DEVOTED TO
THE SCIENCE
AND ART OF
ILLUMINATION

THE ILLUMINATING ENGINEER

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EDITORIAL.

IN this number we deal elsewhere with the subject of the "Illuminating Engineer" and the various comments which the suggestion of the new society and the creation of the new expert have called forth. The views expressed by different critics naturally differ considerably, and in some cases views even of the same critics appear to have passed through a gradual evolution since the date when the subject was first brought to their notice.

In some cases the opinion has been expressed that such a society would be useful, but that the obstacles in the way of its creation would be difficult to surmount. These critics may rest assured that the suggestion is not brought forward without these difficulties having previously been given very careful consideration, and that the necessary support demanded by the starting of such a society will be forthcoming.

In other cases the value of such a society has not been appreciated, though we think that many such objections will be found to be based upon a misconception as to what our suggestion really entails.

We are willing and anxious that all such objections should be raised, as we are sure they can be met. At the same time, we do feel constrained to point out that if those of us who are interested in the subject wish to meet together to discuss problems of illumination, we have a perfect right to do so, if we so desire, and that this should be recognized even by those who doubt the value of our labours. We merely wish to discuss these problems under more favourable conditions than exist elsewhere, and our proposals, whatever their merits, are, at any rate, certainly not of an injurious nature.

It is not as though any demand were being made upon the funds of the general public. If the Illuminating Engineers' Society were to be a public institution supported by the ratepayers, the latter, of course, would be entitled to express their approval or otherwise of the project. But in the case of the Illuminating Engineering Society nothing of this kind is proposed, and, therefore, while we invite opinions upon this subject, we do not recognize the right of those holding them to dictate to us whether or no the society should be formed, so long as the number of members desirous of joining us justifies its formation.

The Efficiency of Light Production.

Several of the articles in the present number illustrate the abstruse nature of the scientific background of the subject of illumination. The problem of efficient light production must be viewed from two distinct aspects, and it is this dual aspect that renders the question so complicated.

Firstly, we have the physical side of the problem—the problem, that is, of selecting suitable light-giving substances which do their work efficiently, and of investigating what it really is that goes on within the atom of the illuminating substance.

Secondly, we have to remember that our impressions of light are all received through the eye, and are therefore complicated by the peculiar behaviour of that organ.

It is only of recent years that the physics of light production have been exhaustively studied, and there is yet much to be learned. It has, of course, been realized that in the case of most of our illuminants by far the greater portion of the energy expended is wasted in the form of radiation of a non-luminous character, and the recent determinations, amongst others, of Dr. Lux and Dr. Drysdale show how small is the percentage of energy usefully employed. We may eventually succeed in limiting the radiation of such a substance to within the limits of $0{\cdot}4\mu$ and $0{\cdot}8\mu$, the approximate range of visible wave length, and the figures for the mechanical equivalent of light quoted by these two authorities give us an idea what the ultimate efficiency of such an illuminant, under these conditions, might be.

Such researches as have at present been carried out on this subject lead us to suppose that we may eventually find it possible to produce a generally useful source of light which only consumes about one-tenth to one-fifth of a watt per candle-power. This, of course, refers to white light. But it may be that for special purposes we do not care about the colour of the light, but are only anxious to get as *bright* a source as possible. In such a case we have to consider which of the rays within the visible portion of the spectrum are the most effective, and we then find that, while those at the extreme ends of this range are the least serviceable, the question as to which ray is absolutely the most efficient brings in at once the physiological peculiarities of the eye.

Dr. Lux points out that the value of the mechanical equivalent of light is very different in the case of different sources, and this may be partially ascribed to their difference in spectral composition.

The Eye and Colour Perception.

The influence of the complex physiological peculiarities of the eye on problems of illumination is also very strikingly illustrated by the paper on the subject of colour photometry by Mr. Dow, which we reproduce in this issue. Heterochromatic photometry was for long regarded as of merely academic interest, but it must be admitted that, at the present day when the methods of producing light are so varied, and the difference in the colour of illuminants is so much more marked than was formerly the case, the subject has a more practical bearing. It will be remembered how, during the discussion of Dr. Bussman's paper on the mercury high pressure arc lamp, much discussion centred around the question of whether the photometry of such lamps was possible by the ordinary methods. We are constantly hearing conflicting opinions expressed on such points, and it is certainly time that these aspects of photometry were thrashed out.

What, however, we regard as of special interest in this connexion is the suggestion that we shall ultimately be able to secure light of any particular colour at will by the use of selective radiation, and that special uses may ultimately exist for light of such special character. For instance, it may be that certain rays are most effective in penetrating the atmosphere, and we therefore draw the conclusion that we ought to try to produce these rays by preference in cases in which the fog-penetrating power of light is of paramount importance.

We cannot, however, enter upon the question of colour without being forced to consider the behaviour of the eye towards light of certain wave lengths. The portion of the spectrum which is most serviceable at high illuminations may not be that portion which is most useful at very low illuminations, and, according to the most recent physiological theories, this can be explained by the consideration of the peculiar behaviour of the small organs of light perception which are distributed over the retina.

In the same way it does not follow that the portion of the spectrum which is most effective in producing the sensation of brightness is also most effective for certain other purposes; and therefore, when undertaking photometrical tests of sources yielding a peculiar coloured light, we ought to bear in mind exactly what functions the light will be called upon to fulfil in practice.

The Nomenclature of Photometrical Quantities.

We have received from Dr. Monasch a copy of his recent article dealing with the present anomalies existing in our methods of defining the unit of intensity of illumination in different countries. This article, which is abstracted elsewhere in this issue, in connexion with the list of standard photometrical definitions which we quoted in our last number, is of great interest at the present moment, and we think that many will agree with the international aspect of these questions on which Dr. Monasch rightly lays stress, and the necessity of coming to some definite understanding.

It is certainly inconvenient for workers of different nationalities to be compelled to convert results into one or other of half a dozen different existing units, and this multiplication of terms must inevitably lead to confusion. As Dr. Monasch explains, we in this country have helped to swell the number of existing terms by the common use of both the candle-foot and the candle-metre, while two values of the plural of the former, namely "candle-feet" and "foot-candles" exist.

The articles mentioned above should be of special interest to some of those in this country who appear to regard the adoption of such terms as "Lux" and "Lumen" as unnecessary efforts to complicate the subject of illumination, and, moreover, appear also to imagine that these terms were created by the American Illuminating Engineering Society. Actually, the terms in question have been in common use on the Continent for many years, and the general recognition of a carefully defined international system of photometrical units would really be of great assistance to workers in illumination. It is of the greatest importance in questions of illumination to form clear ideas of exactly what is meant by certain phrases, and to agree on certain terms and notation which will be understood and accepted all the world over, putting aside any feeling of national bias in these matters. There can be no question that in time this lack of cooperation and misunderstanding will be avoided by the general adoption of some such international system.

THE "POPULAR" AND THE SCIENTIFIC ASPECTS OF ILLUMINATION.

In this editorial we have made special comment upon some of the more abstruse scientific aspects of problems of light-production, and we therefore take this opportunity to refer to a feeling which we have recently seen expressed, that too much insistance upon what may be termed the purely "scientific aspect" of problems of illumination and light-production is liable to produce the impression that illuminating engineering is too complicated a subject to appeal to those at present responsible for illumination.

We have certainly no wish to produce such an impression. On the contrary, we are most anxious that contractors and others should realize the very practical bearing of the scientific side of illumination on the work with which they are associated. At present it must be admitted that the great care which is bestowed on the actual workmanship of the wiring and plumbing is not sufficiently extended to the distribution and use of the light itself.

It must be recognized that in illuminating engineering, as in other professions, there will doubtless be grades of work, in some of which the study of the more scientific sides of the question will be more necessary than in others.

The subject of illumination contains many questions of the very greatest importance, which though simple in character are none the less scientific, and can be acquired by the present lighting contractors. On the other hand, there are certain scientific aspects of illumination which are also vitally important, but which need only be exhaustively studied by the highly trained and impartial expert whom we desire to see evolved from the existing sections of the engineering profession interested in illumination, who by studying this subject will ultimately become the specialist in illuminating engineering.

For the moment we are chiefly anxious that those simple rules of illumination which are of paramount importance should be generally appreciated and carried out.

By the time that this has been done the less readily evident scientific principles of illumination will have been discussed and their application will have become more generally recognized; we are in no wise anxious to cause confusion by insisting on the general adoption of methods which have yet to undergo thorough practical tests.

LEON GASTER.

In addition to the contributors to our January number and the other British and Continental authorities who have promised to contribute, we may mention the following additional names of contributors who have now promised their cordial co-operation and support:—

Herr Biegon von Czudnochowsky, Mons. Granjon, Dr. F. Jacobsohn, Mons. Laporte, Dr. E. Liebenthal, Herr H. Weber.

TECHNICAL SECTION.

Illumination, Its Distribution and Measurement.

(*Continued from p.* 11.)

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

The Advantages of the Harcourt and the Hefner.—The two rivals at present are the Harcourt and the Hefner, with the Carcel in the background as a venerable relic, and the Violle as an unattained ideal of the future. The advantages of the Harcourt for testing gas are very considerable, since correction of this lamp for variations of barometric pressure, moisture, and carbonic dioxide present in the air, practically cancel out against variations in the light of the gas under test. For accurate work against electric light these corrections must be applied. The ten-candle size of the standard is convenient, the colour of the light is good, and slight variations in the specific gravity of the pentane are not serious. The disadvantages are the importance of the necessary corrections and the large size of the apparatus. The barometric corrections doubtless arise out of the gravity-feed of air-gas, and the action of the chimneys. These, however, and the hygrometric corrections do not constitute a serious disadvantage in a well-equipped laboratory where work of high accuracy is carried on.

The advantages of the Hefner are that it needs considerably smaller corrections than the Harcourt, it is inexpensive, easy to use, is only 2¾ inches in diameter, and 5 inches high, and it is widely recognized as a practical unit. The objections to it are the orange colour of the light, and that a one-candle standard is not so useful as a ten-candle.

The Arc Standard.—The idea of screening a flame, and allowing the light from a definitely measured portion to be used as a standard originated with Methven, who screened an Argand gas flame to give one candle or two candle-power. The same system is used in Harcourt's pentane lamp. Violle used a screen with an aperture of one square centimetre. In 1892 Mr. J. Swinburne and Prof. S. P. Thompson independently suggested that a screen having an aperture of one square millimetre should be used with an electric arc, and it was thought that the temperature of the carbon would be uniform, being that of its volatilizing point, and this would cause a standard quantity of light to pass. I had already made a very rough estimate based on a research with a different object.* In that research I was concerned only with relative photometric measurements. These were sufficiently exact for the purpose in view, but the value of the standard was not of importance, and

* *Journal Inst. Elec. Engrs.*, vol. xxi. p. 360.

was not verified. The values 64 to 70 candle-power per square millimetre were deduced from the area of the visible part of the crater or incandescent surface of the positive carbon. I at once attempted to investigate the proposed unit of light, and at about the same time, M. A. Blondel conducted a similar but independent research.

A little study of a well-focussed image of the crater of a continuous current arc, enlarged about 20 times, showed that the brightness of the surface was by no means uniform, and that somewhat erratic changes took place. A bright spot was often seen near the middle of the crater. It was always more noticeable when the arc was humming, but disappeared and was replaced by flashing patches when the arc hissed.

For the purpose of reducing the light by a definite proportion, I used the rotating sector so largely employed by Sir W. de W. Abney, and found that the image on the screen was often covered with shadows connected in some way with the sector. A rotating disc allowing the beam to pass for about 1-1000th of a second, and to be cut off for about 1-100th of a second revealed a bright patch occupying about one-quarter of the crater, revolving about 100 times per second, seldom faster than 450 per second, and difficult to distinguish below 50, though Mrs. Ayrton has observed probably a different kind of patch revolving slowly enough to be seen without the stroboscopic disc.* The maximum brightness was about 170 candles per square millimetre. A fair average is 150.

Circumstances prevented my further investigation of this phenomenon, but it introduced an unexpected and apparently insuperable objection to the use of the proposed standard of light.

Radiation Standards.—Lummer and Kurlbaum in Germany, and Petavel in England have endeavoured to use as a standard the light emitted by one square centimetre of the surface of platinum when raised to such a temperature that 10 per cent. of its radiation would pass through, and 90 per cent. would be absorbed by the thickness of two centimetres of water in a glass cell. The adjustments are difficult. This and the Violle standard seem to share a sort of superior quality, and claims for regarding them as "physical units" have been made on the strength of their dependence on a square centimetre, and a noble metal. The real claim of a standard for recognition must lie in its practical and exact reproducibility. The actual magnitude is of no consequence, since the low mechanical equivalent of light puts a centimetre-gramme-second unit out of the question.

Glow-Lamp Sub-Standards. — While there are practical advantages in using a flame standard such as the Harcourt or Hefner, or even the Carcel, for measuring the intensity of flame-sources of light, electrical engineers and most physicists prefer an electric glow lamp as a practical standard, whatever the ultimate or official standard may be. Dr. J. A. Fleming has given great care to the construction of such substandard glow lamps. The difficulty is that secondary sub-standards must be provided and compared with the carefully standardized lamps, for the candle-power will inevitably alter with use. Another drawback is that very exact measurements of electric current must be made, and the source of this current must be a special secondary battery. The expense of the equipment is therefore considerable, and a Hefner lamp will often be found more convenient.

The next quantity to be considered is illumination. When light falls on a surface, that surface is said to be illuminated. The illumination depends simply on the quantity of light falling upon a given surface, and has nothing to do with the colour or reflecting power of the surface; just as rainfall is independent of the nature of the soil. When rain falls on an absorbent soil it quickly disappears, but the water stands on an impermeable soil. Illu-

* *Proc.* Royal Soc., vol. lvi. (June 12, 1894), and Cantor Lectures Soc. of Arts, S. P. Thompson, 1895, vol. xliii. pp. 973-5.

† *The Electrician*, vol. xxxiv. pp. 37 and 77.

mination falling on a dark-coloured surface is absorbed and wasted, while when the same illumination falls on a light or white surface there seems to be "plenty of light." A careful distinction must be observed, for two rooms may have identical illumination, and one may seem to be well illuminated and the other badly illuminated. There is no paradox here—the word "illumination" is properly used, and the word "illuminated" is misleading. It may appear pedantic to prefer the word "lighted" to "illuminated," but when once a word has a well-defined scientific meaning, borrowed though it be from ordinary language, that meaning should be jealously guarded.

When the same illumination falls, say, on white paper and on brown paper the result is, of course, very different; the brightness resulting from illumination has been called luminosity by Sir W. de W. Abney.

Illumination consists of two factors, candle-power and distance. The illumination produced by 1 candle-power at the distance of 1 ft. is the unit recognized in England and America—it has generally been called the candle-foot. It was used by the late Mr. Sugg about 45 years ago.* In France the unit is naturally the carcel-metre, and it has been in use since 1882. During the last few years the name foot-candle has been used in America. Either name is unfortunate, because, unlike all other compound units, such as the foot-pound, the quantity is not the product of candle-power into length, but it is the quotient, and the divisor is not a length in feet, but the square of a length, for the illumination of 1 candle at 1 ft. is equivalent to 4 candles at 2 ft., or 9 candles at 3 ft. The "candle-power-foot" used by some writers is quite unnecessary, and the "candle per square foot" used by others is a confusion for "candle-per-foot-squared" advocated by Carl Hering.† This seems to be a mistaken expression; it can be supported only by the introduction of unnecessary dimensions, for the square comes in arithmetically and not as an area. Many years ago the editor of *Industries* quarrelled with the candle-foot, and suggested, after the fashion of Lord Kelvin's "mho," that it should be called a "candle-toof-toof." There is something to be said for a "candle-at-a-foot," but perhaps the American name "foot-candle" is the best, for twice this illumination becomes "two-foot-candles," and the candles appear to be multiplied, which is not so misleading as "two-candle-feet," where the candle remains single and the foot becomes plural. I objected to the name when I first encountered it, but I propose to adopt it in future, for the reason which is given here. The symbol in writing may clearly be c/f^2.

All this confusion would be avoided by the recognition of a special name for the unit. Sir William Preece, the first engineer in this country to give attention to the measurement of illumination, adopted the carcel-metre, and he showed* that it was equal to a standard candle at 1·058 ft. At the Paris Electrical Congress of 1889 he proposed the name "lux" for this. Owing to the general apathy with which the subject of the distribution and measurement of illumination has been regarded, neither the name nor the unit came into use. But the carcel-metre has been displaced lately in favour of a unit of illumination produced by a Hefner or bougie-decimal at a metre; this has been called a bougie-metre, and the name "lux" was revived at the Geneva Congress of 1896 and was applied to this unit. In such a case, a name gets over the difficulty of a compound word. The lux is, roughly, one-twelfth of a foot-candle, or about one-fourteenth of Sir W. Preece's lux. The foot-candle is a very convenient and comfortable illumination. It is for most people the best illumination for reading, and is to be found on most well-lighted dining-room tables and billiard tables. More than 3 foot-candles is seldom attained in artificial illumination.

* *Proc.* Inst. Civil Engrs., vol. cx., 1894.

† 'Ready Reference Tables,' Carl Hering, p. 148.

* *Proc.* Royal Soc., vol. xxxvi. p. 276. This was based upon 9·6 candle-power for the carcel.

The law of inverse squares* is easy to understand, but the arithmetical application is not so obvious. To say, off hand, how many foot-candles are produced by a sixteen-candle lamp, at a distance of 8 ft., is rather puzzling at first. The illumination is $\frac{16}{8^2} = 0·25$ foot-candle. Taking the Hefner at 0·913 candle-power and the metre at 3·28 ft., the lux is $\frac{0·913}{3·28^2} = 0·085$ foot-candle, and the foot-candle is 11·8 luxes.†

These calculations are easily done on a slide-rule. Fig. 4 shows a slide rule with 8 (feet) on the C scale set below 16 (candle-power) on the A scale. Then above 1 on the C scale find 0·25 on the A scale. To find how much candle - power at 5 ft. will produce 0·25 foot-candle, with the rule set as in Fig. 4 over 5 on C find 6·25 on A, or for 50 ft., 625 candle-power.

Fig. 5 shows a slide rule set with 3·28 (feet = 1 metre) on C, set below 0·913 (candle-power = 1 Hefner) on A. Then above on C read 1 lux = 0·085

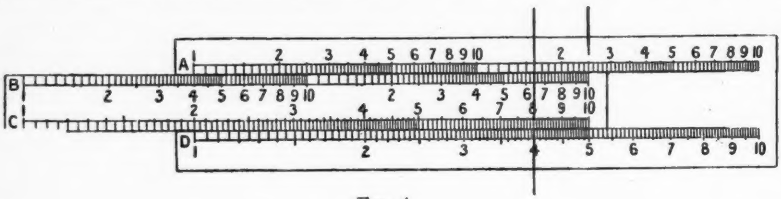


FIG. 4.

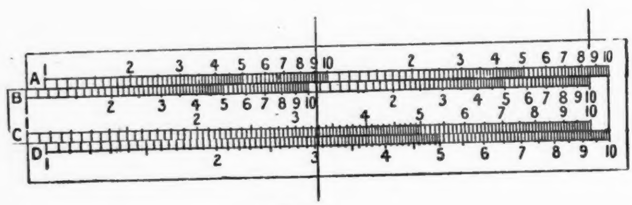


FIG. 5.

* The explanation of the law of inverse squares given by Mr. J. W. Dibdin in his 'Principles of Photometry' (p. 15) can hardly be improved upon:—

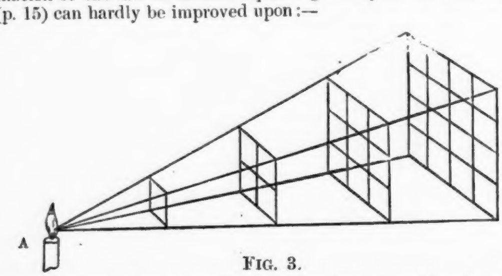


FIG. 3.

"Let it be assumed that the four diverging lines enclose a number of rays of light proceeding from the radiant A. At a distance of one foot, the whole of these rays would fall upon a screen of small dimensions. At twice the distance they would illuminate a surface four times the size of the first screen; and consequently the volume of light impinging upon a screen the same size as that at one foot distance would be only *one-fourth*. At three feet distance, the whole of the rays would have spread, so that a screen nine times the size of the first would be required to arrest them all, and therefore our small screen, if removed to that position, would receive only *one-ninth* of its primary illumination.'

† With the old value, Hefner=0·88 c.p., the lux is 0·0818 foot-candle, and the foot-candle 12·2 luxes.

foot-candle, and below 1 on A read 1 foot-candle = 11·8 luxes.

The foot-candle, as already defined, assumes that the illuminated surface directly faces the source of light. If the surface is inclined to the direction of the rays of light, the illumination will diminish in proportion as the projected area of the surface diminishes when viewed from the source of light. The visible surface varies from unity, as seen full, to nothing when seen on edge. It is a well-established convention among writers on optics (but it is only a convention) that the inclination between a ray and the perpendicular to a surface shall be called the angle of incidence. This angle will frequently be alluded to, and will be designated where necessary by θ. A ray proceeding horizontally, parallel with the ground, will therefore be of 90° incidence, and a ray falling on the point immediately below a lamp will be of 0° incidence on the horizontal plane beneath it.

Let a parallel beam of light pass through a hole AB (Fig. 6) 1 ft. square, and fall on a screen CO parallel with

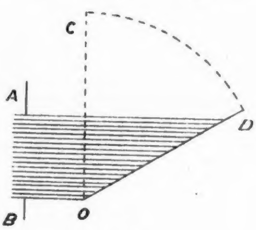


Fig. 6.

the screen AB, and perpendicular to the direction of the beam, that is, with angle of incidence 0°. Let the value of the illumination on CO be called 1. Then let the screen be tilted through 60° to the position DO. It is evident that the illuminated area on the screen is increased from 1 square foot to 2 square feet. The illumination being spread over twice the area, the value is therefore one-half. The angle of incidence is 60°; the cosine of 60° is 0·5; turn the screen through another 30° to OE, or through a right angle with its first position; the light passes by, and theoretically none falls on the screen; the illumination is 0; the angle of incidence is 90°; the cosine of 90° is 0.

In Fig. 7 let AO, BO, DO, FO, and HO be successive positions of the screen.

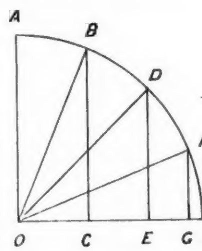


Fig. 7.

Let BC, DE, FG be perpendiculars dropped from the points B, D, and F. Then AO being unity, these perpendiculars measure the cosines of the angles through which the screen is turned, and are proportional to the illumination of the screen. Another aspect of this is to consider how the area of the screen, as seen from the direction in which the light falls, diminishes. It is unity at AO, and becomes zero at OH.

The table on page 11 was an attempt to express the values of the three standards in candle-power. It is better, perhaps, to arrange the table as follows, giving the simple relation between the standards :—

	Carcel.	Harcourt.	Hefner.
Carcel ...	1	0·98	10·75
Harcourt ...	1·02	1	10·95
Hefner ...	0·0932	0·0913	1

(*To be continued.*)

On the Efficiency of the most Common Sources of Light.

By Dr. H. Lux.

(Communication from Dr. H. Lux's Laboratory for Lighting Technics.)

As is well known, only a relatively small fraction of the energy expended in the production of artificial illumination is actually converted into light, the greater part being converted into invisible rays, principally of great wave-length, and usually, though incorrectly, termed "heat rays." The rays of very short wave-length, the ultra-violet rays, which also occur, play but an inferior part quantitively, and may therefore usually be disregarded.

Since, in the production of artificial light, the occurrence of invisible rays of great wave-length is equivalent to waste of energy, it is naturally of great importance in lighting technics to determine the ratio of the visible to the invisible rays. The figures given by various authorities for this ratic, however, differ very essentially, this being due principally to the different methods of research. In most experiments the total radiation of energy by the various sources of light has been determined, and the ratio of the light-giving radiation to the total radiation calculated from the Angström mechanical equivalent of the unit of light and the average spherical luminous intensity. In proceeding according to this method, it has been assumed that the equivalent of the light-unit determined by Angström with a Hefner lamp is a constant physical quantity, somewhat in the same manner as the mechanical equivalent of the heat-unit. The values for the ratio of the light-giving radiation to the total radiation calculated in this manner, however, differ so greatly from the values obtained in various other ways, that the results of the several experiments can scarcely be compared with each other. The greatest differences are those between the values obtained by Prof. Wedding and the values arrived at with the aid of Angström's equivalent.

For this reason I determined to test systematically the most important of the sources of light at present in use, and to ascertain both the total radiation and the light giving radiation by absolute measurement. The radiant energy was measured by means of a Lummer-Kurlbaum bolometer, which enables even the smallest amounts of radiated energy to be detected and measured absolutely. I give seven different methods — three of them original—which, generally speaking, all yield the like good results. In each case the altered bolometer-resistance due to rays being cast upon the bolometer is compared with the like alteration of resistance of the bolometer brought about by a measurable electric current. The measurement of the total radiation, *i.e.*, the radiated energy of all wave-lengths, presents no difficulty.

The difficulties presented are necessarily greater, however, when it is a matter of determining the quantity of radiated energy within the range of the visible part of the spectrum, *i.e.*, of the radiated light. This arises, firstly, from the fact the amounts of radiated energy are extremely small —amounting to only one-millionth of a watt in any given direction of radiation; and, secondly, from the fact that is is extremely difficult, physically, to separate the visible

Source of Light.	Consumption of Energy.	Total Spherical Radiation.	Spherical Light Radiation (between 0·4 and 0·8 μ wave length).	Ratio of Light Radiation to Total Radiation.	Ratio of Light Radiation to Consumption of Energy.	Mean Horizontal c.p.	Mean Spherical c.p.	Watts consumed per mean Spherical Hefner Candle.	Energy equivalent of one mean Spherical Hefner Candle.
	Watt.	Watt.	Watt.	Per Cent.	Per Cent.	H.K.	H.K.	Watt. / H.K.	Watt. / H.K.
Hefner lamp	86·3	9·96	0·089	0·89	0·103	1	0·825	104·6	0·108
14-inch Petroleum lamp* ...	508·0	102·2	1·26	1·23	0·25	14·2	12·0	42·3	0·105
Acetylene flame†	96·0	9·78	0·62	6·36	0·65	7·7	6·04	15·9	0·103
Incandescent gas light :—									
(*a*) Vertical,									
without chimney ...		147		2·26					
	716·7		3·28		0·46	107	89·6	7·98	0·037
with chimney ...		112·1		2·92					
(*b*) Inverted,									
without globe ...		143		2·03					
	571·0		2·9		0·51	107	82·3	6·97	0·035
with globe		97·6		2·97					
Electric carbon filament glow lamp with globe		63·5		3·2		31·5	24·5	4·09	0·085
	98·23		2·03		2·07				
Ditto without globe		75·2		2·7					
Nernst lamp without reducing-rheostat	165·0				4·21			1·74	
		122·2	6·96	5·7		120·1	94·9		0·073
Ditto with reducing-rheostat	181·4				3·85			1·91	
Tantalum lamp‡	44·0	25·2	2·15	8·5	4·87	34·6	26·7	1·65	0·080
Osram lamp‡	38·3	22·5	2·05	9·1	5·36	36·3	27·4	1·43	0·075
Direct current arc lamp	435·0	301·8	24·3	8·1	5·60	190	524	0·83	0·047
Ditto enclosed arc	541·0	308	6·2	2·0	1·16	200	295	1·31	0·021
Flame arc lamp, yellow light ...	349·7	295	46·2	15·7	13·20	907	1145	0·31	0·041
Ditto white light ...	348·0	304·5	23·2	7·6	6·66	602	760	0·46	0·031
Alternating current arc lamp ...	180·6	91·2	3·4	3·7	1·90	109	89	2·03	0·038
Uviol mercury vapour lamp§ ...	198·6	91·3	5·3	5·8	2·24	437	344	0·58	0·015
Quartz lamp	691·0	236·0	41·5	17·6	6·00	3400	2960	0·23	0·014

* Consumption of petroleum per hour, 39·73 grammes; heat of combustion of the petroleum, 11050 gr. cal. The total radiation was measured without chimney.

† Consumption per hour, 7·2 litres; heat of combustion, 13900 gr. cal. per litre.

‡ In calculating the total radiation, the absorption by the glass globe, amounting to about 15·5 per cent., was not estimated.

§ Uviol lamp of Schott & Gen., about 90 cms. long; average P.D., 63 volts; average current, 3·3 amperes. For the average spherical luminous intensity the formula $J_o = \frac{\pi}{4} J_h$ was employed. The value of the total radiation is surprisingly low compared with the consumption of energy. This is probably due to a great proportion of the energy expended being used in vaporising the mercury.

radiation from the total radiation in the same manner as is done physiologically by the eye. I discovered, eventually, that a concentrated solution of ferro-ammonium sulphate in a layer 10 cms. thick yields the best results. This method, at any rate, gives results for the Hefner lamp and the acetylene flame coinciding almost exactly with the results obtained by Angström in an entirely different manner. Thus, Angström found the equivalent for the total light-giving radiation of the Hefner lamp in space to be 0·102 watt, whilst I have arrived at the value 0·108 watt. In view of the difference in the conditions of experiment this may be regarded as almost perfect agreement. It can, therefore, be assumed that the equivalents of total radiation and light-giving radiation ascertained by me for the various other sources of light are reliable as respect serial order.

It will suffice here merely to tabulate the results of my experiments.*

As is seen from the table, the various sources of light are divided into four main groups, which differ very distinctly from each other. The first group includes those luminous sources which have an exposed flame. The least economical of these are the sources in which finely divided carbon is brought to a state of incandescence.

But in the case of the incandescent gaslight, also, the efficiency is exceedingly low, since the energy supplied is chiefly utilized to bring the nitrogen of the air to a higher temperature, so that more than two-thirds of the energy expended is absolutely lost as far as illumination is concerned.

