The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

The Ultra-Violet Element in Daylight and Artificial Light.

In the editorial remarks in the last few numbers we have drawn attention repeatedly to the inconsistency constantly encountered in the prevalent statements as to the colour and physiological effects of different illuminants. We have explained that such statements can serve no useful end unless they are backed up by the weight of scientific evidence and that definite conclusions on the points raised are not at present forthcoming.

The article by Dr. Nichols, which we abstracted in our last number, contained valuable information on the subject of the spectral composition of various illuminants and their deviation from daylight. Whatever view is taken as to the correctness of Dr. Nichols's conclusions, it must at least be recognized that the method of scientific investigation is the only one that can lead us to definite conclusions on these disputed points.

In our present number we have devoted special attention to several recent papers by Dr. F. Schanz, Dr. Voege, and others, on the subject of the ultra-violet constituent present in sunlight and artificial illuminants, and its physiological action. Here again, we can only express satisfaction at the scientific spirit of investigation in which the matter is approached, although in several cases the views taken by the authors are in apparent contradiction. Dr. Schanz, starting from the admitted cases of injury caused by sources rich in ultra-violet rays, proposes to employ a variety of glass which completely absorbs radiation of this nature. Dr. Voege, on the other hand takes the view that natural daylight, to the use of which our eyes have been gradually accustomed, is richer in ultra-violet rays than most artificial illuminants, and that the ultra-violet element in these sources must therefore be regarded as innocuous.

Yet it must not be supposed that because certain conditions occur in nature therefore they are beneficial under all circumstances. Sunlight may be extremely rich in ultra-violet radiation, and it is certainly true that in nature we meet surfaces illuminated by the sun's rays which are far brighter than those encountered inside the home. But we also know for a fact that incautious exposure to the glare of the sun in tropical regions may cause serious injury to eyesight, especially in the case of people unaccustomed to these conditions. It is also highly probable that any one who attempted to gaze straight at the unclouded sun at mid-day constantly would go blind. Snow blindness, again, is now ascribed mainly to the injurious action of the ultra-violet rays prevalent in high altitudes.

The discussion which followed the reading of these two papers before the German Institution of Electrical Engineers serves to show that considerable importance is now attached to these questions, and a number of further researches are to be carried out in order to settle the points in dispute. To this discussion we mean to refer in a subsequent issue.

We have previously expressed the opinion that all these disputed questions affecting the influence of light on eyesight and hygienic aspects of illumination generally might well form the subject of an expert commission. Interesting confirmation of our conviction that the matter calls for authoritative Government control is afforded by the suggestion that has now been put forward in the United States that the Board of Health—an exceedingly active and influential body—should undertake to consider the framing of regulations affecting the hygienic aspects of illumination.

The Specification of Daylight-Illumination.

The article which Mr. Waldram contributes to the present number is an interesting commentary on a point to which we have repeatedly drawn attention, namely, the vital importance of the subject of illumination to the architectural profession.

Our previous remarks have frequently referred mainly to the æsthetic aspects of lighting, with which the architect is obviously concerned, but it must also be remembered that there are many legal and practical aspects of the subject which are at least equally vital to him.

One such question is the provision of adequate window-illumination in buildings, and the disputes that are constantly occurring with regard to ancient lights. Mr. Waldram draws attention to a number of obvious anomalies in the manner in which these questions are often decided. The value of actual measurement, as a means of deciding how far the available illumination in a room has been affected by an adjacent building, can hardly be questioned.

The whole problem of school-illumination, again, is very intimately bound up with the study of daylight-conditions, and we have previously dwelt upon the important work that may be done in this direction by architects who will give the subject scientific study. Daylight - illumination in schoolrooms is the more important on account of the fact that the vast amount of school work is done during the daytime. Moreover, many people have an unconcious feeling that, whatever may be thought of the artificial illumination in a room, the daylight-illumination can be safely regarded as sufficient and adequate unless, indeed, a fog is actually in progress.

As a matter of fact, it is frequently a matter of extreme difficulty to secure that all parts of a room receive even the minimum correct illumination by daylight alone, and it may safely be said that many schoolrooms in use to-day contain dark regions in which the illumination under which the children work is inadequate. The provision of daylight illumination is in the hands of the architect responsible for the arrangement of the window-space and the scheme of decoration adopted. In this connexion Mr. Waldram remarks that it is only those architects with long experience behind them who are able to form some conception as to how far the arbitrary rules by which they are guided are applicable to local conditions. "Younger architects can only trust to guess-work and luck." He remarks, however, with some justice, that there has, until quite lately, been no recognized medium for the discussion of these matters and few suitable textbooks. This need 'THE ILLUMINATING ENGINEER' desires to supply, and we welcome discussion on this important subject.

Illuminated Notices in the Streets.

An article in the present number makes reference to one subject that may be commended to the notice of municipalities and those responsible for public lighting, namely, the provision of suitable illuminated notices and direction-signs in our streets.

We are only slowly emerging from a period of complete indifference to the needs of the stranger in this respect. It is no exaggeration to say that at one time the stranger within our gates was expected to determine his whereabouts and to know the names of streets by a species of instinct. Even to-day names are in many cases far from being as prominent as might be desired, and a point that deserves consideration from authorities is the fact that in many streets such names are quite as essential by night as by day, or even more so. They ought, therefore, to be suitably illuminated.

Apart from the names of streets and buildings, however, there are many instances in which special direction-signs are necessary, *e.g.* for the purpose of indicating the whereabouts of railway stations, &c., while the value of such signs from a purely business point of view is hardly yet sufficiently recognized in this country, in contrast with their great development in the United States.

At the same time there are indications that progress is being made in this direction. As an instance of the convenient use of luminous devices, we may mention those recently installed at the entrances to some of the tubes and those on the platforms of the Metropolitan and District Railway, calling attention to the destination of the next few trains due.

Companies supplying gas and electricity are also awakening to the increase in income to be derived from the extending use of illuminated signs for advertising purposes; and it may be anticipated that in the future they will form a very much more important feature of our streets than at present.

A Home for International Congresses.

AMONG other important forthcoming international events, we note with great pleasure that the International Conference on Electrical Units is to assemble in London on October 12th.

The present year has been signalized by a series of international rapprochements of a varied character, and on a scale that we have never encountered before. In London alone a score or more such congresses on various subjects have taken place, and it is safe to say that international action of this description is now no longer regarded as an act of grace, but also as a matter of the greatest scientific and commercial expediency. There is therefore every reason to believe that this tendency towards free interchange of ideas will continue, and we feel that the present moment is ripe for the organizing of congresses of this nature on a more definite recognized basis.

It is understood that, for the first time this year, a sum is to be set apart by the Government for the promotion of international hospitality. This commencement might well be extended to include one much-needed convenience to international meetings.

At the present moment such congresses have no definite meeting place. The members have necessarily to assemble in quarters of London selected in a haphazard manner, and the building in which the meeting is held is often as inadequate for the purpose in view as it is difficult to locate. Surely when a number of distinguished visitors from other lands assemble in our country, the first duty confronting us is to make the details of the arrangements as simple and agreeable as possible. To this end it would effect a very grateful simplification if a conveniently situated hall were to be provided, specially adapted to the purpose in view and officially regarded as the meeting place of international congresses to be held in this country.

This hall might well constitute a national institution, worthy of the traditional hospitality of this great nation.

Naturally the illumination of the various rooms of such a building, whether libraries or devoted to the meetings of the congresses ought to receive particularly careful consideration, which cannot always be said to be true of the temporary quarters utilized at present.

An International Unit of Light.

Reference has been made above to a coming International Conference on Electrical Units. As we pointed out previously, the question of defining the units applying to the various quantities used in illuminating engineering still calls for international treatment.

In our present number we publish the first of a prospective series of articles dealing with the photometrical laboratories of different countries. On this occasion Dr. Hyde describes the arrangements and work carried out at the Bureau of Standards in Washington, U.S.A. One of our main objects in embarking on this series of articles is to provide a comparison of the methods used in different parts of the world for photometrical testing, and a review of the various problems presented for solution.

Dr. Hyde lays stress upon one matter which is rightly considered one of the most pressing subjects for international consideration, namely, the choice of a common unit of luminous intensity. An additional, closely related matter is the selection of common photometrical terms to denote the units of luminous intensity, intensity of illumination, &c.; and this point, it will be remembered, formed the subject of some controversy between M. Laporte and Dr. Monasch in our columns a short time ago.

A great deal of discussion has raged round the merits and disadvantages of the various standards of light used in different countries. Naturally it would be a great simplification if common primary and secondary standards of light could be agreed upon. A more vital matter, however, as Dr. Hyde points out, is the choice of a common *unit* in which the intensity of sources of light produced in all countries could be expressed. This question has recently received the joint consideration of the Institutions of Gas and Electrical Engineers and the Illuminating Engineering Society in the United States. The British, French, and American units approach each other so closely as to give little trouble, but the 10 per cent change required to bring the German unit into line is naturally a subject of some concern.

The advantages of agreement on this question are so evident that it can hardly be doubted that an international unit of light will not long be delayed. It is therefore all the more essential that nothing should be done to obstruct its coming by any incautious and hasty attempt at settlement by some body not possessing the necessary international representative character and the highest expert backing. The discussion between M. Laporte and Dr. Monasch previously mentioned afforded a valuable instance of the many-sided aspect that such problems present to the experts of different countries, and any attempt at settlement that is not representative both of different nations and different methods of illumination cannot achieve lasting success. LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter now enters upon the consideration of the subject of PHOTOMETRY, and discusses some of the methods that have been suggested for the direct measurement of light, such as those involving the use of photography and the Crookes radiometer. He also deals with the class of instruments known as "discrimination photometers," and explains the principles employed by Fleming, Houston and Kenelly, and others in order to utilize visual acuity as a basis of measurement of illumination.

Dr. C. V. Drysdale, having completed the instalment of his series of articles dealing with the mechanical equivalent of light, embarks upon a discussion of the LAWS AND MEASUREMENT OF RADIATION. He describes, with illustrations, a number of the early attempts to measure the energy of radiation, such as the solar radiation thermometer, and other devices, and the radiometer of Nichols.

Prof. J. T. Morris contributes the results of a comprehensive series of photometrical tests upon the most RECENT TYPES OF FLAME ARC-LAMPS, which he compares with those obtained for some incandescent gas-lights, and described in the last number of *The Illuminating Engineer*. A feature of the article is the complete series of diagrams of polar curves of the different lamps described, which are supplemented in each case by diagrams showing the exact nature of the carbons used.

Prof. H. Bohle, of Cape Town, gives the results of some EXPERIMENTS ON NERNST, CARBON, AND METALLIC FILAMENT GLOW-LAMPS, with the object of comparing their relative sensitiveness to fluctuations in P.D. He illustrates his results by the aid of an actual chart of the pressure supplied, and works out the relative cross-sections of cables required for a building suitably illuminated by each of the varieties of lamps studied.

Mr. P. J. Waldram, F.S.I., deals with the MEASUREMENT OF ILLUMINATION FOR ARCHITECTURAL PURPOSES. He gives a résumé of the existing legislation bearing on the subject, chiefly relating to the window-space for a given floor area. Such conventional rules as exist, however, he regards as inadequate to secure proper illumination, and advocates actual photometric measurements. Apart from the obvious desirability of being able to predetermine illumination in a building, such exact measurements would be of value in settling disputes about ancient lights which are a fruitful source of legislation.

The **Special Section** in the present number is occupied by a contribution by **Dr. E. P. Hyde,** who describes the PHOTOMETRICAL ARRANGEMENTS in use at the BUREAU OF STANDARDS, WASHINGTON, U.S.A. This is the first of a series of articles to appear, dealing with the chief photometrical laboratories of different countries. In addition to a complete description of the character of the work done at the Bureau, and the chief points of interest in the apparatus employed, Dr. Hyde lays special stress on the question of standards and units of light, and explains how the relations between the units in use in various countries are now continually checked by the interchange of carefully calibrated incandescent lamps.

The next step is for the various countries to decide upon a common average unit, even though each country may prefer to utilize its own standard, and this seems quite feasible in the case of Britain, France, and the United States, whose units approach each other so closely

Among other articles in this issue may be mentioned that dealing with

LIGHT AS A MEANS OF ATTRACTING ATTENTION. The author shows how, in daily life, the contrast between light and shade of objects and their surroundings is effectual in making the former "stand out" and attract attention. This principle is naturally not without effect upon the arrangement of light desirable in a reading-room or lecture-theatre. It is likewise worth consideration in the arrangement of shop-windows and illuminated signs in the streets. In the latter connexion the author suggests there is a great field for the more liberal use of direction-signs that are adequately illuminated.

Special reference is also made to the effect of light upon eyesight. This matter is now receiving a considerable amount of attention. In an article entitled SOME EFFECTS OF LIGHT, VISIBLE AND INVISIBLE, the author quotes instances to show how marked physiological effects of light may be taking place without our being aware of them. Attention is drawn to the series of discoveries relating to the effect of ultra-violet light upon the eyes and the skin as exemplified by the work of Finsen, and the effect of such rays on small-pox patients.

The papers by **Dr. F. Schanz** and **Dr. K. Stockhausen** and **Dr. Voege** deal more particularly with the degree of ULTRA-VIOLET LIGHT IN ARTIFICIAL ILLUMINANTS. **Drs. Schanz** and **Stockhausen** quote instances of the injurious action of such rays, and advocate the use of a special variety of glass in order to absorb them. The value of this glass for the purpose is illustrated by a series of photographs of the spectra of illuminants, both with and without the "Euphos" glass.

Dr. Voege, on the other hand, quotes experiments comparing the intensity of the ultra-violet in artificial illuminants with daylight. He comes to the conclusion that the proportion of radiation of this description is greater in the latter case. Yet our eyes have been gradually developed in order to use daylight, and it has not been found necessary to use glasses to eliminate the ultra-violet radiation occurring in it.

The papers by **Dr. H. Seabrook** and **Dr. Krall** are likewise concerned with the influence of artificial light on the eye, though in this case it is the injurious effect of intrinsic brilliancy that is mainly insisted upon.

Under the title WHAT IS LIGHT? we include some speculations by **Mr. P. G. Nutting**, regarding the physiological basis of visionand the part played by those minute organs on the retina, the "rods" and the "cones"; Mr. Nutting suggests the possibility of collecting these physiological effects and reprinting them by some standard series of formulæ.

Among other articles on varied subjects in this number we may draw attention to that dealing with the ILLUMINATION OF THE SINGER BUILDING IN NEW YORK. A portion of this building consists in a very high tower, which is illuminated from without by the aid of searchlights and concealed glow-lamps, instead of the conventional system of "outline-lighting."

Some results of TESTS ON ACETYLENE-BURNERS are also given, and also an account of an ingenious device for improving the performances of incandescent burners. A résumé is given of a report recently issued by **Mr. Frank Sumner** on the COST OF THE LIGHTING OF LONDON STREETS.

Mr. Chas. Baker also contributes a letter to our correspondence columns dealing with the subject, and suggesting the desirability of extending such experiments as those undertaken by Mr. Voysey, so as to include a larger area.

Mr. Lancelot Wild writes commenting upon the article by Prof. J. T. Morris occurring in our last number, and urging the necessity of specifying the conditions under which gas-burners are stated to give certain results. At present, owing to fluctuations in pressure, uncertainty as to quality of gas to be used with burner, and other causes, it is difficult to predict what its exact performance will be.

At the end of this number will be found the usual **Review of Current Literature dealing with 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.* 625.)

Photometry.—Photometry, or the measurement of light and of illumination, differs in several respects from other physical measurements; and before discussing practical apparatus and its use, it is well to give some consideration to the limitations to which photometry is subject. The idea of measuring light is so unfamiliar to many quite intelligent people, that they confuse the word photometry with photography, and have neither the remotest idea that light can be measured nor how any operation of measurement can be carried out when no units of length, volume, weight (for such people do not understand mass in its scientific sense), or time, or appreciable force or movement enter into the question.

