ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

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EDITORIAL.

The Education of the Illuminating Engineer.

THE progress of the illuminating engineering movement in the United States since the inauguration of the Illuminating Engineering Society, two years ago, has been exceedingly rapid. One of the most striking facts brought out by the doings of the society has been the great variety of subjects coming under the notice of the illuminating engineer, and the number of experts of different callings who have come forward to express the views of their respective professions, thus bringing about friendly co-operation and better mutual understanding.

In this connexion the summary of papers read before the society, which we reproduce elsewhere in this issue, should be of interest at the present moment. The list includes papers by engineers, makers of fixtures, &c., architects, professors, members of the medical profession, and others representing many different sections of the engineering profession. It will be seen that the range of subjects dealt with is very wide indeed. Space does not allow us to recapitulate these in detail. We invite our readers to read the titles over and form their own conclusions as to the vastness of the branch of knowledge with which the expert illuminating engineer must make himself acquainted.

There can be no doubt as to the need for men who are really well acquainted with the principles of illumination; the only difficulty at present has been to find those who were properly qualified in this respect. We note that this question is now receiving special recognition in the American universities and technical institutions. Professor Wickenden, of Wisconsin University, and others have described the work that is being done in this connexion in a recent number of our contemporary 'THE ILLUMINATING ENGINEER' of New York.

The university of Wisconsin has been developing a course in illumination for some years past, and at the present time students are not only instructed in the principles underlying the production and measurement of light, but also in the application of these principles to actual practical problems. Similar courses are held at Columbia and Cornell Universities, at the Carnegie Institute, the Stevens Institute, the Massachusetts Institute of Technology, and other similar institutions. In these cases the study of illumination may be said to form a definite integral part of the syllabus. At present stress is laid chiefly on giving the students a grounding in the theoretical side of the subject, and in making them familiar with the fundamental laws of light, as applied to illumination.

We are glad to note that this point is not being lost sight of in this country, and feel confident that the subject of illumination will soon become a recognized portion of the curricula of our engineering institutions. In particular we wish to point out in this connection the syllabus adopted at the Northampton Institute, where Dr. Drysdale, one of the eminent supporters of the illuminating engineering movement in this country, is conducting a course of lectures in *illumination.* Dr. Walmsley, the Principal, is clearly turning to account some of the experience gained in his visit to the States.

It is true that at present a certain amount of information of great value to the illuminating engineer is to be gained in the courses given at many of our leading institutions. It must be recognized, however, that there are several respects in which improvement in the existing facilities is desirable. Students, for instance, may receive useful instruction in photometry, but this instruction is seldom extended to such actual problems of illumination as occur in practice. Again, they frequently listen to lectures embracing a study of one or other of the existing illuminants, incandescent, electric and arc lamps for example, but rarely do all methods of lighting receive a fair share of attention; the result is that the student goes out with an understanding of only one narrow aspect of the question. But the most serious objection to the existing systems is the fact previously mentioned, that while the production of light and its measurement receive attention, the really vital question of the actual application of this light to the illumination of streets and buildings is invariably ignored. As a result, photometry and the whole subject of scientific standardization of light-sources and illumination come to be regarded by the student as misty and unpractical processes which are of merely scientific interest, and are not strictly applicable to practical conditions.

We are, therefore, strongly in favour of the subject of illumination, including the application of theoretical results to practical lighting problems, forming an integral portion of the course of study in technical colleges. There also seems good reason to suggest that instruction of a simple and practical character might in future be given at the technical schools which are under the direction of the L.C.C.

In any case it may safely be predicted that the ever-increasing interest that is being taken in matters of illumination will in time prove the necessity for the creation of courses of study of the nature indicated. The great strides that are continually being made in all varieties of existing illuminants only serve to indicate yet more clearly how essential it is that those dealing with any particular type should make themselves thoroughly acquainted with recent progress in other branches, and there can be no question but that the company that secures representatives with this qualification will reap a very great advantage in its dealings with the consumer. This naturally leads to the consideration of the second subject with which we propose to deal on this occasion.

The Standpoint of the Consumer.

We reproduce elsewhere in abstract the recent interesting paper read by Messrs. Handcock and Dykes, before the Institution of Electrical Engineers, dealing with the influence of metallic filament lamps on the electrical industry. The importance of the situation can hardly be denied, and in our next number we propose to enter into greater detail in considering the suggestions of the authors and the discussion to which they have given rise. For the moment we only wish to draw attention to a few important phases of the subject from the standpoint of the general public. For, after all, the welfare of any supply-company depends on the satisfaction it gives to the consumer. One practical result of the competition between gas and electricity as illuminants has been the gradual recognition of the wisdom of treating the public in a less arbitrary and more courteous manner than was prevalent in the past. Fortunately there is ample evidence that the old feeling of hostility is being replaced by mutual goodwill and understanding.

With this end in view, we think that the electrical supply companies should be prepared to make some sacrifice in order to avoid the imposition of any complicated method of charging, or any other feature of their system which the consumer finds burdensome or difficult to follow. Electricity is undoubtedly at a disadvantage in the multiplication of charging systems which exist, and any attempt to secure greater uniformity deserves every encouragement.

In order to secure the consumers' confidence the supply company, whether furnishing gas or electricity, ought to do all in their power to assist him to make the best use of the power put at his disposal. To effect this purpose it is most essential that canvassers should be employed having a really practical and efficient knowledge not only of the illuminant with the use of which they are mainly concerned, but also of other systems also at the disposal of the consumer. Indeed the consumer himself is now taking a keener interest in the merits of different illuminants, and he will not readily be satisfied by any but a tolerably complete knowledge of this description. A canvasser wishing to induce him to adopt any system of lighting must be prepared to answer inquiries dealing with other methods, and to show him how to get the very best results from the gas or electricity with which he is supplied. This canvasser must, in fact, be conversant with the principles of illuminating engineering. It must now also be recognized that the actual care of the generating plant, and the consideration of the conditions at the consumer's end, are two distinct functions, and it is too much to expect from a single man (the central station manager and engineer) to undertake and carry out both satisfactorily.

The second point to which attention may be drawn is the importance of taking broad views of the fields of action of rival systems of lighting. We have always insisted upon the obvious desirability of those representing two distinct systems of illumination like gas and electricity realizing that there is room for both in their respective spheres, and helping each other instead of wasting money and effort in needless friction.

We should also like to point out that before extending the use of any improved type of lamp the public must first be thoroughly educated to appreciate its merits in particular cases. The indiscriminate pushing of such a lamp under all conditions is more likely eventually to injure than to benefit the lighting industry.

But recent remarkable developments

in illuminants have also contributed to the extension of gas-lighting, and it is not to be expected that an industry employing so many people, and with an invested capital of over 120 million pounds, will be ready to give place to a new system of electric lighting, however great the improvement may appear, without being able to perceive possibilities of remunerative extensions in the other directions.

It therefore seems to us evident that some understanding should be arrived at as to the spheres of action to which the two illuminants are best suited, and that there should be no undue interference in legitimate fields of activity. The definite solution of the problem will probably form part of the services of the impartial and accredited expert whom we desire to see come into existence. Meantime, as has been shown previously, the right to existence of both systems should be recognized, and mutual toleration and good-will might smooth away much of the existing misunderstanding. Those municipal authorities who own both systems of illumination are particularly well placed to practise co-operation of this description, from which the consumer will ultimately benefit.

Gas-Testing in London.

Under the above title Mr. R. A. Dibdin contributes an exceptionally complete description of the modern legal methods of testing gas in force in London, including a record of the existing legislation on the subject. To those readers who are unfamiliar with the regulations relating to gas-testing this article will be of great interest.

One is nevertheless disposed to wonder how far the consumer is in a position to get the full benefit of the tests organized for him. He is adequately protected against the possibility of the gas supplied being of inferior illuminating power, but naturally such precautions avail little if his burners are defective, uneconomical owing to neglect, or placed in such a manner as to distribute the light in an inefficient manner.

Great care is being constantly exercised at the testing stations in order to secure that the gas delivered to his premises comes up to the required standard, but the advantages following are greatly discounted if no adequate provision is made to help him to obtain correspondingly satisfactory conditions from that point onwards. As explained in the previous section, we feel that this duty naturally devolves upon representatives of the supply companies, who now realize that their responsibilities need not stop at the meter. It is very gratifying to note that in some quarters steps are now being taken to educate canvassers on the subject of illumination, and to keep them well posted on recent progress both in their own and other branches of lighting. We hope that this policy will commend itself to other companies.

Abstract of Contents.

We desire to draw the attention of our readers to the short abstract of the contents, which follows this editorial. We realize that certain articles are naturally of greater interest to some readers than to others, but that such readers may nevertheless wish to form an impression of the general contents of the magazine. We, therefore, hope that the present abstract, which we propose to repeat in subsequent numbers, will be found a convenience.

LEON GASTER.

Review of Contents of this Issue.

THE instalment of **Mr. A. P. Trotter's** series of articles in this number is devoted to the discussion of contour lines of equal illumination or "iso-lux" curves. Such curves enable us to map out the combined illumination of several sources of light at a certain distance apart and height from the ground. In the April number Mr. Trotter had explained the methods by which such curves may be drawn, and he now illustrates his previous explanation by means of practical examples.

Mr. Norton H. Humphrys contributes some general notes on illumination. He points out the wastefulness of many existing methods of using light, and the importance of keeping in view the exact purpose for which any such lights are installed. For instance, the nature of the walls of the interior, the variety of buildings in the streets, and the character of goods displayed in shop-windows are all of influence on the correct system to adopt; these remarks are illustrated by examples of every-day conditions to be seen in the streets of London.

Dr. Berthold Monasch discusses the action of different varieties of glass used in windows. He examines four specimens of glass: clear, rippled, frosted, and ribbed respectively, and shows how the light is distributed in each case, and their general effect upon the illumination of the room. He also points out that, while artificial illumination is the subject of constant systematic study very little corresponding attention is expended upon the best utilization of daylight conditions. Yet these are often of at least equal importance.

Dr. Drysdale's present contribution deals with luminous efficiency, and the mechanical equivalent of light. He explains the nature of the radiation in various parts of the spectrum from different illuminants, and proceeds to describe methods by which the radiation can be separated into visible and invisible components, and hence the percentage of energy available in a useful and luminous form computed.

Dr. Paul Krüss describes some forms of apparatus having for their object the screening of the photometer from diffused stray light. This may be accomplished by the cumbrous method of placing screens, provided with suitable orifices, along the photometric bench. Dr. Krüss, however, advocates a special piece of tubular apparatus which is attached to the photometer, and effectually protects the illuminated surfaces from light coming in at the side. When this adjunct to the photometer is employed the greater portion of the bench can be kept free from encumbrances and the inconvenience of screening arrangements is much reduced. Dr. Krüss quotes the results of some actual experiments to show the effect of the apparatus in practice.

Mr. R. A. Dibdin deals with the course of legislation affecting the testing of gas in London, and also describes comprehensively the exact methods by which tests of illuminating and calorific power are carried out by the gas examining authorities. The article is illustrated by a series of photographs showing the nature of the photometers and standards of light, &c., used, and the apparatus in actual operation.

Mr. A. B. Clarke contributes a short article on the calculation of the P.D. drop in supply mains, and its influence upon the light yielded to the consumer. The article is accompanied by a curve showing the relative efficiency of illumination with different pressures at the consumer's terminals.

Dr. F. Jaoobsohn contributes a general review of the recent developments in electric metallic filament lamps. In the first part of the article he passes in review the various substances which may be considered of possible application to the manufacture of glow-lamp filaments, and describes, in general terms, the processes of manufacture of tungsten and other metallic filament lamps. In so doing he refers to the most recent German patents on the subject and criticizes their applicability to existing conditions. The second part will follow in the next number.

The Special Section in this number is again devoted to the standpoint of the architect in matters of illumination, the recent paper on the subject by **Mr. Bassett Jones** before the Illuminating Engineering Society, and the discussion to which it gave rise, being exhaustively dealt with. Mr. Bassett Jones's paper, which is accompanied by a number of illustrations, serves to show the importance of due attention being paid to the æsthetic considerations, which are the main inspiration to the architect in inducing him to adopt certain systems of illumination and to discard others. Briefly, Mr. Jones contends for the realization of the fact that objects which are intended to be beautiful serve a distinct and useful purpose, and ought to be illuminated with the specific object of bringing out their value.

The discussion of the paper turned mainly upon the relative predominance of the æsthetic and purely utilitarian aspects of lighting and the spheres of influence of the architect and the illuminating engineer; all, however, agreed that exchange of views and cooperation between members of both professions was desirable.

Dr. Louis Bell's paper on the physiological basis of illumination deals mainly with the alteration in the behaviour of the eye under various conditions of illumination, notably the effect of illumination upon the pupil-orifice. From these data he draws several important conclusions as to the utilization of light under practical conditions....shows, for instance, the unwisdom of lighting a desk or table extremely brightly, and leaving the rest of the room in comparative darkness.

A recent paper by **M. C. Whitaker** before the Illuminating Engineering Society deals with a new form of thermostatically controlled incandescent burner, by means of which the gradual heating up of the burner as a whole is made to regulate the aperture and allow the proportion of gas and air admitted to adjust themselves to exactly the most favourable conditions. The paper also deals in detail with the general principles underlying the inverted gas burner.

The recent paper by **Messrs. Handcock** and **Dykes,** before the Institution of Electrical Engineers, discusses the effect of the development of the metallic filament lamps upon the electric lighting industry.

A new form of **Holophane** reflector intended specially for street lighting is also described, with illustrations. At the end of this number are to be found the usual review of the existing technical literature on the subject of illumination, and the patent list.

TECHNICAL SECTION.

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

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

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 273.)

Fig. 17 gives the contours for two lamps at a distance apart equal to three times their height. The maximum illumination due to each lamp is 100. The smallest curves, which are indistinguishable from circles, represent an illumination of 90. The resultant maximum is 103·16.

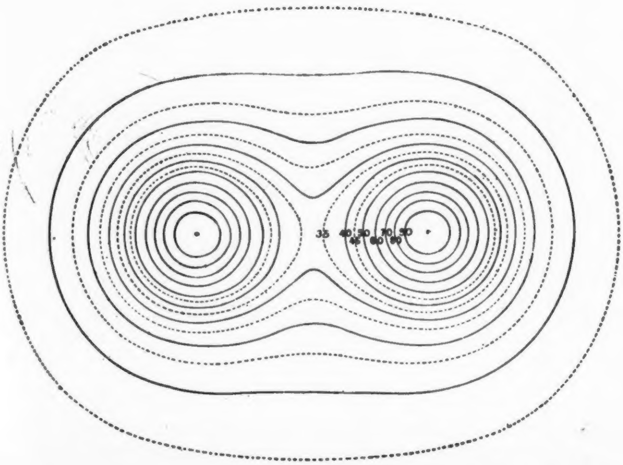


Fig. 17.—Contour lines of equal illumination or iso-lux curves, due to two lights at a distance apart equal to three times their height.

Fig. 18 refers to two lamps at a distance apart equal to four times their height. The smallest curve is 90 and the maximum is 101·4.

If these contours be considered to represent a solid figure, a vertical section gives curves of the kind shown in Figs. 10 to 13. The lowest of the full-line curves in Fig. 12 represented a vertical section along the middle line of Fig. 17.

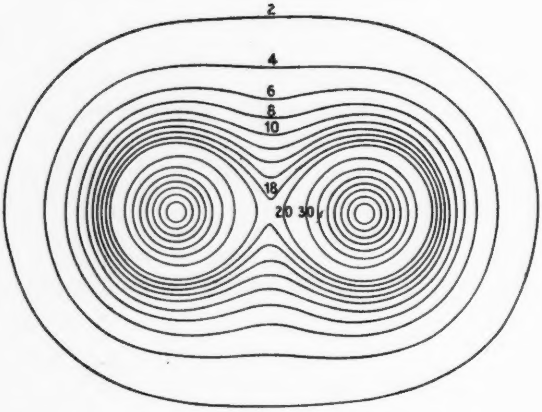


Fig. 18.—Contour lines of equal illumination, or iso-lux curves due to two lights at a distance apart equal to four times their height.

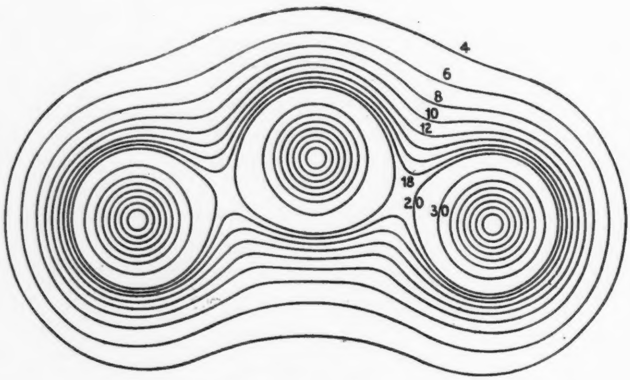


Fig. 19.—Contours or iso-lux curves for three lights. Derived from Fig. 18.

Fig. 19 gives the contours for three lamps in zig-zag, being the contours of Fig. 18 compounded by the tracing paper method with those of a third lamp.

The contour lines for three lamps, placed at the corners of an equilateral triangle, the side of which is 1·5 the height of the lamp above the ground, maxima are not under the lamps, and that within the triangle the light does not vary more than 10 per cent. In most cases of street lighting the

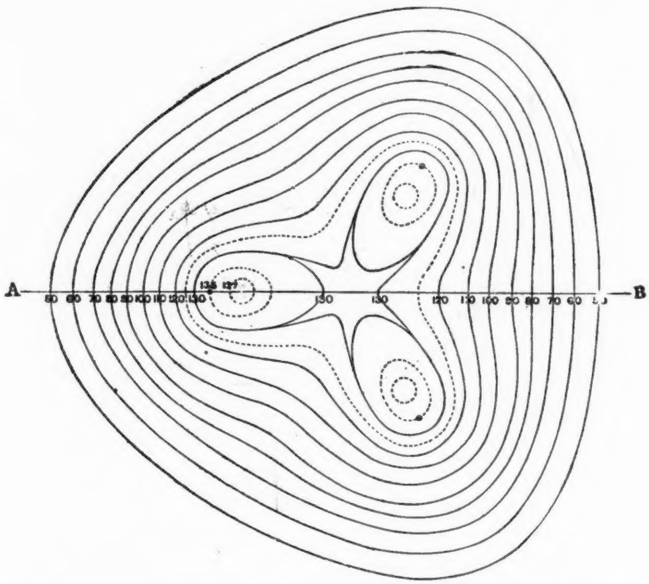


FIG. 20.—Contours or iso-lux curves due to three lights at distances apart equal to one and a half times their height.

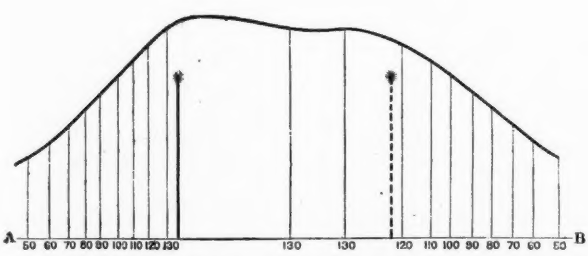


FIG. 21.—Illumination curve due to three lights at distances apart equal to one and a half times their height, being a section of Fig. 20 through the line AB.

are given in Fig. 20. Treating this as a solid figure, Fig. 21, a curve of the same kind as Figs. 10 to 13, is a section of it through the line A B. It is to be noticed that the points of contours are little else but circles; the other curves are negligible, since they would refer to differences of illumination which are too small to be of any practical importance.

With ordinary arc lamps in clear glass lanterns or globes the contour lines present a very different character, owing to the peculiar distribution of the light. The contour lines in Figs. 22 and 24 have been constructed on the assumption that the light is distributed as shown in Fig. 14. Fig. 22 represents the illumination due to three arc lamps at a distance apart equal to 1·5 of their height. Fig. 23 represents a section through Fig. 22. Fig. 24 shows the contour lines for three arc lamps placed at a distance apart equal to three times their height; and Fig. 25 is a section through A B, Fig. 24. The values given for the illumination at each contour are arbitrary, but do not

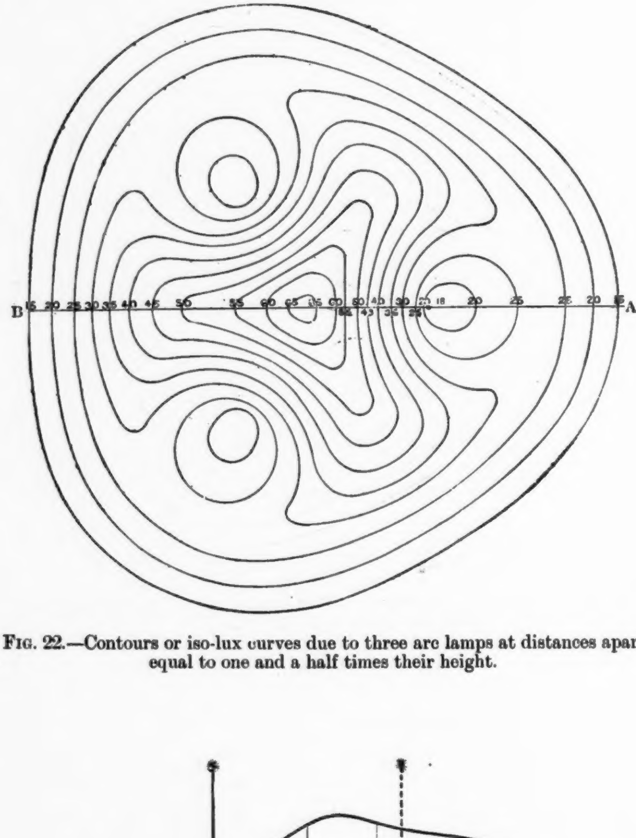


FIG. 22.—Contours or iso-lux curves due to three arc lamps at distances apart equal to one and a half times their height.

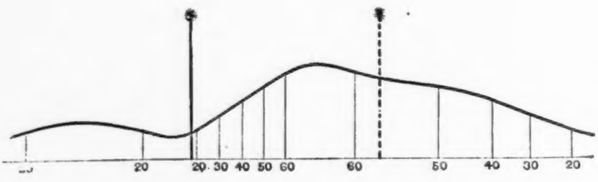


FIG. 23.—Illumination curve along the line AB, Fig. 22.

differ much from the values given in Fig. 14.

With modern flame arcs, or with diffusing globes or lanterns, the distribution would, of course, resemble Fig. 9 rather than Fig. 14.

It is not suggested that the construction of these contour lines should often be carried out, and no great importance is attached to them. The study of a few typical cases is interesting. Many such curves may be found in H. Maréchal's book, 'L'Eclairage à Paris.' André Blondel and F. Uppenborn have produced others, some of them being highly complicated.

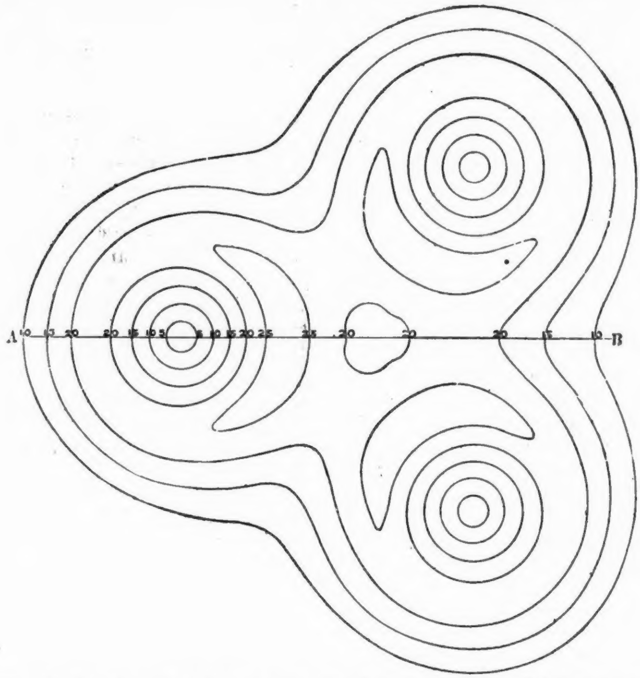


FIG. 24.—Contours or iso-lux curves due to three arc lamps at distances apart equal to three times their height.

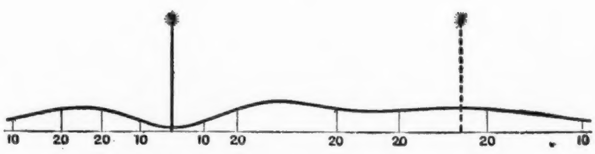


FIG. 25.—Illumination curve along the line AB, Fig. 24.

(*To be continued.*)

Some General Notes on Artificial Illumination.

By Norton H. Humphrys, Assoc. M.Inst.C.E. F.C.S.

It has been my practice for the last twenty-five years or more to take a stroll once or twice a year round the principal streets and districts in the West-End of London after dark, under the impression that some of the best examples of the latest applications of artificial lighting may be seen there, and to make observations from the point of view that might be expected to be held by a lighting or illuminating engineer. Such an individual may be supposed to look for a maximum of efficiency at a minimum of cost. He would wish to avoid waste in every form on the one hand, and to secure a satisfactory degree of efficiency on the other. In the course of the period above named there has been, according to the opinion of the man in the street, a great "improvement." He will tell you that the shops and the streets are "better" lit than they used to be, which simply means that there are more light centres and higher candle-power, but not necessarily that there is any advance from my point of view. I say that the lighting is worse, in the sense that there is more waste, more unequal diffusion, and less consideration for the few elementary principles that we know to be necessary for efficient lighting. In my notes I refer to the light centre or source as "the light," and to the objects to be lighted as "the object," and it will be convenient to retain these terms. We must also remember, in connexion with this subject, the primary purpose for which the light is provided. A street lamp is intended to act as a guide and a help to passengers, a lamp in a shop-window to show off goods, and so on.

We are not at present interested in the description of light, but only with its candle-power. It may be electric, arc or glow, gas, incandescent or open flame, petroleum, or any medium in actual use. But we must avoid the mistake of figuring upon candle-power as being equivalent to money value. The actual cost, even with the same medium does not vary *pro rata*. For various reasons that do not now concern us, the cost of a 200 candle-power light is not necessarily twice that of a 100 candle-power. Nor has the practical value or benefit derived by the user anything more than a very indirect connexion with candle-power. It is affected by the colour, the shape, the area, and the diffusive power, and especially by the extent of the spherical area covered by the light. The burner and the branch or other support must necessarily block out a part of the lighting effect, and the extent and position of the part so stopped will exercise an important effect on the value of the light. A light is also considerably influenced by the nature, and especially by the colour, of its surroundings. In the case of a light of equal candle-power, very different effects are produced (1) when it is placed in a window stocked with white goods; (2) amidst a pile of black goods; (3) surrounded by brilliantly-polished articles, such as jewellery, &c.

In primitive days, from an illuminating standpoint, there was no idea of anything like a broad general effect, but the candle was placed as closely as circumstances would permit to the work or the object. The remainder of the compartment might be in comparative darkness. Even in a shop the lights were confined to the counter. This kind of lighting is now replaced by a more or less equable lighting of the whole area of the room, building, or street. But it is remarkable how deeply rooted old ideas and customs seem to be, and how they retain a hold long after the cause which originated them has disappeared. Even in modern designs there is a tendency to retain the candle-holder or the oil reservoir in the pattern, and the same appears to be the case with regard to the custom of placing the candle or the lamp close at one's elbow. So long as we are only dealing with lights of less than 10 candle-power there is no objection to placing the light close to the object, but when we use lights that are valued in hundreds or even thousands of candle-power several new conditions come in.

Probably the first impression that strikes the thoughtful observer is the *waste* of light, as represented by powerful lights hanging so low as almost to swing in one's face, or placed within a yard of the object. It seems hackneyed to say that the eye should rest upon the object and not on the light; but in practice the lights seem to push forward into the front place. They are located obtrusively on the fronts of buildings, in front of the object, and in other positions where they are bound to be looked at, and where they exercise no useful effect. Why a tradesman should imagine that the public will have a better opinion of his wares or resort more frequently to his establishment because he strains their eyesight and offends their innate sense of the fitness of things by the extravagant and senseless use of light, is not very obvious. Yet there appears to be a widespread impression that moths are not the only things that are attracted by a dazzling light.

There are other considerations even more important than the waste of light and the waste of money. I am glad to see that some attention is being directed to the relation of artificial light to the human eyesight. Many people are engaged for half their working time or more under artificial conditions of lighting, and all are concerned in the matter to an important degree. The way in which 1,000 to 2,000 candle-power lights are used, to say the least, displays very great confidence in the power of the eye to adjust itself to very wide variations. But the eye must be subject to limitations, just like the other senses. The ear, for example, can recognize only a limited number of octaves, as regards sound, and the eye also has its high and its low limit, with no sharp line of demarcation. Suppose we are seeking to note the details of a large poster or the details of a building by the aid of a variable light, such as that afforded by one carried on a motor-car and approaching at a slow rate. At first the light is at such a distance that we cannot see anything. As it approaches nearer and nearer, the details sought for become gradually more and more distinct, until at last there is sufficient light to render the observation easy and comfortable. Assuming the intensity of the light to continue increasing beyond this point, a stage is reached when, to use the common expression, it becomes dazzling or blinding. And if we allow our investigations of the public lighting to extend over some hours, we find by unpleasant experience that a long-continued glaring light is not beneficial to the eyesight. The power of the eye to adjust itself to the lighting surroundings covers considerable limits, between the point when we say that it is too dark to see, and that the light is too bright. But is it safe to assume that any dangerous or prejudicial overtaxing of this power will at once be evidenced by fatigue or other physical discomfort? It does not seem unreasonable to assume that continued or frequent contact with unnecessarily high power lights must tend to weaken or depress the powers of vision. The importance of this is evident when we remember that the majority of workers depend upon eyesight as an indispensable assistant in their daily work, and would be helpless without it.

A rule that was accepted and followed in practice for many years was that a safe, sufficient, and comfortable illumination is afforded by the candle-foot, a light equivalent to that afforded by one standard candle placed at a distance of one foot from the object. The value of this degree of light can be shown on an ordinary photometer, which can readily be made to show one, two, or more candle-feet upon the screen. One or two candle-feet power does not strain or fatigue the eye, but when we get up to ten or more candle-feet the eye is fatigued. Following the rule of the candle-foot I have, in the course of several years, carried out several installations of lighting that were accepted and pronounced to be satisfactory. According to the laws of inverse squares, the distance between the light and object to secure the candle-foot should be as follows :—

C.P.		Feet.	C.P.		Feet.
2,000	...	45	100	...	10
1,000	...	31½	80	...	9
500	...	22	50	...	7
300	...	17	40	...	6
200	...	14	30	...	5½
150	...	12	20	...	4½

Before proceeding to notice conclusions that this table naturally suggests, it will be desirable to glance at one or two other details. The question of angle with the line of sight is quite as important, if not more so, than that of distance. The line of sight is a straight line drawn from the eye of the observer to the object, and obviously may cover any point of the circle or sphere to which the eye can be directed. While walking or sitting in a natural position the line of sight tends to keep in the vicinity of a horizontal direction, and the horizontal may be called the natural line of sight. If we consider daylight, of the actual reality of which the illuminating engineer can produce but a more or less imperfect imitation, we find that the lighting angle is large. The protection afforded by the projecting eyebrow is an indication of the fact that the lighting angle should be not far short of 90 degrees But our practical observations carry the impression that the question of lighting-angle is neglected as much as that of distance, and frequently it is much too small.

As a matter of general experience the difficulty of adopting the powers of vision to suit either a dazzling or a dim light is greatly increased if there is also a small lighting-angle.