The employment of the heating-effect for the production of light is a very circuitous method, even when the electric current is used for heating the illuminating bodies. But with the aid of the electric current it is, at all events, possible—even though at present only theoretically—to improve the ratio of light-giving radiation to the energy expended very considerably by simply increasing the temperature. With the employment of flames —however hot—on the contrary, there is no real improvement possible, even if radiating bodies were to be used which radiate still more selectively than the Welsbach incandescent mantle.

An opinion can be formed respecting this fact, if the values for the energy expended shown in the above table are compared with the total radiation measured. The values ascertained for the luminous sources of the first and second classes, that is, for sources with open flames and the various electric incandescent lamps, are especially instructive. It will be seen that with the sources with open flame only a minute fraction of the energy expended is converted into radiant energy. A substantial elevation of the temperature would, it is true, bring the maximum of radiation into the visible range, but even in the most favourable case, only about 20 per cent. of the energy supplied could be converted into light. It is far simpler to attain more economical production of light by the employment of the Joule heat. As the values of the energy supplied and total amount radiated in the case of the electric incandescent lamps make clear, a very considerable portion of the energy expended is obtained again in a radiant form.

In the case of the Tantalum and Osram lamps the losses are only apparently greater than in the case of the carbon filament and the Nernst lamps; the amount of the radiation absorbed by the glass globes used with the metallic filament lamps could not be estimated. In reality these lamps do not behave essentially differently from the carbon filament lamp, where about 15·5 per cent. of the total radiation is absorbed by the glass globe, *i.e.*, about three-fourths of the energy expended is converted into radiant energy. An increase in the temperature of the illuminating body would alter nothing here, except that the radiation would be of another *quality*. It might enable the total radiation to consist chiefly of luminous rays, and not, as at present, mainly invisible energy. In this manner the yield

* A full report of my investigations will be found in the *Zeitschrift für Beleuchtungswesen*, 1907, No. 16 *et seq.*

of light could be increased to about 60 per cent. and more. The great improvement in economy, which is rendered possible by raising the temperature, is shown by the performances of the metallic filament lamps, the greater efficiency of which, as compared with the carbon filament lamp, is mainly due to the higher temperature of the incandescent metallic filament. This is shown still more clearly by the well-known experiment of overrunning a carbon filament lamp.

The problem which remains to be solved, therefore, is to find a material which can withstand continuously a temperature that the present carbon filament lamp can only bear for a few seconds. For the solution of this problem metallic filamens, even of the most refractory metals, would appear unsuitable, since their melting points must set a limit. It would seem that only a carbon filament could withstand the necessary high temperature permanently. Naturally such a carbon filament would have to be absolutely homogeneous, in order to avoid the disintegrating action following the liberation of occluded gases.

In any case, it is more difficult to bring the economy of the pure temperature-radiators to a higher stage, on account of the essentially circuitous method, than to obtain light-vibrations from the electrons by direct excitation. In the case of those sources of light in which the luminosity is not pure temperature-radiation, but is, to a very great extent, the result of luminescence, we approach the solution of the problem. Among luminous sources of this class may be mentioned firstly, the mercury vapour lamp, and, secondly, electric arc lamps, especially those in which incandescent gases or metallic vapours are intentionally brought to a state of luminosity. The enclosed arc and the alternating small current arc, it is true, are at present less efficient than the metallic filament incandescent lamp, so that attempts to attain success by these means do not appear encouraging.

On the other hand, the ordinary direct current arc lamp and, in particular, the mercury vapour Heræus Quartz lamp are more efficient. From the above table we see the degree of efficiency of these sources of light—even to-day where we are just at the commencement of their development—is very high. Compared with the economy of the ordinary petroleum lamp, which is still by far the most universally used illuminating apparatus, an arc lamp with yellow-flame-carbon is an immense advance. The efficiency of the former is but 0·25 per cent.; while that of the latter is as much as 13 per cent.—that is to say, 52 times as much! It is remarkable that with the present means at our disposal, it is possible, even now, to bring the economy of light-production almost to the same level as occurs in the conversion of one form of energy into another, in the steam engine.

Ceteris paribus, therefore, those sources of light must be held to be the most advantageous which do not depend mainly upon pure temperature radiation, until recently the only method at our disposal. From this point of view those values in the above table, which afford information respecting the mechanical equivalent of light for the various luminous sources, are of special interest.

The assumption sometimes met with in the literature of the subject—that the mechanical equivalent of the light-unit must be a constant quantity for all sources of light—would, in view of the present investigations, appear to be no longer tenable. It is also obvious that the value of the mechanical equivalent of light must depend upon the spectral composition of a source, and the differences in the effective values of various sources, even belonging to the same category, can, perhaps, be explained in this way.

But another remarkable fact is brought out by the figures in the last column of the above table. The sources of light — in which finely-divided carbon is rendered incandescent, and also the electric glow-lamps, have an energy-equivalent for the average spherical light-unit which is approximately equal to 0·1 watt H.K. These are the pure temperature-radiators. In the case of the electric arc lamps, on the contrary, we find values which average about 0·04 watt H.K.; and in the case of the mercury vapour lamp, yielding a pure line-spectrum, this value even sinks to 0·014 watt H.K. Those sources of light which involve luminescence-effects therefore require less than one-half the expenditure of energy that is requisite in the case of pure temperature-radiators.

This appears quite reasonable, if the mechanics of illumination be regarded on the electron theory. We may note, too, the bearing on the theory of the Welsbach mantle, of the fact that the energy-equivalent of the incandescent gaslight ranks with that of the electric arc lamps. The peculiar composition of the Welsbach mantle, therefore, seems to admit of electron-vibrations being excited by pure heat-effect to an extent that is otherwise only possible by the aid of electrical stimulus. The undeniably strong selective radiation of the Welsbach mantle, at any rate, does not alone suffice to explain the extremely low value of the energy-equivalent of the incandescent gaslight.

The Cost of the Common Illuminants.

(From *Lumière Electrique*, Jan. 11, 1908.)

A WRITER in *Lumière Electrique* quotes some results of Prof. H. Dörr, of Frankfort-on-Main, relating to the cost of a wide number of illuminants ranging from the candle to the flame arc.

Other figures of this nature have been previously published, and naturally the results of different workers depend both upon the local conditions and the assumptions made by him in the course of his investigations. In order to be complete such results should include the complete details of cost of lamp itself, recurring cost of energy, or fuel, and cost of renewal and maintenance generally.

The results of Prof. Dörr's investigations are included in the table given below, in which the illuminants are arranged in order of cheapness, should be of interest for purposes of comparison:—

COST OF 10 CANDLE-POWER-HOURS.

Type of Lamp.	Cost (centimes).	Type of Lamp.	Cost. (centimes).
Petrol (under pressure)	0·12	Alcohol Lamp	1.00
Flame Arc	0·20	Alternating Arc Lamp	1·00
Mercury Arc	0·31	Nernst Glow ,,	1.06
Incandescent Mantle (gas)	0·31	Miniature Arc ,,	1·12
,, ,, (petrol)	0·50	Acetylene	1·50
Osram Glow Lamp	0·62	Carbon Filament Glow Lamp	2·00
Petroleum	0·87	Gas (round burner)	2·00
Osmium Glow Lamp	0·94	,, (batswing)	3·00
Tantalum ,, ,,	1·00	Wax Candle	13·7

In these calculations the cost of electrical energy was taken as 62 centimes (6·2 pence) per unit. Also the cost:—

Per cubic metre of	Gas,	20 centimes.
,, kilogram ,,	Petroleum	27 ,,
,, ,, ,,	Alcohol	50 ,,
,, cubic metre ,,	Acetylene	1 fr. 50.
,, ,, ,, ,,	Stearine	1 fr. 85.

The order of the illuminants given above differs in several respects from that of other authorities (*e.g.* Prof. Wedding).

Many people will also be at first surprised to find that the candle proves to be the most expensive of all sources of light, until it is remembered that these results are worked out on the basis of "cost per amount of light yielded."

The Production and Utilization of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 31.)

METHODS OF LIGHT PRODUCTION.

All methods of producing light being reduced to the stimulation of electron vibrations, it follows that they may differ in the method of stimulation and in the nature of the substance stimulated. The first method of producing the requisite stimulus is by the chemical methods, in which a substance is burnt, or oxidized, or undergoes decomposition. In this case what takes place is that the atoms of the combustible material and those of the oxygen in the surrounding air have a strong chemical affinity or electrical attraction for one another, and when they come within a sufficient range, under the action of heat, this attraction causes the atoms of the two substances to rush together, thus giving the necessary agitation to the electrons. The nature of the vibrations or radiation given out, however, varies with the nature of the substance burnt. When pure hydrogen burns in oxygen, for instance, there is a most intense agitation, but the vibrations are nearly all outside the limits of vision, and the flame therefore emits very little light. By introducing a solid substance into the flame, these agitations are communicated to it, and we get the continuous spectrum or white light, if the temperature is sufficiently high. The solid substance may be either in the form of carbon particles disengaged from the fuel itself during combustion, as in ordinary candles, oil lamps, and gas flames; of particles of highly refractory materials introduced into the flame, as in some of the recent attempts which have been made in Germany to improve the efficiency of oil or gas flames; or of solid envelopes or bodies, as in the Welsbach mantle or lime light.

Light is also produced when some substances, such as phosphorus, are slowly oxidized, and when disintegration of complex molecules takes place automatically, as in radium. In the case of radium it is well known that electrons are continually shot off resulting in a chemical change of the radium into helium, argon, and lead, but whether this shooting off is the result of intense kinetic energy in the atom, as surmised by Sir Oliver Lodge, or of static or potential energy like the explosion of a shell, as Lord Kelvin believes, is still a moot point. In neither of the latter cases has the efficiency of light production been determined, but up to the present the amount of light has been too small, and in the case of radium far too costly, to be considered. The production of light directly by chemical combustion or disintegration may be termed chemical luminescence. It is probably the origin of the light of the glow-worm and fire-fly, and deserves serious investigation.

The second method of producing light is by electrical means, which may be employed either to produce incandescence or luminescence. In the former the current is passed through a filament of high resistance, and as an electric current in a conductor is simply a passing on of electrons from one atom to another, as fire buckets are handed on (to use Sir Oliver Lodge's analogy), this is accompanied with agitation of the atoms and emanation of heat. As the current strength is increased the agitation becomes more and more rapid until the electrons of the filament are stimulated to the extent of giving light, which is of the usual continuous character of the solid body, and is accompanied by considerable waste heat radiation. In gases, however, it is now known that the passage of a current is of a different character from that in a solid conductor. In all gases and non-conductors considerable force appears to be necessary to separate their constituents, and in consequence a high P.D. can be maintained between two electrodes a short distance apart without any passage of current. The gaseous molecules in the field between the electrodes are thrown into a state of strain, the positive constituents being attracted towards the negative electrode and the negative constituents towards the positive electrode, but without any separation. When the electric force exceeds a certain amount (about 30,000 volts per cm. at ordinary pressure), however, the atomic forces are overcome, and the charged ions fly towards their attracting poles, forming what is termed an arc. In their passage the charges of opposite sign frequently unite for an instant, and are then hurried on again, causing intense atomic vibration and evolution of heat, which when communicated to the carbon electrode renders it intensely incandescent. The greater brilliancy of the positive carbon is probably due to the much greater velocity of the particles projected from the negative pole, which have therefore a longer free path, and crowd the atomic conflict near to the positive pole.

When, however, a gas is enclosed in a tube and is reduced in pressure, its resistance to the passage of the current is decreased, owing to the reduction of the number of resisting molecules, and the discharge can be maintained over a long tube with a moderate P.D. The longer free path of the separated atoms or ions, and the consequent more sudden impact when they collide enables the gas itself to be made luminous; and, as the pressure is further reduced, the free vibrations are very little interfered with by the collisions, and a light having fine spectrum lines is obtained, as in the Geissler tubes, mercury vapour lamp, &c.

Upon still further exhausting the tube few molecules or atoms are left to vibrate or collide, and we then reach the state known as the Crookes vacuum, when showers of electrons are projected off the negative electrode with a velocity of about 30 millions of metres per second, and drive any residual gas back. These particles do not collide and are quite invisible, but whenever they fall upon a substance they set its electrons into intense vibration, as a shower of rifle bullets fired against a bell might ring it loudly without setting it swinging, or a rapidly moving comet might disturb the planets of the solar system without greatly affecting the sun; and we then have the phenomenon of luminescence, in which the body appears to glow, but with a much more restricted spectrum than is obtained by heating or atomic bombardment, and consequently in many cases with a much more efficient light.

Since light consists of electromagnetic oscillations of a definite range of frequency, the most perfect method of producing it would theoretically be by obtaining alternating currents of this frequency. Hitherto, however, the highest frequencies procurable have been enormously below that required, and so far as can be seen at present there is no possibility of producing such currents directly.

Lastly, light can be produced by what may be termed transformation and storage methods.

Just as a structure is known to quiver with a relatively high frequency when agitated at a lower frequency, like a pier in the sea, when struck by waves, so we have substances which when stimulated by heat or low frequency vibrations, will transform them into high frequency vibrations of light. This phenomenon is known as calorescence, and is perhaps made use of in the "flame" arc lamp.

On the other hand, rapid vibrations may induce slower ones, as is evidenced by the slow heavings of a ship induced by waves of higher frequency, so rapid vibrations of ultra-violet light may induce lower visible vibrations. This phenomenon, known as fluorescence, has already been useful in extending the spectrum of the mercury vapour lamp, and may very likely be of further value in the near future, although its immediate application is not yet apparent.

Again we have substances which when stimulated in one of the foregoing ways continue to give out light after the stimulus has ceased. Substances of this nature are termed phosphorescent bodies, of which calcium sulphide, the basis of luminous paint, is one of the best-known examples among chemical substances.

The following classification shows in compact form the various ways by which light may be produced, and indicates the avenues of future research and development :—

PRODUCTION OF LIGHT.

CLASSIFICATION OF METHODS.

1. *Nature of Stimulus.*

A.	Ionic or atomic impact (large mass, low velocity)	Incandescence	Long spectrum or great range of forced vibrations.
B.	Electronic impact (small mass, high velocity)	Luminescence	Shorter spectrum or freer vibrations.
C.	Etherial vibration { slow	Calorescence	
	Etherial vibration { rapid	Fluorescence	

2. *Origin of Stimulus.*

Chemical	(*a*) Rapid combination (combustion or flame)		Incandescence	Self-luminous— Particles in gas, candle, lamp, &c. Non-luminous— Particles injected. Mantle. Solid body (lime light).
	(*b*) Slow combination (oxidation, &c.)		Chemical Luminescence	Phosphorus. ? Glow worm and fire fly
	(*c*) Disintegration (radio activity)		Chemical Luminescence	Radium.
Electrical	(*d*) Conduction		Incandescence	Glow lamp.
	(*e*) Bombardment	Ionic	Incandescence	Arc lamp. Geissler tube. Mercury vapour lamp.
		Electronic	Luminescence	Crookes tube. Luminiscent lamp.
	(*f*) Oscillation			No example.
Radiation (Etherial vibration)	(*g*) Heat (Transforming up)		Calorescence	Fluorspar, &c.
	(*h*) Light (Storage)		Phosphorescence	Calcium sulphide, &c.
	(*i*) Ultra-violet (Transforming down)		Fluorescence	Uranium glass. Fluorescine, &c.

In what follows, some attention will first be given to the history of artificial lighting, and to optical, photometric, and radiation measurement. Afterwards these various methods of light will be considered in detail.

(*To be continued.*)

The History of Illumination up to the Discovery of the Incandescent Mantle.

By Dr. C. Richard Böhm.

The degree of culture attained by a people is indicated by, among other things, their need for illumination.

Since the days when the legendary Prometheus stole the divine fire from heaven, and the earth thus became acquainted with its warming and illuminating properties, illuminating flames were for long regarded rather as objects of religious veneration than as means of illumination, according to our modern sense of the word.

Wood naturally suggested itself as one of the very simplest sources of illumination, especially the resinous pine, which was known and used not only in the times of Homer, but well on in the middle ages, either in the form of isolated splinters or in the open fireplace. Indeed, in many mountainous districts it was so used even at the commencement of the previous century. The next step was the utilization of resin in torches and vessels, and ere long fats and oils, too, came to be used for this purpose.

Oil-lamps occur even in the most ancient Roman illustrations. Great care was bestowed upon the artistic design of these lamps, but the illumination yielded by them was very poor.

We are told that the illumination of temples, palaces, streets, and so forth was considered a great luxury by the various nations that formerly inhabited Asia and Africa, such as the Medes and Persians, the Assyrians, and the ancient Egyptians. In Memphis, Thebes, Babylon, Susa, and Nineveh special festivals were celebrated by the placing of stone or bronze vases at short intervals in the streets. These vases were filled with liquid fat to the weight of 100 pounds or more, the contents being burnt by means of a wick three inches in thickness.

The records of Pliny and Livy also state that, in the case of funerals, reeds soaked in oil were commonly burnt; here we perceive the beginnings of candle-illumination.

The ancient Greeks were unacquainted with candles, but the Romans of this time already distinguished between those composed of wax and those of the tallow variety, and described their manufacture with wicks.

Wax candles seem to be of Phœnician origin. The Phœnicians bleached wax and constructed candles of it, and they seem to have introduced these into Byzantium. In the fourth century A.D., the emperor Constantine the Great is said to have illuminated Byzantium on Christmas Eve with lamps and wax candles. Under the Turkish rule the art of candle-illumination seems to have been almost lost. Candles are first heard of again in the twelfth century and onwards, when they were used in connexion with the services in Roman Catholic churches, and, subsequently, after the Reformation, to a great extent at court festivals.

Until the last century the manufacture of candles remained essentially the same as a thousand years ago. About the end of the eighteenth century endeavours were made to obtain a harder and less easily molten material from the crude tallow, which was first partially thickened and then pressed out, without, however, obtaining the desired result.

The chief objection to the tallow candle was the wearisome "snuffing" or breaking away of the wick, the necessity for which Goethe had already bemoaned in his whimsical way. This defect was first remedied through the discovery of the stearine candle, which is, in a great measure, due to certain French *savants*, and especially the distinguished chemist, Chevreul. In his famous work 'Recherches Chimiques sur les Corps gras d'Origine Animale' in 1823 he showed that fats consisted of compounds between the then previously known glycerins with the fatty acids. Under pressure he separated out the so-called "stearine."

The practical utilization of stearine was rendered possible by the conclusion of a series of purely technical researches by an Englishman named Milly; to him, indeed, is due the ultimate development of a satisfactory article and also the preparation of the wicks in such a manner to do away with the necessity for snuffing.

In the middle of the previous century the animal and vegetable oils began to be replaced by mineral products. Caucasian "earth-oil," or naphtha had long been known to exist. It was known, too, that very serviceable oils for purposes of illumination (such as paraffin, photogen, solar oil, &c.) could be prepared from the brown and richer varieties of coal. After this was realized greater attention was paid to naphtha. In 1857 the sinking of a bore in Pennsylvania gave rise to the "earth-oil" characteristic of that district, and in this way sprang up the great petroleum industry—one of the greatest industries in the world. Now for the first time satisfaction awaited the old demand—"More light!"

The value of petroleum to mankind as a whole can be judged from the fact that in 1899 the entire world consumed 180 million hectolitres of this product, of which 100 came from America alone, and the remainder principally from the Caucasus.

Meanwhile, great improvements in the construction of lamps kept pace with the spread and cheapening of liquid combustibles. By reason of its mobility and its affinity for cotton thread, petroleum easily rises in the wick, so that it was now possible for the first time to place the oil-reservoir beneath the burner, and to do without the aid of any mechanical contrivance for this purpose. Wicks were also improved, a flat, band-shaped variety, which presented a greater surface of flame to the surrounding oxygen, being now utilized. But the most decided advance ensued through the invention of Aimé Argand, who introduced the ring-shaped wick, which allows the oxygen to have access to the inside in such a manner that both sides of the flame are fed from the surrounding air.

We may also note the further invention by Argand of the glass chimney, which permitted a much greater flame-temperature without the lamp smoking. Argand's invention dates from the year 1783, but its practical application only became evident much later, after the introduction of light oils; still, even previously, this invention had exercised a considerable influence on the improvement of illumination with the fatty oils. The researches of Carcel (1800) were also of value in this respect.

In 1836 the oil lamp reached a high point of economical perfection in the Franchot "Moderateur" type, which almost completely replaced the Carcel lamp, and up to the discovery of petroleum in 1857 found very wide application.

Soon after the introduction of the chimney attempts were made to give it a more serviceable form. Benkler, a tinker of Wiesbaden, was the first to realize that the action of the chimney can be improved by forcing the rising column of air to come into more intimate contact with the flame-surface. He attained this end by narrowing the chimney in the neighbourhood of the flame, a practice which is common at the present time.

Street-illumination was first introduced in Paris towards the end of the fifteenth century, but was then very deficient; subsequently cauldrons of lighted pitch or pine were utilized in 1558, while in 1667 lanterns having a regular period of burning were introduced. Arrangements similar to those obtaining in Paris were afterwards introduced at The Hague in 1618, in Amsterdam in 1669, in Hamburg in 1675, and in Vienna in 1687. In Berlin the Grand Duke introduced the first street illumination, and Frederick the Great in so far improved this that he ordered the erection of 2,470 chandeliers in the place of the single hundred previously existing. In London the streets were first regularly illuminated from 1736 to 1739 onwards.

It was only towards the end of the eighteenth century, with its accompanying violent political, technical, and industrial developments, that scientific chemists had been able to form for themselves a correct conception of the nature of the processes of combustion; thus was laid the foundation of deliberate improvement in the practice of flame-illumination.

One cannot describe the condition of illumination at the end of the eighteenth century more strikingly than by quoting Goethe's couplet :—

Wüsste nicht was sie Besseres erfinden könnten'
Als wenn die Lichter ohne Putzen brennten.

(He could not imagine anything better to invent than that lights would burn without snuffing.)

But already a new method, gaslighting—the flame-light with no wick —was looming on the horizon, of the existence of which Nature had already hinted in the holy fire of Apcheron near Baku, and the burning well at Wigan in England. The latter phenomenon, in particular, had induced Prof. Becher, of Münich, to attempt the distillation of gas from peat and coal, and by so doing to produce the so-called "philosopher's light." In 1789 Clayton, in 1786 Lord Dundonald, and almost simultaneously that enterprising Scotchman William Murdoch, began to experiment. It was Murdoch who first realized the industrial aspect of illuminating-gas in its entirety, and it was he who first succeeded in bringing the process of the dry-distillation of combustibles to a practical stage.

Towards the end of the eighteenth century Murdoch associated himself with the great improver of the steam-engine, James Watt, in this work. The two great inventions which have exerted the greatest, most far-reaching influence on our daily life issued together from the same spot—the factory at Soho, Birmingham—at the commencement of the new century. Simultaneously with the improved steam-engine, the first gas-lighting installation found its way into the spinning and weaving factories of England.

The year 1792 has been termed the birth-year of gaslighting, for in that year Murdoch installed a gaslighting installation in his own house at Redruth. The success of this installation induced him to embark on wider schemes, with cheerful conviction of ultimate success. In 1798 the factory at Soho was illuminated, and in 1802 the whole front of the factory blazed most effectively with home-generated gas, in honour of the Peace of Amiens. Murdoch erected many gasworks in England, and induced Watt's pupil, Clegg, to take up the subject; he may, indeed, be considered the father of gaslighting.

Simultaneously with the efforts of these men in England, the French engineer, Phillip Lebon, attempted to produce gas from the distillation of wood, but his arrangements seem to have been so unpractical that his invention did not receive much recognition. Lebon lost a fortune in his researches, and was found dead on December 2nd, 1804. His attention having been attracted by these researches, Joh. Winzler of Znaim, in Moravia, investigated Lebon's results, and afterwards travelled through Germany and Austria, provided with a charter from George III., and lecturing upon the discovery of illuminating gas. Eventually he came to London, and in 1810 succeeded in forming the great Chartered Company with a capital of 50,000*l.* sterling.

This company illuminated a portion of London from their works in Peter Street in 1813, lighted St. Margaret's Church in 1814, and eventually secured rights for the whole of England. Winzler and Clegg managed the company for some time, but presently disagreement led to their resignation. Winzler went to Paris, where he introduced illuminating gas in 1817. Clegg continued to build gasworks in England on his own account, and died in 1861, highly respected, at Hampstead.

Besides coal, animal and vegetable oils were ulso utilized for the preparation of gas. Such gasworks were built in 1815 by John Taylor of Stratford. Owing, however, to the high price of raw materials, they did not pay well, and have since all been converted into gasworks of the ordinary variety, just as occurred in the case of the wood-gasworks erected by Pettenkofer in Munich and Riedinger in Augsburg about 1850. In 1850 petroleum was introduced from America into Europe, and about 1860 Heinrich Hirzel of Leipsic and others were induced to study the application of the products of distillation to the manufacture of oil-gas, and the re-ection of oil-gasworks, intended specially for small installations; to-day there are in Germany alone 1,000 such oil-gasworks, which, however, now chiefly utilize paraffin oil and the by-products of the distillation of varieties of coal rich in hydrocarbons.

The first gasworks erected in England, apart from those in London, were in Birmingham, Norwich, Hull, Dublin, and Plymouth; this method of illumination only spread to the continent much later. About 1784 Prof. Winckeler of Löwen had published an account of the discovery of the gaslight, and already in 1786 Prof. Sickel of Würzburg had illuminated his laboratory with gas. In 1816 his example was followed by Flashoff, a chemist of Essen, and in 1818 Dinnendahl so illuminated a workshop in which sixty workers were employed. On April 17th in the same year the first lighthouse was illuminated by gas at Salvore on the coast of Istria. In the following year the lighthouse and beacon at Dantzic were lighted in the same way. The first gasworks was built at Hanover in 1828. On the 19th of September, 1827, "Unter den Linden," in Berlin, was lighted by gas for the first time. Dresden followed suit in 1828, Frankfurt in 1830, Leipsic in 1837, and subsequently many other towns, while in Wurtemberg works were laid down at Heilbron in 1842, and Stuttgart in 1845. By the year 1850 the great majority of the larger German towns had installed gas both for the illumination of the streets and also for the lighting of the interiors of buildings, and after this time the medium-sized towns and even the small towns were also provided with gas.

In place of the at first exclusively and even now most generally employed ordinary coal-gas, gas prepared from wood, peat, and special cannel coal, and, more recently, oil-gas was utilized. At the present time the use of water-gas for illumination, especially in America, has become usual. If there is one material which has been subjected to alternations of approval and dislike, it is water-gas. After being repeatedly almost entirely forgotten, it has invariably attracted a great share of attention as soon as it reappeared in the public eye, and rightly so. The merits of this combustible are indeed so marked that any great progress in the development of water-gas will be noted with very general interest.

The advantages of gaslighting lie in the high intensity of the light yielded and the extraordinary cheapness in comparison with the light-effect obtained. In comparison with oil-and petroleum-lighting the convenience of its application, which arises both from the arrangement of the apparatus of combustion and the almost infinite divisability of gas itself, must also be reckoned to the credit of gaslighting.

For more than half a century flame-lighting, either in the form of oil or gaslighting, reigned supreme. But towards the end of the seventieth year of the previous century the flame combustion, or as it might be termed "chemical" light, began to experience the rivalry of a flameless, combustionless source—the electrical glow-lamp, a struggle between the two methods of illumination ensued, of which we are witnesses at the present day In the course of this competition the world was filled with an abundance of light, of the possibility of which the previous generation had had no conception.

The rapid development of the electrical light led many men of business to believe that it would achieve a complete revolution in illumination, and would not only supersede existing systems, but eventually monopolize the entire field of public and private lighting. Others, again, were of the opinion that gas-installations would in future be confined to the possibilities of supplying heat and power, but that even from this point of view they rested on a satisfactory and favourable industrial basis.

Through the above-mentioned and similar events the requirements of gas-lighting were promoted, and improvements in the preparation and burning of gas achieved which rendered reduction of prices possible, and were of great value to the public.

Subsequent years saw a remarkable simultaneous development of all methods of illumination; there remained, however, some doubt as to the future of the gaslighting industry, but this was set at rest by the practical arrival of the incandescent mantle.

With the arrival of the mantle gas-lighting entered upon a new period in its development; at the same time the wish of those who had recommended that the gas industry should confine itself to the production of heating gas was also realized.

For the essentially heat-producing Bunsen burner, which has been, in the main, applied to heating and cooking purposes, is also the basis of the new gaslighting. The glowing gas itself has been replaced by a foreign incandescent material—a new "wick," in fact.

The problem of light-production has therefore been reduced to a question of heating. Hence the gas industry is no longer concerned with the utilization of a very restricted, dear, and occasionally only with difficulty procurable variety of coal. Their choice among raw materials is now considerably enlarged. The introduction of the incandescent mantle opens up a wide field for future activities in the departments of gas utilization and production.

The Economical Illumination of Display Windows.

JOHN D. MACKENZIE, A.I.E.E.

"Where there is too much light, our senses don't perceive; they are only stunned or dazzled or blinded."—Pascal.

THE problems which meet the illuminating engineer, and which it becomes him to successfully solve, are very varied. Each successive scheme has some distinguishing feature to differentiate it from its predecessor, whether that be due to some peculiarity of building, decoration, colour scheme, the purpose for which the illumination is desired, or even to the particular idiosyncrasy of the client. It accordingly is necessary to take each case entirely on its own merits, and to reason out the best arrangement for each particular installation if the best results are to be obtained. At the same time it is possible to give some indication of the lines generally successful in any given class of illumination design, and the author will endeavour to do this in the following remarks for that large class generally described as "display windows."

The problems involved in display window illumination show fewer dissimilarities than perhaps in any other class of lighting work, and yet there is scarcely any other so badly handled. Within the last year or two there has been undoubtedly a great improvement; but any one can see what a large field is still open for the intelligent use of some illuminating engineering knowledge. In order to grasp the general principles involved, a study of the necessary conditions to be fulfilled by successful illumination is essential, and hence it will be well to start with a statement of these conditions, and some preliminary reasons for them.