There is an important branch of physical science which deals with the objective action of light. This department of the science of optics is concerned with the generation of luminous radiation, its transmission. refraction, reflection, polarization, and so on; it deals with dynamic and geometrical considerations, either as pure abstractions or assisted, illustrated, and guided by experiment.

Photometry, in the original sense of the word, as used by Lambert in his treatise 'Photometria sive de Mensura et Gradibus Luminis colorum et umbræ,' published in 1770, was not so much experimental as deductive. Lambert started with such axioms as "Two candles give more light than one," and he developed theorems like Euclid. He used experiments chiefly to illustrate theorems and to verify laws, but he also discovered facts. Some writers have attributed to Lambert the invention of the photometer generally known as Rumford's, but at the beginning of 'Photometria' he discussed at some length the desirability for a photometer, and regretted that no such instrument had been invented. Summing up the discussion in a passage in italics, he said that the eye lacks an instrument analogous to a thermometer. This statement is remarkable, for he describes several experiments in which he actually employed photometric methods.

Photometry in its modern sense is mainly experimental, and the term is hardly applicable to the foregoing section of these articles, which, with the exception of the description of the standards of light, has been of a deductive character.

Photometry differs from those other sections of optics to which reference has been made in that it depends upon the subjective effect produced by the stimulation of a special organ of sense. Whatever results we obtain, however ingenious the apparatus used to arrive at them, and whatever the conditions we prescribe for carrying out the work, our measurements are of no value if they disagree with the commonsense estimate which any-body may make by merely using his eyes.*

If the results of photometry yielded nothing more than an agreement with that commonsense estimate, the labour would be in vain. Allusion was made on p. 8 to the inability of the eye to judge the candle-power of a lamp or the relative candle-power of two sources of light with any degree of accuracy. By means of a photometer the relative candle-power may be measured with little difficulty to 2 per cent, and by taking suitable precautions, and after some practice, and under favourable conditions, an accuracy of half of 1 per cent may be obtained. There is no disagreement here, but a development of our powers.

Photometry is not the measurement of an external or objective dimension or force, but of a sensation. It is difficult to make a quantitative measurement of our sensations. Two pigs under a gate make more noise than one pig, and while it is possible to measure the amplitude of the vibrations of air which produce sounds, and to estimate those which correspond to the faintest audible sound and those which cause the roar of a large organ, we know little of the quantitative measurement of sound. The attempt to apply measurement to sensations of smell has not met with success, and in spite of the delicacy with which different sensations of taste may be discriminated, it not only seems impossible to measure taste, but there appears to be physiological reasons for a rapid approach to a saturated condition of the sensation. A similar difficulty arises in the action of light on the eye.

Most physical measurements depend upon the observation of the relative position of parts of an apparatus, such as an index and a scale. The mistake is sometimes made of supposing that because photometers generally have an index and a scale, there is a direct connexion between the quantity so indicated and the quantity to be measured. The quantity indicated is generally a length, or in the case of certain photometers an angle, though in fact this is only the use of a graduated circle instead of a graduated straight line. The quantity to be measured is the physical intensity of a luminous radiation. The connexion between these is a psychological quantity, and this again depends upon a physiological function.

With the exception of a class of photometers which depend upon the faculty for discriminating the small detail of a pattern or for reading printed matter, all others depend on the judgment of the eye for judging the equality of, or for detecting a small difference between the illuminations of two screens or parts of a screen.* This is surrounded by physiological complications even when the illuminations are of the same colour, but when the colours differ new difficulties arise, and von Helmholtz has declared that no comparison worthy of being called a physical measurement can be made between lights of different colours, on the ground that the sensations are heterogeneous. It is true that with ill-devised apparatus and unsuitable methods some difficulties are experienced, but the judgment that two surfaces of different colours are of equal or of unequal brightness is an operation with which every artist in black and white or monochrome, and every engraver and etcher is familiar.

At the time when the paper of which these articles are an expansion was written,† photometry had been confined chiefly to the commercial testing of gas, and a few scientific researches such as those of Sir W. de W. Abney and General Festing. As a department of physical science the subject does not seem to have been very attractive, probably because it is one of the least accurate kinds of measurement. Many attempts have been made to banish visual photometry altogether from the physical laboratory. At one time it was thought that the radiometer would supplant it, but it was soon found that the

* "In definiendis luminis gradibus solus oculus est judex."—Lambert, 'Photometria,' p. 6.

* "Non tamen inter gradus claritas aliam dignoscere valet rationem præter rationem æqualitatis."—Lambert, 'Photometria,' p. 16.

† May, 1892.

rotation of the "light-mill" depended on thermal rather than on luminous rays. The thermopile and the bolometer have been used to measure the whole radiant energy by means of electrical apparatus, and the dark heat rays or the luminous rays have been filtered out by selective absorption. Considerable accuracy is possible with such methods, but even if by great precautions changes of temperature have been avoided, and unsuspected radiation of heat guarded against, the proportion of luminous energy to thermal energy is so small that it is hopeless to arrive at any precise measurement of light alone. Photometers proposed by Dessendier and by Lion, depending on chemical combinations of gases, may also be dismissed either as insufficiently developed or as unsuitable for practical purposes; and although from time to time the electrical properties of selenium give some promise of quantitative indication of the intensity of light, nothing with a pointer or an index such as Lambert wanted has been produced which can compete with an ordinary visual photometer, or enable a standard of light to be dispensed with.

There is a danger in all these electrical and chemical methods of measuring something that is not light. "Radiant heat and light," said Lord Kelvin,* "are one and indivisible. There are not two things, radiant heat and light; radiant heat is identical with light.... It is light if you see it as light; if it is not light you do not see it.... Radiant light is light if we see it, it is not light if we do not see it."

Photographic methods have been suggested; daylight and sunlight have been investigated by Sir W. Roscoe,† and under certain circumstances useful results might be obtained.

It was stated on p. 183 that an exposure of about 5 foot-candle seconds gives a sensitive shade of grey on "slow" bromide paper. This might be used for integrating or averaging the whole illumination of a street by carrying a strip of such paper about in a systematic manner for a definite time over a definite area.

I have exposed in a street such a strip to an illumination of about 1 foot-candle for 5 seconds and another strip from the same sheet was exposed at home, also for 5 seconds, to different illuminations, namely, 0·8, 0·9, 1·0, 1·1, 1·2 foot-candle. The two strips were then developed together in the same dish. This gave a number of bands of different tone, forming a scale, and the tone of the test strip could be compared with this scale, and its value estimated. The development of a number of strips can be quickly carried out, and, like indicator diagrams, they afford a permanent record of the measurements. But a considerable number of precautions would have to be taken, and in order to avoid differences of actinic power, selective filters or screens would have to be used. It would, indeed, be necessary to do more than this; screens would have to be used so that the measurements represent the effective or useful illumination as judged by the eye.

Discrimination Photometers.—Before entering on the discussion of photometers which depend upon the balancing of two equal illuminations, two classes of photometers based on the power of the eye to discriminate small details may be described.

Long ago, before any practical standards of light had been proposed, instruments had been used for estimating visual acuteness under various conditions, such as different degrees of illumination and various coloured lights. Printed slips or black-and-white patterns were used by Celsius, the Swedish astronomer, in 1735, apparently for the purpose of photometry. "He made it depend upon the distinctness with which we observe very small objects at different distnaces, in accordance with their greater or less illumination, and he did not take into account that it was even more difficult to reduce this distinctness to a certain law than it would be to measure the actual

* Kelvin, 'Popular Lectures and Addresses,' vol. i. p. 291.

† *Proc.* Royal Society, Bunsen and Roscoe, 1862, p. 139, and Roscoe and Brennand, vol. xlix. Dec. 11, 1890; Richardson and Quick, *Phil. Mag.*, vol. xxxvi. 1893, p. 459.

force of the light. He maintained that, to see some small object of an equally distinct manner at twice the distance, it must be illuminated 256 times more, in accordance with the eighth power of the distance: but it is certain that if a very short-sighted person reads with facility small letters at 4 or 5 inches in a dim place, there is no light in the world which could made him decipher them at 14 or 15 inches, unless his eyes were of a most extraordinary kind."* Buffon and Sir W. Herschel employed the same device.

In 1895 the idea was revived by Profs. E. J. Houston and A. E. Kennelly. At that time the inventors were unaware of the existence of any illumination photometer except that of Prof. L. Weber which will be described later. Their instrument† consisted of a small oblong box containing a test object of small printed type at one end (A Fig. 45) and a focussing eyepiece B at the other. One side of the box was provided with an opal glass window C, over which a sliding shutter D could be moved.

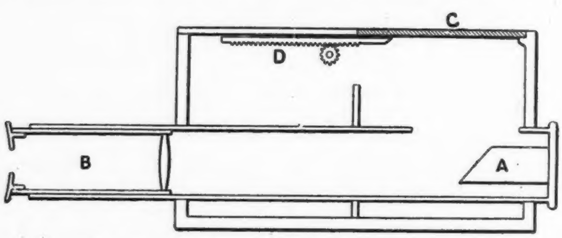


FIG. 45.—Houston and Kennelly's Photometer.

The shutter controlled the lighting of the test object, and an index moving over a graduated scale was used to give the value of the illumination. To make a measurement the window was placed to receive the illumination, and the shutter was moved until the test object was only just legible. The inventors asserted that "a certain intensity of illumination is required to render a definite object, viewed at a definite distance, clearly delineated to the eye." The focussing eyepiece was claimed to annul "the effect of any focal abnormalities of vision." The average deviation of any measurement from the mean of a number of measurements was modestly put at 10 per cent, and the results of different observers did not appear to differ more than this. The scale was, of course, graduated by experiment, and it was proposed to use it for candle-power photometry as well as for the measurement of illumination. The unfortunate name "illuminometer" was given to the instrument, and it is to be regretted that this mongrel word is sometimes used at the present day.

There is another class of discrimination photometer which must not be confused with the one which has been described. The first class endeavours to dispense with a standard source of light and to measure illumination by diminishing it in a known proportion until the test object cannot be distinctly seen; the second class endeavours to compare two different illuminations with reference to their power of revealing small details. The condition of minimum visibility has nothing to do with this. Ritchie applied this principle to the photometer which will be described.

More than fifty years ago Mr. Sugg used printed test slips for street photometry. He did not attempt to use the minimum illumination at which it was possible to read, but he used two slips, one was exposed to the illumination to be measured, and the other to a standard lamp.

In photometric work in the streets and public buildings of London in 1891–2 I occasionally read a Bradshaw,

* Bouguer, 'Traité d'Optique,' p. 48. Referred to also in Bouguer, 'Mem. de Math. et de Physique Ac. des Sci.,' 1757.

† Fully described in *The Electrical World*, New York, March 9, 1895.

or the small type of Bellew's French Dictionary, rather for the purpose of trying whether any difference could be found by such a test, when illuminations due to electric arc-lamps and gas-lamps were the same as measured on a photometer. I found no perceptible difference.

Dr. J. A. Fleming has experimented in this direction. He has prepared* by photography test objects consisting of black or white dots one-fifteenth of a millimetre in diameter, or parallel lines of that width. At a distance of 10 in. from the eye, these have an angular magnitude of one minute.

He attaches these photographed patterns to the sides of a wedge W, Fig. 46. The lights to be compared are in the directions A and B. The wedge is observed through a diaphragm in the eyepiece E. No lens is used, but the hole in the diaphragm is only 1 mm. in diameter. The object of this small hole is to restrict the light to a beam smaller than the size of the pupil of the eye. This prevents the expansion of the pupil when the eye is directed to the dimmer side of the wedge, and its contraction when the brighter side is looked at. Experiment showed that the detail-revealing power of four candles at 2 ft. and nine candles at 3 ft. and one candle at 1 ft. are practically the same. It was found that when an arc-lamp was used, the detail-revealing power of the light was rather less than its brightness, producing power. The difference appears to be slight, and this warrants the use of ordinary and more accurate illumination photometers for practical work.

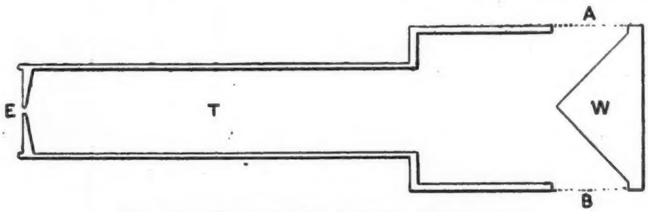


FIG. 46.—Fleming's Discrimination Photometer.

* Fleming, *Journal Inst. Electrical Engineers*, vol. xxxii. p. 156 *et seq.*

The use of instruments of the first class such as that of Profs. Houston and Kennelly in an anthropometric or psychological laboratory would seem to be natural, for the purpose of testing and comparing the keenness of vision of different individuals, or of one individual under different conditions. The second class, if used with great care, and having regard to the physiological conditions of vision through eyepieces, might be of some use in estimating whether ordinary photometers yield comparable measurements of illuminations when they are produced by different coloured lights or by sources of light of widely different intrinsic brilliance.

One of the first symptoms of failing sight is the difficulty of reading small print with a feeble illumination. This is experienced when the optical properties of the eye seem to be still so good that no lens can improve the focussing power. The chief reason seems to be that with a good illumination the aperture of the pupil is contracted, and this, by "stopping down the lens," gives a sharp image on the retina which cannot, perhaps, be improved by the help of a lens. But with feeble illumination the iris expands, and since with old age the power of accommodation (that is to say, the muscular control of the lens, and to a certain extent of the iris also) is diminished, the image is ill-defined. This action of the iris must be distinguished from "focal abnormalities of vision," and cannot be annulled, as Profs. Houston and Kennelly suggest, by a focussing eye-piece, but can be dealt with by the small hole used by Dr. Fleming.

(*To be continued.*)

The Production and Utilization of Light.

The Laws and Measurement of Radiation.

By Dr. C. V. Drysdale.

(*Continued from p.* 644.)

It cannot be too clearly kept in view, in all questions concerning the production of light, that this light is merely one portion of that form of energy which travels through space as waves in the ether, and is called radiation. Our object in seeking for more efficient sources of light is to find a means whereby as large a proportion as possible of their radiation shall be in the form which is of use to us in rendering objects visible; but for this purpose a knowledge of the laws relating to radiation of all kinds, visible and invisible, is of the greatest value. In fact it may be claimed

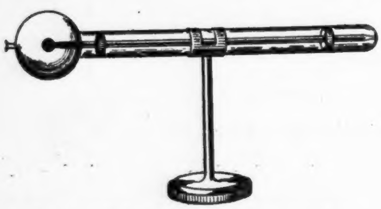


Fig. 1.—Solar Radiation Thermometer.

that practically the whole of the improvements in lighting which have recently taken place have been due to steady investigation of the laws of radiation and the application of these laws to practice; and it may be predicted that further advances will have to be made along the same lines.

Before dealing with the laws of radiation reference may be made to the various devices by which radiation may be detected and measured. Such devices are of value not only for actual radiation measurements, but in connexion with pyrometers for high temperature measurement. Putting aside those which deal with electromagnetic waves of comparatively low frequency, such as Hertz resonators, coherers, &c., we have several which serve for the detection and measurement of heat and light radiation with which we are most concerned.