So far we have been considering properties inherent to the light itself, but the object and its surroundings have an important effect. We have to consider the effects of colour and of reflecting power, and this is especially important as regards the antipodes, the opposite sides of the light. We sit at a table to write or to read with a light, say, 4 ft. above, and provided with no downward reflector. Under these circumstances the lighting effect will be influenced by the character of the ceiling, whether the usual white plaster or wood of various kinds. The colour of the walls and furniture also figure in the matter, but not to such an extent as the ceiling. In the street, note the different effect of the street lamps (*a*) in the vicinity of a clean white stone building, and (*b*) where there are trees or open space behind them. If we can find a white goods shop, a jeweller's, and a boot shop, each lighted by an equal or nearly equal candle-power, we can notice the different effect in each case.

But it would appear that, as a rule, the lighting arrangements are decided in a haphazard sort of way, without any reference to the three important considerations—distance, angle, and environment—as above noticed. There is a story told of a nigger who went into a shop and ordered a pair of boots. When asked to allow the measure of his foot to be taken, he replied to the effect that he did not trouble about that, but would like them as large as possible for the price. Many things are purchased, however, on identical lines, light amongst the number. The power, position, and number of the lights are oftener a matter of mere selection from designs in an illustrated list than of a competent estimate or scheme for producing a predetermined effect.

The power of each light centre should be limited according to the height of the room or apartment as determining the distance between the light and the object; and in rooms with white ceilings a satisfactory result is usually produced when they are situated at about two-thirds of the distance between the floor and the ceiling. To give an example, in a room 12 ft. high, the lights should be 8 or 9 ft. from the floor, and should not exceed 40 to 50 candle-power. In most cases it will be found that the light must be not more than 10 ft. from the object, and therefore it is not too much to say that lights of less than 200 candle-power are sufficient for all ordinary purposes, and, indeed, for anything short of what is known in America as mast-lighting. But I would suggest that the limitations as to the distance, the angle, and the surroundings are affected by the candle-power, and that in regard to any particular degree, whether 50, 100, 200, or 500 candle, there are special conditions suited to each.

A consideration of the distance table above quoted seems to show that there is a tendency towards lights of higher power than are actually necessary, and this leads up to the question of the most appropriate size for the light unit. Until within comparatively recent times this was almost a matter of Hobson's choice. It was not a question of what size was wanted, but of what size could be had. For some reason or other not connected in any way with illumination, the 5 candle-feet per hour gas-burner acquired a leading position, and at one time represented more than half of the total consumption of gas. The same thing occurred with the 16 candle-power electric glow-lamp. But it is now possible to get a range of almost anything between 5 and 200 candles, so there is no longer any excuse for a slavish imitation or preference for any one special size. An important feature to be considered is the area occupied by the light. In theory we assume the light to emanate from one point, but in practice the light always has an appreciable area. All other things being equal it is preferable that the area should be large. Given an equal photometrical value, a light of, say, 4 square inches in area is preferable to one the size of a pea. The smaller area gives sharp shadows and a greater intensity per unit of area. Shadows are always objectionable, and the object of skilful lighting is to neutralize them, or, at any rate, to tone them down. The larger the light area the less sharp will be the shadows, and, therefore, the less noticeable. And since the eye objects to violent contrasts, the lower the intensity the more satisfactory the effect. This is the reason why translucent or "opal" globes are preferred for lights of small area but high intensity. In place of a dazzling point of light, we get a luminous globe of several inches in diameter. There is a large loss of photometrical value, perhaps two-thirds. But the light is pronounced to be better than before.

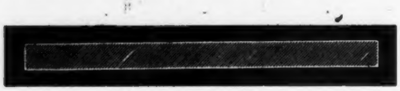
We can considerably alter the effect of objectionable features by the judicious use of globes, shades, or reflectors. By the term "globe" we may understand an arrangement that entirely encloses, and possibly conceals, the true shape of the light centre. A "shade" is usually placed above the light, to deflect a portion that would otherwise be wasted on the ceiling or upper part of the room into a useful direction. A reflector is an opaque shade that need not necessarily be above the light. We can find plenty of examples of globes and shades. A white opal shade above the light is very generally used, but as is the case with the other fittings, the shape appears to be a matter of fanciful selection rather than of predetermined effect. Some recent researches seem to show that the angle of the shade, as compared with the line of vision, might well be a matter of careful investigation and experiment. The same applies to reflectors, the most familiar examples of which are the cardboard shades placed over billiard lights or the desks in a bank or counting-house. One of the most interesting examples of reflectors is the footlights at a theatre, where they not only direct the light to the object, but conceal the light centre. It is by following these lines that the best lighting effects are produced. The concealment of the light is only practicable in particular cases, but much can be done in this direction by keeping the light as far as possible out of the prevalent lines of vision, and by the use of globes and reflectors.

Window-panes and Daylight Illumination.

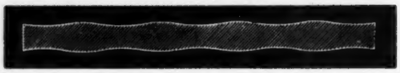
By Dr. Berthold Monasch.

Window-panes serve the double purpose of allowing light and air to enter a dwelling-room.

The entrance of air can, of course, easily be regulated at will, according to the temperature of the room and the climatic conditions generally; the entrance of daylight, on the other hand, depends both upon the brightness of the sky for the time being, and also upon the variety of glass of which the window-pane is composed. Whereas the alterations in illumination that may occur in the case of artificial lighting have been the subject of much careful investigation, the intensity of daylight-illumination enteriug by the window has only rarely received similar attention.

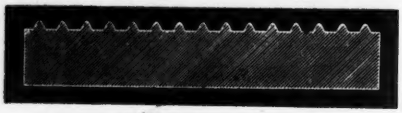


I. Clear Glass.



II. Rippled Glass.

III. Frosted Glass.



IV. Ribbed Glass.

Fig. 1.

In what follows it is proposed to devote closer attention to the variations that may occur in illumination of this nature.

As a general rule, plane-parallel panes of clear glass are utilized for windows; clear glass is naturally adopted for the most economical use of daylight conditions, on account of its relatively small absorption of light. Glass of this nature, however, fulfils a second purpose. Window-panes are intended not only to allow the daylight to enter the room, but also to enable those within to see what is going on outside. The effect of blinds, curtains, and other decorative and absorbing media, in obstructing the entrance of light or the view of those within the room, cannot easily be made a subject of scientific measurement; in such cases æsthetic considerations, which can naturally only be satisfied by a certain loss as regards optical efficiency, enter into the problem. But daylight illumination is in general so powerful that such a reduction in efficiency can be readily sanctioned, on account of the resulting improvement in convenience and comfort.

There are also circumstances under which it is desirable that windows should not be transparent—for instance, in the case of rooms on a level with the street, or in factories in which secret processes are carried out. Then, again, it may also be considered undesirable for those within a room to be able to see out through the windows; some people, for instance, maintain that their employés do less work when they are able to gaze out on the blue sky and green meadows.

Windows are generally obscured by the use of clouded or frosted glass, which have the property of obstructing the direct passage of the rays of light causing them to be diffusely distributed. In spite of the apparent unkindness of preventing the eye from dwelling upon the fair prospect without, this method presents the advantage of preventing the eyes from being dazzled by sudden alterations in the brightness of daylight illumination. In private dwelling-rooms one might, of course, employ curtains under these circumstances. In workshops, where economy must be practised, there are as a rule no curtains, and in any case they would usually accumulate too much dust and involve the expense of frequent cleaning.

In order to render windows opaque as regards the perception of external objects, and yet transparent to light, one must endeavour to reduce the loss through absorption which accompanies the use of frosted glass; with this object in view, clear glass of a cut or rippled nature may be employed. Cut glass, however, presents the disadvantage of being liable to collect dust in its crevices, and of being in addition, exceedingly inconvenient to clean. Rippled glasses keep clean very much longer, but exhibit maxima and minima in the transmitted illumination. They are also open to the further objection that any moving object behind them gives rise to an unpleasant flickering appearance. This effect may, for instance, be caused by any one passing the window.

For the purpose of studying the qualities of these various kinds of glass, an example of each was selected; the cross-sectional appearance of each of the four types is shown in Fig. 1.

I. represents a plane parallel clear-glass pane, 2·2 mm. thick.

II. represents a rippled clear-glass pane.

III. represents a frosted plane parallel glass pane 3 mm. in thickness. This was originally a sheet of clear glass, but was frosted over on one side by means of a sand-blast.

IV. represents a clear sheet of ribbed glass, 5 mm. in thickness up to the base of the ribs. The ribs themselves are 0·75 mm. in height, and run parallel over the surface of the glass at a distance apart of 2 mm.

Measurements of Intensity of Transmitted Light.

Experiments were first made with the object of observing the modifications in the nature of rays of light during their passage through the glass. The vertical filament of a 220 volt

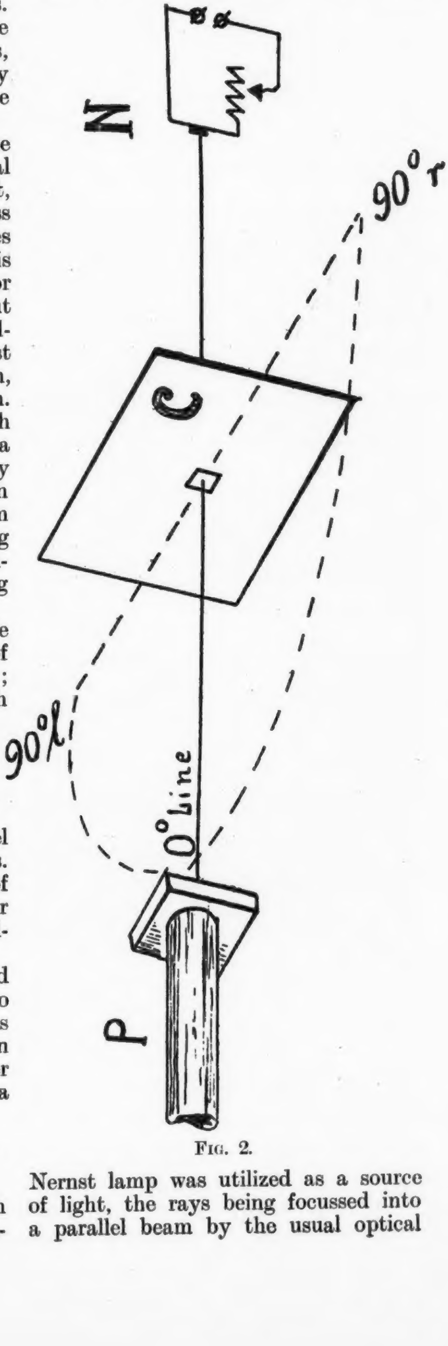


Fig. 2.

Nernst lamp was utilized as a source of light, the rays being focussed into a parallel beam by the usual optical arrangements. This filament is represented by N in Fig. 2.

The circuit of the Nernst lamp was provided with an adjustable rheostat, so that the candle-power of the lamp might be retained constant throughout the experiments. The beam of light impinged upon a cardboard screen C, pierced with an aperture one square centimetre in section. The photometer P was so placed as to face the middle ray passing through this aperture. This direction will be described as 0°. The photometer was of the well-known Weber type equipped with the Lummer-Brodhun prism arrangement; a tungsten lamp served as the source of comparison.

If, therefore, the photometer is situated on the 0° line, it is easy to determine the amount of light absorbed by the various types of glass referred to. All that is necessary is to measure the intensity of the light coming through the aperture when there is no glass in front of it, and then to interpose the sheet of glass to be examined, and repeat the measurement.

In this way the results shown in the following table were obtained.

was placed in front of the aperture are shown, no light emerges on either side of the zero-line, except that yielded by the parallel beam of light itself. Hence we merely obtain the single measurement shown by the point on the diagram surrounded by the small circle, corresponding to the intensity of the light passing through the aperture.

Fig. 4 illustrates the corresponding condition of affairs when the sheet of clear glass was placed in front of the orifice. We again obtain practically no diffusion, and practically the same figure as in the previous case, the only difference being that the intensity is reduced by absorption to only 22·1 H.K. instead of 24·5; the encircled point is therefore merely brought a little nearer the origin. In the case of the other glasses the light is diffused. Figs. 5, 6, and 7, correspond to the ribbed glass IV., the frosted glass III., and the rippled glass II. respectively.

The most uniform diffusion occurs in Fig. 6, the angle over which a measureable illumination in a horizontal plane exists being as much as 20°. In the case of the ribbed glass (Fig. 5)

Variety of Glass.	Intensity of light with no glass plate.	Intensity of light with glass plate.	Percentage loss of light along the line 0°.
——	24·5 H.K.	——	0 per cent.
Clear Glass I.	”	21·1 H.K.	9·8 ”
Rippled Glass II. ...	”	4·65 ”	81·0 ” max. 73·5 ” min.
Frosted Glass III. ...	”	0·60 ”	97·5 ”
Ribbed Glass IV. ...	”	1·67 ”	93·0 ”

A mere knowledge of the light absorbed in the direction of the 0° line, however, by no means yields us all the information that is essential in order to judge the qualities of the specimen of glass under examination. With the exception of the clear plane-parallel glass, all these specimens alter the distribution and diffuse the light of the parallel beam. Therefore the distribution-curves of the light emerging through each of the specimens in a horizontal plane drawn through the line 0° as axis was studied.

In Fig. 3, in which the results obtained when no glass of any kind this range amounted to 35°, but the distribution of light was not so uniform as in the previous case. During these measurements the sheet of glass was so placed that the ribbed lines ran a vertical course, *i.e.*, perpendicular to the plane of measurement. The rippled glass also diffused the light, but only over 6°—a narrower region than in the case of glasses III. and IV. The loss of illumination in the 0° direction is, however, very small.

The curved surface of this glass gives rise to very irregular diffusion, distinct maxima and minima being distinguishable, and in contradistinction to all the other cases, the greatest illumination in this instance does not occur along the direction-line 0°. This, however, naturally depends upon the position of the piece of glass covering the aperture; by altering this position either a maximum or a minimum can be obtained.

MEASUREMENTS OF ILLUMINATION.

In order to study these different specimens under more practical conditions, some measurements of illumination were carried out in a room, the window of which could be occupied by sheets of either of the glasses to be examined. For the purpose of these experiments the Martens photometer was utilized, measurements being made in a horizontal plane, at a height of one meter above the floor. The walls and ceiling of the room were coated with a material yielding a dead-black surface, the only source of illumination being a window 35 centimetres square. In this aperture the various glasses were introduced in turn. This window is shown in plan and outline in Fig. 8.

The measurements took place firstly along the line *a*, which is parallel to, and 50 centimetres distant from the window, and secondly along the parallel line *b*, which is situated at a distance of one metre. Both these lines lie in a horizontal plane through the lower ledge of the window. The small circles, occurring at intervals of 10 centimetres, indicate the points at which measurements were made. The measurements along the line *a* could not be extended any further to the right, as this would have brought the instrument into the shadow of the wall.

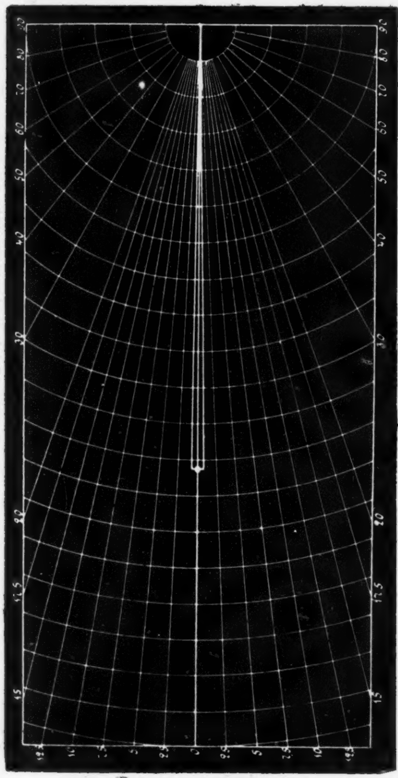


FIG. 3.—No Glass.

ONE DIVISION = 1 H.K.

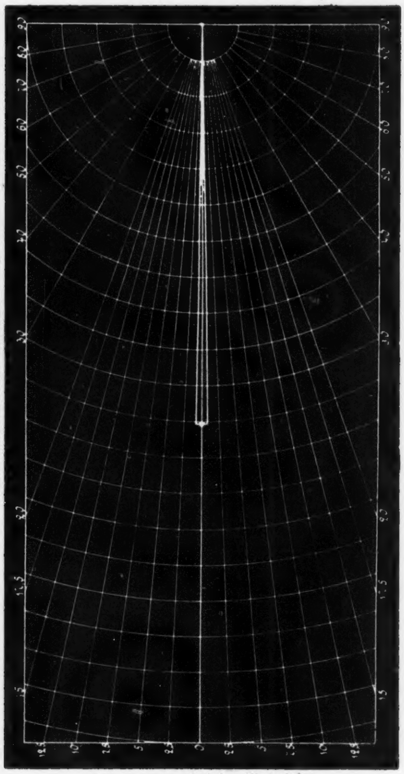


FIG. 4.—Clear Glass.

The intensity of illumination throughout the day varies very greatly when afforded by intermittent sunshine or an irregularly clouded sky; for this reason a dull cloudy day during the month of February, 1908, on which the sky as a whole presented a uniform grey tint, was selected for these experiments. Before and after each measurement,

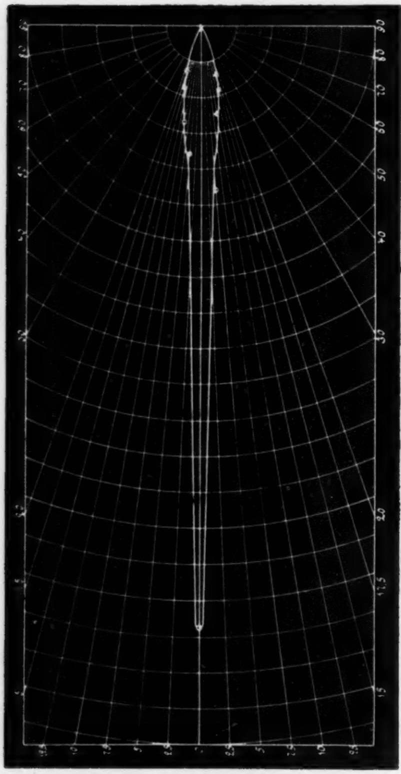


Fig. 5.—Rubbed Glass.

One Division = 1 H.K.

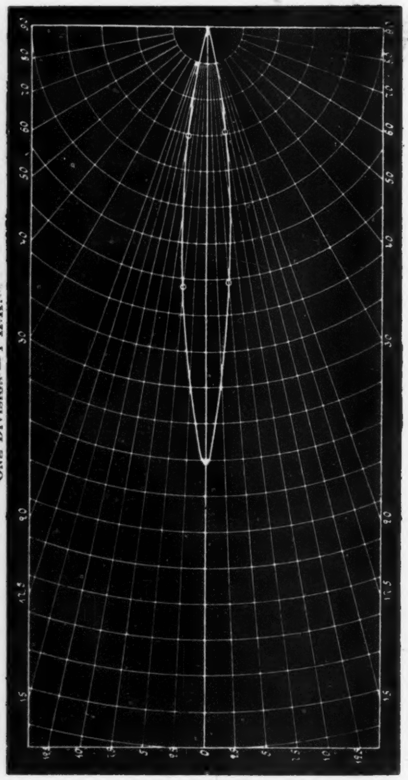


Fig. 6.—Frosted Glass.

the window pane was removed and the value of the illumination at the first left point of reference in the line *a* tested. In this way it was possible to form an idea of the fluctuation in brightness that were likely to occur in the course of the experiments. The following are the greatest variations recorded obtained, as described, with the open window :—

Plate of clear glass, 89–102 lux.
„ „ ribbed „ 76– 80 „
„ „ rippled „ 80– 81 „
„ „ frosted „ 89– 90 „

During the measurements with the plate of clear glass, the illumination was somewhat greater than in the other cases. The curve shown in Fig. 9, illustrating the results of this experiment, along the line *a*, shows that the most intense illumination extended across the breadth of the window, and then gradually fell away to zero. The bending of the curve of illumination for the point furthest to the left along the line *a* arises from the obstruction caused by the central opaque support of the window-pane. It is evident how much weaker, and at the same time how much more uniform, is the illumination along the line *b*.

Figs 10, 11, and 12 represent the corresponding results in the case of the ribbed, frosted, and rippled glass respectively. During these measurements the frosted side of the glass III. and the ribbed side of the glass IV. were presented to the light.

which it is composed, but must also be ascribed to the presence of dirt, which cannot be entirely avoided after glass of this kind has been in use for a short time — at least not without the help of cleaning apparatus which is not likely to be used under practical conditions.

The marked maximum which occurs

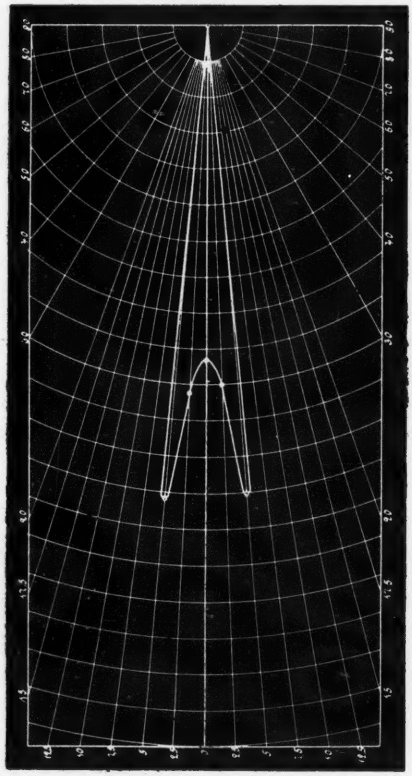


FIG. 7.—Rippled Glass. One division=1 H.K.

at the point of measurement abscissa 20 in the case of the curve of illumination obtained with the rippled specimen (Fig. 12) may be ascribed to the lens-action of the ripples on the surface of the glass.

From a comparison of Figs. 10 and 11 it may be seen that the frosted glass clearly absorbs a greater amount of light than the others, but is more effective in diffusing the light, thus giving rise to a uniform degree of illumination. The want of uniformity in the illumination obtained in the case of the ribbed glass, may be partially due to the irregular nature of the ridges of

The results of measurements of illumination in a blackened room represent what occurs in an extreme case. On the one hand it may be remarked that the general course of the curves of illumination will be unaffected by the light reflected from neighbouring walls, &c. On the other hand the individual readings will be appreciably lower, in the case of a blackened interior, than those which would be obtained under otherwise similar conditions, in a room provided with the usual light-coloured walls and ceiling.

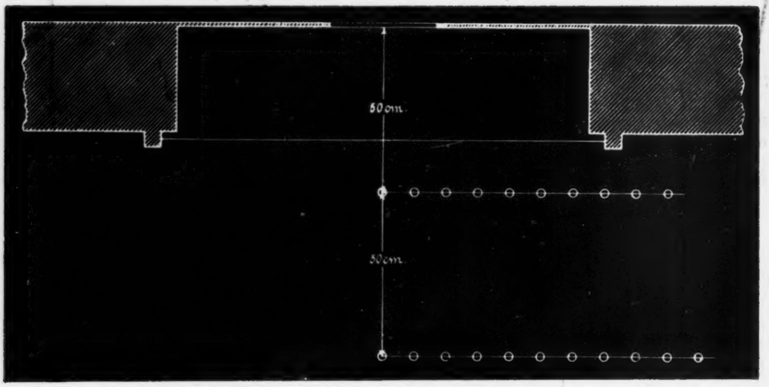


FIG. 8.—Plan of Window. Upper line *a*. Lower line *b*.

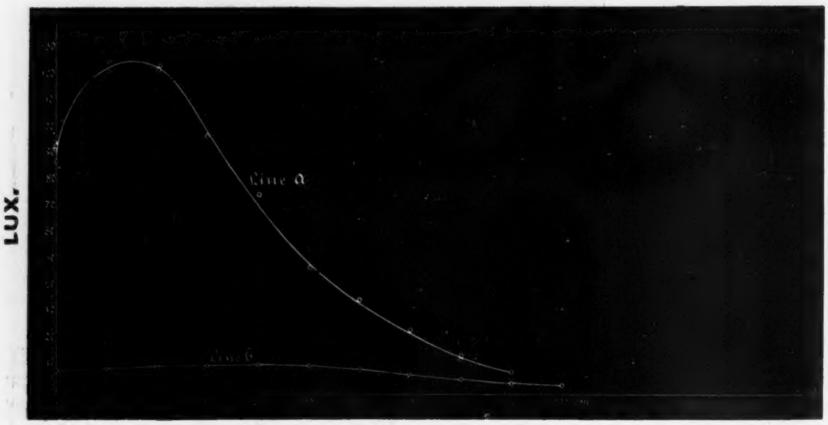


FIG. 9.—Clear glass.

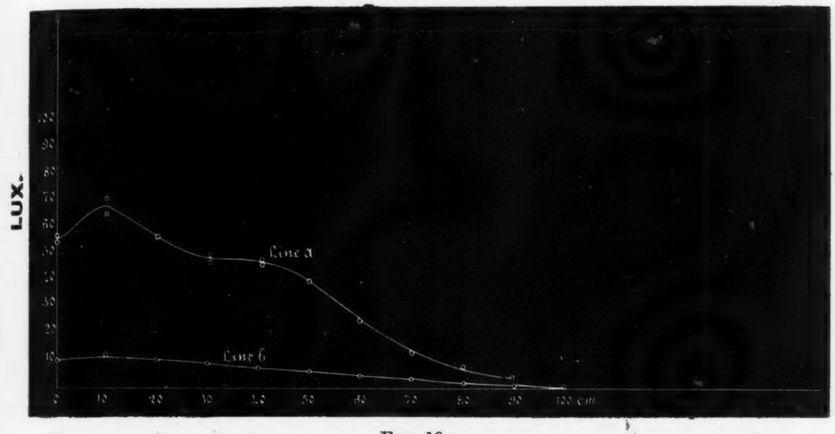


FIG. 10.

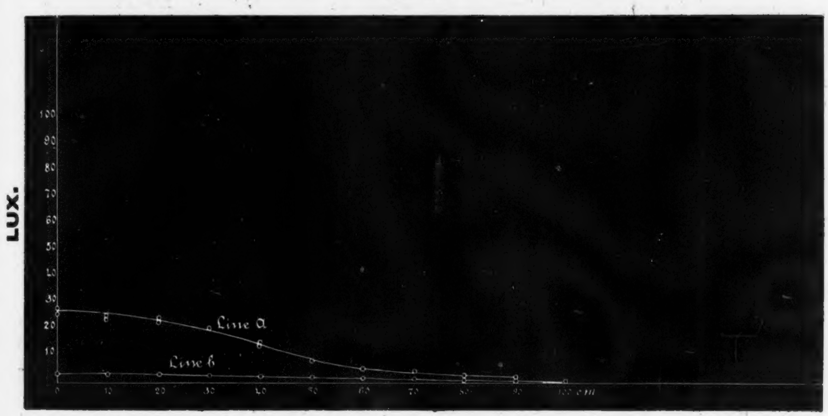


FIG. 11.—Frosted Glass.

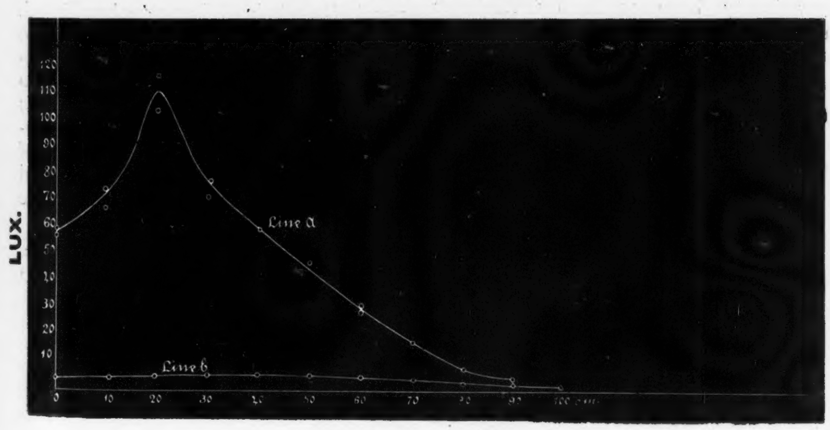


FIG. 12.—Rippled Glass.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 296.)

From the commencement of quantitative work in connexion with radiation, attempts have been made to determine the fraction of the total power or radiation of a luminous source which is given out as light. As early as 1833 Melloni, in the course of his classical studies of radiation, is stated to have made a measurement of the total radiation from a lamp and of that portion transmitted through a transparent plate of crystallized alum which was assumed to be light. Tyndall in 1862 improved on this process, and made several experiments at the Royal Institution on gas flames and the electric arc. He also employed another method in which a spectrum of a source of light was formed, and the distribution of energy for various portions of the spectrum obtained by a thermopile. The efficiency was then deduced from the area of the curve between the limits of the spectrum, compared with the total area. This method has been since developed by Langley to a remarkable extent.

One other method remains to be described, that of the calorimeter, which was first employed by Merritt of Cornell, although attempts had previously been made by Blattner in 1886, and by Staub. In this method the source of light is immersed in a glass vessel containing water, and the amount of heat given to the water is measured when the light escapes, and when it is prevented from escaping by blackening the lamp bulb.

Before going into details of the work and results of various investigators, a few words must be said as to the meaning of the term luminous efficiency, and as to the *rationale* of the three methods above indicated. All sources of light require a supply of power, which power is dissipated as heat and light, as follows :—

Total power (Q) {
- Conduction (through supports, &c.)
- Convection (air currents)
- Total radiation (R) {
  - infra-red—"dark heat"
  - visible—light (L)
  - ultra-violet—"chemical rays"

It is obvious, therefore, that the practical meaning of luminous efficiency should be that fraction of the total power which is given out in the form of light, or $\frac{L}{Q}$. In the majority of experiments, however, this fraction is not directly determined, but an attempt is made to find the fraction of the total *radiation*, which is given out in the form of light, or $\frac{L}{R}$. To remove the confusion which has existed between these two fractions, Prof. Nichols of Cornell has proposed the terms "total efficiency" for the former, and "radiant efficiency" for the latter, so that we have—

$$\text{Total efficiency} \quad \eta = \frac{L}{Q}$$

$$\text{Radiant efficiency} \quad \eta_R = \frac{L}{R}$$

To obtain the total efficiency from the radiant efficiency, therefore, it is necessary to multiply by the fraction $\frac{R}{Q}$. In the case of electric glow lamps, nearly the whole of the power is radiated, as there is no air in contact with the filament, and the supports of the filament are too thin to conduct much ; so that the total and radiant efficiencies are not very different. With combustion, however, a very large amount of convection always takes place, and hence the radiation may not be more than a fifth of the total power.

A further difficulty yet remains, however. The quantities R or Q are perfectly definite in meaning, and can usually be measured with fair accuracy. But the power in the form of light, L, is simply that part of the radiation which affects the retina of the eye, and consequently requires to be taken between the limits of the visible spectrum. These limits are generally taken as between wave-lengths of ·38 and ·76 μ (1 μ = ·001 mm.). But even assuming these limits to be definitely known and invariable, we are not dealing with one kind of light, but with all the colours from red to violet, and the visual value or luminosity of these colours is very different. We are therefore confronted with the difficulty that if we define the total efficiency as $\frac{L}{Q}$, all sources having the same values of L and Q would have the same efficiency, while if one of these sources were of a yellow colour and another of a blue or violet colour, their illuminating powers would be very different.

