square inch. The brightness is therefore 1·8 candle-power per square inch. This brief account of the quantity will suffice here, and other aspects of it will be discussed in a later section.

Quantity of Light and Quantity of Illumination.

M. Blondel has suggested the lumen-hour as a unit on which commercial contracts for lighting may be based, but there seems to be no pressing need for such a unit. A foot-candle-hour is a much more useful unit. The result in foot-candles is what is wanted, the mean spherical candle-power-hour is only a means to an end. At the International Photographic Congress at Brussels in 1891 the "bougie-metre-second" was adopted. Every photographer consciously or unconsciously uses a "time-illumination" unit, for this quantity is nothing more or less than what he calls "exposure." An illumination of 5 foot-candle-seconds gives a sensitive shade of grey on ordinary slow bromide paper.

Distribution of Illumination on a Plane.

The case of the illumination of a horizontal plane by a light radiating uniformly in all directions is the most simple, and at the same time the most useful and common problem for outdoor work. The candle-power may be assumed to be constant, and need not enter into the matter. It will be taken as unity. The height of the lamp above the ground is also constant, and will also be taken as unity. The illumination at any point on the plane varies inversely as the square of the distance from the light; that is, it varies inversely as the square of the slant distance of the lamp. It also varies as the cosine of the angle of incidence. In Fig. 8 it will be seen

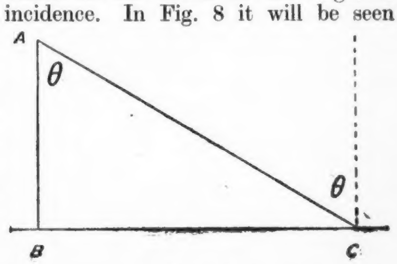

Fig. 8.

that the illumination at C varies inversely as the square of AC since AC is the slant distance, and it also varies as AC, because, when AB is unity, the inverse ratio of AC is the cosine. The illumination will therefore be inversely as AC × AC², or as the cube of the cosine of the angle of incidence. It is not necessary to measure or to know θ, the angle of incidence. The illumination at the point C being inversely proportional to the cube of AC, and proportional to the height AB and to the candle-power of the light

$$i = \frac{AB \times c.p.}{AC^3}$$

where i is the illumination in foot-candles, and *c.p.* the candle-power, and AB and AC distances measured in feet.

The curve in Fig. 9 represents the illumination at any point on the horizontal plane by the height of the ordinate at that point, the maximum being unity. The value of the cubed cosine being of great importance in all such cases, and being somewhat tedious to calculate, the following tables, abridged from those given in the original paper,* together with the tangent of the angles of incidence, are given for convenience in plotting such curves as Fig. 9. The tangent of the angle of incidence θ is the ratio of BC to AB (Fig. 8), and AB being considered here as unity, the tangent is the length BC.

The eye, after a little experience, is better able to judge degrees of illumination than of candle-power. Difficulties introduced by brightness or intrinsic brilliance are absent, but small differences can only be estimated with the help of photometric apparatus. The small and gradual changes of illumination shown so clearly on Fig. 9 could not be estimated or even detected by the eye. Weber has shown that the intensity of visual sensation is not directly proportional to the luminous stimulus. Illuminations, or, indeed, any other sensations cannot be quantitatively compared; but quality can only be estimated, and that very roughly, compared with other measurements.*

But gradual changes of illumination, imperceptible though they may be, have an actual existence; and the tables given here, originally to four figures, and now reduced to three, need not be regarded as aiming at extreme accuracy, but are provided as a basis for other calculations. Illumination on a horizontal plane decreases so rapidly with the distance, that at an angle of incidence of about 37°, or at a horizontal distance of three-quarters the height of the lamp from the ground, it falls off to one-half, at about 45° to one-third, and at 62°, or at a horizontal distance of nearly twice the height of the lamp above the ground, one-tenth of the maximum.

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* *Proc.* Inst. Civil Engrs., vol. cx. p. 120.

* Weber's law has been expressed thus: "The smallest change in the magnitude of a stimulus which we can appreciate through a change in our sensation always bears the same proportion to the whole magnitude of the stimulus......This law holds good within certain limits only: it fails when the stimulus is either above or below a certain range of intensity."—Michael Foster, 'Text-Book of Physiology,' fifth ed., part iv. p. 1211.

Weber discovered this principle in certain special cases; Fechner proves that it holds for all kinds of sensations. The proportion for light sensation is about 1/100, for muscle (*i.e.*, judging weights) about 1/17, and for pressure and sound about 1/3. See Wundt's 'Human and Animal Psychology,' Lecture II. The law may also be expressed in a mathematical form.

A distinction must be observed between the degree of accuracy with which a sensation may be estimated and the smallest perceptible difference between two sensations. Those who are not accustomed to estimating weights would have a difficulty in guessing which of two weights, one a pound and the other a pound and a quarter, was the pound, though, of course, one would appear distinctly heavier than the other. This corresponds with the difficulty of estimating the candle-power of a lamp by looking at it.

Fechner showed that most people can just perceive that a weight of 17 ounces is heavier than a weight of 16 ounces; but the difference between 30 and 31 ounces cannot be detected by muscular sensation; the heavier weight would have to be increased to about 32 ounces. This corresponds to the judgment in photometry, which Fechner puts at $\frac{1}{100}$.

TABLE I.—ROUND NUMBERS OF $\cos^3\theta$.

$\cos^3\theta$	$\cos\theta$	θ		$\tan\theta$	$\cos^3\theta$	$\cos\theta$	θ		$\tan\theta$
		°	′				°	′	
0·995	0·998	3	20	0·058	0·360	0·711	44	39	0·988
0·990	0·997	4	43	0·083	0·340	0·698	45	44	1·026
0·980	0·993	6	38	0·116	0·320	0·684	46	51	1 067
0·960	0·987	9	25	0·166	0·300	0·669	47	59	1·110
0·940	0·980	11	35	0·206	0·280	0·654	49	8	1·156
0·920	0·973	13	27	0 239	0·260	0·638	50	20	1·206
0·900	0·966	15	5	0·270	0·240	0·621	51	35	1·261
0·880	0·958	16	36	0·298	0·220	0·604	52	52	1·321
0·860	0·951	18	1	0·325	0·200	0·585	54	13	1·387
0·840	0·944	19	21	0·351	0·190	0·575	54	54	1·423
0·820	0·936	20	36	0·376	0·180	0·565	55	37	1·461
0·800	0·928	21	50	0·401	0·170	0·554	56	21	1·502
0·780	0·921	23	0	0·425	0·160	0·543	57	7	1·547
0·760	0·913	24	8	0 448	0·150	0·531	57	54	1·594
0·740	0·905	25	15	0·472	0·140	0·519	58	43	1·646
0·720	0·896	26	20	0·495	0·130	0·507	59	34	1·702
0·700	0·888	24	23	0·518	0·120	0·493	60	27	1·764
0·680	0·879	28	26	0·542	0·110	0·479	61	22	1·832
0·660	0·871	29	28	0·565	0·100	0·464	62	20	1·907
0·640	0·862	30	29	0·589	0·090	0·448	63	23	1·995
0·620	0·853	31	30	0·613	0·080	0·431	64	28	2·093
0·600	0·843	32	30	0·637	0·070	0·412	65	40	2·211
0·580	0·834	33	29	0·662	0·060	0 392	66	57	2·350
0·560	0·824	34	29	0·687	0·050	0·368	68	23	2·524
0·540	0·814	35	29	0·713	0·040	0·342	70	0	2·747
0·520	0·804	36	29	0·740	0·030	0·311	71	54	3·059
0·500	0·794	37	28	0·766	0·020	0·271	74	15	3·546
0·480	0·783	38	28	0·795	0·010	0·215	77	34	4·536
0·460	0·772	39	28	0·823	0·008	0·200	78	27	4·893
0·440	0·761	40	29	0·854	0·005	0·171	80	9	5·759
0·420	0·749	41	30	0·885	0·002	0·126	82	46	7·880
0·400	0·737	42	32	0·917	0·001	0·100	84	15	9·931
0·380	0·724	43	35	0·952					

TABLE II.—ROUND NUMBERS OF θ.

θ	$\cos^3\theta$	θ	$\cos^3\theta$
2	0·998	40	0·449
4	0·993	42	0·410
5	0·989	44	0·372
6	0·984	45	0·354
8	0 971	46	0·325
10	0·955	48	0·300
12	0·936	50	0·266
14	0·914	52	0·233
15	0·901	54	0·203
16	0·888	55	0·189
18	0·860	56	0·175
20	0.827	58	0·149
22	0·797	60	0·125
24	0·761	62	0·1035
25	0·744	64	0·0843
26	0·726	65	0 0755
28	0·688	66	0 0673
30	0·650	68	0·0526
32	0·610	70	0·0400
34	0·570	72	0·0295
35	0·550	75	0·0173
36	0·530	80	0·0052
38	0·489	85	0·00066

TABLE III.—COMBINATIONS APPROXIMATELY EQUAL TO ONE FOOT-CANDLE.

Candle-power.	Ft.	In.	Candle-power.	Ft.	In.
1	1	0	64	8	0
4	2	0	100	10	0
8	2	10	144	12	0
9	3	0	200	14	2
16	4	0	400	20	0
20	4	6	600	24	6
30	5	6	1,000	31	8
50	7	1	1,600	40	0

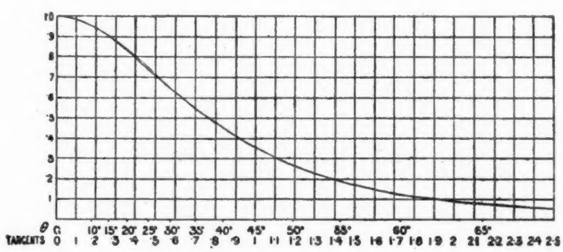

FIG. 9.

(To be continued.)

The Tungsten Lamp.

By Prof. Dr. A. Grau.

Modern methods of producing light tend towards an ever-increasing temperature of incandescence on the part of the light-giving body. Some exact experiments, in recent years, have shown that the total luminosity of such a body is proportional to the twelfth power of the absolute temperature (*i.e.*, degrees Centigrade + 273).

If, therefore, the temperature of a body yielding 10 c.-p. at 1,800 degrees abs. be increased to 2,000 degrees abs., the light yielded at the latter temperature becomes $\left(\frac{2000}{1800}\right)^{12} = 3{\cdot}54$ times as great as before, and the body now yields 35·4 c.-p.; thus an increase in temperature of 11 per cent. has produced an increase in the yield of light of 254 per cent.

The carbon filament incandescent lamp consumes about 3-3·5 watts per c.-p. (Hefner), at an absolute temperature of 1,800 degrees abs., but attempts to increase the efficiency by exceeding this value are defeated by the tendency of the carbon to form a light-absorbing deposit on the inside of the glass bulb. This tendency to increased volatilization on the part of carbon at light temperatures makes it difficult to very appreciably increase the efficiency of the carbon filament lamp. Such efforts only result in increased efficiency at the expense of the durability of the filament. Endeavours were therefore made to secure a refractory substance, which could withstand higher temperatures than carbon without deterioration, and so would successfully work at a smaller consumption than 3 watts per H.K.

Such materials are exemplified in the Nernst, Tantalum, and Osmium lamps, in which 1·5 watt per H.K. were obtained.

But the work of the last few years has shown that the metal Tungsten can bear higher temperatures than the materials mentioned above without either melting or depositing as a film on the bulb of the lamp. As a result of these researches a Tungsten lamp consuming 1 watt per H.K. can now be regarded as an accomplished fact.

Three distinct processes for the manufacture of Tungsten filaments are in use :—

1. The "substitution-process" of Just and Hanaman.
2. The "paste-process" of the Auer-Osmium (Westinghouse) Co.
3. The "colloidal-process" of Kuzel.

In the substitution process the carbon filament is gradually furnished with a metallic deposit of Tungsten. In the paste-process very finely powdered Tungsten is mixed with some binding material into a paste, from which filaments can be squirted. In the colloidal-process very finely divided Tungsten in a colloidal condition is prepared, and filaments can be worked up from this without the aid of an added binding material.

The author has carried out some investigations with the object of ascertaining whether the greater efficiency

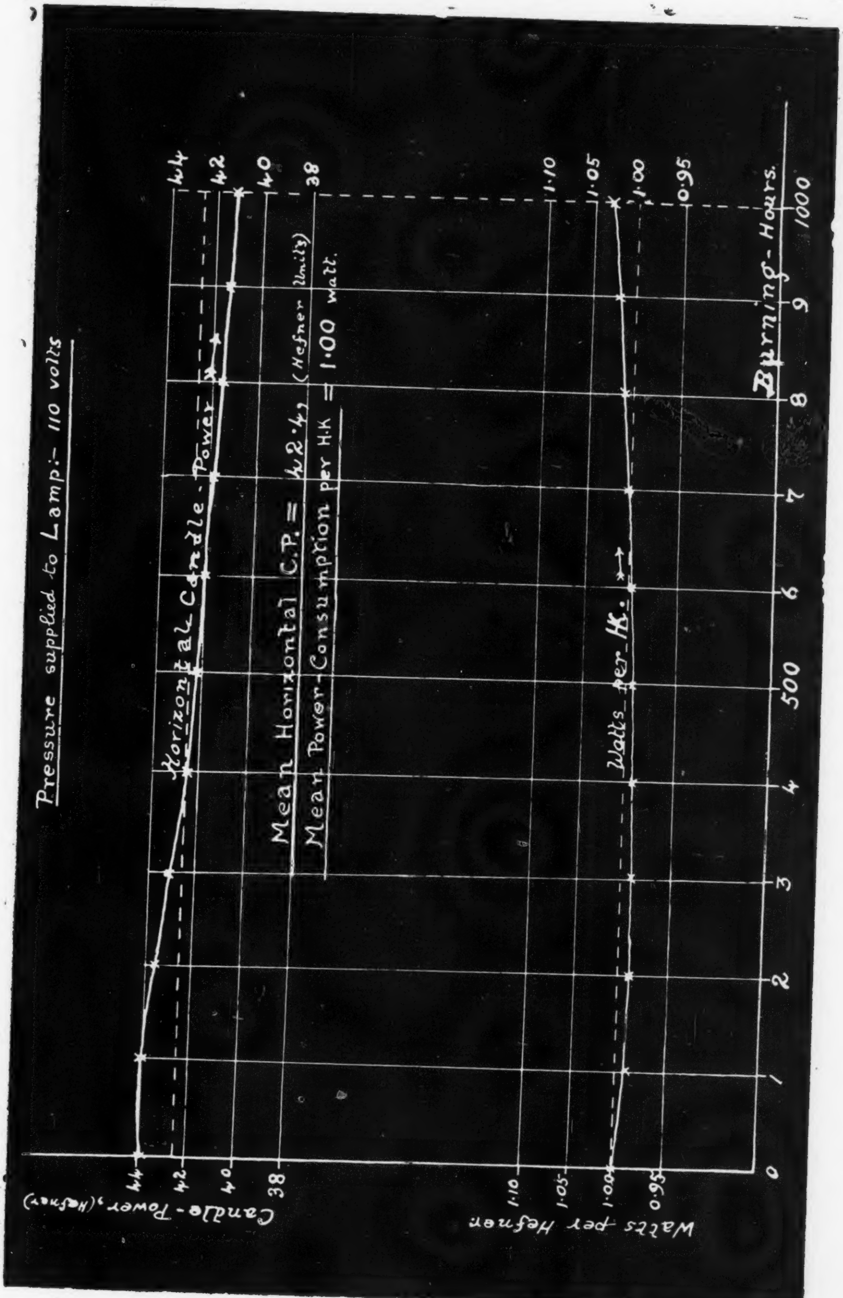
Pressure supplied to Lamp:- 110 volts
Horizontal Candle-Power
Mean Horizontal C.P. = 42·4, (Hefner Units)
Mean Power-Consumption per H.K = 1·00 watt.
Watts per HK.
Burning-Hours.
0
1
2
3
4
500
6
7
8
9
1000
Candle-Power, (Hefner)
44
42
40
38
Watts per Hefner
1·10
1·05
1·00
0·95

FIG. 1.

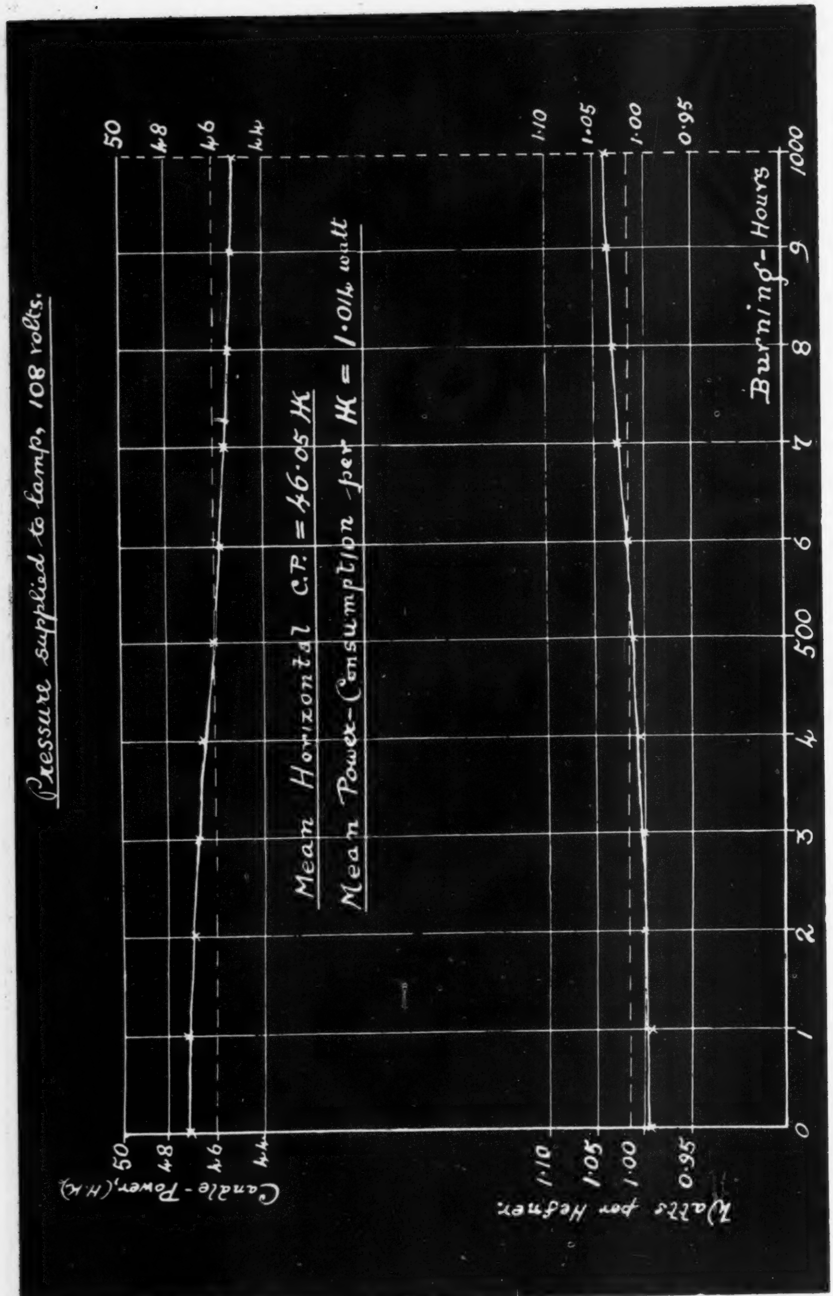
Pressure supplied to lamp, 108 volts.
Mean Horizontal C.P. = 46·05 HK
Mean Power-Consumption per HK = 1·014 watt
Burning-Hours
Candle-Power, (H.K.)
Watts per Hefner.

FIG. 2.

of the Tungsten, as compared with the carbon filament lamp, is to be ascribed to its higher temperature. In these experiments a special optical method was employed.*

The temperature of the carbon filament lamp (taking 3 watts per H.K.) was found, in this way, to approach 1,660 degrees Centigrade, while that of the Tungsten-lamp, burning at 1 watt per H.K., was in the neighbourhood of 1,850 degrees Centigrade.

The empirical law, connecting the temperature and the integral brightness of an incandescent body, has been given by Lummer and Kurlbaum as :—

$$\frac{H_1}{H_2} = \left(\frac{T_1}{T_2}\right)^a$$

where H_1, H_2, denote the brightness corresponding to the absolute temperatures T_1, T_2, respectively, and a is a coefficient which approaches the value 12 for temperatures over 1,900 degrees Centigrade.

For the same energy-consumption the candle-power of a Tungsten lamp, at a temperature of 1,850 degrees Centigrade (*i.e.*, 1,850 + 273 = 2,123 degrees absolute), was found to be three times as great at that of a carbon filament lamp at a temperature of 1,660 degrees Centigrade (*i.e.*, 1,660 + 273 = 1,933 degrees absolute).

If, therefore, the greater output of light from the Tungsten lamp is solely to be ascribed to its higher temperature, we ought to find that :—

$$\left(\frac{2123}{1993}\right)^{12} = \frac{H_1}{H_2} = 3.$$

Actually the above expression works out to 3·07.

This, therefore, seems to show that the higher temperature of the incandescent Tungsten lamp *is* the cause of its greater efficiency.

What has hitherto been a disadvantage of Tungsten lamps was the fact that, owing to the softness of the glowing filament, they could only be burned in a vertical position. More recently, however, the filaments have been provided with suitable support, and can now be burned in any position that is desired.

While the efficiency of the carbon incandescent lamp rapidly diminishes with life, that of the Tungsten lamps only changes comparatively slightly.

The watts per c.-p. diminish during the first portion of the life of a lamp and subsequently slowly increase. The course of the life of an average Tungsten lamp is shown in Figs. 1 and 2, both of which represent the mean of a large number of results.

Lamps both for 110 volts and 220 volts are now available, yielding 25 and 45 c.-p. respectively. The Tungsten lamp is an excellent illustration of the recent progress which has been made in the manufacture of incandescent glow-lamps.

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* "Über Temperatur und Lichtemission von Kohle, Osmium, und Wolfram." *Zeitsch. für Elektrotechnik u. Maschinenbau*, April 14, 1907, p. 295.—The optical method of measuring the temperature of filaments described in the above paper is essentially as follows :—

A piece of iridium foil was brought to incandescence by the passage of an electric current, and its temperature was estimated by means of a Wanner pyrometer, previously calibrated by observation of a radiating "black body." This enabled the author to determine the "black body" temperature of the iridium (*i.e.*, that temperature which a black body must have in order to emit the same radiation as the iridium foil).

The glow lamp-filament to be investigated was then observed through a telescopic tube with the incandescent foil as a background, and the current through the filament was adjusted until it became indistinguishable from the bright background. When this occurred it was assumed that the temperature of the filament was the same as that of the foil, and therefore known.

At the higher temperatures observations were made through a deep red glass which rendered the light monochromatic

The Preservation of the Eyesight in Children.

By Hubert E. J. Biss, M.A. M.D.(Cantab.) D.P.H.

The Education (Administrative Provisions) Act passed last year enforces on education authorities throughout the country the duty of providing machinery for the medical inspection of elementary school children under their care. The potentialities for good which lie in this measure are great, almost overwhelming—that is, if the Act be administered in a broad and generous spirit. At the moment one cannot but be impressed by the fact that authorities generally, while rendering homage to the principle of the measure, seem to wish to get out of the practical responsibilities imposed upon them at the least possible cost. This is not the place to enter into local politics, but it is obvious that cheap inspection is likely to be perfunctory inspection, or if not perfunctory, at least not highly-skilled inspection. If the work is to fall into the hands of callow lads, or bread-and-butter young ladies, fresh from hospital, medical inspection is likely to become something very like a failure, both administratively and medically. Sympathetic knowledge of children and seasoned experience of parents are essential attributes for the work, for the inspector has first of all to entice youngsters to disclose their shortcomings, and then to persuade the parents that preventive or remedial measures are necessary.

In nothing will these qualities be more needed than in the discovery of defective eyesight and the teaching of its significance. The amount of ocular mischief in town-bred children is immense, and so little is it recognized that one is apt to be looked upon as a crank, a faddist, or an alarmist, for insisting on the elementary precautions that sense and science alike show to be necessary, if education is not permanently to damage thousands of the youngsters who are now hustled to school by crusty parents and conscientious attendance-officers. Nor is it only the children of the poor that are threatened, and not infrequently engulfed, by these dangers. It is paradoxical, but no less true, that the qualifications for teaching children and the capacity for understanding them are far more diligently inquired into in the case of most elementary school teachers than in that of those who instruct the young sprigs of the "nobility and gentry." A candidate for a mastership in an upper-class school is considered sufficiently accomplished if he has pursued a mute, inglorious career at one of the universities, and his claim is rendered undeniable if he has played cricket in his college eleven and been "tried for the 'Varsity." That these healthy young barbarians, as Matthew Arnold taught us to call them, have no knowledge of teaching may be a matter for regret; that they have no acquaintance with the physiology of the child is something approaching disaster. How can the pedagogue barbarian be expected to think that a wretched little astigmatic, who can only see half of his book at a time, is anything but a "stupid young ass"? Or what wonder is it if he add two or three dioptres to the myopia of all the short-sighted boys in his class by making them gaze at the blackboard in impossible cross-lights, or write out five hundred lines because their nightwork is constantly unsatisfactory ? Just in proportion as the eye is of higher educative value than all the other senses, so is it worth the more careful preservation, and if parents and the custodians of the young are not instructed in the dangers of eye-strain and its prevention, their wards are likely to be cut off from the most valuable channel of knowledge.

The eye is endowed with capabilities for conveying information to the brain which makes all other sources pale into insignificance. The extent covered by the field of vision is bounded only by the horizon ; the rapidity with which knowledge is conveyed by the eye is as close an approximation to instantaneousness as we are acquainted with in nature ; and the variety of qualities such as form, size, colour, number, and texture, which it can appreciate in an object, has made the verb "to see" synonymous with the verb "to comprehend" in every civilized language. Milton deplored the loss of his sight at least as much from the educative as from the social standpoint, for in his address of 'Light,' after bewailing what his affliction deprived him of in æsthetic joy, he cries,—

> "and for the book of knowledge fair
> Presented with a universal blank
> Of Nature's works, to me expunged and rased,
> *And wisdom at one entrance quite shut out.*"

That that one entrance should by all human effort be preserved is the birthright of every child.

It is only of recent years that it has been possible to obtain definite facts as to the eyesight of the rising generation. The credit of having instituted systematic inquiry belongs to the late London School Board, which in the year 1899 passed a resolution that teachers should be requested to test the eyesight of children by means of certain testing-cards with which they were supplied, and to record the results. The figures obtained were doubtless somewhat crude, as the work was new to the teachers, no checking or supervision by medical men was carried out, and the tests were somewhat hurriedly run through in the foggy month of December. Still, not only as a valuable departure in school hygiene, but as actual demonstrative evidence of the prevalence of eye-defects, the results were little short of epoch-making. To make the figures obtained intelligible to those unacquainted with the usual methods of expressing the results of vision-tests, it may be well to explain that the standard test-type is constructed to be read at a distance of 6 metres. If the examinee cannot read it at that distance he is shown types which a normal eye can read at 9 metres ; if he cannot read those, he is taken on successively to such as can ordinarily be read at 12, 18, 24, 36, and 60 metres. The smallest type the examinee can read is taken as the measure of his vision, and the result is expressed in a fraction, the numerator of which states the distance at which he was standing, namely, 6 metres in the usual way, and the denominator, the distance at which the type which he actually read can be read by a normal eye. Thus normal vision is expressed by the fraction $\frac{6}{6}$, which signifies that the type which should be read at 6 metres has actually been read at 6 metres. Less good is $\frac{6}{9}$, which indicates that the examinee could at 6 metres only read type which should have been read at 9 metres, and so on. In the first examinations under the School Board $\frac{6}{6}$ and $\frac{6}{9}$ were classified as "good vision"—though $\frac{6}{9}$ is already distinctly below par—and $\frac{6}{12}$ or less as "defective vision."

And now as to results. The number of children examined was 338,920. Of these, 259,523, or 76·6 per cent., were returned as having "good vision," and no less than 79,167, or 23·3 per cent. as having "defective vision." In other words, a quarter of this enormous number of children suffered—unsuspected—from marked eye-defects, and of them 2,675 at 6 metres could only see what they should have read at 60 metres, and 230 were unable to read any test type at all ! With regard to districts it is interesting to observe that the highest percentage of defects was found in the City, where only

56·6 per cent. of children—barely more than half—had good vision, the other districts below the average being Westminster, Hackney, Tower Hamlets, Finsbury, and Southwark. These are all thickly populated neighbourhoods, and as bearing out the relationship of congestion to visual deficiency, it is noticeable that in Greenwich, Lambeth, Chelsea, and Marylebone, where homes are less densely packed and open spaces more ample and numerous, the eyesight was above the average. These observations lend further illustration to the principle that where small demand is made on the eye for distant vision, the acuity of sight is proportionately less.