The purpose aimed at in all display window lighting is two-fold, and may simply and tersely be expressed as follows from the shopkeeper's standpoint, namely :—

1. Attract the likely purchaser to *my* window.
2. Rivet his attention *on the goods I wish to sell.*

To achieve this two-fold object it is generally necessary to use two distinct illuminating methods; under certain circumstances one method may be sufficient. In order to achieve the foregoing objective the following conditions must be fulfilled. The illumination—

(1) must be such as to render the premises conspicuous or to arouse interest in the casual passer-by;
(2) must efficiently illuminate the particular goods on show;
(3) must not obtrude harshly on the vision of the prospective buyer;
(4) must not be unnecessarily costly in installation or upkeep.

Before deciding on any particular scheme of illumination some governing factors come up for consideration, and these should all be treated in a commonsense method, without any undue bias. Some of these governing—and often disturbing—factors are as under :—

1. The client.
2. The general illumination of the particular thoroughfare: (*a*) street lighting, (*b*) as to shop lighting.
3. The probable effect the proposed scheme would produce on neighbouring business rivals.
4. The special requirements of the particular case.

1. The first factor in the situation is the *client*, and his desires must always weight heavily in any scheme. Sometimes—though seldom—he gives one a free hand simply to give him "a good light"; but more often he limits first cost of installation and then running cost of consumption. Should the client's limits be insufficient to enable the engineer to give a satisfactory installation, it is then his duty to endeavour to get these limits increased to a reasonable amount, and it is here that one with a full grasp of his subject can prove to his clients the *raison d'être* of his arguments, and by so doing bring the client round to see the necessity of following the engineer's advice.

2. The second factor, namely, the illumination of the thoroughfare, has a great deal of influence on the intensity of illumination which must be reached in order to effectively display the goods in the shop window. And here I may deal with the statement previously made, that to produce the desired results from the shopkeeper's view-point requires generally two distinct-illuminating methods.

As is well known, the eye is invariably and often unconsciously attracted to the brightest object in the field of vision, and hence it has been the aim of the shopkeeper to endeavour, by means of outside lamps of high candle-power, to obtain high illumination. Again, the eye is quick to notice any unusual or curious object, and the will responds to the visual impulse, and causes the eye to be focussed on such an object; so that not only will a brilliantly lighted portion of an average street attract immediate attention, but a flashing sign or a coloured light—such, for example, as the mercury vapour lamp—even if only of moderate brilliancy and placed in a brightly illuminated street, cause the passer-by to stand and gaze.

Consequently this external, or, as I might call it, the "advertising" illumination can only be attained successfully in two ways: (*a*) by having the most intense, or (*b*) the most unusual illumination in the vicinity.

It is evident that the present tendency in exterior illumination is a striving after "light and more light"; the open type arc lamp is being superseded first by the small globe enclosed arc lamp with its intense white light, and both are being surely ousted by the flame arc lamp with its yellow or orange glare. And so, too, with the gas lamp, the tendency is ever to more intense illumination, and more of it. Soon, however, a halt must be called in this mad rush after intensity of light sources, as already it is having a most deleterious effect on our eyesight. The writer knows of no more painful sensation to the eye—at least, in ordinary daily life—than to be whirled each evening home from business by electric tramcar past the intensely brilliant globes of the enclosed arcs, at present in use by so many warehouses; the yellowish light of the flame arc is not nearly so trying, due, no doubt, to the fact that the human eye can bear a greater amount of yellow light than of any other.

These considerations seem to indicate that we have almost reached the practicable limits of intensity in exterior illumination, and that other and more unusual methods must be adopted in order to entice "the quarry from afar"; but as this would lead into a discussion on illuminated signs and various other devices, consideration must be deferred to some future occasion.

Now, speaking generally, it is necessary to have outside lamps of some kind, depending mainly on the surrounding illumination, to attract the prospective buyer, and the only circumstances in which such exterior illumination is sufficient without any interior lighting is when the windows are dressed with goods close to the glass, or where, if not so dressed, they are bright in colour, and able to reflect back a large proportion of the direct illumination they receive from the outside lamps; such, for example, as a jeweller's window, or one filled with white stationery, notepaper, &c.

Conversely the only cases in which interior illumination will do alone without external aid is when the thoroughfare is poorly lighted in comparison with the illumination given in the window. At the same time, so much depends on circumstances that no invariable rule can be given.

3. The probable effect which an increased illumination in any one shop may have on the neighbouring rivals is sometimes very difficult to estimate properly, and the only comment which the writer can offer on the point is this, that the engineer should endeavour to make the particular installation he is interested in so effective as to render it difficult for any other to surpass it.

(*b*) Do not strive for an absolutely uniform illumination, so long as the minimum illumination is not too low. This applies particularly to goods with fine detail, and without any high relief.

(*c*) Do not imagine, because a certain number of lamps or burners lighted a jeweller's window quite satisfactorily that the same will do all right for a bootmaker's window of a similar size.

(*d*) Generally speaking, lamps placed high up and well forward towards the front of the window, with the light directed downward and backward, gives the best effect.

FIG. 1.—CORRESPONDING WITH FIG. 2.

4. The special requirements of each particular case. Here, from the very nature of the subject, no general data or opinions can be given; but the following warnings may be of use in preventing needless mistakes in interior window lighting :—

(*a*) On no account place lamps within the ordinary range of vision.

One or two typical instances of the smaller class of shop windows may now be considered.

Fig. 1 shows a hatter and hosier's window, measuring 9 ft. high by 5 ft. wide by 3 ft. deep, dressed fairly close to the glass, and mostly with light grey to dark grey goods. The exterior illumination is given by two 3-ampere Reason enclosed arc lamps, two in series on 250 volts; the interior lighting consisting of four 30-c.-p. Osram lamps, each backed by an 8-in. hemispherical silver glass reflector at the top of window, and two 26-c.-p. Tantallum lamps—also with similar reflectors—placed about 6 ft. below them, and kept out of the direct line of vision. Here the class of goods displayed may vary from a show of dressed linen shirts and collars to black hats and dark caps, and it is only when a dark class of goods is displayed that the lower lights are necessary. Fig. 2 shows the same window by night, with a 30 seconds exposure at f. 8 on an Imperial Special Sensitive plate. It will be seen that the lower lights are not directly visible, the reflected image of the arc lamps appearing on the silvered back of the reflectors. The

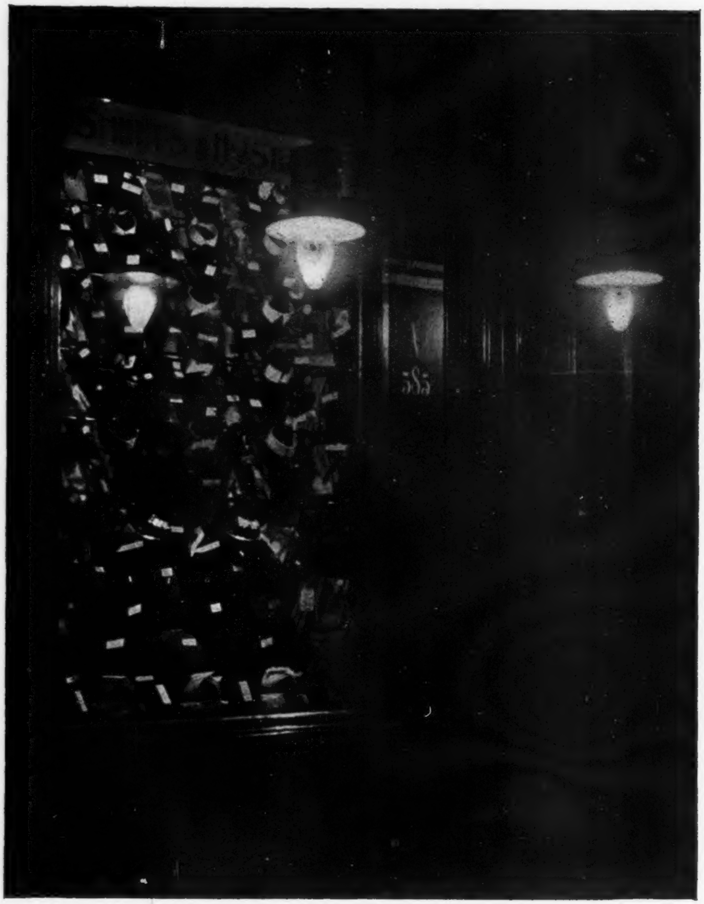


Fig. 2.—Shows the Shop shown in Fig. 1, with lights on, at night.

various data and comparative tests appear in the table given below.

Fig. 3 shows a jeweller's window and spectacle show-case, and Fig. 5 a tobacconist's shop.

The premises shown in Figs. 3 and 5 are shown again, lighted at night, in Figs. 4 and 6.

Fig. 4 shows the jeweller's shop which, it will be seen, has no exterior

FIG. 3.—CORRESPONDING WITH FIG. 4.

FIG. 5.—CORRESPONDING WITH FIG. 6.

lighting; interior, four 26-c.-p. Tantalum lamps at top of enclosure with 6-inch conical silvered glass reflectors; two 26-c.-p. Tantallums with N.P. shell reflectors below the centre line of the window; one 16-c.-p. ordinary lamp with N.P. shell reflector above spectacle case. Here the effect would have been better had the top row of lamps been concealed behind a window-blind or sale-bill, as in the following case.

(The exposure was, in the case of Fig. 4, 100 seconds, f.11. Imperial s.s. plates.)

Fig. 6 shows the tobacconist's shop having two 100-c.-p. Osram lamps—one in doorway, and one in outside lantern; four 30-c.-p. Osrams at top window behind the sale bill.

This photograph was obtained with an exposure of 1 minute, f.8., Imperial s.s. plates.

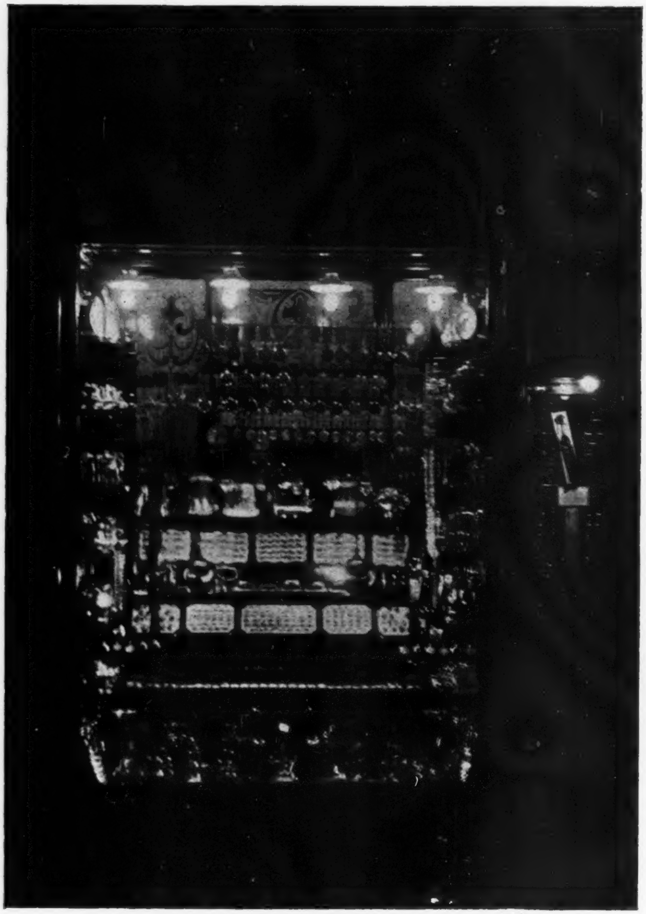


Fig. 4.—Shows the Shop previously shown in Fig. 3, lighted up at night.

These are all well-lighted windows, and from the tables given below it will be seen that they come within the description economical.

In the table it will be noticed that two gas-lighted shops appear. These have been included for purposes of comparison. They are fitted with inverted incandescent gas-burners and are well-lighted windows. From the illuminometer readings a comparison can be obtained with the electrically lighted windows.

In calculating out the burning costs for the electrically lighted shops, no allowance has been made for the fact that the average price per unit taken over the whole year is less than $3\frac{1}{2}d$. In the case of the first two shops, the average price per unit works out to about $3d.$, while in the case of the tobacconist, owing to the longer burning hours, the cost is only $2{\cdot}6d.$ per unit. In all these, however, the costs are reckoned on a basis of $3{\cdot}5d.$ per unit, which is the maximum

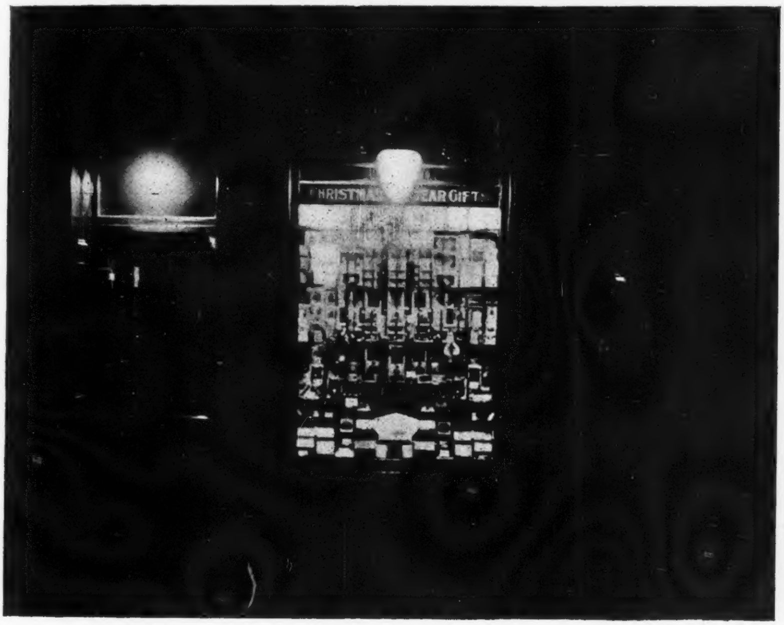


FIG. 6.—SHOWS SHOP PREVIOUSLY SHOWN IN FIG. 5, ILLUMINATED AT NIGHT. (Time, 9.30 P.M.)

charge. In the case of the gas-lighted shops the writer was unable to obtain accurate data as to the actual gas consumption of the inverted burner in use, and has taken 3·5 cubic feet per hour as the basis for his figures: he has reason to believe that this is quite fair to the gas interest.

NOTES ON TABLE I.

The "Illumination in candle-feet on a Vertical Plane" cannot be taken as anything more than a simple comparison; it is not a measure of the illumination on the horizontal plane, and is, indeed, only a small fraction of it; but as all the tests were taken under similar conditions, they can be looked on as accurately representing the comparative illumination.

In the column headed "Relative Costs for Equivalent Illumination" figures are given, using the most eco-

TABLE I.

Tests made with Everett-Edgcumbe Portable Photometer, Glasgow, 10th January, 1908.

Description of Business.	Particulars of Illuminant.	Consumption.		Illumination on Vert. plane in candle feet.		Cost of Illuminant.		Burning cost per hour.	Relative Costs for Equivalent Illumination	Remarks.
		Watts	Cub. ft.	Close to Glass.	3 ft. out from Glass.	Per Kilo-Watt. Hour.	Per 1000 cubic feet.			
						Maximum demand System.		*d.*		
Hatter and Hosier A	2—3 amp. Enclosed Arc Lamps	990	—	·5710	—	3·5*d.* & 1*d.*	—	3·465	3·093	Tests A & A_1 with Arcs "on."
,, ,, A_1	4—30-c.-p. Osram ,,	990	—	—	·4000	,,	—	3·465		Tests B & B_1 with Arcs "off."
,, ,, B	2—26-c.-p. Tantalum ,,	240	—	·4242	—	,,	—	·840	1·000	Mostly dark goods which reflected no light outwards
,, ,, B_1	,, ,, ,,	240	—	—	·3043	,,	—	·840		
Jeweller	6—26-c.-p. ,, ,,	330	—	·3700	—	,,	—	1·155	1·275	Brilliant reflection from Silver goods.
,,	1—16-c.-p. Carbonfil ,,	330	—	—	·4240	,,	—	1·155		
Tobacconist A	4—30-c.-p. Osram ,,	300	—	·0581	—	,,	—	1·050	4·991	A & A with 100 c.p. Osrams "on."
,, A_1	2—100-c.-p. ,, ,,	300	—	—	·1071	,,	—	1·050		B & B_1 with 100 c.p. Osrams "off."
,, B	,, ,, ,,	160	—	·0416	—	,,	—	·560	4 783	Window with a fair proportion of dark non-reflecting goods
,, B_1	,, ,, ,,	160	—	—	·0600	,,	—	·560		
Stationery and Fancy Goods	6—"Falcon" Inverted	—	21	·0395	—	—	2*s.* 4*d.*	·588	6·539	Window largely occupied by dark photo frames, &c.
Stationery and Fancy Goods	Incandescent Gas	—	21	—	·0441	—	,,	·588		
Confectionery	5—"Falcon" Inverted	—	17·5	·1012	—	—	,,	·490	1·836	Window well mirrored and with light goods
,,	Incandescent Gas	—	17·5	—	·1304	—	,,	·490		

nomical installation as a basis of comparison. The writer would like to warn others against using this as an argument for one illuminant in preference to another. It is absolutely impossible to argue intelligently on the subject of illumination unless care is taken to compare things which are alike, and a glance at the last four shops given in the table will show some interesting results.

Taking the two gas-lighted ones first, it will be noticed that the stationer's window had a larger gas consumption than the confectioner's, and yet the illumination of the latter is found to be about three times the former.

The windows are identically the same size, and are quite adjacent to each other, and, as far as could be judged, there was no difference in the amount of light emitted by the burners in the two cases, consequently, the whole phenomenon hinges on the fact that the one window was filled with goods which reflected the light, while the other one had goods which only absorbed light.

Take again the jeweller's window and the latter (B) tests of the tobacconist's window, and a similar state is seen. Here, while the burning cost of the former is only three times that of the latter, the illumination is practically eight-fold. In this case also the shops are adjacent and the windows of the same size.

From considerations such as these it is quite apparent that the only absolutely correct way of comparing the relative costs of the various illuminants is to compare them in the same window and under identical conditions as regards window dressing. The writer hopes at a future date to inaugurate such a set of comparative tests.

Looking at the two which are in any way comparable, namely, the tobacconist (Test B) and the stationer, the goods in both of which were somewhat similar as regards reflecting properties, it will be seen that the relative costs are more in agreement than any of the others, the difference being in favour of the electric light. In this case it may be of interest to note that the electric light has been a proved saving in the annual bill.

The foregoing tests are only preliminary to a series which the writer is presently engaged on, and they are inconclusive in many ways. In future test readings will be taken to enable the illumination on a horizontal plane to be calculated, and an endeavour made to get an approximation to the reflection coefficient for each particular case.

(To be continued.)

The Standard Specification and the Consumer.

By an Engineering Correspondent.

On all sides one hears that we are on the eve of very great developments in electric lighting, due to the advent of the metallized filament lamp in different forms and in sufficient quantities to supply the demand. The future of the electric lighting industry depends to a very large extent upon the electric incandescent lamp.

It has often been pointed out that the determination of the most suitable lamp for the consumer depends to a large extent on the prevailing price of current, and not merely on the employment of the most efficient or cheapest lamp to be obtained in the market. Yet consumers on the whole are entirely ignorant of these facts, and are more or less at the mercy of the contractor.

It is surely time central station engineers employed means to assist their customers in the matter of the choice of their lamps. True, at present it is against clause 18 of the 1882 Act for the undertaker to prescribe any special form of lamp or burner, but this law is practically a dead letter, and, it is to be hoped, will ultimately be removed. The supply engineer will then be able to advise his customers to their mutual advantage, and we shall more nearly approach the ideal in which "light," and not "current" alone is sold to the consumer.

No doubt the establishment of a central station or of a few stations for testing electric lamps, controlled by a committee representing makers and supply engineers, with the assistance of the National Physical Laboratory, would greatly ameliorate the present unsatisfactory state of affairs, and be of untold benefit to the ordinary consumer, who could be advised to buy his lamps through the recognized channel.

Much time and money has been spent by the Engineering Standards Committee in drafting a standard specification for incandescent lamps; but if this specification is to achieve the success it merits, it must not be merely applicable to lamps purchased by the Government departments, but must also control those used by the public generally, and for this some such scheme must, without doubt, be instituted.

Lamp manufacturers would probably welcome such testing station or stations, for, with a standard specification to conform to and adequate supervision, ensuring the "standard" being of the same value throughout the country, it would not only aid them in their own manufacture, but would assist them in meeting foreign competition. Electric lamps can be made by our English makers every bit as good as by our American cousins, notwithstanding the isolated tests which have been published, and appear to prove to the contrary.

The high voltage continuous current circuits are much hampered in their efforts towards progress generally, not only from the fact that an incandescent lamp requires over 20 per cent. more energy for the same amount of light on a 200 volt circuit than on a 100 volt circuit, but also because the metal filament of the new lamps, even for those intended for 100 volts, is of so small a diameter, that it would appear likely to be some considerable time before a 200 volt metal filament lamp is a commercial success.

Thus for the present the low voltage direct current circuits and the alternating current systems, should reap the greatest benefit, and particularly the latter, which permits of a transforming device to reduce the P.D. to any desired value.

Artificial Illumination, and the Education of those concerned in its Production.

By C. W. Hastings.

(*Continued from p.* 57.)

Up to this time very little attempt had been made by gas engineers and managers to study illumination, and even at this epoch practical demonstrations were few and far between.

In 1879 a Select Committee of the House of Commons sat to consider the application of electricity for lighting purposes, the gas industry opposed, and ridiculed the movement—most unwisely as after events proved. The opposition was due mainly, we venture to think, to the want of scientific education; matters proceeded rapidly, and in the latter part of 1879 the first installation of electric lighting was inaugurated upon the Thames Embankment, under the direct auspices of the Metropolitan Board of Works, the then governing body of outer London, represented now by the London County Council and the many Borough Councils. The "City Fathers" were not behindhand in establishing electricity as an illuminant, and the Commissioners of Sewers, who were then the lighting authority for the City of London, installed electricity at Billingsgate Market. Both authorities adopted the Jablochkoff Candle, and although much was said and written about the excellence of the principle, the experiments were costly and short-lived.

We are not intending to trace the improvements made, but are going to endeavour to place in juxtaposition the knowledge that was brought to bear upon electric lighting and gas illumination.

The electric light, from its conception, was the idol of the public, courted by Royalties, Classes, and Masses—the first-born illuminant of the scientist, the chemist, and the mechanician; its production and brilliancy was a marvel to every one. On the other hand, gas and all that appertained thereto, had never been in favour; it was looked upon as an evil-smelling thing, of quite questionable use, and the public turned more and more against it; stocks and shares went down with a rush, but yet it is a fact that at no time during the thirty years under review has the sale of gas, taken as a whole, shown any diminution; from 1877 to the present time the output has greatly increased notwithstanding the millions of money invested in the production of electrical current for lighting and traction purposes.

The writer remembers two of the early demonstrations of electric lighting; the first was at the Albert Hall, when Sir W. H. Preece (then Mr. Preece) was responsible for the transformation of that magnificent building; H.R.H. the late Duke of Edinburgh, presided, and the company present included other members of the Royal Family, the nobility, the leaders of science, chemistry, art, and commerce. The scene was a complete revelation of the new light, and proved a wonderful send-off. The second occasion was even more wonderful, and dazzling in its beauty—the late Sir C. W. Siemens (then Dr. Siemens) was president of the Institution of Civil Engineers, and entertained the members, and a multitude of others, at the Inventions Exhibition at South Kensington; not only were the grounds brilliantly illuminated by electricity, but for the first time the visitors had an opportunity of witnessing the illumination of the fountains in many colours. Baskets of flowers were outlined by glow lamps, although they could not, at that time, be purchased for less than five shillings each; the scene was superb, and will live in the writer's memory for all time.

Well, so much for the start; then came the Electric Lighting Bill of 1882, which, after many days in the Committee stage, became law. This Bill was feebly opposed by a few gas companies and corporations, who owned gas-works, and here as, we think, the great mistake was made—the gas interests should have worked hand in hand with the promoters of the Bill, and annexed the supply of electricity, on the old principle of uniting practice with theory. The gas industry had the organization, control of streets, knowledge of distribution, and their co-operation would have resulted in the saving of hundreds of thousands of pounds, and the ultimate cheapening of electricity per unit; instead, they opposed, shook their heads, and foolishly ridiculed the new light. True, for many years it was a luxury for the rich; but we have heard it said that illumination may be divided up into just the same number of classes as the ordinary railway train—first, electricity; second, gas; and third, oil lamps. Be that as it may, gas engineers and managers had to see their opponent making headway, and large consumers retained gas merely as a stand-by. Public lighting passed out of the hands of the gas companies; at whatever cost the public insisted upon having the new light, and efforts had to be made by the gas-makers to reduce the cost of production, to make the best of residuals, to increase the illuminating power of the gas they sold, and to make experiments with burners in order to secure a better illuminating duty per cubic foot of gas. After much trouble and very considerable expense, Whitehall was handed over to the Gas Light and Coke Company, so that they might show to what extent they could rival the electric light; the Company placed themselves in the hands of Mr. Wm. Sugg, and the important thoroughfare was brilliantly illuminated by means of clustered flat-flame burners, with the result that from the first experiment to the present time, Whitehall, from Charing Cross to Westminster, the Palace Yard, and the precincts of the Houses of Parliament, have been illuminated by gas. To-day the High-pressure gas system is in operation, and we venture to express the opinion that no thoroughfare in the kingdom is better or more cheaply illuminated.

What about the education of those responsible for the illumination of our streets and homes? We must admit that whilst electricity, from its conception, had the advantage of the most advanced scientists and cultured men in the land, very little effort had been made to educate the gas manager. Some few of the sons of the contractors' nominees had come along, and were holding positions, as assistant engineers, with their fathers, and were possibly better acquainted with the science and chemistry of gas-making; some, very few, had given the subject of photometry attention, but, in an industry that had no teachers, it was not likely that pupils should be forthcoming. The best of the men in the "seventies" and in the "eighties" had only received quite an ordinary education—served their time either as pupils to a consulting engineer, or been apprenticed to an engineering firm, who possibly might be engaged in the manufacture of gas-works' plant.

The proceedings of the Institution of Gas Engineers during the last thirty years prove that but few efforts were made to advance the education of the younger members of the profession. Presidents in their addresses have, from time to time, given some attention to the subject, more particularly in later years; but we think that the greatest incentive to the better education of the gas-maker was the movement made by the Corporation and Livery Companies of the City of London, who instituted an association in 1878, entitled the City and Guilds of London Institute, which had for its object the benefiting of those engaged in productive and technical industry. The Institute engaged in much admirable work, and was incorporated by Royal Charter in 1890. The work done in connexion with the Institute is very far reaching; students may sit for examinations in most of the principal cities in the kingdom. There are some seventy or more subjects under the head of 'Technology,' and included in them will be found 'Gas Engineering' and 'Gas Supply.' Originally the course was confined to 'Gas Manufacture,' but in the last year or so the field of work has been extensively widened. Of our personal knowledge, we know many who owe their present position in gas engineering to the fact that they entered for these examinations, commencing in the Ordinary, and proceeding to the Honours grade.

We know of very many who have benefited by entering these examinations. There are now some twenty-four teachers in Technology, qualified for the section devoted to Gas Engineering and Supply. So far no effort has been made to educate the gas engineer in the science of Illumination, and we venture the statement that, although the Institution of Gas Engineers numbers 812 members of all classes, a very small percentage would be able to pass an examination upon the most rudimentary laws that govern Illumination.

(To be continued.)

The Lighting of Dark Spaces in Commercial Houses.

A RECENT article in *The American Gaslight Journal* brings out one important point in the illumination of business places.

The writer points out that in many warehouses and offices are dark corners which are never adequately illuminated, and which, therefore, fall into disuse. The writer's claim, in fact, is that space which is not illuminated is practically space wasted. Some gas and electrical engineers in America actually make a business of searching out dark places of this description, and persuading the houses concerned to adcpt some satisfactory method of illumination. The saving of space which follows amply compensates the increased expenditure in lighting; and it is surprising how common ill-lighted basements and garrets which are devoted to the accumulation of dust and rubbish seem to be.

The author also comments upon the value of small portable lamps for the illumination of dark corners which are not very easy to get at, such as the illumination of the interior of pipes, sewers, and the like. For this purpose, electric portable lights, which can be easily thrust into the orifice in any position, without interfering with their functions, are at a distinct advantage.

Lighthouse Illumination.

By S. D. Chalmers, M.A.

Among the many problems which present themselves in lighthouse work we find two which are of special interest to the illuminating engineer :—

(1) The production of a source of light of sufficient candle-power and intrinsic brightness, and

(2) The design and construction of optical apparatus to utilize the light to the best advantage under the special conditions of each light.

The old-fashioned oil burner with its three or more wicks is still employed in many lighthouses, but in the modern and more important lights it has been replaced by an incandescent mantle burner, or in some cases an electric arc. In some few cases, where gas mains are convenient, the mantle is made incandescent by the use of ordinary lighting gas, but in most cases vapourized oil is used, and as this is capable of producing a more powerful light, it is sometimes preferred, even when lighting gas would be more convenient.

The burner in common use is similar to that known to illuminating engineers as the " Chance " or " Kitson " burner, or a modification of it, taking a Welsbach mantle 55 mm. diameter, and about 70 mm. high. In some special cases mantles as large as 85 mm. in diameter are employed. The candle-power of the standard size is about 1,300, with an intensity of about 50 c.-p.* per square cm. at the brightest parts. In practice different parts of the mantle show different intensities, and generally the *best* portion of the mantle is from 5 to 30 mm. above the burner. As in all incandescent mantles the candle-power falls off very rapidly at points above and below the horizontal, and this must be taken into account in estimating the value of the resultant beam.