To obviate this difficulty Prof. C. Féry and Dr. C. Guilleaume in France have made propositions which are equivalent in meaning. Instead of taking the total power of the source between the spectral limits, it is proposed to substitute the amount of power required to produce the same luminous effect as the source, in light of a definite character, and this light is the yellow-green light corresponding to the wave length ·54 μ which appears from various experiments to be the light which gives the maximum visible effect for a given amount of power. Unless, therefore, the source emits this kind of light, there will be an amount of power L_λ less than L which will give the same luminous intensity as the source in the form of yellow-green light. The present writer has proposed to call the fraction $\eta_\lambda = \frac{L_\lambda}{Q}$ the "reduced" luminous efficiency as it is reduced to light of a standard colour, and although this mode of reckoning luminous efficiency is open to some criticism, it appears to be more definite in meaning and of greater practical value than any other.

This leads us finally, therefore, to a very simple and definite method of determining luminous efficiencies. Instead of finding out the amount of power contained in the light to be tested, we have to find the amount of power required to give the same intensity in yellow-green light. But this means obviously that if we can determine once for all the amount of power to give one mean spherical candle-power of yellow-green light, it will only be necessary to find the power in watts per candle for the source to be tested, by ordinary photometric methods. The total luminous efficiency of the source will then be obtained by dividing the power in watts per candle for the yellow-green light, by the power in watts per candle for the source.

This quantity—the power per mean spherical candle-power of some standard light—is what may be called the mechanical equivalent of light. Hitherto this term has been applied to the power required to produce a mean spherical candle of white light, but this is very indefinite for the reasons above stated, and it would therefore probably be better to restrict it to that required for a mean spherical candle-power of monochromatic light of maximum luminosity. The advantages of this are, firstly, that it is only necessary to fix one quantity, the wave-length of the standard light, which appears to be more or less definitely settled as ·54μ; and, secondly, that as this is taken as the wave-length of maximum luminosity small variations in the purity or wave-length of the light are without great influence on the result.*

With these preliminary remarks we may pass to the experimental methods and results. It will be seen that there are four methods by which luminous efficiencies may be determined.

A. Thermopile or other detector of radiation with absorbing screens (radiant efficiency).

B—Calorimetric measurement with clear and obscured lamp (total efficiency).

C—Measurement of the distribution of power along the spectrum (radiant efficiency).

D—Comparison of power consumption, with the mechanical equivalent of light (reduced total efficiency).

* It is probable, however, that this figure depends to a certain extent upon the part of the retina employed in the observations.

A—*Absorbing screen method.*—The method employed by Tyndall in 1862 appears to have been followed almost exactly by later workers. The radiation from the source under test was first allowed to fall on the blackened face of a thermopile, and a deflection, D_1, was obtained on a galvanometer connected to it proportional to the total radiation from the source. A trough of water or alum solution was then interposed and a second deflection, D_2, obtained. If the trough permitted the whole of the light to pass, and cut off all the invisible radiation, we should have the radiant efficiency $\eta_R = \frac{L}{R} = \frac{D_2}{D_1}$

But as a matter of fact the trough absorbs some of the light and transmits some of the "dark heat." The amount of light lost is simply determined by a photometric measurement of the brightness of the source with and without the trough. If a is the co-efficient of transmission of the trough $= \frac{K_2}{K_1}$ where K_2 is the brightness of the lamp with the trough interposed, and K_1 that without it, it is clear that the deflection D_2 should be increased to $\frac{D_2}{a}$ to allow for this absorption.

To determine the amount of "dark heat" passing the water or alum trough Tyndall sought for a substance which, while opaque to light, would transmit heat freely, and he found that a solution of iodine in carbon bisulphide fulfilled these conditions. A second trough containing this solution was then placed behind the first and the deflection D_3 noted, due to the radiation passing both troughs. The corrected value of the radiant efficiency $\eta_R = \frac{D_2 - D_3}{a\,D_1}$ This method was employed by Prof. Julius Thomsen of Copenhagen in 1865,* who determined the radiant and total efficiencies of candles, gas flames, and lamps. He, however, only used a water cell 20 cm. thick, and does not mention any corrections for absorption. By an ingenious method based on Dulong and Petit's experiments he separated the radiation from the total power consumption of the flame, finding that with a sperm candle 1400 calories per minute were consumed, of which 210 calories or about one-seventh was radiation, the remaining six-sevenths being conduction and convection. The radiant efficiency by the absorption method came out at 2·1 per cent., giving 4·4 calories per minute, or approximately 0·3 watt as the power in the form of light, or the mechanical equivalent of the light of one candle.

* "Das Mechanische Aequivalent des Lichtes," Pogg Ann. CXXV. 1865, p. 348.

Tumlirz and Krug* employed the same method as Thomsen, substituting, however, a large air thermometer for the thermopile. Nearly the whole of the work on luminous efficiencies, however, which has been done until quite recently, has been by Prof. Nichols and his associates at Cornell. E. Merritt† in 1888 determined the efficiency of glow-lamps, using the alum and iodine screens, finding it to vary from ·5 to 7 per cent, depending on the voltage. The upper figure was for about 3 watts per candle-power. Nakano‡ and Marks§ next determined the radiant efficiency of the arc-lamp, obtaining values of from 8 to 16 per cent under the best conditions; while Geer‖ found an efficiency of from 41 to 48 per cent for the mercury vapour-lamp. Drew,¶ using a special form of radiometer as detector, measured the luminous efficiency of a vacuum tube and found it to be about 44 per cent;

* 'Die Energie der Warmestrahlung bei der Weissgluth,' *Sitzungsber der Kais Akad. der Wiss. Wien*, xcvii., 1888, abth. IIa, p. 1523.

† 'Some Determinations of the Energy of the Light from Incandescent Lamps,' *Am. Ass. for the Advancement of Science*, Cleveland, Aug., 1888.

‡ 'The Efficiency of the Arc Lamp,' *Trans. A.I.E.E.*, vol. vi. p. 308, May 23rd, 1889.

§ 'Life and Efficiency of Arc Lamp Carbons,' *Trans. A.I.E.E.*, vol. vii. p. 170, May 21st, 1890.

‖ 'Radiant Efficiency of the Arons Mercury Vapour Lamp,' *Elec. World and Engineer*, vol. xl. p. 86, July 19th, 1902.

¶ 'The Luminous Efficiency of Vacuum Tube Radiation,' *Phys. Review*, vol. xvii. p. 321, 1905.

Nichols* himself, however, after a study of the transmitting properties of various solutions in conjunction with Coblentz,† has come to the conclusion that absorption methods of determining luminous efficiencies are fundamentally unreliable. The prevailing belief in the heat-absorbing property of alum solution was shown to be entirely wrong, while, on the other hand, the iodine solution was found to absorb only a limited range of the heat waves, as shown in Fig. 1. He, however, found

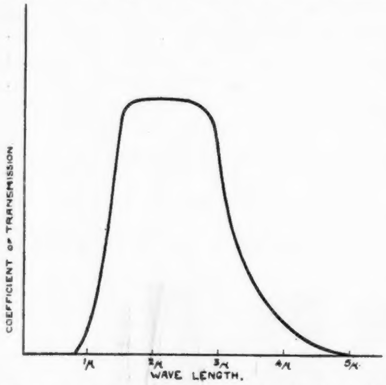


Fig. 1.—Range of wave length absorbed by Iodine Solution.

that a green solution of ferrous-ammonium sulphate $FeSO_4.(NH_4)_2SO_4.6H_2O$ was remarkably opaque to all but luminous radiation; and this solution has been rediscovered in Germany by Russner and by Dr. Lux, whose results appeared in this paper a little while back.

B. *Calorimeter Method.*‡—The arrangement employed by Merritt is typical of this method. The calorimeter consisted of a glass vessel 22 cm. diameter and 38 cm. high, supported on two iron bars so as to allow the light to escape as freely as possible. A continuous stream of water was allowed to flow freely through this vessel, and the temperature of the inflow and outflow water noted, when the lamp was immersed in the calorimeter. The rate of heat production in this case $H_1 = Q - h$, where h is the radiation which escapes in the form of light, &c., while if the lamp is blackened the evolution of heat $H_2 = Q$. If the escaping radiation were the whole of the light we should have $\eta = \frac{L}{Q} = \frac{H_2 - H_1}{H_1}$; but this must be multiplied by a factor $\frac{k}{a}$, where k is the ratio of light to total radiation determined with a thermopile and iodine cell; and a is the proportion of light transmitted, as obtained by a photometer. Merritt obtained results for the total efficiency by this method which were in fairly close argeement with those obtained for the radiant efficiency by the absorbing screen method.

The only other experimenter who has employed the calorimeter method appears to be J. Russner,* who in the early part of last year made some measurements, using the green ferrous ammonium sulphate solution before mentioned. His calorimeter was 10 cm. in diameter and 20 cm. high, and contained 1300 cc. of a 30 per cent solution of the salt, the heat being obtained by the rate of rise of temperature. With this solution he obtained much lower values for the total efficiency than those above given, viz., about 0·6 per cent for the carbon filament lamp, or about one-tenth of Merritt's value. Soon after Mr. Jolley and the present writer experimented with this method, and found that when water was used in the calorimeter, values not far from those of Merritt were obtained, while with the ferrous ammonium sulphate solution extraordinarily low values resulted. In our case, however, it was noticed that the solution decomposed and became turbid during use, giving rise to the idea that chemical action was masking the results. The method was consequently abandoned as unreliable.

(*To be continued.*)

* 'A Study of the Transmission Spectra of certain Substances,' *Phys. Review*, vol. i., July-August, 1893; 'Distribution of Energy in the Spectrum of a Glow Lamp,' *Ibid.*, Jan.-Feb., 1905.

† 'On Methods of Measuring Radiant Efficiencies,' *Ibid.*, vol. xvii. p. 302, 1903.

‡ *Loc. cit. ante.*

* 'Über die Licht und Wärmeenergie von Glühlampen,' *Phys. Zeitschr.*, viii. pp. 120-123, Feb. 15th, 1907.

Devices for Screening Stray Light from Photometers.

By Dr. Paul Krüss.

One source of error which may considerably influence photometrical readings under certain circumstances, consists in the effects of the diffused light reflected from the walls, floor, and ceiling in the photometer-room, owing to their being illuminated by the source of light under test. In order to reduce this stray light to a minimum the walls and ceilings of such rooms are usually coated with some material giving a dull, black, non-reflecting surface. One also endeavours to secure that the dimensions of the room are sufficiently great to enable the photometer to be at least one metre distant from these surfaces. For the same reason it is preferable not to mount the photometer-bench upon a table offering an extended reflecting surface, but upon suitable isolated supports.

In spite of these precautions it is not infrequently found, particularly in the photometry of very powerful sources of light, that results are obtained which deviate very considerably from the true value. Dr. H. Krüss has already described in the *Journal für Gasbeleuchtung* several sets of experimental results which clearly indicate how great errors of this nature may be, when photometry is carried out without any systematic method of screening from stray light being adopted.

One well-known method of avoiding the influence of such stray light consists in the use of a number of suitable screens, covered with black velvet, and placed at intervals along the photometrical bench. These are, of course, provided with apertures for the benefit of the beam of light, the intensity of which is to be tested, as shown in Fig. 1.

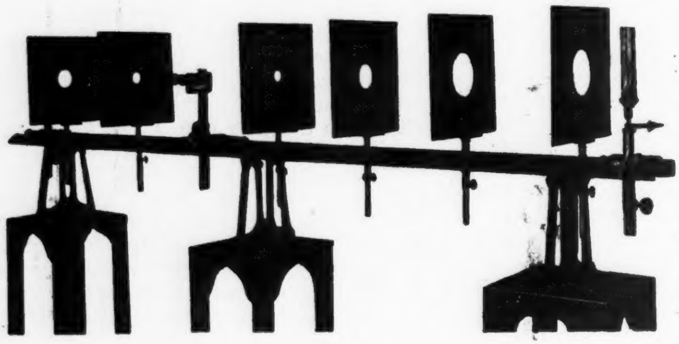


Fig. 1.

These apertures can be so adjusted as to limit the passage of this beam to as narrow a region as possible without actually interfering with photometric measurement by cutting off some of the light from the photometer. The size of these screens, however, necessarily renders them somewhat inconvenient, especially when, owing to the difference in brilliancy of sources of light to be tested, it is desired to move the photometer to and fro over a considerable distance along the photometer-bar. This inconvenience can be effectually reduced by actually attaching the screen to the photometer, so that both are moved along the bar together. The author has found the device shown in Figs. 2 and 3 especially handy for this purpose.

the surfaces in the photometer are so chosen as not to interfere with the free passage of the direct rays. On the other hand, all light coming into the

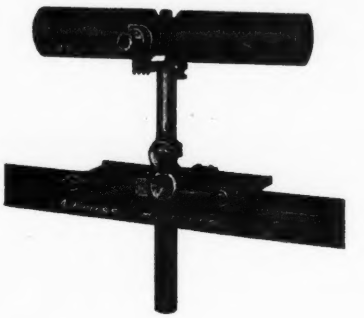


Fig. 2.

The device consists essentially of a hollow tube, the inside of which contains a number of circular blackened screens, pierced with suitable apertures through which the light can pass to the photometric surfaces. The size of these orifices and their distance from tube from the side is reflected to and fro by the blackened surfaces within and effectually absorbed.

This tube cannot be said to render the arrangement of supplementary screens shown in Fig. 1 entirely unnecessary. It may be advisable either

	Without Screens of any kind.	With protecting tube shown in Fig. 2.	With arrangement of screens shown in Fig. 1.
Table I.	89·6 H.K. 87·6 ,, 87·4 ,, 89·1 ,, 85·8 ,,	84·0 H.K. 83·4 ,, 81·6 ,, 84·1 ,, 82·8 ,,	84·0 H.K. 82 8 ,, 83·4 ,, 83·4 ,, 81·6 ,,
	Mean 87·9 H.K. Error + 5·9 per cent.	83 2 H.K. + 0·2 per cent.	83·0 H.K. ±0 per cent.
Table II.	87·3 H.K. 86·0 ,, 88·0 ,, 87·6 ,, 87·2 ,,	83·0 H.K. 81·6 ,, 82·8 ,, 82·7 ,, 82·2 ,,	80·5 H.K. 82·5 ,, 82·8 ,, 80·7 ,, 81·3 ,,
	Mean 87·2 H.K. Error + 6·9 per cent.	82·5 H.K. + 1·1 per cent.	81·6 H.K. ± 0 per cent.
Table III.	145·0 H.K. 148·1 ,, 142·3 ,, 146·7 ,, 140·2 ,,	133·5 H.K. 144·1 ,, 135·0 ,, 136·5 ,, 141·2 ,,	134·1 H.K. 132·6 ,, 135·0 ,, 143·9 ,, 140·2 ,,
	Mean 144·5 H.K. Error + 5·3 per cent.	138·1 H.K. + 0·7 per cent.	137·2 H.K. ± 0 per cent.

to enclose the source of light in some form of light-tight box or to place an additional and relatively large screen in front of it. But there remains the great advantage that practically the entire length of the photometer-bar is free from obstruction, so that the photometer can conveniently be moved to and fro, as desired.

Finally, the author gives the results of some experiments which illustrate the practical utility of the methods of protection outlined above. For the purpose of these experiments a standard photometer-bench 2·5 metres long, as utilized in gas-testing, equipped with a Lummer-Brodhun photometer, was employed. This bench was supported on three trestles, and was placed at the prescribed distance from the blackened walls of the laboratory. The tests were carried out, firstly, without any screens at all being used; secondly, with the protecting tube device shown in Figs. 2 and 3; and thirdly, with the arrangement of screens shown in Fig. 1.

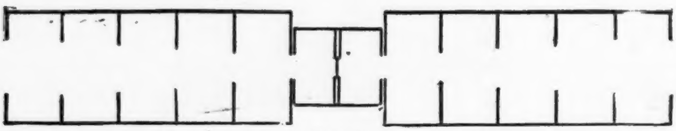


FIG. 3.

Tables 1 and 2 refer to experiments with an incandescent mantle, and Table 3 to a test on a Lilliput arc lamp taking 1·5 amperes, the intensity being measured in a horizontal direction.

Low Candle-Power Lamps for Sign-Lighting.

UNDER the above title an American contemporary recently referred to the merits of small units for use with illuminated devices. Whatever be the merits of this or that form of lamp for sign illumination, the advocacy of small units of light for this purpose certainly represents a point of view which is well worth consideration.

There are many cases in which a lamp is not, strictly speaking, employed for the purpose of "illuminating"—*i.e.*, of making bright its surroundings. In the case of signs taking the form of patterns composed of glow lamps, all we usually desire is that the individual lamps shall be bright enough to be clearly distinguishable from its surroundings, and if these surroundings are relatively dark a very intense source of light is not necessary. Probably it would often be found that the impression on the eye produced by a cluster of 32 c.-p. lamps instead of 8 c.-p. lamps did not justify the greater expenditure of energy involved. Of course in all such cases there are points of view besides the purely utilitarian to be considered. It is conceivable, for instance, that a shopman might resent the superior brightness of his neighbour's illuminated sign, even though his own achieved its object in being perfectly legible to the passer-by, at a fraction of the running cost.

Many other instances will occur to the reader in which lamps are used, not with a view to illumination, but with the object of indicating the position of something. In all such cases the desirable brilliancy of the source of light is certainly governed by other considerations than those determining the brightness of a source intended to *illuminate*, and therefore merits special consideration.

Gas Testing in London.

By R. Aglio Dibdin.

The Metropolis Gas Act, 1860, provided for the testing of gas by an examiner appointed by the local authority, with apparatus provided by the company. The minimum illuminating power of common gas was fixed at 15 candles when tested in an Argand burner with 15 holes and a 7-inch chimney. The illuminating power of cannel gas was not to be lower than 20 candles when burnt in a batswing burner. The legal candle is defined in this Act as a sperm candle weighing six to the pound, and burning 120 grains each per hour. The tests for purity prescribed in this Act allow 20 grains of sulphur per 100 cubic feet; for ammonia there must be no discoloration of turmeric paper, and for sulphuretted hydrogen no discoloration of lead paper when these papers are exposed to a stream of gas under a pressure of five-tenths of an inch of water for one minute. The local authority and the gas company were, however, at liberty to agree upon other methods of testing for purity. Differences between the authority and the company were to be referred to and determined by arbitration as provided by the Companies' Clauses Consolidation Act of 1845.

The penalty for insufficient illuminating power or purity was not to exceed £50 and £10 in addition for every day the defect continued after notice in writing had been received by the company from the local authority. This penalty was not to be imposed when the company could show unavoidable cause or accident for the defect.

The modern official machinery for testing London gas dates from the City of London Gas Act, 1868, and various Companies' Acts of 1868 and 1869, which embodied more or less completely the provisions in the City of London Gas Act.

These Acts provided for the appointment of a chief gas examiner and three gas referees by the Board of Trade, while the Corporation or Metropolitan Board of Works, as controlling authority, appointed examiners. The chief gas examiner was to hear appeals and to issue a quarterly report on the testings.

The referees were to prescribe the number of times and the mode of testing. The burner for testing the illuminating power of gas was to be the most suitable for obtaining the greatest amount of light and to be practicable for use by the consumer.

The gas was to be wholly free from sulphuretted hydrogen.

The testing places were to be as near to, but not less than 1,000 yards from the gas producing station, and not more than one testing place to any station was to be provided. The companies were to provide the apparatus to be under the control of the authority.

The chief gas examiner's decision in the event of an appeal against a report by a gas examiner was to be final and conclusive. In the event of no appeal being made by the Company the gas examiner's report was to be final and conclusive.

In the City of London Gas Act, 1868, the connexion between quality and price of gas was fixed as follows: The illuminating power after Jan. 1st, 1870, was to be 16 candles, as defined in the Metropolis Act of 1860. The Board of Trade, on the recommendation of the referees, with the consent of the companies and the Corporation, might substitute 14 or 15 candles, accompanied with a reduction in price of 2½*d*. per 1,000 cubic feet per candle.

The price of common gas of 16 candle-power was to be no more than 3*s.* 9*d.* per 1,000 cubic feet. The price of cannel gas was to be proportionate to the illuminating power. In the event of the application by the companies or the Corporation the Board of Trade was to appoint two or three commissioners to revise the scale of illuminating power and price. The forfeitures prescribed were 20*s.* per half candle deficient for every 100,000 cubic feet or fraction thereof made at the station on the day of default; and for purity a forfeiture of £50 per station where the defect occurred per day of default. The forfeitures, of course, were not to be enforced when the company could show unavoidable cause or accident.

In the South Metropolitan Company's Act of 1869 the majority of the above provisions were included, but the candle power was fixed at a minimum of 14 candles, and the price at the maximum of 3*s.* 6*d.* per 1,000 cubic feet.

In the Gas Works Clauses Act (1847) Amendment Act, 1871, it was further provided that five consumers can apply to two justices of the peace, who, by order in writing, may appoint a gas examiner if the local authority is negligent. This applies more particularly to authorities outside London. In country districts one often hears complaints and grumblings about the gas supply. It would be interesting to know how many times the consumers have availed themselves of the power placed in their hands by this Act in order to ensure an adequate supply of gas.

In the Gas Light and Coke Company's and other Gas Companies Act of 1880 an important point is the provision that if on any day there be an excess of impurity, the test for purity on that day shall be taken as the average of the tests on that day and on the day before and on the day following. Another point is that the companies may be represented at the testings on making application in writing in the forenoon of the day previous to that on which they intend their representative to be present.

Modifications in the forfeitures and penalties for default were also provided: for example, with regard to illuminating power, the forfeiture for the first half candle of defective power was fixed at 40*s.*, while the forfeiture for the first and every subsequent candle was fixed at not less than £25 nor more than £100. The controlling authority of any testing place having recovered

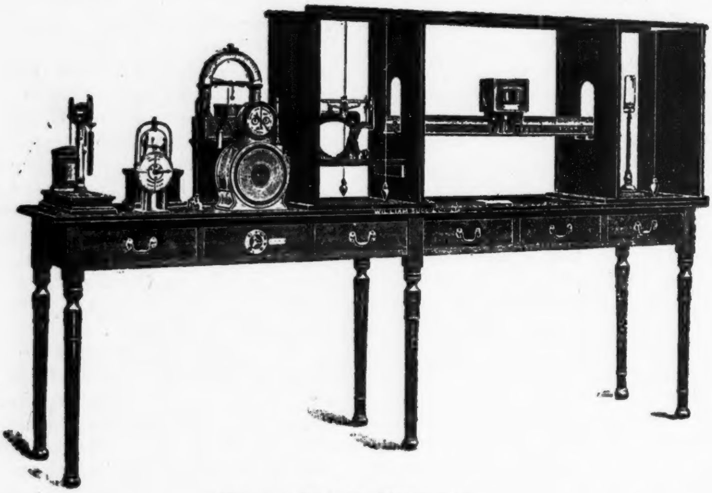


FIG. 1.—Letheby Photometer.

a forfeiture in respect of any testing place on one day could not recover in respect of any other testing place under their control for default on the same day.

The powers conferred by the above and other Acts allowed considerable changes to be effected in the methods

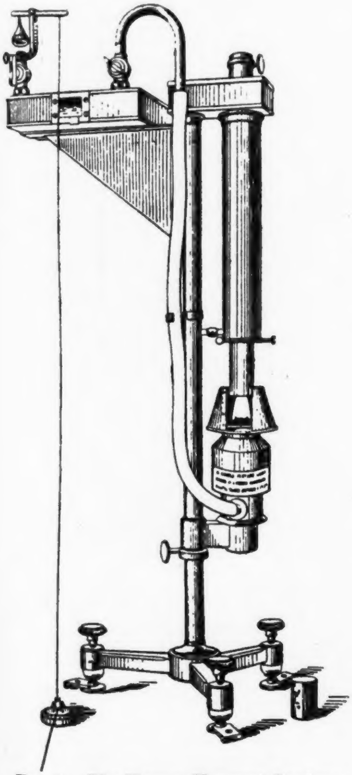


FIG. 2.—The Vernon Harcourt Pentane 10-Candle-Lamp.

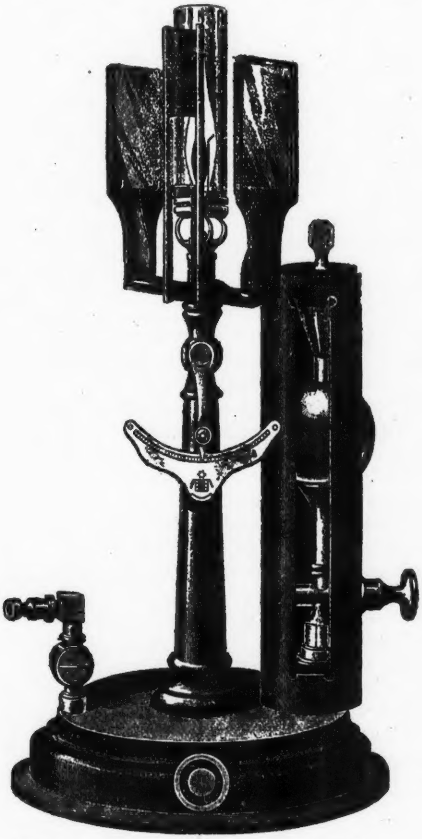


FIG. 3.—W. J. Dibdin's Pentane Argand and Carburetter.

of testing. The Evans and Letheby photometers, both modifications of the Bunsen photometer, were discarded, and the Harcourt table photometer, a modification of the Foucault photometer, was adopted in 1898. The standard candle was a point of contention for a long time. The difficulty of obtaining absolutely reliable candles to conform to the parliamentary standard led to many suggestions. It was also considered desirable to have a standard of comparison which approximated to the intensity of the flame to be tested.

The Board of Trade Committee recommended the adoption of the Dibdin Pentane Argand. The light from this lamp, burning pentane-air, is substantially 10 candles under all conditions of temperature. A change in the height of the flame of 1½ inches makes no appreciable difference in the light emitted from the unscreened portion.

In recommending this lamp as a

standard the Board of Trade Committee made the proviso that the referees, with the consent of the companies, might adopt any modification or improvement thereof as the standard, provided such modification met with the approval of the Board.

The Harcourt Pentane lamp, which was afterwards adopted, had the working advantage of the absence of a glass chimney, the chimney being metal. The light obtained from the unscreened portion of the flame is accepted as 10 candles when the flame is between certain limits of height. Great care in adjusting the height should be exercised, as the variation with change is much greater with this lamp than with the Dibdin lamp. A further point in favour of the Harcourt lamp is the position of the carburetter. With the Dibdin Argand either a stream of gas from the service or a current of air from a holder is necessary. With the Harcourt lamp the carburetter is above the lamp, and the pentane laden air descends, and the need for a holder is abolished.

The two forms of lamp are illustrated in Figs. 2 and 3.

The Harcourt lamp replaced the candle balance and the use of two candles as the standard in 1898. The method of using the table photometer between that date and 1906 depended on burning the gas in a Sugg's London Argand No. 1 at a fixed distance from the screen, and altering the rate of consumption until the illumination afforded by the gas was equal in intensity to the illumination from the Pentane lamp. The distances of the lamp and the burner from the screen, or photoped, were proportionate by the law of inverse squares to the 10 candles of the lamp, and the 16 or 14 candles afforded by the burner.

The method of burning all gases in a burner with a fixed air supply and a varying rate of consumption was open to objection as a poor gas would be "over-burnt" and a rich one "under-burnt." Although the correct value was assigned to the gas when it was exactly at the standard quality, where there was a variation the readings on the instrument greatly exaggerated the deficit or excess of illuminating power.

The London Gas Act, 1905, extended the "three days' average" to the illuminating power, so that if the average of the testings on one day fell short of the prescribed illuminating power then the illuminating power for the day is taken as the average of the testings on that day, on the preceding day, and on the following day.

The sulphur restriction was removed, and the following clause indicates the

FIG. 4.—Sugg's London Argand No. 1.

introduction of non-obligatory calorific tests and flat flame tests :—

5.—(1) Each gas examiner shall at such places and in such manner as may be from time to time prescribed by the gas referees make testings of the gas supplied by the company for the purpose of ascertaining—

(i) The calorific power ;

(ii) The purity as regards sulphur other than sulphuretted hydrogen ; and

(iii) The illuminating power as ascertained by means of a flat flame burner to be prescribed from time to time by the gas referees, which shall be of the best available pattern.

(2) Each gas examiner shall forthwith deliver to the controlling authority to the gas referees to the chief gas examiner and to the company a report of the result of each testing conducted by him under the provisions of this section.

(3) The company shall not be liable to forfeitures in respect of any testings made under the provisions of this section.

(4) The company shall provide and maintain at any testing place such apparatus and materials as the gas referees may from time to time prescribe and certify for use for the purposes of this section and shall give to any gas examiner access to any testing place and shall afford to him all facilities for the proper execution of his duty under this section.

(5) A gas examiner shall make in accordance with this section testings at any place prescribed as hereinbefore provided on such days (exclusive of Sundays) as the controlling authority shall direct.

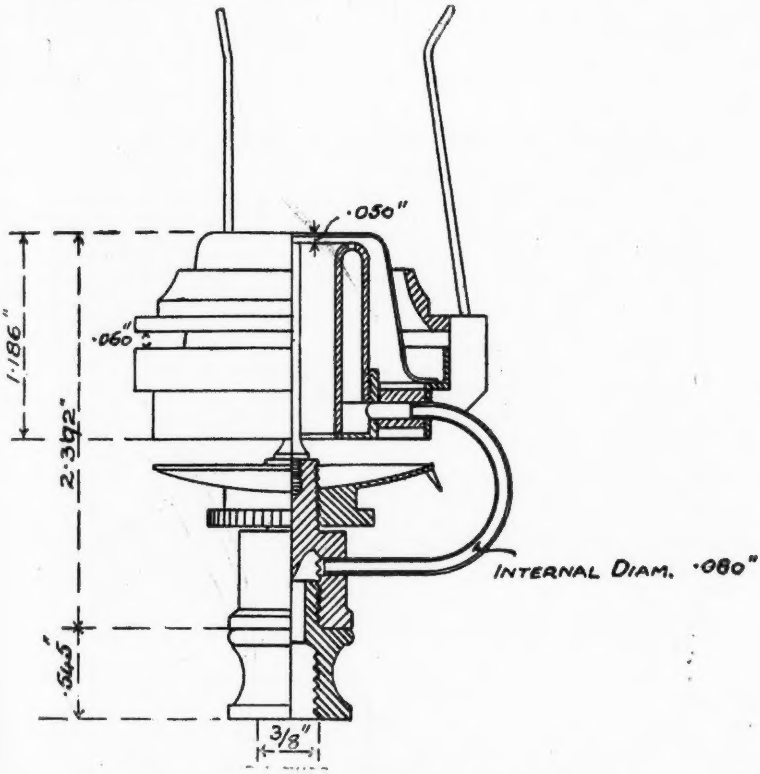


FIG. 5.—Carpenter Metropolitan Argand Burner No. 2.

The Act also makes Sunday testing non-obligatory on the controlling authority.