One of the earliest and simplest detectors of radiation was the blackened bulb thermometer, which is still used for the estimation of the intensity of

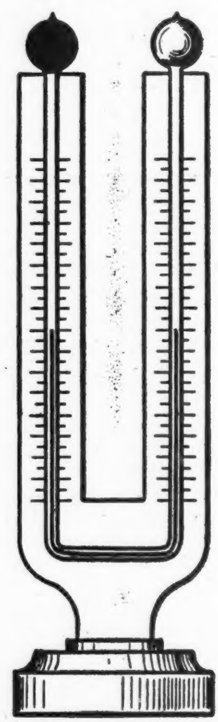


Fig. 2.—Differential Thermometer.

solar radiation. Fig. 1 shows the ordinary solar radiation thermometer, consisting of a mercury thermometer with lampblack-covered bulb, enclosed in an outer exhausted glass bulb, which avoids cooling by air currents.

A much more sensitive form of

radiation measurer is the differential thermometer shown in Fig. 2. Here two similar bulbs of fairly large capacity are connected by a U-tube containing a liquid. If the pressure in the two bulbs is the same, the level of the liquid is the same in both tubes, but if one of them is blackened, and radiation falls upon the instrument, it is absorbed by the black coating, thus heating the air in the blackened

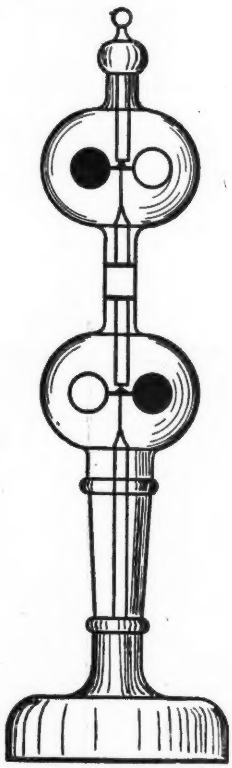


FIG. 3.—Crookes Radiometer.

bulb and causing a depression of the liquid on that side. Such an instrument is unaffected by the external air temperature, which acts equally on both bulbs, and the difference between the level of the liquid on the two sides, therefore, only depends upon the intensity of radiation.

A larger and more sensitive form of air thermometer was employed by Tumlirz in 1888* when making his determination of the mechanical equivalent of light referred to in the last chapter. It consisted of a metal cylinder with horizontal axis 40 mm. in diameter by 50 mm. in length, one end of which was blackened and the other communicated with a long vertical tube to a reservoir. The metal cylinder was enclosed within another, 48 mm. diameter and 62 mm. long, the front end being glazed with a

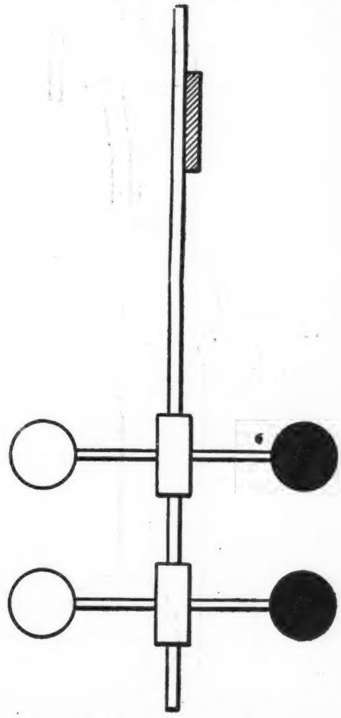


FIG. 4.—Lebedew's Suspended System.

window of rock salt 4 mm. thick, through which the radiation entered.

Although not so frequently used, one of the simplest and most sensitive detectors of radiation is the so-called radiometer of Sir Wm. Crookes. The absorption of radiation produces a pressure of magnitude equal to the energy contained in unit volume of the medium, and in consequence, if a

* 'Sitzungsber. der Kais. Akademie der Wiss. Wien,' Band XCVII. abth. IIa, p. 1523.

vane with one of its surfaces polished and the other blackened is suspended in a vacuum tube where it is unaffected by air movements, the blackened surface will be repelled. In the ordinary "radiometer" (Fig. 3) these vanes are simply pivoted lightly, so that they revolve rapidly when radiation falls on them, but if a single vane is suspended by a fibre and provided with a small mirror it turns through an angle proportional to the intensity of radiation, and forms a true radiometer (Figs. 4 and 5). This device was employed by Lebedew in his investigation of the pressure of light, and by Drew and Geer in measuring the radiant efficiencies of vacuum tubes and the mercury vapour lamp.

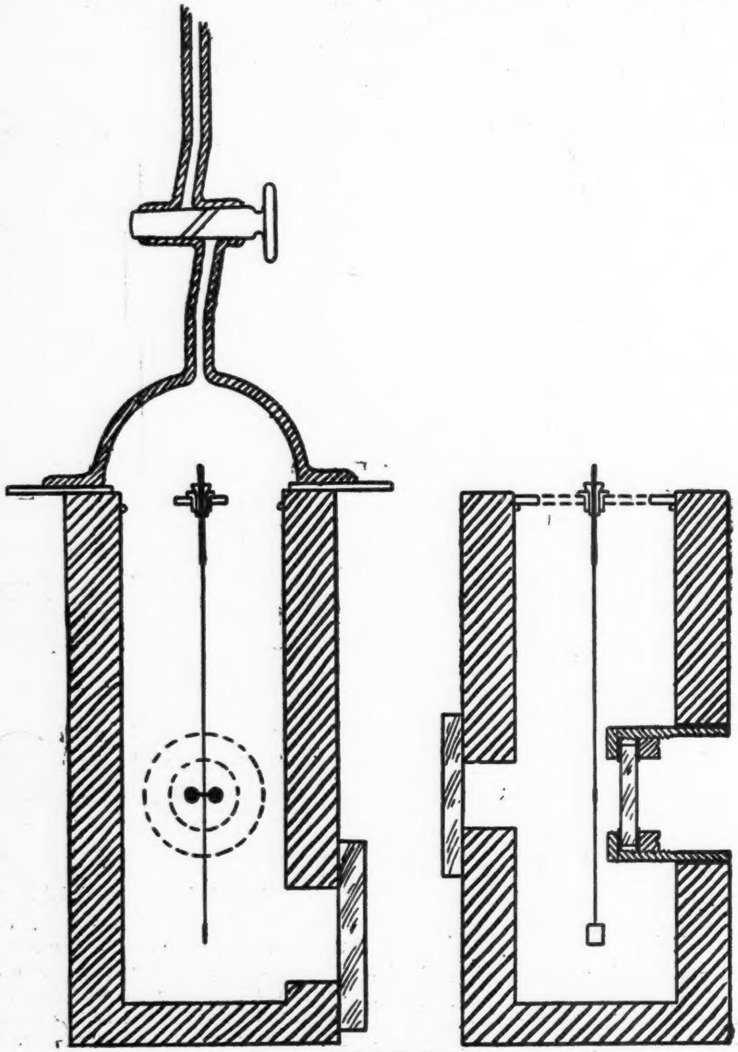


FIG. 5.—Nichols Radiometer.

(*To be continued.*)

Tests of Recent Flame Arcs.

By J. T. Morris, M.I.E.E.

Professor of Electrical Engineering at the East London College.

In an article on 'High and Low Pressure Incandescent Gas Lighting,' which appeared in this journal last month, the author gave the results of some recent tests on incandescent gas lamps made with the object of comparing the two kinds of illuminants—gas and electricity. In this article are collected results obtained for the second of these illuminants, *i.e.*, electricity.

The method of testing was identical with that used in the case of the incandescent gas tests described in the article previously referred to, the polar diagrams being obtained by the help of a pair of movable oval mirrors.

The following is a list of the lamps tested :—

Crompton-Blondel.—Crompton & Co.

Excello.—Union Electric Co.

Gilbert A.C. and D.C.—Gilbert Arc-Lamp Co.

Jandus (enclosed).—Drake and Gorham.

Jandus Flame (enclosed).—The Jandus Arc-Lamp and Electric Co., Ltd.

New Century.

Oriflamme A.C. and D.C. — The Oliver Arc-Lamp Co.

Westinghouse. — British Westinghouse Electric and Manufacturing Co.

The author would like here to express his cordial thanks to all the firms who have so kindly supplied these lamps, and have given help in many ways, including expert personal assistance. His thanks are also due to Mr. W. C. P. Tapper, and, in connexion with the Jandus flame-lamps, to Mr. A. Denman Jones, who has given him valuable help.

All the lamps tested were run for a period of not less than half an hour under normal conditions before any measurements were made for the tests recorded, and in practically all cases the two or more tests made on the same lamp were carried out on different days, the lamp in the interval having been taken down and rehung. In each case two complete polar diagrams were taken for each lamp, one exception only being made, that of the Oriflamme A.C. lamp. For this lamp the results were so consistent, that no further test was deemed necessary. On the other hand, in a few cases three, or even more, tests were made to ensure that the results obtained should be representative of the individual lamp under test. If, for instance, there was any reason to believe that the performance of the lamp during test was in any way unusual, a third test was made at a later date.

It will thus be seen that considerable care has been exercised to ensure fair conditions for each lamp while under test. It should, however, be borne in mind that the total luminous flux per kilowatt given out by a lamp is by no means the sole criterion by which to judge a lamp from the commercial point of view, because, apart from questions of efficiency, kind of globe employed, and polar distribution, there are matters of even greater moment, such as robustness of construction, simplicity of working parts, steadiness of light, length of burning hours, and initial cost of the lamp.

Each lamp was tested with the globe, and also the shade which the manufacturers provided in position. The globes supplied differed so greatly in opacity, that an attempt was made to determine approximately the absorption of light by the various globes.

At first sight the most direct method would appear to be to obtain the polar diagram for each arc first with the globe and then without it, and from the increase in candle-power deduce the absorption of the globe. But this method is open to two serious objections — (1) that the absence of the globe very often causes the light to flicker badly, and (2) the carbon consumption may be appreciably increased and an actual change in the candle-power emitted by the arc and carbons result from air getting at the arc more freely than when the globe is in place. It is also obvious that in the case of enclosed arcs this method is impossible.

In connexion with this matter the results given by Dr. Marchant in the June number of this journal are of considerable interest. He there states that the mean hemispherical candle-power of a particular flame-arc was reduced from 2,650 candles to 360 when the globe was put on, the watts being 380. This means that the light was reduced to less than 14 per cent, *i.e.*, an absorption of over 86 per cent; and in another case is mentioned an absorption of even 90 per cent. It is probable, however, that the mean spherical candle-power, as distinguished from the mean hemispherical candle-power, would not be altered to such a considerable extent, owing to the alteration in the light distribution, brought about by the use of a dense globe.

To overcome the difficulty referred to above a method giving only approximate results had to be adopted. The candle-power of a carbon filament glow-lamp was measured first directly, and then when centrally hung in each of the globes, and the resulting diminution in candle-power thus obtained. This gave an approximate measure of the absorption of the globe.

The method is, however, open to criticism on account of the fact that the light emitted by the arc has a spectrum differing widely from that of the glow-lamp, and in a lesser degree to the fact that the polar distribution is altered, and it is conceivable, and, indeed probable, that the absorption in the two cases would be different. By way of testing this point a "sun" tantalum lamp was used in place of the carbon filament lamp, and practically the same coefficients were obtained, hence a fair degree of reliance may be placed upon the accuracy of these coefficients.

An attempt was made to determine the various degrees of absorption of the globes for different coloured lights by means of a spectroscope, but although diminution was noticeable in the light intensity in certain parts of the spectrum, it was not sufficiently marked to allow of a quantitative use of the observations.

The following table (Table I.) gives a summary of the absorption tests:

TABLE I.

SUMMARY OF TESTS OF APPROXIMATE ABSORPTION OF GLOBES, JULY, 1908.

Name of Lamp.	Fraction of Light passed by Globe.	Percentage Loss.	Remarks.
Westinghouse ..	·6	40	Horizontal beam
	·57	43	Beam at 45° downwards
Crompton-Blondel	·57	43	Horizontal beam
	·57	43 }	—
	·62	38 }	Horizontal, but direction at right angles to previous measurement
Oriflamme A.C. ..	·6	40	Horizontal beam
A.C. ..	·646	35·4 }	Beam at 45° downwards
A.C. ..	·67	33 }	—
D.C. ..	·67	33	Horizontal beam
Gilbert D.C. ..	·77	23	Horizontal beam
,, ..	·78	22	Horizontal (but 90° to preceding)
A.C. ..	·77	23	Horizontal beam
,, ..	·70	30	Horizontal (but 90° to preceding)
cello D.C. ..	·66	33	After long run
,, ..	·71	29	Freshly cleaned
another globe	·79	21	,,
	·69	31	Not cleaned
New Century 15 amp. globe ..	·78	22	
,, ,, ..	·71	29 }	
,, ,, ..	·77	23 }	
10 amp. globe ..	·85	15	
	·895	10·5 }	
	·816	18·4 }	
Jandus Flame ..	·842	15·8	Lets thro' yellow light
,, ,, ..	·845	15·5	
,, Ordinary Opal	·715	28·5 }	
,, ,, ,,	·74	26 }	
,, Ordinary Plain Glass.. ..	·92	8	
	·915	8·5	
	·884	11·6	

it will there be noticed how much the same globe may differ in its absorption in different directions. It is also worthy of note that considerable differences often occur in the absorption of a number of globes supplied in the same batch, a variation in the coefficient of absorption of from 15 to 25 per cent being quite common.

It is singularly difficult to judge by eye of the relative absorption of different kinds of globes. An opalescent globe with a faint milky appear-

The lamps fall naturally into four groups, as follows :—

Ordinary arcs open.
,, ,, enclosed.
Flame arcs open.
,, ,, enclosed.

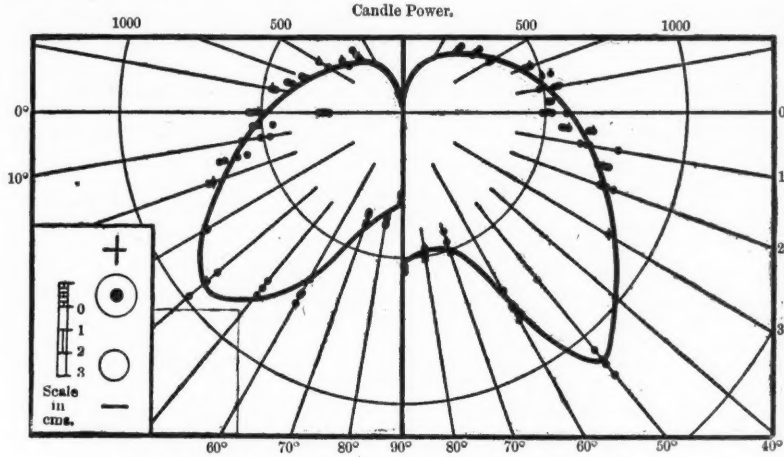


FIG. 1.—New Century Direct-Current Open Ordinary Arc (15 amp.).

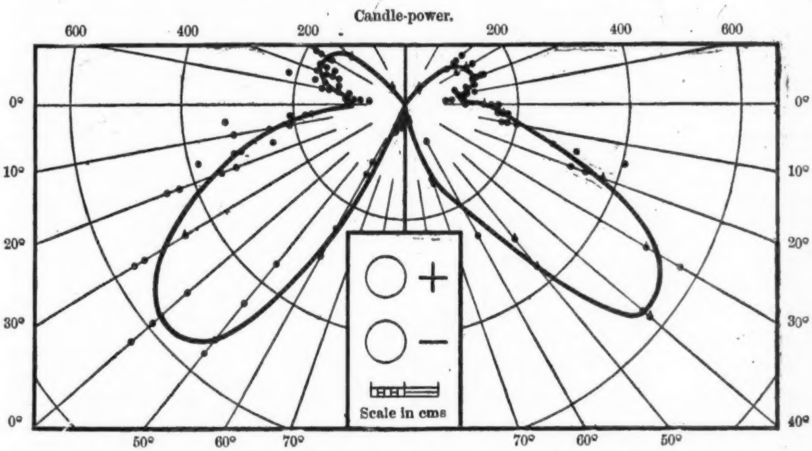


FIG. 2.—Jandus Direct-Current Enclosed Arc (5 amp.) clear Globe and Inner enclosure.

ance in the glass may cut off twice as much light as a globe looking much more opaque, but more of the ground glass type such as the Jandus globe. The actual figures obtained in these are from 22 per cent to 30 per cent for the former, and from 15 per cent to 16 per cent for the latter.