Dr. Kerr, who had been in practice as an ophthalmic surgeon, was appointed Medical Officer to the School Board shortly before that body was disintegrated, and was retained in the same capacity, to the great advantage of the London child, by the Education Committee of the London County Council. The work initiated before his advent met with his warm co-operation on taking office, and under his advice the machinery for examination was elaborated and strengthened. Ophthalmic surgeons were appointed to check the results of the teachers' testing, and various further points were brought under investigation. Vision was now classified as "good" when $\frac{6}{6}$, "fair" when $\frac{6}{9}$ or $\frac{6}{12}$, and "bad" when $\frac{6}{18}$ or less. The effect of defective vision on school progress was examined into, and the effect upon eyesight of crowded and open areas more thoroughly investigated. As the result of the first year's work under the new conditions, five important facts were brought out:—

1. That among children with defective sight the proportion below the average educational standard of their class, at every age from eight years to twelve, is considerably higher than that of those above the standard.

2. That visual acuity increases with each year of school life.

3. That a constant proportion of 10 per cent. of children have "bad" vision throughout school-life.

4. That the greater part of the defective vision is due to slight defects which give imperfect but fair vision, due probably to mental and ocular conditions, and of the greatest importance educationally in the first half of school-life.

5. Finally, that very bad vision ($\frac{6}{36}$ or worse) is met with in a proportion increasing regularly from 1·5 per cent. in the lowest standard to 3·5 per cent. in the highest.

One paragraph of the report is so important that it deserves quotation verbatim. "School effects," wrote Dr. Kerr, "from fine work and poor illumination are more likely to show themselves in general nerve strain and unhealthy neurotic or nutritional conditions than in very defective visual acuity during school-life. The real harm of defective vision and of school-work not adapted to the visual capacity of the young lies in the strain thrown on the developing nervous system."

Further experience has only served to strengthen these conclusions, and the work of weeding out the visually unfit and instilling scientific notions of what are proper conditions of illumination, and what class of work is adapted for children at various ages, has progressed steadily. The last year for which, full returns are available is 1907, and the large number of children examined, over 400,000, the accuracy of the work—all the results being checked by ophthalmic surgeons —and the effect of extended experience as to what constitutes dangerous defect in vision in children, all combine to lend them permanent interest. Of the total examinees, 409,944 in number, the teachers returned 44,139 (10·7 per cent.) as defective for school purposes. This number was reduced on expert examination to 32,149 (7·8 per cent.), and, finally, 28,492 were given cards urging that surgical advice should be sought. A striking fact about these figures is that they include non-provided as well as provided schools, and though the former as a whole contain a rather better class of child, the visual defects were markedly higher in them than in the provided schools. One cannot resist the reflection that the bad hygienic conditions, especially as to the lighting of class-rooms, prevailing in many non-provided schools may be largely responsible for this disparity. There is not room here to discuss more fully the question of the prevalence and significance of these eye-defects, but, lest it should be thought that the London child is gifted with exceptionally bad vision, it is instructive to note that in the investigations carried out among the school children of Aberdeen and Edinburgh under the auspices of the Royal Commission on Physical Training (Scotland), it was found that in Edinburgh the percentage of normal vision, as fully tested by refraction, was only 45·33, and that in Aberdeen was even less, namely, 43·8! It is not to be presumed that all the defective children these figures connote were in need of immediate treatment; but the Commissioners wrote with regard to those in Aberdeen: "The proportion of children requiring correction by spectacles for errors of refraction was slightly under one-fourth of the whole of the children examined"!

Before turning to the preventive measures necessary to obviate the aggravation of visual defects, attention should be drawn to the fact that in the child the eye normally is shallower from before backward than in the adult. The consequence of this is that the amount of accommodation which in an adult would focus the image of the object looked at on the retina, would in the child still throw it behind that structure, and that therefore a child needs to make a stronger effort at accommodation to achieve the same result as a grown-up person. Another difference is that the lens of a child's eye is normally more convex than in the adult, and therefore, whereas the latter relaxes his accommodation for distant vision, in the child a distinct effort is necessary to accomplish the same object. Now eye adjustments, especially those for near vision, are muscular actions. The reading of a book involves no less than three distinct efforts, namely, an effort by the muscles attached to the eyeballs to bring the eyes towards the middle line, so that the visual axes may converge on the print; an effort by the ciliary muscle to adjust the lens to an appropriate condition of convexity; and an effort by the circular muscles of the iris to make the pupil contract and shut out divergent rays of light. Now not only have these muscular efforts to be made, but they have to be kept up all the time that reading is going on, and as all muscles weary under strain, and as the strain in the case of the child is greater than in an adult, it is clear that this fatigue is a very real and trying factor. As the eye develops normally the visual acuity increases. It has already been pointed out in Dr. Kerr's figures that the vision in the various standards improves with age. But if by muscular strain the elastic eyeball of the child be unduly dragged upon, any existing defective condition may be greatly increased, and in any case the mental and nervous symptoms produced not only retard educational progress, but actually endanger the general health.

Though these questions may appear to many to be of more or less academic interest, to all associated with children in every class of society, they "palpitate with actuality," as the French have it. No parent, especially if he be a town-dweller, can afford to let his child run the risks involved to health, progress, and eyesight, which negligence of the hygiene of the eye involved. Some of the necessary elementary measures for avoiding eye-strain may be usefully mentioned. First and foremost is the question of illumination, natural and artificial. Lighting should not be too stinted, nor too abundant, nor wrongly directed. In the schoolroom or nursery the window-area should be at least one-sixth of the floor-space, and one-fourth is better. The windows should reach nearly to the ceiling, and should descend so near the floor that the minimum of shadow is obtained beneath them; moreover, they should be placed as close together as structural stability allows, so that there may be no shadow between them. It is far better that light should be admitted on one side only of the room; in the case of the school this should be the left. The end walls should be blank, covered by a pale neutral tinted paper. Top-lights are rightly forbidden by the Education Code. If sufficient illumination cannot be obtained by the windows on the left, light must be admitted from the right, but it must be distinctly understood that such a supply is supplementary, and the amount of window-space strictly limited by actual needs. Nothing is more puzzling to the eyes than a cross-light. To prevent too great an access of light on sunny days, blinds should be provided to cover the whole window area, and they should be made of green holland or other dark material. For artificial illumination electric lighting is best, especially a high candle-power lamp in a frosted globe. One type of lamp is so excellent that out of gratitude I am almost tempted to mention it, but as my subject is scientific and not commercial, I refrain. No doubt there are plenty as good.

Next to illumination comes the question of position. The near point at which a child should work with its eyes is a distance of twelve inches; at any rate, not a fraction under ten. Any child who cannot read, write, and sew comfortably at this distance is either possessed of defective vision, or is forming habits fatal to ocular health. The body should be upright, supported in the middle of the back, with the thighs at right angles to the body, and the knees at right angles to the thighs; the feet should rest flat on the floor, and the desk or table should admit of this attitude being easily maintained. To prevent the head drooping the surface containing the work should be adjustable to an angle of from 15 degrees to 20 degrees for writing, and from 30 degrees to 40 degrees for reading. In the case of reading it is most important that no printed books should be given to young children under five, and picture-books should only contain bold objects unembellished with fine detail. School-books are much better than they were, but there is still much room for improvement. Children between nine and twelve years of age should be allowed no print smaller than *Pica*.

(This shows the size of Pica.)

Children below that age should have their books printed in *Double Pica*,

(This shows the size of Double Pica.)

or *Great Primer*,

(This shows the size of Great Primer).

The margins should be wide, the lines and letters well leaded out, and all type used should be fresh and sharply cut.

Writing is the most trying of all exercises, and it should never be long continued. Unlined paper and ink are the materials of choice, and the small ruled squares in which the letters have each to be formed separately should never be permitted. All paper for reading or writing should be unglazed, and the so-called vertical script is worthy of hygienic commendation on account of the lack of temptation it offers to the formation of faulty attitudes. For girls there remains the crucial question of sewing, and it must regretfully be admitted that this admirable domestic art is one beset with danger to the youngster's eye. For girls under five it should be absolutely forbidden. After that age a darning needle and coarse yarn may be used if the yarn is of a dark colour, and the material on which it is worked is of a pale shade, or vice versâ. But even this modest accomplishment must be carefully supervised, and if the child be found to bring the work close to the eyes, needle and yarn should be put away for a year or two. Fine needles, fine thread, and fine work are bad for anybody, and they certainly should not be used by girls till they are in their teens. Perhaps the most pernicious sewing-work is the very useful one of "patching," when the object of the seamstress is to make her repairing work as neat and little obtrusive as possible. It is the veriest tempting of Providence to set children to it.

In view of the well-ascertained dwarfing of visual acuity which town life conduces to, it is hardly necessary to say that the open country is the ideal entourage for a child, more especially such as have known defects of vision. To give the eye free play as far as the horizon, with the minimum amount of near work and the least possible confinement to houses and streets, is the natural and rational method of preserving the eyesight. Apart from the direct benefit produced to the general health of children by bringing them up in the country, the value of rural life in sparing the eyes from undue fatigue, and thus sparing much mental and nervous irritability, is very real indeed, and constitutes not the least of the benefits which a back-to-the-land policy would bring about. I shall hardly be deemed guilty of exaggeration by those in a position to judge if I say that much of the change the national character has undergone during the last century is due to the changed ocular conditions under which children are brought up. It is the duty of everyone at least to see that these conditions operate as little harshly as may be.

The First Municipal, Building, and Public Health Exhibition.

THE exhibition described under the above title is the first of its kind, and is to be held at the Agricultural Hall from the 1st to the 12th of May of the present year. We note that among the various subjects to be dealt with the questions of house and street lighting are to receive attention. The interest of these subjects to the municipal engineer, the architect, and others who are concerned with the exhibition referred to, is undeniable.

The opportunity afforded of bringing the need of good illumination prominently before the notice of those interested in municipal matters seems to us an exceptionally good one. We hope that full advantage will be taken of the facilities offered by the organizers of the exhibition, and that arrangements will be made to secure the exhibit of the most recent developments of different methods of lighting, and the most modern methods of measuring illumination.

The Production and Utilization of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 105.)

[The subsequent articles in this series (following the previous introduction), the first of which we reproduce in this month's issue, will deal with the following subjects:—

1. A brief history of lighting.
2. The laws and measurement of radiation.
3. Optical measurements.
4. Luminous efficiency and the mechanical equivalent of light.

It has been found necessary, in order to avoid repetition, to slightly abbreviate the first of this series.]

A BRIEF HISTORY OF ARTIFICIAL LIGHTING.

Before entering upon the consideration of the details of modern methods of lighting, and the underlying theory, some attention may profitably be devoted to the evolution of artificial lighting to its present stage; from which we may see what fields have been already explored, and the extent to which each has been developed.

The origin of artificial lighting is, of course, lost in obscurity, as it dates from the production of fire, which took place long before historic times.

Athenæus (fourth century B.C.) speaks of lamps as not being of ancient origin, but during that century they appear to have been in fairly general use for religious ceremonies. The Greek lamp, or λυχνος, generally consisted of a terra cotta reservoir with handle at one end, and a short spout at the other, into which some threads, forming a wick, were introduced. The lamp was filled with animal oil, through a larger central aperture. In some cases, a ring of wick apertures surrounded the central hole. The spread of Greek civilization caused the introduction of lamps into Rome, Egypt, Persia, Medea, and Assyria; and little advance seems to have been made until comparatively recent times.

Street lighting appears to have been first attempted in Paris, about 1558, by means of pitch or resin soaked torches, but was very unsatisfactory.

During the eighteenth century some investigations were made which led to the rapid advance in artificial lighting in the early part of the last century. Dr. Hales found that when pit coal was heated in closed vessels, nearly one-third of it became volatilized in the form of an inflammable vapour. Dr. J. Clayton in 1739 distilled Newcastle coal, obtaining an aqueous fluid, a black oil, and an inflammable gas which he stored in bladders and lit. In 1767, the Bishop of Llandaff found that coal gas preserved its inflammable character after passing through water. But it is to William Murdoch, who in 1792 commenced experimenting on a larger scale, that we owe the first realization and application of gas lighting. He employed iron retorts, and pipes of tinned iron or copper, by which the gas was carried for distances of as much as seventy feet. He also used gas bags for storage, and experimented on nozzles of different shapes as burners. Other work intervened, and stopped his experiments for a time, but in 1797, at Old Cumnock, in Ayrshire, he repeated his experiments; and in the following year he constructed a gas-making plant at Bolton & Watts foundry in Soho, in which he distilled, washed, and purified the gas.

The Gas Light and Coke Co. was formed in 1810, and the first public use of gas was in lighting Westminster Bridge in 1813.

Modern methods of artificial lighting therefore date, like most other practical applications of science, from the commencement of the nineteenth century. About the same time as gas lighting began to become practicable, the beginnings of electric lighting made their appearance. The glow in a vacuum tube had been observed by Hawksbee in 1709, and in 1746 Dr. Watson noticed that the sparks between different substances were of different colours, and obtained enough light from an electrical machine to make faces visible. But the discovery of the Voltaic pile in 1800, and of the arc by Davy somewhere between 1805 and 1810, as well as his demonstration of incandescent wires about the same time, were the first indications of the possibility of actually producing light electrically on any useful scale, though these suggestions were forced to remain dormant until more economical methods of current generation were available.

We will now consider briefly the more salient features of the progress of light production during the nineteenth century ; taking up first the combustion methods, afterwards the combination of combustion with incandescence, and finally the electrical methods.

Candles have been improved mainly in methods of construction, and by the adoption of new and purer forms of wax. In 1831 De Milly found a means for avoiding the guttering of the wicks, by impregnating them with boric acid, which fused and gave stability to the wick until completely consumed. Chevreul and Gay Lussac in 1825 introduced stearic acid, which was much harder, and less easily melted than tallow. Recently combinations of spermaceti wax with stearic acid have been employed for candles as well as Palmitine, a wax derived from palm oil, while in Germany and Austria ozokerit or cérésine wax is used.

Oil lamps have undergone many modifications from the Argand and Moderator lamps in which vegetable oil was fed up under pressure, to the modern forms employing the lighter mineral oil or petroleum.

In ordinary gas lighting improvements have been made in the form of the burner, and in regulating the pressure of the gas. The early burners were entirely of metal, but this caused a considerable loss of heat through conduction. The most satisfactory substitute has been found to be steatite, which withstands a very high temperature, can be worked into shape, and has a low heat conductivity. The importance of high flame temperature also led Siemen's in 1879 and Wenham in 1892 to introduce regenerative burners, in which the air supplied to the flame was heated by passing over the flame before reaching the burner.

Acetylene.—Although prepared on a small scale by chemical processes as early as 1859, the announcement by Moissan in December, 1892, of the production of calcium carbide by the treatment of carbon and lime in the electric furnace first enabled acetylene to be produced on a large scale. It seems, however, that Wilson, in the United States, in 1888, had noticed the production of carbide in this way, and in 1887, at the Cowles aluminium works, calcium carbide had been accidentally obtained from the union of the carbon with the lining of the furnace. In 1894 Bullier, in France, inaugurated the Société des Carbures Métalliques, which produced crystalline carbide on a large scale by the electric furnace process. The acetylene derived from the immersion of calcium carbide in water burns with a white intense flame ; in fact, Nichols has stated that acetylene burning in oxygen gives the most intense light known.

Incandescent Gas.—The ordinary gas flame suffers from two serious defects. In the first place, the light is derived from incandescent carbon particles, which are bad light radiators ; and, secondly, the costliness of the gas is considerably enhanced by attempting to make it highly luminous. On this account various attempts have been made to substitute solid bodies of better light-emitting power, in flames of little or no luminous power, but of high temperature. Berzelius, Bunsen, and Delafontaine, from 1829 onwards, discovered that various of the oxides of the rarer metals were capable of giving a considerable light when introduced into the non-luminous gas flame. One of the first attempts at the improvement of gas-lighting, however, was made by Faraday, who carburetted gas of poor illuminating power, thereby increasing the quantity of solid carbon particles in the flame. This was developed by Dunnovan in 1830 into the albo-carbon light, in which ordinary illuminating gas, or even water-gas, was passed through a reservoir containing naphthalin on its way to the burner. This was applied to street lighting in Dublin, and was rapidly taken up on the Continent.

Before this, however, a solid substance raised to incandescence in a non-luminous flame had been employed by Thomas Drummond in 1826, who invented the limelight. In order to obtain an efficient light by incandescence a great desideratum is a very high temperature, which is obtainable by employing gases of very great chemical affinity, to form a flame of small dimensions, and hence having a small cooling surface. Such a flame is given by the oxyhydrogen blowpipe, and a powerful and comparatively efficient light is obtained when a refractory substance, such as lime, is introduced into this flame. Its defects lie in the difficulty and expense of preparing oxygen, and in the rapid destruction of the lime cylinder, which must be turned to bring fresh surfaces into use.

The latter difficulty was surmounted by Tessie du Motay in 1867, who substituted zirconia for lime; and this, in spite of the use of oxygen, led to a considerable use of this light for buildings, and even for street lighting, in Paris. Improvements both in the form of the zirconia body and in the burner were made by Caron and by Linnemann. The latter realized the conditions necessary for the production of an efficient flame; that the chemical union of the gases should take place a short distance outside the burner, and that the velocity of the issuing gases must be greater than the velocity of flame propagation. Several other workers made improvements on the zirconia light, but the modern incandescent gaslight using an ordinary bunsen flame with lighting gas, and without oxygen, owes its origin to Clamond in 1881. He produced small baskets of calcined magnesia paste, and hung them under an inverted bunsen flame in a platinum wire envelope. About the same time Khotinsky took out a patent for the employment of calcium, strontium, zirconia, &c., in a similar manner, and Lungren, in America, produced caps or mantles of similar materials. As far back, however, as 1839 Alexander Cruickshanks, following Davy, had employed mantles of quartz or of platinum wire covered with lime and in non-luminous gas, and Poapp, in 1882, revived the idea, but with the result that the refractory material soon cracked away from the platinum. The first practical incandescent gas burner for water-gas was that of Fahnejelm of Stockholm in 1883, who employed a comb having rows of needles of kaolin, quartz, zirconia, or other refractory materials, especially magnesia, or dolomitic magnesia, which gave a yellower light.

None of the foregoing devices appear to have been satisfactory with ordinary illuminating gas, owing to the deposition of soot on the glowers. By the use of the argand form of burner, with glowers or mantles of gauze covered with refractory materials, some progress had been made from Brewster in 1820, and Cruickshanks in 1839, to Edison in 1878. But the solution was reserved for Dr. Carl Auer von Welsbach in 1886, who solved the problem of obtaining mantles of refractory oxides without framework, and scientifically investigated the light emission of different substances, as well as improving the burner. Dr. Welsbach found that two of the rare earths, lanthania and thoria, had the property of selective light emission in the green or most economical part of the spectrum, but failed to obtain sufficiently coherent mantles with the former. The mantles of thoria were, however, found sufficiently stable, and with the admixture of about 1 per cent. of the dark cerium oxide, gave a very intense and economical light. Many other mixtures were tried, but the above combination was finally adopted. From this time the use of the incandescent gaslight has rapidly extended, but little improvement in principle has been effected. Recently, however, the inverted type of burner has come into use, and the mantle has also been employed in conjuntion with high-pressure gas, oil-gas, as in the Kitson light, and petrol air-gas.

Electric Lighting.—As before mentioned, the development of electric lighting from the experiments of Davy was arrested by the want of suitable generators. But some advances were made, Foucault in 1844 made a simple hand-feed arc lamp, using carbons made by Bunsen from gas carbon baked with treacle, instead of the wood charcoal pencils used by Davy, and Deleuil exhibited this light at the Place de la Concorde. In 1845 Thomas Wright, of London, produced the first self-acting lamp, the arc being formed between bevelled carbon discs, which were automatically rotated, and Le Molt about the same time produced a similar lamp which burnt from 20 to 30 hours. Staite and Edwards in 1846, and Le Molt in 1849 improved the manufacture of carbons for arc lighting, the latter using a mixture of two parts gas carbon, two parts wood charcoal, and one part of liquid tar; which were powdered, mixed, compressed and moulded and were then alternately baked and soaked in treacle several times. Foucault and Dubosq in 1848 devised a clockwork self-regulating lamp, and in 1857 Harrison produced a self-acting lamp, in which the negative electrode was a disc and the positive a carbon rod in a spiral tube fed by clockwork. Before this, however, Archereau in 1848 appears to have made a lamp controlled by a series solenoid, and on the development of lighting after the Gramme machine in 1871, lamps on this principle were devised by Jaspar, Jurgensen, Reynier, Serrin, Crompton, &c., the first arc lamp for series working being probably due to Hefner Alteneck in 1878. The earliest public lighting was, however, carried out by the lamp devised by Jablochkoff in 1878, consisting of two parallel carbon pencils cemented close together. Archereau in 1855 produced carbons by the forcing process, employing very pure charcoal powder, coke, and lamp black, with syrup, which were triturated and passed through a draw plate at 100 atmospheres pressure. The sticks were afterwards baked and dipped while red hot into treacle, this process being several times repeated.

The chief defects of the ordinary arc beyond those of the regulating mechanism, lay in the rapid consumption of the carbons, the low voltage permissible, the comparatively poor light emitting qualities of carbon, and the great loss of light due to the shadow of the negative carbon. To prolong the life of the carbons and at the same time increase the voltage, the enclosed arc was developed by Marks and the Jandus Co. in 1897, the arc being formed in a small nearly enclosed vessel, in which the oxygen was soon consumed leaving inert nitrogen and carbon dioxide behind. This increased the life of the carbon from 8 or 10, to 50 or 60 hours or more, and at the same time enabled a longer arc with a P.D. of 80 volts or more to be employed. On the other hand, Archereau in 1877 had introduced magnesia into the carbons, and Carré also made carbons impregnated with metallic salts. The importance of the selective light emission of such salts was, however, first realized by Hugo Bremer in 1898, who introduced 20 to 50 per cent. of magnesium, strontium, silicon and fluorine compounds as well as oxides of the rare metals. He also got rid of the shadow of the carbons by inclining them and blowing the arc aside with a magnet. Since then the use of "flame" lamps employing carbons with metallic salts has greatly increased, and a great improvement in efficiency has been gained thereby. Recently also Steinmetz has devised the magnetite lamp in which the positive electrode is of copper, which rapidly conducts away the heat, while the negative electrode is of magnetite or iron oxide, the length of arc being as much as 22 mm. The light in this case comes chiefly from the arc instead of from the electrode, and the duration may be as high as 200 hours or more.

In 1751 Watson formed an arc inside a mercury barometer, and in 1882, Jamin and Manoevrier experimented with arcs between mercury and carbon. Dr. Arons in Berlin in 1892 produced an arc 60 cm. long between mercury electrodes in a horseshoe shaped tube, and Cooper Hewitt in America introduced the mercury vapour lamps in commercial form with inductive device for breaking down the high negative resistance at starting. The light thus produced was very efficient, but of unpleasant colour, and attempts have been recently made to improve it by the use of other metals or by fluorescent materials.

Heraeus now makes a mercury vapour lamp, using a quartz tube, in which the vapour is said to be at a temperature of no less than 5,000° to 6,000°. This lamp is claimed to have no unpleasant colour effects, and its efficiency is probably the greatest ever attained, the consumption being only 0·27 watt per mean spherical candle.

(*To be continued*).

The Annual Meeting of the Illuminating Engineering Society.

The annual meeting of the society was held on January 10th of this year, when Dr. Louis Bell, the new president, reviewed the progress of the past year. The existence of the society, he said, had been amply justified. No other society could have brought together those representing so many different aspects of illumination, electrical engineers, architects, gas engineers, those interested in acetylene, fixture-dealers, &c. Previously there had been no common meeting ground.

The old hostility between the different sections had arisen through misapprehension. In some cases the differences of opinion had been shown to be unfounded, while in other cases in which disagreement existed the previous bitterness had been replaced by mutual toleration and good-natured criticism.

New Methods of using Acetylene for Lighting Purposes.

By A. Granjon.

In a previous number of *The Illuminating Engineer* Mr. F. H. Leeds wrote as follows :—

> "Another serious fault has been that unconsumed gas has frequently escaped from them (acetylene lamps), a matter which has absurdly, though very naturally, left in the layman's mind the almost ineradicable impression that acetylene itself cannot be burned without the production of an unpleasant odour."

It is a fact that acetylene is generally known as a malodorous gas which cannot be adequately utilized for indoor illumination. This idea, of course, is erroneous; there is no reason why acetylene should escape from the mains confining it in greater quantity than coal-gas, and it may also be said that acetylene, when perfectly purified, as it should be for purposes of indoor illumination, is practically odourless.

It is well known that the odour associated with acetylene is in reality due to the presence of phosphine in the crude product. Were it not for this fact acetylene could be used in the crude state for indoor lighting; unfortunately, apart from its smell, the presence of phosphine exercises a prejudicial action on mains, burners, &c., and if only for this reason, must be eliminated. Yet such elimination is not absolutely essential for lighting purposes, for it is a matter of fact that the majority of acetylene consumers do not use pure gas.

There is, however, one case in which this purification is quite essential, namely, when acetylene is to be employed in connexion with incandescent mantles. This new application of the Welsbach mantle to acetylene lighting appears to the author to be of such importance as to merit special discussion in this article.

Welsbach mantles are, of course, very generally used for gas-lighting in the present day, and this substitution of incandescent burners in place of the old flat-flame burners arises from the two following causes :—

1. The possibility of improved economy.
2. The possibility of obtaining sources of light of greater brilliancy.

In the case of acetylene the second objection cannot be said to exist, for a single acetylene flame can yield as much as 60 candle-power, which certainly amply suffices for indoor illumination. However, the economy following the use of mantles is sufficiently great to merit the study of this application of acetylene by illuminating engineers. This economy is illustrated by the following example: we may obtain 30 candle-power by burning acetylene under a pressure of 120 mm. either by the use of four ordinary burners, consuming in all 42 litres, or by the use of a single incandescent burner, burning 10 litres. Of course, this saving of 76 per cent. of the original cost cannot be obtained in practice, because the use of incandescent burners is only possible when the gas has been very perfectly purified.

Assuming, however, that the cost of purification is 13 centimes per cubic metre of acetylene (one kilogram of material capable of purifying 12 cubic metres of acetylene costs about 1 fr. 50), we should still obtain a saving of at least 50 per cent.

Another question of great practical importance is as follows: Do incandescent burners require more attention than the original acetylene burners? We can answer this in the negative.

The mantles used for the acetylene are small in size, and do not break so readily as those usually employed for gas-lighting; we know of many types of incandescent mantles which when in use burn continuously, without causing the least inconvenience to those in charge of the apparatus; in fact, the use of incandescent mantles dose not unduly complicate acetylene lighting.

FIG. 1.

We may next inquire by what class of consumers will incandescent mantles, in conjunction with acetylene, be utilized?

Naturally people who consume acetylene for home-illumination, irrespective of expense, will not adopt it, but such people are rare. Recent statistics compiled by the Office Central d'Acétylène show that nearly 80 per cent. of the acetylene generated is used for the lighting of shops, restaurants, &c., in small towns and villages. The author believes that those who require both a good and a cheap light will readily adopt the new method of illumination capable of realizing so great an economy, and that the incandescent burner will also find ready use in small towns and villages where the street lighting is accomplished by a central station; the majority of acetylene street lamps in France and Germany are provided with incandescent burners.

In short, he is inclined to think that incandescent burners will be employed in most cases where acetylene is in actual use, but that the new process will not very considerably increase the number of acetylene private supplies. It will, however, greatly facilitate the exploitation of acetylene central stations, by enabling them to reduce the price of acetylene to consumers.

The great inconvenience following the use of acetylene for house-lighting consists in the necessity of the consumer himself being obliged to pay attention to the apparatus. For the user of acetylene must possess in his house a miniature generating works, and while acetylene probably requires less attention than oil lamps, it is still open to objection on this ground.

To reduce this inconvenience the idea of employing dissolved liquid acetylene in cylinders was suggested. The liquid, however, proving to be dangerous and explosive, was soon forbidden by the public authorities. The question was still unsolved, until Messrs. Claude & Hesse discovered a method of dissolving acetylene in acetone, a cheap and volatile material, possessing the power of dissolving 240 times its own volume of acetylene under a pressure of 10 atmospheres at 15 degrees Centigrade. The inexplosive method of solution being thus realized, the exploitation of the process was undertaken by the Cie. d'Acetylene dissous (Dissolved Acetylene Co.). Cylinders containing acetylene dissolved according to this process are now in the market, and have found great application both for lighting and industrial purposes. These cylinders are simple to manipulate, compact, portable, and yield only pure gas. Acetylene produced from them is, of course, dearer than that produced in the ordinary way, and the cylinders themselves, being of considerable value, must be returned after use. Hence dissolved acetylene may only find ready application in the case of easily accessible towns and villages. Its chief application will probably be to automobiles and railway-lighting, and the majority of the motor-cars running in Paris are already lighted by this means.

On the French Northern Railway many carriages are lighted by dissolved acetylene, and the results of using this new method of illumination are said to be satisfactory.