If the Company neglects or refuses to comply with the prescription of the referees or to maintain any testing place or apparatus, the penalty not

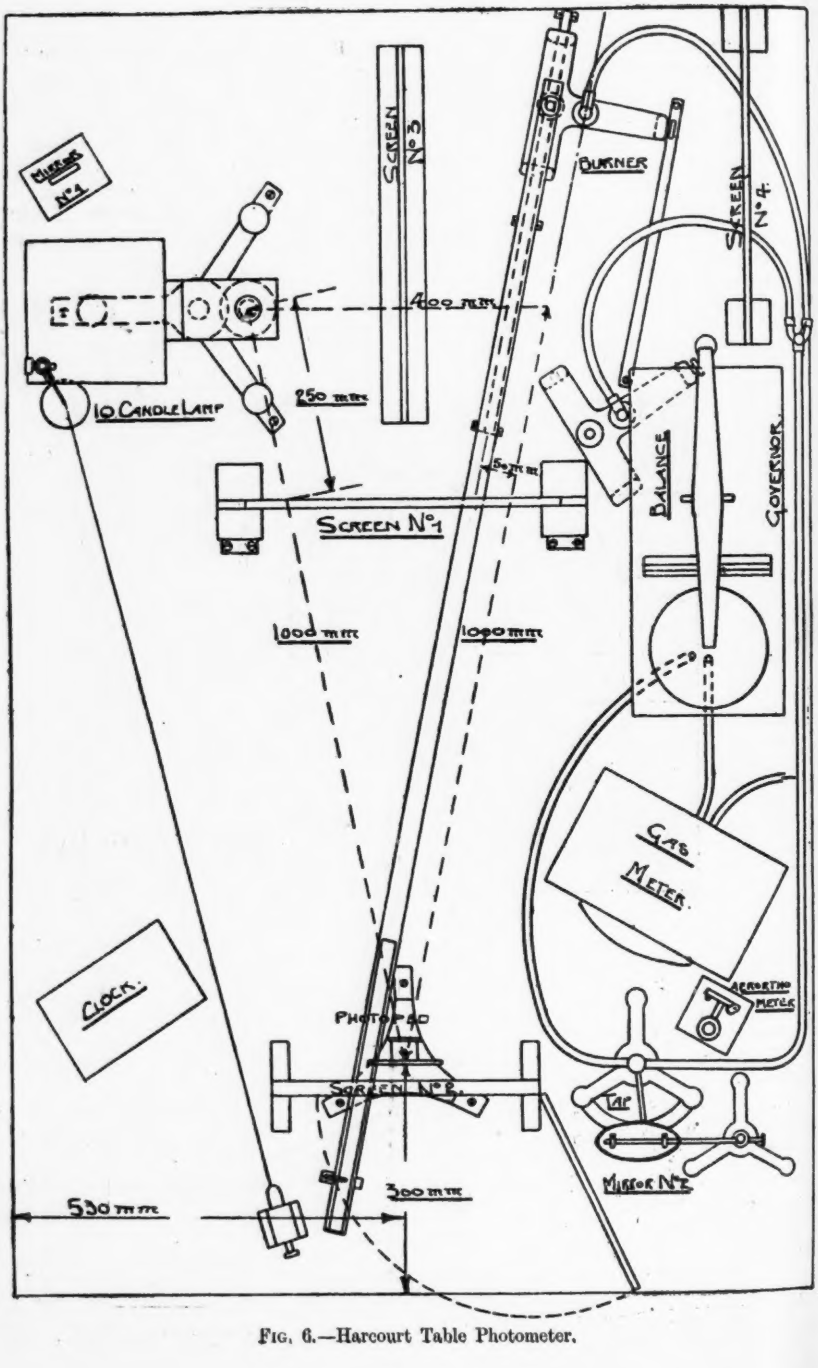


Fig. 6.—Harcourt Table Photometer.

exceeding £50 per day can be imposed on summary conviction.

The foregoing general and rough survey as regards the testing of London gas should give the reader some idea of the importance of the subject. The consumer is guaranteed a supply of gas of a quality corresponding to the maximum price chargeable. The work of the gas examiner, which constitutes, under the Acts, the immediate safeguard of the consumer, is specified in the notification of the gas referees, which is revised from time to time as is provided with a damper, so that the air supply can be adjusted when the rate of burning has been timed to 5 ft. per hour.

Accompanying is a diagram of the photometer table. The operator changes the distance of the burner from the photoped by oscillating the connecting rod until the two lights give equal illuminating effect on the screen of the photoped.

For a test the mean of four readings on the distance scale is taken. This scale on the rod is graduated in candles.

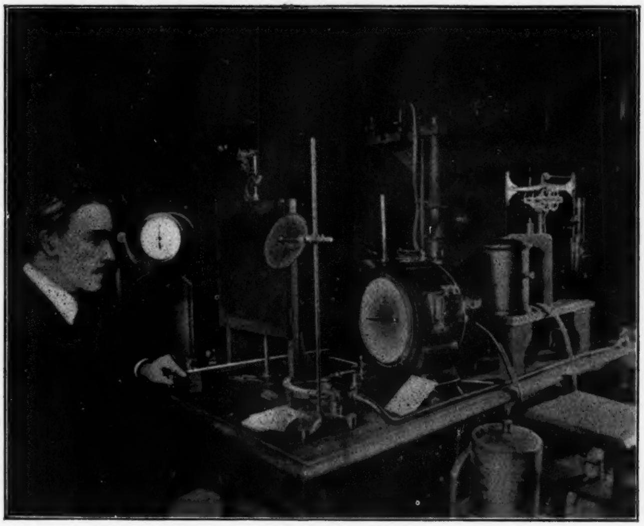


Fig. 7.—Showing photometer-table at testing place. Screens removed to display apparatus.

various modifications or changes seem desirable.

At the present time there are 22 testing places, 2 of which are under the control of the City Corporation, and 20 under the London County Council.

Testings are made daily by a permanent testing staff; and on Sundays, bank holidays, &c., by deputy examiners. Three illuminating power tests are made with the 10 candle pentane lamp, the gas being burnt in Carpenter's "Metropolitan Argand Burner No. 2." (Fig. .) This burner The reading is corrected for temperature of the meter, and the barometric pressure in the room and for the number of seconds taken by the meter hand to revolve twice, indicating the passage of $\frac{1}{6}$ cubic foot of gas. The time must be between 118 and 122 seconds, and the reading of the I.P. is corrected to 120 seconds.

Three tests per day are made with a Bray's burner "marked G/L 5 ft. 15/10, and having a slit 0·028 inch wide."

Before making any illuminating power test gas must be passing through the apparatus for at least 15 minutes.

The examiner must not reject any test "on the ground that the result seems improbable."

The purity tests are for sulphuretted hydrogen and other sulphur compounds. No test is now made for ammonia.

The sulphuretted hydrogen test is made by exposing six strips of absorbent paper, dipped in lead acetate solution, in a glass bell, through which the gas is passing for 3 minutes at about the rate of 5 ft. per hour.

Although the sulphur restriction has been removed, tests are made for other sulphur compounds than sulphuretted hydrogen as a matter of record, and with a view to possible legislation in the future.

Ten feet of gas are burnt at the rate of ½ ft. per hour in a burner round which are arranged pieces of sesqui-carbonate of ammonia. The products of combustion are condensed in a tower filled with damp glass balls. The meter is provided with a catch to cut off the gas when 10 ft. have passed.

The condensed liquor containing ammonium sulphate is treated with hydrochloric acid and barium chloride, and the amount of sulphur in 100 cubic feet of gas is calculated from the barium sulphate formed.

The test for calorific power is made on every day except Sundays. This test is for the purpose of collecting information with a view to possible future legislation. The calorimeter used is one designed by Mr. Boys.

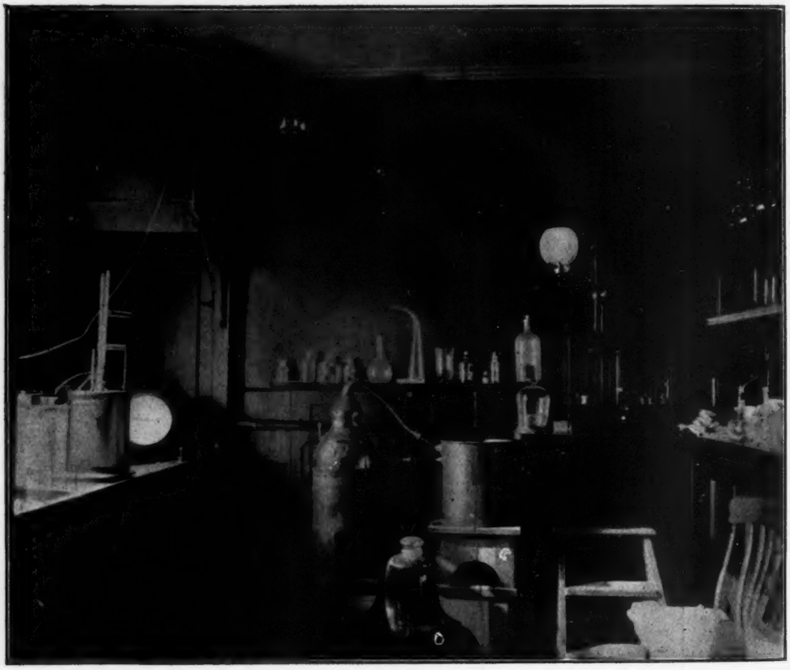


FIG. 8.—Showing Laboratory at a testing place. Calorimeter on the left.

The gas is kept burning and the water running for at least half an hour before any readings are taken. The observations of the temperature of the inflowing and outflowing water extend over 4 to 5 minutes, while ⅓ cubic foot of gas is burnt. The condensed water is collected for a period of 30 minutes, and, from the amount and the time, the amount of heat per foot of gas, given to the water passing through the calorimeter, by the condensation of steam in the burnt gas, is calculated and deducted from the gross calorific power.

Occasionally the controlling authority directs testings for pressure to be made at one of the ordinary public lamps. A portable pressure gauge is used. The prescribed pressure must be such as to balance a column of water not less than $\frac{6}{10}$ inch in height between midnight and sunset, and not less than 1 inch between sunset and midnight.

The examiners are specially selected from a large number of candidates. Those selected as most suitable have to pass a severe practical and *viva voce* examination *in the work* of a testing place. Although other qualifications are taken into consideration, the recommendation of gas examiners is a great factor in the selection of candidates for examination. The Act specifies that the examiners shall be impartial men, and the consumers may rest assured that the ordeal through which a candidate, when selected, has to pass before appointment is no light one. The annual cost of testing London gas is somewhere between 6,000*l.* and 7,000*l.* If we assume that a deficit of one candle is a deficit of one-fifteenth of the illuminating power purchased by the consumer, the loss which would be sustained by the consumer for such deficit in 30 million cubic feet of gas would be 6,000*l.* nearly, assuming that the consumer is buying illuminating power, and not merely so many cubic feet of gas.

The total amount of gas sold per annum in London is about thirty to forty thousand million cubic feet, worth some five million pounds, so that the cost of one candle may be put at 300,000*l.* per annum.

The introduction of the incandescent mantle and of the use of gas for cooking makes the calorific value of gas perhaps of greater importance than the illuminating power in many cases. It remains to be proved definitely how far the one value bears a fixed relation to the other. In any future legislation the results compiled by the examiners with the calorimeter as compared with the illuminating values of the gas supplied from day to day, will be of great importance.

Candle-Power Standards for Gas.

In a recent number of the *Electrical Review* of New York, attention was drawn to one seeming anomaly in the methods of testing gas. The writer points out that it is customary to test such lights by means of flame standards, for under these circumstances the influence of alterations in the atmospheric conditions, effect the candle-power of both sources in the same direction.

Yet after all such a method is not strictly logical, because what we are really concerned in is the actual light yielded by the lamp tested, and not the ratio of candle-power, between the standard and this lamp. It is as though we were to measure the efficiency of a heating apparatus by the difference in temperature between the room than of the outside air. As a matter of fact we do not want merely to keep the temperature of our room a certain amount above that of the external atmosphere, but, on the contrary, to maintain the temperature at a certain constant and convenient value, irrespective of the conditions outside.

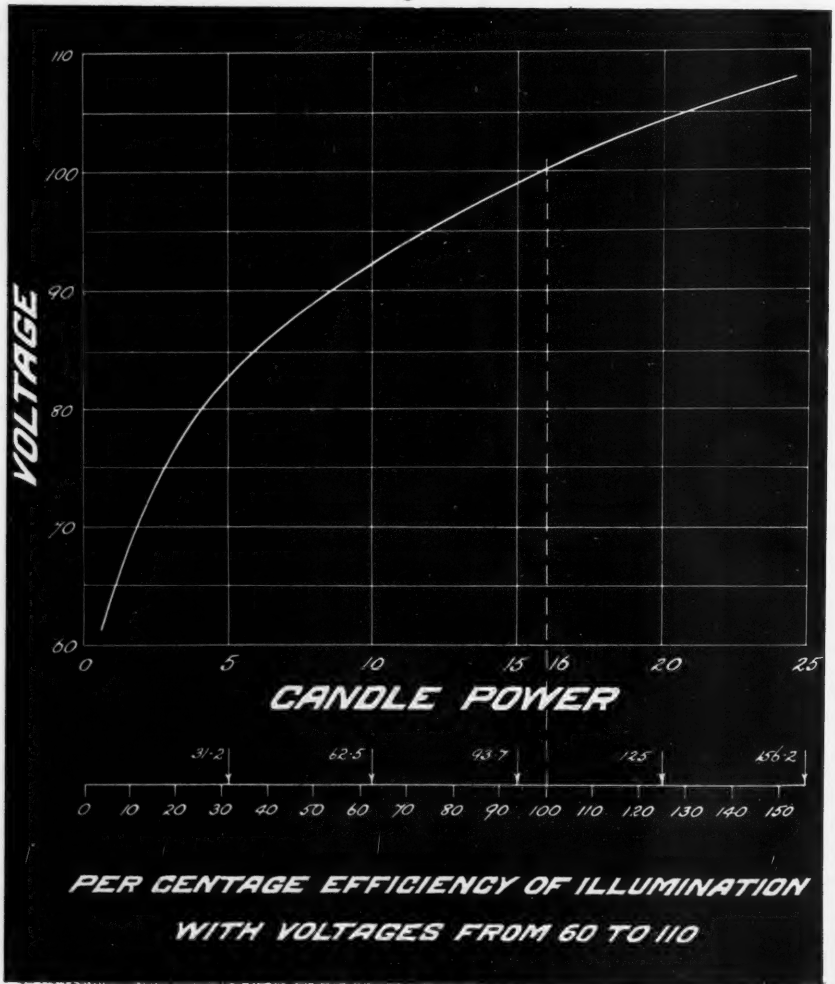
Just in the same way we want our lamp to give a certain amount of light; we are not anxious that it should bear a certain fixed relation to some other lamp when both are varying.

The Effect of Voltage Variation Upon Electric Illumination.

By J. B. Clarke.

From the supply terminals to the lamps of an electric installation there is always a voltage drop or variation due to the resistance of the conducting wires; this has a far-reaching effect upon the illumination, and it is the purpose of this article to show how the size of conductor which will reduce this variation to the lowest degree is arrived at.

The importance of wiring to a specified voltage drop in the conductors of an electric installation becomes apparent when the effect on the illumination emitted by an incandescent electric lamp supplied at varying voltages is considered. The curve which is the result of a test of a nominal 16 candle-power 100 volt



carbon filament lamp, shows this very clearly; the lower line representing the percentage efficiency of illumination at various voltages.

From this it will be observed that a 5 per cent. decrease in the voltage at the lamp terminals gives an efficiency of 74, or a reduction of approximately 26 per cent. in the illuminating power of the lamp; even 2 per cent. decrease of volts produces a considerable reduction in the candle-power, which on an installation of, say, 80–16 c.-p. lamps accounts for a loss of approximately 160 candles.

Since the voltage drop, which so seriously effects the illumination, varies according to the current and the resistance of the conductors, it becomes necessary to carefully consider the means of obtaining the most suitable size of conductor to give a required efficiency.

Taking a case and assuming an installation consisting of 10 electroliers containing 8–16 c.-p. lamps each, radiating from a distributing centre, the length of the circuits being

20	40
30	50
40	60
50	70
60	80
200	300

$$\begin{array}{r} 300 \\ 200 \\ \hline 10)500(50 \end{array}$$

or an average of 50 yards each, with the distributing point situated 20 yards from the source of supply, making the total average length of circuit 70 yards, over which a drop in volts of 2 per cent. may be considered permissible.

For a supply pressure of 105 volts this allowance will be 2·1 volts, and it must be apportioned between the main cable and the distributing circuits. The loss in the main being

$$\frac{2{\cdot}1 \times 20}{70} = {\cdot}6 \text{ volt,}$$

and in the distributing circuit

$$\frac{2{\cdot}1 \times 50}{70} = 1{\cdot}5 \text{ volts.}$$

In arriving at the current for various circuits it is well to allow for carbon filament lamps 4 watts per candle, or for a 16 c.-p. lamp 64 watts. By dividing the watts by the voltage of supply the current per circuit is obtained.

For 80–16 c.-p. lamps on 105 volt supply the current will be

$$\frac{80 \times 64}{105} = 48{\cdot}76 \text{ amperes,}$$

and for 8–16 c.-p. lamps

$$\frac{8 \times 64}{105} = 4{\cdot}87 \text{ amperes.}$$

Calculating the size of the main cable to carry a current of 48·76 amperes with a loss of 0·6 volts, the resistance, by "Ohms" law, $\left(\frac{\text{Volts}}{\text{Amperes}} = \text{Ohms}\right)$ becomes

$$\frac{{\cdot}6}{48{\cdot}76} = {\cdot}0123 \text{ ohms,}$$

the circuit being 20 yards, or a total of 40 yards of conductor which is required to have this resistance.

Most tables of conductors give the resistance of all sizes of conductor per 1,000 yards. For direct comparison it is therefore necessary to find the resistance the conductor will have per 1,000 yards, *i.e.*,

$$\frac{{\cdot}0123 \times 1000}{40} = {\cdot}3075 \text{ ohms}$$

per 1,000 yards; for this 19/15 S.W.G. having a nominal sectional area of ·075 square inches and a resistance of ·3167 ohms per 1,000 yards would be selected.

In the absence of a table the area of the cable may be found by dividing ·0241 by the resistance per 1,000 yards of the conductor.

In this case:

$$\frac{{\cdot}0241}{{\cdot}3075} = {\cdot}0783 \text{ sq. inch.}$$

This method gives the correct area, but the nearest manufactured size is ·075 sq. inch or 19/15 S.W.G. as before.

For the distributing circuits, selecting the one of longest run, viz., 80 yards, in which 1·5 volts drop is allowed, and a current of 4·87 amperes, the resistance is $\frac{1{\cdot}5}{4{\cdot}87} = {\cdot}308$ ohms, the length of conductor being 160 yards, which must have this resistance, and is therefore equivalent to a conductor of

$$\frac{\cdot 308 \times 1000}{160} = 1{\cdot}92 \text{ ohms per } 1{,}000 \text{ yards.}$$

For this 7/18 S.W.G. having a resistance of 1·93 ohms per 1,000 yards would be selected.

For the other circuits the sizes would be proportioned accordingly, depending upon their length, except in the case of short runs, when the size of conductor may be based upon the carrying capacity, allowing 1,000 amperes per square inch of sectional area. Generally speaking, if the run of the circuit is less than 40 yards, and the current density 1,000 amps. per square inch, the voltage drop for any given number of watts transmitted along the cable will be within 2 per cent. of the pressure of supply.

From the foregoing it will be seen that to base the size of the wires throughout on the carrying capacity of 1,000 amps. per square inch would seriously intensify the difficulties of efficiently illuminating large halls and churches, where the length of circuit is considerable.

In the example a 7/18 S.W.G. conductor is required for a current of 4·87 amperes, but in customary practice for short runs this wire would carry treble the current, for at 1,000 amps. per square inch the capacity is 12·5 amps., and by the I.E.E. rules 21 amperes may safely be carried before the temperature effect is sufficient to be taken into consideration. This latter value is a fallacy which often leads contractors to under-estimate the size of wires and produces tenders of disproportionate amounts.

Dust and Illuminating Engineering.

There are probably many cases in which the importance of keeping the bulbs of glow-lamps or the chimneys and shades of incandescent mantles as clean as possible is not sufficiently realized. The introduction of a glow-lamp which was 25 per cent. more efficient than any of its predecessors, or of a form of reflector or globe the coefficient of reflection of which was say, only 10 per cent. higher than that of others, would arouse very great interest.

Yet it is safe to say that these figures are comparable with or in many cases far smaller than the loss of light very frequently occasioned by want of cleanliness. Thus Messrs. Legg and Townsend recently found that the effect of dusting the lamps in a reading-room in Chicago was to increase the illumination, on the average, by 25 per cent., and in one case by as much as 75 per cent. It may confidently be asserted that in many factories, where the conditions as regards cleanliness are so much less favourable, these figures would be exceeded.

Judging by results, therefore, it may be said that the man who introduces a system of supervision by means of which all globes and reflectors, &c., are kept clean, and saves a considerable amount of light thereby, deserves, at least, a share of the credit which is given to the engineer who accomplishes the same result by the design of entirely new apparatus.

The Development and Prospects of the Metallic Filament Glow Lamps.

BY DR. FELIX JACOBSOHN.

THERE is scarcely any branch of industry in which such strenuous efforts towards progress have been made during the last century as in the production of illumination. Each of the two great rival methods of producing light, gas and electricity, has done its utmost to imitate and excel the progress of the other. When, thirty years ago, the first electrical glow-lamp came upon the market, the new invention was hailed with acclamation; nevertheless these lamps consumed the relatively high amount of power of 4·5 to 5 watts per c.-p., and attention was at once bestowed on the possibility of improving these results. But it was the discovery of the incandescent mantle by Auer v. Welsbach and the realization that the hitherto decried illumination by gas had now become a formidable competitor, that stimulated those connected with electric lighting to set to work in earnest. Even when it became possible to produce lamps which could burn with a consumption of 3·5. watt, or—in the case of higher pressures—2·5 to 3 watt per c.-p., there was still every reason to fear that electricity could not compete with the incandescent mantle as regards cheapness. Among the marvellous results achieved indirectly by Welsbach's invention, we may point to the stimulus that was given to the progress of scientific investigation in fields of knowledge which had hitherto only been superficially covered. As a result immense progress in certain directions has been made, and the incandescent lamp industry has been stimulated to seek for other materials in the place of carbon for glow-lamp manufacture; hence the arrival of the metal filament lamp.

The chief weaknesses of the carbon filament lamp are already recognized; what then are the qualities which the desired material must possess? Briefly these may be described as follows: high electrical specific resistance, high melting point, durability, disinclination to volatilize, and lastly ease of manufacture. It was of course soon realized that the material with these ideal qualities did not exist. The already well-known platinum had too low a resistance, and its fellow metal in the same group, Osmium, could only be worked with difficulty. Eventually almost all the elements having relatively high melting point and low conductivity were subjected to investigation, there being always a prospect of somehow finding means to overcome the difficulties militating against their practical utilization. While we must, of course, realize that the application of these materials to the glow-lamp industry is still far from complete, one cannot but be amazed at the scientific progress which has accompanied the development of this branch of industry. Only ten years ago even the most important compounds of the rare elements were barely known. Who, therefore, would have predicted that by to-day we should have learnt how to obtain the pure metal and even to draw this metal into the very finest threads in order to utilize them as filaments?

The results of almost every investigation of this nature were protected, so that there exists to-day an almost innumerable number of patents bearing on this special subject alone. In this connexion one cannot help drawing attention to the misuse of the process of patenting which takes place in connexion with any novelty. In the metallic filament industry, for instance, patent rights have been secured for many unworkable and, from the chemical standpoint, positively ridiculous processes, which it is safe to say will never be worked and still less find their way to practical utility. In such cases the firms in question simply take out a patent, which is soon allowed to lapse, with the object of securing the whole field for themselves and preventing any possible competition.

In what follows we shall only deal with the German patents bearing on the subject, but these naturally afford a very complete review of the most important recent developments. In this connexion the elements occurring in the following groups call for consideration :—

In the Platinum Group, Osmium, Iridium, Ruthenium, Rhodium.

In the Oxygen Group, Chromium, Molybdenum, Wolfram, Uranium.

In the Fifth Group of the Periodic System, Vanadium, Niobium, Tantalum.

Among the Tetravalent elements, Titanium, Zirconium, Thorium.

Finally there remain *the Septavalant Element*, Manganese, several rare earth-metals, and also Boron and Silicon.

Among the various methods of producing metal filaments we may mention four chief processes ; there are, *firstly*, the pressing and drawing methods, by means of which the filament is actually pressed or drawn out into thin wire; *secondly*, substitution methods, according to which the carbon filament is brought to incandescence in an atmosphere of volatile metallic compounds, so that the carbon is eventually replaced by the desired metal ; *thirdly*, paste-methods, in which the metal or an easily reduced metallic compound is prepared in a finely divided state, mixed with some organic binding material into a paste, and then pressed through fine dies into wires ; *fourthly*, there is a special modification of the paste process due to Dr. Kuzel, which we will mention later on in this article. Yet one remark may be added concerning the difficulty of drawing rigid distinctions as regards the variety of processes to be dealt with. While in the main only filaments which are of a truly metallic nature will be mentioned, it may also be inevitable for metallic carbides and oxides to be also touched upon. On the other hand, incandescent bodies which conduct as conductors of the second class, in a purely electrolytic manner, will be excluded.

The utilization of Iridium for filaments of glow-lamps forms the subject of several German patents (class 21 F., Nos. 145456 and 145457) of R. J. Gülcher of Charlottenburg. In accordance with these patents finely divided Iridium is mixed with an organic binding material, pressed out into fine filaments, and heated in the air by means of a Oxy-Hydrogen blow-pipe flame. The subsequent patent mentioned refers to the reduction of the Iridium from the Oxide by incandescence in a stream of hydrogen. Iridium cannot be said to be well adapted to glow-lamp manufacture, for its hardness and brittleness do not admit of its being drawn out finer than about 0·8 mm. Lamps so constructed are, however, only intended for low voltages, such as are supplied by small batteries or accumulators. As usually manufactured they consume from 1 to 1·5 watt per H.K., and are not intended for pressures higher than about 24 volts.

The patents dealing with the application of Osmium to glow-lamp filaments are very much more numerous. The inventor of the Osmium lamp is Dr. Carl Auer v. Welsbach, who was also responsible for the discovery of the incandescent mantle, which has opened a new era in the gas-lighting industry. In the first of these patents (German patent 138135) he describes two processes for the manufacture of filaments of Osmium according to the so-called deposition method. A platinum core is brought to incandescence in an atmosphere of the vapour of Osmium-tetroxide together with water-vapour and reducing Hydrocarbons. As a result the majority of the platinum present disappears in the form of vapour and there remains a tube of Osmium, still, however, containing traces of the platinum ingredient. The second so-called Osmium and Carbon process is essentially the same as the paste processes so largely used at the present time. There is also a method of impregnating natural or artificial threads with salts of Osmium and with the addition of other possible ingredients such as Ruthenium, Rhodium, Iridium, and Thorium and Zirconium Oxides.

According to the German patent 132428 Dr. Fritz Blau and the "Watt" Elektrische Glühlampenfabrik of Vienna utilize the substitution process for the manufacture of filaments of Osmium and Ruthenium. According to this process carbon filaments are burned in an atmosphere of the vapour of Osmium and Ruthenium tetroxide, when the change expressed by the following equations takes place :—

$$\text{I. } OsO_4 + 2C = 2CO_2 + Os$$

$$\text{II. } OsO_4 + 4C = 4CO + Os$$

In the neighbouring patents (138315 and 140468) the Austrian Incandescent Gaslight and Electrical Company advocates the addition of oxides which are volatilised at a white heat, such as those of Titanium and Magnesium clay (not sand), to the Osmium paste, with the result that a more homogeneous Osmium filament can be obtained; also by the further addition of Thorium or Zirconium Oxides the Osmium is coated with a thin layer of the Oxide referred to. According to another patent (German patent 143352) the life and durability of Osmium filaments are improved by a special process involving heating in a vacuum, and consequent expulsion of water vapour and carbonic acid or Hydrogen occluded in the filament. Subsequently (German patent 143454) small quantities of air or Oxygen were admitted to the glowing Osmium filament with the object of accomplishing complete oxidization of the carbonaceous constituents and preventing the possibility of subsequent black deposits on the globe of the lamp.

The German Gasglühlicht-Actien-Gesellschaft of Berlin have also taken out a succession of supplementary patents in continuation of the original master patent of Auer v. Welsbach. For instance, patent No. 162705 of 1899 refers to the use with Osmium or other metals in the platinum group, of small quantities of carbon, thorium, niobium, tantulum, titanium, silicon, and other metals, which are more easily oxidizable than Osmium, so that the Oxide is reduced by the occluded gases or carbonaceous material present in the filament. With this object the porous Osmium filaments are coated with a thin paste of some material containing Oxygen and carbonaceous constituents, and the resulting alloy is said to result in greater elasticity than occurs in the case of filaments made of pure Osmium. In the German patent 174221 of 1905 this company turns its attention to alloying Osmium filaments with Chromium, Molydenum, and Wolfram. The manufacture of these filaments is carried out by the paste process, according to which metallic Osmium, together with the other metals present as Oxides, is formed into a paste with the necessary carbonaceous binding material. According to patent 185545 of 1905 the Auer-Gesellschaft overcome the natural brittleness of Osmium and Iridium by alloying with tin. The relatively easily pulverized material is then converted into light-giving filaments by the paste process in the usual way.

According to patent 154412 Albrecht Heil of Frankfurt obtains extremely fine Osmium filaments by electrolytically dissolving off the surface of an ordinary Osmium wire which serves as an Anode.

After reviewing the patents bearing on utilization of Osmium and its homologues to glow-lamp manufacture, we are driven to the conclusion that pure Osmium is but ill-adapted for this purpose. Apart from the difficulties in manufacture of such filaments and their comparative fragility, the exceedingly high price of the metal is a drawback to its extensive use in this connexion. Lamps containing Osmium pure and simple are not now found on the market in any great quantity. Such lamps could only be manufactured for pressures up to 47 volts, so that it was necessary to run several lamps in series on the customary pressure of 100 volts and over. The consumption of power is in the neighbourhood of 1·5 watts per H.K. The weakness of the filament only enabled these lamps to be used in a hanging vertical position.

It may be stated that the other lamps now in use provided with names closely resembling "Osmium" have really little but the name in common. For instance, the filament and the Osram lamp of the Deutsche-Gasglühlicht-Gesellschaft most probably consists mainly of Wolfram. With careful use these lamps give excellent results, in many cases burning for as long as 1,000 hours. In the case of 25–32 c.-p. lamps the consumption of power is 1·12 and 1·08 watts per H.K. respectively. Lamps of lower intensity than 40 to 50 candle-power cannot be produced for 200 volts, the consumption in this case being 1·2 watts per H.K.; in the case of 50–200 c.-p. lamps this is reduced to 1 watt per H.K.

The so-called "Osmin" lamp of the Osmium-Licht-Unternehmung of Vienna yields about 60 candle-power at a consumption of 1·05 watts per H.K. Lamps intended for 200 volts yield 80 c.-p. In order to accomplish these results, filaments as thin as 0·03 mm. in diameter—that is about half the thickness of fine ladies' hair—are essential, so that it hardly seems possible to produce these metallic filament lamps for voltages in the neighbourhood of 100 with an intensity of less than 30 to 40 candle-power.

We now come to the metals in the sixth carbon in the periodic system, one of which—Wolfram—has already been mentioned. The most important patent bearing on the use of Molybdenum and Wolfram is that of Alex. Just and Franz Hanamann of Vienna (German patent 154262, 1904); it refers to the substitution of the material of carbon filament by some other substance, this being accomplished by bringing the filament to a high temperature in an atmosphere of the vapour of the Oxichloride of Molybdenum or Wolfram, a small quantity of Hydrogen also being present. The process takes place according to the equations:—

$$WO_2Cl_2 + C_2 + H_2 = 2HCl + 2CO + W$$

$$WOCl_4 + C + 2H_2 = 4HCl + CO + W$$

The presence of this Hydrogen is absolutely essential to the success of the process, for otherwise not only no reduction of the metal, but no oxidization of the carbonaceous material could take place. By means of further reduction of the Oxichloride in a stream of Hydrogen, the Wolfram filament can be materially strengthened. The Vereinigte-Elektricitäts-Actien-Gesellschaft of Ujpest, who hold the license to manufacture in Austro-Hungary, Russia, Belgium, Italy, Spain, and Portugal, state that finer filaments can be produced in this way than by the paste process. The holder of the German patent is the Wolfram-Actien-Gesellschaft of Augsburg, who have taken over the rights of manufacture of the firm of Geo. Ludicke & Co., Lechausen.