Lighthouse burners are tested by direct comparison with a 10 c.-p. Harcourt Pentane standard. A Bunsen photometer is used, and a sufficiently long bar to allow the photometer to be used under normal conditions of illumination. No very great accuracy is obtained or claimed for these measurements. In actual use the mantle deteriorates considerably, even during its very short life. The oil consumption of the standard burner with a candle-power of 1300 is about 1¼ pints per hour.

It was at one time thought that the arc would be the ideal illuminant for lighthouse work, when the difficulties of keeping the arc and crater stationary were overcome ; but other and unexpected difficulties arose. It was found that the penetrating power of the arc lamp in fog was very much less than that of the oil or incandescent lamp, even when full advantage was taken of the possibility of increasing the size of carbons, and consequently the candle-power, for foggy weather. With the introduction of the " flame arc " this difficulty might be overcome, but there are difficulties connected with the optical apparatus which would hinder the use of even the " flame arc."

As is suggested above, the fog is one of the great difficulties of the lighthouse engineer. Perhaps the best illustration of its effects was furnished by the following experiment. On a very fine night a " landfall " light was visible on the extreme horizon when the lamp was replaced by an ordinary

* Some recent unpublished measurements by Mr. Walter Rosenhain give 50 to 60 c.-p. per sq. cm. for different mantles.

THE FASTNET LIGHT.

candle. In dull and misty weather the full candle-power of the lamp was required, and it was thought necessary to provide a duplicate apparatus with a similar burner to reinforce the beam in foggy weather.

Optical Apparatus.—There are two types of optical apparatus in ordinary use, the "fixed" and the "revolving." The "fixed" apparatus is designed to show a beam in all directions, or at least all seaward directions. When the angle to be covered does not exceed 180° it is possible to use a mirror to reinforce the light over the whole arc to be covered. The lenses and prisms of a fixed apparatus are designed to condense the light into a beam which has a small vertical divergence; but there is no horizontal condensation. In the "revolving" light the beam has a small divergence both vertically and horizontally, and the different directions are covered by rotating the apparatus, thus showing the beam for a limited time in each direction. In the slow revolving apparatus the period may be up to one minute with a flash of one to two seconds' duration; but in the best modern flashing lights the rotation is much faster, the period being generally 10 seconds and the flash $\frac{1}{15}$ to $\frac{2}{15}$ seconds. In many cases the light from the apparatus is divided into 2, 4, or 6 similar beams, each obtained from a similar "panel" of lenses and prisms. The object of this is to obtain a sufficiently short interval between the flashes without unduly diminishing the duration of each flash.

In some cases the beam is only required to cover a comparatively small angle, and the apparatus of a revolving light may be used in a fixed position, or a fixed light may be used and condensing prisms employed to direct the light, which would otherwise be wasted, into the desired direction. Similar condensing prisms are used to reinforce a coloured (red) beam when it is desired to indicate a danger zone through which ships must not pass.

In all lighthouse apparatus the source of light is placed at the focus of a lens or system of lenses, and thus the light from any one point on the source of light is made as parallel as possible; the light from the brightest part of the source is directed to the horizon, but, owing to the size of the source of light, the beam will have a divergence depending on the size of the source and the focal length of the lens. With a 55 mm. mantle, and a lens of 920 mm. focus (the first order light), the horizontal divergence will be $\frac{55}{920}$, *i.e.*, 1 in 17, or 3° 12′. The vertical divergence will be rather greater. It is sometimes, however, necessary to artificially increase this vertical divergence, by directing light from some parts of the apparatus to the near sea. The horizontal divergence represents about $\frac{1}{100}$ of the complete circle, *i.e.*, one flash would be $\frac{1}{100}$ of the time of a complete revolution.

It is not desirable to reduce the flash below one-tenth of a second, as otherwise the full intensity of the flash would, owing to physiological reasons, not be obtained, and many lighthouse engineers consider that flashes should not be separated by more than 5 seconds. This would require two flashes to each complete revolution, *i.e.*, a two-panel light. In the case of the landfall light on Fastnet Rock four panels are used; probably on account of the special prevalence of fog, which makes it desirable to have a greater proportion of light to dark intervals.

In some lights, groups of flashes are used to identify the light, two or more flashes occur in rapid succession, followed by an interval of darkness.

When less intense beams are desired, as for secondary or harbour lights, the size of the apparatus can be reduced and the beam made more divergent.

Since the intensity of the beam will depend on the quantity of light concentrated into it, as well as on its divergence, it is desirable to extend the lens system to intercept as much of the light as possible. Considerations of weight, absorption, &c., make it impossible to use one very large lens; Fig. 1 shows the vertical section of the lenses and prisms of a lighthouse system. The "fixed" system is obtained by rotating this section about the vertical axis through the focus (F);

the revolving system by rotating about the line (A F).

As each of the lenses A, B, C, &c., is made separately, it is customary to choose the curves so that all light from the focus is made as nearly parallel as possible. When the angle A F D is greater than 40° the losses by

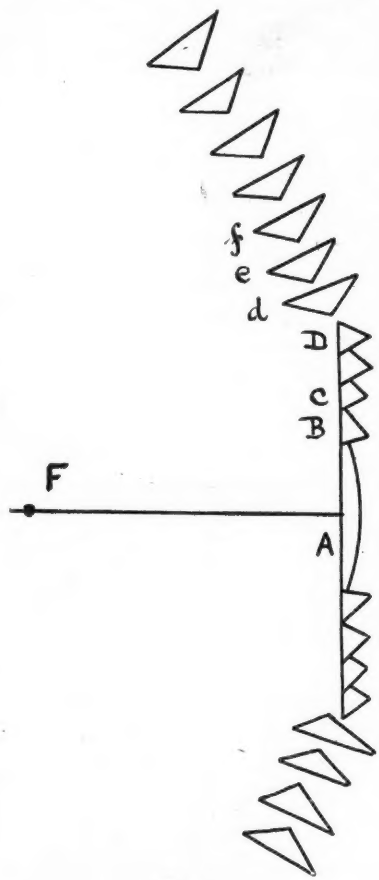


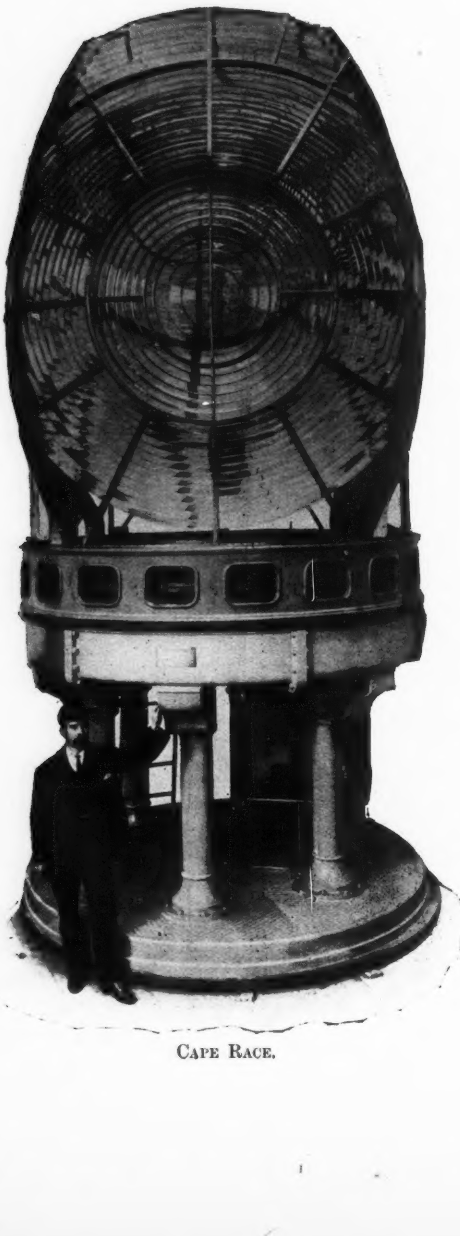
FIG. 1.

reflection from the surface of the lens are so great that it is preferable to use totally reflecting prisms *d*, *e*, *f*, &c. Such prisms may be continued up to an angle of about 88°, while at the sides they are limited only by the other panels or the framework. The lower prisms are fewer in number, partly owing to the cutting off of the light by the burner, but also on account of the service of the lamp. When mirrors are used they are generally constructed entirely of glass in the form of totally reflecting prisms, and are designed to concentrate the light nearly on the actual source.

The intensity of the beam obtained depends on the intrinsic brightness of the source and the area of the lens system. Were it possible to concentrate the whole of the light from the mantle into a uniform beam of divergence 1 in 17, this beam would represent a candle-power of $1,300 \times 4\pi \times 289 =$ 4,600,000 c.-p. approximately; but it is impossible to utilize all the light in the direction opposite to that of the final beam, as the dioptric mirror only gives about one-third of the beam which would be obtained from the corresponding lens. Thus the full candle-power would be not more than 3,000,000. As a matter of practice light is wasted owing to the framework, and by reflection and absorption, while the candle-power of the mantle decreases rapidly as we depart from the horizontal plane.

In actual practice the beams from the various parts of the apparatus are of different divergences, and thus in the brightest part of the beam the candle-power will be rather higher than for the assumed uniform beam. It is more usual to calculate the beam as if the actual surface of the lens were of the same intrinsic brightness as the part of the mantle chosen for the focus of the lenses, adding one-third if there be a dioptric mirror reinforcing the beam. A normal first order light of one flash has a candle-power of about 2,000,000, while a double flash will give about two-thirds of this candle-power.

The actual candle-power is obtained by direct measurements. Each part of the apparatus is uncovered in turn and photometered, care being taken that the photometer receives the light which is emerging parallel to the axis of the apparatus. The sum of all these measured candle-powers gives the total candle-power of the beam in the direction of the axis; the total



Cape Race.

beam has also been directly measured at a sufficient distance to allow the photometer to receive light from all parts of the apparatus; but difficulties due to atmospheric absorption, as well as the falling off of the various partial beams towards the edges, render such measurements untrustworthy.

The present directions of progress in lighthouse design consist in the use of much larger mantles (up to 85 mm. in diameter) with apparatus of increased focal length of 1,330 mm., giving about the same divergence as the present first order apparatus, and increasing the candle-power to one and a half of the value given above; bi-form lights, in which two similar systems, each with its own light, are mounted, either side by side, or one above the other, give twice the candle-power of the present lights. Burners are being continually improved, and the optical apparatus modified to secure better results.

The great outstanding difficulty is the production of a source of light which has great power of penetrating fog. Its intrinsic brightness and candle-power should not be much inferior to the mantles and burners at present in use, while absolute reliability in the hands of careful and skilled keepers is of the utmost importance, though it would receive every care and attention.

Some Notable Ocean Lights.

By A Correspondent.

A correspondent sends us some interesting particulars of some of the best-known lighthouses. Such lights are now usually run on the group-flashing system, originally introduced by Dr. Hopkinson, which serves to distinguish them from one another. This distinction is introduced by the variation in the nature of the flash itself, which may be single, double, or quadruple, and also by the interval between the flashes.

Three of the best-known lights constructed by Messrs. Chance of Birmingham are shown in the illustrations.

Cape Race is one of the largest ever produced, having an illuminator 85 millimetres in diameter. It is fitted with the incandescent vapour oil system, and has a hyper-radial single flashing apparatus of 1,330 mm. focal distance, consisting of four panels of 90 degrees horizontal angle. The light is also floated on mercury and operated by clockwork mechanism.

St. Catherine's has the distinction of being the second lighthouse to be equipped with electricity, and, like the Lizard, is one of the largest electrically illuminated lighthouses in the world. It is furnished with single flashing arrangements, the focal distance being 700 mm.; there are four panels of 90 degrees horizontal angle.

The Fastnet light is rendered peculiar by its dual form. It is supported on a single column, is described as a bi-form flashing apparatus of 920 mm. focal length, and consists of four panels in two tiers, having a vertical and horizontal angle of 90 degrees. The light has been in operation for four years.

St. Catharine's.

Church Lighting.

BY AN ENGINEERING CORRESPONDENT.

IT has always seemed to me that church lighting, judging from the standpoint of an electrician, must be placed in a category of its own. In almost every case where such work has to be carried out, problems of illumination are encountered which are met with in no other class of buildings. Theatres may be instanced as possessing peculiar features which throw obstacles in the way of satisfactory lighting, but it must be remembered that these difficulties are artificial. They exist because some unnatural effect is to be obtained, or some result entirely foreign to natural lighting is desired. With theatres the difficulty is not to light them effectively, but to light them to suit some particular stage effect, to produce some illusion of the senses, to work to the requirements of the artist rather than to the dictates of common sense.

With churches this is not, or at any rate very rarely is, the case. The difficulties which are to be met and overcome are the result of the building, and are solely due to its character. They are a part and parcel of its unusual shape, its extraordinary height, its arches, its huge shadow-casting pillars, its seating accommodation, its general arrangement. The man who has had no experience with such work, and who has hitherto only installed the electric light in shop windows and private houses, will find himself very much at sea when he first accepts a church lighting contract. Unless he approaches the problem in a scientific spirit and reasons the whole thing out at length, it is extremely improbable that he will turn out a satisfactory piece of work with a good lighting effect; it is much more likely that both he and every one else will be disgusted with he result, and that in the endeavour to improve matters he will put extra lights here, and lights of higher candle-power there, until he has produced a fairly satisfactory lighting effect, but at a ruinous price not only for installation, but for current consumption.

Nothing is ever lost by a few moments' thought and consideration. It may seem a waste of time to sit down and think out a job in every detail, instead of starting and getting it done; but in few things is this idea less true than in church lighting.

Everything has to be considered. The position where the supply authorities will enter the building should be ascertained first of all, and from that the whole arrangement must be built up mentally before a single light is fixed, or length of wiring run. The general scheme of lighting control must be gone into, bearing in mind the fact that at certain times very few lights will be required, and that it will be necessary to turn on a large number, or the whole, with very little trouble, and without the slightest confusion. The switching arrangement must therefore be so contrived that the switches are accessible to whoever it may be has charge of them at the moment when the extra lighting is required. There must be no scurrying across the church to get at the switchboard, no dislocation of the routine of the services.

Certain lights must be under the control of the organist, and these must be ascertained and planned out; others should be under the hands of the preacher, and these again must be placed where he will be at the moment when they are needed. Neither the organist nor the clergyman can with dignity rise and walk to a switch; it must be just where it can be used without disturbing in any way, either physically or mentally, the audience or the officials.

Apart from the general arrangement and run of wires, the lighting itself requires considerable thought. It is to be remembered that it is most important that the lighting should be out of the direct line of sight of the audience. The effect aimed at is not brilliancy, nor a dazzling blaze, but a quiet, unobtrusive, subdued, and yet sufficient degree of illumination. The fittings are not designed to add to the appearance of the church, for it is always to be remembered that church architecture is of a type that gains nothing from such comparatively small affairs as electric light fittings and shades. The church effect is gained by bold sweeping curves, and springing columns; and the light should be contrived so as to bring out the beauties of wood and stone that otherwise are hidden from sight and knowledge; not so fixed as to attract the eye of the beholder. I have known architects who had control of church lighting, and who fixed the most vulgar of all vulgar *art nouveau* electroliers where-ever, or so it seemed, the eyes of the audience could rest upon them. I have seen nice brassy garter-shaped fittings, with little brass bird-cage chains and nice yellow flexibles tastefully curled in and out, with sweet little rose-tinted shades hanging in the centre of grand old Transition arches in a fine old Transition church, where every stone spoke of the majesty of the past, and the abominable shrieking brassy vandalism of the electric light fittings simply told of the pitiful lack of taste of the present.

The fittings must be plain and unobtrusive, with the lights as far out of direct sight as possible consistent with proper effect and economy of burning. The old plan of lighting such buildings as we are discussing with immense electroliers containing fourteen- or eighteen-light fittings, in egg-shaped cut (or imitation cut) glass shades, must be considered to have had its day. It was the plan of the man who wanted to fix as few points as possible, and get as much for them as he could; and it was carried out by the man who, consciously or unconsciously, considered his work firstly from the standpoint of profit, and secondly from the point of view of speedy and easy working; the effect being quite a minor consideration. The church authorities were generally inwardly grumbling if outwardly uncomplaining. Grumbling not at the workman, be it noted, for he, it may have been felt, had done his best; the grumbling would be at the expensive nature of electric lighting compared with the results obtained. The electric light would be said to be trying to the eyes. The electric light would be too expensive. The electric light would be difficult to see by; and the electric light would be everything that was bad. And all for the want of thought on the part of some one or other in the first place!

With the old method mentioned the effect was that the light would be unavoidable except by those who were seated right in the front of the church. To those behind it would be impossible to look at the preacher except through a sort of halo of glass shades messed up with spidery fittings.

Such a method is therefore to be condemned. And but little if any better is the old-fashioned system of altering the existing gas fittings. It will almost always be found that these consist of upright brass standards, with seven or more branching arms carrying flat fish-tail burners. The gas-lighting was not particularly trying to the eyes, for two reasons. First, the standards were rarely arranged in the direct line of sight of more than a very few of the congregation, and, secondly, the light was never sufficiently powerful to do more than make the darkness visible. The method followed by many—usually because it is a simple and inexpensive plan—is to convert these standards. To that end, the branches are unscrewed and turned downwards with a half turn from the top bend, half-inch holders are fixed, and lamps inserted. The result is that the lights are some six or eight inches lower than previously, they are much more powerful, and they are conspicuous. The electric light is once more condemned. Though it is admitted that the lighting is improved, yet it is considered trying for the eyes.

If this plan is followed, but the lights left upright instead of being turned down, the effect is perhaps not so trying, but the lighting is distinctly worse. The bulk of the light is thrown to the roofing, which is usually too far off to be reached, the principal portion of the light being, therefore, either lost, or else, in cases where the place of worship is fitted with a gallery, used to blind the eyes of the unfortunate worshippers sitting therein.

Speaking of galleries, it may be well to dispose of them as soon as possible by pointing out that these can be usually effectively illuminated by lights placed well back, so that the light is thrown from behind rather than from above or in front. Brackets on the stonework between the windows are usually adequate for this effect, but if insufficient, they can be supplemented by fittings of the Linolite type placed either on the pillars where convenient, or else hung down from the roof by light iron chains, the reflector being placed at such an angle as to prevent any of the people sitting behind seeing any of the actual lamps.

Another favourite method of church lighting is from the pillars, surrounding them with an array of lights, fixed on short wrought-iron arms pointing downwards at an angle of about forty-five degrees. In places this may be effective, but again the question of eyesight comes into consideration. In any case, the lamps should be frosted, unless the contractor is bold enough and strong enough to insist upon the use of a cup-shaped metal reflector shade that will entirely cover the lamp from sight, allowing only the space immediately beneath the lamp to be illuminated. In such a case the trouble is that the lights will have to be arranged with some degree of irregularity to get a good lighting result; but the use of such shades entirely prevents the bad effects mentioned.

The lights used must be powerful, unless they are in plain view, in which case they must be toned down as much as possible, and should consist of frosted lamps. But if the source of light can be concealed or totally screened from the eye, let the lights used be as powerful as possible. It is a fact that very excellent results have been obtained by the use of flame arcs; but without actually recommending these, it is evident that if they could be fixed so as to offend neither the visual nor the artistic senses, they would certainly be a most effective means of illumination; more particularly those of the pure white, daylight-effect type.

But without dealing with this point here, it is evident that the more powerful the lights, the fewer the points that will be needed, and for that reason it is evident that metallic filament, rather than carbon filament lamps should be used. The trouble in the way of this is that at the moment few of these lamps can be used other than in a vertical direction, and most fittings suitable for churches are designed for lamps to burn at an angle. But this difficulty can be surmounted with a little trouble and attention, if suitable reflectors are contrived for their use.

The ideal form of church lighting would be that in which the artificial illumination would be practically equal to that obtained during the average day; that would be free from alternations of glare and gloom, and that would be entirely hidden from the view of any one who had his or her attention fixed decorously upon the preacher or their books—the kind of lighting that would make a man observe to an acquaintance that such and such a church is beautifully lighted, and then be unable to explain how it was illuminated because he had not noticed.

It may be said that such a scheme might be admirable in theory, but well-nigh impracticable, on the ground of expense alone. I do not think this is so. The powerful nature of the lights would tend to cut down the number of points to some slight degree, and with lights fitted with metal shades and reflectors, placed in embrasures and niches, the expense of costly fittings would not be incurred. A considerable portion of the lighting would be effected by what might be described as a kind of batten light, such as is used in theatres, and fed by a length of twin lead-covered cable. It is possible that all the risk and trouble of roof work would be saved, and it is certain that the effect of the work would be well worth the extra expense, if any.

With regard to the actual wiring, there is no method so suitable in every way as lead-covered work. Whether it be the lead-covered paper insulated system, or that in which vulcanized rubber wires are brought together and lead-covered, is practically immaterial. Personally I prefer the former, if only on account of the circular section, most of the small conductors of the other system being oval, and as such looking more like electric light leads; especially where bent out of the straight to turn at right angles.

These circular twin lead-covered wires can be run with ease practically anywhere in a church, and if the cable —which is comparatively inexpensive— is lavishly used, all points being brought back to the distributing centre, with no attempt at looping out or jointing unless such operations can be carried out without trouble, and in some hidden, or at any rate inconspicuous position, a very neat effect can be gained with a minimum of trouble.

Of course, a good deal depends on the structure of the building. As the lead-covered wire is to be unnoticeable, and we are insisting upon the fact that there must be nothing visible to offend the eye, either as regards fittings, lights, or wiring, and yet it may be necessary to run it along some stringer, or up the side of some pillar; it is obvious that it must be covered in some way by something that will harmonize with and blend into the building so as to be indistinguishable.

Stone and woodwork, fortunately for the artist-electrician, are the usual features of church work, so that he has not to consider a multitude of tones and shades. There are seldom any colour effects to be studied; and if there are, they are not insurmountable. The problem is how to run the wiring economically, taking all things into consideration, and yet to harmonize it with the building. For carrying out this four things only are necessary: common sense, paint, sand, and single-groove casing of similar wood to that used in the building. As the wire is wound off the drums it should be painted with a good quality paint of the same colour as the stone work; and as it is painted, fine sand or powdered bath brick should be sprinkled upon it and the whole left to dry. It will then, if run in straight lines, or curves to match the position, be practically invisible, especially after dust has toned down the newness of the work. Where it runs along the woodwork it should be covered with the casing, washed with water stain to match in tone. This is particularly easy with oak, which is the wood principally used in churches. Where other wood is used it is not quite so easy, and the wires must be run as much out of sight as possible. But with due consideration as to position of lights, on the general lines laid down in this article, and with sound common sense as to running of wires, it is not only possible, but comparatively easy, to realize the ideal lighting wherein the lighting effect is good, the lights practically invisible, and the wiring as inconspicuous as in the best class of concealed work.

SPECIAL SECTION.

The Illuminating Engineer as a Specialist.

THE "New Specialist," the Illuminating Engineer, and the proposed Illuminating Engineeing Society have formed the subject of much recent discussion in the technical press.

In this section we are reproducing a number of the views which have been expressed on this subject, some of which date back to February, 1906, when the author drew attention to the subject in the course of a paper before the Society of Arts. It will be seen that the opinions expressed as to the value of the suggested "new profession" differ very considerably indeed.

On one point, however, there is now almost invariable agreement. It is generally recognized that many aspects of the subject of illumination are deserving of much more attention than they have hitherto received, and that a considerable saving could often be affected by an engineer who understood the requirements of good illumination.

Apart from the industrial aspects of the question, many people would also concede that the scientific side of illumination would benefit by some attempt to link together those interested, in order that a number of outstanding questions in photometry could be thoroughly thrashed out.

The only difficulty which some appear to find is the means by which these ends are to be accomplished. Our conviction of the value of the illuminating engineer and of an illuminating engineering society is evidently not shared by some of our contemporaries. We are sure that all possible objections to the proposed society, if fairly stated, can be met. We have therefore collected in these pages as many opinions, favourable and otherwise, as space will allow us to reprint.

THE ILLUMINATING ENGINEERING SOCIETY.

When the author in June, 1906, first drew attention to the value of such a society, the general interest in illumination was small in comparison with that existing at the present time. If any reader is in doubt on this statement, let him compare the number of articles dealing with illumination appearing in the technical press during the year previous to the date specified. Such articles were few and far between, and almost invariably referred to purely photometrical questions. At the present time the study of the current literature on the subject is almost too much for one man to accomplish. Some of us, however, even before that date had become convinced of the necessity of *some* system by which those interested in illumination could be brought together, and the author had conversations with the leading authorities on this subject.

The most natural suggestion was, of course, to endeavour to interest some existing society in the subject. It soon became evident, however, that no satisfactory solution could be reached in this way, and for several weighty reasons.

In the first place, we felt that the ground to be covered in the subject was too wide to enable any existing society to be able to do justice to it. The second objection to the suggestion that illumination can be dealt with by existing societies, is the impossibility of bringing into contact the various interested parties under the present conditions.

For, naturally, the members of any society connected with an existing system of illumination cannot, however much they may desire it, take an impartial view of other systems, and would inevitably consider the subject only from their interested standpoint; consequently the electrical engineer would continue to be unacquainted with the systems of gas and oil lighting, &c., and vice versâ, or would treat the subject in a biassed manner.

Apart from the benefits which the engineers connected with different systems of illumination would derive from free intercourse with each other, they would also learn much by hearing the views of many, who though directly concerned with illumination, are not directly connected with the various engineering societies, such as, among others, the oculists, architects, and physiologists, whom an illuminating engineering society might succeed in bringing together.

These considerations led the author to next turn his attention to the possibility of bringing the various interested parties together on a joint commission. (It is interesting to note that one of our contemporaries, who had hitherto contended that the matter could be satisfactorily dealt with by existing institutions, has recently come into line with our ideas so far as to recommend co-operation between the gas and electrical societies.)

The author approached some of the leading authorities connected with the subject of illumination.

All agreed that some form of co-operation was desirable, but raised several difficulties, among the most serious of which was the question whence were the necessary funds and support for such a commission to be forthcoming, in order to carry on the necessary investigations, and what legal powers could be associated with their recommendations?

Moreover, it is common knowledge that even Commissions which receive Government support frequently lead to but small results after very protracted work, and that their recommendations, even when admittedly beneficial, often fail to be carried out in practice, or are postponed so long that their sphere of usefulness is much diminished.

In the case of illumination, too, much has yet to be learned before such a commission could issue definite recommendations, and it seems doubtful, therefore, whether the commission could lead to useful results before the subject was much further advanced. A society, however, by securing the necessary exchange of views, could collect data by watching the result of carrying their own recommendations into practice.

By this time the Illuminating Engineering Society had been started in the United States, and though its success was not then established, the author felt that such a society in this country would probably lead to useful results. He therefore addressed a letter on the subject to the editors of the great majority of the interested technical journals, as this, as will be seen, elicited many favourable opinions. From that date up to the present time he has also placed the matter before a great number of those most intimately connected with illumination in England, and while some doubted the feasibility of such a society, it was almost invariably conceded that it would do good work—if the various interested sections could be brought together.

Last year he also paid a visit to the United States in order to learn, by observations on the spot, the conditions which have contributed to the success of the American society. When the American society was first started, the illuminating engineer was regarded —to quote the expression of an electrical contemporary—"as a man likely to add to the gaiety of nations."

It was prophesied that it would be impossible to keep together in peace representatives of the different branches of lighting, that the subject of illumination would be quickly exhausted, and that the discussions of the society would quickly become weary, stale, and unprofitable.

But—to quote our contemporary once more—" the prophets have turned out to be windbags." The American society, which started with a membership of 89 members, has now, after an existence of only two years, a muster-roll of over 1,000, and five local sections, and the number of members and sections is continually increasing.

The papers read before this society are evidently regarded as of interest, for scarcely a week passes without one or other being reprinted in the chief American technical papers, while our own journals have not been slow to avail themselves of a similar privilege, and have frequently spoken in praise of their papers which they reproduced. This certainly does not convey the impression that the transactions of the American society had fallen to the low level foolishly predicted by some.

Nor does there seem to have been much of the anticipated friction between those representing the various branches of illumination to interfere with the working of the society.

As a result of many interviews with those representing the various interests, however, the author is confident that this difficulty will not prove to be serious in this country either, and that all sections will find it to their mutual benefit to hear what the other has to say.

It has been argued that the United States is more favourably situated in this respect than we are, because the gas and electrical concerns over there are frequently owned by the same people.

Yet there are a considerable number of cases in which gas and electric light undertakings are owned by the same authorities in this country. It is therefore of importance to the ratepayers to see that the lighting under these conditions is carried out in a scientific and satisfactory manner.

It seems to us evident that the existing institutions, though doing excellent work in their own spheres of activity, cannot attempt to deal adequately with such a wide subject as illumination.

For this reason there seems to us little ground for any fear that the Illuminating Engineering Society will prove inconvenient, in any way, to existing societies. In this connexion, however, we have a precedent in the result of the formation of the American society. When in the United States the author was personally assured by the secretaries of the various societies that the formation of the Illuminating Engineering Society, in spite of its rapid growth and comparatively great membership, had not proved inconvenient in any respect, but, on the contrary, had actually proved an assistance.

It is interesting to recall that exactly similar objections were raised against the formation of the Institution of Electrical Engineers. At that time many people professed to be unable to understand the necessity for more than one kind of engineer, and deplored the, in reality, perfectly natural tendency towards specialization ; yet the value of the electrical engineer as a specialist is to-day fully recognized.

Now it is urged that the engineer has already more societies than he can attend to, and does not want another. It is, of course, becoming more and more difficult, even for a specialized engineer, to gain more than a very superficial knowledge of his special province. But to our mind, the increased specializing of societies is a perfectly natural movement, and, so far from being an inconvenience, is actually a facility to those interested in the special subject in question. One of the greatest inconveniences to which those interested in illumination have been exposed has been the fact that data bearing on this subject have been so extensively scattered. They have been obliged to scan the journals of many societies for the occasional papers and articles in which they were interested.