ORDINARY ARCS (OPEN).—The only example of this type tested was the New Century. This lamp was taken as a fair example of the ordinary open type of arc, being considerably used for street lighting. It had a cored positive carbon for the top and a solid carbon for the lower—these being arranged directly one above the other. In Fig. 1 are given the polar diagrams for the two tests. Here it should be mentioned that throughout the tests not a single observation taken has been discarded, but all appear on the diagrams.

The method of taking the observations was in general to take them every 5 degrees from 20 degrees above to 20 degrees below the horizontal, and other observations every 10 degrees, four consecutive observations being taken at each point; and generally the more important parts of the test were repeated near the conclusion of the experiment. The method of indicating the observations on the diagrams is as follows: one observation thus ●; two observations falling on the same spot thus ●; and three or more thus ●.

A scale drawing of a section of the two carbons used is shown with each diagram, where the pure carbon is shown in white, and the core, impregnated or otherwise, in black. The small black dots indicate the position of the wire, which is used in some long thin carbons.

Ordinary Arcs (enclosed).—The lamp tested was a Jandus ordinary enclosed, which was made seven years ago. It had a clear inner enclosure and outer globe, and the usual solid carbons—top and bottom—of the same size. The polar diagrams are given in Fig. 2.

Flame-Arcs (open)—(axial carbons).—A Crompton-Blondel was the lamp tested of this class. In this lamp the positive carbon is the lower, and consists almost entirely of core; the negative being the upper carbon, and having a small core of more usual proportions. This carbon protrudes a short distance through a flat plate, upon which a white deposit settles very shortly after putting the lamp into operation, and thus serves as an excellent reflector.

The colour of light emitted by these carbons is in the author's opinion the closest approach to an ideal artificial illuminant, and it is to be hoped that the constant slight flickering of this lamp may in time be obviated. The polar diagrams for this lamp are shown in Fig. 3. As was mentioned in the previous article, either a Wild flicker photometer or a grease-spot photometer were used in all the photometric measurements; and in the tests with this lamp more experience was required to use the flicker photometer satisfactorily owing to the rapid fluctuations of light which occur in the normal operation of this lamp. The lamp was supplied with a single large globe, which was rather opaque, and the supply of air to the lamp fixed by the manufacturers by the

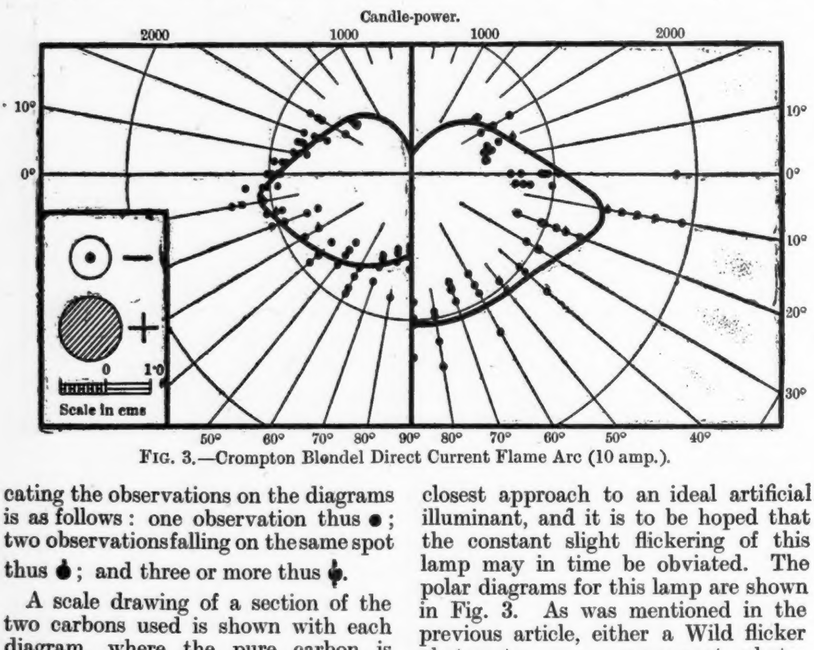


Fig. 3.—Crompton Blondel Direct Current Flame Arc (10 amp.).

adjustment of the size of certain apertures.

FLAME-ARCS (OPEN) (inclined carbons).—The lamps of this class which were tested were Excello D.C., Gilbert D.C. and A.C., Oriflamme D.C. and A.C., and the Westinghouse. The polar diagrams—Figs. 4, 5, 6, 7, 8, and 9—relating to these lamps speak for themselves.

FLAME ARCS ENCLOSED.—Many experimenters have been attracted by the fact that carbons in an enclosed lamp burn, or, to speak more correctly, fritter away far more slowly than in lamps of the open type, and hence have devoted a considerable amount of time to developing a flame-arc which should be enclosed. The saving in the consumption of the more costly flame carbons and consequent increased length of burning hours being the attractive features. On the other hand there are many difficulties to surmount, in order to obtain a commercially satisfactory enclosed flame arc. Chief among these is the dense deposit which flame carbons produce, and

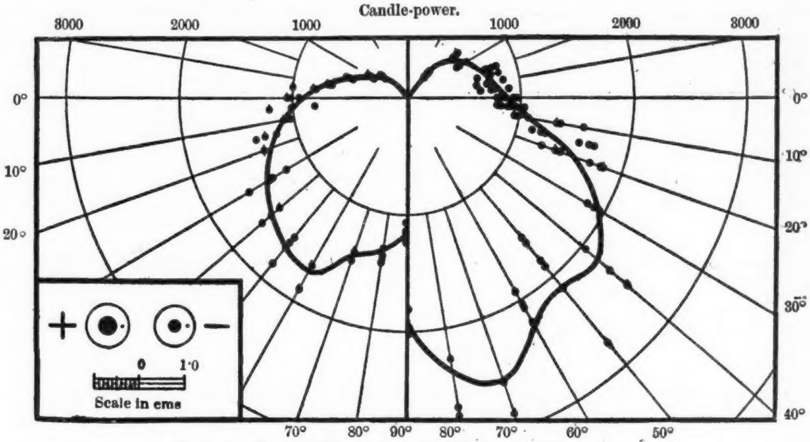


FIG. 4.—Excello Direct-Current Flame Arc (10 amp.).

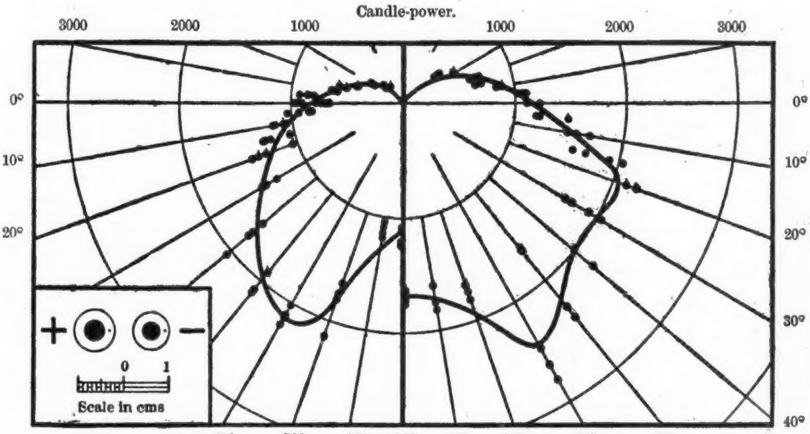


FIG. 5.—Gilbert Direct-Current Flame Arc (10 amp.).

next to this the increased unsteadiness of the light itself.

The lamp of this type tested was the Jandus regenerative arc-lamp.* This lamp is provided with what may be termed two chimneys, in which the principal deposit takes place; these chimneys, made of metal and enamelled white on the outside, are disposed on either side of the lamp with the object of obstructing as little of the light as is possible.

This lamp being of such recent development, the author thought it desirable to test, besides its polar distribution of light and luminous efficiency, the volt ampere characteristics of the arc itself. In Fig. 10 are given the results of two tests for the polar distribution of light. A glance at these diagrams shows how considerable are the fluctuations in candle-power which have occurred during the tests. This is not so much due to a flicker as to a slower change in the light. Beside this change in candle-power a still slower change also

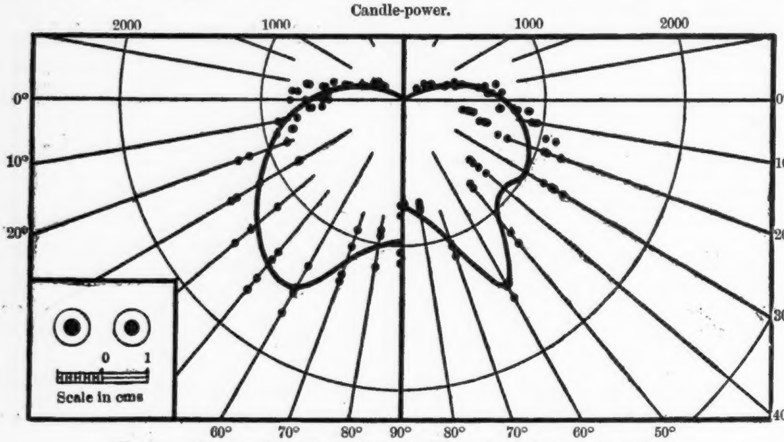


FIG. 6.—Gilbert Alternating Current Flame Arc (12 amp. 60 cycles).

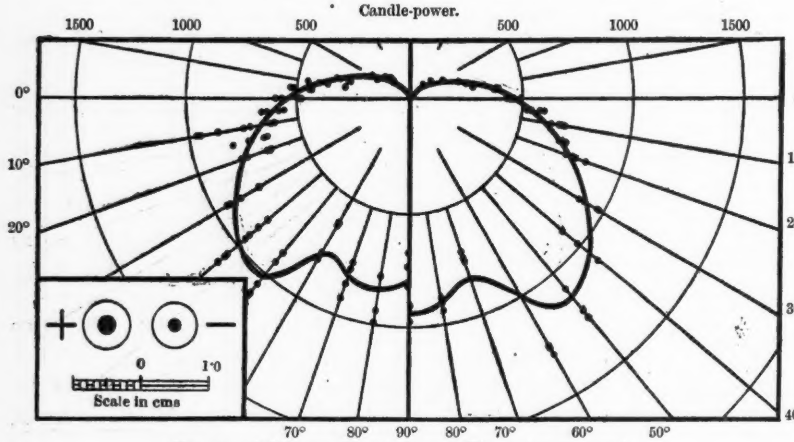


FIG. 7.—Oriflamme Direct Current Flame Arc (9 amp.).

* See an article on this lamp by Mr. A. Denman Jones, *Illuminating Engineer*, April, 1908, pp. 310-312.

takes place in the colour of the light. No doubt these fluctuations will be minimized when the lamp has been further developed. Sections of the carbons are shown at the side of the diagram. It will be noted that the positive carbon, which is the lower, has a shape very similar to that employed in some of the early lighthouse carbons—the intervening spaces are, however, filled up with the special chemicals used to increase the luminous efficiency. In Fig. 11 are collected the approximate results of the volt ampere characteristics for this arc when controlled by hand instead of by the mechanism. The cross on one of the

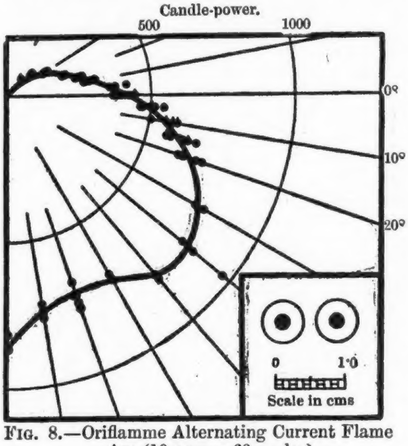


FIG. 8.—Oriflamme Alternating Current Flame Arc (10 amp. 60 cycles).

curves indicates the point for normal working conditions (volts 70, amperes 5·4, length 1·5 inches). No observations are shown on these curves, as the arc was rather erratic, although between one and two hundred measurements were made: the curves represent the mean of these observations. The figures on them give the apparent length of the arc in inches.

With the object of showing the diminished voltage drop between carbons and the arc, the curves in Fig. 12 have been plotted. Here are collected the observations connecting length of arc with volts on terminals of the arc for two constant currents, 2 amperes, and 5 amperes. Both of these curves indicate that a voltage as low as 20 is all that would be required for an arc of no apparent length, which, of course, is much lower than that obtaining for an ordinary open arc.

SPECTRA OF ARCS.—A number of observations have kindly been made for the author by Mr. A. G. Warren, B.Sc., on the spectra of the various arcs, during the course of these experiments. An ordinary table spectroscope was used, fitted with a scale, and the instrument had the usual 60 degrees prism. The results obtained, drawn to scale, are collected in Fig. 13. It will there be seen on inspection that the whiter light obtained with the Crompton-Blondel lamp when compared with the light emitted by the ordinary yellow flame carbons is due to the almost complete absence of a strong yellowish-green band, and to the accentuation of the blue and violet lines in its spectrum. For the purposes of comparison a few additional spectra were measured, such as the familiar sodium D lines, the spectrum of a hydrogen tube, and that of the Cooper-Hewitt mercury vapour lamp. As calcium salts are so largely used in the impregnation of flame carbons, it was thought desirable to obtain the spectrum of a salt of calcium through the intermediary of first a Bunsen flame, and, second, an electric arc. Calcium carbonate in the form of a fine precipitate was used as the salt. The method of obtaining the spectrum in the electric arc was to drill the core out of an ordinary cored carbon, and pack it with the calcium carbonate powder, using this as the positive carbon which formed the lower electrode of a hand-feed electric arc.

COLLECTION OF RESULTS OBTAINED.—In comparing the efficiencies obtained with the various arc lamps in these tests, due weight must be given to the fact that the quality of the carbons supplied with the lamps by the different manufacturers was very varied. It is well known that some of these lamps are capable of burning well, though consuming a cheap quality of carbon, whilst others require for proper performance a more expensive quality. With the object of being able to draw correct conclusions from these tests

Table II. has been drawn up, giving particulars of the carbons as far as is possible.

In Table III. are collected the available data of the lamps (with the exception of the carbons, particulars of which are given above) and the results of the tests. The lamps are grouped as before, viz., (1) open type, (2) enclosed, (3) [a] open flame D.C., [b] open flame A.C., and (4) enclosed flame. The facts given are date of test and maximum candle-power, this being read off from the curve drawn in the polar diagram, and giving a mean maximum rather than an actual instantaneous maximum. The next column contains the angle below the horizontal at which the maximum candle-power occurs. Then follows the mean spherical candle-power (M.S.C.P.) and the mean hemispherical candle-power (M.H.C.P.), obtained by means of the Rousseau diagram. Next the mean volts and amperes and the mean watts. It should be mentioned that the alternating watts given are really the apparent watts, and as the power factor of the

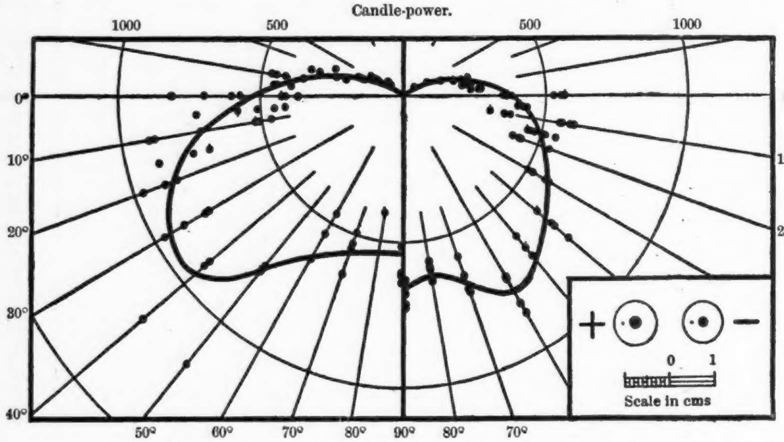


FIG. 9. Alternating Direct Current Flame Arc (9 amp.).