In a more recent patent (February, 1905) Dr. Just has returned to the paste process; he brings finely divided metals into intimate contact with some liquid which is, however, free from carbonaceous materials, the paste so obtained being pressed into filaments and reduction being completed in a stream of Hydrogen. By this process lamps for 110 volts burning at 1 watt per H.K. giving 30–40 candle-power can be produced.

Although other metals of this group possess similar qualities to Wolfram as regards high melting point, only this particular metal appears to have been actually utilized. Chromium, produced by Moissan's process in the electrical furnace, melts at a much higher temperature than platinum, and appears to be easily workable when sufficiently pure; its degree of hardness is less than that of glass. Metallic Molybdenum can be easily obtained by reduction of the Oxide with carbon, water vapour, and aluminium (Goldschmidt's process). In this case one employs by preference the known volatile brown Molybdenum dioxide (see the method of Biltz of Kiel), in order to avoid the generation of heat and great loss of material through evaporation which occurs in the case of the yellow-green trioxide.

By means of this process Molybdenum is obtained as a workable metallic regulus, which is subsequently mixed with 1 to 2 per cent. of clay. Molybdenum may be easily obtained by reduction of the easily volatile chloride in a stream of Hydrogen, as a very fine and pure powder. By

Moissan's process* it is only fusible at the higher temperatures of the electrical furnace, and under these conditions becomes malleable. Wolfram is obtained in a metallic state by a very similar process to this employed in the case of Molybdenum.† Hallopeau,‡ however, describes a method by means of which Wolfram separates out in the metallic state when the Lithium Parawolframate is melted and subjected to Electrolysis. It is conceivable that this might open out a way of preparing Wolfram filaments in which the electrodes consisted of the supports to which the filaments are attached. Emphasis, however, must be laid upon the fact that the Electrolysis of molten material is much more complicated than that of aqueous solutions on account of the numberless inconvenient phenomena accompanying the production of the misty metallic vapour.

The metal Wolfram is even more fusible than Chromium and Molybdenum, its density being about eighteen. Uranium, which can be obtained in the metallic state by similar processes to those used in the case of its homologues|| is, in spite of its metallic resemblance to the metals referred to, but little adapted to the manufacture of metallic glow-lamp filaments, for it melts at a lower temperature than iron; for this reason all the patents which have been taken out with the object of utilizing Uranium for this purpose are illusory.

(*To be continued.*)

* *Compt. rend.*, **116**, 1225, 1893; **120**, 1320, 1895.

† Moissan, *Compt. rend.*, **116**, *l.c.*; **123**, 13, 1896. *An. Chim. Phys.*, **8**, 570, 1896.

‡ *Compt. rend.*, **127**, 755, 1898.

|| Moissan, *Compt. rend.*, **116**, 349, 1893. 'Ueber die Schmelzflüssige Elektrolyse von $UCl_4.2ClN_a$ bei 50 Amp. und 8-10 Volt' see *Compt. rend.*, **122**, 1088, 1896.

Efficiency of Various Electric Lamps.

An American correspondent sends us the following interesting set of figures relating to the actual efficiency of various electrical illuminants :—

Comparative Values of Various Forms of Electric Lamps,
As given by Mr. Arthur Sweet, Westinghouse Co., Newark, N. J.,
Before the Pittsburg Section of the Illuminating Engineering Society, June 8th, 1907.

KIND OF LAMP.	Mean Spherical Candle Power.	Watts per candle.	Candles per Kw.
Common 56 watt carbon filament incandescent lamp, rated at 3·5 w.p.c. 16 horizontal candle power	13·2	4·24	236
Common 50 watt Carbon filament incandescent lamp, rated at 3·1 w.p.c. 16 horizontal candle power	13·2	3·78	264
Three-glower, 264 watt Nernst lamp	81·0	3·26	307
GEM 125 watt, graphitized carbon filament lamp of 50 horizontal candle power	40·7	3·07	326
44 watt Tantalum lamp, rated at 22 horizontal candle power	16·0	2·75	364
Direct current 5·1 ampere enclosed arc on 110 volt circuit, 1·5 in. carbons	213·0	2·63	380
Alternating current enclosed 5·7 ampere arc, taking 388n watts on 110 volt circuit, 5 in. carbons	152·0	2·55	392
60 watt 110 volt Tungsten filament lamp, burning at 1·25 watts per horizontal candle	37·0	1·62	617
Luminous 8 ampere arc 440 watt, two in series on 110 volt circuit	1080·0	·431	2,320

SPECIAL SECTION.

The Relation of Architectural Principles to Illuminating Engineering Practice.

By Bassett Jones.

(A Paper read before the Illuminating Engineering Society, Dec. 12, 1907. Conditions of space do not enable us to reproduce Mr. Bassett Jones's valuable paper and the instructive discussion following it *in extenso*, and we content ourselves with bringing before our readers some of the most interesting features in full, and referring to the remainder in abstract.)

In sections (1) to (22) Mr. Bassett Jones explains some of the complex principles upon which our own impressions of beauty depend. Successful illumination of structures, making an appeal to this sense of beauty, demands sympathy with the æsthetic qualities of the design, and the engineer who, unfortunately, has not always the opportunity of learning to appreciate beautiful things, is apt to lay undue stress on "practical considerations." The author considers that the engineer who fails to appreciate the æsthetic side of lighting will not receive the recognition that the importance of his work demands. Let us in the first place consider what is involved in the term "æsthetic." What, therefore, are the sensations which an artistic creation calls into play ?

In the first place such a creation must arouse the curiosity and challenge the attention of the observer, and this it does mainly by producing a delicate mental poise between recognition and novelty. But the attention so aroused is maintained primarily by the sympathy of the onlooker—a feeling that the design expresses his own ideas, and strikes him as appropriate. When an object strikes us as being beautiful we experience actual physically pleasurable sensations. Thus the sense of ease and abandon with which our eye travels over a beautiful curve is gratifying to the senses. There is no abrupt alteration in the orderly sequence of muscular efforts required.

Yet apart from such actual physical pleasure, we derive intellectual enjoyment from the play of imagination—the train of associations and ideas which an artistic object calls forth.

Here, of course, previous artistic training comes in. Readiness in appreciating the harmonious or incongruous qualities of a scheme of decoration demands artistic knowledge. In many cases the artistically ignorant man would not notice any incongruities, nor would he notice the congruity.

The feeling of peace and restfulness, called forth by much of the best architecture is chiefly dependent upon harmonious proportions. Continual experience of the contrast between safe and unsafe construction is the basis upon which the imagination builds the æsthetic qualities of proportion ; but this feeling is complicated by the sense of *familiarity*, and other overlapping impressions.

Beauty, therefore, may be of different kinds, and may call forth a very complex series of emotions. Let us now consider its application to the principles of architecture.

The Principles of Architecture.

(23) The impulse to avoid injurious or painful stimuli and prolong pleasurable stimuli, is the foundation of all organic activities. With the rise of consciousness and the development of volition this impulse becomes, we may almost say, the fundamental purpose in life. In the higher reaches of mental development this purpose makes itself evident in an almost infinite variety of attempts so to modify the environment that its pleasure-giving stimuli will be greatly in preponderance over its pain-giving stimuli. Any object that furthers this end is termed "useful," whether that object be a lead pencil or the canvas of a master. This, the utilitarian purpose, is the basic actuating principle of all our beneficial activities. Distorted and misdirected, it also becomes the fundamental source of evil.

(24) Architecture, then, primarily has for its purpose the provision of structures designed to furnish protection from the vicissitudes of climate, and the fulfilment of this purpose alone is sufficient to give pleasure of a very elementary sort. The requirement of familiarity then demands of the architect that his structures shall so appeal to memory as to make evident its secondary purpose. The pleasure is not in the puzzle, but in its solution. The mind instinctively asks, "What is the thing for?" and unless the answer is forthcoming, no amount of grace or ornament can overcome the ensuing feeling of repulsion. We find ourselves in a strange place, and the ruling impulse is to escape.

(25) The tendency to make every useful object more pleasing is, as we have noted, fundamental in the imagining activities of the mind, and there naturally results an effort so to fashion the object that while it still serves its primary utilitarian purpose, it will stimulate the senses in a manner conducive to the greatest amount of pleasure possible. We have seen that this effort finds its highest expression in the form known as æsthetic, and that the perception of the beautiful makes three demands upon the object:—

(*a*) The sensations aroused by the object shall be of such a form that they may be readily responded to by the organism in its habitual manner, and,

FIG. 1.—Old English Wall Bracket.

therefore, there must be no discontinuity or sudden alteration in their flow. If discontinuity occurs, the reason for it must be evident and natural. Some attractive provision must be made, often by means of appropriate ornament, so that the mind can readily bridge the gap. Take, as an example, the old English

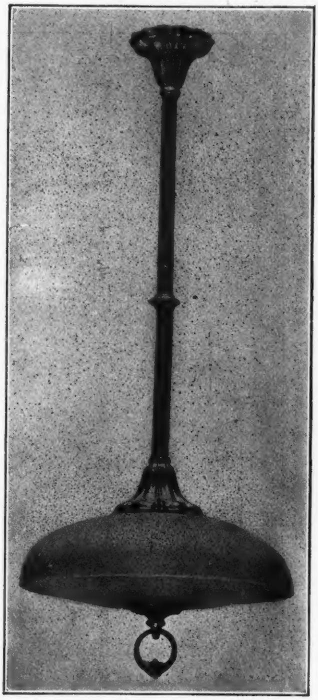


FIG. 2.—Showing Clever Use of Ornaments.

wall bracket shown in Fig. 1. Its great charm lies in an exquisite harmony of curves. The lines generating each part sweep into one another without break or raggedness. The eye follows its contours with pleasurable ease. Beauty has been added to usefulness by conceding to the simple demands of the visual sense. On the other hand, we have in Fig. 2 a discontinuity in lines cleverly bridged by decorative ornament. So the architect, in designing a building, must contrive its featural lines so that the eye can follow them and the mind perceive them in a natural and unconstrained manner.

(*b*) The object must be sufficiently suggestive in its aspect to demand some effort of the imagination in discovering its full meaning and relations to its environment. The interior shown in Fig. 3 finds, perhaps, its greatest æsthetic effect in its religious symbolism. To those to whom the appeal can be made it suggests the strength and mysticism of the early Christianity. Its feeling is tense with the exalted religious spirit of its builders. It has a story to tell, and is successful because must be in harmony. This requires that the parts be different, while at the same time the perception of each part must lead naturally (with smooth organic flexes) to the perception of the next.

FIG. 3.—Lighting of Westminster Abbey Choir.

it is full of imaginative suggestion. It carries us beyond its bare objective presence to a realm of ideal and contemplative construction that transcends the limits of actual experience.

(c) The several parts of the object The relations between the parts, and the relation of each part to the whole, must be reasonably evident....

(26) The requirement, that the several parts of the object or building shall arouse concordant sensations, demands

that the relations between the several parts of the object shall be apparent. The technical name of this character is "proportion." Its importance cannot be over-estimated. And we find throughout ancient classical architecture an evident attempt to carry it to its logical extreme....

(27) We have earlier (§§ 15, 16) touched upon the sense of structural proportion aroused by experience with safe and unsafe construction, and it only remains for us to draw conclusions in the light of our study of the memory coefficient. We must remember that the use of steel, and similar materials requiring slender proportions, is of very recent occurrence So far is this true that any degree of study of the æsthetic features of buildings will produce a great superabundance of feeling for the heavier construction of wood and stone. And the memory coefficient will naturally produce a sentiment in favour of heavy proportions, even where steel is used. The time is by no means ripe for a deliberate use of steel as steel, unless some means is adopted to increase its apparent weight. This requirement, of course, does not occur in subsidiary construction, where there is historic precedent, although this must not be taken as a reason for ignoring the structural proportions of the environment. To take an example, a lighting fixture must be proportionately heavy, if it is to be employed in a room of massive construction. Otherwise the feeling of balance will be disturbed. This, I may remark in passing, is a rule that has not been duly considered in some recent discussions of fixture design.

(28) A simple example serving to illustrate the basic organic principle of proportion is given in Fig. 4. The square there shown has a certain proportion between its sides due to the fact that their relation is of the order of unity. There is, however, no appeal to the attention because the case is one of mere repetition, and possesses no novelty. A single glance of the eye is sufficient to determine all its possibilities. The imagination remains dormant. But let us lengthen two of the sides so that their relation to the remaining sides is of the order two to one. At once we perceive the difference. There is an alteration in the form of the visual sensation as the eye passes from one side to the next. The attention is at once challenged, and curiosity is aroused. But there is no confusion between the perceptions of any two adjacent sides, and the mind readily adapts itself to the order of change.

Now turn to Fig. 5. This interior at once appeals to the attention, and for the reason noted above. The featural lines form a definite proportion, the one with the next following. A scaled section of the building would make this evident at once. The enclosed spaces are also in proportion to each other, and in proportion to the lines bounding them. Where the eye is likely to find any abruptness, ornament has been well used to detain the attention and make the transition more gradual. And this brings us to the last point we have time to discuss—the use of ornament.

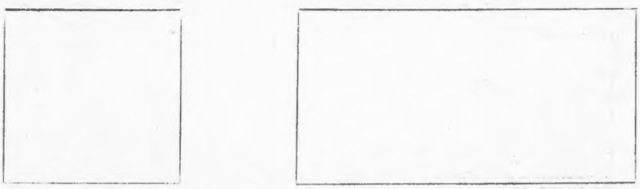


Fig. 4.—Example Illustrating the Basic Organic Principle of Proportion.

(29) The genesis of ornament has its root in the very human characters of conceit and pride. It appears first in the rings and feathers of the savage and in the war paint of the Indian, expressing the desire to improve and accent the object of beauty, or ferociousness, that appeals to the elemental mind. But we, whose trained intellects can grasp the true worth of proportion, require no bangles or paint to attract our attention to the naked beauty of the human form.

(30) As Ruskin has expressed it, "The works of God are perfect." They are so admirably fitted and proportioned to the fulfilment of their purpose that ornament could only serve to mar their beauty. But human effort and skill are so far limited that the deed is never the perfection of the thought. The meaning is always clouded by the ineffectiveness of its presentation.

(31) This lack of unambiguous expression of the function of each part of our

utilitarian construction compels the use of ornament as a means of emphasis and as a sign of the use to which each part is put; for parts differing in function must differ in appearance. Is it not evident, then, that in the proper or improper use of ornament is the success or failure of the whole design? And it is also evident that the slavish use of decoration is but a concession to bad proportion and lack of expressive ideas. Ornament, not to be vulgar, must be handled with most exquisite taste and sense of propriety, for in ornament more than in anything else we may read the mental standards of the period. An intimate knowledge of its history and use is essential for its proper treatment. Fig. 6 is inserted as an example of the perverted use of ornament to hide the lack of constructive lines.

The Architect and the Illuminating Engineer.

(32) The principles of architecture are, we now see, no mere whim on the part of the designer. They are as deeply rooted in a basis of fact as are the principles of natural philosophy. The conceptions of good architecture are subject to the same order of constraint that limits the postulates of science.

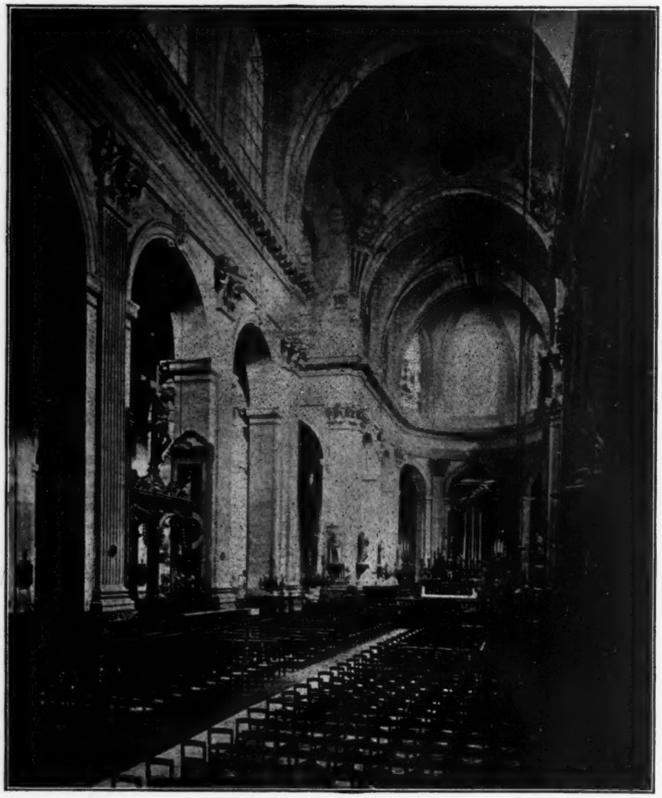


Fig. 5.—St. Sulpice Nave, showing Lighting Fixtures Suspended from Roof.

(33) I have considered it necessary to devote so much of our time to this inadequate and sketchy outline, because I have noted, on the part of many contributors to the literature of illumination, a disposition to decry and criticize the limitations which architects place upon their work. They do not seem to realize that the beauty and effectiveness of good architectural construction, both from æsthetic and utilitarian standpoints, de-

pend upon a strict adherence to the principles outlined above, and that the feeling of the design, dependent, as it must be, upon historical precedent, is bound by centuries of usage to certain effects of colour and light which have become established because of their appeal to the sentiments aroused by pleasurable visual perception. The business of the illuminating engineer is to modernize old methods of illumination without destroying them. If we are to discard tradition altogether, then we may as well abandon the architecture of the past, and ignore its influence. This, as I have tried to make evident, is impossible, if not on æsthetic grounds, then on

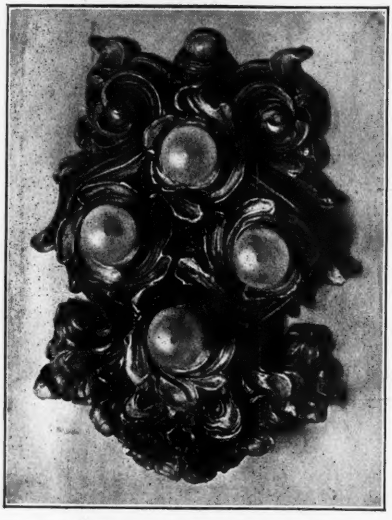


FIG. 6.—Example of Illegitimate Use of Ornament.

physiological grounds, and to deny its demands would be suicidal. "Habit," says James, "is the great fly-wheel of Society." Any sudden alteration in its movement would only serve to smash the whole machine. Change can only be brought about by infinitesimal alterations in its progress. The illuminating engineer who imagines that he will be permitted to introduce anything radically new into the illumination of buildings possessing historic feeling, is doomed to disappointment. Rather is it his duty to maintain and conserve that feeling in spite of modern appliances and means.

(34) The "feeling" of the design must be carried out consistently even to the last detail of the fixtures. It is the duty of the architect to see that this is done. His conception of the whole arrangement must include the lighting, for as he sees it "in his mind's eye" so must it be seen objectively. The light that must be provided, its tone, its intensity, its quality, is a feature of his mental conception, and it is this ideal illumination that the engineer must seek to approximate. Of course, he can only hope to do this when he, too, is able to see the design as the architect sees it, and not through the eyes of the illuminating specialist alone. The engineer must be able to discern where direct or indirect illumination is required, and the kind of fixtures associated historically and æsthetically with the general design, by means of which he must obtain the proper results. For instance, examine Figs. 7 and 8. Note the absolute harmony both in proportion and detail, denoting throughout the expression of a single ideal. No other scheme of illumination, and no other style or type of fixture could have been used without marring the entire effect. Such illumination is good illumination. The resulting distribution may not be perfect from the engineer's standpoint—but then his standpoint is itself imperfect if he fails to consider just the limitations imposed upon him by the design. Illuminating engineering is not a matter of light distribution—it is a matter of suitable lighting, and the conditions determining what is suitable are just as different as any two designs are different —no more, no less. Does the architect consider a building unsuccessful unless each part of it is laid out according to the laws of construction? Not a bit of it! The laws of construction are an after consideration—a means of checking the proportion to see if, after all, it is safe. So, too, the illuminating engineer must use the laws of distribution, not as a method of determining what the distribution shall be, but as a means of adapting the lamps to the distribution required. It is not a question of foot-candles; it is a question of how much light is needed. And it is more often a question of quality than quantity.

(35) You will say that foot-candles and quantity of light are one and the same thing, but I assure you, that from the architect's point of view, they are quite different. Two lamps giving an identical quantity of light may give entirely different quantities of illumination. The room shown in Fig. 9 is furnished with a very small quantity of light, but with ample illumination. The same quantity of light, if used in Fig. 7, assuming the rooms to be of the same

FIG. 7.—Salon des Gardes, Grand Trianon.

FIG. 8.—Salle à Manger, Grand Trianon.

general dimensions, would give practically no illumination, even if the general coefficients of reflection were in both cases identical. For what we see is, as the early part of this paper sought to make clear, not only what our optical nerves bring to the visual centres, but, in addition, a vast amount of suggestive material aroused to consciousness through the associative brain tracks.

(36) This associative material, with the actual sensory matter, together make up the perception which is conceived as an idea. The idea tends to find itself realized or embodied objectively, and this tendency toward the habitual or normal, conversion of the idea, is sentiment. In art, sentiment is defined objectively as the "feeling" of the design, and where the sentiment is not realized we say that the design is out of keeping, and, in so far, defective.

(37) How, then, is the illuminating engineer successfully to cope with his problem and advise with the architect as to the best means of achieving results, if the engineer cannot appreciate and understand the architect's viewpoint? Manifestly it is impossible for him to do so.

(38) It seems, then, that a very important, if not essential, feature of the engineer's preparation is a study of the history of illumination and its relation to architectural design. He must make himself intimately acquainted with the means, methods, and results of earlier work—and good work it is—where any attempts were made to obtain adequate and suitable lighting. We must not think, because we alone can formulate and employ the laws governing the distribution of light, that good lighting has not been earlier achieved by empirical methods. We are simply in a position to do more efficiently what the masters have done in spite of their manifest limitations.

(39) This branch of illuminating engineering is unquestionably an art, and only a science in so far as an art is scientific in its method. The illuminating engineer, who hopes to cope with the lighting features of architectural problems, must be familiar with architecture, and particularly with the use of colour in decoration; for, as we well know, the æsthetic value of colour arrangements depends on extreme nicety of contrast, and colour contrast is very susceptible to variations in tone and intensity of light, particularly at the low intensities very generally desirable from an artistic standpoint.

(40) The question as to the proper location and arrangement of fixtures, then, resolves itself into the question as to the way in which the design is to be seen. The proportions of the structure, its constructive lines and the points where they originate and end—these are to be brought out in relative prominence,

FIG. 9.—A Colonial Room. Note that a Centre Ceiling Fixture would Ruin the Effect.

and to do this properly the individual responsible for the lighting must be able to discern and select these features and modify his illumination accordingly. must be thoroughly lighted for its entire length. The architect, if he is alive to the necessities of the problem, will have allowed for this feature by giving a con-

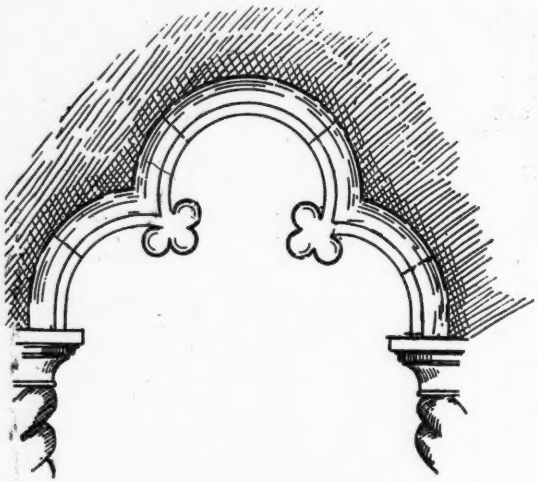


FIG. 10.—Trefoil Gothic Arch.

cave form to the ornament, and by deepening the space between it and the arch line.....The architect must allow for these requirements in his design. It is, in fact, impossible properly to light a design that has not been conceived

Take as an example the trefoil Gothic arch shown in Fig. 10. This, we will assume, by its importance in the structure, requires to be seen in its entirety. It is not sufficient that one segment, or even the two lower segments, be brought into prominence. It is demanded by the nature of the problem that the light so fall upon it that the eye shall be capable of tracing its outline from one abutment to the other, and if this cannot be done there will result a feeling of insecurity and of incompleteness. The problem, then, becomes one of so locating the lights that this result be accomplished.....

An example of the illumination of ornament is shown in Fig. 11. Suppose it is desired to place a single lamp at the centre of the relief ornament used to decorate the opening of a small arch, such as might be found in the dome of a rotunda.

(42) If the rotunda is to achieve its full effect, its decoration must be brought into prominence, and to accomplish this the lamp must be so located that, in addition to its work of furnishing light to the space below, it will bring out the principal generating lines of the decorative relief, that is, the ridges of the cockle in this particular example. In other words, the curve A—A—C of each member

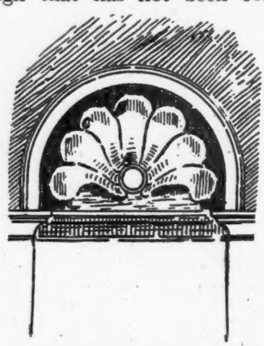


FIG. 11.—Example of the Illumination of Ornament.

as illuminated and suitably adapted therefor....

Historic Precedent in Illumination.

In this section of the paper the author traces the development of lighting-fixtures from the old Roman lamps, drip-

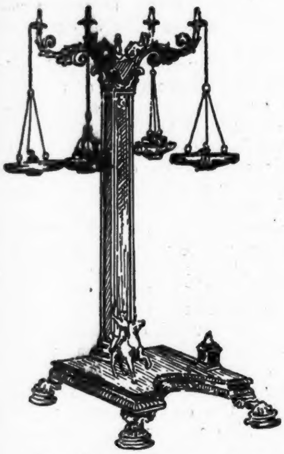


FIG. 12.—Old Roman Lamp Bearer.

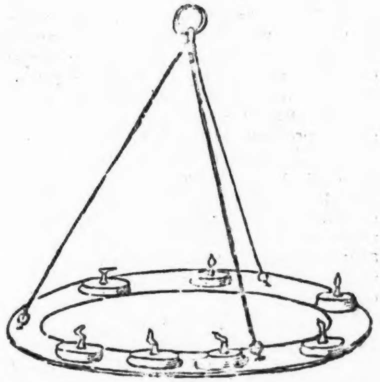


FIG. 13.—Form of Lighting Fixture Used in Early Christian Basilicas.

FIG. 14.—Adaptation of Fixture Shown in Fig. 13 to Modern Methods.

saucers, &c. Such lamps were often exquisite in design, but yielded a comparatively poor illumination.

But in ancient times, and in Roman and Gothic churches, very little artificial illumination was provided. Churches were rarely used at night, and reading in church was regarded as unnecessary. The lighting fixtures in historic English churches are chiefly of recent date, and many of them are inappropriate.

The author sums up the difficulties of the problem in section (50) as follows:

(50) A study of the history of church lighting will make one fact evident. The palpable artificiality of every kind of illumination presents an almost insurmountable difficulty. It is practically impossible to design any adequate system that would not seem totally out of place in such interiors as that of Durham and Amiens and the earlier portions of Canterbury or Westminster Cathedrals. The architecture of these great edifices makes its appeal purely through the sublimity of its proportions. Decoration and ornament are unnecessary, and have been but sparingly used. To attempt to light these buildings by any means less impressive in its effect than they are themselves would be little short of desecration, and artificial illumination is essentially decorative in its results. It may, in general, be taken as a rule that the simpler the architecture —provided it be good architecture— the more difficult becomes the problem of illumination.

(51) It is only by such historical study that we can learn the nature of the ideal which the great masters of architecture sought to embody in their work, and only as we succeed in making this ideal our own, can we hope to express, in our efforts, the truth of architectural beauty.

PHYSIOLOGICAL.

(52) This paper has carefully avoided any discussion of the physiological effects of artificial illumination, for it is the writer's belief that no architectural design, conceived in the right spirit, and properly executed, can demand any suitable artificial illumination that is injurious in the optical sense. The reasons for this lie deeper than the physiology of the eye can lead us, and have to do also with visual perception and psychology. It is a subject demanding separate treatment, and cannot be encroached upon in this discussion. Artistic illumination is, *ipso facto*, good illumination; and no illumination can be artistic that is not conceived as a feature of a truly artistic design.

DISCUSSION.

THE CHAIRMAN (E. L. ELLIOTT) expressed his sense of the value of the paper. There was no denying the importance of these questions of taste, which could not be reduced to mathematical calculation, and afforded great scope for discussion.

L. B. MARKS hardly agreed that the illuminating engineer, who did not consider the æsthetic side of the problem besides the practical side, was doomed to ultimate failure. There were many cases in which these æsthetic aspects were of secondary importance, and under these conditions the illuminating engineer might achieve success, even though he were not concerned with the artistic side of his work.

Mr. Jones had stated that the mind instinctively asks, "What is a thing for?" Surely lighting fixtures are intended primarily to illuminate—to enable us to see—and no amount of grace or ornament can make up for their failure to do so.

In a fixture intended to give useful light rather than decorative effects, engineering should take precedence of æsthetics in design, whereas in a fixture intended for decorative purposes this order might be reversed.

Mr. Jones, referring to Figs. 7 and 8, said that no other style of fixture would have adequately met the conditions. Apart from the æsthetic standpoint these fixtures left much to be desired as producers of good and uniform illumination. For instance, according to Fig. 8, an observer viewing the pictures at short range might find himself between the light and the picture, while at longer range the light would strike his eye at an inconvenient angle.

Mr. Jones maintained that adequate illumination was not a matter of foot-candles, and that quality, rather than quantity, was often needed.

The illuminating engineer, however, ought to assist the architect to secure a particular effect by exact and scientific methods. The study of illumination leads to definite and accurate methods of producing results hitherto only obtained in an empirical manner.

In the same way, if it were true that "it is, in fact, impossible properly to illuminate a design that has not been conceived as illuminated and adapted therefor," co-operation between the architect and the illuminating engineer was all the more essential. The position of the architect a generation or so ago was very different from at present. To-day he has many illuminants to consider, and has at his command new means of directing and distributing the light previously unknown.

S. W. Jones thought that the illuminating engineer should be free to illuminate buildings in which æsthetic and historical principles were not of paramount importance. But in cases in which this last point of view was of consequence the architect was best fitted to deal with the problem.

W. S. Kellog referred to the inartistic nature of many existing fittings. It was very essential that architects should be free to exercise a rather arbitrary control of the decoration of buildings under their charge. Otherwise each individual contributing to the scheme would insist on his own views being recognized, and chaos would result.

He agreed that the business of illuminating engineers was to modernize old methods of illumination without destroying them.

"Softness" of light was very desirable, and the present 16 candle-power lamp was too high a unit. Many people were wearing glasses as a result of our abuse of modern improvements in lighting. The speaker had recently received complaints of poor lighting in a recently erected building. Knowing the lamps provided to be ample, he was disposed to laugh at them, until he discovered that a type of reflector and fixture had been adopted that produced a perfect glare of light. The users suffered, not from too little light, but from too great intrinsic brilliancy.

In the case of the rooms described by Mr. Jones in paragraph 34, the illumination was, of course, intended to show off the decorative scheme to the best advantage—not to permit the easy reading of a newspaper. Engineers were too apt to insist upon mere efficiency, without considering the countless other factors in the problem.