But the formation of a society

dealing with illumination alone would assist *everybody* to whom the subject must be indirectly of interest, for illumination is one of the necessities of life. Then, at any rate, every one would know where information on this particular subject was to be found when wanted.

Lastly, we wish to correct an impression that the proposed society is necessarily intended for the benefit of the declared "illuminating engineer" alone. It is quite clear that a society which depended for its support solely on the adherence of a type of expert who, at present, is—to say the least of it—rare in this country, would have a bad prospect before it.

It would, on the contrary, be of assistance to any one remotely interested in illumination, even if he proposes to restrict himself to one aspect of the question only. The success of the American society is in no small measure due to the wide variety of occupations followed by its members. An illuminating engineering society, in fact, commands the support of all who are interested in illumination, whatever be the special section with which they are associated. Only good can follow from a free exchange of the opinions of these different experts.

THE ILLUMINATING ENGINEER.

Let us now turn to the consideration of the "illuminating engineer."

From the outspoken opposition which has been excited in some quarters by the suggested creation of their expert, it might have been supposed that an army of illuminating engineers could be created in the course of a night, to swamp the overburdened engineering profession.

We only suggested that those connected with certain methods of lighting should themselves make a closer study of the various aspects of illumination in order to benefit the consumer and their particular branch.

We have never suggested that the expert impartial illuminating engineer must be developed from some class of engineer independent of any existing system of illumination. We see every reason to suppose that the necessary number of impartial experts will be recruited from those at first connected with electric gas or some other system of lighting, who, by gradually making themselves conversant with the merits and faults of the various illuminants from every point of view, will ultimately become illuminating engineers.

One of our contemporaries, in seemingly marked contradiction to views elsewhere expressed, goes as far as to declare :—

> "It would, of course, be an ideal thing to have an expert illuminating engineer without bias—an engineer capable of advising equally on the merits of gas, electricity, acetylene, oil, and other illuminants without any bias whatever,"

but fears that such an engineer cannot easily be produced.

Well, an ideal is worth striving for. It does not follow that because the present-day conditions are not, as yet, adapted to the needs of the illuminating engineer, they cannot be made so. We have not the least doubt that as the value of the illuminating engineer is more generally realized, any difficulties in his education will be overcome.

We believe that an expert of this description will ultimately be found to be a necessity, because illumination presents problems quite distinct from the system of lighting employed to produce it, and because the consumer would benefit by the existence of a specialist who would make an honest attempt to decide which of the various systems was most applicable to his needs on an impartial basis.

At the same time, we fully realize that such a qualified specialist can only be gradually evolved, and that his exact functions will be duly settled as his necessity becomes more evident.

THE NECESSITY FOR A JOURNAL DEVOTED TO ILLUMINATION.

While expressing our acknowledgment of the favourable comments on the appearance of our first number, we cannot refrain from referring to one criticism which was prematurely expressed before this number appeared.

We have been informed that "the subject of illuminating engineering is necessarily small" and that "the creation of a technical journal devoted to the subject will only result in the artificial production of literature of a low standard."

It is a singular fact that all of the men who have really studied the subject of illumination—authorities like Sir Wm. Preece, Mr. Trotter, Prof. Blondel, Dr. Fleming, Dr. Bunte, Prof. Wedding, &c., to mention only a few names from the list of those who have promised their warm support to the movement—have been impressed with its vastness, and with the difficulty of keeping ahead of the ever-increasing development of the subject. It has sometimes been assumed that because those interested in illumination devote themselves to drawing attention to the more glaring and obvious defects, the subject will be exhausted when these points are dealt with.

We hear it said "Oh, we do not need an illuminating engineer to tell us *that*." "No one but a *lunatic* could think of doing so and so," &c.

Experts are agreed that these obvious and confessed defects in lighting exist on all sides. Naturally, therefore, our first duty is to draw attention to such examples of illumination as are obviously and unquestionably wrong. But in so doing we only touch the fringe of a very extensive and difficult subject.

We are satisfied that we can count on the co-operation of an extensive and distinguished collection of contributors. But, quite apart from the value of the original matter to be published, we believe that our systematic collection and reproduction of results published in this country, in America, and on the Continent will, in itself, render *The Illuminating Engineer* of great value to all those who are concerned with the study of proper and efficient illumination, and that the magazine will therefore satisfy a great want.

In what follows we give a résumé of comments which have appeared in the technical press during the last two years on the subject of illuminating engineering.

The space at our disposal only enables us to reproduce in abstract some of the views which appear to us of the greatest interest, and we have been obliged to omit those many instances in which the proposal of the Illuminating Engineering Society was referred to, without comment. In order to trace the gradual formation of public opinion on this point, we now give a brief history of the various articles, papers, and other publications which have been influential in turning it on the subject.

Interest may be said to have been first aroused on the question of illumination by an article by the author in *The Times* (October 25, 1905) on 'The Standardization of Electric Light.' The publication of this article was followed by prolonged correspondence from manufacturers of glow-lamps and others concerned.

The author subsequently read a paper before the Society of Arts (February 7, 1906) on 'The Progress of Electric Light,' in which the value of the illuminating engineer was referred to, and finally contributed an article to *The Electrical Magazine* (June, 1906), entitled 'The Need for the Illuminating Engineer.' This article was reprinted, and reprints and abstracts of it were sent to the section of the technical press, and those authorities likely to be interested in the subject. Much comment on the subject followed, and the author had opportunities of discussing the matter in the course of interviews with those representing the different branches of illumination.

In August, 1906, Sir William Preece read a paper before the British Association on 'Glow-Lamps and the Grading of Voltages,' and commented favourably on the illumination specialist therein. During this meeting of the Association the author had again the opportunity of hearing the views of many experts on the subject, almost all agreeing with him as to the desirability of putting illumination on a more scientific footing.

In August, 1907, the author again referred to the subject in a paper before the British Association at Leicester, on recent developments in electric lighting. Before reading the paper, and immediately after, he undertook visits to the United States and to the Continent in order to hear the views of those who were likely to be able to speak with authority on the subject, and to obtain their co-operation, and he has received every encouragement from all.

Finally, the author raised the question once more in his recent paper on 'The Province of the Illuminating Engineer,' read before the Association of Engineers in Charge (December 11, 1907).

The various comments which have been called forth by these different papers are reproduced below, the journals concerned being arranged in alphabetical order, and the individual references by date.

It is interesting to observe how the opinions changed as soon as the matter became more understood, and the position clearer defined. Readers will be able to form their own opinion afterwards, and, we trust, will agree with us that the matter of properly studying the illuminating problems deserves every encouragement.

There is one other point to which attention may be drawn. In what has been said above, the Editor has found it necessary to refer to his own pioneering work on the subject of illumination, but he wishes to make it clear that this has been done merely in order to trace the march of events.

The movement has received so many adherents as to be now an established fact; its success in the future is secured by the great number of authorities on illumination in this country and on the Continent, who are giving their warm support, and can no longer be considered to be dependent upon the efforts of any one man.

Comments of the Technical Press on Illuminating Engineering.

THE BUILDERS' JOURNAL.

July 18th, 1906.

ELECTRICAL NOTES.

An Illuminating Engineering Society.

"We drew attention in these columns recently to the necessity of lighting matters being placed in the hands of trained men."

The writer then describes the suggested Illuminating Engineering Society, and quotes from the article in which the suggestion was made in order to bring out its value.

ELECTRICAL ENGINEER.

July 6th, 1906.

"ILLUMINATION AND PHOTOMETRY.—There was read before the Illuminating Engineering Society a paper on this subject, the author of which, Dr. Louis Bell, made some valuable observations from an engineering standpoint, based upon physiological data. This important subject is only just beginning to receive the attention which is due to it, and we cannot conceive any body of men better fitted for its discussion than those who make the problem of illumination the speciality of their work and study. These are days of specialization; we can only expect, therefore, that engineering specialists shall set up their distinctive institutions for the organization and promotion of their interests. However much some may deprecate the multiplication of technical societies, it must be borne in mind that the weakness arising from this can only be urged when the diverse societies are likely to weaken any existing societies which have for their object the general advancement of a particular industry, or when their activities are out of unison with those of other societies. But we do not believe that a society, with objects similar to the Illuminating Society, comes under either of the categories we have mentioned, but, on the contrary, we are of the opinion that such a society is decidedly opportune. It is for this reason that we would encourage the formation of an Illuminating Society in this country, which we believe is already afoot."

The article then proceeds to discuss the possible efficiency of illuminants, and concludes: "There is a wide field open for investigations in this direction, and any results which would teach us how to place luminous sources with the greatest effectiveness at a minimum of expense and maintenance costs would be invaluable."

ELECTRICAL INDUSTRIES AND INVESTMENTS.

June 20th, 1906.

Comments upon the suggestion that an Illuminating Engineering Society, involving the co-operation of gas, electric, and oil authorities, so as to give the best possible results from the artistic, illuminating, and economical points of view.

The author remarks that Mr. Gaster "is evidently of opinion that the millennium has actually arrived, but for our part we question whether the mutually abusive interests could possibly work in harmony."

He then proceeds to deprecate the suggestion that the existing number of scientific societies should be increased, but concludes: "On the other hand, it cannot be denied that the illuminating question, together with the type of lamps, shades, and reflectors used under specified conditions, is a most important one."

August 28th, 1907.

"Let there be light."

Presumably Mr. Leon Gaster has been following the proceedings of the American Illuminating Engineering Society with an interest bordering upon absorption. The Convention, which has recently been held in Boston, certainly demonstrates the progress which has been made in the art of correct illumination on the other side of the Atlantic, and the many interesting papers read before the meeting will, perhaps, spur Mr. Gaster to fresh pioneering efforts in this country. At the time of his inception the illuminating engineer was hailed as a man likely to add to the gaiety of nations. It was freely prophesied, owing to the conflicting interests of electricity, oil, and gas, that a meeting of an illuminating society would have more the aspect of a bear garden than a sedate scientific assembly. Even in these columns doubts have been expressed as to whether all these interests could possibly be made to work in harmony; but, as is often the case, the prophets have turned out to be windbags, and the illuminating engineer, at least in America, is an established fact. Nevertheless, it is obvious that such an individual must be a person of strong will and even temper. He may have to deal with gas or with electricity, oil or acetylene, and know how to make the best use of any or all of them; and all this in spite of the fact that his usual work will commonly run in a single line.

But even these qualifications do not constitute all that is required of the illuminating engineer. He must possess a sound grounding in physics and chemistry, and some knowledge of physiological optics. He must be well up in the science and art of photometry, but above all he must have a lively sense of the artistic. We are quite in agreement with the necessity of scientific lighting by scientific methods, but science—even illuminating science—must not come along and abolish all the things it pleases us to call beautiful, because they do not happen to conform with the scientific ideas of the illuminating engineer." For science is not always beautiful.... According to the *Electrical World*, it will be some years before any proper training for illuminating engineers will be available; but it is not likely that illuminating engineers will ever become a great independent profession any more than has sanitary engineering, but it will doubtless become a well recognized branch, in which there will be many an opportunity for admirable work. Certainly Mr. Gaster and his followers are faced with a task not to be passed over lightly.

October 23rd, 1907.

"The Contractor."

Day by day the question of scientific illumination becomes of greater importance. There can be no doubt that this point has not, in the past, received that careful attention which the subject deserves, but with the introduction of high efficiency lamps, installation engineers all over the country are rapidly coming to recognize illuminating engineering as a most important branch of installation work. We can only echo the remarks of our contemporary, *Electrocraft*, in this matter. Illuminating engineering, says this bright American publication, is a horribly neglected matter; and there is much profit and reputation for the contractor who has the sagacity to take hold of this practically unused and tremendously important branch of knowledge. Illuminating engineering is a high-sounding title, but there is no need to be scared at this rather formidable name; it is not half as discouraging as it looks. And if its few professional votaries joyfully revel in energy curves, photometrics, luminosities, and pupillary diameters, there is no cause for worry, The intelligent contractor may feel perfectly assured that a fair working knowledge of the principles governing the effective arrangement of lighting units can be easily enough acquired, and that its possession will give him an immense advantage over his fellow contractors not so equipped.

December 18th, 1907.

Is an Illuminating Engineer a Necessity?

The writer of this article is not sure, and thinks that the art of correct illuminating should be understood by the station engineer or contractor, and that there is little need for a profession entirely devoted to illumination

"It is all very well to talk about physical constants, units of light—the lumen, the lux, and the candle-foot—but, above all, sight must not be lost of the physiological aspect of the situation."

"There is no doubt that many installations could be improved, and present special difficulties, but the knowledge required for such successful lighting is a matter of experience."

In order to illustrate this contention the writer quotes some recent utterances on the subject of illumination, referring to the illumination of factories and libraries, &c.

ELECTRICAL MAGAZINE.

April 24th, 1906.

In our "Lighting Section" this month will be found the first portion of an interesting article by Mr. L. Gaster, pointing to the immediate need, not only for qualified illuminating engineers, but also for an association to further the science of illumination. It cannot be doubted that the time is now ripe for a concentration of effort to this desirable end, and we speciallly direct the attention of our readers to Mr. Gaster's admirable appeal for support.

The chief reason why this movement should be fostered and carried to fruition is its tendency to focus the interests of electrical and gas engineers on a common object, namely, the provision of efficient illumination apart from commercial rivalry. To achieve this object would be worth the expenditure of tireless effort, and if it can be attained, the thanks of the industry as a whole will be due to those directly or indirectly responsible for the result.

A Society of Illuminating Engineers would admit the exponents of lighting by electricity, gas, and oil; in fact, an effort would be made to give men a knowledge of all three without prejudice to either, so that an "illuminating engineer" would be qualified to advise on the installation of one and all such lighting methods. If this idea can be brought home, it will form a class of experts whose advice can be sought without fear of prejudice in favour of this light or that. Obviously here is an opening for the young men in the profession, men who, on leaving college, find new fields for the exploitation of their energies, and who frequently accept uncongenial and unprofitable berths. In the last part of his article, to be published next month, Mr. Gaster makes a direct appeal for help, which, however, we will not anticipate, but commend the subject generally to the notice of our readers.

ELECTRICAL REVIEW.

September 6th, 1907.

After describing a series of experiments on different methods of lighting carried out by the New York Edison Co., the writer on the subject concludes:—

"These results and conclusions are very valuable, and will probably be used with good effect by English station engineers. But, in all humility, we should like to know where in England there is a station staff which hunts round with a luminometer in order to record results for the benefit of its competitors as well as its consumers, and moreover where, on this side of the water, there is an office belonging to an electrical lighting company scientifically enough illuminated to be the happy hunting ground of a man intent on writing a research thesis?"

September 27th, 1907.

Illuminating Engineering and Electrical Contracting.

"The keen competition between rival forms of illumination is developing a very critical and discriminating spirit among those who are responsible for installing electrical fittings and accessories. It was formerly considered sufficient if the electrolier or bracket was artistic, novel in design. and moderately cheap. The design of globe or shade was left entirely to the fancy of the artist, and within a very wide range the questions as to the total or partial frosting the engraving or etching of patterns, &c., on the glass, did not very materially affect the sale of the shade. Quite recently, however, the illuminating engineer has spoken somewhat emphatially with regard to electric light fittings, and those who are in any way interested in the design and manufacture of shades, pendants, and brackets, may be advised to note very carefully what this new form of scientist has to say."

The article then proceeds to refer to the difficulty of reconciling the artistic and utilitarian aspects of illumination, and proceeds :—

"There is every reason to believe that the illuminating engineer has come to stay, and that he is going to show the necessity for certain modifications of electric lighting fixtures." . . . .

And :—

"There is no doubt that the science of illuminating engineering is going to open up a new field of commercial exploitation. Large manufactures are becoming standardized. Development in future will probably proceed on the successful study of the requirements of consumers in their multifarious needs. For this reason the manufacturers of electrical fittings and accessories will doubtless make it their business to keep a very close eye indeed upon the investigations of those who are studying light effects."

October 4th, 1907.

Light Production and Illumination.

Points out distinction between light and illumination.

"Our methods of producing light are appallingly inefficient. We have got to learn the physical side of the problem, and to select substances, the molecular condition of which is favourable to light-production.

"But what makes questions of illumination so perplexing, is the fact that the physiological side—the effect on the eye—has also to be considered. Probably particular light of particular frequencies is suitable for special purposes. For reading print, for instance, we may not desire the same quality of light as for general illumination. Again, the condition of the eye at very weak illuminations is verv different to the normal state.

"This point of view is far away from that of the average man with the photometer, who makes simple tests of 16 c.-p. lamps. It shows us that it will probably be years before the amount of knowledge concerning illuminating engineering will be sufficient to render operations in this field at all commensurate with the development in other spheres of engineering activity."

October 25th.

"The great danger about the new science of illumination is that in the multitude of voices raised in the professional pronouncement, with the ulterior object of constituting for each prophet a pretty little private practice, will ultimately get the subject into disrepute. Already the temptation among practical men is to argue that they got on very well with lighting their houses and chapels before all this attention began to be devoted to the higher science of illumination, and they cannot, or will not, see why the old empirical rules should not be followed as before."

The Electrical Review then proceeds to give some simple rules of illumination, quoting from *The Engineering News*, as respects the amount of light required for reading, and the illumination of drawing - offices, &c., and continues, "with such simple rules for guidance the plain unvarnished type of electrical engineer can go a long way towards designing his illumination, so as to give good and scientific effects, and the higher flights of calculation and obfuscation may be, to a large degree, left to those who have a larger amount of spare time on their hands than the ordinary electrical contractor who is conducting a thriving business."

THE ELECTRICAL TIMES.

December 19th, 1907.

"Can illuminating be measured with sufficient accuracy and with sufficiently simple apparatus to make it a practical basis for money matters ? "

The writer of this article apparently thinks not, and is impressed by the difficulties of applying the system in practice, even if its merits be acknowledged. The subject is treated in a humorous manner, however, and the article can hardly be considered in the light of a serious attempt to discuss the merits of the question at issue.

THE ELECTRICAL WORLD OF NEW YORK.

June 16th, 1906.

Illuminating Engineering in Great Britain.

"Our British contemporary, *The Electrical Magazine*, in commenting on a series of articles in its columns, by Mr. L. Gaster, on 'The Need for the Illuminating Engineer,' expresses the hope that its readers will respond heartily to the appeal for aid in the formation of a British Illuminating Engineering Society. No time, it says, should be lost, as the present position of illumination demands co-ordinate interest and co-operative effort for its establishment on an authoritative basis in this country. 'America has led off well. Already it can boast a society and two independent journals devoted to the subject. The state of affairs here needs both of these, and just as soon as they can be fashioned from the materials at disposal. We want the gas and oil man as well, and hope they will stand by the movement, as their interests are likely to be safeguarded equally with those of other illuminants represented. We have now done with the talking. The sooner the practical business is got down to the quicker the end in view will be attained.'"

That in this country the formation of a society to foster the interests of illuminating engineering was entirely justified is shown by the rapidly growing membership of the present society, which is now little short of 600, and promises to reach 1,000 by the end of the year, by the high character of the contributions available for its *Transactions*, and by the lively interest in the meetings as manifested in the discussions. Our British friends should not delay getting into line with the latest branch of technical specialization.

ELECTRICIAN.

April 12th.

'*The Engineering of Illumination.*'

"There has been a good deal of talk recently about the illuminating engineer, the idea being that a new kind of engineer should be evolved, to see that out buildings and our streets are lighted to the best advantage. Whether such an engineer, with a good knowledge of all methods of illumination, and not merely of one particular branch, is likely to be evolved, or whether, if produced, he would combine the disadvantage of a diffused knowledge with an incomplete knowledge of any particular branch, may be a matter of opinion; but certainly there does not seem to be any marked call for specialization."

The article goes on to declare that the engineer already feels himself overburdened by the number of technical societies, to which he must devote himself, and would not welcome another. Nevertheless, the writer realizes the necessity for better methods of illumination, and expresses his views on the subject for another column.

August 30th, 1907.

The Illuminating Engineering Society.

"An organization bearing the above title has recently been formed in America, and its roll of membership includes considerably more than 1,000 names. So vigorous, indeed, has been its growth, that a first annual Convention was held at Boston during the last two days of July, and, according to our American contemporaries, this Convention proved a 'noteworthy success.' The President of this society is Dr. C. H. Sharp, an abstract of whose address will be found in another column....At present, commercial photometry is delightfully simple, and it is questionable whether anything tending to complicate it will be welcomed by practical men. Of course if a new society, devoted exclusively to the study of illumination, is formed, then it is only natural that a large number of fresh suggestions should be made. However, as we pointed out in a leading article some time ago, the entire matter might very well be dealt with by existing societies, and we trust that the day is far distant which will mark the birth of an English society having the same functions as that just called into existence in America."

December 20th, 1907.

The Illuminating Engineer.

"There is probably no subject whose principles are equally well understood and so frequently violated as the subject of illumination. This is due partly, no doubt, to ignorance, and often to carelessness; for there is no great difficulty in understanding the principles themselves, although elaboration has been introduced from time to time in the units and phraseology that are used.

"In order to remedy this state of things it has been suggested that a special type of engineer, namely, the illuminating engineer, should be evolved. The process of evolution has, indeed, started with vigour in America, and now it has extended to this country, largely due to the efforts of Mr. Leon Gaster, who last week read a paper on the subject before the Association of Engineers in Charge ....It appears to us, however, that existing engineers—the consulting engineer, the station engineer, or whoever is concerned with such matters as part of his usual work—should take the trouble to inform themselves on these questions without producing a new class of engineer ....It would, of course, be an ideal thing to have an expert illuminating engineer without bias, as Mr. Gaster suggests he would be—an engineer capable of advising equally upon the merits of gas, electricity, acetylene, oil, and other illuminants without any bias whatever. As a matter of fact, however, no engineer can receive his training in several branches of engineering. The chance is that he will be trained either as an electrical engineer or as a gas engineer, and he will naturally be biassed along the lines on which he has been trained.

"On the other hand, there is room for a good deal of useful information to be collected, and partly on that account it is proposed to form a new society, to consist of engineers of all kinds who are interested in illumination.

"Undoubtedly," the article continues, "societies working along such special lines often do useful work." It is feared, however, the multiplication of such societies is undesirable, and therefore the writer advocates co-operative action between the Institutions of Gas and Electrical Engineers and the formation of a Joint Committee.

ELECTRICITY.

February 16th, 1906.

"To fill the gap which at present exists between the supply authority and consumer, neither of whom profess a knowledge of the principles of illumination, Mr. Gaster suggests the creation of a new profession, namely, that of properly trained illuminating engineers. The suggestion is distinctly good; there is ample need for a consultant who thoroughly understands the principles of illumination, and the best way of securing maximum lighting efficiency at a minimum cost of electrical energy. At present our installations are planned by rule-of-thumb methods; so many candle-power for so many square feet to be lighted, and in the majority of cases, regardless of the purpose for which the light is ultimately intended, whether for reading or sewing by, or merely to illuminate a staircase or cupboard. All the many purposes for which artificial light is required call for different treatment in the matter of distribution, reflection, and shading, if the best results are to be obtained. There is obviously a field here for the man who makes a special study of the subject and becomes, in effect, an 'illuminating engineer.'"

December 27th, 1907.

Illuminating Engineering.

"It has now come to be regarded as almost inevitable that the efforts of pioneers in nearly every sphere of activity should meet with a resistance, both active and passive (of vigorous opposition on the one hand, and of ridicule, perhaps, on the other), which, at a later date, seems altogether out of proportion. But if resistance to the progress of any new idea or undertaking does not necessarily connote the futility or weakness of that taken in hand, neither does that sympathy which the foresight and courage of pioneering spirits awaken within us, exempt us from turning the searchlight of investigation upon that which we are asked to accept. Many of us in this country are watching closely the attempt which is now being made to create a new specialist in the engineering profession under the style of 'illuminating engineer,' and to combine the interests of electricity, gas, oil, and acetylene lighting. Mr. Leon Gaster is foremost among those who are trying to bring about this desirable state of affairs, and one cannot but admire the energy he is throwing into the movement, even if one doubts its feasibility......Mr. Gaster is quite impartial in his leanings as between gas and electricity. What the public want, he says, is best illumination for the money spent, and it is quite unconcerned whether this is produced by gas or electricity. I doubt, however, whether Mr. Gaster will get either gas or electric light engineers to agree to this, and while the inevitable rivalry between the two illuminants continues, I fail to see how a common ground can be found upon which to combine two opposing interests."

THE ENGINEERING TIMES.

June 14th, 1906.

Notes.

"Mr. Leon Gaster, of 32, Victoria Street, Westminster, writes to us suggesting that the formation of an Illuminating Engineering Society would do much to advance and disseminate the knowledge relating to the science and art of illumination. The merits and faults of the different illuminants now used for public or other lighting purposes will have a better chance to be discussed on a more scientific basis, and the sphere of useful application be easier defined for each of them. There is no doubt that great economics can be derived from the judicious selection of the system of lighting adopted and the type of lamps, shades, reflectors, &c., used for different purposes.......Such a society as Mr. Gaster suggests is already in existence in the United States, and is doing useful service."

After briefly outlining the nature of the sugested Illuminating Engineering Society and the advantages to be derived from it, the article concludes :—

"There is no reason why one formed in the United Kingdom should not meet with a large amount of success. We are acquainted with several lighting experts connected with large manufacturing concerns who would welcome the innovation."

GAS WORLD.

August 24th, 1907.

The Study of Lights and of Lighting.

"We reproduce in another part of our present issue some extremely interesting and useful particulars relating to the rating and application of various descriptions of artificial light sources, gas and electric, from the *Proceedings* of the New York Section of the Illuminating Engineering Society. The salient feature of the work of this society is the regard which is paid to the science and practice of lighting ; which is a study that has not hitherto received in England anything like the systematic and sustained cultivation that its importance deserves. We have on record a number of able papers treating of the subject ; but they are quite occasional in their origin and purpose, and it is by no means easy for a gas engineer, who happens to be called upon to solve a problem of lighting, to lay his hand upon precisely the kind of guidance in the matter which he may desire. In this country, both gas engineers and electricians appear to have concerned themselves more with the production of luminosity than with its proper applications, with the result that examples of the misuse of shades and reflectors, or their neglect altogether, are distressingly evident to any one with an eye for such things who takes an evening walk through an otherwise well-lighted street. It is not too much to say that the production of a good light is only half the battle. An equally important half is the proper distribution and utilization of the lighting effect, and this part of the field of operation of the two great lighting industries remains in a sadly chaotic state. In America, both kinds of light are now usually in the same hands, which greatly favours the development of a sound body of practice in their use. Gas engineers and electricians work in a common interest in many, perhaps in the majority, of the largest cities of the United States; and one result of this unity of purpose is, according to such witnesses as Mr. H. L. Doherty, that the public indulges in lighting on a scale that has no parallel in Europe. Be this as it may, it cannot be doubted that the Illuminating Engineering Society, which is manned equally by those who on this side never meet upon the same platform, is doing excellent work in laying the foundations of a science of artificial lighting, upon which a sound edifice of practice can be safely reared. It is not for us to copy their organization ; but we can, at least, learn from their labours."

November 2nd, 1907.

The Science of Artificial Illumination.

Quoting from *The Electrical Review* of October 25th, agrees that :—

"The scientific aspects of lighting are being so overdone, that plain men can hardly understand what the high science means." The rules of good lighting, *The Gas World* thinks, are few and simple :—

"We quite agree that the fundamental rules of good lighting are few, and not at all difficult to understand, and that there is certainly no need for the creation of another technical society in England to cultivate this department of a gas or electrical engineer's professional acquirements, which has already been advocated in some quarters."

December 14th, 1907.

"Whether there is enough in the science and practice of illumination by gas or electricity to support a distinct branch of engineering is a question on which professional opinion is, and we think, will remain divided.....There is room for improvement in some departments of existing lighting systems. On the other hand, the success of the New York society appears to be largely due to the local circumstance of the gas and electricity supplies being in the same hands, which is not the case in England."

JOURNAL OF GAS LIGHTING.

February 20th, 1906.

"Our readers are aware that a society has lately been formed in New York for dealing with questions relating specially to illumination; and it may be remembered that in the 'Journal' for the 20th of March last we offered a few observations on the scheme. It was then recognized that the idea of working up the art of illumination was an excellent one, and one which it was suggested might profitably engage the attention of the Institution of Gas Engineers, with, of course, special reference to the use of gas. We pointed out that outdoor and interior lighting are both susceptible of improvement—the latter chiefly from the hygienic standpoint—and remarked that a great deal might be done by 'the enunciation of correct and economic principles in regard to the distribution of light.' We gave a list of the papers to come before the new society, and heartily wished it success. It will be seen, from a communication which appears elsewhere, that a movement is on foot for the formation in this country of a society corresponding to the one in request of which our remarks were made. ....Mr. Gaster....acknowledges that by looking after the lighting business gas engineers have made illumination by gas what it is; but, with us, he thinks there is still more to be done in this direction. He does not anticipate that any antagonistic feeling would be created between different illuminating engineers by the formation of the proposed society. On the contrary, he thinks that each would endeavour to bring apparently conflicting interests closer together, by the exchange of views on the relative merits of the various illuminants. He considers that a society such as the one proposed should receive the hearty support of the councils of the gas and electric professional organizations and of the newly formed British Science Guild. We are pleased to direct our readers' attention to Mr. Gaster's proposal, and shall be glad to know their views thereon."

July 21, 1906.

A Society of Illuminating Engineers.