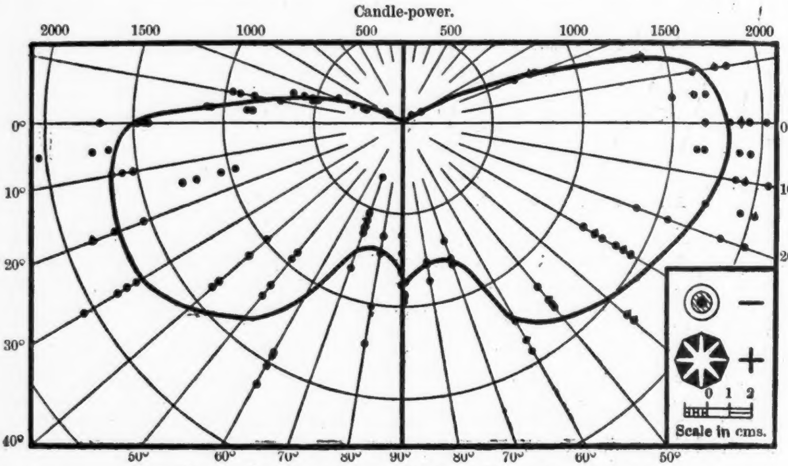


FIG. 10.—Jandus Direct Current Enclosed Flame Arc ($5\frac{1}{2}$ amp.).

TABLE II.

Name of Lamp.	Style of Carbons.	Remarks.	Diameter in Millimetres. External.	Diameter in Millimetres. Core.
Excello D.C.	"Krone-Excello" 104 [crown] C. Conradty " " 105 " "	Wire embedded in carbon throughout its entire length.	10 9	4 positive. 2·5 negative.
Gilbert D.C.	"Noris-Excello" 104 * * * C. Conradty "Noris-Excello" 104 * * * D. R. Patent 150956 * * * C. Conradty	Wire embedded in carbon throughout its entire length	9 8	4·5 positive. 4 negative.
Gilbert A.C.	* A F — Ship-Carbons [ship] Vienna-Austria	Copperplated	8	3
Oriflamme D.C.	— A F — Ship-Carbons ΛΛΛ Vienna-Austria		{ 7 { 6·4	2·3 positive. 1·8 negative.
Oriflamme A.C.	Ship Carbons Vienna Austria Q F		6·25	2·0
Westinghouse D.C.	Excello Noris Conradty { 104 { 105		10 9	2·5 positive. 2 negative.
Jandus Enclosed Flame D.C.	Special star-shaped Carbon for Positive —L—A—Dochtkohle C—Niederspannung, Gebr. Siemens & Co., Charlottenberg		15	positive. 9 and 5 negative.
Crompton Blondel D.C.	////// Cont 51 //////// + S. F. Auer + //// Brevete S G D C - - - - - Charbons Mainbottel — C C - - - -		14 9	14 positive. 2 negative.
New Century D.C.	—— C. Conradty Nuernberg — Marke C ——		{ 18 { 13	5 0
Jandus Enclosed D.C.	— — — — Eos — — — — — — — — — Jandus — — — — —		{ 13 { 13	0 positive. 0 negative.

TABLE III.

Name of Lamp.	Date.	Max. C.P.	Angle of Max.	M.S.C.P.	M.H.C.P.	Mean V. A.	Mean Watts.	M.S.C.P. per Watt.	M.H.C.P. per Watt.	Light emitted.	Corrected M.S.C.P. per Watt.
			Degrees.							Per Cent.	
New Century D.C. open 15 amp.	9/6/08 6/7/08	930 1,100	43 50	600 570	810 790	51 × 15 54 × 15	765 810	0·78 0·71 } 0·75	1·06 0·98 } 1·0	75	1·0
Jandus Enclosed Ordinary 5 amp.	25/5/08 27/5/08	570 560	42 39	250 230	340 350	80 × 5·8 80 × 5·7	465 455	0·54 0·55 } 0·55	0·73 0·77 } 0·75	91	0·6
Crompton-Blondel 10 amp.	29/5/08 10/7/08	1,080 1,380	10 14	720 845	910 1,110	40 × 10 40 × 10	400 400	1·80 2·11 } 1·95	2·27 2·77 } 2·5	60	3·25
Excello 10 amp.	1/6/08 6/7/08	1,720 2,550	60 70	900 1,130	1,400 1,830	47 × 10 44 × 10	470 440	1·92 2·57 } 2·25	2·98 4·16 } 3·55	74	3·05
Gilbert D.C. 10 amp.	16/6/08 10/7/08	2,450 2,140	60 61	1,240 915	2,000 1,490	48 × 10 47 × 10	480 470	2·58 1·95 } 2·25	4·17 3·17 } 3·65	78	2·9
Oriflamme D.C. 9 amp.	12/6/08 6/7/08	1,020 1,140	47 52	495 540	825 880	38 × 10? 34 × 9	380 305	1·30 1·77 } 1·55	2·17 2·89 } 2·55	67	2·3
Westinghouse 9 amp.	13/6/08 10/7/08	960 750	36 59	550 340	790 585	54 × 9 55 × 9	485 495	1·13 0·69 } 0·9	1·63 1·18 } 1·4	58	1·55
Gilbert A.C. 12 amp.	19/6/08 15/7/08	1,520 1,500	56 60	695 640	1,130 1,000	55 × 11·5 55 × 11·8	630 650	1·10 0·98 } 1·05	1·79 1·54 } 1·65	73	1·45
Oriflamme A.C.	13/7/08	820 880	45 90	430	690	44·2 × 10	440	0·98 } 1·0	1·57 } 1·55	65	1·55
Jandus Enclosed Flame 5½ amp.	24/6/08 26/6/08	1,700 1,820	15—30 0—10	885 1,045	1,425 1,400	58 × 6·1 59 × 6·3	355 370	2·49 2·82 } 2·65	4·01 3·78 } 3·9	84	3·15

arc-lamp may be ·95 or even ·90, this may cause these alternating lamps to appear some 5 per cent or 10 per cent low in their performance. The next two columns give the M.S.C.P. per watt and the M.H.C.P. per watt, and in the same column are contained the mean figures for the results of the two tests on each lamp. In the last column but one appear figures deduced from Table I. expressing the percentage of light passed by the globe or other exterior enclosure. It should be remarked that in the case of the enclosed lamps the absorption produced by the inner enclosure has not been allowed for, as it is impossible for these lamps to operate with less than one enclosure. The last column gives the M.S.C.P. per watt, increased by the amount of light cut off by the globe (corrected M.S.C.P. per watt). The angle at which the maximum candle-power occurs will be found to have a very wide range, viz., from 0 degrees to 90 degrees.

Degree of Accuracy. — Although great vigilance has been exercised in the working out of the observations, it is to be feared that some small errors may have crept in, as over 2,000 distinct measurements, to take candle-power alone, have been made for these tests. The author, however, is of the opinion that the degree of accuracy obtained by the means of the two tests is well within 10 per cent, with one possible exception. Taking the lamps as a whole, the enclosed flame takes the first position as far as efficiency is concerned, yielding 2⅝ M.S.C.P. per watt; next come those lamps using the higher grade Excello carbons (2¼ M.S.C.P.); these are closely followed by the lamp using the Auer carbons (about 2 M.S.C.P.). When, however, an attempt is made to eliminate the diminution of light due to the absorption of the globe, the Auer carbons, the enclosed flame, and the high-grade Excello carbons, all give results ranging from 3 to 3¼ M.S.C.P. per watt. In fact, a brief summary of the present position as regards *true efficiency* is as follows:—

	M.S.C.P. per Watt.
High Grade Flame Carbons	2·9 to 3·3
Lower Grade „ „	1·5 to 2·5
Ordinary Carbons Open	About 1
„ „ Enclosed	About 0·6

Whilst, considering the efficiency in a more commercial way, the results being based on the mean *hemi*spherical candle-power, and referring to the *complete* lamps as supplied by the manufacturers are:—

	M.H.C.P. per Watt.
Lamp with High Grade Flame Carbons Enclosed	3·9
Ditto Open	3·5—3·7
Lamp with Auer Carbons	2·5
Lamp with Lower Grade Flame Carbons	1·4—2·5
Lamp with Ordinary Carbons Open	About 1
Ditto Ditto Enclosed	About 0·75

General Remarks.—An examination of the polar diagrams obtained for all the arcs tested, as also for the gas lamps referred to in the previous article, reveals a very great diversity in the forms of the light distribution curves. These variations are due, first, to the different disposition of the carbons; second, to the form of reflector employed, internal and external; and third, to the opacity of the globe.

The author has lately had the advantage of discussing this matter of correct distribution of light for the particula- case of public street lighting with quit a number of arc-lamp manufacturers and other engineers, and finds that widely divergent opinions are held upon this subject. On the whole it seems to him that the following are

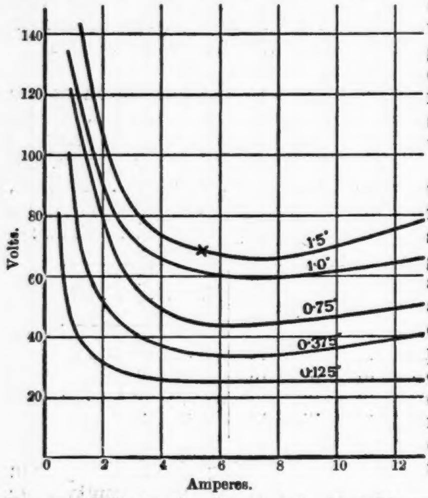


FIG. 11.—Volt-ampere characteristic for various arc-lengths for Jandus enclosed flame arc.

some of the more important points: (*a*) Distribution of light from naked arc, including any internal reflectors; (*b*) absorption of globe and its effect in redistributing the light; (*c*) use of an external reflector and its permissible size; and (*d*) height of centre of arc from ground.

The author considers that, for the purposes of street lighting, practically no light should escape above an angle of some 15 degrees to 20 degrees below the horizontal, and, further, it is obvious that the candle-power in directions vertically downward should be considerably below that sent out in sloping directions. The objects to be attained are: (1) a uniform vertical illumination on the ground; and (2) the screening of the light from the horizontal line of sight of the observer. The first of these objects appears to be fairly appreciated, but the second is very far from receiving the attention it deserves; in fact, to the author it appears that many members of electric lighting committees and a large section of the general public would not consider a street properly lighted if the sources of light were not at once conspicuous to the eye. He is fully alive to the fact that to prevent the eye being dazzled by the source of light, the use of almost unmanageably large reflectors would be necessary with the sizes of globe at present in vogue; but more ordinary-sized reflectors could be used, if the lamps could be provided with smaller globes, particularly enclosures whose vertical dimension is small.

Much more attention should be given to the production of suitable globes for intense lights. The foregoing tests show absorptions for partly obscured globes ranging between 15 per cent and 45 per cent, whilst Dr. Marchant, as referred to above, mentions amongst others a case of as much as even 90 per cent loss. This is a matter requiring careful testing, as appearances are decidedly misleading, and a globe which reduces the candle-power considerably does not necessarily greatly diminish the staring effect of the light.

The author is convinced that it would well repay many arc lamp manufacturers, and also extensive users

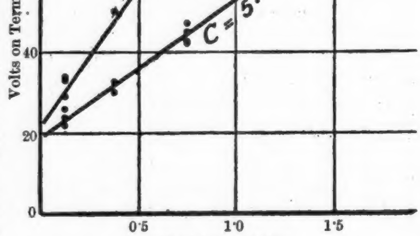


FIG. 12. Volt-length characteristics for various constant currents for a hand-feed Jandus enclosed Flame Arc.

of arc lamps to wholly reconsider the methods of screening and reflecting now in use.

The author desires, in conclusion,

to express his thanks to many students of the Electrical Engineering Department of the East London College who have assisted him in several ways during the preparation of material for this article. Specially would he mention Mr. J. F. Forrest for the enthusiastic assistance which he has rendered throughout the whole of the photometric tests; his thanks are also due to Mr. E. J. Surman. To Messrs. A. G. Warren, B.Sc., and F. Stroude, B.Sc., he is also much indebted for their kind help in working out these tests.

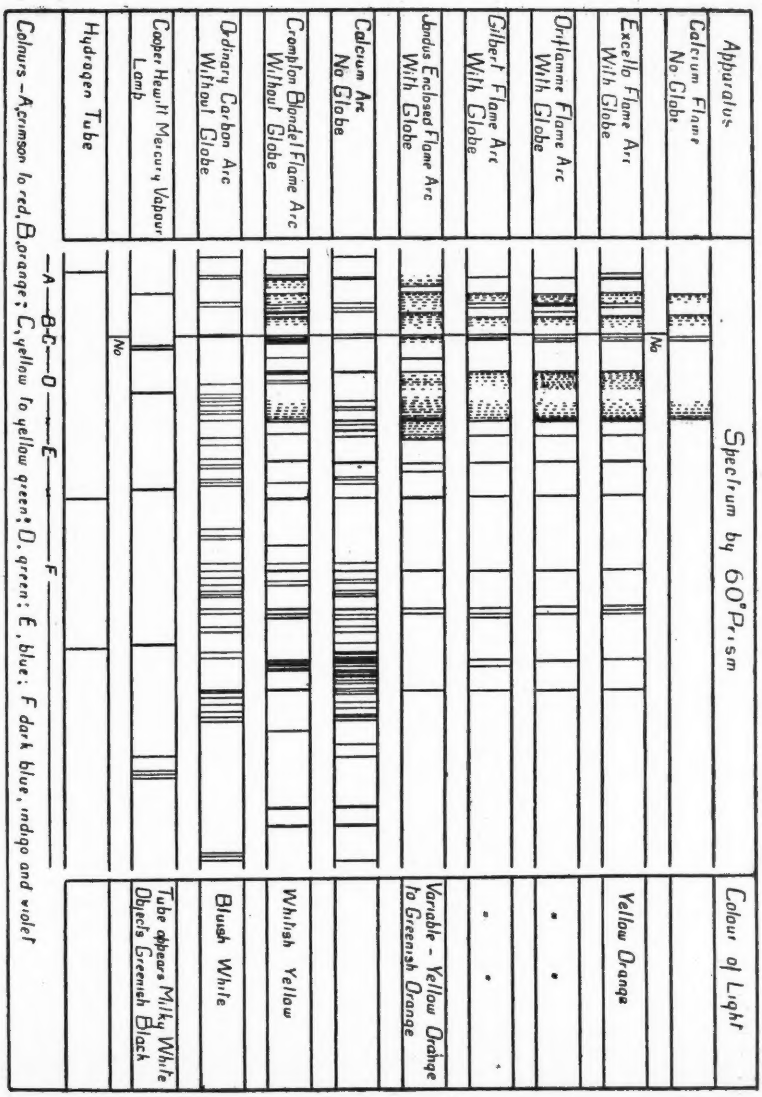


FIG. 13.—Spectra of various Arc Lamps.

The Running Cost of Acetylene Lighting.

By A French Correspondent.

Acetylene is always obtainable in practically the same degree of purity from carbide of calcium, and should invariably yield the same illuminating power when utilized in exactly the same way. A given volume of acetylene, burnt under given conditions, should therefore always give us the same light, although it may be difficult to say beforehand the intensity of light that will be derived from a given volume of ordinary illuminating gas, as the composition of the mixture is very variable.