Fig. 1 represents special arrangements used for motor-car lighting.

In Fig. 2 are shown two cylinders as ordinarily employed for house-lighting.

In both cases the set of two cylinders is provided with an expansion arrangement and a monometer. 350 litres of acetylene, under a pressure of 10 atmospheres, can be dissolved in a single bottle. A couple of bottles containing 700 litres are amply sufficient for motor-car lighting, when it is borne in mind that the burner employed in this usually consumes from 10 to 20 litres of acetylene per hour.

Yet, although dissolved acetylene is a very convenient and simple method of attacking the problem, it is quite possible that the process may only find application in the special cases previously enumerated. The great objection to its universal adoption is the high price of the gas itself—about three times as dear as that generated in the ordinary way. This high price is chiefly due to the enormous capital expended in exploitation, and it seems at present improbable that dissolved acetylene will ever be very generally employed for indoor illumination.

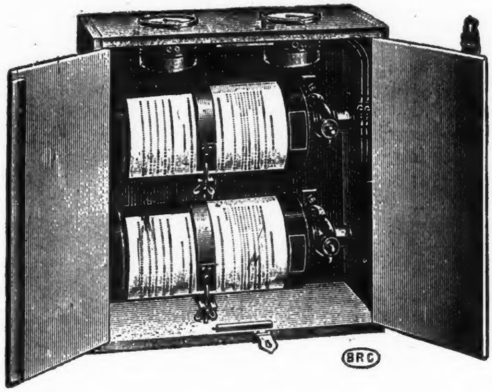

FIG. 2.

Artificial Illumination and the Education of Those Concerned in its Production.

By Charles W. Hastings.

(*Continued from p.* 123.)

Continuing the discussion of the education of those engaged in illumination, we must for purposes of comparison refer very briefly to the subject of electric lighting.

In the first place it cannot be denied that the student of electricity was, from the start, a man of distinctly better general education than the gasmaker, to whose failings and shortcomings we referred in a previous chapter; he brought to bear upon the special study a knowledge of higher mathematics, physics, and chemistry. He had for his mentors men well known in the scientific world, as witness those who gave evidence in the promotion of the Electric Lighting Act, 1882. Whatever the faults of that particular Act may have been, there were marshalled before the Select Committee of the House of Commons men of high scientific and intellectual attainments. The principal witnesses were: Sir Frederick F. Bramwell, Mr. William Spottiswoode, Dr. Charles W. Siemens, Dr. John Hopkinson, Sir John Lubbock, Mr. Edward H. Johnson, representing Edison's interest in electric lighting, and Mr. R. E. Crompton; the last named gentleman was, we believe, the first electric light engineer in this country.

It is interesting to glance through the minutes of evidence, and to read the opinions of these able men upon the future of electric lighting; of those we have named several have passed away, but all lived to see electric lighting successfully installed and in keen competition with gas for both public and private illumination. So we find that the electric lighting engineer had reason to be proud of his sponsors. The class of men who went in for electric lighting had means; many of them were graduates of the universities—Oxford, Cambridge, Dublin, Edinburgh, &c. Others were students from Owens College, Manchester, Mason College, Birmingham, and similar semi-technical colleges, which have in these latter days been merged into the modern universities. Lectureships in electrical engineering were established, and to-day we find that a department of electrical engineering is associated with practically all the newer universities.

Particulars of such a section are before us. The Professor is a D.Sc. of London, the Assistant Lecturers are respectively B.Sc. of London and M.Sc. of Victoria (Manchester). In the Elementary Course no special study is made of electricity as an illuminant, but in the second year electric lighting is included in both the lecture and laboratory course. So it will be seen that it is possible for a young man to prepare himself theoretically, and, to a certain extent, practically, whilst at college for the position of an electric lighting engineer.

It has become a common practice for large firms of electrical engineers to receive graduates from the universities as pupils, and to make special terms and arrangements for their articles. In this way the graduate acquires a thoroughly sound and practical experience, and enters upon his career with a very different knowledge of the possibilities of electric lighting to that of his illuminating brother, the gas engineer.

Looking down the list of persons qualified as teachers in connexion with the Department of Technology of the

City and Guilds of London Institute, we find, under the heading 'Electrical Engineering,' ninety-eight men; of these twenty-eight are graduates. The department 'Gas Engineering and Supply' have only twenty-four teachers, none of whom are graduates; few, we think, are members or even Associates, of the Institution of Civil Engineers. Only three possess qualifications other than everyday experience. Two of these are Fellows of the Institute of Chemistry and one a Fellow of the Chemical Society.

It must therefore be admitted that notwithstanding the enormous capital invested in gas undertakings—approximating 125,000,000*l.*—the education of those responsible for the profit-return upon this capital has not had the consideration that it deserves.

Following up the question of the possibilities of studying the science of illumination as regards gas lighting, we will look back upon one or two of the steps that have been taken to instruct, if not to educate, the gas engineer.

Primarily his work has been to make gas, and it is only within the last two or three years that any consideration has been given to the question of the best method of utilizing gas for illuminating purposes.

The directors of the companies or the committees of corporations owning gas undertakings have been alike quite indifferent to this exceedingly important question.

The sale of gas is to-day controlled by the somewhat ancient Sale of Gas Act, passed in 1859. Under the City of London Gas Act, 1868, the appointment of gas referees was established. These gentlemen issue annually their notifications, and from about that time up to the passing of the London Gas Act in 1905, they permitted and enforced the use of Suggs' London Argand Burner, as the legal standard for testing gas. No one ever appears to have thought it necessary to legally test gas for its luminosity when in actual use; no indisputable data exists as to the penetrative power of gas illumination, its intensity at the point of flame, or the loss of luminosity at stated distances from the burner.

From time to time elaborate papers have been read at meetings of gas engineers, but the figures have never been, so far as we know, standardized. To-day, just as years ago, photometrists give elaborate laboratory results instead of those obtained in actual practice, which might become golden rules for all interested in illumination.

An elaborate report upon testing gas by candle was recently presented by a special committee to the American Gas Institute, in which compilers show that much disagreement exists as to the best method of arriving at the candle-power. The Harcourt 10 candle Pentane lamp is now the standard for the district under the control of the Gas Referees, and covers the London County Council area. It is hoped that at no distant date it will be universally adopted throughout Great Britain as the "candle" illuminant, but even then it simply means uniformity in the laboratory.

The gas engineer—or the illuminating engineer, as our Editor would prefer us to say—needs to know more about the actual volume of light at his disposal. How is he to acquire this knowledge? Who is to teach him? There are no special textbooks worth his study. As we write we have upon the table half-a-dozen books issued within the last six months. In all of these otherwise excellent publications the sections dealing with illuminating power give only stereotyped information set out in different form. Reading one after another we find ourselves "no forrader."

Prof. Vivian B. Lewes, in 'Liquid and Gaseous Fuels,' devotes some space to the 'Structure and Proportions of Flame.' He illustrates his remarks and shows examples of the Cockspur and Cockscomb burners, which have been before the public as stock illustrations for many years. His next illuminating picture is the reproduction of an 'Old Flat Flame Burner.' The subject of illumination is dismissed with the briefest reference to the Siemens, Wenham, and Cromartie regenerative burners. The chapter is concluded with some forty or fifty lines upon the discovery of the incandescent mantle and the Welsbach burner.

Take the next, Henry O'Connor's 'Gas Engineer's Pocket-Book,' which contains much that is useful and but little that is new. The section treating of 'Illuminating Power and Purity of Gas' is simply an extract from the Gas Works Clauses Act, 1871, and the notification of the Gas Referees revised to August, 1906, *verbatim et literatim*, with the appendices thereto. This is all the author gives to help educate the illuminating engineer.

Another volume is 'Chemistry of Gas Manufacture,' by H. M. Royle. In this admirable book Chap. xi. is headed, 'Photometry and Gas Testing.' It opens with references to Kepler's 'Law of Inverse Squares,' Lambert's 'Cosine Law and the Generalized Photometrical Law.' These three rules he states "form the basis of all photometrical works, no further study of physics is absolutely necessary for the comprehensive study of photometry." The author describes very briefly several standards, and refers to Appendix A, which we find, upon turning to the end of the book, to be the notifications of the Gas Referees, set out fully, and occupying some forty-eight pages!!

In Mr. W. F. A. Butterfield's book, 'The Chemistry of Gas Manufacture,' only very slight reference is made to the illuminating power of gas; but we hope that as the author is engaged upon another volume covering the 'Testing and Use of Gas,' that he may be able to strike out something more original than the Gas Referees' notifications, and at least bring the study of illumination into line with modern thought and practical necessity.

We will conclude this chapter with a reference to, and a hearty appreciation of, Mr. Walter Hole's 'Distribution of Gas,' an expensive book, but one written by a man who knows and who has done his best to bring together illustrated details of all the best systems, methods, and apparatus connected with illumination by gas. There is much in the book which should be studied by all illuminating engineers. Mr. Hole has set himself the task of dealing with the distribution of gas from the station meter to the burner, confining himself, however, to public lighting, and leaving, probably for another volume, domestic illumination.

In the next chapter we shall venture to sketch a short syllabus, which we trust will aid the student who intends to qualify himself for the position of illuminating engineer.

(*To be continued.*)

The Advantages of the Metallic Filament Lamp for Low Voltage, Isolated Plants.

By An Engineering Correspondent.

It is proposed to demonstrate in this article the particularly useful field for the metallic filament lamp, when used with small private electric lighting plants.

The writer is enabled to supply some actual cost figures on a small gas-driven plant, which was originally installed to light twenty-five 8-c.-p. carbon glow lamps.

A terminal pressure of twenty-five volts was adopted in order to keep the initial cost of the storage battery as low as possible. The plant consists of a 2¾ B.H.P. gas engine driving a 1·5 K.W. 25–35 volt dynamo, in conjunction with a storage battery. As not more than 750 watts are required to light twenty-five 8-c.-p. lamps, an ample margin of power is available for charging the battery during lighting hours. Fourteen cells, of 120 ampere hour capacity at a nine-hour discharge rate, are installed, sufficient to run about eleven 8-c.-p. lamps for nine hours.

It is interesting to note that an open type arc lamp, using flame carbons, burns quite satisfactorily on this circuit, at the charging voltage of 28–34 volts, the current consumption being about 10 amperes.

Great care has to be taken with all connections to switches and fittings at this low voltage, because a loose screw, and consequently high contact resistance, causes a drop of 1 volt or more, which, at a pressure of 25 volts, will result in 8–10 per cent. decrease in the light.

The first metallic filament lamp was tried on the circuit at the end of the year 1904, this being a 25 volt 16 hefner candle-power Osmium lamp. This lamp was tested for candle-power and watt consumption every 100 hours, and finally burnt out after 960 hours' use. The results of the first and last tests on this 16-c.-p. 25-volt Osmium lamp are given below.

Hours of burning.	Candle-power (British).	Watt consumption.	Watts per candle-power.
0	15·1	24·4	1·62
900	12·5	23·8	1·9

After the completion of this test it was decided to extend the use of the Osmium lamp, in spite of its high price, for the following reasons :—

1. Greatly reduced current consumption.
2. Reduced voltage drop on remote lamp circuits.
3. Reduced sensibility to voltage fluctuations, which are unavoidable on small gas-driven plants.

Osmium lamps were at first rather difficult to obtain, and even the 25-volt lamps were very fragile, as compared with the more recent forms of tungsten lamps, therefore it was not until the tungsten filament lamps were on the market that reliable cost results could be obtained.

The output from the plant has not been appreciably reduced by the use of these metallic filament lamps, but the opportunity has been taken to light another house, and also to increase the candle-power standard. The average costs of generation of current per unit will be given. These costs will serve for the former installation of carbon filament lamps, and the recent installation of metallic filament lamps. In these costs, gas, oil, and depreciation charges only are taken into account, labour charges not being included, as the lighting plant is run in conjunction with a workshop, thus not occasioning the employment of special labour to attend to the lighting plant.

If it were necessary, with a small installation, to employ some one merely to attend to the plant, the wages bill would run up the cost per unit to an abnormal figure.

In many cases it is practicable to train some one to attend to an installation in addition to their other duties, as a small plant does not require a great deal of attention.

Number of units used, and av rage cost of same, during a period of twelve months.

Total number of units	690
Cubic feet of gas	57,000
Cubic feet per unit	83
6 gallons of oil at 3*s.* per gallon ...	18*s.*
Engine depreciation per annum taken at	30*s.*
Dynamo do. do. ...	10*s.*
Battery do. do. ...	20*s.*
Sundries	8*s.*

Cost per Unit.

Gas at 2*s.* 3*d.* per 1,000 cubic feet ...	2·24
Oil	0·31
Plant depreciation	1·04
Sundries	0·14
Total cost ...	3·73

Or about 3·75*d.* per unit.

The total installation of tungsten filament lamps now consists of thirty 10-c.-p. (hefner) and twenty - four 16-c.-p. (hefner) lamps. Both the carbon and the metal filament lamps have an average life of over 1,000 hours on this low voltage, this probably being due to the much greater strength of the filament, as compared with standard high voltage lamps. The carbon lamps were renewed once per year, although in many cases not being actually burnt out, but on account of the decrease in candle-power.

The average number of units consumed per 8-c.-p. carbon lamp per year $= \frac{690}{25} = 27{,}600$ watt hours. At 30 watts per lamp this gives an average of 920 hours useful life per lamp.

The cost of lamp renewals per 1,000 candle-hours, at 15*d.* each, is therefore $\frac{15 \times 1000}{920 \times 8} = 2{\cdot}05d.$ for renewals per 1,000 candle-hours, or per kilo-candle hour.

The tungsten filament lamps now in use are not renewed until the filaments are burnt out, as the decrease in candle-power during life is not nearly so noticeable as with the carbon lamps.

One of the original Osmium lamps burnt for over 2,000 hours before giving out, and was then giving at least 75 per cent. of its original candle-power.

Allowing the average life to be 1,000 hours for tungsten lamps, and the price 3*s.* per lamp (25 v.), the renewal costs will be as follows :—

$\frac{36 \times 1000}{1000 \times 10} = 3{\cdot}6d.$ per kilo. candle-hour.

The current costs per 1,000 candle-hours are as follows :—

Carbon lamp 3·75*d.* × 3 75 watts per candle 14*d*
Tungsten lamps 3·75*d* × 1·3 do. do. 4 9*d*
Total costs per kilo-candle-hour (carbon) 16*d*
do. do. do. (tungsten) 8 5*d*

thus reducing the cost of light to nearly one-half.

It has been possible to increase the total candle-power from 200 c.-p. to 600 c.-p., no additional plant being required, the only extra cost being for lamp renewals. Below are given the total costs per year, the current consumption being taken at 690 units.

Type of Lamp.	Total candle power.	Cost for current.	Cost of lamp renewals.	Total cost per year.
		£	£	£
Carbon ...	200	11	1·5	12·5
Tungsten	600	11	7·5	18·5

In the distribution of electricity, high voltage circuits are employed chiefly to keep the cost of the mains and leads as low as possible. But in determining the cross section of the conductor for electric lighting purposes, in the branch wires it is frequently necessary to consider the mechanical strength in addition to current-carrying capacity.

The smallest size wires used in practice are S.W.G. 18 and S.W.G. 3/22, each having a copper cross section equivalent to ·0018 square inches. At a current density of 1,000 amps. per square inch a current of 1·8–2 amperes is obtained, using the smallest permissible wires consistent with mechanical strength. As it is usual, with parallel systems of wiring, not to place more than two or three lamps on one circuit, it is obvious that the introduction of the metallic filament lamp at lower voltages will not occasion any higher costs for copper, as far as the individual circuit wiring is concerned.

Take the comparison between two installations of 16 c.-p. lamps, one consisting of 100-volt carbon lamps, and the other 25-volt tungsten lamps. The 16 candle-power 100 volt carbon lamps require ·6 amperes each, and the 16 candle-power 25 volt tungsten require about ·7 amperes each, therefore approximately the same cross-section of copper would be required in each case. Therefore where a four to one reduction in voltage is made, no extra cost is occasioned for increased section of cables or wires where the low voltage system with tungsten lamps is employed.

The low voltage system has, in addition, the following advantages :—

1. Absolute safety from shock.
2. Reduced fire risks, owing to lessened possibility of leakage.
3. Superior lamps, having a much less fragile filament, and capable of being used in other than vertical positions.
4. Possibility of obtaining single lamps of relatively small candle-power (10–16 c.-p.).

In the following table, suitable voltages are given for small plants, supplying lighting installations using tungsten lamps.

No. of lamps installed.	Candle power per lamp.	Total watts.	Suitable voltage.	Full load current.
25 or 18	10 14	300	14	21·5
33 or 25	12 16	500	16	31
80 or 50	10 16	1,000	25	40
100	16	2,000	25	80
200	16	4,000	50	80
400 or 250	16 25	8,000	50	160
500 or 400	25 32	16,000	100	160

Up to the present, many people who are not situated in the area of an electric supply company have not been able to make use of the electric light, on account of the large capital outlay necessary for a private generating plant. This outlay will be largely reduced in an isolated plant designed to supply an installation of tungsten lamps.

For purposes of comparison, the following table has been prepared from recent catalogues of engine-makers and manufacturers of electrical plant, and serves to show the difference in capital outlay required for plant, for installations of carbon and tungsten lamps, for a given number of lamps of equal candle-power. These prices vary with different makers, but will be useful for purposes of comparison.

No. of 16 c.p. lamps.	Capital outlay required for generating plant, including engine, dynamo, storage batteries, and switch-gear.	
	Tungsten lamp.	Carbon lamp.
	£	£
15	36	60
25	44	73
50	63	113
100	92	187
200	130	270
400	200	420
800	300	720

From the preceding table of figures, it will be noticed that the cost of plant for an installation of fifteen 16 c.-p. tungsten lamps is reduced to 60 per cent. of the cost of plant necessary for an installation of fifteen 16 c.-p. carbon lamps, while in a large installation of 800 lamps the cost of plant is reduced to 40 per cent.

The new metallic filament lamp should therefore open up a fresh field for electric lighting by means of isolated plants, and better enable it to compete with coal or acetylene gas as regards capital outlay and working costs. However, when current is obtainable from a supply company, it is usually cheaper to take the current from their mains, the source of supply being more reliable, and it is much more convenient when the light is only required for intermittent periods.

The International Electrotechnical Commission.

In September, 1904, an International Electrical Congress was held at St. Louis, Prof. Elihu Thomson being the President and Dr. A. E. Kennelly General Secretary.

Colonel R. E. Crompton, C.B., read a paper before the Congress which resulted in the adoption of the following resolution by the Chamber of Government Delegates :—

"That steps should be taken to secure the co-operation of the technical societies of the world by the appointment of a representative Commission to consider the question of the standardization of the Nomenclature and Ratings of Electrical Apparatus and Machinery."

A great deal of preliminary correspondence took place, which finally culminated in a preliminary meeting being held in London in June, 1906, at which fourteen countries were represented. Mr. Alexander Siemens was in the chair, and a set of rules which place every country, large and small, on an equal footing as regards voting power and taxation, were adopted, and now await ratification by the authorities by whom the delegates were appointed.

The late Lord Kelvin was elected the first President, and Col. Crompton was appointed the first Honorary Secretary.

Electrotechnical Committees have now been formed in Austria, Belgium, Denmark, England, France, Germany, Hungary, Mexico, Spain, Sweden, and the U.S.A., and the matter is also being considered in several other countries.

The British Institution of Electrical Engineers have taken a very prominent part in this work, for they not only defrayed the preliminary expenses, but granted the Commission a very substantial loan, so that the work of organization should not be hampered at the commencement.

The British Electrotechnical Committee have appointed two Sub-Committees, one to deal with nomenclature, and the other with symbols. The Sub-Committee which is engaged in drawing up the list of terms, with their explanations, in use in the electrical industry will, of course, include the nomenclature of illumination in their glossary, and the decisions of the International Photometric Commission have already come under the official notice of the Committees with a view to being considered internationally.

The attention of the Committees is being confined, as far as possible, to the question of nomenclature and symbols, which form the basis of the work of the Commission, the more difficult subjects being deferred until later.

The new President is to be formally elected at a meeting of the Council, which will most likely be held in London in the autumn.

STANDARD SYMBOLS FOR WIRING PLANS

AS ADOPTED AND RECOMMENDED BY

THE NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION OF THE UNITED STATES.

COPIES MAY BE HAD ON APPLICATION TO THE SECRETARY, UTICA, N. Y.

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Ceiling Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Bracket Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Stand. 16 C. P. Incan. Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. $\frac{6}{6}$ indicates 6-16 C. P. Stand. Incan. Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.

S^2 D. P. Switch Outlet.

S^3 3-Way Switch Outlet.

S^4 4-Way Switch Outlet.

S^D Automatic Door Switch Outlet.

S^E Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus; S^1 XII; meaning 12 Single Pole Switches. Describe Type of Switch in Specifications, that is, Flush or Surface Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

Pole Line.

Riser.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

Watchman Clock Outlet.

Watchman Station Outlet.

Master Time Clock Outlet.

Secondary Time Clock Outlet.

Door Opener.

Special Outlet; for Signal Systems, as described in Specifications.

Battery Outlet.

Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

Circuit for Clock, Telephone, Bell or other Service, run under Floor above concealed. Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 16 C. P. Incandescent lamps are desired, Specifications should describe capacity of Lamp to be used.

Factory Lighting.

By an Engineering Correspondent.

Factories, inasmuch as they must be placed in a category of their own, resemble churches, but with that one point of similarity the likeness ends. In my last article on 'Church Lighting,' I endeavoured to emphasize the necessity for placing art before utility; of paying special attention to the harmonizing and blending of the lighting effect with the general scheme of architecture; of avoiding anything that might jar in the slightest degree on the senses of the beholder, or of distracting his thoughts by lights placed where they were a source of discomfort. It is true that no extraordinary difficulties have to be overcome, or artistic problems solved in the illuminating of factories, but there are nevertheless certain conditions that obtain in this work that are not encountered in any other class of buildings.

The main considerations are economy and effective lighting, and it is to be remembered that the lighting has to be applied not for purposes of display, nor for the benefit of an onlooker, but for the purpose of assisting the employee in his work. Factory lighting requires very careful attention on the part of the electrical engineer who is entrusted with the carrying out of such work as a contractor, or who is required to draw up a scheme to be followed out and adhered to by another who does the actual installation work; and so much work of an unsatisfactory nature has been carried out in the past in buildings of this character, that the importance of having the system planned out and laid down in accordance with the laws of illumination cannot be neglected by the owners of such premises. It has been said that it is not only the hygienic conditions affecting the well-being of the workpeople that have been neglected, but that many installations have been badly designed, and consequently wasteful and inefficient as regards consumption of current.

Doubtless this is more true than is generally supposed, for it is possible to have lights fixed as to produce brain fag or strained eyesight in those working with them, as well as placed in positions where they are not of great use, as well as in places where they are not required. All these points lead to increased cost of production, either on account of downright wastefulness and extravagance, or by reason of decreased output on the part of the workmen. It is common knowledge that investigations into illumination and its relation to output were made many years ago in connexion with a cotton mill in this country, and we learn that the improvement in the lighting not only increased the output, but also reduced the number of wastes, or "seconds" that were made, thus showing improved economy on both accounts. From this it is evident that an intelligent study of the subject is required, and that the old happy-go-lucky plan of installing lights where it was most easy to find proper fixing must give place to the carefully thought out scheme whereby waste will be reduced to a minimum, and every light placed so as to be utilized to the fullest advantage.

To begin with, it is at once evident that factory lighting consists in almost every case of general and applied illumination There are large floor spaces without closely placed benches and machinery, such as the bobbin winding rooms in lace factories, or sorting rooms, where the small individual light units are not required. On the other hand, there are benches and machines where it is necessary that lights shall be so placed as to give a suitable illumination on some particular object. An illustration of this is well seen in foundry work, where the general casting floor may be taken as an example of space lighting, but the operations of making the more delicate moulds and cores require light directly applied to the work in hand. And for this reason it would appear that in the majority of cases mixed lighting, by means of arc or mercury vapour lamps for open spaces, with small incandescent units for the applied processes, would be most suitable. Between the two extremes will be found small spaces which are not sufficiently large to need an arc lamp, but which, if lighted by incandescent lamps, would be more costly than was advisable. For such positions large Nernst or high candle-power Tantalum or Osram lamps should be used. The province of the illuminating engineer is to study the special requirements of every part of the building he is dealing with, and advise or act according to the laws of lighting.

In the majority of cases factories are supplied with current from their own plant. Out of some eighteen or twenty large factories in which the writer has installed electric light and power, only some two or three were connected to a central station supply. The reason for this is not far to seek. Factory lighting cannot be considered as a valuable acquisiton to the supply company unless the hours of working keep the load out of the peak. Of course, in the case of factories working night and day shifts alternately throughout the year, as in the case of most lace factories, for twenty-four hours per day, the matter is different, as the long-hour output pays for the inconvenience of having the factory load synchronize with the shop lighting load for an hour or so. But, unfortunately for the station engineer, these are the very factories who prefer to install their own plant; the customers who are anxious to be connected are those who only require a supply of energy for lighting purposes for a very few hours per diem, and this at the same time when every one else requires current also. For this reason electric lighting authorities are unable to offer such premises any lower terms—by which I mean terms calculated on a maximum demand system—than other customers, with the inevitable result that the coupling-up is not only productive of no profit to the suppliers, but is a fertile cause of complaint, on account of high charges, on the part of the factory owner. There is no doubt but that this is the reason that so many factories have retained their old gas systems, or, when driven to change, installed some high pressure method of gas-lighting. This problem of cost of current will no doubt be simplified in the near future, when the electric drive on the group or individual machine principle is more largely adopted than at present, but to-day, in the majority of cases, factory lighting must be considered from the point of view of the private plant.

It is outside the province of this article to consider this in detail, except so far as relates to the arrangement of lighting from the standpoint of the illuminating engineer who has decided that electricity is the medium most suited to the requirements of the particular building.

The majority of modern factories are built on one level, the arrangement followed being in the form of a series of bays, in which natural light is utilized to the fullest extent by glazed roofing. These bays are supported on iron or steel pillars, and tied and braced with steel rods, thus affording but little assistance to the installation contractor during the wiring. As a general thing the plan of progressive dealing with the goods is adopted, the raw material being sent in to the material stores or sorting rooms at one end, and the stores for the finished articles, and the delivery bays being at the other. It is usual, seeing that natural light is not so much required in the latter stores, to build the offices above these, and overlooking the factory generally. The space and applied lighting, in such a building can be dealt with very easily, and the whole business is much more simple than in the older type of storied factories, where the only natural light is obtained from side windows. In these there is but little space lighting, as the benches, &c., where the actual manual labour is carried out are fixed under these windows, so that artificial light has to be arranged in small individual units to illuminate these benches. The machines are placed in the centre of the rooms as a general thing, and owing to this small light units have again to be provided; there being consequently but little opportunity for utilizing arcs or high candle-power lamps in any except packing or store rooms where the throwing of shadows is not so material a disadvantage. Experience has taught that no hard-and-fast rules can be laid down to meet the many varied conditions that are to be found in such buildings, and that every factory must be the subject of particular and separate study before any decision can be arrived at as to the type of lamps to be used, or their best positions be determined.

Where space lighting can be dealt with there are a number of suitable lamps which could be installed, and the question of area and height will be important factors for consideration. In some buildings, owing to the height being suitable, some admirable results have been obtained by arc-lighting alone. For example, in the very extensive works of Messrs. Napier, of Acton, the well-known motor car builders, some hundreds of flame arcs have been installed, to the entire or almost entire exclusion of smaller lighting units. The lamps, run four in series, are hung at a uniform height of twelve feet from the floor, and it is said that so perfect is the effect obtained that even the most delicate of operations can be carried out without difficulty. It is evident that such lamps could be arranged so as to kill all shadows, and give even illumination throughout. But it is but seldom that a factory is met with where such a method could be adopted in entirety with such success, and in the majority of cases mixed lighting must of necessity be installed.

For space lighting, the most suitable lamps, where there is sufficient height, are undoubtedly those of the flame arc type; and in cases where accurate colour rendering is of the slightest importance, as in practically all textile, litho, cleaning and dyeing, or colour printing works, lamps of the pure white, daylight effect, as those made under "Carbone" patents, are far superior to those obtaining their flame effect from the use of impregnated carbons. But where top space is not available, smaller arcs, as the "Radiant," or similar small white light arc lamps, consuming about three amperes will give a good effect, and can be easily arranged in the majority of cases so as to kill all (or practically all) shadows. The Nernst lamp is particularly suited for small space lighting, and has been adopted more largely in America than in this country, where it is for some reason not popular amongst contractors. But for foundries and low-ceiling machine shops it answers admirably, and when installed at a standard height of about nine feet, and spaced from eight to ten feet apart, gives excellent results. An argument in its favour is the low current consumption, although against this has to be placed the cost of renewals, which at one time represented an appreciable amount. It is only right to mention here, however, that the makers claim to have discovered the cause of the frequent failures of these lamps, and to have rendered the Nernst lamp as reliable as any other.