"As many of our readers are doubtless aware, a Society of Illuminating Engineers was formed recently in New York, the object being to discuss questions and disseminate knowledge respecting artificial illumination. A proposal is on foot to form a similar institution in this country. The British Institution of Gas Engineers is an able and influential association; but it naturally devotes most of its energies to problems relating to the manufacture and distribution of coal-gas. It therefore resembles the Institution of Electrical Engineers in dealing solely with the utilization of one form of artificial illuminant. The Society of Illuminating Engineers (we do not yet know precisely the title it is proposed to adopt) will thus fill a perfectly distinct gap in the existing list of technical bodies, as it will study the employment of any kind of illuminating agent irrespective of its origin. The private householder and the ratepayer display much ignorance regarding, and suffer seriously in pocket from unfamilarity with, the best methods of developing useful and economical light; and perhaps it is almost as safe to say that large numbers of men well acquainted with the manufacture and distribution of 'coal' gas or electric current are almost as ignorant of the best way to develop light as their own customers. Evidence of these misconceptions is seen in many of the contributions which appear in the technical Press."

The writer then proceeds to point out difficulties in the way of measuring the illumination and comparing the merits of different illuminants, and the first two refer to the necessity for carefully considering the arrangement of the fittings in a room, of the location of switches, &c. "Hence if the new Society of Lighting Engineers assists the technical man in acquiring trustworthy data as to illuminating effect and the result of particular style of furnishing upon reflection, if it gives him figures as to the loss in candle-power brought about by badly designed globes and the like, and by dirty fittings, it will do much public service."

July 30, 1907.

Illuminating Engineering Society of New York.

Refers to the list of papers to be read before the first annual convention of the society at Boston.

"This list of papers should make a most attractive programme, covering a wide range of topics, and laying before the members the results of a large amount of original research."

December 17, 1907.

The New Specialist.

The article acknowledges the need for greater care in the present methods of illumination, but doubts whether the new expert will receive due recognition.

It will be difficult to find the man who can maintain the requisite impartial attitude, and it is questionable whether his ruling would be accepted by those connected with a special department of illumination.

THE OPTICIAN.

August 30, 1907.

The Illumination Specialist.

"The illumination engineer would seem to be a modern necessity, and that his advent will not be long delayed seems pretty certain. Mr. L. Gaster, who has an important article on 'Illumination' in a recent issue of *The Times,* tells us that it is surprising how little attention has been given until recently to the systematic application of the scientific principles of artificial illumination. In addition to the imperfect methods of converting electric energy, &c., into light, a large amount of the artificial light that is now produced is unnecessarily wasted. There are many cases where the loss may exceed half or even two-thirds, as Mr. Gaster points out, but even more important than the economical side of the subject is the disastrous effect on the eyes caused by the numerous faulty lighting arrangements.

"*The Optician and Illumination.*

"The different purposes for which artificial lighting is required call for special treatment, if the best results are to be obtained, and it is this authority's object to indicate how, to a certain extent, matters may be improved by devoting special attention to the problems dealing with illumination. The important rôle this new specialist—the 'illuminating engineer'—will have to play in the near future may perhaps be better understood, Mr. Gaster considers, when it is realized that the expenditure for lighting in this country is estimated to exceed 36,000,000*l.* per annum. To make a conservative estimate, about 10 per cent. could easily be saved by properly looking into this matter, so that 3,600,000*l.* could be turned to better advantage and more satisfactory illumination be obtained. And as Mr. Val. Mackinney asked in our columns some good time back, what is the optician doing to get his share of this new development?"

PLUMBER AND DECORATOR.

July 2nd, 1906.

Illuminating Engineering.

"It is curious to notice how, amid the mutations of time and circumstances, the ordinary terms and expressions of common language change their significance and acquire new meanings. Had we spoken of 'illumination' to one of our predecessors represented in the recent pageants at Glastonbury or Warwick, he would, of course, have understood us to mean the decoration of missals and other dainty devices of that artistic kind. But Mr. Leon Gaster, the Consulting Electrical Engineer, writing in *The Electrical Magazine,* brings us up to date by suggesting that we of the twentieth century should be as artistic in our way as were our forefathers in the days of 'illumination' proper. Gas and electrical engineers, he holds, should form a society for artistic adornment in their separate methods of contemporary illumination. In place of the feud that now exists between the advocates of the separate illuminants, he proposes an exchange of views and a community of interests. Such an object he considers to be fitly comprised among the methods of the newly formed British Science Guild. One is always glad to welcome fraternization of this kind; and Mr. Gaster is able to point to an American solution of the problem which shows his idea is not impracticable. The growing recognition of illuminating engineering as an art is, he urges, indicated by the establishment of illuminating engineering under an expert at the American General Electric Company's works. If in America, why not in England? Why not, indeed!

"*Gas* v. *Electricity.*

"Why versus? Is there any real reason for the importation of this objectionable forensic term into the apparently peaceful atmosphere of general illumination? The question was approached rather than stated at the annual general meeting of gas engineers. It was, as we used to say in our schoolboy days, 'understood but not expressed.' With regard to the competition of electricity with gas, says the President, it might be that some epoch-making discovery like the Welsbach mantle might revolutionize the supply of electricity as this has done in the case of gas. Then where would gas be? At present the prospects of gas were never so promising. And yet even the presidential mind could not shake itself quite clear from the obnoxious 'versus.' Why should there not be room for both? The age needs illuminating from every possible quarter and in every possible way. The remedy suggested by the President is a sound one —'Cheap Gas.' Given that, we might hope to substitute for the objectionable 'versus' our own happier combination, 'Gas and Electricity.'"

THE TIMES ENGINEERING SUPPLEMENT.

August 21st, 1907.

"While in this country the gas and electric lighting interests carry on their controversial warfare at long range, in America there has just been held the first annual Convention of the Illuminating Engineering Society, which already numbers over 1,000 members, and which discussed quite impartially such subjects as 'Standards of Light,' 'The Inverted Gas Light,' and 'Acetylene Lighting.' While it may appear a matter of speculation as to whether any annual convention of this society may become a peace conference or a battlefield, there is undoubtedly a case to be made out for the friendly discussion of the respective claims of various methods of exterior and interior illumination, and the competing interests will naturally join forces in raising the general standard of lighting so that the consumer will provide more revenue for whichever system succeeds in obtaining his custom. There would certainly be no reluctance on the part of electrical engineers here to come into similar close association with gas managers, and it is not to be doubted that both could learn much more about illumination than the present average knowledge on the subject."

October 2, 1907.

(Page 319, under "Electrical Notes," by an Engineering Correspondent.)

"An effort is being made to repeat in this country the extraordinary success which has attended the organization of a Society of Illuminating Engineers in America, to which reference was made recently in these columns. No better time could have been chosen for the formation of a similar British society, for we are undoubtedly on the eve of a very important advance in the art of illumination. Both in the electrical and gas industries, considerable improvements are being made in lamps, both as regards economical consumption and effective distribution of light.....It will be the work of the illuminating engineer to advise how the utmost benefit may be gained in the employment of the products of the gas and electrical engineer; that is to say, how the light may be most usefully diffused and how its effects on the eyesight or general health may be avoided. As *The Illuminating Engineer* of New York claims 'Artificial lighting is one of the greatest industries of the world.'"

December 18th, 1907.

In view of the previously favourable attitude taken up with regard to illuminating engineering by this paper, and the fact that several recent numbers had contained a full column on the subject of illumination, and a résumé on the proceedings of the Illuminating Engineering Society, at the first annual Convention at Boston, the following remarks come as a surprise. In discussing the paper before the Association of Engineers in Charge on 'The Province of the Illuminating Engineer,' the writer remarks that the illuminations of the present day are much more satisfactory than the paper would lead us to suppose, and quotes the lighting of Oxford Street, the House of Commons, and St. Paul's Cathedral as prominent instances of progress in this respect. The writer concludes:—

"We are inclined to allow that there is need for a society or institution more adequately to represent industrial physics —somewhat on the lines of the Society of Chemical Industry; but while the present machinery is active, and while illumination forms so large a subject of discussion and experiment among existing technical societies, it is difficult to comprehend why a society should be formed to produce the 'new professional' for illumination purposes."

[The examples cited certainly do not justify assertions so divergent from those held by experts in illumination; all such opinions require careful consideration. We ourselves have emphasized the fact that much progress in the art of illuminating has been made in recent years, but we are equally certain that very great further progress is possible, especially by concerted instead of individual effort, and, it is to say the least, gross exaggeration to say that illumination forms such a frequent subject of discussion at existing societies.]

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Incongruities of the Present International Nomenclature Referring to Illumination.

By Dr. B. Monasch.

(Abstracted from the *Journal für Gas,*) *&c.*

The attempts that have been made to find an international unit of light by the Parisian Congress of 1881 were carried on by the Congresses of 1882, 1884, and 1889, and also by the International Electrical Congress at Chicago in 1893, and a similar Congress at Geneva in 1896. The formation of the International Photometrical Commission in 1900 did not result in the discovery of the desired unit. The Hefner lamp in Germany, the candle in England, and the Carcel in France were not to be displaced. Therefore, an attempt was made in 1903 to ascertain the relations between the commonly expected units, and the results carried out in the prescribed laboratories in England, France, and Germany, were officially communicated by the Commission at Zürich in July, 1907.

The system of 1896 proposed the international adoption of the word "Lux," as a unit of intensity of illumination; this term had been previously proposed by Preece at the Congress of 1889. We find, however, that the word "Lux" is followed by the word "meterkerze" in brackets, which apparently was intended to convey that the terms were synonymous.

It is not often that a term has found its way into general use as rapidly as the word "Lux," and it occurs in almost all the works of consequence which have appeared in Germany and France since the year 1900.

The word is short and etymologically correct, and is especially adapted to be the name of a unit in that neither the unit of light nor the unit of length enter into it. A unit is preferably denoted by a pure name rather than an attempt of definition. We call the unit of force a dyne and not a gram-centimetre (second)^2 similar remarks apply to the word "Meterkerze." Moreover the word Meterkerze is applied to the unit of illumination on the basis of the old German "Vereinskerze" = 1·2 HK. Thus 1 Meterkerze became 1·2 Lux, and at the same time two expressions were in simultaneous use for one and the same quantity.

The confusion which has arisen between the Lux and the Meterkerze is illustrated by the case of the well-known figures of the oculist Cohn, who in 1885 gave the value of 10 Meterkerzen as the weakest illumination permissible from a physiological point of view, and 50 Meterkerzen for the illumination by which the eye, without any effort of accommodation, can see as well as by daylight. These results are expressed in terms of the old German "Vereinskerze." If one converts them into Lux they become 12 and 60 Lux respectively. Yet one never sees these figures quoted, but invariably 10 and 50 Lux or Meterkerzen. The fact that the unit of candle-power in Germany has been altered since 1897 is sometimes lost sight of, and now, when figures of the older authors are quoted, one is uncertain whether they are really expressed in Hefner-candles or merely quoted historically.

It is, therefore, time that the word Meterkerze was struck out of the list of photometrical terms and superseded by the word Lux.

The confusion becomes more confounded when we consider the differing phraseology of different nations. The following standards of life are in use:—

In Germany the Hefner Lamp.
In England the Pentane „
In France the Carcel „
In America electrical incandescent lamps, attested by the Bureau of Standards at Washington, are utilized.

The units of light corresponding with the Standards utilized in the different countries are as follows:—

In Germany the Hefner candle.

In England and the United States the candle.

In France the Carcel and the Bougie.

Moreover, the word Lux has not found common use in some countries, which have relied upon compound expressions containing both a variable unit of light and a unit of length, which is also variable. We have, for instance, both the "candle-foot" and the "candle-metre," and both these quantities are used at the present day according to the taste of the author. One can, indeed, find all the following terms in photometrical literature of the present day:—

1. Candle-foot (England and the United States).
2. Candle-metre (American Institute of Electrical Engineers).
3. Carcel-metre (France).
4. Bougie-metre (France).
5. Hefner-foot (United States).
6. Hefner-metre (United States).
7. Lux (Germany, France, and the United States).
8. Meterkerze (Germany, now to be replaced by Lux).

This collection of words corresponds to the growth of the conception of illumination among different nationalities, and it appears possible that when the subject has been more fully taken up elsewhere, the list may be considerably augmented. Just as the poet, in the richness of his vocabulary, speaks first of the sea, then of the "briny ocean," and finally of the "grave of sailors," so the English term candle-foot undergoes several variations, and we find that in the hands of competent authorities this term in the plural becomes both "candle-feet" and "foot-candles."

Clayton Sharp has explained that combined words like candle-foot are essentially incorrect, because they denote the product of two quantities. Now the quantity candle-foot does not mean one "candle multiplied by one foot," not even one candle divided by one foot, but one candle divided by one $(\text{foot})^2$.

Further confusion also occurs when the term candle-power is used, for at the present day there are great varieties of lamps in use, arc lamps with coaxial and inclined carbons, inverted incandescent gas lamps, glow lamps with filaments of various forms, &c., which all possess different characteristic polar curves of distribution of light, these variations being accentuated by the use of various globes or reflectors. Therefore the term mean spherical candle-power no longer tells us all we want to know about a source. Similarly the introduction of tubes of light such as the Mercury lamp and the Moore lamp renders those laws, which are only applicable to "point-sources," no longer strictly correct.

Illumination is an idea which naturally grows up in our minds from the appearance of the surrounding illuminated objects. We know that the intensity of illumination due to strong moonlight is about 0·1 to 0·16 Lux. In the same way we know that 12 Lux enables us to read with comfort and without fatigue, and that even 60 Lux can be used without the eye becoming tired; but when we find these illuminations expressed in terms of different units, when, for instance, 0·1 to 0·16 Lux becomes 0·015 to 0·03 candle-feet, we do not readily recognize them. Yet the physiological impression of intensity of illumination itself is something quite apart from the method by which it is expressed. What we want to do is to form a mental image of this intensity of illumination, and the physiological impression is the same, whether we deal in Lux, candle-feet, or candle-metres. The extreme variations that may occur is illustrated by the following table:—

Results expressed in ...	Factor for conversion into the desired Unit.					
	1 Lux.	2 Hefner-foot.	3 Candle-foot.	4 Candle-metre.	5 Carcel-metre.	6 Bougie-metre.
1. Lux (Hefner-meter)	1	0·0929	0·0848	0·9132	0·093	0·8849
2. Hefner-foot	10·76	1	0·9132	9·84	1·001	9·52
3. Candle-foot	11·78	1·095	1	1·076	1·097	10·43
4. Candle-metre	1·095	0·1016	0·0929	1	0·1018	0·969
5. Carcel-metre	10·75	0·9986	0·9115	9·817	1	9·513
6. Bougie-metre	1·13	0·105	0·0958	1·031	0·1051	1

Hyde has recently pointed out that 1 H.K. is not equal to 0·88 candle power but 0·893.

At the recent International Commission of Zürich, too, Paterson showed that the old British spermaceti candle becomes 5 per cent. less than it used to be, if we expressed our candle-power in terms of the 10 c.p. Pentane standard, and two distinct values for the British candle-power are liable to be introduced by this circumstance. The Hefner-candle expressed in terms of the 10 c.p. Pentane standard has been found to be equal to 0·195. In the same way the Bougie-Decimale is equal to 1·13 H.K.

All this shows how important it is, when denoting all physiological impressions by a number, to be careful of the units in which it is expressed.

Finally as a result of these considerations the author submits the following suggestion:—

(1) That the International Commission on Photometry should insist upon the value of intensity of illumination being expressed in the selected international unit, and that while the different countries are at liberty to use their own units of length and candle-power in their measurements and calculations, the results obtained should be converted into values expressed in terms of the international unit—the Lux—by multiplying by a suitable factor. The word Lux seems best adapted for adoption as an international term specifying intensity of illumination.

(2) That the various German societies interested should decide that the word "meterkerze," regarded according to the system of 1897 as synonymous with Lux, should be removed from the list in favour of the latter term.

Arc Light Carbons for the Production of Actinic Light.

By Dr. Ludwig Marquart. D.R.P. 176,419.

From the *Zeitschrift für Beleuchtungswesen.*

Researches have shown that the photochemical effect of light from the flame arc is strongly accentuated by the presence of certain metallic salts in the carbons. This photochemical effect is quite distinct from the luminous intensity of the source, and is a function of the atomic weight of the added metal. By the addition of small quantities of such salts the actinic power of the ordinary arc light can be materially increased.

The metallic combination recommended consists of a mixture of equal quantities by weight of yttrium nitrate and lead nitrate, the mixture being added to the carbon dust in the proportion of ½ per cent. only. The resulting carbons have excellent qualities for photographic work; the luminous efficiency is not exceptional, but it is said that their action on silver bromide is five times that of ordinary carbons.

The Problem of Colour Photometry.

By J. S. Dow.

(Abstracted from *The Electrical World.*)

Until recently our sources of light resembled each other very closely in colour, because our light was invariably derived from incandescent solid particles, which, however, resembled the theoretical "black body" more or less closely. Under these circumstances, the natural period of the atomic systems of which the incandescent body was composed were not given free play; we therefore obtained a confused jumble of vibrations and a continuous spectrum.

But lately the utilization of "selectively radiating" substances—that is, which exhibit a preference for radiation of a particular wave length not in accordance with the black body law—has entirely altered the aspect of colour problems. By the use of this principle we may hope to be able to control ultimately the spectrum of our illuminants much more completely than at present; we may even succeed in limiting the output of a source of light to radiation of a single frequency, and, therefore, the value of light of certain colours, for particular purposes, is of greater interest than in the past.

In the first place, it must certainly be definitely recognized that, quite apart from the technical difficulties of colour-photometry, no rigorous photometrical system, not even measurements upon the spot with illuminometers, can yield all the information about a source of light that the illuminating engineer will frequently desire to know.

A source of light may be called upon to achieve many different objects, some of them not really connected with the power of creating brightness, *i.e.*, the "illuminating power" of the source. One extreme instance is the chemical and photographic properties of a source of light, but there are many others less remotely connected with the brightness, and yet depending upon certain frequencies of vibration, which may be of but little use from the point of view of illumination.

It does not follow that a source of light which is intended to illuminate a dwelling-room is also a good one to read by, or for the revelation of fine detail. In the first case we chiefly desire to exhibit the æsthetic qualities of the room, and our source of light must therefore be such as to give to delicate shades of colour their true values. In the second case we are chiefly anxious that the fine detail we are illuminating shall appear as "sharp" and clear as possible, and this is not a matter of brightness only.

Yet other cases occur in which the *brightness* is the essential quality, quite apart from the true delineation of colour. In such cases our object should clearly be to produce the efficient yellow light in the spectrum only, and not to waste energy in producing the deep red and violet components which, for a given expenditure of energy, add but little to the total luminosity of the source.

These are only a few of the many existing cases, each of which demands special qualities from the light employed, and therefore special methods of measurement. Photometry, as usually understood, concerns itself with the measurement of the power of creating brightness, on the part of the light tested—certainly its most useful but not its only function. In order to measure the value of light for other purposes we can only devise additional tests, not, however, made upon a strictly photometrical basis.

Let us now turn to the consideration of some of the difficulties which beset photometry proper.

In accordance with what has been said already, it will be admitted that a photometrical method of testing any illuminant, ought, strictly speaking, to be carried out in such a manner as to compare the brightness of two illuminated surfaces. This is accomplished in photometers of the ordinary "equality of brightness" pattern, such as the Lummer-Brodhun, the Joly, and the grease-spot photometer.

Unfortunately, in the case of differently coloured sources of light, the average observer finds it very difficult to decide when the two photometrical surfaces appear equally bright. The author, however, is inclined to think that there is no insuperable difficulty in making such a judgment, that proficiency is chiefly a matter of practice, and that the personal differences of different observers who are not actually colour-blind are not so great as is commonly supposed. Probably many supposed "personal" errors may be traced to the fact that the two observers did not utilize the same portion of the retina during their observations, or otherwise failed to secure exactly the same physiological conditions.

To facilitate such judgments many special systems of photometry have been proposed.

For the moment, however, let us admit the possibility of a practised observer being able to make a fairly accurate judgment of the equality of brightness of two differently coloured surfaces, and consider what this judgment really means.

Such a judgment must invariably be affected by the effect mentioned by Lauriol, and by Dr. Lummer, in his recent letter (*Electrical World*, Sept. 21, 1907), namely, the influence of the portion of the retina on which the image of the illuminated surfaces is received.

It has long been known by physiologists that the central portion of the retina, the "macula lutea" or "yellow spot" as it is termed, is less sensitive to the green end of the spectrum than the surrounding portion. Suppose, therefore, that the image of the surfaces in a photometer illuminated by two sources which differ in colour, is received upon the retina, and we adjust the position of the photometer until the two surfaces appear equally bright.

Now, if we observe these surfaces at a different distance away, or replace them by others of a different size—if, in short, we do anything that causes the image of them to cover a different region of the retina—the photometer may no longer appear in balance.

When dealing with more or less pure colours the effect may be very marked indeed. In a recent paper before the Physical Society of London (*Proc.* Phys. Soc., vol. xx., 1906) the author described some experiments involving the photometric comparison of two glow-lamps screened with red and green glass respectively. The Lummer - Brodhun, Joly, and grease - spot photometers, which had previously been found to give concordant results for lights of the same colour, gave utterly divergent results in this case, while the results obtained from each of the photometers depended upon the distance away of the eye from the photometrical surfaces.

The "yellow-spot" effect, as for shortness we may term it, is well known to those who have studied colour photometry, but its importance from a practical point of view is certainly not sufficiently realized. In the experiment referred to, in which fairly pure colours were used, differences of the order of over 100 per cent. could be easily produced. Even when an Argand gas burner and an incandescent mantle were compared under the same circumstances, differences of more than 5 per cent. were readily obtainable, while the writer has met with differences between 20 and 30 per cent. when comparing a mercury vapour lamp with a carbon-filament lamp.

We must remember, too, that quite apart from the discrepancies in the readings of the various photometers, the sources of light which they compare will certainly be used to illuminate surfaces subtending a much greater angle at the eye than the surfaces in the photometers normally do, and that such photometrical tests may therefore fail to represent the illuminating power of a source in practice.

It may be remarked, however, that these effects are much more noticeable when the illumination of the photometer screen is low. There is, as we shall see later, a reason for this. Meanwhile it may be pointed out that, according to the author's experience, the difficulties of colour photometry are reduced to a minimum by using a moderately high illumination of the photometer screen, of not less than about one candle-foot, and only become really urgent when the illumination is reduced below one candle-meter.

This question of the illumination of the photometer screen naturally leads us to the consideration of another allied colour effect—the Purkinje phenomenon —which has been aptly termed "the nightmare of colour photometry." For some reason the Purkinje effect is much better known than the yellow-spot effect. Yet, although both effects are now believed to have a common physiological basis, the Purkinje effect, in spite of its notoriety, seems to exert but little influence on photometry as ordinarily carried out.

By the Purkinje effect is meant that, with increasing stimulus, the luminous sensation produced by the red end of the spectrum increases more rapidly than in the case of the green end. The effect is now understood to be merely part of a more general physiological change which occurs in the behaviour of the eye at low illuminations, and has been often illustrated by the following simple experiment :—

Suppose we place two similar pieces of green and red paper, and illuminate them with white light. The red will then in general appear the brighter of the two when the illumination is strong. But when the illumination is weakened, the red darkens more rapidly than the green, which soon appears unquestionably the brighter of the two. After this point the colours begin to fade, and eventually the green appears white and the red becomes jet black. If the illumination is weakened still further, the green, too, fades away into darkness. In order to show this experiment well, the coloured surfaces must subtend a great angle at the eye ; while if the angle is very small indeed, the colours fade away together and the Purkinje effect does not take place.

Modern physiological optics endeavours to explain these phenomena by the consideration of the functions assigned to minute light-perceiving organs scattered over the retina and known, from their appearance, as the "rods" and "cones" respectively. According to the modern theory of the action of these organs, which in its most complete form is attributed to the German physiologist von Kries, the perception of colour is associated with the *cones*. These organs are also believed to be most sensitive to yellow light, and, while inactive at very weak illuminations, continue to respond to increased stimulus, once they have started, long after the rods have ceased to do so.

The rods, on the other hand, are supposed to be unable to perceive colour. All light, therefore, seen by means of the rods appears white, but the organs are most powerfully affected by light which is blue-green in character. The rods are also believed to be sensitive to very weak light at which the cones do not act ; but with increasing stimulus they soon become, as it were, saturated, and fail to respond any further.

At ordinary illuminations our vision is mainly carried out through the cone organs, and we see colour. At very weak illuminations, on the other hand, only the rods are in action. We cannot distinguish colours properly, and all objects appear a "ghostly" grey. As the illumination is increased, the cones suddenly begin to act. The colours appear, and a struggle for predominance between the rods and the cones takes place. It is to this struggle that the Purkinje effect must be mainly attributed, though there are possibly other influences at work.

From a photometrical point of view, therefore, it is of interest to know at what order of illumination the struggle between the rods and cones has been decided in favour of cone vision. This question, however, is complicated by the peculiar distribution of the rods and cones over the retina. The extreme central portion of the retina contains practically only cones, and therefore if the image of the illuminated surfaces falls within this nearly rodless region, the Purkinje effect is absent, or at any rate very weak. If, however, the angle subtended at the eye by the illuminated surfaces is great, many rods are in play, and by reason of their numerical superiority, exert an influence comparable with, and even greater than that of the cones. The Purkinje effect is therefore accentuated.

In ordinary photometry the angle subtended at the eye by the illuminated surfaces is usually small, and therefore the Purkinje effect does not become really noticeable except at very low illuminations; indeed, in the case of the author, well below one lux—are reached. In practice, however, things are somewhat different. In street lighting, in particular, where the illumination is frequently very low, and where vast tracts of pavement and roadway have to be illuminated, the Purkinje effect cannot fail to be in evidence. Illuminometer measurements on the spot are therefore preferable to values calculated from the candle-power of sources as determined at ordinary illuminations, with which, indeed, they are frequently in disagreement.

The irregular distribution of the rods and cones over the retina also explains very satisfactorily the "yellow-spot" effect, since the variations in the relative brightness of two heterochromatic surfaces can be ascribed to the variation of the proportions of rods and cones on the portion of the retina on which they fall. Other explanations, however, have been suggested.

The physiological peculiarities of the eye which arise out of the behaviour attributed to the rods and cones seems to be the chief difficulty in the way of accurate heterochromatic photometry. There are many points in dispute about these organs which are only imperfectly understood, and there are also other little understood minor peculiarities of the eye which affect the photometric comparison of sources of light differing noticeably in colour.

We see, however, that there is no escape from these physiological colour effects. Even if we could devise some method of photometrical measurement which was not affected by them, we should still have to face their existence in practice, and the divergencies between the results of photometric tests and practical results would be greater than ever. The most satisfactory plan would perhaps be to fix, arbitrarily, the angle subtended at the eye by the photometrical surfaces, and the order of illumination at which the tests are to be carried out. Tests made on this system would possibly fail to represent the illuminating value of a source in practice, and would therefore have to be applied with caution, but they would at least be consistent among themselves.

Finally, a word or two may be said with regard to the various methods which have been devised to facilitate colour photometry. Evidently no such method can get over the inherent difficulties of the subject, but only postpone them. Many of the methods are open to grave objection on other grounds.

One class of these methods involves the comparison of the integral brightness of the differently coloured sources by utilizing certain portions of the spectrum only, and ignoring the others. In the methods of Macé de Lépinay and Weber the two illuminated surfaces of the photometer were equalized, first when observed through a red and then through a green medium. The photometrical results of the comparison of the red and green components in the spectrum, so obtained, were then introduced into a formula for the comparison of the integral brightness of the two lights which, be it noted, depended on the observation of colour effects by the deviser of the method.

Crova proposed to estimate the relative brightness of two heterochromatic sources by observation of brightness in the yellow region of the spectrum only. Apart from the experimental difficulties in the way of applying this method practically, it has much to recommend it, for, unlike the previous one, it certainly utilizes the most valuable portion of the spectrum from the point of view of illumination.

But all such methods as those of Crova and Macé de Lépinay are open to one objection, which limits their application very seriously. They are obviously only strictly applicable to the comparison of sources yielding a continuous spectrum. In the case of such sources as the mercury lamp, which yields a spectrum composed of isolated bright groups of lines, they break down entirely.

A method which has often been proposed, and which Dr. Lummer in his recent letters seems to approve, is the comparison, not of the power of creating brightness, but the power of revealing detail of a source of light. It has been urged, with a certain amount of justice, that what we chiefly desire from a source of light is this very power of revealing detail. Yet this is not invariably the case, and as the writer has suggested at the commencement of this article, tests undertaken with the object of determining the capabilities in this particular direction, must be regarded as additional, and not as a substitute for photometry proper.

Moreover, while feeling some trepidation in questioning the dictum of such an authority as Dr. Lummer, the author must confess that his own experience does not lead him to suppose that the "sharpness" of detail illuminated by coloured light could ever be made the subject of a reliable method photometry. For, apart from the seemingly inevitable want of sensitiveness of such a method, this "sharpness" seems to depend very greatly on the accommodation of the eye, which is not acromatic. The writer has recently* described some instances of the effect of this want of achromatism. We are virtually very short-sighted for the violet end of the spectrum. Therefore, while violet light is usually somewhat better than white light for the illumination of detail which is viewed at very close range, it is extremely bad for the illumination of objects which are to be viewed from a distance. Red light, on the other hand, is usually best for the illumination of distant objects.

These effects are naturally affected by the optical peculiarities of the eyes of the observer, and are not equally evident to every one. Indeed, the author has even met with some cases of observers who declare themselves unable to see any difference between the sharpness of the red and blue, under the conditions described above, and whose eyes were presumably either exceptionally well achromatized or capable of an exceptional degree of accommodation. But this only emphasizes the difficulty of devising any system of photometrical measurement dependent upon acuteness of vision. In any case results obtained with a photometer in which near vision is utilized would certainly be found inapplicable to the appearance of illuminated detail viewed at a distance of a few meters. When we remember, too, that the addition

* American *Illuminating Engineer*, March, 1907.

of light of an undesirable frequency may, while increasing the *brightness* of illuminated detail, actually render it more difficult to distinguish, the desirability of keeping any such method distinct from ordinary photometry is obvious.