On the other hand, it may be urged that the ordinary user of acetylene does not actually purchase this gas. From his point of view, acetylene is merely an intermediary between the carbide and the actual light obtained, and he is mainly concerned with the quantity of light to be obtained from a given amount of calcium carbide.

This, of course, is perfectly true. The cost of acetylene lighting depends on two factors—the price of calcium carbide and the return that may be secured by making use of it. However, it may be accepted that in the case of a satisfactory installation a cubic metre of acetylene will be obtained at a cost of 1·16 francs, or, in round numbers, 1·20 fr., assuming the cost of carbide to be 35fr. per 100 kilos. On this figure we shall base such results as are given in the present article.

In the first place it may be remarked that here, as in the case of coal-gas, we must distinguish between :—

1. Lighting by means of an open illuminating flame.
2. Lighting by incandescence.

As regards the first of these methods it may be stated that acetylene, being the hydrocarbon richest in carbon, is, in virtue of this richness, in the position to yield a particularly luminous flame. The illuminating value of a flame depends upon the presence of a large number of solid particles of carbon, carried to incandescence by the heat of combustion and the temperature to which these particles are subjected. Now the acetylene flame possesses a high temperature and, being so rich in carbon, is also particularly adapted to the formation of a large number of particles of this nature.

The actual illuminating value of acetylene, however, depends upon the variety of burner utilized. In general burners consuming a large amount of gas are more efficient than those consuming comparatively little. For example, the "Conjugué" standard series of burners, consuming 10, 20, 25, 30, and 35 litres respectively, give the following results :—

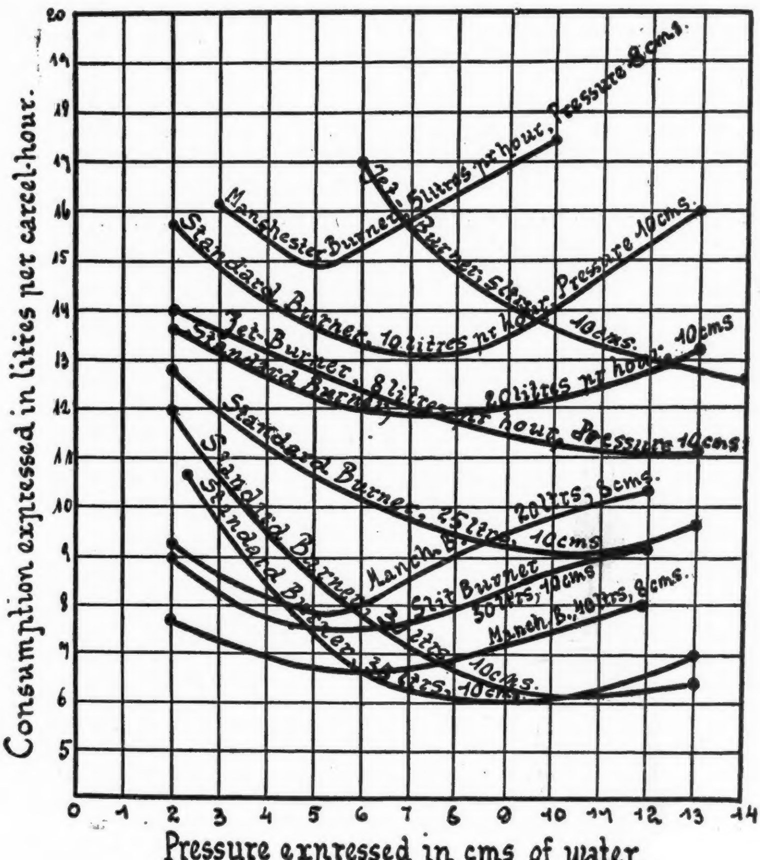
The	10	litre burner	consumes	13·1	litres	per carcel-hour.
,,	20	,,	,,	11·8	,,	,,
,,	25	,,	,,	9·2	,,	,,
,,	30	,,	,,	6·2	,,	,,
,,	35	,,	,,	6·1	,,	,,

These results were obtained by using the most suitable pressures, namely 7 centimeters in the case of the first two burners and 10 in the case of the others. Assuming, therefore, our previously stated price of 1·20 fr. per cubic metre of acetylene, we see that the price of a carcel-hour varies from about 1·57 centimes in the case of the first burner, consuming 10 litres per hour, to 0·73 in the case of the burner consuming 35 litres.

The pressure under which acetylene is burnt at the burner is of considerable importance. As a rule, in the case of a certain burner, there exists one definite pressure more favourable than any other. Thus in the figure we see the illuminating powers of various types of burner expressed as a function of the pressure, as recently communicated by M. Granjon at the International Congress on Acetylene and Calcium Carbide.

It may be interesting to compare the cost of acetylene lighting by illuminating flames with that of coal-gas on the same methods. A flat-flame "butterfly" gas burner consumes about 100 litres per carcel-hour, and therefore costs about 1·5 centimes per carcel-hour, assuming the cost of gas to be 15 centimes per cubic metre. On the basis of the cost of the more old-fashioned method of gas lighting, therefore, acetylene lighting would work out the cheaper of the two. This result is now only of interest retrospectively, but it shows that the contention of the earlier workers in the domain of acetylene lighting, that their system would displace gas for street lighting, was not without justification at that time, when the incandescent mantle had not been developed, or had led to but meagre results.

To-day the discovery of the incandescent mantle has revolutionized gas lighting. But it may also be said that the application of incandescent mantles to acetylene lighting has achieved great results.



The writer proposes to deal with this aspect of the subject in greater detail in a subsequent article. It may, however, be said in the meantime that the use of incandescent mantles with acetylene has reduced the cost of lighting by about 60 per cent, and that the running cost of lighting by this means now amounts on the average to about 0·40 centimetres only.

There is, of course, also the cost of the mantles to be borne in mind, but this is extremely small provided mantles of the right kind are utilized.

The writer is actually using mantles which have burnt for ten hours daily for three months without being changed or undergoing any noticeable deterioration. This longevity is partially due to the smallness of the mantles, but there are probably other contributory causes. There are those who consider the introduction of mantles a complication, but in reality it is much simpler to change the mantle at the end of 900 hours than to clean out, after only 100 hours' burning, choked-up burners of the ordinary variety.

A Recent Method of Increasing the Efficiency of Incandescent Gas-Burners.

A RECENT number of *The Journal of Gaslighting* contains a description of an ingenious method of increasing lighting efficiency. The method consists in fitting

FIG. 1.

a solid conical body made of refractory material over the ordinary supporting prop for the mantle as shown in the illustration.

One object of this device is to control the volume of flame coming in contact with the mantle, and to direct this flame on to it, so that the entire surface of the mantle becomes incandescent. In addition to this the presence of the heated solid body in the centre of the flame has the effect of increasing the flame temperature. As a result, it is claimed that an increase in illuminating power of 20 per cent is secured, and on one series of tests it was found that a No. 4 Kern burner yielded 58 candles without the core, and an average of 81 candles with it, for a consumption of 4·2 cubic feet.

It is also suggested that the life of a mantle is improved, and for two reasons: in the first place the introduction of the solid core tends to stiffen the flame and to steady the mantle. Many mantles of the upright variety are broken by their tendency to sway to and fro when lighted up. In the second place, it seems likely that the life of a burner is affected by the severe changes of temperature occasioned by lighting up and extinguishing; and the presence of a heated solid body having considerable heat-capacity affords the mantle the protection of a slower method of cooling. It is stated, for instance, that in one breezy road in Brighton the average mantle-renewal for three months has been reduced to 1·6 per lamp as opposed to 3·8 without the core.

The system is also applicable to inverted mantles, a pear-shaped core, having its apex in the burner-nozzle, being used. At present, however, owing to the irregular shapes often assumed by burners of this class during use, the results have not been so successful.

Tests on Electric Incandescent Lamps.

By Prof. H. Bohle,
South African College, Cape Town.

In the present article a number of simple tests on electric lamps have been analyzed with interesting results. The lamps tested were the following :—

(1) Carbon filament lamps.
(2) Nernst lamps.
(3) Tantalum lamps.
(4) Osram lamps.

The results of the experiments were represented by plotting the candle powers against (1) the volts, (2) the amperes, (3) the watts, (4) the watts per candle power, and (5) the current against the resistance in ohms. The equations to the different curves are as follows :—

Carbon lamp.	Nernst lamp.	Tantalum lamp.	Osram lamp.
$T=5{\cdot}08\times10^{-16}\,V^{7}$	$T=0{\cdot}28\times10^{-20}\,V^{9{\cdot}35}$	$T=0{\cdot}11\times10^{-7}\,V^{4{\cdot}4}$	$T=0{\cdot}16\times10^{-6}\,V^{4{\cdot}0}$
$=16{,}000\,I^{5{\cdot}5}$	$=536\,I^{2{\cdot}6}$	$=16{,}400\,I^{6{\cdot}0}$	$=16{,}000\,I^{6{\cdot}0}$
$=0{\cdot}392\times10^{-4}\,P^{3{\cdot}1}$	$=3\times10^{-3}\,P^{2{\cdot}15}$	$=6{\cdot}4\times10^{-3}\,P^{2{\cdot}15}$	$=5{\cdot}8\times10^{-3}\,P^{2{\cdot}3}$
$=124\,\eta^{-1{\cdot}476}$	$=160\,\eta^{-1{\cdot}87}$	$=80{\cdot}7\,\eta^{-1{\cdot}87}$	$=52\,\eta^{-1{\cdot}77}$
$R=610\,I^{-0{\cdot}214}$	$=310\,I^{-{\cdot}72}$	$R=580\,I^{0{\cdot}36}$	$R=562\,I^{0{\cdot}5}$

in which

T=luminous intensity in pentane candles.
V=volts at terminals of lamp.
I=current in amperes.
P=watts absorbed by lamp.
η=economy or watts per candle.
R=resistance in ohms.

In each case new and old lamps were tested, but it was found that the exponents in the various equations were practically constant for the same type of lamp, and that only the coefficients varied. Carbon lamps from different makers possess, however, different exponents. Thus the voltage exponent for a Stearn lamp was 6·5, for an Ediswan lamp 7·2. One Nernst lamp was apparently a freak, the voltage exponent being as high as 14!

The results given here are of considerable importance, not only to the manufacturer of electric lamps, but also to the consumer. We see that the Nernst lamp is mostly affected by variations in the supply P.D., the Osram lamp least. From the curves $f(T, \eta)$ it would appear that the Tantalum and Nernst lamps were capable of being made more economical than carbon and Osram lamps, because the negative exponent is 1·87 against 1·476 of the carbon and 1·77 of the Osram lamp. Because these exponents will depend chiefly upon the material of the filaments, whereas the coefficients relate more to the process of manufacture, the age of the lamp, the state of the bulb, &c. That the ultimate Tantalum lamp will be vastly more economical than the present one I have not the slightest doubt. The tests on the latest type show already the following improved results :—

Lamp 1. C.-p.=18·96, Economy=1·46.
,, 2. ,, =16·62, ,, =1·65.

At present the economy of the Osram lamp is superior to that of the Tantalum lamp, this being possibly due to easier methods for economic manufacture and greater competition.

Of great importance are the curves $f(T, V)$. To make the variation of candle-power small as the supply P.D. varies, the manufacturer should aim at producing filaments with positive temperature co-efficients, as in the Tantalum and Osram lamps, so that the resistance increases with the current instead of being lowered as the temperature goes up, as occurs in carbon filament and Nernst lamps

To see how much the light of various lamps varies on a central station supply, a record was taken of the voltage of one side of a three-wire network between 4.30 and 9.30 P.M. From this record the curve has been reproduced on a larger scale, as is shown in Fig. 1, the readings having been plotted in intervals of five minutes. It will be noticed that the total variation is from 212 to 230 volts, the normal P.D. being 220. A variation of 18 volts in 220, or 8 per cent, must be called excessive. The variation may be due to a non-uniform supply at the bus bars or to drop in the mains.

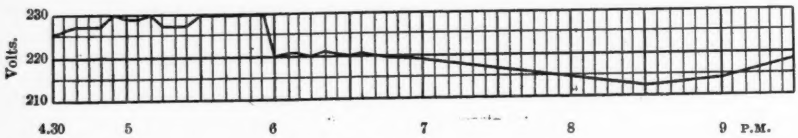


FIG. 1.

The variation in candle-powers for the various types of lamps has been plotted in Fig. 2, and the percentage variation in Fig. 3. We see from these figures the enormous advantages which the metal filament lamps held over the carbon and Nernst lamps. The irregularity of the Nernst lamp would have been even worse if it were not for the iron resistance in the lamp, the resistivity of which increases enormously as the current rises above the normal. In spite of this the candle power rises 36 per cent above and drops 34 per cent below the normal, all within the time of five hours.

That such a variation cannot but be harmful to the eyes of people who have to work under these conditions goes without saying.

F. Hirschauer, Munich,* has expressed the percentage total variation of candle-power by $2px_v$, in which p is the variation of the supply P.D. above or below the normal. This is proved as follows. The candle-power of any lamp may be expressed by

$$T = K_v V^{X_v}$$

In this equation X_v is constant for the same type of lamp, for instance $X_v = 4{\cdot}0$ for the Osram lamp. K_v is a coefficient constant for the same lamp, but dependent upon the age of the lamp and the maker. Suppose now the voltage V is increased or decreased by p per cent, then

$$T_1 = K_v\left(V + V\frac{p}{100}\right)^{X_v} = K_v\left\{\left(1 + \frac{p}{100}\right)V\right\}^{X_v}$$

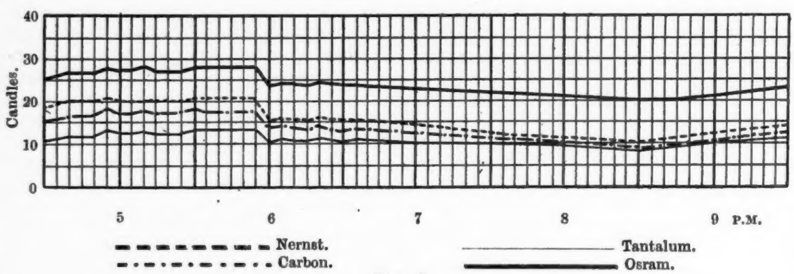


FIG. 2.

$$T_2 = K_v\left(V - V\frac{p}{100}\right)^{X_v} = K_v\left\{\left(1 - \frac{p}{100}\right)V\right\}^{X_v}$$

The total variation in the candle-power is then

* *Elektrotechnische Zeitschrift*, 1908, p. 87.

$$T_1 - T_2 = K_v\, V^{x_v}\left\{\left(1+\frac{p}{100}\right)^{x_v} - \left(1-\frac{p}{100}\right)^{x_v}\right\}$$

But according to the binominal theorem

$$\left(1+\frac{p}{100}\right)^{x_v} = 1 + x_{v_1}\frac{p}{100} + \frac{x_{v_2}}{\underline{|2}}\left(\frac{p}{100}\right)^2 + \frac{x_{v_3}}{\underline{|3}}\left(\frac{p}{100}\right)^3 + \dots$$

$$\left(1-\frac{p}{100}\right)^{x_v} = 1 - x_{v_1}\frac{p}{100} + \frac{x_{v_2}}{\underline{|2}}\left(\frac{p}{100}\right)^2 - \frac{x_{v_3}}{\underline{|3}}\left(\frac{p}{100}\right)^3 + \dots$$

and

$$\left(1+\frac{p}{100}\right)^{x_v} - \left(1-\frac{p}{100}\right)^{x_v} = 2x_{v_1}\frac{p}{100} + 2\frac{x_{v_3}}{\underline{|3}}\left(\frac{p}{100}\right)^3 + \dots$$

This series converges very rapidly, so that even the second member may be neglected, since for $X_v=14$ the result is affected by less than 1 per cent. We obtain, therefore,

$$T_1 - T_2 = K_v\, V^{x_v}\, 2\, x_v\frac{p}{100},$$

and the percentage candle-power variation

$$\frac{T_1 - T_2}{T}\times 100 = \frac{K_v\, V^{x_v}\, 2\, x_v\frac{p}{100}}{K_v\, V^{x_v}}\times 100 = 2\, x_v\, p.$$

By plotting this variation in the candle-power as function of 2p, we obtain Fig. 4.