V. R. Lansingh appreciated the ideas expressed by Mr. Jones and Mr. Kellog, and quite agreed that the lighting of a room should be in keeping with the purpose for which it was intended. At the same time he felt that architects ought to be familiar with the principles of illumination, and that the illuminating engineer could often be of service, even in cases where æsthetic principles were of aramount importance. Both the architect and the illuminating engineer might learn much by trying to understand their mutual points of view.

A. J. Marshall quite agreed that illuminating engineers ought to be acquainted with the æsthetic sides of the problem, but thought it was a mistake to suppose that there are no members of the illuminating engineering profession capable of appreciating beautiful things, though, of course, there might not yet be as many as was desirable.

G. H. Stickney likewise appreciated the need for co-operation between the architect and the engineer. In particular, he thought it very essential that engineers should exercise caution in applying the data at their disposal. The conditions of daylight illumination had considerably influenced the engineer's view of lighting problems, and being so much stronger, as a rule, than that produced by artificial means, sometimes led him to neglect historical standards.

Mr. Hopkins said that the fixture-designer and the manufacturer had been watching the progress of the illuminating engineer with great interest. It was the function of this expert to determine the power of light sources, decide their location and distribution, and generally accumulate data for the problem to be attacked. Only, in applying his data, he must realize the restriction imposed by the architect's design, and not apply indiscrminately the rules which guide him in the lighting of commercial buildings.

Mr. Hopkins also thought that in matters of lighting too sharp a line was often drawn between cost of maintenance and interest on investment. When a considerable sum of money had been expended on ornamentation and decoration of interiors it was short-sighted policy to grudge the addition of adequate illumination, and so jeopardize the return of pleasure to be derived from effects which the owner had been at such pains to secure.

Finally, Mr. Hopkins urged those present not to suppose that all fixture-designers—or nearly all—were indifferent to the claims of good illumination.

E. L. Elliott remarked that the architect and the illuminating engineer met on a certain zone of neutral ground. On the other hand, the relative predominance of the two aspects of illumination in which they were respectively interested, naturally depended upon the variety of building to be illuminated. In many cases where a building served a purely utilitarian purpose the scheme of lighting might be left to the illuminating engineer. For instance, in the building and lighting of a central station the work of the engineer naturally ought to take precedence over that of the architect, and no architectural considerations would be allowed to limit the requirements of efficiency and economy in operation. But in matters concerning the general æsthetic effect, both interior and exterior, the claims of the architect should take precedence. Yet even in many cases of this nature there need be no reason why the scheme of lighting should not be at once decorative and efficient.

Mr. Jones had explained that in regard to æsthetic features the mind instinctively asks, "What is the thing for?" He wished to apply this to the wall-bracket in Fig. 1. The eye followed the lines of the design with ease and comfort, and was led to suppose that the fixture was designed to carry a candle. But it was not; it was merely holding a clumsy and childish imitation of a candle, in the form of a piece of opal glass tubing surrounding an electric bulb lamp. This fixture therefore transgressed Mr. Jones's maxim, "Beauty is truth, and truth beauty."

In the same way it might be asked, "What is the use of the ring at the base of the design shown in Fig. 2?"

Mr. Jones said it was a switch.

Mr. Elliott replied that it was a misplaced switch, and ought to have been on the side walls. The eye supplied no reason for its existence.

Mr. Elliott agreed that the illumination of a cathedral was certainly a difficult problem, but possibly a change of sentiment might simplify the existing difficulties. He did not agree with Mr. Jones, however, that in a massive building fixtures must be designed on a corresponding scale. It would be quite as logical to put legs 8 ft. high on tables and chairs for use in a room with a 40 ft. ceiling. Certainly this view was not upheld in ancient times, and the candelabras of ancient Greece and Rome, in spite of their exquisite workmanship, often bore no relation to the proportions of the buildings in which they were used. Again, the coronas in the early churches were delicate and well adapted to sustain their own weight, but never unnecessarily massive, in spite of the hugeness of the building. In every case the builder used the best light-sources then available, and did not attempt to imitate one light-source by another. We, to-day, ought likewise to take advantage of the improved means of illumination at our disposal.

In reply Mr. Basset Jones stated that the criticisms were very much what he anticipated.

In the first place, it might be admitted that there was work for the illuminating engineer in treating cases where the æsthetic considerations were of secondary importance, but if he confined himself to cases of this nature the scope of his work must be an ever narrowing one: civilization and interest in æsthetics moved forward simultaneously.

Certainly, as Mr. Marks and Mr. Elliott had said, a lighting fixture was intended to enable us to see, but it must also enable us to see with pleasure; this depended on the effect produced, and was not a mere matter of candle-feet. Similarly he held that usefulness was important, but that beauty was itself eminently "useful." Mr. Elliott had said that every object of utility must express a truth; but truth was not confined to the practical point of view, and a lighting-fixture did not justify its existence merely by giving a certain amount of light. In short, a lighting-fixture is only imperfectly useful if out of harmony with its surroundings.

The speaker agreed with Mr. Marks that the æsthetic value of the fixture shown in Fig. 1 would be lost if the lamps used were of too high brilliancy; but here, again, such brilliancy is not only unsatisfactory from the utilitarian standpoint, but also inartistic.

As regards the view of the Grand Trianon dining-room in Fig. 8, it might be remarked that this room was only a picture-gallery in so far as this palace had become a national museum. To disturb its form of lighting would be to rob it of historic interest. It was, however, unfortunate that the room should be used to exhibit objects of art, for it was not designed or adapted to this purpose. In the same way it might be admitted that if the Salon des Gardes, shown in Fig. 7, was used as a study instead of as a reception-room, it might have to be differently lighted; but this would entail a loss of that unity of design so essential in good architecture.

He did not agree with Mr. Elliott's criticism, based on the delicate work of some Gothic coronas. In these cases the lines of the building were also intended to furnish lightness of feeling rather than massive proportions, and therefore the light work referred to was in harmony with the whole.

Mr. Marks was quite correct in saying that the illuminating engineer ought to secure the desired effect by exact and scientific methods. It was this *effect*, and not the quantity of light, that was all-important. On the other hand, illuminating engineering had yet to furnish data that could direct the ultimate determination of what was good and bad taste. It was the part of taste to furnish the illuminating engineer with data on which to work.

The architect naturally resented the attempt of the engineer to deal with duties he imperfectly understood, and the failure of the illuminating engineer to realize this point might do much harm to the profession as a whole. Nevertheless co-operation between both professions and a willingness to recognize each other's functions and point of view was extremely desirable. The architect had need of the illuminating engineer's advice, for the complexities in the means of illumination at his disposal were increasing daily.

Some such illuminants, however, were inadmissible on artistic grounds. Moreover, illumination that was not hygienically and physiologically correct must cause discomfort, and must therefore fail æsthetically.

Finally, the speaker disclaimed any intention of suggesting that engineers were necessarily inartistic. But it was important for engineers to appreciate the fact that in buildings of any artistic pretensions the purely engineering side of the problem must take a secondary position, and must be devoted to the economical production of the effects required by the design.

The Illumination of the Canals in Venice.

An interesting situation seems to have arisen in Venice in connexion with the proposal to replace the old flat-flame burners in that city by incandescent mantles.

The proposal has been very unfavourably received by many artists and others on the ground that the æsthetic value of many of the celebrated streets and waterways in Venice would be most prejudicially affected by the proposed innovation. At present these canals are but dimly lighted, and it is asserted that the artistic moonlight effects for which they are celebrated would be all but obliterated by the introduction of a uniformly brilliant illumination.

This seems to be just one of those cases in which the services are needed of an expert sufficiently broad-minded to perceive the claims of both the utilitarian and æsthetic aspects of the situation. Without wishing to convey the impression that the introduction of a useful standard of illumination is necessarily inartistic, one cannot but feel that in the present circumstances the æsthetic standpoint deserves special consideration, and that the incautious application of methods of lighting which are considered satisfactory in the case of an ordinary thoroughfare might justly be resented.

In street illumination, for instance, there are undoubtedly many cases in which other than purely utilitarian considerations must be taken into account.

We do not always desire merely to illuminate the pavement or the traffic. We are constantly erecting beautiful buildings in our streets, and we certainly ought not to ignore the possibility of so selecting and spacing illuminants as to show off their architectural features to the best advantage.

The question is one which is likely to frequently recur, in a less acute form, in this country. Every such problem involves special circumstances and demands attention at the hands of a man who is both willing and able to appreciate these two distinct, but not necessarily conflicting points of view.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Physiological Basis of Illumination.

By Dr. Louis Bell.

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

(*Continued from p.* 332.)

The human eye seems, however, to have become specialized for considerable acuity in a moderate light rather than for such extreme sensitiveness as is found in many nocturnal animals whose pupillary apertures vary over a much wider range than in man.

The curves of Fig. 1 show simple retinal sensitiveness, and in reckoning from them one must at low illuminations take account of the gain from increased aperture. At ordinary working values of the illumination the gain is small; but at 1 or 2 meter-candles it is very material, and plays a most important part in practical vision. For example, by curve *a*, Fig. 1, an illumination of 0·5 meter-candle would imply a value of Fechner's fraction of about 0·2, which would, in turn, imply very much impaired shade-perception. In point of fact, one can see quite tolerably by a candle at the equivalent distance of 1·4 meters.

For if the pupil has adjusted itself to this situation the virtual illumination is that corresponding to about 2 meter-candles, the equivalent area of the pupil having increased to at least four times its ordinary value, which is that to which the curves of Fig. 1 pertain. The result is a value of 0·1 or less for Fechner's fraction, which is quite another matter.

Were it not for this assistance, it would be quite impossible to get accurate photometric readings at the low intensities common upon the photometer screen. Similarly it would be exceeding difficult to get about at night, even by moonlight. In this latitude moonlight near full moon may fall to about 0·2 meter-candle, which would give Fechner's fraction at nearly ·5, barring aid from the iris. With this aid increasing the aperture perhaps 6 times, one can see to get about very easily, and can even read very large print. The same conditions have an important bearing on vision in presence of a strong radiant. For example, suppose that in a general illumination of 1 meter-candle one can make out objects having a contrast $\frac{dI}{I} = \cdot 15$. Then let a light giving 20 meter-candles come fairly into the field of vision without materially illuminating these objects. The pupil will close to about one-third its former area, giving a virtual illumination of about 0·3 meter-candles and a shade-perception of about ·30, in which, of course, the objects disappear. Hence one cannot see well across a bright light, and even objects illuminated by it lose in visibility, unless the change in illumination from them is greater than the concomitant change in aperture ratio.

The loss in visibility by the presence of a brilliant radiant in the field of view is increased by the change in adaptation of the eye. It is also probable that the intrinsic brilliancy of the radiant, as well as the light received from it, has a bearing on the pupillary aperture. Certainly at equal illuminations a well-shaded lamp gives higher visibility than a bare one, both being assumed to be in the field of view. There is therefore every reason for keeping such things as bare gas-lights and electric lamps entirely out of the visual field, only admitting them thereto when they are so shaded as to keep the intrinsic brilliancy to low limits.

The eye has been evolved under conditions that imply rather moderate intrinsic brilliancy, admitting the general desire to keep the direct rays of the sun out of one's eyes. Sky light, of course, varies very widely in apparent intensity, being most intense in the presence of white cloud of moderate density. An average all the year round mean for the northern part of the United States, giving the intrinsic brilliancy of an aperture fully exposed to the upper sky, would be, from measurements by Dr. Basquin,* in the neighbourhood of 0·4 candle-power per square centimeter. This is lower than the intrinsic brilliancy of any flame, and approximates that of a bright lamp behind a thin opal shade. The ordinary window, which is in a wall rather than the roof, and gets its light largely from low altitudes, and somewhat reduced by trees or buildings, is much less brilliant.

For instance, a window 1 m. wide and 2 m. high would be unusually effective if it gave 50 meter-candles at a point 5 m. within the room. This illumination would imply a virtual intensity of about 1,250 candles at the window or an intrinsic brilliancy over the window area of 0·0625 candle-power per square centimeter. Natural intrinsic brilliancies are decidedly low, and the chief difference between natural and artificial illumination, from the standpoint of wear and tear upon the visual organs, is the high intrinsic brilliancy of artificial light. If radiants are to be within the field of vision, they should be screened by diffusing globes or shades down to a maximum intrinsic brilliancy of preferably not above 0·1 or 0·2 candle-power per square centimeter, certainly not above double these figures. As I have pointed out in a former paper,† if one plots the pupillary apertures as ordinates and the function $\frac{1}{\sqrt{I}}$ as abscissæ, the result is nearly a straight line, so that if one measures the visual usefulness u of a certain illumination I in terms of what one may call the *admittance* of the pupil, then approximately

$$u = c\sqrt{I},$$

assuming that I is within ordinary ranges of intensity; that is, the eye works most efficiently at moderate illumination. The adverse factors in lowering the illumination are the optical errors introduced by increase of pupillary aperture, and the general failure of shade-perception and acuity as the illumination falls below about 10 meter-candles. Spherical aberration and astigmatism increase rapidly at large apertures, so that definition of objects is much impaired. This, doubtless, plays its part in the failure of acuity in very poor light, although a more prominent fact is the increase of acuity as the eye is stopped down at illuminations considerably above the critical value at which the eye comes into normal working condition.

* *The Illuminating Engineer* of New York Jan., 1907.

† *Trans.* Ill. Eng. Soc., July, 1906.

This critical value to which shade-perception, acuity, and pupillary reaction all point relates, it must be remembered, to the illumination received from the objects viewed considered as secondary light-sources. In too strong light thus received the eye is as seriously dazzled as if the source were a primary one, and the usual effects of after images and other evidences of retinal exhaustion and irritation at once appear. In very insufficient illumination there is failure to see contrast and detail, and there is an instinctive effort to push the eye near to the object at the risk of straining the mechanism of accommodation seriously. The familiar success of this expedient opens up some of the most curious questions of physiological optics.

Suppose, for instance, that one is viewing white letters on a dark ground. Evidently the letter acts as a secondary source of illumination, which proceeds from it, following the law of inverse squares. Now by halving the distance to the eye the intensity at the pupil is quadrupled, and at first thought one would infer that inspection of the shade-perception and acuity curves would give ample reason for the gain in visibility. But at half the distance the object subtends double the visual angle, and the retinal image is therefore quadrupled in area, leaving the luminous energy per unit of area the same as before; why, therefore, any gain in visibility? A similar question in a more aggravated form arises in accounting for improved vision through night glasses.

The key to the situation is found in the fact, put on a sound experimental basis by Dr. Charpentier,* that for the visible brightness of objects giving images less than about 0·15 mm. in diameter the simple law of inverse squares holds. In other words, for weak stimuli at least, the visibility of small objects is determined by the total light emitted, and by the distance and not by the surface brilliancy. It is as if a retinal area of about 0·15 mm. diameter acted as a visual unit, all stimuli acting upon this as a whole. As Charpentier (*loc. cit.*) puts the case with reference to distance, "In a word, the apparent brightness of a luminous object varies, other things being equal and within the limits indicated, in inverse ratio with the square of its distance from the eye."

As the eye then approaches a luminous object its apparent brightness increases, and it is distinguished more plainly so long as its image dimenson is anywhere

* 'La Lumière et les Couleurs,' p. 138 *et seq.*

within the limit mentioned. As this corresponds to an object 2 mm. long at a distance of about 20 cm., the rule holds for reading type and the observation of small objects generally. The cause of this phenomenon is somewhat obscure. The natural supposition that it might well be due to spherical aberration and faulty accommodation in an eye with its pupil expanded, fails, as Charpentier (*loc. cit.*) shows, in two ways. First, the circle of diffusion in the eye due to spherical aberration is much smaller than the critical diameter in this case, and second, the phenomenon occurs when the eye is stopped by a diaphragm. I have tried it with a wedge photometer provided with a pair of 2 mm. apertures in line and separated by 6 mm., so that the ray pencil was of very narrow aperture, and find it still very conspicuous and apparently unchanged.

Charpentier and others are disposed to think its origin purely retinal, resulting from the spreading of the stimulus over retinal elements adjacent to those immediately concerned, and closely allied to the phenomenon of irradiation.

This latter phenomenon, however, is charged by Helmholtz largely to aberrations and dioptric faults generally. One of the best sources for studying irradiation is an incandescent lamp filament. At a distance of, say, 2 meters the apparent diameter of the filament at full incandescence is 4 or 5 mm. Using the wedge photometer upon it, the diminution of apparent diameter is at first rapid, until it falls to about 0·5 mm., at which it remains nearly constant until it completely vanishes. Stopping down the pencil of rays to 1 mm. or so cuts off most of the irradiation, but this seems to act in the main merely as a reduction of intensity, since the same effect is produced by a similar reduction in intensity by the wedge retaining the full aperture of about 5 mm. At a few hundredths of a meter-candle most of the irradiation has disappeared. The apparent breadth of the filament decreases without any marked shading off at the edges, something as if a slit were being closed. The appearances indicate that beside the undoubted aberrations which come into play, there is considerable spreading of light in the retina at high intensities reinforced very likely by reflection from the choroid, producing an effect quite analogous to the halation observed in a photographic plate.

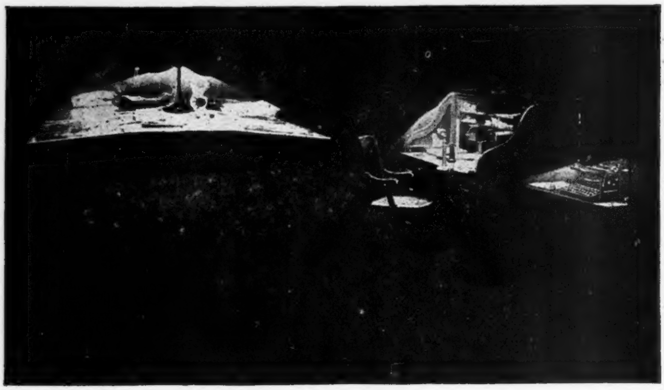


FIGURE 3.

The dimensions of the irradiation effect thus observed are inferior to the dimensions required by Charpentier, but it is quite probable that with a dark-adapted eye and feeble illumination, lessened contrast with the chief image would render the outlying portions more conspicuous.

The increased visibility of rather large areas is a still more puzzling matter, for which no satisfactory explanation has been produced. Inasmuch as all dealings like these with threshold sensibility have by this condition eliminated the cones of the retina from action, and depend upon rod vision entirely, it may be, since the rods are relatively more numerous away from the fovea, that mere size of image insures its falling on retinal areas relatively rich in active visual elements.

Aside from questions of intensity in artificial illumination is the matter of steadiness. It is, of course, well known that violent transitions of light and darkness, whether by moving the person or the eye, or by changing the intensity of the light itself, are distressing and injurious. The retina has a certain amount of visual inertia, which furnishes protection against very rapid changes, else one could not use lights successfully with alternating current. Flicker, from a practical standpoint, is troublesome and the frequency. With lamps of ordinary voltage and candle-power the flickering is perceptible at between 20 and 30 cycles per second, the new high-efficiency lamps being worse than the older ones. Practically all lighting is done at above 30 ~, and troublesome flickering comes only from the irregular fluctuations of bad service. It must not be forgotten that one can impress serious fluctuations of light on the retina

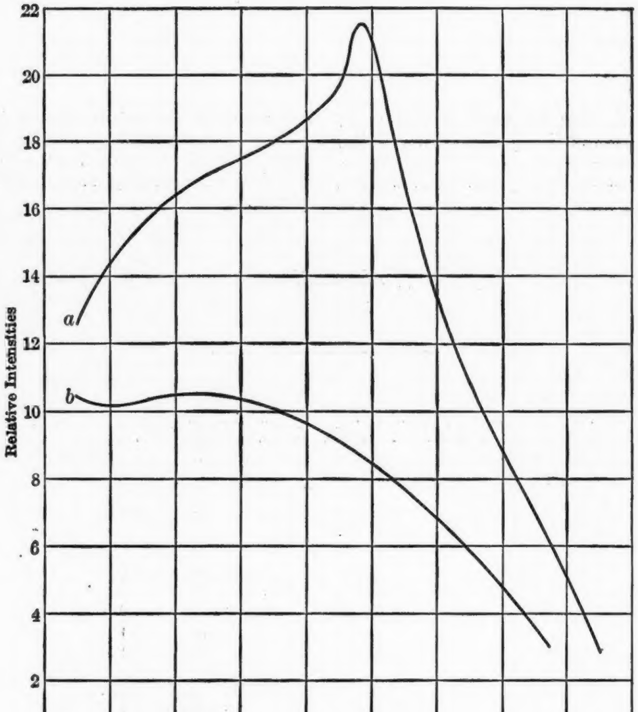


FIGURE 4.

about in direct proportion to its magnitude and in inverse proportion to its frequency. A change of intensity, however, covering some seconds, giving the iris plenty of time for readjustment, is hardly noticeable, while one of the same numerical magnitude, say 20 per cent. each side of the mean, occurring once or a few times per second, is most painful. Ordinary incandescent lamps run on alternating current vary from 5 to 15 per cent. on each side of the mean, according to the thermal inertia of the filament, by compelling the eye to confront great variations of illumination when it moves. No artificial light should be arranged so that it forces the eye to make sudden transitions from blackness to brilliancy. Fig. 3 is given here as a horrible example of what should never be permitted. I am sorry to say that it is from the catalogue of a maker of reflectors who should have known better. Note the blackness of the interior and the excessive brilliancy of the light on the work.

In this connexion should be mentioned

the trouble that may come from the glare of light reflected from white paper, a risk to which book-keepers are especially subject. I have been in counting rooms where I found every clerk with signs of bad eyes.

Much paper is too highly calendered, and from this cause gives a combination of regular and diffuse reflection. Obviously a mirror placed on one's desk would give at certain angles an image of the lamp of distressing brilliancy, and as the head might move this image would dodge into and out of the field of vision, giving an added cause of trouble. Glossy paper does somewhat the same thing. Fig. 4 shows from Trotter's data* the relative reflection at various angles of incidence from ordinary Bristol board (*a*), and from the nearly pure matt surface of freshly set plaster of Paris (*b*). The sharp peak corresponding to the angle of regular reflection is very striking. Light on a desk should therefore come from the side or rear rather than from the front, especially if the source is of high intrinsic brilliancy. For a similar reason the direction of illumination should be such as to free the eye from the effect of wavering shadows of the hand or head. The avoidance of shadow from the hand is the rationale of the sound old rule that the light should come from the left (left-handed people were forgotten). Shadows from the head and shoulders are much more troublesome, as they may exist to an annoying degree in rooms otherwise well lighted, and they are, in fact, difficult to avoid in the general lighting of counting rooms and similar places.

* *The Illuminating Engineer* of New York, 1, 488.

(*To be continued.*)

Colour Vision and Fatigue.

Prof. Burch delivered a most interesting lecture on 'Colour Vision' before the Optical Society of London on April 7th. The lecture dealt briefly with the general physiological structure of the eye and then passed on to the main theories of colour vision, giving a résumé of some of his own experiments which have formed the subject of several communications to the Royal Society.

One of the most interesting points referred to, from the point of view of illumination, was the possibility of producing temporary artificial colour blindness by concentrating light of one particular colour on the retina. Thus the result of subjecting the eye to very intense red light is to produce fatigue for this colour, and so to cause red objects—brightly coloured geraniums, &c.—to appear dark in hue, or even black.

In Prof. Burch's own case the results of exposure to very strong monochromatic light were actually so severe as to affect one region of the retina for years afterwards.

An instructive experiment on this point was as follows. The audience were asked to close the left eye and, with the right eye open, to look steadily for a few seconds at some red coloured fire. Subsequently a yellow flame appeared very distinctly redder in tint to the unopened left eye than to the right eye, which had been fatigued by exposure to this red light.

Such experiments lead us to wonder whether the results of working under a new light of some peculiar colour for long intervals of time might not possibly prove injurious—might, for instance, as in the case of the Röntgen rays, lead to some ill-effect which only gradually makes its appearance.

One would also like to know definitely whether light of a given intensity of a certain colour is really more fatiguing in its action on the eye than another, and whether any appreciable difference in the action of ordinary illuminants could be ascribed to this cause. Moreover, if any such difference does exist one would naturally expect photometric readings to be influenced thereby. At present the influence of "fatigue" is often vaguely referred to as influential in photometric tests, but it is always difficult to form an exact conception of the exact nature of the source of error, the evil influence of which is feared.

Inverted Gas Lighting.

By M. C. Whitaker.

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

(*Continued from* p. 337.)

The history of the modern inverted burner is confined almost entirely to the development of various systems of meeting the complicated conditions of inverted combustion; and a careful study of the difficulties and principles involved in the production of the most recent forms of inverted lamps will serve to show the trend of development.

Two general divisions may be made which involve the utilization of different principles of combustion.

The first is based on a burner calculated to pre-heat the gas or air, or the mixture; and the other is a type where the construction is so arranged as to avoid, as far as possible, increasing the temperature of the gases before they reach the point of combustion.

The advantage of pre-heating the gases before combustion is questionable, and prominent authorities may be quoted for and against the increased efficiency to be obtained by this method. From a theoretical standpoint it might be inferred that the incandescence of the mantle would be increased by raising the initial temperature of the gases before entering the combustion chamber, but practical results show conclusively that the abnormal rarefaction of the gases due to the increased temperature of the mixture tends to produce the opposite effect.

On the other hand, artificially cooling the gaseous mixture before combustion produces a decrease in the efficiency of the inverted lamp. Furthermore, the pre-heating or extreme cooling of the mixture necessarily complicates the construction of the burner.

Based upon these observations, inverted burner designers are usually adopting the medium system, and are constructing a burner so that the gaseous mixture will maintain a temperature ranging between the extremely hot gases produced in the regenerative type and the cold gases produced in the cooling type. The development in the art at the present time is largely based upon the adoption of the medium system.

In modern practice, inverted burner construction falls under three general designs:—

1. The upright Bunsen, with the tube carrying the gas and air mixture curved through half the arc of a circle.
2. The horizontal Bunsen tube, with the mixing chamber curved through one-quarter of an arc.
3. The vertical Bunsen, with a straight tube for the delivery of the mixture to the point of combustion.

Modifications of these designs are noted, in which the Bunsens are placed at various intermediate angles, but they are not in sufficient favour to be considered in a general classification. The prevailing types of inverted burners now on the market fall under these classifications.

In the study of the problems involved in the proper design, construction, and use of an inverted gas lamp, special consideration must be given to the following points:—

1. The production of a proper mixture of gas and air under all conditions of operation, so as to insure a perfect combustion.
2. Means for positively preventing flash backs under all conditions of operation.
3. Special construction of the Bunsen tube designed to project the gas and air mixture downward to the point of combustion with maximum velocity, thereby overcoming the ascending tendency of the mixture, due to its light specific gravity.
4. The elimination of gauzes, long and circuitous passages for the mixture, or any other features offering frictional resistance to the projection of the gases toward the point of combustion.
5. The protection of the fresh air supply from vitiation by the products of combustion.
6. Well designed and constructed adjustable gas check.
7. The effect of the corrosive action of the flame at the point of combustion; and the necessity of refractory construction at this point.
8. Good mantles.

9. Glassware and reflectors specially selected and adapted for effective and economical distribution of the light.

In the study of combustion as applied to the Bunsen burner we recognize three basic essentials—(*a*) the combustible, represented by the gas; (*b*) the supporter of combustion, represented by the oxygen of the air, and (*c*) the kindling temperature necessary to start the combustion, applied through the medium of a match or some other heating device. Eliminate any one or more of these three essentials and combustion ceases.

The combustion is the chemical union of the active constituents of the gas with the oxygen of the air, and the products of this combustion are definite chemical compounds in which the proportions never vary. Therefore, when a certain amount of gas is admitted to the mixing tube of the Bunsen burner, a certain definite amount of oxygen (air containing oxygen) must be entrained and mixed with it in order completely to consume the combustible constituents of the gas. If the air supply is insufficient to meet these requirements, unconsumed or partially consumed constituents of the gas will be discharged from the burner, either in the form of solid particles of carbon or as noxious gases.

On the other hand, an excess in the supply of air results in a great reduction in the incandescing power of the flame, and carries the mixture beyond the critical point, which may result in a "flash back."

It is the true function of a Bunsen burner to take in and mix with the gas in the mixing tube air containing the exact amount of oxygen required to consume all the combustible constitutents of the gas and convert these into inert, harmless products.

A Bunsen burner which meets these conditions derives the maximum heating value from the gas consumed and produces perfect combustion—both essential features in an efficient incandescent gas burner.

The working conditions of the upright burner are such that when the proper proportions of gas and air are once fixed perfect combustion will continue as long as the composition and pressure of the gas remain uniform. A perfect mixture in the Bunsen tube is indicated by the formation of the characteristic blue cone in the non-luminous flame. If the proportion of air is reduced beyond the proper point, the flame will change to the luminous variety, due to the incandescent particles of carbon. On the other hand, if the proportion of gas is reduced below the critical point, a flash back will result, unless prevented by the introduction of some mechanical appliance, such as a gauze.

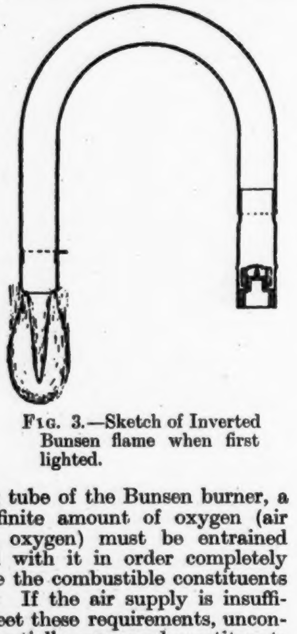


Fig. 3.—Sketch of Inverted Bunsen flame when first lighted.

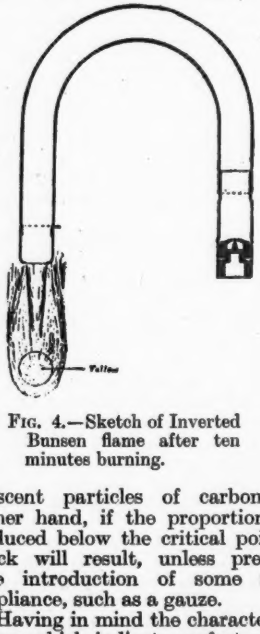


Fig. 4.—Sketch of Inverted Bunsen flame after ten minutes burning.

Having in mind the characteristics of a flame which indicate perfect combustion, a study of the form of flame produced by the elementary inverted Bunsen burner shows that a new condition is introduced in this form of lamp. When the simple form of inverted burner is lighted, and the gas and air proportions adjusted for the formation of a flame indicating perfect combustion (Fig. 3), it is observed that the characteristic non-luminous flame gradually changes, as the burner becomes heated, to a longer and more luminous flame (Fig. 4), indicating that the proportions of the mixture have been changed by the reduction of the quantity of air entrained by the mixer. Inasmuch as this change does not take place until the burner tube becomes heated, it is safe to conclude that the modification in the proportions of the mixture is due to the rarefaction of the gases by the heat in the mixing tube, which prevents the aeration of the mixture in the same proportions as when the burner is cold. On the other hand, if the gas and air mixture is adjusted while the burner is hot, it is found that on relighting the burner, after it has thoroughly cooled, the proportion of air exceeds the critical point and the burner will flash back, unless prevented by some mechanical means; and, even if the flash back is prevented, the over-aeration materially reduces the mantle incandescence.

These observations established in the minds of the early investigators of this subject the idea of so constructing a burner as to regulate mechanically the amount of air admitted to the burner and to govern this mechanical regulation automatically by means of the heat developed by the burner. In other words, to utilize the heat which was the cause of the change in the composition of the mixture automatically to readjust the mixture to meet the requirements of perfect combustion.

It is obvious that the users of an inverted burner cannot be expected to readjust the lamp every time it is lighted, and to wait until it is thoroughly heated in order to put on the finishing touches of a proper adjustment. An automatic compensating device which permits of the burner being properly adjusted when first lighted, and which will gradually increase its air-entraining capacity as it becomes more heated from its own combustion, is obviously a feature upon which depends the success of the inverted incandescent gas burner.