Finally, mention may be made of a type of instrument which has recently attracted some attention, namely the flicker photometer of Rood. From what has been said it will readily be understood that whether the flicker photometer is affected by the usual colour phenomena or not, it cannot be expected to give consistent results with photometers of the equality of brightness pattern, which differ among themselves so greatly when the comparison of sources of light which differ in colour is attempted. As a means of avoiding the natural difficulty of forming a judgment of equality of brightness in the case of lights of different colours, this type of instrument has certain advantages.

On the other hand, while the claim that this instrument is independent of all colour effects, such as the results of colour-blindness, for instance, certainly cannot be substantiated, there is good reason to believe that the influence of the peculiar behaviour of the rods and cones is less evident in instruments of the flicker class. Yet it is very doubtful whether this is to be regarded as an advantage, and whether the instrument is not open to objection on physiological grounds for this very reason. The author has made some experiments on this point, the results of which he hopes to publish shortly. A complete investigation into the theory of the flicker photometer, especially from the point of view of reconciling its behaviour with the theory of the rods and cones, is very much to be desired, and no doubt the research which Dr. Lummer is undertaking on this point will afford very valuable information.

Meanwhile, a more general acquaintance with the physiological peculiarities of the eye as regards the perception of colour is greatly needed. The requisite knowledge, which would enable the illuminating engineer to cope with the difficulties which are inseparable from the use of coloured light, is almost entirely confined to physiologists, and is rarely available in a form which is applicable to actual problems of illumination. Many of the chief experimental results of the past, too, are the work of only a few, and how far they are applicable to the normal eye, and how greatly the eyes of different individuals differ amongst themselves, has never been satisfactorily determined.

We have yet much to learn as to the possible uses of light from different portions of the spectrum, and we have yet to contrive satisfactory and universally recognized methods by which the value of these portions of the spectrum for special purposes can be measured.

Colour Values of Artificial Illuminants.

By G. H. Stickney.

Transactions of the Illuminating Engineering Society (American), May, 1907, p. 282.

Artificial lights differ from daylight more or less in their composition—that is, in the proportion of different colours they contain; for instance, a light may have too much red or the violet waves may not be present in sufficient quantity. On the other hand, certain artificial lights emit an excess of violet, and others are exceedingly rich in yellow or green.

In all cases where the so-called "daylight balance" is not maintained the light is no longer white, but the excess or absence of some particular colour is noticeable not only in the colour effect, but in a general lack of clearness.

It is generally known that the mercury arc does not contain any appreciable amount of red. A piece of material which would reflect red rays under a white light would appear black by total absorption under the mercury light.

Yellow materials displayed in the light of the Nernst or incandescent lamps become pronounced, and slight differences in pale yellow can hardly be distinguished from white, as the latter is capable of re-radiating almost as much yellow light as the former. The same relation exists between green and white exhibited under the Welsbach gas or vapour hydrocarbon lights.

Direct and alternating current enclosed arcs, particularly the latter, emit an excessive amount of violet light when equipped with clear globes, so that blue and violet materials exhibited under this light are stronger than they would be in average daylight. The violet light is emitted by the arc itself, while the white light, which forms 75 to 80 per cent. of the total luminous flux, is emitted directly by the crater.

Before the enclosed arc is suitable for accurate colour selection, the excess violet light must be disposed of. This can be accomplished by using opal enclosing globes, and still further improvement may be made by the use of suitable reflectors coated with enamel, having a high selective absorption for violet waves. We, therefore, have at our disposal means of purifying the arc light to a high degree, so that coloured goods can be displayed with practically daylight effect.

Instruments for Colour Comparison.

In order to bring out prominently the superiority of the arc lamp for colour-matching and selection, three instruments have been devised, namely, the "lumichromoscope," "photochromoscope," and "parachromoscope."

With any of these instruments a prospective buyer may compare the effects of various lights on coloured fabrics, and such apparatus should be of value

The Effect of Coloured Lights on Aniline Dyed Materials.
From Tests by M. Chevreul at the Goblin Tapestry Works.
With Additions by W. D'A. Ryan.

Orange	rays	falling	on	white	make	it	appear	orange.
,,	,,	,,	,,	red	,,	,,	,,	reddish-orange.
,,	,,	,,	,,	orange	,,	,,	,,	deeper orange.
,,	,,	,,	,,	yellow	,,	,,	,,	orange-yellow.
,,	,,	,,	,,	green	,,	,,	,,	dark yellow green.
,,	,,	,,	,,	blue	,,	,,	,,	dark reddish-grey.
,,	,,	,,	,,	violet	,,	,,	,,	dark purplish-grey.
,,	,,	,,	,,	black	,,	,,	,,	brownish-black.
Red	,,	,,	,,	white	,,	,,	,,	red.
,,	,,	,,	,,	red	,,	,,	,,	deeper-red.
,,	,,	,,	,,	orange	,,	,,	,,	orange-red.
,,	,,	,,	,,	yellow	,,	,,	,,	orange.
,,	,,	,,	,,	green	,,	,,	,,	yellowish-grey.
,,	,,	,,	,,	blue	,,	,,	,,	violet.

Red	rays	falling	on	violet	make	it	appear	purple.
,,	,,	,,	,,	black	,,	,,	,,	rusty-black.
Yellow	,,	,,	,,	white	,,	,,	,,	yellow.
,,	,,	,,	,,	red	,,	,,	,,	orange-brown.
,,	,,	,,	,,	orange	,,	,,	,,	orange-yellow.
,,	,,	,,	,,	yellow	,,	,,	,,	deeper-yellow.
,,	,,	,,	,,	green	,,	,,	,,	yellowish-green.
,,	,,	,,	,,	blue	,,	,,	,,	slaty-grey.
,,	,,	,,	,,	violet	,,	,,	,,	purplish-grey.
,,	,,	,,	,,	black	,,	,,	,,	olive-black.
Green	,,	,,	,,	white	,,	,,	,,	green.
,,	,,	,,	,,	red	,,	,,	,,	yellowish-brown.
,,	,,	,,	,,	orange	,,	,,	,,	greyish-leaf-green.
,,	,,	,,	,,	yellow	,,	,,	,,	yellowish-green.
,,	,,	,,	,,	green	,,	,,	,,	deeper-green.
,,	,,	,,	,,	blue	,,	,,	,,	bluish-green.
,,	,,	,,	,,	violet	,,	,,	,,	bluish-grey.
,,	,,	,,	,,	black	,,	,,	,,	dark greenish-grey.
Blue	,,	,,	,,	white	,,	,,	,,	blue.
,,	,,	,,	,,	red	,,	,,	,,	purple.
,,	,,	,,	,,	orange	,,	,,	,,	plum-brown.
,,	,,	,,	,,	yellow	,,	,,	,,	yellowish-grey.
,,	,,	,,	,,	green	,,	,,	,,	bluish-green.
,,	,,	,,	,,	blue	,,	,,	,,	deeper-blue.
,,	,,	,,	,,	violet	,,	,,	,,	deep bluish-violet.
,,	,,	,,	,,	black	,,	,,	,,	bluish-black.
Violet	,,	,,	,,	white	,,	,,	,,	violet.
,,	,,	,,	,,	red	,,	,,	,,	purple.
,,	,,	,,	,,	orange	,,	,,	,,	reddish-grey.
,,	,,	,,	,,	yellow	,,	,,	,,	purplish-grey.
,,	,,	,,	,,	green	,,	,,	,,	bluish-grey.
,,	,,	,,	,,	blue	,,	,,	,,	bluish-violet.
,,	,,	,,	,,	violet	,,	,,	,,	deeper-violet.
,,	,,	,,	,,	black	,,	,,	,,	violet-black.

Predominating Colour of Artificial Lights.

Lamp.	Colour.
Enclosed arc—clear globes	Bluish white.
Enclosed arc—opal globe and selective diffuser	White.
3½ amp. 140 volt d.c. enc. arc.	Violet (beyond colour correction).
Nernst lamp—new glower	Pale lemon-yellow.
Nernst lamp—seasoned glower	Deep lemon-yellow.
Incandescent—new	Yellow.
Incandescent—seasoned	Pale orange-yellow.
Welsbach and vapour hydrocarbon—new . .	Greenish-white.
Welsbach and vapour hydrocarbon—seasoned . .	Greenish-yellow.
Ordinary gas flame	Reddish-yellow.
Mercury arc lamp	Blue-green.

in convincing customers that a white light is indispensable for many classes of mercantile illumination.

The lumichromoscope is probably the most practical instrument for general demonstration purposes. This apparatus is arranged so that four lights, say of the arc, Welsbach, Nernst, and incandescent lamps, fall simultaneously on the material to be examined. Each light forms a patch 2½ inches square with a black border separating each square so as to reduce simultaneous contrast or gradation.

The lamps are arranged at such a distance that the relative intensity of the different lights falling on the material is the same, thus eliminating tint and shade effects, which take place when the intensities are of unequal strength.

The above tabulations give the effect of coloured lights on aniline dyed materials and the predominating colour of artificial lights in common use.

Intrinsic Brilliancy and Distribution.

It is generally admitted that the arc lamp is the most efficient source of artificial illumination, but, unfortunately, high efficiency generally goes hand in hand with high intrinsic brilliancy, and the distribution of the arc, in common with other artificial light sources, is not by any means ideal for general interior illumination.

This objection is partly met by the use of low power lamps, taking about 300 watts. These are especially useful in low studded rooms, or where there are many light intercepting objects in the area to be illuminated.

While the small units provide, possibly, a more uniform distribution, they are, unfortunately, associated with a considerable decrease in efficiency as compared with 500 to 700 watt lamps commonly used, to say nothing of the further disadvantage of a larger number of units to install and maintain.

With the elements of intrinsic brilliancy and distribution once properly disposed of, less weight will be given to the life of carbons, and greater attention will be paid to improving the efficiecny and stability of the arc by raising the current to the highest point consistent with a reasonable globe life.

There appears to be nothing on the horizon at the present time to rival the enclosed arc lamp for interior mercantile lighting, particularly where colour values are important.

While the tantalum and tungsten lamps represent a marked improvement in efficiency for lamps of the incandescent class, the colour has not been sufficiently changed to warrant classifying them as white lights. The magnetite and flaming arcs represent a class of efficient illuminants which, unfortunately, in the present forms, are not particularly adapted to general interior illumination, and therefore need not be considered in this instance.

The most promising immediate improvement in general lighting is through the use of high current enclosed arcs with proper diffusing devices.

DISCUSSION BEFORE THE NEW YORK SECTION.

(Slightly abbreviated.)

The Chairman (L. B. Marks).—I call the attention of those members who may not have seen it to an article in the April number of the *Century Magazine*, by Dr. E. A. Ayers, which gives a very able and interesting illustrated discussion of the subject of the address. It is well worth reading.

Among others we are favoured this evening with the presence of a distinguished representative of the English section of illuminating engineers, Mr. Leon Gaster.

Leon Gaster.—The question of the influence of colour upon sight is one which has received very little attention because the illuminants which vary much in colour have been very few, until quite recently. What the influence of the different coloured light sources, which have been recently introduced will be upon the sight, few have been able as yet to determine, as there has not been a great deal of information published upon the subject. It is believed that the defect of colour blindness transmits itself from generation to generation. Prof. Starling, at the Royal Institution of London, recently lectured on the question of 'Colour & Sight,' and showed the remarkable fact that colour blindness is mostly transmitted to the male descendants. If a man is colour blind and he has a son, the son will also be colour blind; but if he has a daughter, she will not be colour blind; yet if the daughter marries, her male descendants may be colour blind, although she may not be.

D. McFarlan Moore.—The three most important facts in connexion with any illuminant are efficiency, colour, and steadiness. A few years ago there was practically no way of changing the colours of the various forms of lamps—that is, the candle had its colour perforce: such a thing as modifying it was not dreamed of. The oil lamp had its colour; the open burner gas-flame its colour; the incandescent lamp its colour; and the arc lamp its colour. Then gradually attempts were made to increase the flexibility of our systems of illumination so far as colour was concerned, and, as we all know, the successful experiments in connexion with the Welsbach lamp form probably the most prominent example. At the present time there are only two ways widely in use of varying the colour: that is, if a person wishes to have a light of a different colour, there are two main ways of getting it. One way is to get another light source, and the other way is to use a diffusion globe of some kind which, in any instance, is extremely unscientific and inefficient. Some of the most recent advances in this line are connected with the flaming arc lamp. There we have an instance where the first step, at least, was taken toward scientifically controlling the colour value. I refer to placing different chemicals in the carbon and thereby obtaining a colour which can, to a very great extent, be determined previously. But still it by no means can be said that by means of the flaming arc lamp the colour factor is under perfect control. However, it is possible now to have the colour value under perfect control, and this is obtained by utilizing a vacuum tube, and by changing the various gases used in the tube to change the colour. This has many advantages, and from a scientific standpoint it cannot be criticized as can the other methods which have been used. For example, if you use a properly regulated vacuum tube and feed it with air only, a pink light results; if you feed it with nitrogen a yellow light results, and such a light can be used for a great many purposes; in fact, its range of usefulness so far as the colour is concerned, is about the same as that of the ordinary incandescent lamp, and therefore can be used by florists or by clothing merchants, and the distortion is not any worse than that of the ordinary incandescent lamp. However, it is not by any means claimed that when a tube is fed nitrogen, that the colour is at all near daylight; it is simply a colour which appears about the same as that produced by the ordinary incandescent lamp. Due to the enormous radiating surfaces of the tube, the colour in daytime looks considerably redder than that of the incandescent lamp, because the lamp is extremely small as compared with the tube. When such a tube is fed with carbon dioxide at a definite pressure, and at a definite intensity, a light is obtained that undoubtedly is closer to average daylight colour values than any light which has ever been produced before, and we can almost say that it is entirely satisfactory. For instance, experts in matching colours in the largest dye works of this country, men who have tried all other forms of light and found them not at all suitable for their uses, have matched their colours under a vacuum tube supplied with carbon dioxide, and have found after months of practical use that they could not detect any difference between the most delicate lavender shades, when they are matched at night-time under the tube and in daytime by daylight, not direct sunlight.

Such a tube ought to be used as a standard of light. We are here to-night in an endeavour to reduce to an exact science the subject of artificial illumination, one branch of which has to do with colour values. The first step in reducing to a scientific basis any subject is to eliminate variables and decide on constants. This society should unite with other scientific societies, and decide on standard specifications for accurately reproducing the pure white light due to carbon dioxide in a vacuum tube. Then we could express other forms of light in terms of it. For example, if it was claimed that a certain light had a pink colour, it would mean that it was pink as compared with a standard carbon dioxide light. The next thought is that the standard of light, as regards colour values, ought to be the final form of light to use as the standard for photometric measurements, which are now influenced by the kind and quality of the light used as the standard.

The efficiency of any light source is largely dependent on its colour. This is due to the fact that the yellow rays have a maximum effect upon our eyes, and therefore a light which predominates in yellow or green has a better efficiency than one with a larger number of prominent colours.

Measurements of illumination are extremely complicated and will always remain complicated since they depend on the eye. The sphere of activity for illuminating engineers, as this matter of colour values becomes more and more refined, will become larger and larger. It is not a subject that will ever be reduced to simple mathematical terms. We can determine with great exactness the efficiency of a motor, but if we take the same amount of electrical energy and endeavour to determine the efficiency of the transformation when it is turned into useful illumination, immediately not only does the problem become complicated, but the objects illuminated also become of prime importance.

The history of colours of light as depicted by the various forms of light is extremely interesting, and the main point to be noticed is that as time has advanced the various forms of light have become whiter. The flaming torches of the Romans were extremely red. Then came the candle, the oil lamp, the gas flame, the incandescent lamp, and the arc lamp. We all remember how the arc lamp was considered a ghostly white light, and there was a great deal of objection to it on that score. But artificial illumination has progressed, until we have come to the vacuum tube, which, when supplied with carbon dioxide, was criticized as being a bluish-white by those who did not realize that daylight is a bluish-white. Some of the best experts on illumination have declared, even in recent years, that a white light at night-time was unnatural. Such statements are dying out, and we will gradually hear less and less of them, until artificial daylight all night will be the universal demand.

G. L. Hunter.—The efficiency of the different colours of lights in illumination varies greatly with the colour of the walls. When the incandescent bulb is used, a slight tint of orange on the walls renders the room more cheerful and brighter. A room with a light green paper is distinctly better lighted by the Welsbach lamp than a room with paper slightly orange. In practical illumination the colour of the light, as compared with the colour of the wall, must be taken into consideration; the colour of the wall is of the greatest importance. You may have all the efficiency in the light that is possible, but unless you carefully consider the various furnishings you do not get the effect that is desired. For instance, in a room where the upholsterings are of green and the walls of orange, the use of an orange light may actually reverse the contrast effects obtained with a green light. The orange light makes the furniture stand out, while the walls recede; with the green light the walls come toward you, and the furniture becomes less prominent.

Dr. H. H. Seabrook.—Mr. Stickney did not make entirely clear the question of the spectral colours in vision and pigment colours as applied to decoration. Most eyes see six primary colours; some of us are favoured by seeing seven. From the three fundamental pigment colours, red, green, and violet, all other colours may be formed by mixing. Colour blindness, absolute colour blindness, a pathological condition, cannot be helped. There is really no need of trying to educate people to see correctly who have real colour blindness. There is a lack of knowledge of colour affecting about five times as many men as women, and that is a condition which can be cured by education. With mixed colours, spectral colours and pigments follow a different law. The pigments, yellow and blue, will make green when mixed, because the yellow and blue neutralize, making grey, leaving the green to show; whereas in the spectrum yellow and blue, when mixed, are complementary colours, and form grey. Upon this the whole mathematical doctrine of the neutralization of colours by artificial light rests.

The question which Mr. Stickney brought out is not entirely that of matching colours in one special light; the point which might interest some more is the change of colours in different lights: how to know what the colour would be in daylight or some artificial light. Meyer in 1879 gave a colour analysis of the three light sources—kerosene, gas, and electric light; the constant was taken as 1 for yellow, expressing equal luminosity (these three lights are warm, with an excess of red); electric 2, kerosene 3, gas 4. For green these lights show respectively ·1, ·6, ·4; for blue ·8, ·2, ·2; for violet ·1, ·1, ·1. If you will remember that complementary colours are neutralized by an excess of a given colour in artificial light and corresponding colours intensified, you have what might be called the law of colours by artificial light. This law has been worked into exact mathematical formula by Dr. Franz Becker in an article entitled 'Untersuchungen über den Farbensinn bei künstlicher Beleuchtung,' to be found in No. 3 of Vol. LIX. of the *Archiv für Ophthalmologie.*

There is, however, a more important question than colour vision in choosing artificial light. In 1845 Brucke began the study of the effects of ultra-violet rays upon the eye, and injuries caused by these rays to the eye have been studied very thoroughly in certain quarters ever since by eminent experimenters. Briefly stated, all of them have shown that the anterior structures of the eyes are inflamed by ultra-violet rays, and that the human lens is injured by them, causing cataract, but that the lens absorbs these rays to a variable extent, thus protecting more or less the posterior structures of the eyes. As might have been expected, it has been shown that the blue and violet spectral light rays cause damage less in degree to the ultra-violet rays. Perhaps the most curious demonstration is that made by Dr. A. Birch-Hirschfeld. Eyes which retain the lens and the retina and are sensitive to ultra-violet rays are also sensitive to infra-red rays, but eyes without the lens are sensitive to ultra-violet rays only.

In 1887 Dr. Van Generen Short, in his experiments upon animals, found that the chemical rays of light which were not absorbed by the lens of the eye produced disassimilation of the retinal pigment. He found that the disassimilation and cell wandering was at a minimum in yellow light, which is, of course, the light which contains the luminous rays in the greatest quantity. Following these experiments, Fieuzel suggested that protective glasses for the eyes should be of a grey yellow colour. Snow blindness and injuries from the electric light are both due to the chemical rays of light, including the ultra-violet rays. Snow blindness occurs only in the rarified atmosphere, because, as Tyndall showed long ago, the chemical light and ultra-violet rays are absorbed by the dust of the atmosphere. This gives a yellow tone to the light. Mr. Moore remarked that we do not have such a thing as constant daylight, and he picked out as a standard light, light on a cloudy day. Von Helmholz said that the best standard light was that found just inside a closed window, where the sun did not shine, on a bright day.

T. J. Litle, Jr.—In the demonstration made by Mr. Stickney, unfortunately the best mantles were not used, but instead those giving what is known as a greenish-white light. In order for the Welsbach mantle to give a mellower light, the cerium content has been increased. We find that by so doing we increase the number of red rays and neutralize some of the green rays. I performed a very simple experiment in the laboratory recently by placing a bright red cone reflector above one of these green-white mantles, thereby increasing the red rays in the light thrown below the lamp, and differently coloured calicoes placed below the lamp immediately assumed their true tints, they having been first examined under daylight. The same material was then viewed beneath the light from a standard high grade Welsbach mantle, and the same result obtained as with the red reflector, showing that the green-white mantle could be improved in two ways: first, mechanically by the use of a red reflector, and second, chemically by increasing the cerium content. I believe the time is soon coming when all artificial light will be toned down to a soft colour.

G. H. Stickney.—From the general trend of the discussion I think, perhaps, that I have given the impression that I considered the arc lamp sort of a panacea for all lighting ills. I did not mean to do so. There are certain places where the enclosed arc light is unquestionably the most desirable illuminant available. In the lighting of large areas where good general illumination is desired, and especially where colour values are important, as in department stores, we have been able to obtain the best results by using the enclosed arc lamp, modifying the light distribution to suit conditions.

There are certain places, such as restaurants, residences, &c., where it does not seem desirable to illuminate with white light, yellow tinted light being preferable. In such cases, and where areas are small and ceilings low, it would be a mistake to install arc lamps.

On Luminous Efficiency and the Mechanical Equivalent of Light.

BY DR. C. V. DRYSDALE, D.SC.

(From *Proceedings* Royal Society, A Vol. 80, 1907.)

IN this paper the author describes some experiments carried out by Mr. A. C. Jolley and himself on the mechanical equivalent of light and luminous efficiency.

By "luminous efficiency," or, as Nicholls terms it, "total efficiency," is meant the percentage of the total energy of a source which appears in a visible form, *i.e.*, between the limits of 0·39 μ and 0·76 μ, in the spectrum.

"Radiant efficiency" is defined in a similar manner, except that in this case no account is taken of conduction and convection losses.

Luminous efficiency is a function of the wave-length of the light referred to, and, according to Dr. Guilleaume, is greatest in the case of light of wave-length 0·54 μ.

By the "mechanical equivalent of light"—as the author contends, a most important quantity from the point of view of light-production—we understand the power which must be radiated by a source of light in any direction in order that the intensity in that direction may be one candle-power.

The mechanical equivalent of light therefore enables us to estimate the actual energy needed to produce a given output of light, on the assumption that none is wasted in producing non-luminous radiation.

The author then proceeds to describe the actual apparatus and method of measurement employed, which involved the production of the spectrum of the source of light under investigation, and measurements of the luminosity and energy of the same.

Observations were carried out on approximately white light, and also on light on the yellow-green portion of the spectrum, where the greatest luminous efficiency was found by Dr. Guilleaume to occur.

The results of the author and those of some previous observers are grouped together in the following table :—

MECHANICAL EQUIVALENT OF LIGHT.—COLLECTED VALUES.

Observer.	Date.	Method	Source.	Unit.	Mechanical equivalent.			
					Calories per second.		Watts.	
					Per Hefner.	Per C.P.	Per Hefner.	Per C.P.
J. Thomsen...	1863	A.	Sperm candle	Sperm candle, 8·2 grammes per hour	0·065	0·0733	0 276	0 3075
	,,	,,	Moderator lamp...		0·0585	0 065	0·245	0·272
	,,	,,			0 0615	0·0683	0 257	0·286
	,,	,,	Gas flame........		0·063	0·070	0·264	0·293
	,,	,,			0·0553	0 0615	0 232	0·258
O. Tumlirz and Krug	1888	A.	Incandescent platinum wire	Hefner	0·041	0·0455	0·1715	0·19
O. Tumlirz...	1889	A.	Hefner lamp.........	Hefner	0·0455	0 0505	0·191	0·212
K. Ångström	1903	C.	Hefner lamp..........	Hefner	0·0259	0·0288	0·1085	0·121
Writer and A.C. Jolley	1907	C.	Nernst filament ...	Candle	0·0256	0 0284	0·107	0·119
	,,	,,	Arc	,, ...	0·0173	0·0192	0·0725	0·0805
	,,	,,	Monochromatic, yellow-green......	,, ...	0·01285	0 0143	0 0538	0·0598

Method A.—Thermopile and absorptive screens.
Method C.—Direct measurement of energy in spectrum.
In this table the Hefner has been taken as 0·90 C.P. See Paterson, 'Proc. Inst. E. E.,' vol. xxxviii. p. 286 and Fleming, p. 311.

Some Notes on Arc Lighting.

By William Krause.

(Paper read before the Junior Institution of Engineers, Dec. 10, 1907.)

The author specifies the year 1896 as marking the beginnings of progress in the arc lamp. The state of arc-lighting in that year is illustrated by a list in *The Electrical Review*, showing that of 123 stations in the United Kingdom, 73 reported a number of 2,260 arcs in use. The author, however, states that the total number probably approached nearer 3,000.

Although many "multiple-carbon" types of lamp have been designed, the industrial development of this idea has not been carried beyond the twin-carbon lamp. The longest burning on a single trim of a twin or double-carbon lamp using 12 amperes, and using 20 and 30 mm. carbons 12 inches long, is about 32 to 34 hours. By reducing the current to 10 amperes this can be increased to 40 hours, but, of course, only by a corresponding reduction in the light.

The development of the open arc is illustrated by the recent increase in the number of such lamps in use for public lighting. By the year 1903 291 out of 322 stations used lamps of this description, aggregating a total of 17,209, of which London alone contributed 5,138. By 1907 this number had reached 23,134, but, the author adds, the last two years have seen a diminution, the maximum being reached in 1906. The numbers quoted, he also points out, are not exact in that a few enclosed arcs were included among them.

The enclosed arc was also in use in 1896, but its advantage of long burning was very seriously discounted by the unpleasant violet colour of the light yielded by the lamp. Eventually, however, a compromise was effected by admitting more air to the arc. This resulted in a whiter light, but somewhat reduced the burning-hours. Another important improvement consisted in the doing away of the outer opalescent globe with the inevitable loss of light occasioned thereby, and making the inner globe also the diffusing one.

The idea of employing a volatile metallic salt in the core of the carbon in an arc lamp dates back as early as 1896, though the methods then proposed did not lead to any very marked result owing to several important essentials in flame-carbon manufacture being overlooked.

In such carbons it is of vital importance that the arc should remain centred in the core.

The rate of combustion of carbons is greatly influenced by the "economizer," or half-open chamber within which combustion takes place. In order to secure steady burning it is necessary to make the carbons of small diameter, with the result that both the rapidity of consumption and resistance of the carbons is increased. It has therefore been found necessary either to coat the carbons with metal or to introduce a metallic wire into the carbon; the latter appears to have given the best results. Another difficulty which the flame arc has to contend with is the deposition of a fluffy metallic oxides on the interior of the globe, &c., and as these fumes cannot well be avoided altogether, attempts are now being made to render the apparatus self-cleaning.

The author quotes the following figures of Prof. Elihu Thompson for the inefficiencies of the various types of arc lamp:—

	Watts per C.P.
Open type	0·70
Alternating open type with reflector	0·80
Single enclosed arc	1·50
Alternating open type without reflector	1·12
Enclosed alternating	2·0
Flame	0·15 to 0·30

One feature of arc-lighting in the streets on which the author comments is the tendency of the public to judge the illuminating efficiency of a source by the intrinsic brightness of the source itself. Thus while the introduction of intense arcs enables us to place them high up out of the line of vision, the man in the street is apt to think he is not getting his money's worth. In one instance lamps were actually lowered in deference to public opinion so as to produce the desired effect.

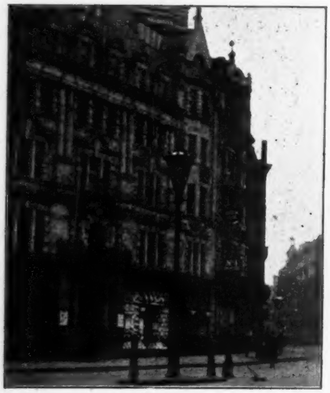


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 1, Brush Open Type.

Fig. 2, Oliver & Gilbert.

Fig. 3, Angold Flame.

Fig. 4, Gilbert Flame.

Fig. 5, Angold Open Type

Fig. 6, Excello Flame.

Fig. 7, Oliver & Gilbert.

Fig. 5.

Fig. 6.

Fig. 7.

Methods of Suspending Arc Lamps in the Streets of England.

CORRESPONDENCE.

The Moore Light.

January 20, 1908.

DEAR SIR,—I have read with interest Dr. Fleming's article in your last number, and there are two points in connexion with it that seem to me of interest.

Firstly, I should like to inquire whether Dr. Fleming has examined the spectrum of the light at the Savoy Hotel or the Moore carbon dioxide tube. Mr. Moore has stated that the latter approaches daylight very closely in spectrum composition, and has even recommended its use as a standard of white light on this account.

Yet I have always understood that luminescent rarefied gases yield discontinuous spectrum, which only becomes continuous when the gas in the tube is subjected to pressure so as to bring the atoms closer together and produce forced vibrations. If this is so in the case of the carbon di-oxide tube, I do not understand how colours illuminated by it can appear the same as daylight. If on the other hand the carbon dioxide tube gives a continuous spectrum, there must seemingly be something peculiar about the nature of the Moore discharge different from the discharge in the ordinary exhausted tube, to account for this fact.

The second point I wish to refer to is Dr. Fleming's statement that the inverse square law does not apply to the Moore tube. Naturally, as Dr. Fleming says, the calculation on page 25 cannot give correct information as to the illuminating power and the sources in practice. For this calculation assumes that all the light is concentrated at one point, and that therefore all portions of the light-giving surface are equidistant from the illuminated one. Whereas, it is in reality spread over a tube 176 feet long.