Suppose now the percentage variation in the candle power is given, then we find the corresponding allowable percentage pressure variation by drawing a horizontal line through the given percentage candle-power variation, which cuts the lines for the various lamps in the desired points. Assume, for instance, the light variation is not to exceed 15 per cent, then the percentages of the allowable pressure variations to either side are

Carbon lamp	1·07	or total 2·14
Nernst lamp	0·8	,, ,, 1·6
Tantalum lamp	1·7	,, ,, 3·4
Osram lamp	1·87	,, ,, 3·74

In the case of a 220 volt supply the pressure at the terminals of the lamp would have to be regulated to within—

Carbon lamp	217·65 to 222·35	volts.
Nernst lamp	218·24 to 221·76	,,
Tantalum lamp	216·26 to 223·74	,,
Osram lamp	215·89 to 224·11	,,

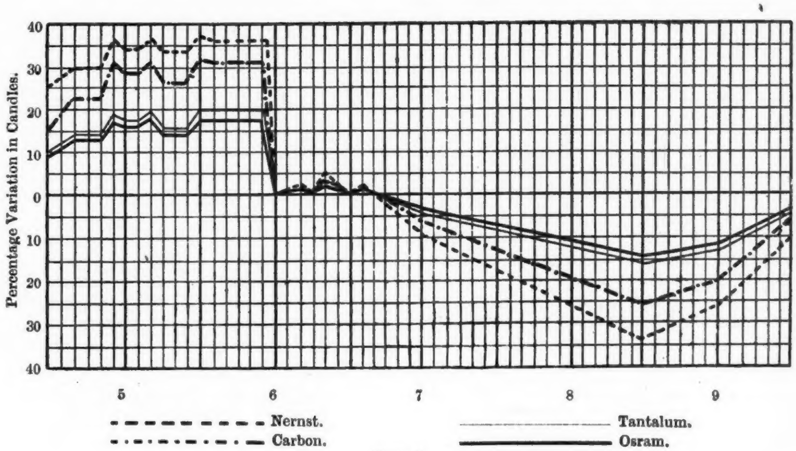


FIG. 3.

With these figures it is easy to calculate the cross sections of feeders. Take the following example :—

A large building requires light to the extent of 16,000 candle-powers, and the variation in the light is not to exceed 15 per cent in all. Let us assume that the supply pressure at the central station bus bars is constant,

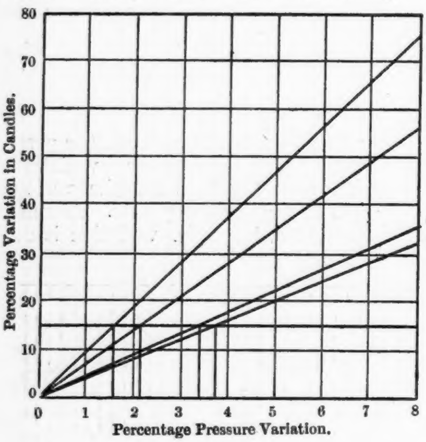


FIG. 4.

that the economies of the different types of lamps are

Carbon lamp $\eta = 3{\cdot}5$ watts per candle
Nernst lamp $\eta = 2{\cdot}0$ „ „ „
Tantalum lamp $\eta = 1{\cdot}5$ „ „ „
Osram lamp $\eta = 1{\cdot}3$ „ „ „

and that the distance from the station to the building is 1 kilometre. The drop in the mains is given by the above allowable total pressure variation. We have

Carbon lamp, drop$=\frac{2{\cdot}14}{100} \times 220 = 4{\cdot}7$volts

Nernst „ „ $= \frac{1{\cdot}6}{100} \times 220 = 3{\cdot}52$ „

Tantalum „ $= \frac{3{\cdot}4}{100} \times 220 = 7{\cdot}48$ „

Osram „ „ $= \frac{3{\cdot}74}{100} \times 220 = 8{\cdot}23$ „

The currents carried by the mains in the various cases are :—

Carbon lamp, 255 amperes.
Nernst lamp, 146 „
Tantalum lamp, 109 „
Osram lamp, 95 „

The resistances of the mains are :—
Carbon lamp 0·0184 ohm.
Nernst lamp 0·0241 „
Tantalum lamp 0·0687 „
Osram lamp 0·0866 „

The cross sections of the mains follow from :—

$$S = P \times \frac{1}{R} = 0{\cdot}017 \frac{2000}{R}$$

Carbon lamp 1,848 mms.^{2} (100 per cent)
Nernst lamp 1,410 „ (75·7 „)
Tantalam lamp 495 „ (26·8 „)
Osram lamp 392 „ (21·2 „)

These cross sections are excessively large, due to the fact that we have assumed constant station P.D., whereas it is more economical for constant light to lay out a station plant and network for constant P.D. at the feeding points. With constant P.D. at the feeding points, the following cross sections would have been sufficient :—

Carbon lamp 170 mms.^{2}
Nernst lamp 97 „
Tantalum lamp 73 „
Osram lamp 64 „

Whatever the arrangement of plant and network be, we may summarize our results as follows :—

(1) The new metal filament lamps are vastly superior to the carbon lamp as regards economy and uniformity of light on an irregular supply, and also superior to the Nernst lamp as regards the latter.

(2) For a given variation in the candle-power of lamps, the regulation of the supply P.D. must be much closer for Nernst and carbon lamps than for Tantalum and Osram lamps.

(3) If no provision is made for raising the P.D. at the bus bars at the station so as to keep the P.D. at the feeding points constant, the calculation of the feeders for carbon and Nernst lamps must be far more liberal than for Tantalum and Osram lamps, if the variation of the light is to be kept within reasonable limits.

In conclusion I have to thank Messrs. Jack and Pickard, students in my department, for carrying out part of the experimental work connected with this paper.

A New Method of Illuminating the Exteriors of Buildings.

An article in our special section in the August number of *The Illuminating Engineer* dealt with the illumination of the exteriors of buildings with a view to bringing out their architectural features by night. It was suggested that the most natural method of achieving this effect was by illuminating the building as a whole from without rather than by attempting to reproduce its main outlines in incandescent lamps.

We notice in a recent number of *The Electrical World* an account of the lighting of the Singer Building Tower in New York, in which this method has been aimed at for the purpose of spectacular effect. The highest point on the roof of this tower is 612 feet above the pavement, and it contains forty stories above the level of the street, and covers a ground area of 24,000 sq. feet. It is therefore a striking object, visible from a considerable distance, and specially suitable to the method of illumination adopted.

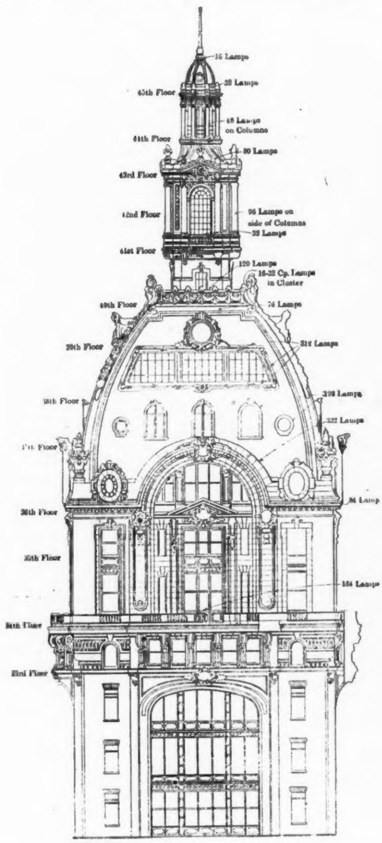


Fig. 1.

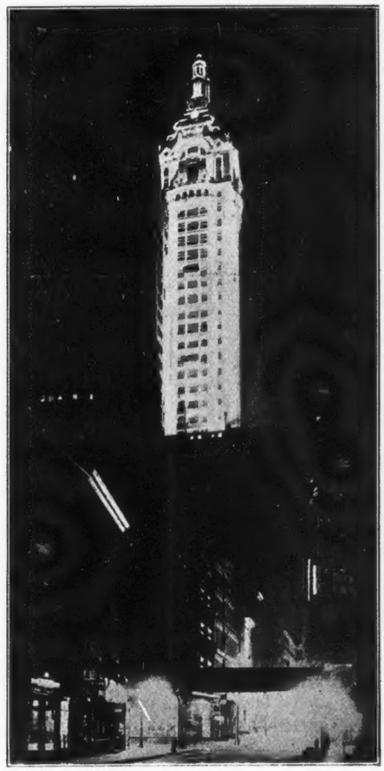


Fig. 2.

The illumination of the outside of the building is obtained mainly by the use of incandescent lamps. Instead of being employed for "outline-lighting," however, these lamps are concealed behind the cornices and balconies surrounding the building, and are equipped with reflectors concentrating their light upon its exterior. The general method of arranging these lamps will be understood from Fig. 1; there are said to be 1,600 lamps in all used to illuminate the section of the tower above the thirty-fourth floor. On the top of the dome is an ornamental lantern 16 feet square at the base and 60 feet high, and above this again a small flagpole reaching, eventually, a height of 652 feet.

In addition to the local lighting by incandescent lamps, intended to bring out special features of the exterior of the building, searchlights are made to illuminate the building as a whole, and to wash with light wide tracts of area that could not easily be effectually treated otherwise. Over twenty-five of these special searchlights are located on the roofs of the buildings at the base of the tower, shutters being provided to restrict the light to the space occupied by the tower and cause it to stand out against a dark background. It is also proposed to keep a searchlight beam playing upon the flag at the summit of the tower.

As will readily be understood from the illustration in Fig. 2, the tower forms a striking object by night, and is visible a considerable distance away. It is stated, moreover, that this illustration hardly conveys the pleasing character of the effect, as the tower here seems to present a somewhat ghostly and spectral appearance. Actually the warm tones of the brick and the tint of the copper dome at the summit of the building preserve it from giving this impression.

The possibilities of this method of lighting from a purely spectacular and advertising point of view are interesting. There seems, however, also ample room for the ingenuity of the architect in applying the system to buildings of exceptional architectural and historic interest. For, having artificial light at his command, he is in a position to secure that the light comes from the correct direction, producing the desired play of light and shadow, and throwing into prominence and relief just those portions of the building that justify this treatment.

Some Instances of the Need for the Illuminating Engineer.

REFERENCE has recently been made in our columns to the cases that are constantly arising in which the need for a reliable impartial authority is made evident. We notice a number of instances, referred to in the current technical press, in which the method of illuminating some public building is discussed and the decision of the authorities questioned.

It need only be repeated that in such cases it is essential that the matter should be placed in the hands of a competent expert in illumination. At present there is a growing tendency to consult an outside adviser in such circumstances. It is becoming more and more generally realized that important issues are involved. But the decisions of such an expert can only give satisfaction when his acquaintance with different systems of lighting and impartiality are recognized.

At present, it must be admitted that in many cases an outside expert is consulted mainly on account of his repute in general engineering and quite irrespective of his knowledge of the subject of *illumination*. Under these circumstances it is hardly to be wondered at that his decision is often called in question and remains a source of dissatisfaction.

The Photometric Measurement of Illumination for Architectural Purposes.

By Percy J. Waldram, F.S.I.

The determination of the proper amount of illumination for interiors is a problem which architects are constantly being called upon to face. Whilst on the one hand insufficient window - space or meagre artificial illumination will at once condemn an otherwise good building in the eyes of the most easy critic, on the other hand over-large windows have to be avoided as giving a particularly cheerless, uncomfortable appearance in dull weather, making rooms cold and draughty in winter, and being liable to destroy the internal and external balance and harmony of a design. In the case also of buildings in large towns erected on highly expensive land and let necessarily at high rentals, the space to be devoted to light wells becomes a matter for the most serious consideration.

In the same way excessive artificial lighting has to be avoided, being almost as bad in its general effects as too little, and being even more trying to the eyes, as well as unduly expensive.

Important as these considerations are in the case of private houses, they impose an infinitely greater responsibility upon the architect designing schools, libraries, hospitals, &c., where mistakes in the predetermination of illumination, whether natural or artificial, are of so much greater moment. But whatever the building, every architect is aware of the enormous advantage to be obtained by well-proportioned windows and by artificial lighting, where the proper mean has been found between glare and gloom.

Yet although architects are constantly fixing the dimensions of windows and the extent and distribution of artificial lighting; although they are constantly rendering themselves responsible for the comfort and health of those who will occupy their buildings for generations—although, to put it at the lowest level, successful illumination means money to them whilst unsuccessful illumination means loss, it is not too much to say that they are guided in this important matter by guesswork only, or at the best by the application of approximate empirical rules which do not vary with varying conditions.

The London Building Act, 1894, Section 70(c), enacts that "Every habitable room shall have one or more windows....with a total superficies clear of the sash frames, free from any obstruction to the light equal to at least one-tenth of the floor area of the room....but a room having no external wall or a room constructed wholly or partially in the roof may be lighted through the roof by a dormer window with a total superficies clear of the sash frame equal to at least one twelfth of the floor area of the room ....or such room may be lighted by lantern light." The same regulations are contained in the Model Bye Laws of the Local Government Board and in nearly all by-laws founded upon them for urban districts.

It is by no means uncommon for the dimensions of proposed windows to be determined by considerations entirely unconnected with illumination so long as these minima are not infringed, although they are the same for windows in an enclosed area as for windows overlooking a park.

The aspect of a window, its shape, the solid angle subtended in the clear sky visible from it, the colour of the opposing walls, and the interior decoration all affect its illuminating power, but so completely has the science of illumination been ignored hitherto, that not one architect in a hundred, probably not one in a thousand, would know how to calculate the additional window space required to afford equal illumination under adverse conditions.

Experienced architects, when fixing window dimensions, can depend upon the intuition derived from a series of previous approximations more or less successful; younger architects can only trust to guesswork and luck.

In the Building Regulations (1907) issued by the Board of Education for new schools under their control will be found the following regulations as to windows.

RULE 6—LIGHTING.

The area of window glass should approximate to one-fifth the area of the floor space in rooms used for teaching, and in other rooms to not less than one-eighth. Every part and corner of a school should be well lighted. The light in class-rooms must be admitted from the left side of the scholars. All other windows in class rooms should be regarded as supplementary or for ventilation. Where left light is impossible right light is next best. Windows full in the eyes of scholars cannot be approved. Unless the top of the windows be more than 12 ft. above the floor the plan should show no space more than 20 ft. from the window-wall in any room used for teaching.

(*a*) Windows should never be provided for the sake merely of external effect. All kinds of glazing which diminish the light and are troublesome to keep clean and in repair must be avoided. A large portion of each window should be made to open for ventilation and for cleaning.

(*b*) The sills of the main lighting windows should be placed not more than 4 ft. above the floor; tops of windows should, as a rule, reach nearly to the ceiling; . . . .

(*c*) Skylights are objectionable. They cannot be approved in school rooms or class rooms. They will only be allowed in central halls having ridge or apex ventilation.

(*d*) The colouring of the walls and ceilings and of all fittings in the rooms should be carefully considered as affecting the light. This point and the size and position of the windows are especially important in their bearing on the eyesight of the children.