The value of the new metal filament lamps has yet to be thoroughly tested for factory lighting, since up to the present very little reliable data can be obtained. The question of vibration has to be taken closely into consideration, and the matters of life and depreciation must be taken into account. Their great advantage lies in their low specific consumption of energy, and it is probable that with the high candle-power lamps of this type better results as regards light and economy could be obtained than with any other lamp. It is too soon, as has been said, to speak authoritatively as to these, but the choice is already large and is certainly likely to become larger. As a matter of fact, metal filament lamps are quite in their infancy. Many large and well-known lamp-makers have not as yet completed their arrangements, and are no doubt going very closely into the subject, with a view to overcoming some of the disadvantages and weaknesses which are inseparable from all new departures.

In many cases of lighting the carbon lamp, in spite of the fact that compared with other types it is not economical in current consumption, as yet holds its own, as it withstands almost any amount of vibration, and can be used, as indeed can the "Tantalum," in any position. But it is not probable that the carbon lamp will occupy this position of superiority for any lengthy period, in view of the improvements in metal filament lamps that have been foreshadowed, and which may indeed be confidently expected. But at the present it more than holds its own for factory lighting, particularly if care is taken to install a high grade lamp. But it is with the arrangement of these small light units that the opportunity for economy comes, and it is in this respect that work carried out by a contractor who has studied the science of illumination will be superior in every respect to that carried out by one who has no further thought than to put in a light wherever some one, whether architect or factory owner, recommends it, or consideration of price per point affect the decision. In many instances the usual practice is to install a sixteen candle-power lamp at each machine, and it has been said that this, although not always considered altogether suitable by the illuminating engineer, has the sanction of custom and the hearty endorsement of those who are under the impression that only by this means can the same rate of output be obtained by artificial as by natural light. An interesting statement was made before the Chicago section of the Illuminating Engineering Society last year, to the effect that a bare lamp placed thirteen inches above the face plate of a drill press and seven inches from the centre gave when new and clean an illumination of five and a half foot candles at the centre of the plate, whilst an old and dirty lamp only gave approximately one and a half foot candles. From this it will be seen that a good deal depends on the illuminating engineer inside the factory, whose duty it is to keep the bulbs clean and in good order, and to install new lamps where and when necessary. If lamps are allowed to burn until they are black inside and coated with dust and dirt, even the best results of arrangement are nullified, and dissatisfaction certain to arise.

One point may be mentioned, and that is the matter of shades. Even in space lighting efforts should be made to ensure as much light as possible being thrown in a downward direction —except in cases where a suitable white ceiling makes diffused lighting admissible; and in applied lighting enamelled iron shades of sharp angle should always be used. With a suitable shade an eight candle-power lamp will give as good a result as a sixteen, with consequent reduction in cost of energy; and in many cases special reflectors of the poke-bonnet type will be even more suitable.

And so, to sum up, we have arrived, after due consideration, at the fact that in lighting workshops and factories, the services of an illuminating engineer who will intelligently study the individual requirements of each building are more than necessary, and are absolutely essential to ensure adequate, efficient, and economical lighting.

The Standardization of Coloured Glasses Applied to Illuminated Signals by Night.

By Auguste Pihan,
Director of the Lighting Laboratory of the French Northern Railway.

Coloured glasses have been for a long time applied to night signals, and it would seem that these should, therefore, be the subject of careful standardization; nevertheless, we have had occasion to observe that the depth of colour given to these glasses often bears no relation to the intensity of the source of light used to illuminate them, and that their utility is considerably restricted in consequence.

We often notice, for instance, that such signals show different colours from those demanded by the regulations applying to them; it is, therefore, the author's intention, in the course of this article, to indicate the conditions which make for the most perfect utility, and the lines on which a judicious choice of the coloured screens utilized in connexion with signal-lights should proceed. He proposes in what follows to define standards for glasses of various colours, and describe the practical method of testing them adopted by him.

Examination of Coloured Glasses.—Coloured glasses intended for signals should not be examined by daylight, but by the aid of the particular variety of light by means of which they will be illuminated under practical conditions. For the light passing through such a coloured glass depends not only on the nature of the metallic oxide used to tint the glass, but also on the spectral composition of the illuminating sources; thus certain blue glasses, when illuminated by sources rich in red and yellow light, may appear violet or even green, while many glasses which appear a beautiful violet under daylight conditions assume a nondescript hue when illuminated by artificial light.

The importance of establishing standards of colouration becomes evident when we consider the frequent application of such apparatus in connexion with the railways. For each particular colour, green or red for example, certain limits of colouration ought to be established, and a maximum and minimum laid down for the permissible variation of samples submitted for test. In the case of blue and violet, which necessarily absorb a large proportion of the light falling upon them, it is essential to establish one single standard of colouration for reasons which will appear later.

Method of comparing Glasses of a certain Colour among Themselves.—In making these measurements a convenient plan is to place the glass to be examined between two similar pieces of the standard glass, and place behind them a sheet of white paper illuminated by light from the source which will ultimately be employed in connexion with the glass in practice. Under these conditions any variation from the standard on the part of the middle glass, even though it be small, is rendered easily visible.

Determination of Maximum and Minimum Standards of Colouration for the Coloured Glasses commonly used in Signal Lights.—The intensity of the colouration, which it is convenient to adopt in a signal lamp, depends upon the intensity of the light employed, it being in general necessary to use weaker glasses according as the source is also weaker in intensity.

Red Glasses: A Standard of Minimum Colouration.—As the author has previously shown, it is not necessary to employ a very deep red glass in order to obtain a very clearly distinguishable red light at the minimum distance fixed by practical conditions at 100 metres. In reality, a pencil of coloured rays of light seems to behave somewhat like the rays passing through a tube filled with feebly coloured solution: the greater the depth of the solution the greater the accentuation of the colour appears.

In the same way the greater the distance between very weakly tinted red glasses, illuminated from behind, and the observer, the more accentuated becomes their apparent colour. Hence, if one makes use of a very deeply coloured glass it becomes indistinguishable a short distance away, and therefore imperfectly fulfils its function as a signal lamp.

In defining the minimum standard of colouration for red glasses the following process has been employed: the flame of the signal lamp is adjusted to its normal intensity, and then, at intervals of two seconds, a series of five glasses, varying in colour from orange to a deep red, are in turn placed in front of the flame so as to be presented to the eye of an observer standing 100 metres away. The least deeply tinted glass which, at the prescribed distance, appears undeniably and distinctly red is then selected.

B. Standard of Maximum Colouration.—For the degree of maximum colouration we select a shade twice as deep as that specified for the minimum standard above. This is easily accomplished, by utilizing two sheets of the minimum standard glass placed one above the other in front of the illuminated white paper as previously described. This still allows sufficient light to pass to be available as signals intended to be seen at a distance of several kilometres.

Ordinary Green Glass. — Maximum and Minimum Standard of Colouration. —In defining the limiting standards in the case of glass of this colour, one proceeds in exactly the same manner as in the case of red glass.

Signal Green Glasses.—Maximum and Minimum Standards of Colouration.— Signal green glass is chiefly utilized in connexion with signals at sea. By daylight illumination the glass appears bluish, but assumes a greener tinge when illuminated by a yellowish source, such as a kerosene lamp. Weakly coloured signal green lights appear white when viewed at a distance under certain conditions. For this reason it seems desirable to fix a single standard colour for glasses of this character, which must not be departed from.

Blue Glasses.—One Single Standard. While in the nature of things absorbing a great deal of light, blue glass, still more than signal green, does not encourage any departure from a suitably specified standard. It also presents the drawback of appearing colourless at a distance if the glass is too weakly coloured. Therefore, it seems essential to select, by actual observation at a distance of 100 metres, the type of glass which gives an unmistakable blue colour, coupled with as little absorption of light as possible, and to adhere to this standard.

Certain blue glasses give a violet colouration in conjunction with yellowish light, and these should be rejected because they might easily lead to a mistaken interpretation of the signals for which they are intended.

Violet Glasses.—One Single Standard. —This colour is but little utilized for night signals, and the author has no knowledge of any variety of glass employed for this purpose except the blue cobalt. This produces an apparently violet colouration, with the yellow flames normally employed as signals. The selection of a standard for this glass would have to be carefully carried out, for the least variation in the intensity of colouration of the glass causes the light emitted to be dominated by the red rays which the glass also allows to pass, and this might lead to serious misunderstanding.

The author is convinced from a wide experience that, by proceeding in the exact manner which has been described in this article, to fix the limits of colouration of glasses intended to be used with night signals, it is possible, in certain cases, to at least double the effective utility of such signals without any additional expense.

These recommendations are the result of prolonged experiments on the subject, which, however, space does not allow him to describe in detail in the present article.

SPECIAL SECTION.

Illumination and the Architect.

THE study of illumination is of exceptional interest to the architect, for the decorative schemes planned by him, and the architectural features of both the interiors and exteriors of buildings for which he is responsible, can only be rendered visible to the onlooker by means of adequate illumination. If the illumination is insufficient or incorrectly distributed, the general effects which the architect intended to produce will inevitably be more or less interfered with.

In the same way the intentions of the architect often bear very definitely on the nature of the scheme of illumination which an engineer may be called upon to introduce into an interior. The amount of light required is very greatly dependent upon the nature of the general scheme of decoration employed, and the placing of the sources of light in the room may be very greatly facilitated or otherwise by the arrangements of mouldings, friezes, &c., which the architect has seen fit to adopt. Hence the most perfect system of illumination would seem to entail some degree of co-operation between the man who is responsible for the architectural features of a building and the man who is concerned in the illumination of it.

The services which the architect can render to the cause of illumination are undoubtedly very valuable. In the first place, the degree of daylight illumination in a room is almost entirely the result of his efforts, and it must not be forgotten that in the majority of cases the greater portion of the work carried out in a building is done under daylight illumination. Yet whether such illumination is satisfactory or no depends chiefly upon the location and extent of the window-space and the method of decoration utilized. If the walls and furniture of a room are dark in texture it is usually not an easy matter to secure that all portions of the room are provided with adequate illumination.

In many cases it will, of course, be admitted that it is not necessary to secure an equally high illumination in all portions of a room, but even in this case no little skill is necessary to secure that the light in a desired position is both sufficiently strong and comes from the correct direction. In other cases, a number of people are equally distributed over the floor space of a room, and all desire to be able to read or write with comfort. In this connexion we may mention the important question of schoolroom lighting. The recent experiments of Prof. Scott in America showed that in many cases the illumination in the portions of schoolrooms most remote from the windows was very far from being satisfactory, and it seems to be admitted that in this country likewise the conditions are not always all that could be desired. Architects may do most valuable work by drawing attention to such defects, and co-operating with those responsible for the provision of artificial lighting in schools in order to see that adequate arrangements are made in the future. In Germany and America co-operation of this description is already customary, a joint committee, composed of lighting engineers, architects, and oculists having been formed with the object of designing the systems of daylight and artificial illumination in schools now being erected. And it seems possible that the defective conditions in schools, to which attention has recently been drawn by the publication of statistics referring to the eyesight of school children, would be found on examination to be at least equally prevalent in many factories, workshops, &c.

This, however, is only one of the aspects of illumination with which the architect is concerned, and in connexion with which he can do valuable work. There are many quite distinct objects which light is intended to accomplish, and the provision of adequate reading illumination is only one of these. As mentioned at the commencement of this article, light must also be regarded as often intended purely and simply to exhibit objects of decorative and artistic value—mouldings, friezes, and architectural features generally. In some cases this object has to be accomplished conjointly with the production of illumination for purely utilitarian purposes. In others the æsthetic may be said to be the predominant or even the exclusive aspect to be considered.

The nature of the contents of a room or building which we desire to exhibit must often influence both the quality and quantity of light desirable, quite apart from any conventional standard as to what constitutes a "good" illumination—by which is usually meant a good reading or writing illumination.

One cannot but feel that the lighting of many historic buildings and churches, &c., has often been carried out in a casual and unsatisfactory manner without receiving the care and study that such illumination demands.

In some cases the illumination has been quite insufficient to enable the true character of the building to be seen, while in others the illumination has been bright enough, certainly, but quite out of harmony with the surroundings.

Even in cases in which the illumination cannot be said to actually violate the dictates of good taste, one is often conscious that more might have been done to emphasize special features in the building. Architects themselves would doubtless be the first to acknowledge that the utilization of light for purely decorative purposes with the object, for instance, of creating certain play of light and shadow, and of stimulating the imagination of the observer, deserves far more study than the subject has received at present. We are constantly erecting buildings in our streets which, we consider, improve the appearance of our city by day, but are hardly visible by night. Something might doubtless be done to illuminate the exterior of such buildings in such a way as to produce a tasteful and artistic effect. Again the value of soft and diffusing sources of light as objects of decoration pure and simple certainly deserves more general appreciation.

There is also a wide field for the application of artistic principles to fixture design. The relation of these to their surroundings is certainly not as generally respected as the architect would desire, and it rests largely with him whether this point is sufficiently respected among engineers in the future. At present the difficulty is not that the latter are not anxious to learn what really constitutes æsthetic illumination, but that information on such points is not readily accessible or is presented in technical form not readily assimulated.

On all such questions as this the advice of the architect is valuable, and it is very desirable he should take an opportunity of putting his views on this question before those who are responsible for the illumination of public buildings. There has been a deplorable impression among both architects and engineers in the past that their views as regards questions of utility and artistic appearance were necessarily at variance. In reality the aims of engineer and architect are alike; both desire to produce a system of illumination best adapted for the purpose in view, but for want of the opportunity of discussing these questions each has occasionally failed to be sufficiently sympathetic with the objects with which the other is mainly concerned. Engineers have naturally been chiefly impressed with questions of efficiency of light production, and have been very ready to condemn so-called artistic fixtures, or globes which they consider badly adapted to the purpose of efficient light distribution. At the same time it is to be feared that they themselves, in their zeal for producing systems of illumination which are efficient from the utilitarian point of view, have occasionally adopted methods which are open to objection on artistic grounds.

Why should it be regarded as impossible to devise illuminating apparatus which is itself pleasing to the eye, which is arranged so as to produce the æsthetic conditions demanded, and which, nevertheless, is scientifically designed to effect its purpose with a minimum expenditure of energy ?

We have already suggested how valuable would be the co-operation of the architect in leading to a more general appreciation of what really constitutes artistic lighting. It is equally true that the architect would benefit by the co-operation of the engineer. The latter would be able to bring before him the very latest developments in the methods of illumination with which the architect naturally has not time to identify himself ; he might even be able to suggest how a globe or fixture might, by a slight modification, fulfil its æsthetic purpose and yet be vastly improved as an efficient distributor of light.

It may fairly be urged, too, that the requirements of illumination from a physiological standpoint would in the long run be found to be in harmony with the principles of the æsthetic lighting. Methods of illumination which are trying to the eyes, bright "speckly" patterns and violent contrasts of light and darkness, are usually not only physiologically bad, but would probably be considered the reverse of pleasing from an artistic view. Our conceptions of what is beautiful are probably physiological and psychological in origin ; anything which is distressing to either sense must tend to become inartistic.

In short, the requirements of good light from these three points of view, the utilitarian, physiological, and æsthetic, are not necessarily inartistic. In certain cases each of these aspects becomes the predominant one. The expert illuminating engineer of the future must be a man who is conversant with all three, and is able to judge the claims of each in an impartial manner. By the co-operation of those chiefly connected with one or other of these three aspects their relative importance in special cases will gradually come to be appreciated, and thus the impartial expert may eventually come into existence.

Electric Light as Related to Architecture.

By C. Howard Walker.

(From the Transactions of the Illuminating Engineering Society.)

In speaking about electric light as related to architecture, I have naturally to take the architect's point of view, that is to consider that when architecture is illuminated decoratively, it is not so much for the purpose of displaying the lamps as it is for the illumination of the architecture itself; which is a somewhat difficult problem, as our architecture is so diverse, and as most of it is far from being good. The illumination of architecture must be considered discriminatively. There are many buildings which would be very much better if they were not illuminated, and upon those buildings electric lamps may be placed, of which the effect is better than the architecture. There are buildings which have architectural merit, and in lighting those buildings, discrimination is necessary, and suppression of direct electrical effect is advisable if the building is to be shown at its best. I have seen buildings at night with electrical displays placed upon them which appeared better than they did by day, because of the ingenuity and the skill and the good taste of the electrician; and I have also seen buildings that were excellent in the daytime, but which lost all their merit at night, because the electrician had applied to them the same type of work he would have placed upon an inferior building. I suggest, therefore, that when a building is to be illuminated, you should ask yourselves as to the merit of that building, and if it is a thoroughly fine building architecturally, that you should suppress your electrical devices and your electrical effects *per se*, and apply electric lighting entirely toward illuminating the building so as to show it at its best at night, which means, that to a certain extent, you must adopt a day method of lighting. It is for this reason that I have divided the illuminating of the buildings, first, into different methods of lighting, and then have considered the application of these methods.

The factors which influence the electrical illumination of architecture can be readily analyzed; first, in regard to the character of the lighting; second, in regard to its position upon the buildings. The effects desired may be obtained by reflected light, the source of the light itself being concealed; by diffused light, shining through some translucent substance interposed between the light and the spectator, or by direct light, in which each source of light is undisguised.

In both direct and diffused lighting the effect is that of a series of luminous spots, each with or without a penumbra, which, by repetition, form lines, foci, and patterns. This type of lighting is the outlining of buildings by lamps, in much the same manner as a child draws with chalk on a slate. All light effects obtained by this method are independent of their background, except in so far as they follow its lines; as far as its masses, surfaces, and details are concerned, the lamps might as well be erected as a framework in the air. They are merely set pieces of permanent fireworks.

Diffused lighting through translucent material serves both to soften direct lighting, and also to afford a luminous background to inscriptions, devices, and other details, or to form conspicuous luminous areas.

Reflected lighting brings out the surfaces and details of a building in much the same way as does moonlight. As a matter of fact, all architecture is designed for effect by reflecting the light of the sun and, being so designed, it is but natural that it should appear at its best under artificial light when that light is reflected by the architecture. But the light reflected by architecture by day comes from one direction only, and produces shadows in one direction only, while that produced by artificial light must be received from several sources and directions. Artificially lighted architecture, therefore, depends for its effect more upon lighted areas than upon its shadows, these latter being constantly reduced by cross lights. The architectural skeleton, therefore, the cornices, beltcourses, columns, &c., are defined more by high lights than by heavy shadows, and these high lights should be more evident upon the projections than in the recesses. A dark building with light trims is always more satisfactory than a light building with dark trims. The latter seems like a photographer's negative, and much of the electric lighting of buildings also has this effect.

The fact that a line of lamps at the top of a cornice is usually satisfactory, is not entirely due to the spots of light, but largely to the fact that they illumine a strong structural projection, and produce the high light where it was intended in the design of the building. And in most buildings the horizontal lines are the proper ones to accent, especially if direct lighting is to be used. The intensity of light is such, that each spot diminishes very slightly in luminosity by increase of distance. There is little or no additional atmospheric diminution between lamps at 50 feet distance and those at 200 feet distance. Consequently the whole tendency of direct lighting is to diminish the apparent distance, excepting when perspective convergence of lines is very definite.

This convergence is, of course, apparent in all horizontal lines of light on planes receding from the spectator. It is but little apparent in groups of vertical lines. Consequently, the outlining of vertical structure, excepting in isolated towers, tends to diminish the effect of space, and should be avoided.

This fact has been demonstrated in exposition work.

There should also exist in direct lighting a discriminating sense of which are the major or minor factors of a building, especially when arches occur. It is the constant practice to outline an arch, merely because it is an arch, regardless of its relation to the remainder of the lighting. When the arch is a continuously repeated factor, as in an arcade of considerable length, of at least seven or more arches, it becomes a major factor, and can be satisfactorily outlined; otherwise it is isolated, and of little value. This does not, of course, apply to large central portal arches.

The outlining of openings tends to nullify the proper effect of architecture. The penetrations of a building should be maintained, and the thickness of wall and the reveals shown by reflected light.

The general indications, therefore, for good electrical illumination of architecture are these: First, that such illumination is best obtained by reflected lighting; second, that when the direct lighting is associated with reflected lighting, as it needs must be, a new and entirely separate intent is introduced; *i.e.* that of making a design in light itself associated with the architecture, and indicating its structure, but not its masses. All devices of lights only are of value for their own intrinsic beauty alone, having nothing whatever to do with the architecture, excepting that they indicate axes or terminations.

As vertical lines of light tend to diminish effect of space, they should be avoided, and horizontal lines of light which assist the effect of perspective and space should be used. It is manifest that reflected lighting must be produced from sources of light at some little distance from the surfaces lighted, and some of the most successful illuminations of architecture have resulted from combinations of direct lighting in horizontal lines, and reflected light from standards or large lamps away from the building. Wall-brackets and lamps in ceilings of porticoes, &c., are always successful.

It is natural that there should be a desire for some coloured light, merely as an effect of colour. If this is used, the effect is merely spectacular. Foci of colour, or entire lines of colour, may occur, but white light tempered by ground glass is the most permanently pleasing. If colour is used, alterations of strong colour, such as red and blue, are not nearly as effective as alternate lamps of white and colour. Variations of candle-power in arrangement and grouping of lights afford opportunities for very pleasing effects.

For instance, the main factors of a building, the cornices and lintels, would have a higher candle-power than the candle-power of the small details. Very often I have seen this reversed, and the effect of the architecture thereby destroyed.

There is a constant demand for new effects, the fact being somewhat ignored that good taste would be the most novel incident which could occur, and that there is no definite formula for good taste. Careful experiment and a discriminating sense of the difference between the lighting, which is intended to enhance the effect of the architecture, and that which is spectacular with architecture as its background, and the power to combine the two is to be desired.

There is another thing to be considered and that is the connexion between one set or line of lamps and another, especially in direct lighting. Electricians are very prone to run along until they strike something which they cannot get over, and do not know how to get around, and there is a gap of darkness before another lighted place appears. Immediately the continuity of the skeleton disappears, and the effect is of disjointed members.

The architect, as his name indicates, is the chief builder and constructor. His building should be solid, it ought to appear to have a strong structure, and it should be made in beautiful proportions. It is erected for daylight purposes. If it is successful at all, it should be best in daylight. The illumination which throws cross lights, and which has centres of reflection which grade into shadows, is a fairly low illumination; it is unsubstantial illumination; it begins to make architecture not so much solid as ephemeral. It has a beauty of its own; it is theatrical. The motif of reflected light from above, which has in it luminous deep shadows, is excellent lighting by night. It gives a new pleasure, and is perfectly consistent with any good architecture, but it is different from the daylight. The architect is designing for daylight, and if he cannot design a building that looks better for the time for which it is designed than it does when lighted in another manner, he has not succeeded, and that is what I meant when I said that a very large proportion of our buildings were not worthy of having light thrown on them. It would be a great deal better if the sun did not shine on them. Take the court-house in Boston for example; I have seen the court-house on moonlight nights when the series of great arches was very effective, and there is nothing finer than a great arcade, as the aqueducts which approach Rome testify, but our present court-house is so much superior by moonlight than daylight that you would not know it was the same building.

DISCUSSION.

President Sharp.—This paper comprises the two very important properties of being very instructive and very entertaining as well, and I am sure we feel indebted to the member who has presented it. This paper is now open for discussion. Is there any discussion?

Dr. E. P. Hyde.—There is one question suggested by Mr. Walker's paper on which I wish he would give us an expression of opinion—Is the architectural beauty of most buildings the greatest by daylight illumination? In other words, even in the case of a building which is architecturally very fine, is it not possible to bring out the architectural beauty of the building by artificial means better than we can by natural illumination? Are there not certain limitations that the architect cannot get around?

Mr. Walker.—There ought not to be, but there sometimes are.

Mr. Calvert.—Do I understand Mr. Walker that in the outlining of the outside of a building all vertical lines should be omitted?

Mr. Walker.—That depends upon whether your building is isolated or not. I meant to have made that definite. If you are standing directly in front of a building, and that building is a unit, there is no reason why vertical lines should not be used; but when you wish the effect of a vista, as in exposition work, and there are a series of buildings down a vista, the effect of vertical lines, as I found by experience, tends to diminish apparent distances. There is no atmosphere to render electric lighting effective. I have never seen frosted lamps tried in that way. I should suppose they would be much better than clear lamps, but you can realize at the distance of 50 ft. or 100 ft. the comparative intensity of the direct light from lamps at 800 ft. distance is not appreciable.

Mr. Willcox.—I ask Mr. Walker if he considers that as a general criticism of the modern practice, particularly in the West, of outlining buildings by lamps. We know it has grown to be the practice, to outline buildings with electric lamps, the verticals and horizontals, window tops and door tops, all over these buildings.

Mr. Walker.—The outlining of buildings with electric lights is exactly like a child drawing on a blackboard. The contrast between the lamps and the building is so great that you do not see the building—you see the lamps. If the building is bad I am glad to have the lamps there, but if the building is good I prefer to have it comparatively undisturbed by brilliant points of light. It is much better to use reflected light, with occasional points, where wanted, of direct light. The direct light is spectacular, and it might just as well, in most cases, be put up on a frame in the centre of Boston Common as far as it has to do with the buildings, but it is sometimes more effective than the building on which it is placed.

Artificial Illumination from the Architect's Standpoint

BY WALDO S. KELLOGG.

(From the *Transactions* of the Illuminating Engineering Society, March, 1906, No. 2.)

THIS paper will touch upon a few of the general features of interior illumination while attempting to outline the architect's interest and his relation to others interested in the same subject, but from a different standpoint.

The high intrinsic brilliancy of most lights is largely, I think, responsible for an immense part of the light usually wasted. In figuring on a high efficiency the maker forgets that the dazzling effect of an unshaded light so blinds the eye, that a much higher degree of illumination is required. In thus getting, for advertising purposes, a slightly higher theoretical efficiency, practical considerations are lost sight of. If the makers of lamps considered the best interests of the consumer, rather than the seller of current or gas, well-shaded lamps would be the rule, and not a special article supplied reluctantly at a price calculated to discourage their use.

The so-called 16 candle-power lamp has become the generally accepted lamp, but recently the tendency seems to be toward more powerful lamps, not because there is a demand for them, but by reason of improvement in lamp efficiency. It was remarked above that manufacturers catered to distributors of light, hence to induce them to take up their lamp, new units are made up using the former amount of gas or current, and a great noise is made about the intensity of illumination. If the public can get an innings it may pay to advertise. "We can give you the same light for half the money," instead of as now, "For the same money we can double your illumination."

There is no generally accepted standard lamp rating, except such as best suits the eccentric distribution of the lamp for which, at that moment, some manufacturer is claiming the merits of all other lamps besides other virtues. The candle is a reasonably satisfactory unit of measure, but the rating of lamps in candle-power should mean something and enable one to judge what the illuminating value really is. Spherical candle-power rating is a fair basis of comparison, and until the spherical rating is adopted no one, except he is able privately to ascertain the true rating, is prepared to say that a certain intensity of illumination can be obtained by using a given number of lamps of one kind or a different number of another kind. If without means to get data he must, to protect himself, put in outlets for two, and to be really safe, three times the number of lamps the manufacturer's rating in candle-power calls for, and the client is apt to complain of large lighting bills. It is in this necessity for protecting himself that the architect lays the foundation for the unpopularity of the light distributor.

In all cases a lamp should be so constructed as to harmonize with its architectural surroundings. In a carefully designed building the lamp, with as small a sacrifice of efficiency as possible, must conform to the architectural background. Thus, when a manufacturer professes to be unable to adopt a standard design to suit the architect's ideas, he must expect to be told that if such is the case the lamp will not be used, as considerations of efficiency are of less importance than the æsthetic ones.

The colour of any light plays a more important part than some manufacturers like to believe. Man has become so accustomed to the warm glow of candles or similar light that in domestic work he prefers a light of this colour, and a bluish white or greenish white light will be used only when a very strong light is needed. Women say that candle light adds to their natural attractiveness, and with them in opposition the sickly light is very heavily handicapped.

The architect is employed to make a structure both convenient and beautiful, and in doing this it is often necessary to sacrifice so-called practical considerations for others of an æsthetic nature naturally of great importance in the practice of a fine art.

DISCUSSION.

DR. EDWARD L. NICHOLS.—It is quite by accident that I happened upon your meeting to-night, but it was a very happy accident, and I take this opportunity of congratulating the new Society upon the attendance and the interest manifested in its objects......

Although we have been using light since prehistoric times, is it not true that at the present time we are still guessing about it? The architect and the contractor—everybody pretty much—are still guessing about it, and yet it is an art which is capable of being reduced to computation, and which can be made as much a matter of precision as any of the other specifications with which engineers have to deal. I hope that this society will bring it about, or help to bring it about, that these things in the future shall be attended with greater and greater certainty. We must stop measuring candle-power and begin to measure the illuminating effects. We must educate the public so that they will not look at the lights, but will consider the advantage of the illumination of surrounding objects from these lights. Of course, these things have been more or less dimly understood, and occasionally the principles have been worked out with great success; but there is a great field in this for the education of the public, and also for the education of the engineer himself. I really think that the organization of this Illuminating Engineering Society is something which will be memorable; that it will take a leading place among scientific and technical bodies, and that it will be an important factor in the development of a very old and imperfect art into a very new and highly perfect art. Especially will this be the case if you can get the scientific, the technical, the architectural, and the æsthetic interests to join hands. I shall not say anything about the papers now, but I did want to bring this word of welcome to the new society, and to wish all its members high success in their undertaking.