I imagine, however, that it is only the extensive area of the light-giving surface which renders the inverse square law inapplicable. Presumably there is not (as I have seen suggested) anything peculiar about the manner in which the rays of light are emitted from the tube, and the inverse square law would apply all right if a sufficiently small area of the tube was used.

I am, yours truly,

I. WANTERNO.

TRADE NOTES.

TANTALUM LAMP.—Messrs. Siemens Bros. inform us that they are now introducing a 16 c.p. Tantalum lamp, suitable for 100 to 120 volts, which is not more fragile than other types of Tantalum lamps, and will burn in any position.

WESTMINSTER ELECTRIC TESTING LABORATORY REPORT.—The Westminster Electrical Testing Laboratory are issuing a printed report of life tests carried out on a dozen different makes of glow lamps. The price of the report is 2*l.* 2*s.*, additional copies being procurable at a cost of 1*l.* 1*s.*

'ELECTRICIAN' 'ELECTRICAL TRADES DIRECTORY.'—We are requested to state that the 1908 edition of the above directory is now in course of completion, and that particulars intended for inclusion in the same should be forwarded at once to the publishing office.

REVIEWS OF BOOKS.

PRAKTISCHE PHOTOMETRIE.

By Dr. E. Liebenthal.

(Published by Friedrich Vieweg & Son, Brunswick.)

In the preface of this work Dr. Liebenthal remarks that the recent progress in the subject of photometry has been so rapid that the earlier works of Krüss, Palaz, and Stine, which answered their purpose at the time of publication, no longer suffice.

He has therefore endeavoured to undertake a more exhaustive treatment of the subject, for which Dr. Liebenthal's long experience at the Reichsanstalt eminently fits him. The completeness of this book will be gathered from the fact that it covers nearly 450 pages.

In the first three chapters the fundamental ideas of illumination are dealt with, coupled with a brief discussion of the physiology of the eye as it affects photometry, and a résumé of recent work on the subject of radiation. In the third chapter, for instance, there is a brief discussion of the most modern theories of colour-vision. The work of Lummer and Pringsheim on the radiation of the black body also receives treatment, and the distinction between luminescence and temperature-radiation is duly brought out.

The author next enters into the discussion of the chief photometric standards, his own well-known work on the Hefner and pentane standards finding due expression. The relations between the various standards of light are expressed in tabular form, and the definitions of the chief photometrical quantities are briefly explained.

The fifth chapter is given up to the subject of colour photometry, and includes a discussion of the various photometers which have been devised in order to meet the difficulties of the subject. This is brought up to date by the inclusion of a description of the chief types of flicker-photometers. A valuable addition to the treatment of this subject is an up-to-date chapter on spectro-photometry.

The eighth, ninth, tenth, and eleventh chapters deal very fully with the practical aspects of photometry, and are of special interest. The author discusses the measurement of mean spherical and mean horizontal candle-power, the so-called integrating photometers, and the efficiency and distribution and light from various sources, the subject matter being illustrated by many clear and adequate diagrams.

The remaining chapter contains a summary of directions covering various aspects of photometric testing in different countries,

On the whole Dr. Liebenthal has succeeded in producing what is probably the most exhaustive textbook on the subject of photometry as yet in existence, and the book should prove of great value to the student of this subject.

PRACTICAL ILLUMINATION.

By James Raley Cravath and Van Rensselaer Lansingh.

(The McGraw Publishing Co., New York.)

In this book, in which a series of articles recently appearing in *The Electrical World* are collected together, the authors deal in a simple and attractive manner with the practical application of light to the illumination of various kinds of buildings, including theatres, churches, shops, factories, &c. The book should be found of great value by those concerned with the practical aspect of illumination, as it treats the subject from a thoroughly practical and commonsense point of view, and is written in a lucid and interesting manner. One feature which deserves special commendation is a number of excellent diagrams and photographs by which the subject matter is illustrated.

Special attention is paid by the authors to the question of the use and value of concentrating or diffusing globes and reflectors in order to produce any desired effect. The numerous curves showing the relative values of the different kinds of globes and reflectors now commonly in use will be found very instructive.

We would have liked the book to have contained more numerical details giving the exact degree of illumination which must be provided for different purposes. This, however, will doubtless be remedied as the practical side of illumination reaches a more advanced stage. This book should not fail to attract the attention which it deserves from those in this country who are studying the problems dealt with therein.

Review of the Technical Press.

ILLUMINATION.

THE recent paper by Dr. Louis Bell, before the American Academy of Arts and Sciences has been reproduced in the English technical papers. The ground covered by Dr. Bell's admirable paper is too great to be referred to in any detail here. The author deals with the values of "Fechner's Constant" at different Intensities of Illumination. He also discusses the connexion between the area of the pupil orifice and the intensity of the light striking the eye, and shows how violent contrasts of light and shade tire the eye, by causing successive adaptations to the two conditions.

He next turns to some complex questions of colour, and the question of acuteness of vision, pointing out how the want of achromatism of the eye enters into these problems. In this connexion he makes the interesting suggestion that the difficulty experienced in reading a book illuminated simultaneously by artificial and twilight illumination may be explained by the different accommodation of the eye to the two colours.

Dr. Monasch (*Jour. für Gas*, &c., Dec. 21, 1907) discussed the various methods of denoting units of intensity of illumination, and advocates the general adoption of the unit "lux," which is already very extensively used on the Continent. He also points out that the name of a unit ought not to be an attempt at definition such as is presented by combined expressions, such as "candle-foot" or "candle-metre," which inevitably lead to the multiplication of units and much confusion.

Several articles and papers have also appeared, in which the connexion of the principles of Architecture with Illuminating Engineering are discussed. In this connexion a recent paper before the Illuminating Society by Mr. Basset Jones has been much commented upon. Naturally both sides of the question must be considered, if we are to secure records of light which are tasteful and yet efficient. At present, however, it would seem that both sides have yet to learn to appreciate the other's point of view.

Some recent correspondence has taken place on the question of the correct method of specifying the desirable order of illumination for street-lighting, and in particular on the point whether this illumination should be measured exclusively in a horizontal plane or no.

Some object to this method, on the ground that we are very much concerned with the illumination of objects in a vertical plane. For instance, we may wish to be able to recognize a person walking down the street. Clearly the light falling upon his face would be ignored by measurements of horizontal illuminations only.

On the other hand, measurements other than those in the horizontal plane are subject to the drawback that the photometrical surface may frequently be illuminated by only a few of the sources which furnish general illumination. This view is taken by Mr. Roger T. Smith, who advocates horizontal measurements at a distance of 4 ft. above the ground.

Attention has also been drawn to a recent report by Dr. Kerr, Medical Officer to the L.C.C., who discusses the illumination of schoolrooms. The importance of this question cannot be gainsaid, and the simple rules of illumination on which Dr. Kerr insists deserve general recognition. Briefly, Dr. Kerr advocates even and adequate illumination over the schoolroom of not less than 1 candle-foot, the placing of sources of light so as to be outside the direct line of sight, and the separate treatment of the teachers' and scholars' portions of the schoolrooms. It is essential not only to secure satisfactory reading illumination for the children, but also to make special provision for the teachers' needs, and the illumination of blackboards, diagrams, &c.

C. A. Baker (*Electrical Review*, Jan. 17, 1908) criticizes the illumination of Westminster Abbey, which he regards as not only unsuited to the needs of the congregation, but also not coming up to the æsthetic standard which the illumination of such a building demands.

PHOTOMETRY.

The *Elektrotechnische Zeitschrift* for January 2 contains an interesting description of the photometrical laboratory of an arc lamp factory at Leipsic. The laboratories are very completely equipped for the measurement of high candle-power, and the taking of polar curves of distribution of light, and the illustrations show the use of the Ulbricht globe for obtaining values of the M.S.C.P. of arc lamps, &c. The globe shown in the illustration is no less than 3 metres in diameter, and it is a little surprising that such globes, which seem to be now regarded as thoroughly practical and serviceable bits of apparatus in Germany, have not found their way into any but very casual use over here.

Krüss (*Jour. für Gas*, &c., Dec. 28, 1907) describes some experiments, the main object of which was to obtain the distribution of light from the Hefner lamp and the relation between its horizontal and mean spherical candle-power. The distribution of light from such a source as the incandescent mantle can be calculated theoretically with very fair exactitude, but that of flames, owing to their transparent nature, cannot. Krüss finds that the candle-power of the Hefner flame, for example, falls off less rapidly on either side of the maximum value than theoretical calculation would suggest. He gives the M.S.C.P. as 0·89, the mean upper hemispherical candle-power as 0·94, and the mean lower hemispherical candle-power as 0·83.

Voege (*E.T.Z.*, Jan. 16, 1908), explains his method of applying the thermopile to the measurement of the distribution of light from a source. He points out that the obtaining of polar curves in the usual way is very laborious, and in the case of a fluctuating source, such as the arc light, not very accurate either. He states further that a sensitive thermopile, in spite of the fact that it measures energy and not light, may be used for the determination of the polar curves of such sources as the glow lamp, each portion of the filament of which radiates energy of the same character, and shows some curves of the tantalum and other lamps thus obtained. The application of the method to such sources as arc lamps is less evident, because in this case part of the light comes from the carbons, and part from the incandescent vapour, and it is uncertain whether the radiation from both would be of the same nature.

The author, however, claims to have minimized this difficulty by causing the light falling upon the thermopile to first pass through a thickness of clear glass and also a layer of green glass, which very largely absorbs the heat rays. He also arranges a reflecting galvanometer to throw a beam upon a suitable photographic screen, so that a record can be obtained of the variation of a source of light.

Tufts (*Physical Review*, Dec., 1907), investigates the curve of spectral luminosity of various observers, some colour-blind and others normal. He finds that the colour-blindness *may* influence the sensation of luminosity of an observer, but not necessarily so. In some cases a colour-blind observer would, therefore, obtain peculiar photometrical readings, but in others not. He also investigates the effect of prolonged exposure to light of one particular colour, and, contrary to the results of other observers, finds that the spectral curve of luminosity is not much affected thereby, except in the case of red light. Finally, he considers that his experiments, on the whole, support the contention that a distinct sense of *light* exists as distinguished from colour.

The Electrician for Jan. 24 contains a description of a form of universal photometer due to C. H. Sharp and P. S. Millar. The instrument may be used either for the measurement of candle-power or illumination. It depends upon the inverse square law, but the range of the instrument is increased by the use of either of two absorption screens, absorbing 90 per cent. and 99 per cent. of the light striking them respectively. In this way a range of 0·004 to 2,000 foot-candle can be measured. It is also claimed that the instrument is specially suitable for rapidly executed measurements, and in proof of this, a series of readings of the candle-power of an arc lamp during the space of ten minutes are given.

The Gas World and *The Journal of Gaslighting* contain further abstracts of the report of the American Gas Institute previously mentioned.

In the most recent bulletins of the Société Internationale des Electriciens,

M. Laporte gives a résumé of the decisions of the International Commission of Photometry, and also particulars of the exact recognized dimensions of the standard Carcel lamp.

Electric Lighting.

Loring (*Electrical World*, Jan. 4, 1908) discusses the metallic filament lamps, drawing special attention to the fact that their alteration in candle-power for a given alteration in P.D. is less than in the case of lamps of the carbon variety. This at first seems inconsistent with the view expressed by those (Prof. Niethammer, for example) who have shown that the metallic lamps are particularly susceptible to small variations of voltage. In reality there seem to be two separate points to be considered. It is true that a certain definite and permanent change in pressure alters the candle-power of a metallic filament less than the carbon one. On the other hand, it must be remembered that the low specific heat of the metallic filament renders it more liable to lose its temperature and so alter in candle-power, owing to very rapid temporary changes in voltage, and on this account may be found to " flicker " more on an unsteady supply than the carbon lamp.

A technical discussion of the chemical and physical aspects of the process of graphitizing filaments is to be found in the *Zeitschrift für Beleuchtungswesen* for Jan. 10. It would appear that the chief point to be gained by special treatments of the carbon filament is the rendering the pores in the material as small as possible. By so doing the influence of the escaping gases from the filament and their presumable deteriorating effect are reduced to a minimum.

Böhm has also compiled an exhaustive and useful résumé of recent patents on the subject of the metallic filament lamps.

Several articles on the subject of arc lighting have recently appeared.

Krause and Dyott deal with arc lighting in general and the magnetite arc respectively. *The Illuminating Engineer* for December contains an interesting description of the application of an ingenious form of inverted arc light to the colour-printing room of the Curtis Publishing Co. The light from the arc itself is thrown up on to a concentric diffusing reflector, forming part of the lamp. In addition to the merit of being easily cleaned, the reflecting surface above the lamp can be tinted any desired shade, and in this case special efforts have been made to secure just such a tint as to produce reflected light exactly resembling daylight in colour. It is said that this method is so successful, that colours can be matched by the light with the same certainty as by daylight.

Gaslighting, &c.

Mr. F. W. Goodenough, in a recent lecture on shoplighting, drew attention to the merits of gas for this purpose, and incidentally emphasized several simple but vital points in shoplighting. He gave some simple rules for general lighting, on the basis of so many candle-power per cubic foot of contents of shop, and per foot run of shop frontage, and impressed upon his hearers the necessity for attending to the maintenance of burners, &c., and allowing them plenty of pressure, and mentioned some cases in which gas had been installed with very satisfactory economical results.

Mr. H. Butterfield (*Journal of Gaslighting*, Jan. 17) described an installation which had been converted from low to high pressure on the Keith system.

Wedler (*Jour. für Gas*, &c., Dec. 28, 1907) gives some details of the application of incandescent mantles to train lighting. The great difficulty in the way of the general application of incandescent mantles to this purpose has hitherto been the fragility of the mantles, but now that their strength has been very much improved, they are finding more application. Inverted burners are specially suited for carriage illumination in one respect, namely, owing to the fact that no shadow is thrown by them, as is the case with the upright type. On the other hand, they have a tendency to break and fall from their holders in time, and when this happens the passenger may be left without any light. To guard against this contingency, an Austrian company provide a cock which in an emergency can be turned on, so as to provide a second light. On one of the French railways a mantle only lasts 17 days, but it must be added that these mantles are in use for 18 hours each day. On the Prussian lines a mantle usually lasts 50 to 60 days.

Acetylene for January contains some interesting notes on the value of acetylene for lighthouses, buoys, &c. In this connexion the report of Capt. Ross of the United States navy is quoted. Acetylene for buoys, &c., claims the advantages that more light can be obtained than from the same volume of gas, that the apparatus is more portable, especially owing to the fact that relatively little pressure is needed, and that when over 10 atmospheres pressure is used for the compression of gas the heavier hydrocarbons begin to condense as oil, and the richness of the gas from an illuminating point of view is diminished thereby. Some attention is also given to the use of acetylene, chiefly in France, with incandescent mantles. A difficulty which some appear to find at present is that the adjustment of the burners, which have to be specially constructed, is rather too delicate for the average householder to handle.

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Dyott, G. M. The Characteristics of the Magnetic Arc (*Elec. World*, N.Y., Dec. 7, 1907.
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Butterfield, H. High Pressure Gas Lighting (*Journal of Gaslighting*, Jan. 17, 1908).
Dettman, G. Die angebliche Gefahrlichkeit des Leuchtgases in Lichte statischen. Thatsachen (*Jour. für Gas*, &c., Dec. 7, 1907).
Goodenough, F. W. Shoplighting by Gas (*Jour. of Gaslighting*, Jan. 17, 1908).
Kern. Distance Lighting (from the *Jour. für Gas*, &c.. abstracted in the *Gas World*, Dec. 21, 1907).
Little, T. J. Show-window Lighting by Gas (*Am. Ill. Engineer*, Jan., 1908).
Wedler. Invert Gasglühlicht zur Eisenbahnwagenbeleuchtung (*Jour. für Gas*, &c., Dec. 28, 1907).
Whitaker. Inverted Gas Lighting (*Trans.* Ill. Engineer Soc., Dec., 1907).
The Use of Acetylene for Lighthouses and Buoys (*Acetylene*, Jan., 1908).
Uber Versuchen an den Lübecken Gasferneinleitungen (*Jour. für Gas*, Nov. 30, 1907

On the Theory of the Incandescent Mantle.

(From the *Zeitschrift für Beleuchtungswesen.*)

In this note the author comments on some of the previous speculations on the theory of the incandescent mantle, by H. W. Fischer (*Sammlung chemischen und chemische-technischen Vorträge*, Band XI., Heft 4).

Fischer refers, firstly, to the now well-known fact that the incandescent mantle is most efficient when containing about 0·8 per cent. of Cerium, and the remainder pure Thorium. He emphasizes the point, also, that very small amounts of impurities have a notoriously bad effect on the light from the mantle, and that iron and præso-didymium are particularly effective in this respect. He then passes on to discuss the rival theories of luminescence and temperature-radiation, and favours the view that the radiation from the mantle is of the latter variety.

To decide this point experiments on the external heating of black bodies have been devised. If, for instance, a foreign body is placed inside a heated porcelain tube, so as to be completely enclosed except for a very small opening, and if, after temperature-equilibrium is attained, the foreign body vanishes optically, then we can assume that we are dealing with temperature - radiation. This method was followed by St. John, who, however, did not work with the mixture utilized in mantles, but with certain other rare earths, so that, in his case, although the foreign body vanished optically, the result might not be rigidly applicable to the incandescent mantle.

More recently Dr. Bunte was able to make the material of an incandescent mantle vanish in this way. Yet, even so, we have only proved the non-existence of thermal, and not chemical luminescence. The incandescent mantle glows in the Bunsen flame, which is known to be rich in ultra-violet rays, and these rays easily set up chemical luminescence. In the black body experiment, the temperature was only 1,600 to 1,800 degrees centigrade, so that the maximum energy of the curve would be right out in the infra-red, and very little ultra-violet light would be present.

On the other hand, there are important grounds for believing in the existence of luminescence in the mantle, some of which are as follows :—

1. The incandescent body still glows for an appreciable time after the flame is withdrawn.

2. The rare earths exhibit luminescence under the action of cathode rays, but only when they contain small impurities of the order of the percentage of Cerium included in incandescent mantles. Whether it has been shown that *pure* rare earths luminesce in this way is uncertain.

3. There is reason to suppose that, when dealing with a mixture of Cerium and Thorium, we have a stable solution, in the sense of Van T'Hoff, and many such stable solutions show lumirescence : for instance, combinations of the alkaline earths, zinc, magnesium, and small quantities of the corresponding salt of manganese, &c.

4. The Bunsen flame, as we have seen, is rich in ultra-violet light, and these rays are known to cause luminescence, and are, indeed, often recognized by means of the exhibition of fluorescent properties.

5. It is known that the addition of small quantities of iron to a luminescent stable solution may suppress the luminescence. Now, if an incandescent mantle is soaked in ink, it loses its luminosity almost entirely, in consequence of glowing iron oxide. If one regards the light from an incandescent mantle as due to temperature-radiation, this fact is very imperfectly explained by the black-body law.

6. The mechanical equivalent of light of an incandesent mantle is in the neighbourhood of 0·04 watts per H.K., very nearly the same value as the mechanical equivalent of light from the arc light, in which, it is believed, temperature and other forms of radiation take place simultaneously. In the case of pure temperature-radiation, as, for instance, the flames composed of glowing incandescent carbon, and the carbon filament glow-lamp, the mechanical equivalent is in the neighbourhood of 0·08 to 1 watts per H.K.

The general evidence against the supposition that the action of the incandescent mantle is due to pure temperature-radiation is so weighty that even Herr Fischer cannot be said to dispose of it.

PATENT LIST.

PATENTS APPLIED FOR.

I.—ELECTRIC LIGHTING.

27,076. Incandescent lamps. Dec. 7, 1907. J. H. Hegner, 16, Place de la République, Paris.
27,130. Incandescent lamps. Dec. 7, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
27,132. Arc lamps. Dec. 7, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From Allgemeine Elektricitäts-Ges., Germany.)
27,223. Arc lamp. Dec. 9, 1907. The British Thomson-Houston Co., Ltd., and W. H. Dalton, 83, Cannon Street, London.
27,412. Arc Lamps. Dec. 12, 1907. H. Bevis and A. E. Angold, Peel Works, Adelphi, Salford.
27,497. Metallic incandescent bodies for glow lamps. Dec. 13, 1907. H. W. Purle, 17, Denver Road, Stamford Hill, London.
27,541. Incandescent lamps (C.S.). Dec. 13, 1907. C. Pauli, 20, High Holborn, London.
27,809. Incandescent lamps (C.S.). Dec. 17, 1907. E. C. R. Marks, 18, Southampton Buildings, London. (From Parker-Clark Electric Co., U.S.A.)
28,175. Arc lamps. Dec. 21, 1907. F. M. Lewis, 11, Buckingham Road, Brighton.
28,291. Incandescent lamps. Dec. 23, 1907. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
28,451. Lengthening life of incandescent lamps (C.S.). Dec. 27, 1907. W. Herrmann, 40, Chancery Lane, London.
2. Portable lamp. Jan. 1, 1908. T. Shepherd, 20, Martineau Street, Birmingham.
66. Arc lamp electrodes. Jan. 1, 1908 (I.C. Jan. 5, 1907, U.S.A.). G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.
461. Incandescent lamps. Jan. 8, 1908. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
732. Incandescent lamps. Jan. 11, 1908. The British Thomson-Houston Co., Ltd., and H. H. Needham, 83, Cannon Street, London.

II.—GAS LIGHTING.

27,127. Incandescent mantles. Dec. 7, 1907. B. Young, 129, The Grove, Wandsworth, London.
27,137. Inverted incandescent lamps. Dec. 9, 1907. P. Wigley, G. N. Arculus, and J. Warry, trading as Alfred Arculus & Co., 128, Colmore Row, Birmingham.
27,367. Manufacture of incandescent mantles. Dec. 11, 1907. W. G. Head, 6, Bream's Buildings, London.
27,455. Inverted incandescent lamps. Dec. 12, 1907. S. G. How and E. S. Wright, 6, Bream's Buildings, London.
27,679. Inverted incandescent burner. Dec. 16, 1907. H. Pullen, 27, Listerhills Road, Bradford.
28,301. Inverted mantles and fittings for same. Dec. 23, 1907. G. H. Barber and S. R. Barrett, 18, Southampton Buildings, London.
28,360. Gas lamps. Dec. 24, 1907. J. Keith and G. Keith, 65, Chancery Lane, London.
28,393. Inverted incandescent lamps. Dec. 24, 1907. S. Biheller, 1, Great James Street, Bedford Row, London.
28,462. Inverted burners and lamps. Dec. 27, 1907. W. G. Potter, 14, Ingleton Street, Brixton, London.
28,519. Inverted burners. Dec. 28, 1907. W. H. Wood, 32, Warwick Road, Sparkhill, Birmingham.
227. Appliances for use with incandescent lamps. Jan. 4, 1908. S. A. Jackson, 317, Regent Road, Salford, Lancs.
350. Inverted incandescent burners. Jan. 6, 1908. F. Turner and G. Hands, trading as G. Hands & Co., 77, Chancery Lane, London.

III.—MISCELLANEOUS.

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

27,581. Lamps for church, synagogue, and like uses. Dec. 14, 1907. M. Shrensky, 55, Market Street Manchester.
28,245. Acetylene burners. Dec. 23, 1907. A. Bray, Sunbridge Chambers, Bradford, Yorks.
28,495. Lamps. Dec. 27, 1907. Clarke's "Pyramid" and "Fairy" Light Co., Ltd., S. B. Clarke, and H. Clarke, 24, Southampton Buildings, London.
28,707. Lighting streets, docks, warehouses, railway stations, &c. Dec. 31, 1907. O. Hellstern and G. T. Vincent, 1, Ranelagh Gardens, Barnes, London.
330. Lamp shade (C.S.). Jan. 6, 1908 (I.C. Jan. 11, 1907, U.S.A.). W. O. Holt and R. L. Foster, 173, Fleet Street, London.
391. Incandescent lamps. Jan. 7, 1908. J. Stott, 62, Grains Road, Shaw.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

23,009. Arc lamps. Oct. 17, 1906. Accepted Dec. 27, 1907. The British Thomson-Houston Co., Ltd. and W. H. Dalton, 83, Cannon Street, London.

24,179. Incandescent lamps. Oct. 30, 1906. Accepted Dec. 11, 1907. F. W. le Tall, 2, Norfolk Street, Strand, London. (From A. Lederer, Austria.)

27,725. Arc lamp with inclined carbon holders. Dec. 5, 1906. Accepted Dec. 11, 1907. J. Brockie, Birkbeck Bank Chambers, London.

28,775. Metallic incandescence bodies for glow lamps. (I.C. March 27, 1906, Germany.) Accepted Dec. 18, 1907. Deutsche Gasglühlicht Akt.-Ges. (Auerges), 55, Chancery Lane, London.

29,758. Systems of train lighting. Dec, 31, 1906. Accepted Dec. 31, 1907. H. Leitner, 4, South Street, Finsbury, London.

155. Incandescent lamps. Jan. 3, 1907. Accepted Jan. 8, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From the General Electric Co., U.S.A.)

521. Inclined-carbon arc lamps. Jan. 8, 1907. Accepted Jan. 8, 1908. E. Pearce and S. Walton, Norfolk House, Norfolk Street, Strand, London.

15,017. Incandescent lamps with metal filaments (C.S.). June 29, 1907. Accepted Dec. 27, 1907. H. Kuzel, 322, High Holborn, London.

17,973. Filaments of refractory metals (C.S.). Aug. 7, 1907. Accepted Dec. 11, 1907. A. G. Bloxam, Birkbeck Bank Chambers, London. (From Siemens & Halske, Germany.)

18,923. Incandescent lamps (C.S.). I.C. Nov. 23, 1906, Germany. Accepted Dec. 11, 1907. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Building, Norfolk Street, Strand, London.

19,829. Reflector incandescent lamps (C.S.). Sept. 5, 1907. Accepted Jan. 15, 1908. H. Gilmore, Old South Building, Boston, Mass.

26,846. Arc lamps (C.S.). I.C. Dec. 5, 1906, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

27,739. Arc lamp (C.S.). I.C. Dec. 20, 1906, Germany. F. Janecek, 27, Chancery Lane, London.

28,138. Lamps (C.S.). I.C. Dec. 27, 1906, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

66. Arc lamp electrodes (C.S.). I.C. Jan. 5, 1907, U.S.A. G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.

II.—GAS LIGHTING.

19,753. Incandescent burner. Sept. 5, 1906. Accepted Dec. 18, 1907. H Fischer, 24, Meineckestrasse, Post Office 15, Berlin.

28,094. Lighting gas at a distance. Dec. 01, 1906. Accepted Dec. 18, 1907. H. Birnbach, 19, Farringdon Street, London.

28,213. Incandescent lamps. Dec. 11, 1906. Accepted Dec. 11, 1907. A. G. Smith, 34, Castle Street, Liverpool.

1,577. Incandescent burner. Jan. 21, 1907. Accepted Dec. 11. F. Kratky, 65, Chancery Lane, London.

4,112. Inverted incandescent burners. Feb. 19, 1907. Accepted Dec. 27. W. Anderson and H. Anderson, 41, Reform Street, Dundee.

6,322. Gas light apparatus. March 15, 1907. Accepted Jan. 15, 1908. J. W. Hardt, 65, Chancery Lane, London.

8,323. Incandescent burners. April 10, 1907. Accepted Dec. 18. J. W. Bray, Sunbridge Chambers, Bradford.

8,330. Inverted lamps. April 10, 1907. Accepted Dec. 27. S. Biheller, 1, Great James Street, Bedford Row, London.

8,331. Lamps or lanterns for incandescent lighting. April 10, 1907. Accepted Dec. 27. S. Biheller, 1, Great James Street, Bedford Row, London.

13,665. Inverted incandescent burners for railway carriages, &c. June 13, 1907. Accepted Dec. 18. F. W. Marillier and T. Stanton, Engineer's Office, Great Western Railway, Swindon.

14,317. Incandescent burners. June 21, 1907. Accepted Jan. 15, 1908. T. Thorp, 57, Barton Arcade, Manchester.

15,776. Inverted incandescent lamps (C.S.). I.C. May 18, 1907, Germany. Accepted Dec. 18. C. Reiss, 18, Southampton Buildings, London.

16,867. Incandescent mantles (C.S.). July 23, 1907. Accepted Jan. 15, 1908. H. Süssman, 1, Great James Street, Bedford Row, London.

19,278. Inverted incandescent burners (C.S.). Aug. 27, 1907. Accepted Dec. 31. J. Altman, 322, High Holborn, London.

22,403. Catalytic lighting appliances (C.S.). I.C. Oct. 12, 1906, Germany. Accepted Dec. 18, 1907. G. Salomonsohn, 6, Lord Street, Liverpool.

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

III.—MISCELLANEOUS.

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

3,621. Incandescent petroleum lamps. Feb. 13, 1907. Accepted Jan. 15, 1908. A. B. Krzywiec, 6, Lord Street, Liverpool.

5,916. Lighting lighthouses, &c. March 12, 1907. Accepted Dec. 18. C. A. Stevenson, 28, Douglas Crescent, Edinburgh.

17,838. Incandescent spirit lamps (C.S.). Aug. 6, 1907. Accepted Dec. 18. W. Lauda and H. Wictorin, 91 Lindenallee, Essen-on-the-Ruhr, Germany.

19,344. Incandescent lamp for liquid fuel (C.S.). Aug. 28, 1907. Accepted Dec. 18. A. Mathieu, 7, Staple Inn, London.

19,473. Acetylene lamps (C.S.). I.C. Aug. 31, 1906, Germany. Accepted Dec. 31, 1907. E. Schichtmeyer, 111, Hatton Garden, 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.

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.

[The Editor of 'The Illuminating Engineer' does not necessarily identify himself in any way with the opinions expressed by his Contributors.]