Face to face with the positive necessity for this automatic compensating device, the situation is met by the invention of an attachment technically known as a "thermostat." The operation of the thermostat depends upon the fact that it is constructed from two pieces of metal possessing different coefficients of expansion when heated, and which are rolled together to form a single sheet. The thermostat, as applied to the inverted burner, is made by the formation of a slitted cone from a small sheet of this metal. It is placed in the mixing chamber of the lamp in such a position as to be protected from the corrosive action of the burning gases, and at the same time within range of the heat due to the combustion. When the mixing tube becomes heated, the fingers of the thermostatic cone open for the unobstructed flow of the gas and air mixture as long as the tube remains heated; when the light is extinguished and allowed to cool, the thermostat automatically assumes the conical form.

By maintaining the proper relations between the size of the mixing chamber and the dimensions of the thermostatic cone, it will be found that when the burner is cold the closed fingers of the thermostat interpose a sufficient amount of resistance to the entraining capacity of the mixing tube to prevent over-aeration. As the tube becomes heated and the thermostatic fingers open, this resistance is removed at a proper rate to compensate exactly for the reduced entraining capacity occasioned by the gradual heating of the tube. Figure 5 is a sketch of the flame of a burner containing the thermostat, showing the form at the moment of lighting; and Figure 6 shows the same flame after the burner has been lighted some time and has become thoroughly heated.

The fact that the flame in a thermostatically controlled burner remains practically uniform throughout the change from the cold to the heated state, establishes beyond question the practical value of this device for automatically controlling the gas and air mixture for the production of perfect combustion in the inverted burner.

The direct cause of a flash back is an explosive action which carries the flame into the mixing tube and sets up combustion at the gas orifice. This explosive action occurs in several ways, the common cause being the existence of an over-aerated mixture in the burner tube. It sometimes occurs, on lighting an incandescent gas burner, that an explosion takes place in the glass chimney or globe with such force as to drive the flame back into the mixing tube of the burner. The usual method used for overcoming the tendency to flash back is that of placing a gauze in the burner tube at or near the point of combustion. This gauze serves to maintain the mixed gases in the burner tube at a temperature somewhat below the kindling temperature, and thereby prevents a flash back. This will be recognized as the principle involved in the safety lamp invented by Sir Humphrey Davy.

The use of the gauze in the inverted burner for the purpose of preventing "flash backs" is objectionable on the ground that it obstructs and materially retards the downward projection of the mixture in the burner tube, thereby defeating the object aimed at in the construction of an efficient Bunsen gas projector—an essential device to meet all conditions in operating a Bunsen flame in the inverted position.

Furthermore, the gauze acts as a sieve, collecting dust and lint entrained at the air ports of the Bunsen, and unless cleaned or renewed at frequent intervals will render the burner unfit for use.

An alternative method for overcoming the flash back is that of adjusting the air supply at the Bunsen ports so as to keep the mixture safely above the critical point at which a flash back occurs. Inasmuch as this critical point is very near the desired mixture for perfect combustion, there is great danger of reducing the air supply to a point which will result in discharging imperfectly consumed products. Furthermore, in view of the conditions explained under the heading of combustion, it should be noted that the gradual reduction of the air-entraining capacity, due to the heat of the mixing tube in the inverted burner, will further aggravate this danger.

That the relation between the cause of the flash back and the production of a proper mixture for perfect combustion is close is established not only upon the theoretical consideration of the conditions involved, but by the fact that the thermostatic cone introduced into the tube for the primary purpose of automatically adjusting the combustible mixture also prevents flash backs. Its operation is made doubly secure because its construction enables it to fulfil the function of a gauze, utilizing the principle involved in the Davy lamp, and also from the fact that it maintains the gas and air mixture throughout the entire operation of the lamp in a proportion which keeps it well within the critical limits.

In fulfilling the function of a gauze, the thermostat does not introduce any of its objectionable features, as the automatic movements of its fingers prevent it from collecting dust and lint. Furthermore, it is open during the operation of the lamp, and is removed completely from the pathway of the combustible mixture, and therefore does not offer any resistance to the passage of the gases projected from the raceway.

FIG. 5.—Sketch of Inverted Bunsen flame when first lighted, thermostatically controlled.

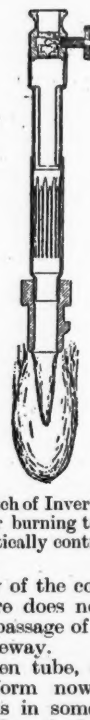


FIG. 6.—Sketch of Inverted Bunsen flame after burning ten minutes thermostatically controlled.

The Bunsen tube, even in the highly developed form now used in upright burners, fails in some essential features when applied to the inverted burner. In considering this problem, it should be noted that the ordinary illuminating gases are lighter than the air, and possess a marked ascending tendency even at the normal temperature. When considered in connexion with the heated condition of the inverted mixing tube between the gas orifice and the point of combustion, it is seen that this ascending tendency is thereby greatly increased.

The method used for overcoming the ascending tendency of the mixture is to project it downward with sufficient velocity to carry to the point of combustion.

The only force available for projecting the mixture downward is that obtained from the velocity of the gas at the check orifice. When it is considered that in many cases the initial gas pressure is very low, thereby greatly reducing the available force, and also that a certain portion of this force must be given to entraining the air for the mixture, it is obvious that great importance attaches to the production of a highly efficient Bunsen projector. The problem of construction involved is comparable to that arising in the designing of syphons or injectors used in moving liquids. In these devices it is well known that the efficiency depends not only upon the available driving force, but also upon the dimensions of the raceways, nozzles, and ports, and the careful adjustment of their relations to each other. With gases, these relations have to be more carefully worked out than with liquids, and no device in inverted burner construction has received more careful study than the proper and efficient Bunsen projector.

In the elementary forms of inverted lamps the projector feature is ignored and a plain tube of uniform diameter is used. While this construction serves as well as could be expected, when the operating conditions are uniform and within certain favourable limits, it fails utterly to meet the requirements of universal application.

To meet the conditions of varying composition and pressure, or uniformly low pressure in the gas supply, a construction is required embodying all the features of a highly efficient projector for gases. This requires an adjustable check which will give the greatest jet velocity to the gas as it is admitted to the Bunsen; air ports properly placed to give the most efficient entraining capacity; a "raceway" of correct diameter and length, to give the mixed gases the velocity necessary to carry them through the mixing chamber and to the point of combustion; a complete elimination of all features which would tend to reduce, by friction, the velocity of the projected mixture, such as gauzes, long or curved mixing tubes, &c.

An adjustable gas check is an essential feature of an inverted burner, in order to meet the conditions of varying compositions and pressures in the gases supplied for illumination. This is especially true in the construction of a burner for universal distribution in territories using different kinds of gas—coal gas, water gas, or natural gas.

While the primary purpose of the adjustable check is to regulate the gas consumption of the burner so as to develop its highest efficiency, it will be found that the design and construction of this device has a very important bearing on the continued successful operation of the light.

The velocity of the gas as it issues from the check orifice gives the force which entrains the air at the Bunsen ports, mixes this air with the gas to form the combustible mixture, and projects this mixture through the raceway and mixing chamber to the point of combustion. This requires a construction embodying the best known principles of efficiency to obtain the maximum velocity in the jet of gas as it issues from the orifice.

The most satisfactory construction to meet the requirements of the inverted burner is the single-hole check, controlled by the sliding needle. Great care must be given to the details of construction, such as determination of the proper size of hole to pass the required amount of gas at minimum pressure; the thickness of the check plate; accurate drilling, to insure the discharge of the jet into the centre of the raceway; and an adjusting needle which registers perfectly, to avoid deflecting the jet and thereby destroying the force of the discharge from the orifice. The adjusting screw should be easily accessible and headed with some non-conductor of heat to facilitate adjustment.

The protection of the fresh air supply for the inverted burner is a simple problem in mechanical construction; yet this matter has not received, in many instances, the care which its importance warrants. In the best types, a form of deflecting shield is incorporated in the general design to serve the multiple function of protecting the fresh air supply from vitiation, deflecting the products of combustion from the fixture arms, and safeguarding the adjusting screws from undue heating.

Another very important point in construction is the method used to prevent corrosive oxidation of the burner at the point of combustion. Metal tips have been found highly unsatisfactory in operation, and experience proves that the use of a refractory magnesia tip at the point of combustion is a well-justified addition to the first cost of the burner.

A New Form of Reflector for Street Lighting.

THE problem of street-illumination presents several peculiar difficulties, not the elast of these arising from the fact that it is essential to illuminate a wide area of road and pavement without dazzling the eyes of pedestrians. A new form of holophane reflector has recently been described, which is specially intended for street-lighting, and is said to overcome this difficulty very effectually.

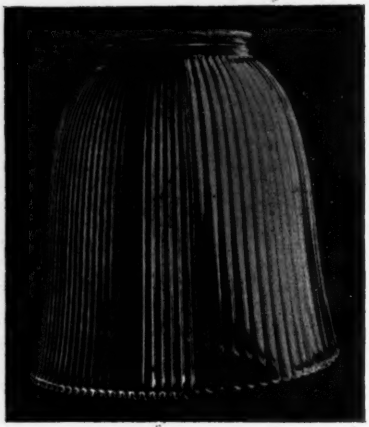


FIG. 1.

The general nature of this reflector will be understood from Fig. 1. This consists essentially of two distinct portions, a face and a back. The face, *i.e.*, that portion that faces the street proper, has a smooth exterior surface, with vertical totally reflecting and refracting prisms on the interior. The back, on the other hand, which is presented to the side wall, has a series of vertical totally reflecting prisms on the exterior and a smooth interior. It is claimed that these prisms, being vertical, do not afford an easy resting-place for dust, and, in addition, are partially cleansed by falling rain.

The distribution of light from the fixture is illustrated by Figs. 2 and 3. Fig. 2 refers to a 40 candle-power gem lamp, equipped with this reflector, and represents the intensity in a plane 10 degrees below the horizontal. The zero polar co-ordinate represents a plane at right angles to the line of the pavement, and it will be seen that the greatest intensity occurs in a plane at 65 degrees to this direction. As a result the strongest light is not thrown past obstructions that line the curb in the form of trees, posts, &c. The comparatively

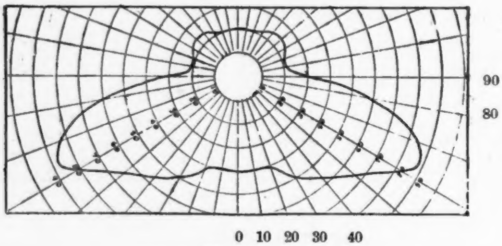


FIG. 2.

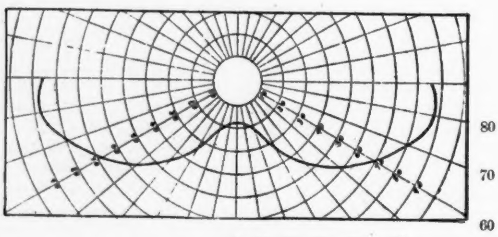


FIG. 3.

small amount of light thrown on the pavement is amply sufficient to illuminate it without distressing the eye. This is also secured very effectually by the

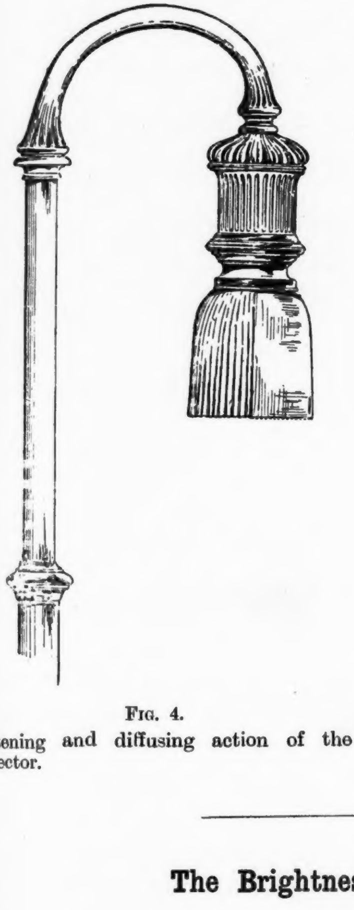


FIG. 4.

softening and diffusing action of the reflector.

This diffusing action should mitigate the objection of those who naturally dislike having a high power illuminant of great intrinsic brilliancy in front of their houses.

Fig. 3 represents the distribution of intensity of light in a vertical plane

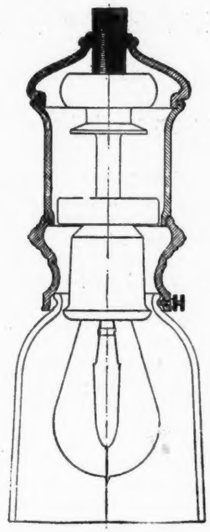


FIG. 5

through the 65 degrees ordinate of maximum candle-power shown in Fig. 2. Fig. 4 shows a suggestion for the application of the reflector in connexion with a conventional support, and Fig. 5 is a sectional drawing of the details of the arrangement.

The Brightness of the Sky.

BY E. KAHLER.

(*Metereolog. Zeitschrift*, February, 1908.)

THE author gives the results of a series of experiments having for their object the study of the intrinsic brilliancy of the sky under different metereological conditions, in its relation to the illumination of the interiors of buildings. He also works out relations by the aid of which the actual illumination under certain specified conditions can be predicted if the brightness of the effective region of the sky is known.

The brilliancy of the same part of the sky differs very greatly on different days, and, of course, the light derived from different regions of the sky also varies. It is not even possible to deduce any rigid connexion between the brightness at the zenith and at any other specified angle to the horizon, chiefly because of the widely different atmospheric conditions as regards clouds and mists that may prevail.

Electric Supply Prospects and Charges as Affected by Metallic Filament Lamps and Electric Heating.

By H. W. Handcock and A. H. Dykes, Members.

(Abstract of paper read before the Institution of Electrical Engineers, April 8th, 1908.)

It is very satisfactory at the moment to be able to induce a wavering possible consumer to decide in favour of electricity by pointing out that with the new metallic filament lamps two to three times the light can be obtained for the same current as compared with the ordinary carbon lamps which he has used hitherto.

But what will happen when every consumer uses high-efficiency lamps throughout? Can we feel sure that the only effect will be that the consumer will get more light, and will use as much as or more current than before?

Although the introduction of the gas mantle actually served to accustom people to a higher standard of illumination, it was nevertheless found that the consumption of gas per customer fell off considerably. In the same way the introduction of the inverted mantle has in some cases had an appreciable effect on the output of the works.

The present 110 volt tantalum or osram lamps, giving 23 to 30 candle-power at a consumption of 40 watts, although they have usually to be arranged in series, might appear to correspond very closely with the original gas-mantles in gas lighting.

In some cases consumers will be able to do with fewer points, and thus reduce their consumption. In others it will happen that they will improve their lighting, but not very greatly reduce their consumption. Some engineers seem to think the first state of affairs will predominate, whilst others incline to the latter. If metallic filament lamps were always to remain at the present price, and were only available in comparatively large units and at 100 volts, it is probable that the total effect on the station supplying principally private consumers would not be very marked.

The cost of the lamps—4*s.* for osrams and 2*s.* 9*d.* for tantalums—is a very considerable item, and consumers, therefore, will not adopt them to any great extent unless they can feel assured that their *total* lighting bill will be reduced, or, at any rate, not increased.

In the case of private consumers, where a large proportion of the points are single lights, with separate switches for each point, the saving in current, if any, with two lamps in series will, except where current is dear, not be great enough to ensure a general adoption of the lamps at present prices.

In the case of shops, halls, and factories, it generally happens that the lamps are mostly on all at once, so that the question as to whether a switch controls one or two lamps does not come in. The effect in this case, even if the same total number of lamps be used, is to decrease the current consumption by about one-third, with an increase in the illumination of 50 per cent. or more.

The total saving thus effected, after allowing for the increased cost of lamp renewals, depends on—

(*a*) The price charged for current.
(*b*) The price of the lamps.
(*c*) The life of the lamps.

The authors present, in this connexion, a very complete and useful table of the performances of tantalum and osram lamps of various intensities, as compared with an 8 candle-power carbon lamp, under different practical conditions. In most cases the use of a metallic filament, while enabling the consumer to save expense, causes a reduction in the current sold by the supply company of from 50 to 70 per cent.

Of course the metallic filament lamps have still several serious drawbacks, among which may be mentioned the liability of the lamps to breakage in transit, and the necessity for running two or more lamps in series on high pressures.

It is, however, common knowledge that even with the drawbacks above referred to, many large business consumers are putting in metallic filament lamps, two in series, and many stations can testify to great reductions occasioned thereby in consumers' accounts. One thing is certain, that if a larger proportion of the total annual outlay on lighting is to be paid to the lamp-makers, the amount coming to the supply station must be considerably reduced if the total is to be reduced or even to remain the same.

If the consumption per consumer be reduced by, say, one-third, it is not sufficient to increase the number of consumers by 50 per cent., as this only just keeps the output at its former figure, without allowing for increased capital outlay on services, and increased expense in meter reading and general administration. It is, moreover, very doubtful if there are many districts where the number of consumers could be *quickly doubled*, whatever may be the result in the long run.

The foregoing remarks apply to those cases where 100-volt 25 to 30 candle-power lamps are used, two in series, on 200 volts or thereabouts.

The authors next refer to the use of transformers to reduce the supply pressure at the consumer's terminals to 25 volts or thereabouts. Their experience is very favourable. It may be objected that the transformer losses during the daytime would go far towards neutralizing the saving in current during the lighting hours. This difficulty may be obviated by keeping carbon filament lamps in the bedrooms, and arranging to switch off the transformers last thing at night, and then put them in circuit again, when the downstairs lights are again needed. There is now, however, on the market more than one switch which automatically switches the transformer off when the last lamp is turned off, and switches it on again when a lamp is turned on.

Under these circumstances we find that the consumption of current for the same illumination is only from one-third to one-half of what it was formerly.

In many cases—shops and business premises, for instance—the provision of a switch to turn off the transformer during the non-lighting hours presents no difficulty.

Since then these transformers have been made in large quantities, and it is quite evident that as soon as they become general the accounts of consumers on alternating current systems will be reduced by at least one-half.

Continuous current stations are not affected in the same way, but who can doubt that before long the price of metallic filament lamps will be largely reduced, and a satisfactory 200-volt lamp put on the market?

Such an event would largely increase the number of users of high-efficiency lamps and lead to a general reduction in lighting accounts. This will not affect so seriously the large companies in the manufacturing centres which have a large power load, and are able to supply lighting current at very low rates; but it will, we think, prove most serious for a large number of stations in residential districts dependent almost entirely on the supply of current for lighting.

What steps are the supply stations going to take to meet this? For some time to come it is hopeless to expect that the number of new consumers attracted by lower bills will keep the receipts up to the present level if the present rates and methods of charging be adhered to. Even in the case of the gas undertakings a severe check was received from the gas-mantle, and from the very nature of the business electrical stations are in a far worse position to withstand any reduction in receipts.

Taking the whole of the gas undertakings in the country, the Board of Trade returns are as follows:—

Total capital expenditure	£124,184,000
Total gross revenue ..	27,254,000
Total gross expenditure ..	20,496,000

For the electrical undertakings the figures are:—

Total capital expenditure	£50,767,000
Total gross revenue ..	6,514,000
Total gross expenditure ..	3,019,000

It will be thus seen that, whilst to obtain a gross revenue of £1 per annum a gas-works has to lay out £4 10*s*., an electrical undertaking must spend £7 10*s*.; and, whilst the ratio of working expenses to receipts is 75 per cent. in the one case, in the other it is 46·3 per cent. This means, of course, that in a gas company a much smaller margin of receipts over working expenses is sufficient to pay interest and financial charges and profit on account of its smaller capital than is the case with an electrical company. An electrical undertaking requires a much greater margin between gross receipts and working expenses than a gas undertaking for two reasons:—

1. Because, as shown above, it has to pay interest on a much greater capital outlay per £1 of gross earnings.

2. Because, in addition to paying this interest, it is generally liable to be bought out for a nominal sum at the end of forty-two years, and has therefore also to provide out of the margin for a substantial sinking fund—a contingency that gas companies have not to meet.

The two causes, both disadvantageous *per se* to electrical supply, have really a cumulative effect, as an increase in the first increases the second. They also render loss of output a much more serious matter than to a gas company.

Speaking of the revenue to be derived from extending electrical supply to the smaller consumers, the authors state that, in their experience, this class of customer is not remunerative, especially when the cost of facilities of "free-wiring," slot-meters, services, &c., are borne in mind.

On the whole, therefore, while the consumer may expect to benefit from the introduction of metallic filament lamps, it is less certain whether the supply companies will derive any advantage.

If the consumer is to save money, and the lamp-maker to get a higher price for his lamps, is it unfair to ask that the supply station should get a higher price for its current, or, at any rate, that the present downward tendency in the price charged should be checked ?

The authors, therefore, remark that the time is opportune for a further consideration of the method of charging in the case of those electricity supply companies, a large proportion of whose current is sold for lighting purposes, to see whether by any rearrangement it is possible, without raising the price to the average profitable consumer, to make those contribute their fair proportion who at present do not do so, and also to encourage the use of current for various purposes beside lighting, thereby extending the hours over which the station's large capital expenditure is earning interest.

It is probable that nobody has done more to advance the electrical industry than Mr. Arthur Wright by his masterly exposition of the principles underlying the costs of electric supply. All interested in these matters are naturally familiar with Mr. Wright's papers on the subject, more especially the one read by him before the Institution in 1901.

The situation created by the introduction of metallic filaments only serves to lend additional force to the principles he then enunciated. Unfortunately, however, the public have not always realized the advantages that the use of the maximum demand indicator confers.

In many cases stations which formerly charged on the maximum demand system have now reverted to, or offer, as an alternative, the flat rate, not because the latter is a fair and equitable system, but because of the trouble in getting consumers to understand the theoretically more perfect one. In addition a lower rate is granted for current required for heating or power.

In this connexion the authors quote several examples to show how a difference in the charge for lighting and heating, or lighting and power, may lead to absurdities. A heated dinner plate or a private electric lift may be in use during peak hours, and yet be charged at the low rate.

According to the view taken by the authors, the only satisfactory system is one which is intermediate between the flate rate system of gas charging and the fixed rental of the water companies, in the same way that the conditions controlling the cost of supply are intermediate between those of gas and water; in other words, a fixed rental in addition to the charge per unit.

It will be noted that nearly every station has to give flat rates as an alternative, and also special rates for power. Indeed, many large stations, having abandoned the use of demand indicators and the maximum demand system of charging, get over the difficulty in a rough-and-ready sort of way by quoting each consumer a special flat rate depending on what they consider is likely to be the nature of his demand. The difficulty here is, of course, in making one consumer who is charged, say, 5*d.* per unit, understand why he should pay more than his neighbour, who, perhaps, has a smaller consumption, but is only charged 2*d.* per unit. This may work in a large London district where no one knows his neighbour, but it would be unworkable in a country town.

According to the existing legislation any consumer has the right by giving one month's notice in writing to require the undertakers to charge him by the actual amount of energy supplied to him.

The result of this is, of course, that if it pays a man to take a supply on any special system, he accepts it, whilst those at the other end of the scale who are unprofitable at a flat rate, but would be forced to pay more on a special system, naturally elect to pay a flat rate, so that any special system at a point where it would become advantageous to the company is defeated by the provisions of the Electric Lighting Acts.

Owing to the conditions that pertain, electricity, when in competition with gas, should be able to show a considerable advantage to long-hour consumers, while gas, on the other hand, should be able to supply very short-hour consumers at a profit where an electric supply company would possibly make a loss.

If electrical undertakings are to be helped at the present juncture by the extended use of current for power, cooking, and similar uses, in the same way that the gas stove and cooker came to the rescue of the gas companies, it is essential that the whole of the business be simplified. It must not be necessary to put in a separate meter, separate wiring, and to render two separate accounts, but, nevertheless, it is equally essential that current for power should not be sold for a low rate simply because it is for power, and the loss made good by lighting consumers.

The great majority of domestic heating appliances take a current of under 5 amperes, and it should be possible to attach any such piece of apparatus to any convenient plug on the general house wiring. The ordinary householder will not buy an electric kettle—he will not even use it if given to him free—if he has to pull the house about to put in special wiring and to pay 3*s.* per quarter for the rent of a second meter. Electric heating appliances could be put on the market much more cheaply than at present if the demand were greater, but there is little inducement to the makers to cheapen them under existing conditions.

The authors suggest that all the above difficulties, practical and theoretical, might be met if the present minimum charge authorized by the Board of Trade were made to depend on the maximum power with which any consumer should be entitled to be supplied.

A consumer is thus to pay a fixed sum yearly depending on his "contract demand," *i.e.*, an estimate of the greatest power he will probably require; this will probably be somewhat greater than his *mean* maximum demand, but less than its highest value.

This is illustrated by several numerical examples.

The question may be asked, How does the station know that any consumer will not exceed the demand he has contracted for? This, of course, rests with the judgment of the company, based on what they estimate their load factor to be. The authors, however, recommend the insertion in the consumer's house of a "limit indicator," the function of which is to throw a resistance into circuit, and thus indicate to the consumer, by a reduction in the brilliancy of his lamps, when he is exceeding his contract limit.

If the consumer thinks that his demand is not so high as the station engineer suggests, the latter will set the instrument to a lower limit, when the contract charge will be correspondingly reduced. In the event of the consumer having underestimated his contract demand, he will soon ask for his limit to be increased, when his account will automatically increase in the same way.

The point in which this method differs from the Wright system is that the consumer can determine his own maximum, and unless he asks for his limit to be raised, he knows within a little just exactly what his bill for current is to be. He cannot, as with the maximum demand system, inadvertently switch on a number of lights for an hour or so, with the result that he finds that he has a much higher bill than the previous quarter when he used the same number of units. That he had under these circumstances to pay a higher bill might be quite just, but it is precisely because the average consumer could not be got to see this, that the system, admirable as it is, has been given up in many districts.

On the new plan, if he exceeds his demand he knows it, and has either to reduce it or to apply to the station to have his limit indicator set higher, thereby acknowledging that his requirements are greater, and therefore should be paid for accordingly.

There is also every inducement to use radiators and cooking apparatus.

When an electric kettle can be brought as an ordinary article, taken home and plugged into any of the ordinary plug sockets, the demand will be such that the price will quickly come down and their use increase at compound interest rate, for as long as they are used in such a way as not to increase the load beyond the contract limit, the only charge will be the small one for so much additional current, in the case of the station above referred to, for instance, 0·95d. per unit. The contract rental will, of course, be regulated to suit the prevailing conditions, and include the ordinary meter rental, which will disappear. Special circuits and meters for heaters and motors will also be no longer necessary.

Although the authors consider the use of a limit indicator to be the best method of working the system, it can be dispensed with and the contract rental arbitrarily fixed by the station as is now being done in the case of varying flat rates, or an ordinary maximum demand indicator can be installed and the consumer informed that the contract rental will be so much, provided that the indicator does not show that the assumed contract demand has been exceeded at any period during the whole year.

REVIEWS OF BOOKS.

Der Eingeschlossene Lichtbogen bei Gleichstrom.

By Dr. Karl Stockhausen.

(*Published by J. A. Barth, Leipzig,* 1907.)

In this volume the author includes a description of his previous researches on the gaseous contents and the relation between candle-power and the amount of air admitted in the direct current enclosed arc-lamp. Besides detailing the results of specific researches, however, the author now includes a variety of information relating to the enclosed arc which will be found of exceptional interest.

Chap. i. contains a brief study of the existing literature and the historical development of the enclosed arc, including a short discussion of the arc from the standpoint of the ionic theory.

Chap. ii. deals mainly with the mechanical effects taking place within the globe; the author touches on the structure of the arc, and the possibility of the formation of a crater and the "wandering" of the arc round the carbons. Especially interesting are the results of investigations upon the temperature of the globe and a comparison of the same with that of other electric lamps.

The author also enters into the connexion between P.D., current, and arc-length, in the light of Mrs. Ayrton's results. He brings out the characteristic distinctions between the behaviour of the enclosed and the open arc, and states that the formulæ of Mrs. Ayrton only apply in the latter case, when the connexion between the apparent resistance and length of arc is a linear function. In the next chapter he refers to the chemical changes taking place within the lamp, especially with the view of explaining the explosion known to occur occasionally on striking the arc. He analyzes the contents of the globe under various conditions, and shows that an explosive mixture can occur; a considerable initial rise in the internal pressure may also follow the increase in temperature accompanying the striking of the arc.

The next chapter is concerned with the nature of the radiation, both in the visible and chemical regions of the spectrum of the enclosed arc-lamp. The sixth and last chapter is of a general character, and deals fully with the photometry of arc-lamps. The short discussion of the relative value of the contrast and the flicker photometer is interesting, though it must be recognized that the experience of a large number of observers on such a question as this is essential; it is therefore quite possible that many observers would not agree with the conclusions arrived at by the author. The full description of the Ulbricht globe and its application to the photometry of arc-lamps is exceptionally instructive, and is accompanied by several effective illustrations. Among other points discussed in this chapter we note the absorption of globes, the method of rating the candle-power of arc-lamps, and the connexion between the amount of air admitted to the globe and the light emitted. In the latter case the author arrives at the result that the intensity is appreciably increased by the admission of a small amount of air.

The book is written in a clear and interesting manner, and accompanied by useful references on the subject. The system adopted of summarizing the contents of important sections in order that the reader may see at a glance the essential conclusions arrived at, is worthy of special commendation.

The Junior Institution of Engineers.

Through the munificence of Mrs. Frank R. Durham a Bursary of the value of £25 per annum, to be called, after the Chairman of the Institution, the Durham Bursary, is about to be announced to the members and associates, of whom those between the age of 20 and 22 will be eligible to compete by writing a thesis on some technical subject chosen by the candidate. The first award will be made in October, and competing theses must be in the hands of the Secretary at 39, Victoria Street, Westminster, not later than September 1st next.

RECENT PAPERS ON ILLUMINATION IN THE UNITED STATES.

Summary of Papers Presented to the Illuminating Engineering Society.

(From *The Illuminating Engineer* of New York, March, 1908.

A Summary of Recent Papers Presented to Various Technical Associations in the United States.

National Electric Light Association, 30th Convention, June, 1907.

Indefinite Candle-Power in Municipal Contracts, by E. Leavenworth Elliott.
Indefinite Obligations in Municipal Contracts, by Henry Floy.
Efficiency of Various Methods of Illumination, by E. A. Norman.
The Frequencies of Flicker at which Variations in Illumination Vanish, by A. E. Kennelly and S. E. Whiting.
The Effect of Frosting Incandescent Lamps, by Edward P. Hyde and F. E. Cady.
Electric Lighting in Germany, by G. Klingenberg.
Illuminating Engineering, as an Aid to Securing and Retaining Business, by C. F. Oehlmann.
Co-operative Lighting of Streets by Merchants, by H. J. Gille.
Methods of Securing Science Outlining Window Lighting, by Homer Honeywell.
Report of Committee to Consider Specifications for Street Lighting, by Dudley Farrand, Chairman.
New Developments in Arc Lamps and High Efficiency Electrodes, by G. M. Little.

North-Western Electric Light Association.

Outline Lighting, by Homer Honeywell, February 11, 1907.
Some Points on Illuminating Engineering for Small Central Stations, by J. R. Cravath, February 4, 1907.

National Commercial Gas Association, Second Annual Convention, January, 1908.

Gas Lighting in the Factory, by T. J. Litle, Jun.
Observations of the Methods of Handling the Lighting Industry Abroad, by R. M. Searle.
Practical Talk on Light and Illumination, by V. R. Lansingh.