Suggestions as to how the Architect and the Engineer can Combine.

BY PERCY J. WALDRAM, F.S.I., *Past Chairman J.I.E.*

(Paper read before the Junior Institution of Engineers, Feb. 12th, 1908.)

ALTHOUGH this paper deals with the question of co-operation between the architect and the engineer from a general point of view, and not exclusively from the point of view of artificial lighting, much of what Mr. Waldram has to say applies very closely to the possibility of co-operation between the architect and the illuminating engineer. The author begins by quoting from a previous paper on the subject in which the suggestion was made that "Engineers should not hesitate to seek the collaboration of architects whenever architectural skill was necessary with their work. Architects have the responsible control of a very large field of engineering work, and a still larger field of potential work now left untouched," and:—

"It is the imperative duty of Institutions, on both sides, having a proportion of younger members, to do all in their power to extend early and fruitful connexions."

These words were written exactly ten years ago. Yet the author fears that not much progress has been made since that date, and that continental and American practice is to-day far ahead of British in the facility with which each profession absorbs all that is best in the other. The author does not, however, mean to suggest that the engineering and architectural professions should amalgamate, but simply that each should seek the assistance and co-operation of the other. There are many highly specialized branches of work in which the special knowledge of engineers would be very valuable; for instance, in such matters as water supply, heating, artificial lighting, ventilation, and reinforced concrete construction, &c. In this connexion the architect is fully aware that his knowledge and experience is limited to ordinary expedients, and when special appliances are necessary would be willing to seek the expert in these matters.

One difficulty which faces any attempt at co-operation is the question of where the engineer's fees are to come from, and the author considers that it is partially this difficulty which has led the architect not unfrequently to rely on the technical advice of the manufacturing engineer alone. Yet the latter is frequently adverse to subordinating his designs and methods to the intentions of the architect, and grows accustomed to giving him whatever he has generally been accustomed to produce in ordinary practice, without due regard to æsthetic considerations. Thus arrives the unfortunate condition of affairs that even an experienced and broad-minded architect, who appreciates to the full the constant triumphs of the engineer, yet prefers to have as little to do with him as possible in his work. In this he is unduly prejudiced, but has a considerable amount of reason on his side.

"What architects really need is the work of engineers who, whilst skilful, experienced, and well abreast of the times, are neither biassed nor in a position tending to influence their work and their judgment in the commercial interests of their own pockets. Architects want men who are ready to undertake small work at correspondingly small fees, and who will be willing to frame and vary their designs to comply with the requirements of their buildings. There is plenty of work for such men if the architect only knew where to find them, and the need of their services is increasing every day."

Engineers are equally in need of the assistance of the architect, though the average manufacturing engineer, unfortunately, seldom appreciates the work of the architect to the same extent that the latter appreciates his. He is apt to consider the architect as devoted to old traditions and customs, not very practical in his methods, and, in short, the last man to whom an engineer would go for practical assistance. This view is really very wrong and quite unjust to any architect worthy of the name, for in many cases the special knowledge of the architect would not only lead to the æsthetic appearance of the building being more satisfactory, but also to a considerable reduction of costs.

In short: "The kind of architects whom engineers need are experienced, practical, up-to-date men possessed of a discriminating knowledge of materials and processes, ready to undertake small work, and who are, above all things, able to express their ideas of beauty (at least in utilitarian buildings) through the best adaptation of means to an end, rather than by the application of extraneous ornamentation."

Among the present difficulties in the way of co-operation the author mentions:

(*a*) The difficulty of finding the right man at the right fee;
(*b*) Professional prejudice;
(*c*) Custom.

The first is regarded by the author as most serious, and, in order to secure the right man, he advocates the collaboration of societies devoted to the engineering and architectural professions. As a means of providing the fees demanded by the specialist engineer, he mentions the possibility of setting aside a proportion of the cost of such items as reinforced concrete, electric light, special ventilation, &c., which are generally included in the contract, and on which a quantity surveyor generally, but not invariably, receives a certain percentage.

By drawing on funds of this nature, small as they are, the cost of employing the specialist engineer might frequently be met without encroaching on the well-earned fees of the architect.

[Space does not allow us to include also the interesting recent paper by W. Basset Jones before the Illuminating Engineering Society of New York dealing with this subject. With this paper, and the instructive discussion to which it gave rise, we mean to deal fully in a subsequent issue.]

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Legislation of Gas-Testing.

THE BRENTFORD GAS CO. FINED FOR DEFICIENT ILLUMINATING POWER.

(Abstracted from the *Journal of Gas-Lighting*, Jan. 28th, 1908.)

AN interesting illustration of the anomalies that are sometimes presented by the prescribed methods of gas-testing is furnished by a recent judgment against the Brentford Gas Co.

In accordance with the Brentford Gas Act of 1868, this company is legally bound to supply 14 candle-power gas, the gas being tested by means of an Argand burner having 15 holes and using a 7 in. chimney, and passing 5 cubic feet of gas per hour.

On behalf of the Chiswick Urban District Council it was stated that on two occasions—Oct. 10th, 1907, and Jan. 15th, 1908—the company failed to supply gas of the statutory illuminating power. On Oct. 10th the tests made by the Council showed that an illuminating power of 11·13 candles only was obtained, while on Jan. 15th the value was also only 11·24 candles. Under the same circumstances the tests carried out by the Company, however, gave values well over 14 candle-power.

This difference was ascribed to the fact that the standard burners used in the two cases, though complying with the description above, were not the same.

According to the view taken by the Council the Company were legally obliged to adhere to the burner which was presumably intended by the Act of 1868, namely, the Sugg-Letheby Argand burner. The Company, however, contended that it was absurd to ignore all the changes in the manufacture and use of gas since 1868, and to tie them down to an admittedly obsolete and defective type of burner. "The Brentford gas-burner was thoroughly efficient," but the Sugg-Letheby burner was a "poor thing."

The use of this burner instead of the former one actually made a difference of 3 candle-power to the illuminating value of the gas tested, and if the local authority were correct in insisting that the Sugg-Letheby burner ought to be used, the price of gas would have to be increased by 3*d.* per 1,000 feet. The object of the Brentford Gas Co. was to sell gas as cheaply as possible.

Eventually, however, the Bench decided in favour of the District Council, holding that the Act of 1868 prescribed the burner used by the Council, and imposed on the Company a penalty of 10*l.* on each summons, and 100 guineas costs.

In commenting on the case the *Journal of Gas-Lighting* remarks that the Brentford Co. are indirectly responsible for the present unsatisfactory and uncertain position, owing to their not having applied to the Board of Trade with a view to obtaining a more modern system of testing.

On the other hand, not much sympathy can be expressed with a decision based on such antiquated conditions. The exact legal aspect of the matter turns upon what was really in the minds of the authorities in 1868. The expressed opinion of Mr. W. H. Patterson, one of the gas referees at this date, seems to suggest that in 1868 there was really no "standard" burner, in the strict sense of the word, and it appears possible that it was a mere coincidence that in 1868 Mr. Sugg introduced his No. 1 Argand burner, a burner that, in scientific refinement, was preferable to its predecessors.

Modern Photometrical Appliances.

(From the *Elektrotechnische Zeitschrift.* We are indebted to the courtesy of Messrs. The Union Electric Co., Ltd., for the use of the blocks illustrating this interesting article. The completeness of the photometrical equipment of the laboratories described therein may come as a revelation to many of those engaged in the testing of arc-lights in this country).

At their meeting in Hamburg during the present year the German Institution of Electrical Engineers (Verband Deutscher Elektrotechniker) laid down regulations referring to photometry: conferences have also taken place between the delegates of the International Photometrical Commission, the Union of Electrical Generating Stations (Vereinigung der Elektricitätswerke), and the Institution of Gas-and-Hydraulic-Engineers (Verein der Gas und Wasserfachmänner), with the object of determining, if possible, standard methods of procedure in photometrical testing. It was therefore thought that a description of an up-to-date photometrical laboratory, such as that utilized by Messrs. Körting and Mathiesen for arc-light testing, might be of general interest.

Two special rooms are devoted to photometry. The first of these occupies 9 by 10 metres in ground space and is 6·3 metres high, the whole of the interior of the room being thoroughly coated with a dull-black varnish. The second occupies 6 by 10 metres in floor area, and is 5 metres high, and in this case the walls and ceiling are left white.

The blackened photometer-room (which is shown in Figs. 1 to 4) is devoted to general photometric measurements, to the study of polar curves of distribution of light, and, in the case of alternating current, also to the investigation of waveforms of P.D. and current. Measurements of the colour-values of sources of light are also carried out in this room. The white photometer room (Fig. 5) serves mainly for the purpose of studying ground illumination with direct and inverted methods of illumination, and the performances of arc lights generally.

In the blackened room there exist three distinct photometric appliances, the oldest of which—a mirror "polar photometer"—is shown in Fig. 1. A fixed standard is attached to the table and carries at its upper extremity a horizontal axis, in front of which a stationary scale of angles is fixed. Two arms of equal length and each carrying a mirror are capable of rotating about this axis. Both mirrors are inclined to the axis at the same angle, and during rotation describe a circle at the mid point of which the lamp to be tested is placed, the light of the latter being screened in the direction of the axis referred to.

Both the arms carrying mirrors are displaced simultaneously through 5 degrees at a time, and the beam of light reflected from them at any particular angle is received on a photometric bench, which is to be seen on the left in Fig. 4. The intensity of this beam is compared with standardized glow lamps of 10, 16, and 25 H.K. respectively, by means of a Lummer-Brodhun photometer, the photometer being maintained stationary, while the observer adjusts the distance away of the glow lamp by utilizing a cord and pulley arrangement. The electrical measuring instruments are placed near the arc lamp, and this space is completely screened off except for the necessary aperture through which the beam of light from the arc is to pass. By means of this piece of apparatus polar curves of distribution of light can be obtained, due attention being paid to the co-efficient of reflection of the mirrors, but as a rule only lamps without globes are tested by this means.

A second appliance, for the purpose of obtaining polar curves is the "diagonal photometer" shown in Fig. 2. In the middle of the room are situated two vertical guide bars, between which the arc lamp to be tested is suspended and can be moved to and fro. The guide-bars are provided with graduation marks, corresponding to the position of the lamp. At right angles to these bars and running diagonally across the photometer room are placed four photometric benches which travel on fixed rails, and are all provided with Lummer-Brodhun photometers and calibrated comparison lamps. Measurements can then be made simultaneously by two or four observers in the following manner. The arc lamp and the photometric benches (at the zero point of which the photometer is

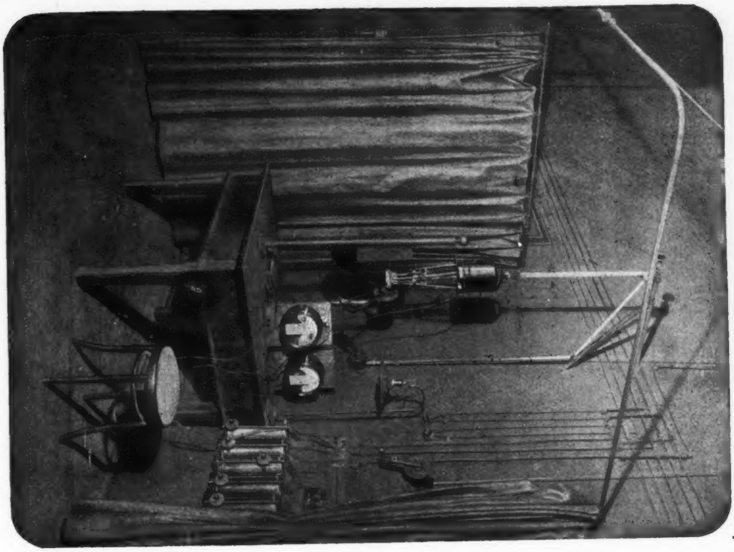

FIG. 1.—MIRROR "POLAR PHOTOMETER."

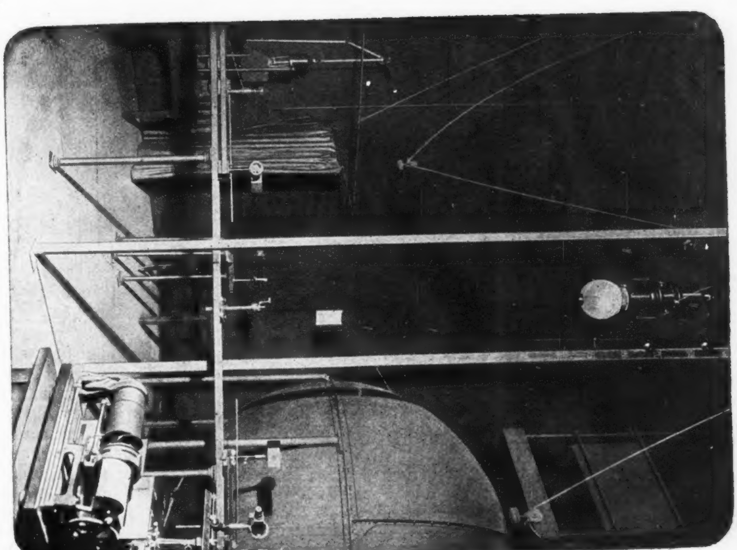

FIG. 2.—"DIAGONAL PHOTOMETER."

maintained) are adjusted to certain corresponding positions which have been calculated once and for all as being equivalent to certain angles of radiation to the horizontal on the part of the arc lamp under test. The photometer heads are then rotated through half this angle in the recognized way, and the observer obtains photometric balance by adjusting the distance of the comparison lamp. In this case also the electrical measuring instruments are situated in the screened room beside the mirror photometer, and are illuminated by a glow lamp.

The third photometric appliance consists of an Ulbricht globe photometer, 3 metres in diameter, which is used in combination with a Weber photometer (Fig. 3). The Ulbricht photometer enables the mean spherical or mean hemispherical candle-power to be obtained by a single measurement. Without entering into the theory of the instrument here, we content ourselves with describing a concrete instance of its application.

The globe is not divisible, but the interior is accessible by means of two openings at top and bottom respectively. By making use of the latter a man can work very comfortably in the interior of the globe—for the purpose of renewing the enamel, for instance. The lamp to be tested is lowered into the globe through the upper opening. A gallery is erected above the globe, which carries the necessary arrangements of suspension for the lamp and also the switchboard, series resistances, terminals, &c., and a movable table on which the electrical measuring instruments are erected. The suspending arrangements are so designed that an arc lamp can be withdrawn

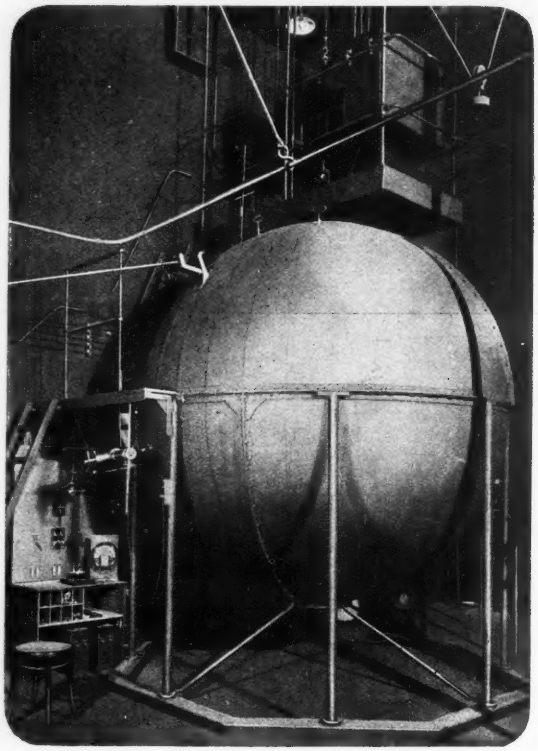

FIG. 3.—ULBRICHT GLOBE, WITH WEBER PHOTOMETER.

from the globe and then let down again without there being any reason to fear that its position has been altered. In the ordinary course of events one observer sits in this gallery, and it is his duty to attend to the arc lamps under test and read the instruments. At half the height of the globe a second gallery is erected. At this point there is a sight-hole, at the edge of the upper hemisphere, by the aid of which the position of lamps can be adjusted when it is desired to determine their mean lower hemispherical candle-power. Beneath this gallery is the window in the globe to P.D. is utilized throughout the photometer room.

For the study of the colour differences between various illuminants, a special piece of apparatus is employed which enables the two sources to illuminate two adjacent screens of diffusing glass. The spectrophotometer, seen in the background of Fig. 2, is also utilized for this purpose.

As a rule the polar photometer shown in Fig. 1 is only used for naked lights, as the mirrors are hardly large enough to permit the study of lamps equipped with globes. In such a case the diagona

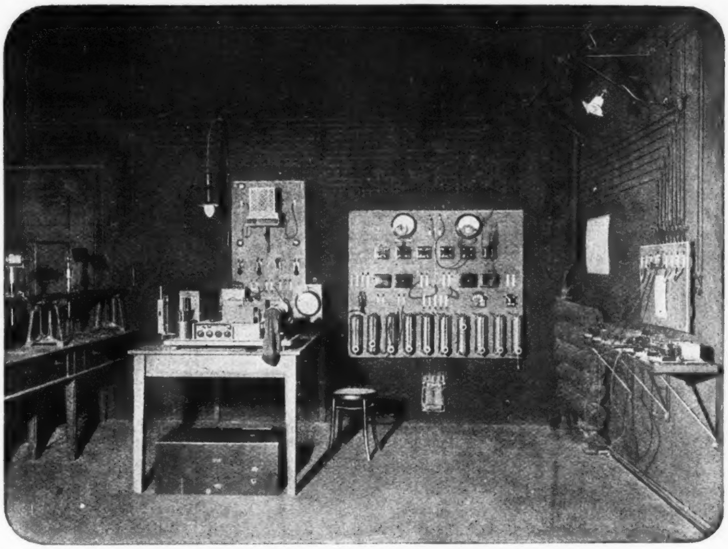

FIG. 4.—On the left is seen a photometric bench, in the centre an oscillograph, and on the right the distribution board.

which the Weber photometer is applied for the purpose of photometrical measurement. To the left of this is an arrangement for the purpose of calibrating the globe, together with the necessary switches, measuring instruments, &c., for the comparison lamps. These consist of three 100 H.K. calibrated glow lamps, the photometrical properties of which have been exactly determined.

All comparison lamps are fed by a battery of 60 accumulators the P.D. of which can be exactly regulated by a suitable adjustable resistance. The wiring of the circuits leading to the lamps is so contrived that exactly the same photometer proves serviceable; with this instrument one can obtain the polar curve of a source equipped with any form of shade or reflector. Both these appliances are suitable for the determination of mean hemi- and mean spherical C.P., but the process necessitates the obtaining of a great number of readings, and is therefore both laborious and inconvenient when the source of light to be tested is an unsteady one. The process is also too lengthy to be conveniently applied to the general study of the influence of different factors on the M.S.C.P.

To all such purposes the Ulbricht globe, which permits measurements to be made involving only a single reading, is specially adapted. With this instrument we are in a position to obtain reliable results in the case of even an unsteady and fluctuating source of light, and also to conduct researches on the actual influence of the alteration of this or that factor in connexion with the arc on the total light emitted.

For the purpose of studying the changes in the arc itself during the tests a projection arrangement is provided which throws an image of the arc on a screen situated behind the observer at the Weber photometer. This image is rendered visible to the observer by being reflected into a small mirror to the left of the photometer, so that he can follow all the variations in the structure of the arc while the experiments are in progress.

In order to utilize the globe for the measurement of mean hemispherical candle-power the centre of radiation of the lamp to be tested must be known. This last is determined on the diagonal photometer previously referred to by means of a vertically adjusted Lummer-Brodhun photometer-head.

Fig. 4 shows the arrangements utilized for the purpose of studying the wave-forms of current and P.D., which are in general obtained by means of an oscillograph. This apparatus serves for the study of the influence of the circuit on the nature of the current wave, observations of rectified alternating currents, and so forth. On the wall facing the table is erected a switchboard on which the necessary apparatus utilized in connexion with the oscillograph is mounted.

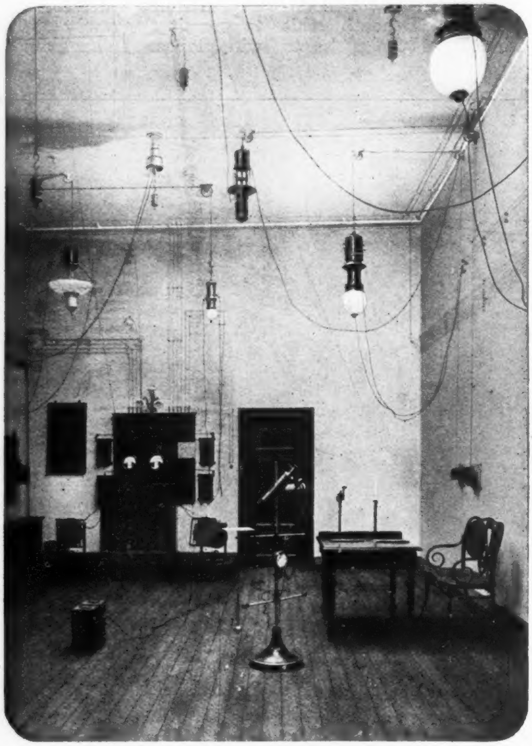

FIG. 5.—Measurements of Ground Illumination with Weber Photometer.

To the right of the table is seen the distribution board for the whole laboratory. The installation of the room is so contrived that an arc lamp can be used with any of the three photometrical arrangements described, with the same measuring instruments, and without it being necessary to disturb the circuits. In addition to this any rheostat or choking-coil can be switched into either of the circuits, and the wave-form of the current or P.D. of any lamp, in position for test, can be ascertained by the use of the oscillograph.

Finally attention must be drawn to the uses of the white photometer room shown in Fig. 5. The lamps to be studied are suspended near the ceiling of the room, and the illumination at a height of 1 meter above various points on the floor can be measured by means of a travelling Weber photometer. The comparison source in the Weber photometer consists of a small glow lamp which is fed by four portable accumulators. The photometer is calibrated by comparison with the Hefner lamp in the usual way. The influence of wall- and ceiling-reflection can also be studied. A shadow photometer is also provided by means of which two lamps having approximately the same candle-power can be compared.

The Influence of Atmospheric Pressure on the Sensitiveness of Selenium to Light.

The possibility of using selenium as a measurer of light is attracting no little attention at the present time, and repeated efforts have been made to obtain the substance in a reliable state so as to avoid the various irregularities in its behaviour which have hitherto hindered its successful application to photometry.

The discussion which has recently centred round the behaviour of selenium in vacuo in various journals is, therefore, of considerable interest. Reference may first be made to a letter by Mr. W. J. Hammer (*Electrical Review*, N.Y., October 12th, 1907). In this letter Mr. Hammer expresses the conviction that a selenium cell, enclosed in a satisfactory vacuum, showed no "photoelectric effect," *i.e.*, did not give rise to an E.M.F. under the influence of light. The existence of such an E.M.F. must, presumably, be considered an obstacle to the utilization of the well-known alteration in resistance of sensitive selenium cells when acted upon by light. Mr. Hammer upheld the view that such photoelectric effects are only caused by impurities, especially moisture, occurring when the cell is not protected from the atmosphere ; in short, cells enclosed in a vacuum are more constant in their behaviour and apparently better adapted to light measurements. Mr. Hammer has recently devised a new form of cells of this class (*Elec. World*, N.Y., Sept. 28th, 1907).

In a recent letter, however, Prof. Minchin (*Nature*, Dec. 26th, 1907) describes the results of an experiment which are quite contrary to the above supposition. In these experiments it was found that the resistance of a very sensitive cell, originally 61 million ohms, fell to only about 61 ohms when placed in an exhausted vessel, while the sensitiveness to light had disappeared. Three other cells behaved in the same way.

This letter called forth two further communications on the subject from Mr. R. J. Moss and Mr. Shelford Bidwell (*Nature*, Jan. 2nd, 1908). Mr. Shelford Bidwell suggested that the diminution in resistance referred to might be caused by a partial short circuit in the cell. Mr. Moss inquired if a mercury pump had been used in producing the vacuum surrounding the cell, because he had previously found that mercury readily combines with selenium. This might account for the change in its properties observed by Prof. Minchin.

In reply (*Nature*, Jan. 9th, 1908) Prof. Minchin states that the construction of the cells used rendered a short circuit out of the question. A mercury pump had, however, been used in the evacuation, and on repeating the experiments with another pump the resistance was found to increase slightly in vacuo, while the sensibility to light was retained.

Primary, Secondary, and Working Standards of Light.

BY EDWARD P. HYDE.

Taken from *Transactions* of the Illuminating Engineering Society, October, 1907, "Convention Issue."

(*Continued from p.* 76.)

THE situation with regard to secondary standards is quite different. It is generally conceded that the well-seasoned incandescent lamp meets every requirement of a secondary standard of light. The objection that is occasionally raised, that it changes with the time of burning, is not, in my opinion, as important as the changes which seem to take place at times when the lamp is stored away. A four-watts-per-candle lamp, if properly seasoned, will not change appreciably, *i.e.*, more than two or three parts in a thousand in fifty or seventy-five hours continuous burning. Since it only requires several minutes to measure an incandescent lamp, the standard lamp could be measured 500 or 1,000 times before it would change appreciably in intensity. Since at the Bureau of Standards there are incandescent lamp secondary standards that are only used once or twice a year, it is evident that if only the change in candle-power due to burning is to be reckoned with, the unit, in terms of which the secondary standards are expressed, could be maintained constant to within two or three parts in 1,000 for several hundred years.

On the other hand there seem to be much larger changes in the lamps from time to time while the lamps are not burning. Occasionally a lamp developes a bad vacuum; at other times, a change in resistance is noticed, indicating probably an altered contact resistance between the filament and the leading-in wires. But apart from these changes in candle-power, which are accompanied by changes in the electrical properties of the lamps, and which can probably be explained, there are apparent changes in intensity which are just over the limit of observational error, and for which we can offer no explanation. In determining the relative values of a number of incandescent lamps that have been intercompared before, one of the lamps may seem to be high or low in intensity, with respect to the mean of the remaining lamps, by a ½ per cent. or more. I do not mean that a single observer with one set of readings finds the lamp off by that amount—observational error might possibly account for that; but the mean of a number of sets by one observer agrees with the mean of a number of sets by another observer, in giving to that lamp a value somewhat different from that which it previously had. In another set of measurements, some time later, the lamp may come back to its original value.

Whether these apparent changes are due to slight differences in the condition of measurement at different times, or whether they are real changes in the lamps, it would be premature to say at present. They are small, however, and if a number of lamps are used, the mean value should remain sensibly constant over a long period.

The well-seasoned incandescent lamp is also an entirely satisfactory working standard in the photometry of electric lamps, but it is not suitable for use in gas photometry. It requires electric power to operate it and electrical measuring instruments to control it, and these are usually not available, particularly in small gas plants. But apart from its inconvenience, it is unsatisfactory. The intensity of a gas flame is a function of the atmospheric conditions, and it would not be practicable to correct all measurements to standard conditions, as that would involve determinations not only of water vapour and carbon dioxide, but also of the proportion of oxygen present in the atmosphere. In supplying gas, however, it is desirable for the manufacturer to state that the candle-power of the gas furnished would be up to the requirement, under normal atmospheric conditions. The way in which to determine this, without actually making the corrections, is to have as a working standard a lamp that is affected by the atmospheric conditions in the same way and to the same amount as the gas under test. If the intensity of the standard lamp under normal conditions is known, the candle-power of the gas under normal conditions is obtained immediately, by direct comparison with the standard lamp, independent of the atmospheric condition of the photometer room, provided it is uniform throughout the room.

The consensus of opinion among gas engineers is certainly that the working standard for gas photometry should be a flame standard. There seems to be less unanimity, however, in regard to what flame standard should be used. Candles are still used to some extent in the United States and abroad, but recently there has been considerable advancement, both in this country and in England, in the adoption of the Harcourt 10-candle-power pentane lamp. In Germany the Hefner lamp is used now to a great extent in gas photometry, I believe, and in France the Carcel lamp continues to be used almost exclusively. But although flame standards have been, and still are, used in gas photometry, I do not know of any investigation of the relative influence of atmospheric changes on the gas and the standard lamp. It is scarcely justifiable to assume that the coefficients are the same for two such flames as the pentane flame and the gas flame, which are controlled in entirely different ways. The pentane lamp is adjusted for flame height, whereas in much of the gaswork the flame of the bat-wing burner is adjusted to a definite rate of consumption of gas by weight. Recently, in co-operation with the United Gas Improvement Company of Philadelphia, the Bureau of Standards made some experiments along this line in one of the company's gas-testing photometer rooms in Philadelphia. Although these preliminary experiments were not carried far enough to warrant any very definite conclusions, they indicated that the two flames, the pentane and the gas, are affected in the same way, to approximately the same extent, by changes in the atmosphere. Since differences of 8 or 10 per cent. in the intensity of the standard lamp may readily occur under normal working conditions, it is evident that if results of any accuracy are sought, it is not sufficient that the atmospheric conditions affect the standard flame and the gas flame in the same direction; the coefficients of change for the two should be very nearly the same.

Another interesting fact in connexion with the working standards in gas photometry is that, with the possible exception of the Carcel lamp, which, I believe, has been calibrated in terms of the Violle standard, all of the lamps used as working standards are at the same time primary standards. In the photometry of electric lamps, the seasoned incandescent lamp soon came to be used as the working standard, since the primary flame standards were not convenient. But in the photometry of gas, since a flame standard was desired, the primary standards came to be used as the working standards. Although this is a logical result, it is questionable whether it is the most satisfactory one.

Is it not possible that a cheap and portable lamp, which would remain constant in intensity after having been calibrated, might be found which would be more convenient and more easily manipulated than the Harcourt pentane lamp, for example? It does not follow that the lamp which best satisfies the requirements of both a primary and a working standard will satisfy the requirements of a working standard alone better than any other lamp. In other words, the lamp which is best with respect to both constancy and reproducibility need not be the most constant lamp, if reproducibility is eliminated. With authoritative testing laboratories available, where secondary standards are maintained, it is no longer necessary that the primary standards should be used in industrial photometry.

I have no such lamp to suggest as a working standard for gas, and it is possible that none can be found, but I think it is well to divorce the functions of the two kinds of standards. Reproducibility is the chief requirement for a primary standard, and constancy with burning is only a convenience. With the working standard, reproducibility is of no consequence; the lamp, however, should remain constant while burning, thus maintaining the candle-power assigned to it on calibration. If the lamp which is the most reproducible is the most constant and convenient, then use it as a working standard, but do not confine the search for a working standard to those lamps which are reproducible.

The use of a primary standard as a working standard may, however, lead to a confusion of units between the gas and electric industries. This is exemplified by the situation in our own country at present. Both in the photometry of gas and of electric lamps the intention was to use the British parliamentary candle. The American Institute of Electrical Engineers recommended obtaining the candle through the hefner by the use of the ratio one hefner equals 0·88 candle, which was supposed to be the mean value of the best determinations of that ratio In gas photometry the sperm candle, or, more generally in recent years, the Harcourt pentane lamp, has been used.

It is definitely known now that the candle obtained through the pentane lamp does not bear to the hefner candle the ratio of 1 to 0·88. From comparisons through electric lamps measured at the National Physical Laboratory in England and at the Physikalische-Technische - Reichsan - stalt in Germany, the above ratio is found to be in error by 2 per cent. From direct comparisons of Hefner and Harcourt pentane lamps the ratio appears to be in error by 4 or 5 per cent. If now both the gas and electric lighting industries adopted the same unit, which could be maintained at a national laboratory, and in terms of which working standards for both gas and electric lamps could be calibrated, "candle-power" would have a single significance throughout the entire country.

The final step would be to agree with other civilized countries on the value of the unit adopted, so that we might have in photometry, as in most other branches of physical science, an international unit. Although the German unit is so different from the others as to offer considerable difficulty to the realization of this plan, the units of England, France, and the United States are sufficiently close to warrant a compromise. This compromise would not entail the abolishment of the present standards; it would merely necessitate assigning to the standards different numerical values. Thus the Carcel would no longer be 9·6 bougies décimales, but probably 9·5 or 9·4 international candles. Each country could maintain the unit through whatever standards it chose, primary or secondary, but by frequent intercomparisons among the various countries, the unit would be maintained. Let the search for a suitable primary standard be continued, and may the time soon come when there shall not only be an international unit, but an international standard, which shall take rank with the other international standards of modern science.

DISCUSSION.

(Slightly abridged.)

President Sharp.—The paper by Dr. Hyde is of unusual importance, in that it recommends the adoption of an international unit of light as independent of the standard. This paper is now open for discussion.

Dr. Louis Bell, Boston.—I am much interested in Dr. Hyde's very able discussion of this troublesome question of standards. The work of this Society lends particular importance to work of this kind. The work of this Society is more difficult from a technical standpoint than that of any other scientific body with which I am connected, chiefly because we have no standards. We have an art without any standards of measurement, and, moreover, we are in a greater danger than any other body with which I am acquainted of falling apart from a lack of these standards of measurement, because we lack definite specifications for methods of reaching these standards, and we run greater risks of apparent inaccuracy than any other class of engineers with which I am connected. That is particularly true in the measurement of illumination—measurement of intensity is bad enough, but measurement of illumination is tenfold worse. It has nearly, in fact, tenfold the probability of possible error.

It seems to me that Dr. Hyde's suggestion as to the final step to take is really the preliminary step to which all our energies should be centred—towards getting an international standard of light to which we can make reference through any system of working standards we please, and which would be one and the same in all civilized countries. That was the preliminary step which had to be taken before we got our electrical measurements and electrical nomenclature in anything like systematic form. We tumbled around for years with two or three standards of volts and resistances, and when I began to study electricity the ampere was known as the Weber, a name which now means something very different. This Society, with its international membership and its catholicity of interests, representing all branches of engineering which have to do with light and illumination, is in better shape than any society has been before to deal with the international side of the question through the co-operation of our foreign confrères.

The best energy of the Society should be turned toward getting some sort of international convention as to a uniform standard of light and intensity, and upon which we can base a systematic treatment of derived units. It is the international feature of the work which appeals to me particularly, because, once given a definite international standard, so that we are all talking about the same thing, it will be comparatively easy to settle down upon some definite illumination photometers which will lead to less devious and wild results than are now obtainable.

Preston S. Millar, New York.—I am very glad to learn Dr. Hyde's high appreciation of the excellence of the incandescent electric lamp as a secondary standard of light. Probably a concrete instance of its reliability may be of interest at this time. I think it was in 1889 that a group of incandescent electric lamps was standardized at the German Reichsanstalt against the Hefner lamp. These lamps were secured by the General Electric Company, and, I believe, are still in their possession. In 1896 we, at the Electrical Testing Laboratories, were permitted to make copies of those lamps. From that time we have endeavoured to maintain that standard. Recent comparisons with the Reichsanstalt indicated that the standard has not varied, since that time, by as much as 1 per cent., and probably by not more than ½ per cent.

When the National Bureau of Standards very properly took up this problem, a few years ago, we were very much gratified to learn that the standard which they had decided upon, after studying the situation carefully, was, so far as could be determined, in absolute accord with that which we had endeavoured to maintain. So, at the present time, electric lighting in this country is based, so far as the candle-power unit is concerned, on incandescent lamps which were standardized in 1889, and which to-day we believe have not changed in value, except in individual cases where lamps have altered materially for certain obvious reasons.

I think there is something to be said regarding the use of the flame standards in gas photometry, particularly that of mantle burners. It is true that it is the consensus of opinion among gas engineers that the pentane lamp is the most suitable standard, but is it not also true that they believe this because they have never given a fair trial to the incandescent electric lamp ? I believe, from personal experience, that the incandescent electric lamp merits such a trial, and I think the conviction is growing among gas engineers that such is the case.

A. E. Forstall, New York.—I think that Mr. Millar is a little mistaken as to the reason for the predilection of gas engineers for the flame standard for photometric purposes. I think Dr. Hyde expresses the real reason quite fully in his paper. I know in discussions which have taken place on photometric standards at gas association meetings, that has been the point brought out most frankly as the reason for preferring a flame standard, even by the people who use an electrical standard as a working standard for some of their work. If you are going to be tied by law to a definite illuminating value for your gas, under penalty of a fine if the photometric test does not come up to that standard, you certainly should not be subjected to a fine because the atmospheric conditions affect your flame and do not affect the standard, and therefore it seems to me it is a logical necessity that the standard used for testing gas, or testing any other flame, should be a flame standard which will be affected by atmospheric conditions to the same extent as the flame under test.

There is a point in Dr. Hyde's paper that I am not certain I understand. He says: "It is definitely known now that the candle obtained through the pentane lamp does not bear to the Hefner candle the ratio of one to 0·88." I had never known that in the United States there was a candle obtained through the pentane lamp. If I am correct, the practice in Great Britain is to consider that every pentane lamp gives a light of exactly 10 standard candles; but as far as I am acquainted with the practice in the United States, each lamp is separately calibrated by a number of tests against standard candles, and its value, as thus determined, is used when it is used as standard; in fact, in the United States the pentane lamp is not really a primary standard, but a working standard.

Dr. Hyde.—The statement in my paper has significance only in reference to the use of the pentane lamp as a primary standard of light. At the National Physical Laboratory, which is supposed to maintain the authoritative standards for England, they take as their standard of candle-power the intensity of the pentane lamp in their possession which they define to be 10 candles. It is usually assumed that all pentane lamps, if made according to specifications, would have the same intensity, and, if I am correctly informed, the intention of the practice in this country in the use of the pentane lamp is to reproduce the same unit of candle-power as that used in England. As stated in my paper, every recent determination has shown the ratio of the Hefner unit to this English parliamentary candle to be greater than 0·88, the value commonly accepted from earlier determinations, and expressing the ratio of the Hefner to the candle unit used in the photometry of electric lamps in this country.

T. J. LITLE, Jr., Gloucester, N.J.—We have a number of organizations in this country, some gas and some electric, and inasmuch as the electrical organizations will probably favour the electrical standards of the present day, and as the gas organizations would in the same way favour the standards they are now using, and realizing that the adoption of Dr. Hyde's ideals of standardization of the unit of light would be rather difficult, and inasmuch as this Society is not affiliated with either one directly, and is supposed to be for both or all of the various lighting systems, it seems to me that this would be the logical organization to push the scheme suggested. I should think it would be in order to have a committee take the suggestions, in whole or in part, which have been presented in Dr. Hyde's paper, and try in some way to propagate the idea, and bring the matter forcibly to the attention of the two great forces of the country—the electric and the gas organizations. Dr. Bell calls my attention to the International Photometrical Commission, but quite irrespective of this commission, it seems to me that this is the logical society to exploit the scheme.

C. O. BOND, Philadelphia.—There are two points in connexion with the paper to which I desire to call attention. One is that at the present time a meeting of the International Photometrical Commission is being held at Zurich, and it is discussing this very question. Three sub-committees — the English, German, and French—have worked out the ratios existing between the values of the respective countries, and the report of these three sub-committees will be embodied in a common report. Any action which they may take will be taken very shortly probably. Would it not be possible for the Committee on Nomenclature and Standards of this organization to keep in touch with this International Incandescent Photometric Commission to act in unison with it?

PRESIDENT SHARP.—If I may be allowed, I would like to call attention to two or three things in this paper. I think we should ponder deeply on the statement on the first page that the eye is made the scapegoat for faulty methods or incorrect measurements. I think that this is too often the case. I should like to know from a practical incandescent lamp manufacturer, such as I know is present, whether it would not be practicable—this is wholly hypothetical—in case all of our primary and secondary standards were lost, for a lamp manufacturer to reproduce our present standard by the manufacture of a large number of incandescent lamps, computing as the manufacturers do, what the candle-power should be beforehand, and averaging up the actual candle-power of the whole lot. Would he not come very close to our present standard?

I would call attention to the fact that nothing is said in this paper regarding the photometry of the incandescent mantle burner, and proper standards for use in that connexion. That is an important field, and should be gone into. I raise the question whether it is not probable that lamps of the same temperature are very similarly affected by humidity conditions. I also call attention to the lamp which the last speaker referred to, Dr. Elliott's lamp, which has certain merits as a working standard for gas photometry, such as Dr. Hyde proposes. I will call on Dr. Hyde to close the discussion.

DR. EDWARD P. HYDE.—It seems to me the subject has been threshed so thoroughly now, that there is very little for me to say in closing the discussion. I do want to endorse heartily what Dr. Bell said, and what Mr. Litle and several of the other members referred to in their remarks, in regard to some possible action along this line. I did not describe the situation in the paper, because I thought that the members of the Society understood it perfectly well. It seems to me that there is no other association in this country or abroad better fitted to push this question of an international unit than the Illuminating Engineering Society, and I would be very glad if this Society would take the initiative in this matter. It will be a slow process, naturally. We probably cannot reach an agreement in two or three years; but if we are working for the right end we ought to be satisfied. The longer we delay starting, however, the more difficult will the problem become, as the methods of photometry are becoming more accurate, and the ratios of the different standards are becoming more definitely determined every year. If we want to get this international unit, the thing to do is to strike right now while the iron is hot.

A New Process for obtaining Polar Curves of Distribution of Light of Artificial Illuminants.

By W. Voege.

(From the *Electrotechnische Zeitschrift.* January 16th, 1908.)

During the last few years successfu efforts have been made to devise apparatus enabling the mean-spherical and mean-hemispherical candle-power from sources of light to be determined by a single measurement. In this connexion mention may be made of the Ulbricht globe photometer and the Matthews integrating photometer. These photometers, however, do not enable us to investigate the polar curves of light distribution of the sources under test. Yet nowadays it is very essential that this distribution should be studied. Our artificial lights are now so varied. We may wish, for instance, to compare the merits of arc lamps with vertical and inclined carbons, glow-lamps with filaments of various shapes, different types of diffusing globes, &c. The process of obtaining these curves by photometrical measurements at various angles to the horizontal is an extremely tedious one, and, in the case of lamps which are inclined to burn unsteadily, is also far from accurate.

The process would be greatly facilitated if photometrical measurements could be replaced by observations of the deflections of a galvanometer. Selenium naturally occurs to our minds in this connexion. We may, for instance, make use of the alteration in resistance of a selenium cell attached to an arm rotating about the source of light under test. The author has made many researches on the value of selenium from this point of view, but without really satisfactory results. The sensitiveness of the selenium cell is certainly ample, but the inertia, even in the case of the latest forms, is very considerable. The variation in resistance caused by a given intensity of illumination, is affected by the duration of exposure, and the time which must elapse before a constant state is attained is very uncertain. It is also unfortunate that the alteration in resistance of the selenium cell is not directly proportional to the intensity of the illumination. One never knows whether gradual changes in the condition of the selenium cell may not have taken place. This necessitates occasional recalibration, and—owing to the peculiarity of selenium referred to above—calibration over the whole scale.

On this ground the author has been obliged to abandon the use of selenium for obtaining curves of light distribution.

On the other hand he has succeeded in attaining his aim by utilizing the thermopile. The thermopile naturally does not react to visible rays alone, but is affected by the entire spectrum, by the radiating body, and mainly by the invisible heat rays. These rays, therefore, in the author's apparatus, are absorbed by fixed slips of clear glass, which are placed in front of the face of the thermopile.

The thermopile naturally cannot be utilized for absolute measurement of light, but, on the other hand, is well adapted for the comparison of the radiation in different directions of the same source where the ratio visible to total radiation is the same for all portions of the incandescent material. This is true in the case of an electric incandescent lamp, the filament of which is in the radiating condition throughout its entire length. Precautions must, of course, be taken to secure that the distance of the thermopile from such a lamp is so great that the dimensions of the filament can be neglected in comparison.

As the E.M.F. of the thermopile is directly proportional to the intensity of the radiation striking it, we need only observe the deflections of a galvanometer in order to obtain a polar curve, which closely resembles the usual curve of distribution of light. If we then obtain the candle-power in any specified direction by a photometrical method, we can multiply by a suitable factor and express the curve in candle-power throughout.

Whether this process is equally applicable in the case of arc lamps is not so certain. In the case of flame arcs, for instance, the radiation of heat is effected mainly by the glowing tips of the carbons, while the main source of light, on the other hand, is the luminescent vapour. We might, therefore, obtain a different curve by this process from that obtained by a purely photometrical method. By taking the following precautions, however, the author believes that he has succeeded in rendering the process of practical application to arc lamps :—

1. In the case of arc lamps a piece of green glass, as well as the clear glasses previously mentioned, is placed in front of the face of the thermopile. This glass absorbs the red rays to a great extent, and so reduces any error introduced thereby to a minimum. The sensitiveness of the thermopile is naturally reduced, but still suffices. The author in his experiments used coloured glass about the thickness of 3 millimetres, and green glass 1·5 millimetres thick.

2. The thermopile is provided with a collector which concentrates the rays given out in different directions from the source over a certain solid angle on the face of the thermopile. We thus measure the mean of the radiation coming from different points in the arc itself or the globe surrounding it, and collected in this way, just as under practical conditions. For, in practice, an extended surface is illuminated by the rays coming from all the various points in the radiating body.

The results of a large number of experiments have convinced the author that a correct conception of the distribution of light from an arc lamp is obtained by this means, especially when the lamp is surrounded by a globe. In doubtful cases we can easily check the results by observing whether the distribution curve obtained is the same when obtained, first with red glass, and secondly with green glass. Under these conditions both curves should agree, and this was invariably the case during the author's experiments. The following table shows the results of a recent test on this point :—

Angle of inclination to vertical.	Green Glass a_{gr}	Red Glass a_r	$\frac{a_r}{a_{gr}}$
0	56	66	1·18
10	74	83	1·12
20	74·5	85·5	1·15
30	71	87	1·22
40	71·5	86	1·20
50	69·5	85	1·22
60	66·5	78	1·17
70	64·5	71·5	1·12
80	49	62·5	1·26
90	16	46	2·88 (?)

It will be seen that the ratio $\frac{a_r}{a_{gr}}$ does not differ materially throughout, if we bear in mind the irregularities necessarily introduced by the regulation of the arc itself. The discrepancy occurring at an angle of 90 degrees is probably to be attributed entirely to this cause.

By this process distribution curves can be simply and easily obtained in a few minutes. By varying the length of the arm carrying the thermopile, or the thickness of the glasses screening the face of it, the same arrangements can be applied to the study of arc lamps and also glow lamps, which are relatively weak in candle-power. In the author's experiments a Rubens thermopile and a Siemens and Halske galvanometer of 30 ohms resistance were employed, and the distance of the scale from the galvanometer was 5 metres. Under these conditions a deflection of up to 1½ metres was obtainable. The length of the arm carrying the thermopile was 40 to 60 centimetres in the case of glow-lamps, and 80 to 100 in the case of arc lamps. The readings were very steady, any irregularities due to draughts being avoided by the glass screen in front of the face of the thermopile. A constant and steady deflection was reached in 20 seconds; the variation in zero in the course of the experiment did not exceed 2 to 3 millimetres, and can therefore be ignored. In Fig. 1, one of the curves of distribution of light obtained by this means is represented.

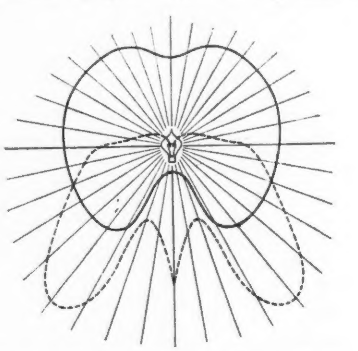

FIG. 1.—CARBON FILAMENT GLOW LAMP.
—— Clear glass bulb.
------ Upper half of bulb silvered over.

This refers to a carbon filament glow-lamp. The author, however, also gives the results of testing Tantalum, arc, and incandescent gas lamps by his method.

The process can be further simplified by making such arrangements that a spot of light from the reflecting galvanometer automatically traces out a polar curve of light distribution. This is effected by enclosing a disc of sensitive paper in a light-tight box, a slit only being provided through which can pass the beam of light from the mirror galvanometer. The sensitive screen is fixed to the arm carrying the thermopile, and rotates about the same axis as the latter, as it is adjusted to its successive positions. The spot of light meanwhile light under test can furnish the light required for the mirror galvanometer, as shown in the diagram.

The arrangements just described can also be conveniently utilized to register the fluctuations in candle-power of the source of light tested. For this purpose a spot of light is caused to fall upon a sheet of sensitive paper stretched on a

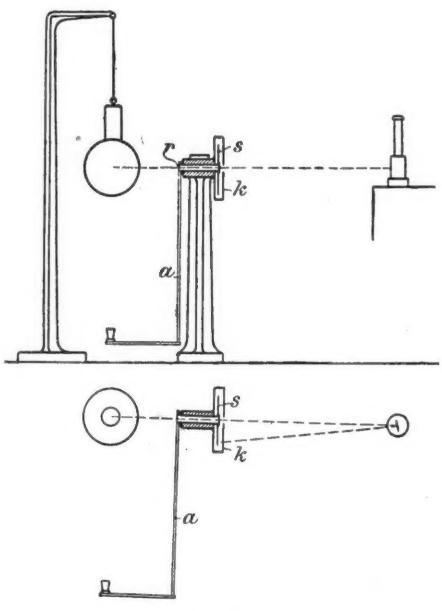

FIG. 2.

"*s*" Sensitive screen, "*k*" light-tight box.
"*r*" Rotating tube to which the arm carrying thermopile, is attached.
"*a*" Arm carrying thermopile.

travels diagonally across the disc, and its ultimate position, corresponding to each position of the arm, traces out the curve.

The arrangement is shown in Fig. 2, where *s* is the sensitive screen, *k* the light-tight box enclosing it, and *r* the rotating tube to which the arm *a* is attached. If desirable, the source of drum rotated by clockwork at a uniform and known rate. Three of the records obtained by the author in this way are shown in Figs. 3, 4, and 5. Of special interest is Fig. 3, in which the variation in candle-power of a glow-lamp running on the Hamburg electrical supply mains is represented. The two gaps *a* to *b* are caused by the momentary fall in P.D., caused by switching a large induction coil on to the lighting mains. The remaining Figs. 4 and 5 represent the performances of two enclosed arc lamps which were provided with opal globes, and supplied from a battery of accumulators producing a very steady pressure.

Fig. 4 shows the working of one of the older type of Lilliput lamps, and Fig. 5 the improved regulation of a more recent efficient enclosed arc lamp by the same firm.

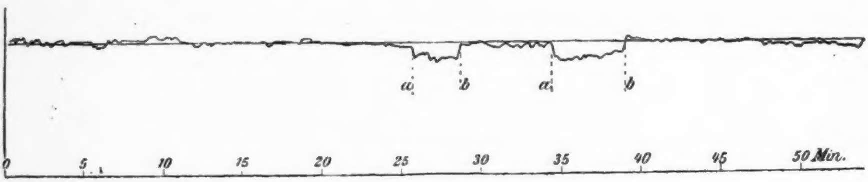

Fig. 3.

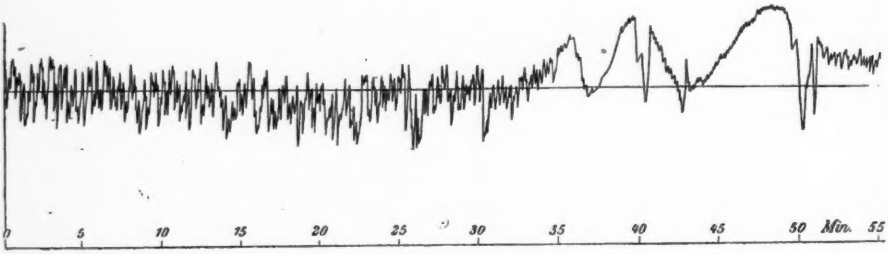

Fig. 4.

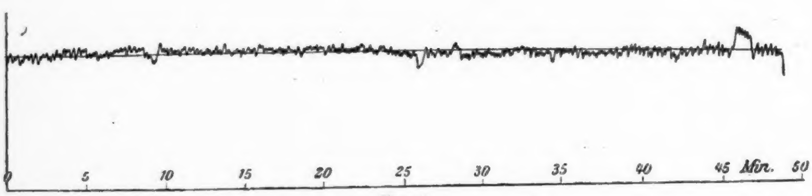

Fig. 5.

Some Aspects of the Metallic Filament Lamp Situation.

By H. M. Hobart.

(Abstracted from the *Times* Eng. Supplement, Feb. 5th, 1908.)

The term "metallic filament lamp" is understood to refer to lamps consuming about 1·2 watt per candle-power, with a life of about 1,000 hours. The writer, however, thinks that in spite of the enthusiasm naturally aroused by their high efficiency, the drawbacks of metallic lamps, as at present utilized, are not sufficiently realized. The use of such lamps on 200 volt circuits often means using more candle-power than is actually necessary, with a corresponding loss in economy. The greater concentration of the light in single high candle-power units is also a drawback. It is better to use five 10 candle-power lamps than one 50 candle-power lamp as regards distribution of light.

How, therefore, are the desired conditions to be obtained ?

The author advocates the use of a static transformer, and the adoption of alternating pressures of say 2,200 volts on the part of the Electrical Supply Co., the pressure being reduced to about 25 volts at the consumer's premises by means of a static transformer.

In this way, great economies can doubtless be effected, but, naturally, each case must be considered on its merits.

The author mentions the impression that some engineers, taking a short-sighted view of the loss in revenue which would follow the rapid introduction of efficient metallic lamps, are opposed to encouraging their immediate adoption. In reality, however, the use of these lamps would ultimately enable electrical supply companies to compete more effectively with gas, and present such a marked development in electric lighting as to justify fundamental changes in the nature of the method of supply previously referred to. Thus, the introduction of high alternating pressures of 2,200 volts or more will not only improve the economy which the consumer may expect to derive, but will also enormously reduce the transmission loss, as compared with that occurring with the present customary pressure of 220 volts, in spite of the heavy initial outlay.

Finally, the author refers to the advantages enjoyed by the metallic lamps, of being less sensitive to variations of pressure, in comparison with the old carbon lamps. This may be of assistance in the design of distributing systems. A voltage drop in the consumer's mains, which would have been regarded as very unsatisfactory in the case of carbon lamps, is therefore of less consequence in this case, and a smaller cross-section of copper may be permissible.

The Economical Production of Good Petroleum Illumination.

By A. Guiselin.

(From the *Journal du Pétrole*, Jan. 20th, 1908.)

In a report presented to the recent congress of Bucarest, M. Pihan insisted upon the care necessary in the case of tests of combustion intended to determine the commercial value of oils used for illuminating purposes. The precautions suggested by this chemist seem to us so indispensable, that we are publishing the results of an interesting series of tests on the subject by MM. Guiselin and Madoulé at the Laboratoire Central de la Compagnie Industrielle de Petrole.

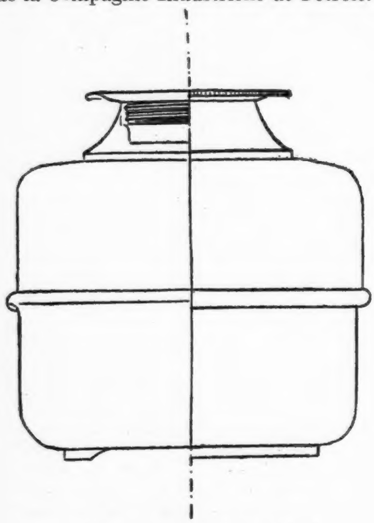

Fig. 1.—Scale of 56/100.

The object of these experiments was to study the influence upon the flame of the distance separating the upper level of liquid and the extreme upper end of the wick. The burners selected for the purpose of these tests were those of the round "Kosmos" type, with twelve slots, which are clearly the most generally used burners in France, while the varieties of petroleum utilized were selected among the varieties of oil of good quality sold under the names of "Pétrole de Luxe" and "Pétrole ordinaire" by the company referred to above.

In order to generalize the problem, MM. Guiselin and Madoulé have also utilized four distinct burners having carriers of different construction designed to distribute the air in different ways within the chimney; these are shown in Figs. 2, 3, 4, and 5. In all these four lamps the wicks utilized were of the same nature and the glass reservoirs of the same dimensions. The reservoirs shown in Fig. 1 were originally provided with 500 cc. of ordinary petroleum (Pétrole ordinaire). These were utilized in connexion with the burners previously described. At the commencement of the test, which lasted ten hours, the flame was adjusted to its maximum intensity, that is to say, a position such that the slightest raising of the wick would cause the flame to smoke. The candle-power of each flame was obtained at intervals of 1, 3, 6, 8, 9, and 10 hours. By utilizing these figures we obtain the curves shown dotted in Figs. 2a, 3a, 4a, and 5a. The difference in weight, measured very exactly in the case of each lamp, enables us to calculate :—

1. The mean consumption per hour.
2. The consumption per Carcel-hour.

The results here given show clearly enough the influence of the slightly different construction of the burners used.

This was repeated under exactly the same conditions, *i.e.*, utilizing the same reservoirs, the same wicks, and the same burners, but this time filling the reservoirs completely with 700 cc. of the same variety of petrol. In every case the candle-power and mean hourly consumption had increased. The curves obtained by plotting these results graphically are shown fully in Figs. 2b, 3b, 4b, and 5b.