Empire State Gas and Electric Association.

Buying and Selling Illumination, by E. L. Elliott, November 11, 1907.

New England Association of Gas Engineers.

Some Instances of School-Room Lighting, by N. W. Gifford, April 1, 1907.

American Institute of Electrical Engineers.

Light from Gaseous Conductors Within Glass Tubes, by D. MacFarlan Moore, April, 1907.

Pittsburgh Section, American Institute of Electrical Engineers.

Illumination, by Arthur J. Sweet.

National Bureau of Standards, Washington, D.C.

Geometrical Theory of Radiating Surfaces, with a Discussion of Light Tubes, by Edward P. Hyde: Reprint No. 51.
Talbot's Law as Applied to the Rotating Sectored Disc, by E. P. Hyde: Reprint No. 26.

Comparison of the Unit of Illuminating Intensity of the United States with those of Germany, England, and France, by Edward P. Hyde: Reprint No. 50.

On the Determination of the Mean Horizontal Intensity of Incandescent Lamps, by E. P. Hyde and F. E. Cady: Reprint No. 63.

Use of White Walls in a Photometric Laboratory, by F. E. Cady: Reprint No. 20.

An Efficiency Meter for Electrical Incandescent Lamps, by E. P. Hyde and H. Brooks: Reprint No. 30.

On the Theory of the Matthews and the Russell Leonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities, by E. P. Hyde: Bulletin No. 2.

On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method, by E. P. Hyde and F. E. Cady: Reprint No. 3.

An Explanation of the Short Life of Frosted Lamps, by E. P. Hyde: Reprint No. 61.

A Comparative Study of Plain and Frosted Lamps, by E. P. Hyde and F. E. Cady: Reprint No. 72.

Review of the Technical Press.

Illumination.

THERE do not appear to have been many important papers dealing with illumination pure and simple during the past month. Several recent editorials in *The Electrical World*, however, deal with points of interest and importance, particularly those dealing with 'Architecture and Illumination' and 'Diffusing Light from High Candle-Power Sources.'

The whole question of the correct methods of lighting buildings of historic and æsthetic interest seems to have been prominently to the front in the United States, as is shown by the recent papers by Mr. Bassett Jones, Mr. E. L. Elliott, and others on the subject.

Cravath and Lansingh also contribute a short article to *The Electrical World* on the subject of residence lighting, in which they discuss the varieties of fixtures most suitable for living-rooms, dining-rooms, halls, kitchens, &c.

Recent numbers of the *Journal für Gasbeleuchtung* contain some description of the recent display of shop-lighting at the "Augur" exhibition in Berlin. It seems to be generally agreed that the methods of lighting of many of the firms exhibiting were not all that could be desired, attention being paid to the production of great brilliancy rather than to the illumination of the goods to the best advantage. It is remarked that there are several points which are specially important in shop-lighting. We wish first and foremost to light the goods so that every object in the window can be clearly and distinctly seen. This intention is often interfered with by the method of placing brilliant lights so that they are in the direct line of sight. We must also take care not to employ any kind of light which may have a damaging effect on the goods....such, for instance, as causing coloured goods to fade rapidly. Also, when, as often occurs, lights are placed very near to the window panes, we must arrange so that the heat given out by them does not cause the deposition of moisture on the cold glass in winter, and so obscure the window. The article contains several illustrations of shops lighted by gas at the exhibition referred to.

McBeth (*Illum. Engineer*, N.Y., March) describes a form of calculator for the use of illuminating engineers. In ordinary work we usually employ the simple inverse square law, and wish to calculate the illumination at a given distance in terms of the intensity of the illuminating source and its distance away, or, conversely, to determine the candle-power necessary to produce a certain illumination. This can be accomplished by the calculator in question, and it is also possible to predict the ground-illumination at a given angle, yielded by a source of specified brilliancy and height from the ground.

Photometry.

C. O. Bond, in a recent paper before the Franklin Institute, discusses the various types of standards of light in use in the United States for gas-testing. These include the Hefner and Harcourt standards, and also the Elliott and Edgerton lamps, which are little known in this country. In the course of his paper he explains what the functions of such a working standard should be, and criticizes the various lamps in use from this point of view.

One of the most interesting portions of the paper is that in which the author gives his experiences of the Harcourt lamp in the United States. He considers this lamp as the best gas standard, and quotes several instances of the exactitude with which such lamps have been reproduced from English standards. It is to be noted that the lamp in use in the United States differs in several details from that in use in this country, and this, in a standard, is undesirable, although the author states that the differences in design which occur are of trifling consequence, and do not materially affect the light yielded by the lamp.

Dow (*Gas World*, April 11th) discusses the effect of colour-blindness on the flicker-photometer. It has been suggested that such photometers are unaffected by any peculiarity in vision of this nature. The author points out that many different types of colour-blindness exist, and that adequate evidence does not seem to exist to induce any one to maintain this opinion with conviction. He himself has obtained results in accordance with those of Dr. Brodhun, who found that, in certain cases, colour-blind observers do obtain abnormal readings. Similar conclusions have been reached by Rood, Tufts, and others. In any case it is pointed out that such a property must be a very doubtful advantage in a photometer. Certain red-blind people, for instance, are defective both in colour and light sensation. Red objects appear dark in hue to them. Therefore, if such a person obtained normal results with a flicker instrument we should be disposed to fear that the flicker instrument in question did not really measure *brightness*.

Dr. Steinmetz has recently contributed a suggestion for a primary standard of light to the American Institution of Electrical Engineers. He points out that the comparatively small variations in the nature of what is called " white light " as exemplified by the various standards of light now in use does, to some extent, constitute a source of uncertainty. He appears to suggest the production of a variety of white light composed of light and the primary coloursof certain specified wave-lengths in certain definite proportions. Some such lines occur in the mercury lamp. In the ordinary mercury amp there are three light lines in the green, blue, and yellow respectively. In order to obtain the red constituent it is necessary to employ a high-temperature such as is utilized in the quartz lamp of Heraeus; in the spectrum of this lamp distinct red lines occur.

Several recently published articles deal with graphical methods of obtaining mean spherical candle-power.

A. E. Kenelly (*Elec. World*, March 28th) describes a new method involving the measurement of the length of a line in place of an area as has hitherto been usual. The method only requires the use of a proctractor and a pair of compasses, and, it is claimed, is much simpler than the ordinary Rousseau diagram construction, but equally accurate. Kilmer and McBeth (*Illuminating Engineer*, N.Y., March) describe modifications of the ordinary methods. Kilmer employed squared paper and a cosine-scale in order to simplify the graphical construction. McBeth, working backwards from Kilmer's method, merely superimposes a transparent semicircular scale, on which polar co-ordinates at certain intervals are ruled, over the polar diagram of distribution of light of the source. We can then read off the values of candle-power corresponding to these ordinates and takes the mean.

Electric Lighting.

An important recent paper by H. W. Handcock and A. H. Dykes deals with the influence of the metallic filament lamp on existing methods of charging for electricity. The authors recognize the importance of the influence of these lamps, which may be soon available for high pressure and of small candle-power, on the industry. After reviewing the existing methods of charging they advocate the adoption of a system involving a fixed annual charge based upon the " contract-demand " of the consumer *plus* a charge per energy consumed. They are also impressed with the inequality of the prevailing system of allowing low rates of supply for heating and power which may, notwithstanding, be used at peak times. Nevertheless they suggest that the heating and cooking business should be welcomed on the ground that such business may enable companies to tide over the loss of revenue following the universal adoption of the metallic lamps. The introduction of the mantle, they point out, in spite of raising the general standard of candle-power, caused a marked decrease in the amount of gas sold for the time being; under these circumstances, the gas companies had found the extension of gas for heating and cooking a useful asset, and electricity might have a similar experience.

A recent article in *The Electrical Review* (April 10th, 'The "Metallic" in Use') deprecated the present careless methods of using metallic filaments commonly in use. These lamps were sold to many small consumers and contractors without their drawbacks as well as their advantages being clearly explained to them. The new lamps would prove a blessing in the industry only if care was taken to ensure their being used only when really advantageous. The technical press of current date also contains a number of editorials and articles dealing with the recent paper by Messrs. Handcock and Dykes, and the discussion thereon. In this connexion mention may be made of an amusing contribution, entitled 'Reason and Wright' (*Elec. Review*, April 17th), in which some possible incongruities arising from existing systems of charging are displayed.

There have also been a number of contributions bearing on the recent developments of electric lamps, some of them exceptionally complete and valuable, but too lengthy to be more than mentioned here. In a recent lecture Dr. Clayton Sharp (*Elec. World*, April 14th) dealt with 'The Tungsten Lamp,' and described the chief modern methods of manufacturing these lamps.

Recent numbers of the *Zeitschrift für Beleuchtungswesen* contain an exhaustive and valuable summary of processes of manufacture of metallic filament lamps in various countries, including full reference to the existing patents on the subject. The tungsten lamps have been fully dealt with, and the recent instalments of the series touch upon the application of thorium, yttrium, and other elements to glow-lamp manufacture. Mention is made of a recent patent of Lux, having for its object detection of inferior filaments. The graphitizing processes, rendering carbon filaments more homogeneous, are also described. Howell was the first to produce carbon filament lamps by this method, which would burn for 500 hours at an inefficiency of only 2·2 watts per candle-power. It is stated, however, that improved methods enable lamps burning satisfactorily for the same period at 1 to 1·5 watts per candle-power are now becoming practicable. The Parker and Clarke "Helion" lamp, in which a carbon filament is partially replaced by silicon, is also dealt with.

A somewhat similar series of articles, but on different lines, has recently been contributed by Duschnitz (*Elek. Anz.*, April 12th, 16th, and 19th). He deals with the recent developments in methods of leading in conductors to which the filaments of a lamp are attached, and the processes by which the required junction is accomplished. Finally, mention must be made of a summary (*Elek. u. Masch.*, April 12th) on the subject of recent patents applying to the mechanisms and structural details of arc-lamps.

Gas, Oil, and Acetylene Lighting.

One important recent contribution on this subject is that of Drs. Bunte, Mayer, and Teichel (*J. f. G.*, March 28th, and April 4th), on the processes of combustion occurring in the inverted incandescent mantle. In the first section of the article they enter into the theory of the inverted burner and the mantle generally, with special reference to high pressure lamps of the Lucas and Pintsch type. Subsequently they describe some interesting original experiments on the subject, chiefly bearing on the proportions of air and gas to be admitted. This portion of the paper is accompanied by photographs illustrating the modification in the shape of the flame with different mixtures, and also a curve and various tables illustrating the variation in intensity of light emitted from a lamp with different values of the gas-consumption, the relative proportions of gas and air being kept constant.

Equally interesting are the experiments of Prof. Wedding on the pressure of gas in burners, which are summarized in *The Journal of Gas-Lighting* (April 14th). Dr. Wedding traces the alterations in gas-pressure up to the nipple of the burner, where it is reduced to about 1·10 in passing through the fine orifice. With so low a pressure one need not wonder at the tendency to fire back, and it is important to keep what pressure remains as high as possible. Dr. Wedding prefers the drilling of a single in preference to several small ones; this single hole must, however, be smooth and well-drilled. He also refers to the benefit accruing from the preheating of gas before passing through the nipple, on which such divergent opinions have been expressed.

T. J. Little contributes to *The Illuminating Engineer* of New York a review of progress in inverted gas-lighting during the year 1907. Needless to say he considers the inverted mantle a great advance, and states that it has enabled gas to be profitably utilized, in many cases in which its use would otherwise have been out of the question. He refers to the efforts of gas companies in the United States to instruct the consumer as to the best methods of using gas, both by means of organized meetings, and by distribution of educational pamphlets. Inverted mantles have found an extensive use in railway-carriage lighting. In shops they are now often supplied with flexible metallic tubes attached to overhead brackets. Self-lighting and distance-lighting devices are also making headway.

Mention must also be made of the series of contributions to the *Zeitschrift für Beleuchtungswesen* dealing with the most recent developments in inverted burners. Like the corresponding articles on the subject of glow-lamp manufacture, these contributions contain a full *resumé* of the existing patents, and should be of considerable value to those interested in the technicalities of the subject.

A recent number of *The Electrical Review* of New York contains a reference to a new method of producing gas from waste products. It is stated that 15,000 cubic feet of gas can be produced from one ton of refuse by sprinkling with an alkali chemical solution, and subsequently distilling at a temperature of 1,200 degrees F. The illuminating power is stated to be twice that of the ordinary grade of coal gas, and we are told that the gas "contains for power purposes 800 heat units."

Lastly, we may refer to the use of acetylene in connexion with inverted mantles for train-lighting on the French Northern Railway, which is described in the most recent number of *Acetylene*. Now that strong mantles, capable of resisting the wear and tear of railway traffic, are available, and the initial difficulties accompanying the application of acetylene gas to the incandescent mantle are to a large extent overcome, the simple storage of soluble acetylene is finding useful application. On these trains each coach contains 4 main burners yielding 25 candle-power, and burning 0·25 to 0·28 cubic feet per hour, and 2 additional smaller ones placed in the lavatories. A single charge of gas will supply the 8 burners in the carriage for nine go and return journeys, lasting about 5½ hours each.

Miscellaneous.

Electrolytically formed metallic mirrors have recently been found very effective for this purpose, but a recently-developed system, not based upon the electrolytic process alone, due to Mr. Cowper Coles, is said to lead to exceptionally good results. Alternate bands of golden and white reflecting surface are produced, and, it is claimed, that the resulting surface, enables a beam of exceptional intensity and penetrating power to be obtained. It is also asserted that the surface is unusually durable, withstanding concussion remarkably well, and being only locally affected by the impact of bullets.

The recent lecture by Professor Burch on Colour Vision is referred to elsewhere in this number.

List of References:—

ILLUMINATION.

Cravath and Lansingh. Economical and Efficient Plans for Lighting Small Houses (*Elec. World*, April 4, 1908).
Editorials. Architecture and Illumination (*Elec. World*, March 26).
Diffusing Light from High Candle-power sources (*Elec. World*, April 4, 1908).
McBeth, N. A Calculator for the use of Illuminating Engineers (*Illuminating Engineer*, N.Y. March).
The Lighting of a Shoe Store (*Illuminating Engineer*, N.Y., March).
Uber Schaufensterbeleuchtung (J. f. G., March 21 and April 11).

PHOTOMETRY.

Bond, C. A. Working Standards of Light and their use in the Photometry of Gas (*Jour. of the Franklin Institute*, March).
Dow, J. S. Colour-Blindness and the Flicker Photometer (G. W. April 11, 1908).
Kenelly, J. S. A new method of Determining the Mean Spherical Intensity of a lamp by the length of a straight line, the curve of meridional intensity being given (*Elec. World*, March 28).
Kilmer, A. A convenient method of drawing the Rousseau diagram (*Illum. Engineer*, N.Y., March).
McBeth, N. A method of determining Mean Sperical C.P., without the aid of the Rousseau diagram (*Illum. Engineer*, March.)
Steinmetz, C. P. A Primary Standard of Light (*Trans. Am. Inst. of E. E.*, March).

ELECTRIC LIGHTING.

Duschnitz, Bert. Die Bestrebungen zur Herstellung von Glühlampen-Elektroden aus unedlen Metallen oder deren Legierung (*Elek. Anz.*, April, 12, 13, 16).

Handcock, H. W., and Dykes, A. H. Electric Supply Prospects and Charges as affected by metallic filament lamps (Paper read before the Institution of Electrical Engineers, April 8, 1908. See also comment on the same in current numbers of Electrical Press in England).

Neumann, L. Uber die Konstruktion der Glühlampenfassungen und Glühlampensockel (*Elektrot. u. Masch.*, March 29).

Sharp, Dr. Clayton. The Tungsten Lamp (*Elek. World*, April 14).
The "Metallic" in use (*Elec. Review*, April 10).
Transformers for metallic filament lamps (*Elec. Engineer*, April 10)
Fortschritte auf dem Gebiete der Elektrotechnik und des Maschinenbaues Elektrische Beleuchtung, *Bogenlampen* (*Elec. u. Masch.*, April 12).
Fortschritte in der Glühlampenindustrie (*Zeit. f. Bel.*, March 30, April 10 & 20).
Reason and Wright (*Elec. Review*, April 17).

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

Bunte, H., Mayer, M., and Teichel, E., Studien über Verbrennungsvorgänge bei Gasglühlichtlampen (J. f. G. March 28 and April 4).

Humphreys, N. H. The Gas of the Future (G. W., April 18).

Little, T. G. Progress of Inverted Gas Lighting during 1907 (*Illum. Engineer*, N.Y., March).

Smith. A. G. Public Lighting in Liverpool (Annual Report, G. W., J. G. L., March 31).

Wedding, W. Pressure in Inverted Burners (J. G. L., April 14).

Winkler, E. Vorrichtung zum anzünden mehrflammiger Gasglühlichtlampen (*Zeit. f. Bel.*, March 20).
Neue Invertbrenner (*Zeit. f. Bel.*, March 20 and 30, April 10 and 20, continued).
Incandescent Acetylene for Train-Lighting (*Acetylene*, April).
Lampe à incandescence pour le pétrole lourd (*Jour. du Pétrole*, March 1).
Producing Illuminating Gas from Waste Products (*Elec. Review*, N.Y., March 28).

MISCELLANEOUS.

Burch, Professor G. J. Colour Vision (Lecture delivered before the Optical Society, April 1).

Jones, Bassett. A Plea for a Liberal Education for Engineers (*Elec. Review*, N.Y., April 11).
The Relation between the Conductivity and Illumination of Selenium (*Elec. Engineering*, April 3).
A New Metallic Mirror for Searchlights (*Elec. Engineering*, April 9).

CONTRACTIONS USED.

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

Acetylene Lamps on the Battlefield.

It is stated that the German War Office have been experimenting with acetylene lamps for use in war. For signalling purposes some such source of light, at once powerful and portable, is needed. A further case where these same qualities are very essential is in connexion with the army medical department, who are frequently in need of an easily movable strong source of light at short notice, for instance, when improvising shelters and conducting operations, or searching for the wounded.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

5,719. Swing out lamp carriers. March 14. T. L. Scott, 51, Broomfield Avenue, Palmers Green, London.
5,829. Arc lamps. March 16. A. D. Jones, Hartham Works, Hartham Road, Holloway, London.
5,905. Lamp shade holders. March 17. J. H. Naylor and F. W. Cotton, Penny Bank Chambers, Halifax.
5,996. Brackets for supporting electric light globes. March 18. J. Pinson and P. H. Bibby, 5, Corporation Street, Birmingham.
6,059. Suspension devices for lamps. March 18. R. Baron, 111, Hatton Garden, London.
6,229. Arc lamps for theatrical stages, &c. (C.S.). March 20. T. J. Digby, 37, Essex Street, Strand, London.
6,407. Absorbing vibration in filament lamps. March 23. P. Druseidt, 20, High Holborn, London.
6,409. Incandescent filament lamps (C.S.). March 23. C. Pauli, 20, High Holborn, London. (Addition to 27,541/07.)
6,421. Arc lamps. March 23. Crompton & Co., Ltd., and C. Crompton, Arc Works, Chelmsford.
6,687. Incandescent lamps. March 25. The British Thomson-Houston Co., Ltd., and H. H. Needham, 83, Cannon Street, London.
6,751. Arc lamps. March 26. A. Holman, 44, West George Street, Glasgow.
6,974. Lamp holders. March 30. W. Fennell and W. P. Perry, 68, Dudley Road, Tipton, Staffs.
7,077. Arc lamps. March 31. H. Bevis and A. E. Angold, 3, Brown Street, Market Street, Manchester. (D.A. April 5, 1907.)
7,328. Arc lamps (C.S.). April 2. (I.C. Aug. 2, 1907, Germany.) Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
7,593. Water-tight lamp-holders. April 6. E. G. Byng and C. E. Gunner, 71, Queen Victoria Street, London.
7,674. Attaching shades and reflectors to incandescent lamps. April 7. C. W. Dawson, 30, Park Row, Leeds.
7,822. Electric lamps and their circuits. April 8. H. W. Handcock, A. H. Dykes, C. H. Stearn, and C. F. Topham, 47, Lincoln's Inn Fields, London.

II.—GAS LIGHTING.

5,732. Inverted incandescent lamps. March 14. J. Milne, Milton House Works, Edinburgh.
5,793. Lighting and extinguishing by varying pressure in mains. March 16. J. Rosie and J. McKelvie, 37, West Nile Street, Glasgow.
5,833. Inverted incandescent burners. March 16. E. J. Shaw, 60, Queen Victoria Street, London.
5,848. Incandescent burners. March 16. C. W. Harrison, 7, Southampton Buildings, London.
6,026. Incandescent mantles (C.S.). March 18. E. Ross, 56, Myddelton Square, London.
6,109. Controlling device for gas lights. March 19. J. M. Tourtel, 33, Cannon Street, London.
6,306. Incandescent lamps. March 21. R. O. Tweedie, 65, Chancery Lane, London.
6,365. Gas-light pendants (C.S.). March 21. S. Chandler and J. Chandler, Birkbeck Bank Chambers, Southampton Buildings, London.
6,468. Gas mantles (C.S.). March 23. (I.C. Aug. 10, 1907, U.S.A.) P. R. Finch, 31, Bedford Street, Strand, London.
7,157. Incandescent lamps. April 1. J. W. Bowley, 5, Corporation Street, Birmingham.
7,161. Gas mantles. April 1. A. A. Wade, 253, Hyde Park Road, Leeds, Yorks.
7,220. Inverted incandescent burners. April 1. J. Webber, 18, Southampton Buildings, London.
7,221. Fittings of inverted incandescent burners. April 1. J. Webber, 18, Southampton Buildings, London.
7,309. Controlling gas supply to lamps at a distance (C.S.). April 2. (I.C. July 23, 1907, Germany.) G. Himmel, 18, Southampton Buildings, London.
7,318. Controlling gas supply to lamps at a distance (C.S.). April 2. (I.C. Feb. 3, 1908, Germany.) G. Himmel, 18, Southampton Buildings, London. (Addition to 7,309/08.)
7,329. Intermittent gas lights for advertising, &c. April 2. A. T. Gilbert, 53, Chancery Lane, London.
7,461. Incandescent lighting. April 4. W. A. Handcock, 39, The Avenue, Beckenham, Kent.
7,541. Gas lamps. April 6. J. Keith and G. Keith, 65, Chancery Lane, London.
7,548. Gas lamps and burners. April 6. G. Helps, Izons Croft, Ansley, Atherstone.
7,791. Fittings for inverted incandescent burners and lamps. April 8. A. E. Podmore and J. Thomas, 256, Croxted Road, Herne Hill, London.
7,867. Anti-vibration attachment for incandescent burners. April 9. A. E. Baxter, 52, Monk Road, Bishopston, Bristol.

III.—MISCELLANEOUS.

5,708. Carrying shades of electric and gas lamps adjustably. March 14. E. A. Showell and E. H. Harris, Prudential Buildings, Corporation Street, Birmingham.
6,115. Lamps or lanterns. March 19. J. Hofmann, A. Koester, and F. Kumpernass, 111, Hatton Garden, London.

6,219. Means for illuminating. March 20. H. C. Dickson, 24, Southampton Buildings, London.
6,605. Holding gas or electric globes or shades in their galleries. March 25. A. Morrison, 13, Randolph Place, Edinburgh.
6,701. Increasing lighting power and durability of candles. March 26. T. S. Kendrick, 26, Upper Cox Street, Birmingham.
6,840. Solid wax lamps. March 27. E. Chalmers, 77, Colmore Row, Birmingham.
6,971. Photometer. March 30. W. Fennell and W. P. Perry, 68, Dudley Road, Tipton, Staffs.
6,997. Shade holder. March 30. R. Moore, 6, Kirkmanshulme Lane, Manchester.
7,240. Intensifying and diffusing illuminants. April 2. H. Sparks, 41, Mount Pleasant Road, Hastings, Sussex.
7,251. Acetylene generators and burners (high candle-power). April 2. W. Mills, 3, Brown Street, Market Street, Manchester. (Addition to 4,555/07.)
7,707. Lamps for illuminating, &c. April 7. G. Epstein, 54, Willow Road, Hampstead.
7,740. Globe galleries for gas burners, electric lamps, &c. April 7. S. Mundler, 4, South Street, Finsbury, London.
7,840. Lighting attachments for gas and acetylene burners (C.S.). April 8. (I.C. Aug. 10, 1907, U.S.A.). C. J. Larkin, 72, Cannon Street, London.
8,010. Acetylene burners (C.S.). April 10. D. J. Van Praag, 18, Southampton Buildings, London.
8,104. Filaments for illuminating and heating (C.S.). April 11. G. Michaud and E. Delasson, 7, Southampton Buildings, London. (Addition to 4,461/08.)

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

1,373. Lighting of railway and other vehicles. Jan. 18, 1907. Accepted March 25, 1908. C. A. Park and C. L. Mason, 77, Chancery Lane, London.
6,409. Lighting of railway and other vehicles. March 16, 1907. Accepted March 18, 1908. Sir W. G. Armstrong, Whitworth & Co., Ltd., and J. Honner, 24, Southampton Buildings, London.
6,913. Arc lamps. March 22, 1907. Accepted March 25, 1908. W. J. Davy, 40, Chancery Lane, London.
7,642. Filaments for incandescent lamps (C.S.). March 30, 1907. Accepted April 8, 1908. H. H. Lake, 7, Southampton Buildings, London. (From Parker Clark Electric Co., U.S.A.)
7,926. Arc lamps. April 4, 1907. Accepted April 1, 1908. H. S. Hatfield and F. M. Lewis, 18, Palmeira Square, Hove, Sussex.
7,941. Arc lamps. April 5, 1907. Accepted April 15, 1908. H. Bevis and A. E. Angold, Peel Works, Adelphi, Salford.
7,941A. Arc lamps. Oct. 21, 1907. H. Bevis and A. E. Angold, 3, Brown Street, Market Street, Manchester. (D.A. April 5, 1907.)
8,151. Fixing lamp shades or reflectors adjustably. April 8, 1907. Accepted March 25, 1908. J. Rawlings and R. T. Smith, 34, High Holborn, London.
8,388. Systems of lighting by arc lamps. April 11, 1907. Accepted April 1, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
8,563. Metallic illuminating bodies for incandescent lamps (C.S.). I.C. Aug. 30, 1906, Germany. Accepted April 15, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
8,641. Joints between lamp filaments and leads. April 13, 1907. Accepted April 15, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,071. Supports for filaments of incandescent lamps. April 30, 1907. Accepted April 8, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,931. Incandescent lamp bulbs (C.S.). May 10, 1907. Accepted April 1, 1908. D. F. Campbell, Fairfield Building, Vancouver, British Columbia.
16,383. Electric light fittings. July 17, 1907. Accepted April 15, 1908. H. M. Appleyard and E. Quiggin, 15, Water Street, Liverpool.
17,655. Arc lamps (C.S.). Aug. 2, 1907. Accepted April 15, 1908. W. G. Heys, 51, Deansgate Arcade, Manchester. (From The Scott Electrical Co., U.S.A.)
17,781. Arc lamps. Aug. 3, 1907. Accepted April 8, 1908. A. D. Jones, 18, Southampton Buildings, London.
17,972. Incandescent lamps with filaments made from a plastic mass (C.S.). I.C. Aug. 28, 1906, Germany. Accepted April 8, 1908. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London.
23,098. Incandescent lamps (C.S.). I.C. Nov. 5, 1906, Germany. Accepted March 18, 1908. Schott and Gen., Jena, Germany.
23,225. Arc lamps (C.S.). I.C. Sept. 6, 1907, Germany. Accepted March 18, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
2,676. Holders for incandescent lamps (C.S.). Feb. 6, 1908. Accepted April 15, 1908. A. Loebl and British Ever Ready Electrical Co., Ltd., 111, Hatton Garden, London.
5,783. Incandescent lamps (C.S.). March 14, 1908. I.C. March 16, 1907, U.S.A. J. W. Howell, 83, Cannon Street, London.
6,245. Metal filament lamps (C.S.). March 20, 1908. I.C. March 27, 1907, Germany. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand.

II.—GAS LIGHTING.

6,828. Incandescent mantles (C.S.). I.C. Jan. 28, 1906, Germany. Accepted April 1, 1908. G. Buhlmann, 111, Hatton Garden, London.
7,049. Inverted incandescent lamps. March 23, 1907. Accepted March 25, 1908. O. Imray, Birkbeck Bank Chambers, London. (From J. Pintsch, Germany.)
7,197. Lighting and extinguishing by varying pressure in mains. March 26, 1907. Accepted April 1, 1908. J. M. Tourtel and W. R. Mealing, 57, Chiswell Street, London.
7,540. Fabric for gas mantles (C.S.). March 28, 1907. Accepted April 1, 1908. G. J. Seckel, 40 Chancery Lane, London.
8,371. Self-lighting incandescent burners. April 10, 1907. Accepted April 15, 1908. W. C. Edwards, 325, Vauxhall Bridge Road, London.
8,535. Burners for flare lights. April 12, 1907. Accepted April 15, 1908. C. C. Wakefield, 111 Hatton Garden, London.
11,768. Incandescent lamps with horizontal burners. May 21, 1907. Accepted April 15, 1908. J. Hudler, 100, Wellington Street, Glasgow.
15,047. Lighting and extinguishing from a distance (C.S.). I.C. Aug. 18, 1906, Sweden. Accepted April 1, 1908. Aktiebolaget Gas-Accumulator, 46, Lincoln's Inn Fields, London.
22,821. Inverted incandescent burners (C.S.). I.C. May 13, 1907, Germany. Accepted March 25, 1908. (Firm of Ehrich and Graetz, 1, Broad Street Buildings, Liverpool Street, London.
793. Inverted incandescent burners (C.S.). Jan. 13, 1908. Accepted April 15, 1908. M. Graetz, 18, Southampton Buildings, London.
2,285. Inverted incandescent burners (C.S.). Feb. 1, 1908. Accepted April 15, 1908. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.

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

7,497. Incandescent petroleum lamps. March 28, 1907. Accepted March 25, 1908. A. Meissner and J. Danischevski, 6, Lord Street, Liverpool.
13,476. Vapour-burning lamps (C.S.). Jan. 11, 1907. Accepted April 8, 1908. M. W. Pitner, 616 F. St., N.W., Washington, D.C., U.S.A.
23,796. Use of compounds of ammonia and higher fatty acids for illuminating purposes (C.S.). I.C. Nov. 13, 1906. Accepted April 8, 1908. F. Engelhorn, 47, Lincoln's Inn Fields, London.
330. Lamp shades (C.S.). I.C. Jan. 11, 1907, U.S.A. Accepted April 8, 1908. W. O. Holt and R. L. Foster, 173, Fleet Street, London.
5,030. Illumination and heating by vapour burners (C.S.). March 5, 1908. I.C. March 6, 1907, France.
6,775. Non-combustible lamp wick (C.S.). March 26, 1907. I.C. March 28, 1907, Germany. B. Monasch, 27, Chancery Lane, London.

EXPLANATORY NOTES.

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

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

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

Accepted.—Date of advertisement of acceptance.

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

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

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

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

TRADE NOTES.

A New Arc Lamp Coupling.

We have received from Messrs. The Union Electric Co., Ltd., an account of a new form of strain release and arc lamp coupling. The distinctive feature claimed for this arrangement is that no question can arise as to whether or no the lamp has been hoisted to exactly the correct position; it is merely necessary to hoist up to a certain stop.

Metallic Filament Lamps of British Manufacture.

The "Metallite" lamp is described in a leaflet recently issued by the Bryant Trading Syndicate. From the results of some tests on these lamps, we are given to understand that a life of 1,000 hours, at 1 watt per c.p., with practically no diminution in initial candle-power and efficiency, was realised. The lamps are also listed for pressures up to 250 volts.