This result, which is easily explained by the greater facility experienced by the petroleum in attaining the extremity of the wick, should cause no surprise, and only serves to confirm the recommendations of M. Pihan. But it is more surprising to find that in the case of all the burners the consumption per Carcel-hour is much greater in the first case than in the second, *i.e.*, when the lamps were completely filled. This result is

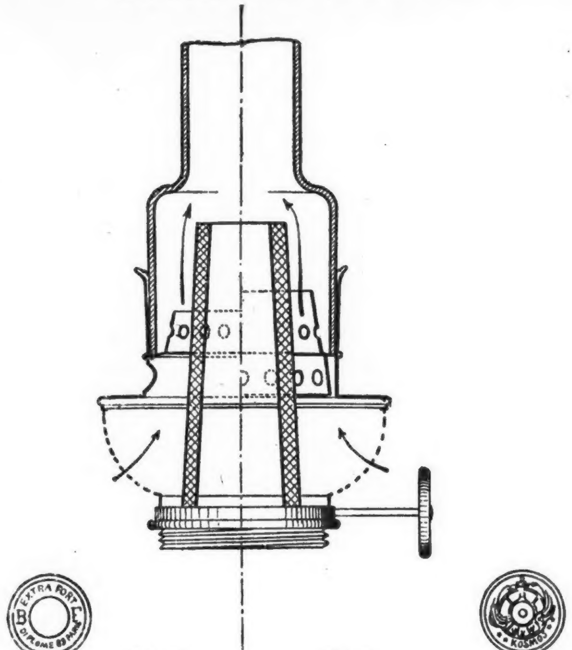

FIG. 2. FIG. 3.

"Kosmos" Burners (scale of 6/10).

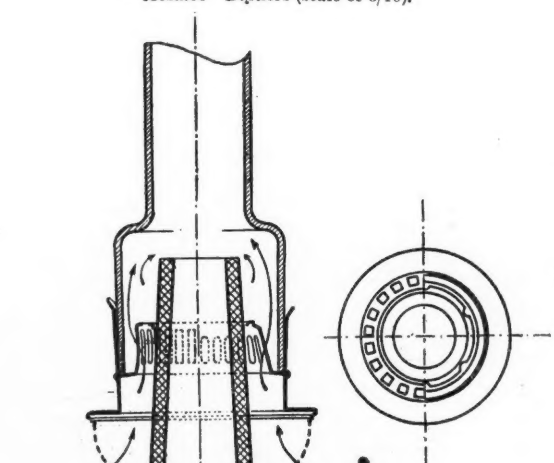

FIG. 4. FIG. 5.

Ordinary Burners (scale of 66/100).

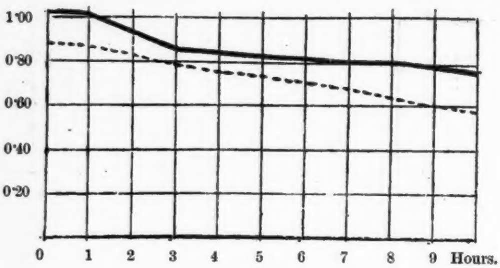

Fig. 2a (with burner shown in Fig. 2).

	With 500 cc.	With 700 cc.
Mean consumption per hour	31·8	33·5
Mean intensity ...	0·749	0·872
Consumption per Carcel-hour	42·45	38·39

Coefficient of economy, 0·903.

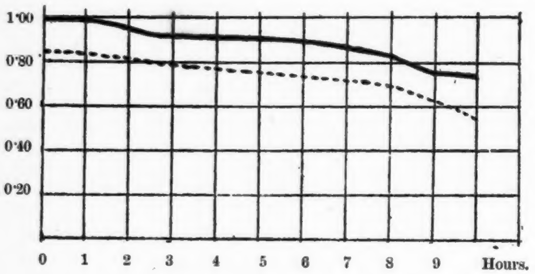

Fig. 3a (with burner shown in Fig. 3.)

	With 500 cc.	With 700cc.
Mean consumption per hour	30·7	32·0
Mean intensity ...	0·757	0·912
Consumption per Carcel-hour	40·55	35·09

Coefficient of economy, 0 862.

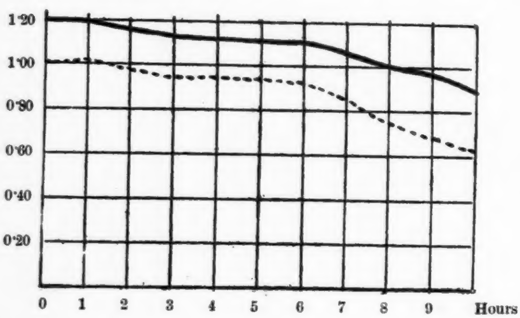

Fig. 4a (with burner shown in Fig. 4).

	With 500 cc.	With 700 cc.
Mean consumption per hour	35·0	38·6
Mean intensity ..	0 900	1·099
Consumption per Carcel-hour	38·82	35·12

Coefficient of economy, 0·905.

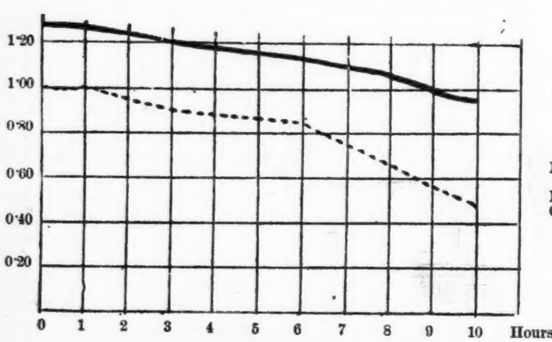

Fig. 5a (with burner shown in Fig. 5).

	With 500 cc.	With 700 cc.
Mean consumption per hour	31·2	37·5
Mean intensity ..	0·824	1·16
Consumption per Carcel-hour	37·86	32·3

Coefficient of economy, 0·931.

TESTS CARRIED OUT ON "PETROLE ORDINAIRE."

—— with 700cc. petroleum in reservoir.
...... with 500cc. " "

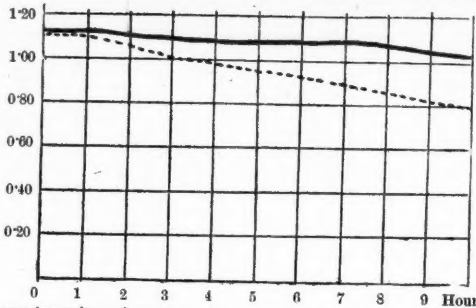

FIG. 2 b (using burner shown in Fig. 2).

	With 500cc.	With 700cc.
Mean consumption per hour	34·2	35·4
Mean intensity ...	0·973	1·101
Consumption per Carcel-hour	35·13	32·13

Coefficient of economy, 0·914.

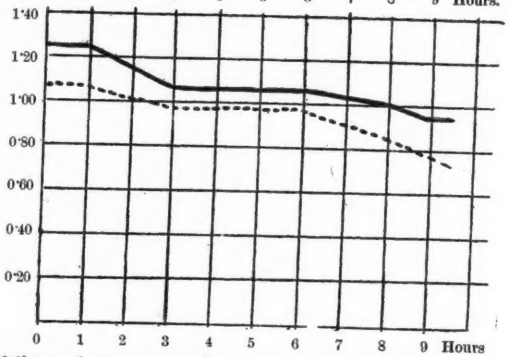

FIG. 3 b (using burner shown in Fig. 3).

	With 500cc.	With 700cc.
Mean consumption per hour	30·5	33·0
Mean intensity ...	0·799	0·918
Consumption per Carcel-hour	38·56	35·92

Coefficient of economy, 0·931.

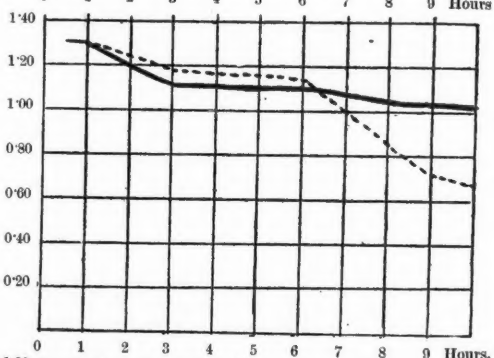

FIG. 4 b (using burner shown in Fig. 4).

	With 500cc.	With 700cc.
Mean consumption per hour	36·0	37·0
Mean intensity ...	1·067	1·102
Consumption per Carcel-hour	33·74	33·57

Coefficient of economy, 0·995.

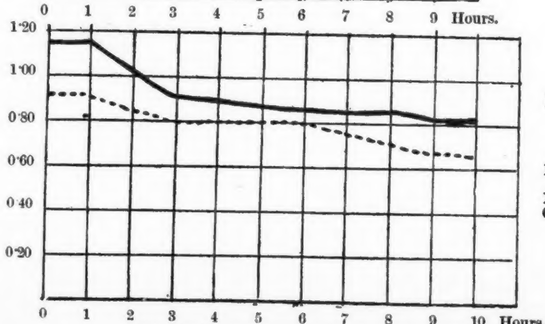

FIG. 5 b (using burner shown in Fig. 5).

	With 500cc.	With 700cc.
Mean consumption per hour	35·0	36·3
Mean intensity ...	0·936	1·102
Consumption per Carcel-hour	37·37	32·92

Coefficient of economy, 0·881.

TESTS CARRIED OUT ON "PETROLE DE LUXE."

—— with 700cc. petroleum in reservoir.
...... with 500cc. " "

of special interest, because it enables us to clearly demonstrate the economy which is effected by the consumer when he refills his lamp.

When the same series of burners was employed with a better quality of petrol the authors obtained results which enable us to draw the same conclusions.

of both kinds of petroleum, a greater candle-power is obtained when the reservoir is completely filled with 700cc. of oil than when it is only partially filled with 500cc.

In order to make the tests quite complete it would be necessary to repeat them, utilizing a constant level of petrol in the reservoirs. But the end which this

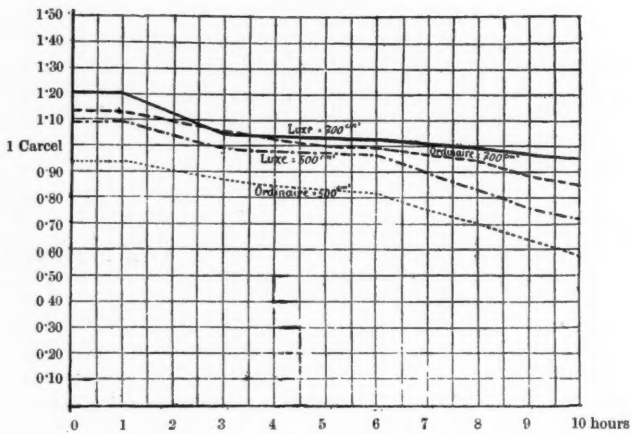

Fig. 6.

These curves show the mean results deduced from Figs. 2a, 3a, 4a, 5a, and 2b, 3b, 4b, 5b respectively.

The final average results deduced from the tests referred to are shown in Fig. 6. Here it appears, *firstly*, that the light obtained with "pétrole de luxe" is, on the whole, greater than that obtained by the use of "pétrole ordinaire," and, *secondly*, that in the case

interesting investigation has in view may be said to have been attained in so far as it enables us to advise the consumer to keep his lamp constantly refilled if he is anxious to obtain the most satisfactory illumination at the lowest expense.

The Influence of Fluctuations in Pressure on Glow Lamps.

By F. Hirschauer.

(Abstracted from the *Elektrische Zeitschrift*, Jan. 30th, 1908.)

The connexion between the alteration in candle-power of a glow lamp and the variation in pressure producing it is given by the following relation :—

$$h = Ce^n$$

where h = the candle-power of the lamp
e = the P.D. in volts
n, C, = constants which are the same for a particular type of lamp.

The author then proceeds to describe certain experiments which were carried out with the object of investigating this connexion, and determining the constants "n" and "C" for various types of lamps. The most important of these two constants from a practical point of view is "n," for this determines the variation in candle-power which is caused by a given change in P.D. In the table given below the author gives the value of this constant for various types of filaments in order of decreasing magnitude, and also the value of the alteration in candle-power which would be produced by a variation of $\pm$ 2·5 per cent. in the supply pressure.

Type of Filament.	Value of "n."	Variation in candle-power caused by an alteration of $\pm$2·5 per cent. in the pressure applied to lamp.
Nernst ...	10	50
Carbon ...	6·3	31·5
Tantalum ...	4·3	21·5
Osmium ...	4·2	21
Osram ...	4·0	20
Just-Wolfram	4·0	20

It will be seen that, as might have been expected, the sensitiveness to alteration in pressure is greatest in the case of the Nernst filament, and becomes less pronounced in the case of the metallic ones. We may also calculate out the permissible variation in pressure in order that the candle-power of the lamp may not vary more than 12 per cent. This works out as follows :—

Nernst	1·2	per cent.
Carbon	1·9	,, ,,
Tantalum	2·8	,, ,,
Osmium	2·85	,, ,,
Osram	3·0	,, ,,
Just-Wolfram ..	3·0	,, ,,

The use of the new metallic filament lamps may, therefore, be expected to lead to economy in the amount of copper used in two ways. In the first place, their greater efficiency means that, in order to produce a given candle-power at a given pressure, less current will be required, and hence a smaller cross section of copper is admissible. Secondly, we might allow a greater drop of P.D. in the case of metallic filament lamps, on account of the smaller change in candle-power, caused by a given variation in the pressure at the lamp terminals, referred to above.

Magnetite Arc Lamps.

By F. Dressler.

(Abstracted from the *Elektrotechnischer Anzeiger*, Jan. 30th.)

The magnetite lamp appears to occupy a position intermediate between the enclosed arc lamp and a lamp utilizing carbons of the ordinary variety, to which the air has free access.

In the intensity of the light it resembles the open arc, but in the length or time which may elapse before the lamp requires attention, it rather resembles the enclosed lamp. The arc itself, however, is not so steady as that in the case of the latter. In America this defect is tolerated on account of the long burning hours of the magnetite arc, and its consequent cheapness in maintenance.

The name of the lamp is derived from the main constituent of the negative electrode. The positive electrode usually consists of a slab of copper. It is not feasible to maintain an alternating current arc between metallic electrodes, and hence the magnetite arc lamp is essentially intended for direct currents.

In the case of the usual arc between carbon electrodes, about 85 per cent. of the light comes from the crater of the positive electrode; in the case of the magnetite arc, on the contrary, practically all the light comes from the vapour of the arc itself. Owing to this fact the distribution of light is essentially different from that of the ordinary carbon arc. The quality of the light is controlled by the nature of the negative electrode, which gradually wastes away while the positive remains practically unaffected.

The exact constituents of the negative electrode form the subject of many patents. In order to improve the steadiness of burning and also to improve the efficiency a certain percentage of Titanium compounds is desirable.

The time of wasting away of the negative is also very dependent on the material of which it is composed, and can be varied between 50 and 500 hours.

Table I.

Current, In Amperes.	Rate of Burning Away Millimetres per hour.
4	0·4 – 0·5
6	1·0
8	1·5 – 1·6

As a rule the constituents of the electrode are mixed into a fine paste with glycerine, and pressed into cylinders 200 mm. in length and 16 mm. in diameter.

One difficulty experienced in the design of these lamps is the production of fumes of red iron oxide, which deposit on the interior of the glass globe surrounding the lamp if precautions are not taken to secure good ventilation. Even so the production of such fumes is a drawback to the magnetite lamp, and renders it unsatisfactory for the illumination of interiors. For the actual process of combustion itself the amount of air necessary is smaller even that which is necessary in the case of enclosed arc lamps.

The author then refers to the regulating mechanism of the lamp. He appears to have found the arc of a very unsteady and fluctuating character.

Table II.

Type of Lamp.	Current Amperes.	Mean Hemispherical Intensity (H.K.)	Water/H.K. (Mean Hemispherical).
Ordinary Open Caslon Arc Lamp (Vertical Carbons)	4	2×240	0·65
	6	2×400	0·58
	8	2×620	0·52
Magnetite Arc ...	4	420	0·70
	6	710	0·61
	8	1,000	0·58
Enclosed Carbon Arc	4	350	0·86
	6	620	0·77
	8	750	0·72

Another drawback to which he makes reference is the necessity for some form of tray underneath the electrodes to catch the glowing particles occasionally falling from them which would otherwise crack the glass of the globe. The dimensions of this tray are such as to throw an unpleasantly deep shadow beneath the lamp.

The length of the arc varies from 20 to 26 mm,; with a current of 4 amperes it is about 22 mm. The light yielded by the lamp is pure white in colour, receiving, however, a yellowish tinge from the admixture of glycerine. The naked arc acts powerfully upon the eyes and skin, and one would therefore suppose it to be of value for photographic purposes. Experiments have shown, however, that the magnetite arc does not equal the enclosed lamp for this purpose. The P.D. across the arc is usually about 72 volts. The series resistance is usually built into the frame of the lamp, which can be run straight off a supply pressure of 110 volts.

The results of some tests on open and enclosed carbon arc lamps and magnetite lamps are given by the author in Table II.

In this table the values of the intensity of open arc lamps are doubled on the ground that it is possible to run two such lamps in series on a P.D. of 110 volts.

On the whole the author considers that the drawbacks under which the magnetite arc at present suffers limit its application to cases in which the cost of electrical energy and labour are relatively high.

Luminous Signs for the Experiment Table in Darkened Lecture Theatres.

By H. J. Reiff.

(Abstracted from the *Physikalische Zeitschrift*, Nov. 1st, 1907.

There are many lecture experiments, such as the exhibition of vacuum tube discharges, &c., which have to be conducted in a darkened room, in order to be seen properly. In such cases an ordinary source of light, however well screened, is more or less unsatisfactory, for, even when directed away from the audience, and too subdued to interfere with the experiment, it is apt to dazzle the eyes of the lecturer.

For the purpose of revealing the situation of the various pieces of apparatus, the author has found the following device very convenient. He arranges small luminous signs, which are cut out of tin and coated with luminous paint, and are attached to or placed beside these pieces of apparatus, serving to indicate any feature which the lecturer desires to bear in mind. These signs can be arranged so as to be invisible to the audience by merely turning them with the coated face towards the lecturer; yet their brilliancy is so subdued that they do not produce any impression of dazzle. The signs frequently take the form of letters: they are also very useful for the purpose of indicating the polarity of mains, terminals, &c.

Although, as stated above, it is usually desirable to arrange these devices so as to be visible to the lecturer only, it is occasionally convenient to use them in another way. In experiments in which the gaze of the audience has to be rivetted for a long time in a certain direction, awaiting the appearance of some phenomenon, there is a danger that the effect may be missed owing to the direction of view being gradually altered. It is not easy to maintain one's direction of vision in the dark. The attention of the audience may therefore be focussed in the desired direction by the use of a luminous sign. Such a sign is easily visible at a considerable distance in a darkened room, yet there is no danger of the eyes of the observers being dazzled or confused by it.

REVIEWS OF BOOKS.

Elektrische Beleuchtung.

By Dr. Berthold Monasch.

(Published by Dr. Max Janecke, Hanover.)

Although this work appeared in 1906, it is possible that many of our readers have not yet had an opportunity of studying its contents, which are of great interest to those concerned with modern progress in the measurement and theory of illumination. We therefore give a brief summary of the ground covered in the volume referred to.

The book is systematically divided into eight sections, which are again subjected to subdivision. The first section, occupying about a quarter of the book, is devoted to photometry. The author defines the chief photometric quantities, and then passes on to the chief standards of light and photometers, which he describes in a brief but satisfactory manner. Special attention is paid to the photometry of arc lamps, and the description of the various methods is brought up to date by a reference to the integrating photometers of Matthews, Blondel, Ulbricht, &c.

The second and third sections deal with arc lamps and glow lamps respectively, and a useful summary of the recent progress in this subject is given. We note, however, that no reference is made to the magnetite arc, while the necessarily brief description of mercury lamps is already rendered out of date by the more recent introduction of the Küch lamp.

The fourth and fifth sections are devoted to the arrangement of lighting circuits and the maintenance of lamps generally, and contain much useful information. The seventh section is devoted to polar curves of light distribution from various illuminants, and represents a rather unique and certainly very serviceable collection of data. The seventh section is mainly concerned with questions of efficiency and cost of various illuminants, and also contains useful information, though the scientific reader would naturally not rely too closely on figures which necessarily depend upon somewhat local conditions. The eighth and last section contains a very brief discussion of illuminating problems in general.

On the whole, we think Dr. Monasch has produced a very useful book of reference. The illustrations are plentiful and clear, and the general scheme of the book is very convenient.

New Publications Received.

We have received a copy of the first number of *The Electrical Field,* which is described as a journal devoted to the interests of the contractor, and is got up in an attractive and readable form. The Editorial and Publishing offices are 30 and 31, St. Swithin's Lane, E.C.

CORRESPONDENCE.

International Photometrical Nomenclature.

[In matters of great scientific importance it is very essential that the original phrasing of communications should be preserved as closely as possible. We are, therefore, printing the letter which M. Laporte has kindly addressed to us, in French, but also append an English version by the side.]

MONSIEUR,—Je viens de lire dans le numéro de Février de *l'Illuminating Engineer* le compte rendu de l'article de M. Monasch sur la nécessité de bien définir les unités dont on se sert dans les questions d'éclairage et en particulier dans les mesures d'éclairement. Je partage entièrement cette opinion, mais, comme dans le travail que je viens de citer il s'est glissé une erreur, je tiens à la signaler à vos lecteurs.

Il est dit en effet qu'en Allemagne et en France on a adopté le mot de *lux* pour exprimer l'éclairement produit par un hefner placé à un mètre.

Depuis le Congrès de Genève qui, en 1896, sur la proposition de M. Blondel, a défini si heureusement les différentes grandeurs photomètriques et qui a choisi les unités correspondantes, le " lux " est employé en France dans les travaux de photomètrie de même que le " lumen " dont M. Monasch ne parle pas d'ailleurs. Mais en France, j'insiste sur ce point, nous lui donnons la même définition que le Congrès de Genève : le " lux " est l'éclairement produit par une bougie décimale placée à la distance de un mètre. Nous n'employons pas et n'avons jamais employé le mot " lux " avec la signification de l'éclairement produit par un hefner à un mètre.

Pour comparer les éclairements mesurés dans les différents pays, fussent-ils tous exprimés en lux, il est nécessaire de tenir compte de la valeur du rapport des unités d'intensité

DEAR SIR,—I have just been reading an abstract of an article by Dr. Monasch in the February number of *The Illuminating Engineer* on the necessity of defining, in a satisfactory manner, the units employed in problems of illumination, and particularly in the measurement of this quantity. I am in complete agreement with this opinion, but an error has crept into the article mentioned to which I wish to draw the attention of your readers.

It is, indeed, stated that in Germany and France the word " lux "' has been adopted to signify the intensity of illumination produced by one Hefner, at a distance of one metre.

Ever since the Geneva Congress of 1896, which, acting on the suggestion of M. Blondel, defined the various photometrical quantities so successfully, and selected the corresponding units, the term " Lux " and also the term " Lumen," which, however, Dr. Monasch does not mention, have been employed in French treatises on photometry.

But in France—and I emphasize this point—we give this quantity the same significance as the Congress of Geneva : the " lux " is the intensity of illumination produced by a " bougie-décimale," placed at a mistance of one metre. We do not, and we never have used the word " lux " in the sense of the intensity of illumination produced by one Hefner at a distance of one metre.

In order to compare the intensities

lumineuse employées dans ces pays—
Comme :—
Hefner = 0·895 Bougie décimale
de même
Lux (dans les travaux allemands) = 0·895 lux (des travaux français).
La même observation s'applique naturellement à l'unité de flux lumineux le " lumen."

Heureusement la candle de spermaceti, la candle dixième de l'etalon Vernon Harcourt et la bougie décimale sont voisines les unes des autres et complètement équivalentes dans la pratique industrielle. L'Angleterre, l'Amérique et la France se trouvent donc employer en fait la même unité lumineuse et c'est une grande simplification fort avantageuse sous tous les rapports. Veuillez agréer....

F. LAPORTE.
Sous Directeur du Laboratoire Central d'Electricité.

of illumination, as measured in the different countries, if expressed in " lux," it is necessary to take account of the value of the relation between the standards of luminous intensity, employed in these countries.

Since the Hefner = 0·895 Bougie décimale, it follows that the Lux (as occurring in German treatises) = 0·895 Lux (as occurring in French treatises). Naturally the same observation applies to the unit of luminous flux, " the Lumen."

Fortunately, the spermaceti candle, the candle deduced as the tenth part of the intensity of the Vernon Harcourt standard and the " bougie décimale " approach each other closely, and may be regarded as completely equivalent from an industrial point of view. Practically the same unit of luminous intensity is in use in England, America, and France, and the resulting simplicity is, in every respect, a very great advantage. I am, yours faithfully,

F. LAPORTE,
Assistant Director at the Laboratoire Central d'Electricité.

The Moore Light.

DEAR SIR,—In reply to the letter from Mr. I. Wanterno in your February issue, I may say that I examined the spectrum of the Moore tube in the Savoy Hotel, and also of another tube filled with carbon dioxide, with my spectroscope. In both cases I found the spectrum consisting entirely of bright lines. In the case of the nitrogen tube at the Savoy Hotel the lines are chiefly collected in the yellow and red part of the spectrum, but in the case of the carbon dioxide tube they are well distributed through the blue and green as well; hence, although the spectrum is not continuous, the effect is to radiate a light not dissimilar to daylight.

With regard to Mr. Wanterno's second point, the inverse square law does not apply to the tube, as a whole, but I assume it applies to each element of the tube. The case is exactly parallel to that of the magnetic effect of an electric current. An element of a current in a conductor produces a magnetic force at any point inversely proportional to the square of the distance, but the magnetic force due to a long straight conductor carrying a current as a whole is inversely as the distance, and not as the square of the distance, as is easily proved by integration. I am, yours faithfully,

J. A. FLEMING.

Co-operation between Those representing Gas and Electric Lighting.

[Mr. Marks's letter, coming from a former president of the Illuminating Engineering Society, is particularly opportune as showing the possibility of co-operation and friendly discussion between those representing different systems of illumination.

We think it should be studied by those in this country who are still incredulous as to the results that have been achieved in this direction in the United States.]

MY DEAR MR. GASTER,—No. 1, vol. i. of your new journal has just come to hand. Permit me to congratulate you on the excellent showing you make in this introductory issue.

I understand that illuminating engineering as a speciality has not received much encouragement in England, and note that some of the British journals go so far as to say there is no need of an illuminating engineer as such. The publication of your journal will, if you maintain the high standard of the first number, go far towards giving the art of illumination a definite and fixed status. Sooner or later the opposition which has been shown by some of the other journals and by some engineers will, in my opinion, materially lessen if not disappear.

History repeats itself, and I assume you will have to go through in England what we have gone through in the United States. You will recall my experience in the organization of the Illuminating Engineering Society. Although there was much opposition at first to the formation of this Society, we now have almost 1,000 members scattered throughout the United States, and in some foreign countries, and are working in harmony with the older societies, such as the American Institute of Electrical Engineers, the National Electric Light Association, and the American Gas Institute. You will be gratified to learn that both the A.I.E.E. and the American Gas Institute have appointed committees to meet the Committee on Nomenclature and Standards of the Illuminating Engineering Society, with a view to agreeing on a unit of light. Thus the gas and electrical interests in the United States have for the first time been brought together in a practical way to endeavour to arrive at an understanding on questions of this character.

With renewed congratulations and best wishes for the success of your journal, I remain, Very truly yours,

L. B. MARKS.

The Mechanical Equivalent of Light.

Sir,—In your last issue appeared an interesting communication from Dr. H. Lux, giving a very complete list of tests upon different sources of light. This list contains, among other things, values for the luminous efficiency of the sources, and of the mechanical equivalent of light deduced from these figures; and the conclusion is drawn that the mechanical equivalent of light is not a definite quantity, but depends upon the form of the spectrum energy curve of the source.

As I have recently taken considerable interest in this subject, I should like in the first place to express agreement with the last statement, and to point out that it is a necessary consequence of the properties of the eye. As the eye is only sensitive to a very restricted range of vibrations, and varies in its sensitiveness for different parts of that range, it is obvious that if we define the mechanical equivalent of light as the number of watts or calories per second, per candle-power of white light, we are beset with difficulties as to the exact limits between which the radiation should be included in our measurements; or as to differences between the absorptive properties of any screens we may employ, and that which would make our radiation measuring device equivalent to the eye. Even if a perfect screen were obtained, it is obvious that a source having selective emission of wavelengths corresponding to the maximum sensitiveness of the eye must give a lower value for the mechanical equivalent of light.

On this account it appears to me futile at the present time, with our imperfect knowledge both of the sensitiveness of the eye and of the absorbing properties of screens over a long range, to obtain anything like a definite value for the mechanical equivalent of white light. But the difficulty disappears when we employ monochromatic light of a definite wavelength, and especially if we select that wave-length as about $\cdot 54\mu$, which appears to be fairly definitely known as the point of maximum sensitiveness of the eye. In the neighbourhood of this point small variations are of less importance, and if we employ a discrimination method of comparing the intensity of the monochromatic source with that of a standard lamp, and arrange that the intensity of illumination at our photometer is some definite value (say 1 candle-foot), to avoid possible troubles with the Purkinje phenomenon, I see no reason why any serious indefiniteness should arise.

For the above reasons, in the recent investigations made by Mr. Jolley and myself, referred to in your last issue, an attempt was made, probably for the first time, to determine what we consider to be *the* mechanical equivalent of light, directly, by obtaining a beam of monochromatic yellow-green light by a prism, measuring its luminous intensity by a discrimination photometer, and the radiation by a bolometer. Measurements with white light were also made, but were regarded as of subsidiary importance.

While agreeing with Dr. Lux, therefore, as to the variations in the value of the mechanical equivalent obtained by tests on lamps, I am extremely surprised at the low values he obtains in several cases. Until three years ago all the results obtained by careful investigators on the Continent and at Cornell gave values for the mechanical equivalent of the Hefner from ·108 watts (Angstrom) to ·5 watts or higher. Within this time, however, Wedding has given values as low as ·0016, Russner ·02, and Dr. Lux ·014 watts per Hefner. Curiously, as far as I can make out, Wedding has used a water cell only for absorbing the heat rays, and consequently should have obtained results which were too high, as was the case with the earlier workers. Russner and Dr. Lux have, however, worked with the green solution of double sulphate of iron and ammonium discovered by Nichols, and in some experiments which Mr. Jolley and I made lately with this solution we discarded it, owing to its becoming turbid, indicating chemical changes in its constitution. Whether this has affected the results of Russner and of Dr. Lux I do not know, but it is clear that the mechanical equivalent cannot be less than the value for the monochromatic light of ·54μ, for which we find the value ·0598 watts per c.-p., or ·0538 per Hefner. As this is the first time that this determination has been made, it would be unfair to lay too much stress upon it, although considerable care was taken. But I would most certainly urge that attempts should be made by as many workers as possible to get a definite value of the mechanical equivalent for one wave-length by direct measurement, instead of spending time on absorption tests which seem to give such hopelessly discordant results.

In the series of articles I am writing, I hope shortly to give a complete account of the early and recent work on this important subject.

I am, Sir,

Yours faithfully,

CHARLES V. DRYSDALE.

Northampton Institute, London,
February 19th, 1908.

Review of the Technical Press.

Illumination.

Some discussion has been raised in several of the American journals by a recent paper before the Illuminating Engineering Society by Dr. Seabrook, in which the physiological effect of illuminants was discussed. Dr. Seabrook mentioned the bad effects of excessive intrinsic brilliancy on the eye, and suggested that under normal conditions the eye rested itself by continual movement, so that a different portion of the retina was constantly being presented to the light.

He also dealt with the effects of light of different colours, and expressed the view that rays of short wave-length were the most effective in causing physiological action, the effect becoming more marked as we proceed towards the ultraviolet. In commenting on this point it is pertinently remarked in *The Electrical World* that the fact that the eye is most sensitive to yellow light must surely show that physiological action is most readily caused by rays of this colour.

Another recent paper of interest is that of Legg and Townsend (reported *Elec. World*, Feb. 1st). The illumination in some Chicago reading-rooms is discussed. Some interesting figures are given of the order of illumination provided, which appears to have usually been sufficient, and the order of cleanliness, which was not. In one case the effect of dusting the lamps above the reading tables was to increase the light by 75 per cent., while an average of about 25 per cent. seems to have been obtained. It is possible that very similar results would be obtained in many libraries in this country were the lamps examined. The order of illumination necessary in order to produce a general effect, apart from that intended for reading, is given as 0·3 to 0·5 per cent. The reading illumination appears to have varied from 1 to 3 candle-feet, and the authors remark that readers usually preferred to have as low a value as they could read by with comfort.

The valuable paper by Mr. Basset Jones on the relation of architectural principles to illuminating engineering was mentioned in the last review. It is now available in the January number of the Society's *Transactions*, together with the discussion.

Dr. Monasch (*Jour. für Gas*, &c., Jan. 25th, Feb. 1st and 8th) discusses the distribution of light from various forms of portable lamps, among which he includes electric reading lamps, petroleum kitchen lamps, &c. He gives the distribution curves of the various lamps under consideration. In the case of a reading lamp some form of shade is essential, because the form is usually such as to throw a shadow just where the light is required. The common "kitchen" lamp comes in for some deserved criticism. These lamps are usually suspended on the wall with the object of illuminating the whole room. To assist this object a reflector throwing the light out at right angles to the room is provided. The illumination so produced is, however, rarely satisfactory, and the result is that the lamp is often taken off the wall and placed near at hand on the table; for this purpose the reflector is specially ill-adapted, for it throws the light straight into the eyes of the observer instead of downwards on to the table. Dr. Monasch also discusses the various methods of rating lamps. From one point of view the mean spherical candle-power is an impartial basis of comparison between different lamps, but frequently fails to express the illuminating value of a source under practical conditions. Dr. Monasch winds up by giving a series of curves of horizontal illumination, plotted out from results obtained by experiment, and intimates that this is really the most satisfactory method of comparing results.

The editorial columns of the *Journal of Gaslighting* contain some reference to the supposed difficulty in co-operation experienced between those representing the gas and electrical lighting in the

Illuminating Engineering Society. That there is in reality very serviceable and satisfactory co-operation between the representatives of both forms of lighting in the United States is suggested to those who have been studying the question by the recent combined action of the Illuminating Engineering Society, the Institute of Electrical Engineers, and the Institute of Gas Engineers, in order to discuss the question of standards of light.

The Electrical Review for Feb. 7th contains some sensible remarks on the subject of the inspection of residence lighting, in order to secure the goodwill of the consumer.

The correspondence on the measurement of street illumination still continues. Mr. Mackenzie emphasizes the fact that all such measurements are only an indication; we are also concerned with the physiological impression of brightness or otherwise that the pedestrian in the street receives. Such an impression is very greatly influenced by the vertical illumination which does not receive justice by the horizontal method. Mr. Wild is impressed by the inaccuracies of street photometry, arising very largely from the low order of illumination which has to be measured. He also refers to the possibility of the cosine law not being applicable at the very oblique angles at which the rays in these cases fall upon the photometer screen, and the limit to accuracy set by the possibility of "angle-errors."

Photometry.

No very notable contributions to the literature on this subject have been made since the last review, though several of the articles mentioned therein have been reproduced elsewhere.

The Electrician (Feb. 2nd) contains a résumé of the recent study of plain and frosted lamps by Hyde and Cady (*Bull.* of the Bureau of Standards). One interesting point raised in this paper is the question of the great reduction candle-power question of glow lamps with frosted bulbs during their life. This seems to be entirely due to the light-absorbing deposit formed on the bulb of the lamp, and not any alteration in the structure of the filament.

The new form of 'Universal Photometer' of P. S. Millar is discussed in several places, while the recent article in the *Electrotechnische Zeitschrift* dealing with the photometrical laboratory of Messrs. Körting and Matthiesen has been also reproduced.

Houston (*Phys. Zeit.*, Feb. 4th) discusses a new form of spectrophotometer.

Electric Lighting.

The recent literature on this subject is again mainly concerned with the metallic filament lamps and the effect of their introduction on industrial conditions.

Hirschauer (*E.T.Z.*, Jan. 30th) calculates the influence of variations in the supply P.D. on the light given by the various existing types of glow lamps. The candle-power of an incandescent lamp is connected with the P.D. across it by the following relation:—

$(c.p.) = C(P.D.)^n$, where C. and n. are constants.

The most important constant is n, as this determines the variation in candle-power caused by an alteration in P.D. The author gives a table of results showing the variation in light caused by a variation of $\pm$ 2·5 per cent. in the P.D. across the lamp.

Electrical Engineering (Feb. 13th) contains a résumé of this article and a previous one on the same subject by Loring (*Elec. World*, Jan. 4th).

The situation has also been dealt with in an interesting article by Hobart (*Times Eng. Supplement*, Feb. 5th). The author remarks on the drawbacks of applying metallic lamps to high pressure circuits, and even advocates the adoption of a 2,200 volt supply stepped down to 25 volts at the consumer's premises. He also points out the short-sighted policy of the engineer, who, fearing a loss of revenue, does not encourage consumers to adopt the most efficient lamps.

This last point is taken up in a long article by a writer in *The Electrical Times.* He, too, believes that the new lamps will ultimately prove a benefit to supply authorities, in spite of a temporary loss in revenue. It will be remembered that "A Lamp Maker" (*Elec. Engineer*, Dec. 6th) took a somewhat gloomy view of the situation.

O'Hanlon (*Elec. Rev.*, Jan. 3rd) discusses the design of small transformers for use with metallic filament lamps.

In *The Electrical Engineer* for Feb. 21st appears an abstract of a recent paper by Remané before the Electrotechnische Verein. The author gives a summary of the three chief methods of making Tungsten filaments, the "Paste" method of Auer, the Just flashing process, and the Kuzel colloidal method. He also describes more particularly the manufacture of Osram lamps, which are made by the "paste process," and gives the results of tests on these lamps, according to which a life of 1,000 hours is possible without the watts per H.K. having very appreciably altered from the original value of near unity.

Dressler (*Elek. Anz.*, Jan. 30th) gives a description of the magnetite arc. This lamp has found its widest application in the United States, and is not so well known in Germany. He describes the essential construction of the positive copper-slab electrode, and the negative magnetite and titanium one, the rate of burning away in which can be controlled between wide limits. Thus one negative electrode 200 mm. long and 16 mm. diam. lasts 50–500 hours according to its composition.

In the case of the carbon arc 85 per cent. of the light comes from the positive electrode, and 10 per cent. from the negative. In the magnetite arc practically all the light comes from the arc itself, which is 20–26 mm. in length, and usually requires about 70 volts.

The light given by this lamp is very white in character, but the author considers it somewhat unsteady. The naked arc is liable to cause inflammation of the eyes, if incautiously used, owing to the presence of a strong ultra-violet element.

The watts per H.K. he gives as about 0·5 to 0·6 (per mean hemispherical intensity).

The Elec. World (Jan. 18th and Feb. 1st) contains abstracts of the recent patents for the Cazin metallic filament, and the Heraeus mercury vapour lamps.

Gas, Oil, and Acetylene Lighting.

Under the heading of 'An Illuminating Power Test twice removed from Modern Conditions' *The Journal of Gaslighting* discusses a recent judgment against an English gas company, in which the use of an obsolete form of burner for gas testing, specified by an Act of 1868, was enforced.

Webber (*Gas World*, Feb. 6th) insists on the fact that photometrical measurements ought only to serve as a tool, and that the conclusions to be drawn from them must be modified by the special circumstances of the case.

In particular, when several different methods of securing a given ground illumination are possible, we must apply ourselves to the problem of also producing the most tasteful effect. The author illustrates this point by means of three examples of different arrangements of lights, arranged to give the same illumination, but differing in their æsthetic results. He also considers that electric lighting has hitherto suffered from the æsthetic point of view through lack of units of exactly the right intensity, and remarks that the infinite gradations in the value of incandescent gas units is a great advantage in this respect.

A writer in a recent number of the *Zeitschrift für Beleuchtungswesen* comments on the necessity for some effort at standardization in the matter of inverted incandescent mantles and burners. At present a great variety of such fittings are in use, owing to the narrow view taken by many manufacturers who have constructed their burners in such a way that they can only be used with the one particular type of mantle sold by the same firm. The object of this is to force a consumer who has adopted a certain type of burner to always buy his mantles from the same source. A similar plan, at one time adopted by glow lamp makers, was to make the lamps in such a way as only to fit one special holder.

Naturally all such efforts have the effect of disgusting the consumer with that particular form of lighting. The rapid strides of the upright type of mantles were only attained through adherence to uniformity. A recent letter addressed to the various makers of incandescent mantles on the subject elicited favourable support, and it is hoped that some agreement on this vital point will soon be reached.

Guiselin (*Journal du Pétrole*, Jan. 20th) gives the results of some recent tests of oil lamps carried out in accordance with the recommendations of the recent Petroleum Congress. One essential point brought out by these tests is the influence on the efficiency of the lamp of the amount of oil in the reservoir. A lamp containing 700 cc. of oil invariably gave better results than one containing 500 cc.

The consumer is therefore recommended to fill his lamp at frequent intervals in order to get the best results.

Acetylene for February contains some interesting information as to the application of acetylene to "flare lights," buoys, and lighthouses. There is also an account of the system of free inspection of acetylene generators by the French Society of Acetylene Apparatus Owners. Prizes are offered for the best kept arrangment. The writer regrets that there seems but little prospect of such cooperation becoming general in this country.

Miscellaneous.

Some discussion has recently taken place with reference to the influence of light on selenium in *Nature* (Dec. 26th, Jan. 2nd and 9th). It has been contended by Hammer and others that the enclosure in a vacuum selenium cell intended for light measurement is beneficial in that it eliminates "photoelectric" effects, *i.e.*, the production of an E.M.F. under the influence of light.

Minchin, however (see *Nature, ref. cit.*), found that the result of placing a selenium cell in an exhausted envelope was to greatly decrease the resistance and destroy the sensitiveness of the cell to light. It was suggested subsequently that this effect might be due to the fact that a mercury pump had been used, for mercury vapour readily combines with selenium.

On repeating his experiments Minchin found this to be the case. When exhaustion was carried out by another method in which no mercury was used, the sensitiveness was not destroyed and the resistance was somewhat increased.

The Electrician (Feb. 21st) abstracts a recent paper by Meritt on the recovery of selenium cells after exposure to light. Some curves are given illustrating this recovery, which the author finds to closely resemble the peculiarities of certain phosphorescent substances which he has recently been studying.

ILLUMINATION.

Editorials. How is Intrinsic Brilliancy Harmful? (*Elec. Rev.* N.Y., Jan. 18; *Elec. World*, Jan. 18).
Editorial. Inspection of Residence Lighting (*Elec. Rev.*, Feb. 7).
Legg, E. F., and Townsend, H. A Study of the Illumination of Interiors (*Elec. World*, Feb. 1).
Monasch, B. Lichtausstrahlung und Beleuchtung bei Transportablen Tischlampen (*Journal für Gas*, &c., Jan. 25, Feb. 1, 8).
Trotter, Harrison, Mackenzie, Smith, Wild, &c. The Measurement of Illumination and City Lighting (*Elec. Rev.*, Jan. 24, 31, Feb. 14, 21).
The Third Annual Show at Chicago (*Elec. Rev.* N.Y., Jan. 25).
Drawing Office Illumination (*Electrician*, Feb. 4).
In the Camp of the Illuminating Engineer (*Jour. of Gaslighting*, Feb. 11).

The Transactions of the Illuminating Engineering Society for January also contain :—
Basset Jones, W. The Relation of Architectural Principles to Illuminating Engineers.
Puffer, W. L. The Variables of Illuminating Engineering.
Lansingh and Heck. Fixture Design from the Standpoint of Illuminating Engineers (Discussion).

PHOTOMETRY.

Houstoun, R.A. Ein neues Spektrophotometer von Hüfner Typus (*Phys. Zeit.*, Feb.).
Hyde and Cady. A Comparative Study of Plain and Frosted Lamps (*Electrician*, Feb. 2, from the *Bull.* of the Bureau of Standards).
Miller, P. S. A New Universal Photometer (*Elec. Rev.* N.Y., Jan. 25, 1908; *Elec. World*, Jan. 18).
Modern Photometrical Apparatus (*Electrician*, Feb. 20, from *E. T. Z.*, Jan. 2).

ELECTRIC LIGHTING.

Auerbacher, L. J. High Efficiency Lamps in Kaiserlautern (*Elec. World*, Feb. 1).
Dressler, F. Magnetitbogenlampen (*Elek. Anz.*, Jan. 3).
Hirschauer, F. Einfluss von Spannungsschwankungen auf Glühlampen (*E.T.Z.*, Jan. 30).
Hobart, A. M. Some aspects of the Metallic Filament Lamp Situation (*Times*, Eng , Supplement, Feb. 5).
O'Hanlon, J. B. The Design of Small Transformers for Metallic Filament Lamps (*Elec. Rev.*, Jan. 31).
Remané, H. The New Metal-Filament Lamps, their Qualities and their Commercial Importance (*Elec. Engineer*).
The Tantalum Lamp in Central Station practice (*Elec. World*, Jan. 18).
The Heraeus Lamp Patents (*Elec. World*, Jan. 18).
The Cazin Metallic Lamp Patents (*Elec. World*, Feb. 1).
Helion Lamp Patents (*Elec. World*, Jan. 18).
Metallic Filament Lamps and Revision of Tariffs (*Elec. Times*, Jan. 23 *et seq*).
Carbon and Metallic Filament Lamps (*Elec. Engineering*, Feb. 13).
Searchlights (*Elec. Engineer*, Jan. 31, 1908).
Webber, W. H. Y. The newer types of Electric Lamps.

GAS, OIL, AND ACETYLENE LIGHTING.

Editorial. An Illuminating Power Test Twice Removed from Modern Conditions (*Jour. of Gaslighting*, Jan. 28).
Guiselin. Pour obtenir economiquement un bon Eclairage du Pétrole (*Jour. du Pétrole*, Jan. 20, 1908).
Himmel. Neue Zentralzündung für offentliche Beleuchtung (*Jour. für Gas*, Feb. 1).
Little, T. J. Gaslighting in the Factory (*Am. Gaslight Jour.*, Jan. 27).
Seabrook, H. (Correspondence). Combination of Gas and Electricity (*Elec. Rev.*, Feb. 7).
Walker, S. F., &c. (Correspondence). Gas *v.* Electricity (*Elec. Rev.*, Feb. 7).
Lighting Gas Lamps at a distance by Electricity (*Gas World*, Jan. 11 and 18).
Webber, W. H. Y. Illustrations of the Art of Gaslighting (*Gas World*, Feb. 8).
Whitwell, C. Gas in Libraries (*Electrical Engineer*, Jan. 31).
Einheitliche Glühkorper fur hängendes Gasglühlicht (*Zeit. für Bel.*, Jan. 10).
The Lighting and Ventilation of Schools (*Gas World*, Feb. 15).

MISCELLANEOUS.

Merrit. The Recovery of Selenium Cells after exposure to Light (*Electrician*, Feb. 21, from the *Physical Review*).
Influence of Light on Selenium (*Elec. Rev.*, N.Y., Jan. 25, Feb. 1, *Nature*, Dec. 26, Jan. 2, Jan. 9).

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

27,412A/07. Arc lamps. Jan. 13 (D.A. Dec. 12, 1907). H. Bevis and A. E. Angold Peel Works, Adelphi, Salford.
1,596. Arc lamps. Jan. 23. H. E. Moul, 18, Kensington Court Place, London.
2,103. Lamps. Jan. 30. Cutler, Wardle & Co., Ltd., and W. Wardle, 55, Market Street, Manchester.
2,120. Arc lamps. Jan. 30. A. H. Greening and C. Petitjean, 15, Clifford's Inn, London.
2,254. Supports for lamp filaments. Feb. 1. A. H. S. Colebrooke, Stanley Road, Huyton, near Liverpool.
2,261. Arc lamps. Feb. 1. A. Holman, 44, West George Street, Glasgow.
2,707. Incandescent lamps. Feb. 6. J. Howard, 70, Chancery Lane, London.
2,797. Incandescent lamp. Feb. 7. W. E. Lake, 7, Southampton Buildings, London (from R. Jahoda and Elektrische Glühlampenfabrik "Watt" Scharf, Loti and Latzko, Austria).
13,076. Incandescent lamps. Feb. 11. J. A. Leon, 60, Queen Victoria Street, London.

II.—GAS LIGHTING.

756. Incandescent lamps. Jan. 13. E. Kreuzberger, 72, Acomb Street, Manchester.
793. Inverted incandescent burners (C.S.). Jan. 13. M. Graetz, 18, Southampton Buildings, London.
887. Holders for inverted mantles. Jan. 14. M. Peiser, Chancery Lane Station Chambers, London.
1,026. Supporting incandescent mantles. Jan. 16. M. Kriegel, Prudential Buildings, Corporation Street, Birmingham.
1,074. Burners for incandescent lamps (C.S.). Jan. 16. A. Pöschl, Thanet House, Temple Bar, London.
1,453. Controlling, igniting, and extinguishing gas from a distance. Jan. 21. H. L. Down and Telephos, Ltd., 115, Cannon Street, London.
1,486. Regulating Bunsen burners for incandescent light. Jan. 22. P. Wigley, G. N. Arculus, and J. Warry, 128, Colmore Row, Birmingham.
1,493. Distance gas-lighters. Jan. 22. H. E. Kelvey, Cromford House, The Square, St. Anne's-on-the-Sea.
1,757. Automatic lighting and extinguishing. Jan. 25. J. L. Cloudsley, jun., 18, Southampton Buildings, London.
1,789. Intermittent gas-lighting. Jan. 27. H. J. Pearce, Zetland Lodge, New Cross Road, London.
1,844. Inverted regenerative incandescent lamps (C.S.). Jan. 27. L. Zechnall and J. Altman, 70, Chancery Lane, London.
1,852. Manufacture of incandescent mantles (C.S.). Jan. 27. W. E. Lake, 7, Southampton Buildings, London. (From Akt.-Ges. für Selas-Beleuchtung, Germany.)
1,881. Inverted incandescent burners (C.S.). Jan. 28. G. Cranmer and H. Cheshire, trading as Cranmer & Cheshire, Carlton Buildings, Paradise Street, Birmingham.
1,994. Gas lamps. Jan. 29. J. Keith and G. Keith, 65, Chancery Lane, London.
2,057. Manufacture of double incandescent mantles (C.S.). Jan. 29 (I.C., July 27, 1907, Germany). Akt.-Ges. für Selas-Beleuchtung, 7, Southampton Buildings, London.
2,240. New method of producing incandescent mantles. Jan. 31. The British Cerofirm Co, Ltd., Chancery Lane, London. (From the Cerofirm-Ges., m b.H., Germany.)
2,285. Inverted incandescent burners (C.S.). Feb. 1. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.
2,300. Systems of gas-lighting (C.S.). Feb. 1. R. E. Andrews, 37, Oakhurst Grove, East Dulwich, London.
2,330. Manufacture of mantles for inverted burners. Feb. 1. W. Kampf, 4, South Street, Finsbury, London.
2,352. Igniting gas jets in buildings, &c. Feb. 3. F. Bloomer, 5, Corporation Street, Birmingham.
2,572. Preparation of mantles or incandescent bodies (C.S.). Feb. 5. M. Weickert, 37, Essex Street, Strand, London.
2,605. High-pressure incandescent burners. Feb. 5. T. Glover, 173, Fleet Street, London.
2,606. Street lamps, &c., for incandescent lighting. Feb. 5. T. Glover, 173, Fleet Street, London.
2,607. Incandescent street lamps, lanterns, &c. Feb. 5. T. Glover, 173, Fleet Street, London.

2,608. High-pressure incandescent burners. Feb. 5. W. Glover, 173, Fleet Street, London.
2,701. Incandescent burners. Feb. 6. E. M. Smith, 33, Cannon Street, London.
2,800. Incandescent burners. Feb. 7. A. S. Francis, 77, Chancery Lane, London.
2,816. Lighting and extinguishing from a distance. Feb. 7. E. H. Elton and R. Stephens, 27, Chancery Lane, London.
2,973. Inverted incandescent pressure gas lamps (C.S.). Feb. 10. (I.C. Feb. 26, 1907, Germany.) M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
3,055. Incandescent mantles (C.S.). Feb. 11. (I.C. Nov. 16, 1907, U.S.A.) A. P. White, 28, New Bridge Street, London.

III.—MISCELLANEOUS.

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

943. Portable advertising lamps. Jan. 15. D. H. Warden, Imperial Chambers B., Colmore Row, Birmingham.
1,064. Lighting apparatus (C.S.). Jan. 16. W. Lindner, 116, High Holborn, London.
1,113. Burners for acetylene flare lamps. Jan. 17. W. Harris and F. R. Stone, Lloyds' Bank Buildings, Bristol.
1,400. Oil or vapour lamps. Jan. 21. H. Brough and J. Major, 18, Southampton Buildings, London.
1,866. Acetylene gas light. Jan. 28. M. Charissi, 64, Bushey Hill Road, Peckham, London.
2,104. Vapour lamps. Jan. 30. W. Hartley, 5, Corporation Street, Birmingham. (Addition to No. 4,014/06.)
2,492. Turning on and off gas or electric lamps from a distance (C.S.). Feb. 4. G. V. Wengelin, 111, Hatton Garden, London.
3,087. Incandescent petroleum lamps. Feb. 11. M. Malkiel, 6, Lord Street, Liverpool.
3,163. Acetylene lamps (C.S.). Feb. 12. L. Jouvenet, Birkbeck Bank Chambers, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

24,232. Incandescing bodies for lamps. Oct. 30, 1906. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London (from Allgemeine Elektricitäts-Ges., Germany).
24,233. Incandescent lamps. Oct. 30, 1906. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From Allgemeine Elektricitäts-Ges., Germany.)
2,963. Arc lamps. Feb. 6, 1907. Accepted Feb. 12, 1908. J. M. Wellington and W. F. Daniell, 88, Chancery Lane, London.
2,964. Arc lamps. Feb. 6, 1907. Accepted Feb. 12, 1908. J. M. Wellington and W. F. Daniell, 88, Chancery Lane, London.
3,060. Arc lamps. Feb. 7, 1907. Accepted Feb. 12, 1908. A. D. Jones, 39, Hartham Road, Holloway.
4,364. Incandescing bodies for lamps. Feb. 21, 1907. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From The General Electric Co., U.S.A.)
5,424. Incandescent lamps and their supports. March 6, 1907. Accepted Jan. 22, 1908. R. J.-B. M. Damseaux, 111, Hatton Garden, London.
5,575. Conductors for use as incandescing bodies. March 7, 1907. Accepted Jan. 29, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
7,279. Arc lamps. March 26, 1907. Accepted Jan. 22, 1908. H. E. Angold and The Maxim Electrical Co., Ltd., 18, Southampton Buildings, London.
8,642. Mounting incandescent lamp filaments. April 13, 1907. Accepted Feb. 12, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
9,345. Pendant lamps. April 22, 1907. Accepted Feb. 12, 1908. T. Elliott, 110, Strand, London.
11,717. Incandescence filaments of tungsten or its alloys (C.S.). I.C. May 19, 1906, Germany. Accepted Jan. 22, 1908. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London.
22,746. Manufacture of incandescence filaments (C.S.). I.C. Oct. 26, 1906, Germany. Accepted Feb. 12, 1908. Siemens & Halske Akt.-Ges., Birkbeck Bank Chambers, London.
24,706. Arc lamps (C.S.). Nov. 7, 1907. Accepted Feb. 12, 1908. Johnson & Phillips, Ltd., and C. F. Tubbs, Birkbeck Bank Chambers, London.
25,846. Arc lamps (C.S.). I.C. Dec. 5, 1906, Germany. Accepted Jan. 22, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
27,541. Incandescent lamps (C.S.). Dec. 13, 1907. Accepted Feb. 5, 1908. C. Pauli, 20, High Holborn, London.

II.—GAS LIGHTING.

1,862. Lighting apparatus for gas lamps (C.S.). Jan. 24, 1907. Accepted Jan. 29, 1908. F. W. Howorth, 46, Lincoln's Inn Fields, London. (From Deutsche Gasglühlicht Akt.-Ges. (Auerges.), Germany.)
2,736. Burners for lighting and heating. Feb. 4, 1907. Accepted Jan. 22, 1908. E. J. Parker, 14, Alwyne Villas, Canonbury, London.

2,749. **Burners for incandescent lamps, &c.** Feb. 4, 1907. Accepted Feb. 12, 1908. J. H. D. Gooding, 343, Queen's Road, London.

3,101. **Inverted incandescent lamps** (C.S.). I.C. Feb. 10, 1906, Germany. Accepted Feb. 5, 1908. Akt.-Ges. für Selas-Beleuchtung, 7, Southampton Buildings, London.

5,139. **Incandescent burners.** March 4, 1907. Accepted Jan. 22, 1908. E. Hinton and F. A. Andrews, 82, New Bond Street, London.

10,294. **Lighting arrangements for incandescent burners.** May 3, 1907. Accepted Feb. 5, 1908. J. Keith, 65, Chancery Lane, London.

11,734. **Lighting and extinguishing gas lamps** (C.S.). May 21, 1907. Accepted Jan. 29, 1908. H. H. Johnson and E. Moin, 77, Colmore Row, Birmingham.

15,893. **Lighting gas at a distance.** I.C. July 10, 1906, Switzerland. Accepted Feb. 5, 1908. F. Blaser, 6, Lord Street, Liverpool.

19,283. **Inverted incandescent lamps** (C.S.). Aug. 27, 1907. Accepted Jan. 22, 1908. G. Steinicke, 6, Lord Street, Liverpool.

III.—MISCELLANEOUS

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

2,470. **Incandescent petroleum burner.** Jan. 31, 1907. Accepted Feb. 5, 1908. E. Holy, 18, Southampton Buildings, London.

7,726. **Incandescent vapour lamps** (C.S.). April 2, 1907. Accepted Jan. 29, 1908. C. A. Black and G. M. Thompson, 18, Southampton Buildings, 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.