(*e*) The windows should be properly distributed over the walls of the class rooms so that every desk shall be sufficiently lighted. The glass line of the window furthest from the teacher should be on a line with the back of the last row of desks.

These rules are a great advance on the regulations governing ordinary buildings, and are excellent so far as they go, but their want of precision with regard to lighting angles, visible sky, &c., is an eloquent testimony to the need of more exact knowledge of the extent to which such factors affect illumination.

The regulations are even more eloquently silent as to artificial lighting. They require detailed plans and specifications of new schools to be submitted for the approval of the Board of Education, including particulars of such items as sanitary arrangements, ventilation, boundary walls, desks, fireplaces, &c., but artificial lighting is not even mentioned.

With regard to the artificial lighting of buildings generally an architect applies at most only such simple rules as so much candle-power per square of floor space, without regard to the height of lights, the character of the reflection, or whether the globes are to be frosted, tinted, or clear. For the disposition of the lights he would probably rely upon the advice of the electrical or gas fitting firm whose tender is accepted. One would have to search diligently to find in England an architect measuring in candle-feet, and recording for future reference, a degree of artificial illumination which he had found to be both sufficient and pleasing for any given situation. Yet the measurement of illumination by say a Trotter illumination photometer or "illuminometer" is simply a direct reading on the dial of an instrument of about the same size, weight, and cost as a hand camera.

The use of illuminometers would enable architects to invite tenders for electric lighting or gas fitting on the basis of specified illumination in candle-feet at certain points with specified lamps, globes, &c., and thus secure effects which had been found pleasing and satisfactory elsewhere. At present few architects would have the faintest idea of what illumination in candle-feet to specify at any given point, fewer still would know how to take the necessary simple measurements to see whether they had obtained it. But illumination in candle-feet at certain points (and not candle-power at uncertain points) is precisely what architects are most particularly concerned with. Their province is the result, the means lie in the hands of the engineer. At present architects know a little about the means and nothing at all about the result until they see it. New and economical systems of artificial lighting are constantly being placed on the market and widely used. Whereas a few years ago flat-flame gas lamps and arc and 8 to 16 candle-power incandescent electric lamps comprised practically all systems of lighting, there are to-day a dozen or more well-known systems whose illumination differs from these older ones almost as widely as they differed from candles and oil lamps.

Every day it becomes more important that the architect should be able to specify at least the general distribution of his artificial lighting and the illumination in candle-feet that he requires at every point. Not until he can do this can he compare intelligently the relative advantage and economy of different systems for the particular purpose which he may have in hand. The fact that he cannot do so is not so much his fault as that of engineers and scientists, who in this country have so neglected the science of illumination that the architect has no suitable text-books from which to obtain the necessary information, and very few experts indeed who can assist him. The general neglect of the subject is clearly shown in the curricula of the different architectural schools. An examination of any syllabus shows perhaps one lecture on window areas to third or fourth year students, the subject of illumination from different systems of artificial lighting being ignored as completely as it is in the papers of the qualifying technical examinations.

As the height and extent of buildings tends to increase, the problem of daylight illumination is becoming almost as complex as that of artificial lighting, and methods which when combined with experience are sufficient to predetermine successfully the daylight illumination of, say, a county mansion, can be hopelessly at sea over town schools, hospitals, and libraries, or blocks of buildings covering large areas.

Even if private clients may be satisfied to trust to their architects' skill and experience, the erection of practically all large modern buildings is in the hands of public or semi-public bodies or their building committees, the architect for any large building being almost invariably selected from the result of an architectural competition. Quite properly such committees, as the trustees of other peoples' money, look very closely into all possible details of proposed buildings. Architects need now, and will need even more in the near future, to justify their plans before such committees with regard to illumination as in other respects, and in terms certainly more exact than are in general use at present. Even if unable to state in candle-feet the illumination which, having regard to all the circumstances, will be given by the windows they have designed on the desks of schools, on the tables of libraries and public offices, and in the wards of hospitals with any given degree of sky brightness, they will at least require to be in a position to state definitely whether such illumination will vary from standard existing buildings and approximately to what extent. They should certainly be able to explain in exact terms the illumination resulting from the artificial lighting they propose to employ, instead of merely stating the candle-power and to refer to existing examples of similar illumination. None of these would be particularly difficult problems were the illuminometer added to the everyday working tools of the architect or of the expert advising him.

Disputes as to ancient lights also

present another difficulty to architects and surveyors, which can only be solved by the intelligent use of the illuminometer. The courts are continually in need of expert evidence as to the damage done by new buildings to the daylight illumination of old ones. The character of the expert evidence given in such cases is almost invariably a vague statement of the personal conclusions of each particular expert, unsupported by a shred of scientific reason that a judge and jury can grasp, often betraying ignorance of some of the most essential factors, but always backed emphatically by the lengthy experience, the high professional standing, and the many qualifications of the deponent. It is generally opposed by the diametrically opposite conclusions arrived at by equally eminent experts on the other side. One frequently hears elaborate calculations, illustrated by diagrams, of the proportion of sky which has been obscured, and which was previously visible with the eye say a foot from the centre of the window or even on the glass itself; and the result given as the exact proportion of damage, quite regardless of the large part played by reflected and diffused light in any but purely rural districts.

Visits to the rooms alleged to be damaged are described by experts who found them poorly lit on cloudless days, probably in blissful ignorance of the fact that blue sky is by no means a good condition for the reflected diffused light upon which town premises of necessity largely depend for illumination.

In opposition to this, testimony would probably be borne to wonderful feats of reading minute print performed in the same rooms on cloudy days by professional men of equally unimpeachable character and equally eminent, but who are probably equally unconscious of the extent to which a slight cloudiness *increases* diffused illumination.

Small wonder it is that the Courts are showing growing impatience, and that judges sometimes evince a cynical mistrust of expert evidence given in ancient light cases and not infrequently prefer to visit the premises and form their own opinions.

The problems involved in ancient light cases are really insoluble except by the application of practical photometry, but when so solved they are quite simple. The law first requires to know whether a new building has or has not damaged the light of an existing one, to a degree below that generally obtaining in the surrounding districts, and which is in fact a nuisance. If that is the case it then requires such damage to be stated in terms which can be translated into monetary damages. Every window is simply a means for obtaining a certain proportion of the sky brightness for interior illumination. Windows with an horizon more or less obscured are naturally less efficient illuminators, but their efficiency remains practically constant throughout the wide range of constantly varying sky brightness. If the middle of a room enjoys an illumination of 2 candle-feet with a grey sky brightness of 280 candle-power per foot superficial it will enjoy 0·5 candle-feet with a grey sky brightness of 70 candles. The use of a Trotter illuminometer provided with a daylight reducer will fix for any room in a few minutes the ratio between sky brightness and interior illumination and a comparison showing this "window efficiency" of rooms alleged to be damaged as compared with that of a number of rooms at the same floor level in the neighbourhood can be easily obtained, and is precisely the evidence required by the Courts.

Our knowledge of relative sky brightness over yearly periods is even now sufficiently extensive for an expert to calculate with fair accuracy, the average amount of extra artificial lighting per annum which corresponds to any given loss of "window efficiency." This not only gives in exact terms the most important item of damage, but is a fair criterion of the damage to the general amenities of the building.

The Courts now grant injunctions against the erection of proposed buildings on the ground of possible interferance with existing rights of light in fewer cases than formerly, preferring generally to allow the erection, and assess damages on completion. Injunctions are, however, sometimes granted in flagrant cases or where the the lights affected are of great importance. Prospective damage is particularly difficult to prove, but in the hands of a competent expert whom the Courts can trust, relative photometric measurements on scale models should form definite reliable evidence of its extent. As it is not easy to prove simply to lay minds that the relative photometric measurements in small scale models are scientifically correct representations of what takes place in full size rooms, it is desirable, in order to convince a judge and jury as to this important point, that the expert should be in a position to detail a number of coinciding measurements taken in actual rooms and in scale models of them.

There is no more hopeful field of investigation to the lighting expert than that of relative photometry and the practical experiences of those who have experimented in it would be of great value to all investigators in illumination. The interesting article on the subject by Dr. Ruzicka, which appeared in the June number of *The Illuminating Engineer*, unfortunately does not detail any actual experiments, and the particulars given of the photometer used are hardly sufficient to enable an estimate to be formed of its value for such work. Apparently, it compares, by direct reading, illuminations which differ by at least as much as 100 to 1, and which would in the models of ordinary rooms differ by as much as 1500 or 2000 to 1; a direct reading instrument giving accurate results over those ranges, and dispensing with the necessity for a standard comparison lamp and a reduction device would be the greatest value. So limited is the range over which the eye is sensible to differences of daylight illumination on white paper that direct comparison over such ranges has, as far as the author is aware, never yet been attempted. The use of the same photometer in the model as is used for the full sized rooms entails somewhat large models, but a scale of 2 in. to the foot, which is not excessive, enables table height readings to be easily made in the model and the use of the same instrument is a ready check upon the accuracy of the results.

Mr. V. R. Lansingh in London.

During the last month we have received a visit from another distinguished member of the Illuminating Engineering Society of New York, Mr. V. R. Lansingh, the General Secretary and Treasurer of that Society, and the author of one of the very first books on the subject of illuminating engineering (see *Illuminating Engineer*, Feb., p. 168).

Mr. Lansingh is making a trip through many of the principal cities of Europe with the object of studying the progress of illumination and recent developments of the various systems of lighting in use.

Mr. Lansingh was one of the original three founding members of the Society in the United States, and its progress owes not a little to his energy and experience. We were pleased to hear that the work of the Society is prospering. The list of papers to be read before the approaching Convention, published in our last number, affords ample evidence of its vitality.

While explaining the experiences of the Society in America, Mr. Lansingh spoke encouragingly of the prospects of a society on similar lines in this country. He stated that his American experience led him to the conviction that the lines on which we were working and our efforts to form such a society must ultimately prove successful, and that though some might think that the conditions in the two countries are somewhat different, we, too, would meet and triumph over any initial difficulties that might occur.

Light as a Means of Attracting Attention.

By an Engineering Correspondent.

Probably few people realize the exact reasons why their attention is involuntarily attracted to certain objects in the streets, and why so many others fail to receive any notice though they may pass them on their way to business every day. It is only through the agency of light that the objects surrounding us are seen at all, and it will therefore be readily granted that the illumination of such objects may have more than a little to do with their power of attracting notice.

There can be no question but that the exact qualities in a sign or notice that rivet the attention are very greatly dependent upon the scheme of illumination adopted.

When any object has exactly the same shade of colour and exactly the same brightness as its background, it becomes practically indistinguishable at a little distance. When, therefore, we wish any object to " stand out," and to attract attention, we must secure that either one or the other of these qualities is very distinctively different from the surroundings. The application of such considerations to street - signs, shop-lighting, and advertising problems generally, is obvious.

But there are also a number of cases in ordinary life when the same considerations must come into play, though we may not be aware of them. Let us, for instance, take the case of a man working at a desk in his office. It is a much debated point whether a general diffused system of illumination is the best in such a case or no. This method, a good example of which is seen in Figs. 1 and 2, has certainly several points to recommend it.

It is generally recognized that such systems of lighting represent the nearest approach to natural daylight conditions in which a uniformly diffused illumination from the sky is utilized. The possibility of " glare " from too brilliant sources of light is effectually avoided, and the absence of shadows, such as are often inevitable when more or less " point-sources " of light are employed, is also an advantage in many respects.

On the other hand, many people will be found who cannot tolerate such inverted methods of lighting in any room having any æsthetic pretensions, because they are conscious that the complete absence of shadow makes the room uninteresting. No doubt this is partly to be explained on the assumption that the eye, searching the room for some point of interest, sees nothing that " stands out," and so attracts the attention.

The same feeling may prove a hindrance even when the person in the room wishes to concentrate his attention on the work on his desk before him. For there is no decided contrast in shade between the papers before him and the surroundings, and he therefore does not receive any optical inducement to keep his attention on his work. A very violent contrast to the method of lighting shown in Fig. 2 is that exhibited in Fig. 3.

This illustration is taken from Dr. Bell's recent paper on 'The Physiological Basis of Illumination.' Here the attention of any one entering the room is inevitably attracted to the brightly illuminated table. But, as Dr. Bell explains, the contrast between the brightly illuminated table and the dark surroundings is too severe. Every time the eye wanders from the table it undergoes rapid accommodation to the darkness that amounts to a positive shock, and the ultimate effect is very wearisome.

Probably the best plan of all, therefore, is something intermediate between these two sets of conditions, and the most perfect condition of affairs would probably be secured by using a moderate general illumination, coupled with stronger local illumination, so as to tend to rivet attention on the table. It may be deemed far-fetched to suggest that such extra illumination can make any difference to the comfort of the worker; but when we remember the importance of such details in the case of a man who is constantly engaged upon exacting brain work for long intervals of time, we can see that such details, however trifling in themselves, are at least worth consideration.

The same principle must apply to lecture-theatres and schoolrooms with even greater force. In such cases we ought to do all that is possible to attract the attention of the audience to the lecturer. We ought therefore to provide sufficient general illumination to enable them to take notes, &c., but we should also make special efforts to illuminate the lecturer's table, or the blackboard or diagram to which he is referring. On the other hand, any diagrams that may be distributed about the room for future reference, ought presumably not to be illuminated to the same extent; otherwise the attention of the audience will be inclined to wander to them. Above all, there must be no bright points of light visible out of the tail of the eye, as such sources of light cannot but have a very distracting effect.

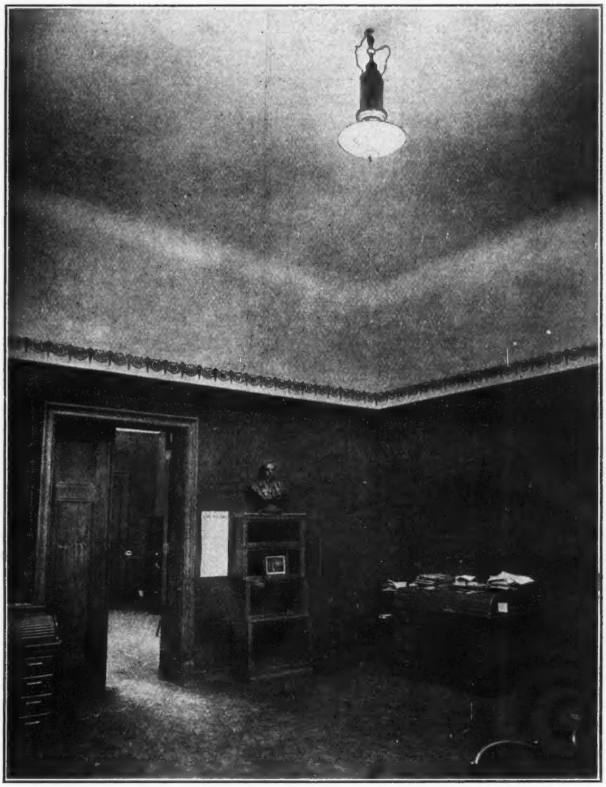


FIG. 1.—General Diffused Illumination by Inverted "Regina" Arc Lamp.

We can easily call to mind many

other cases in which similar considerations apply. In a church, for instance, one would be inclined to suggest that, while a certain general illumination is necessary during the singing of hymns, &c., this illumination ought to be weakened during the sermon, in order to render the specially illuminated pulpit the central point of interest. As a matter of fact this is very often involuntarily recognized, and the lights are turned down at this stage. There are, however, also churches in which the bright sources of light are allowed to fall into the line of sight of any one looking towards the preacher, and thus tend towards somnolence on the part of the congregation.

There are many other cases in which the necessity for making special arrangements to illuminate important objects of interest is not sufficiently realized. It has only recently begun to be appreciated that our methods of giving directions to strangers in our midst, whether they refer to the names of streets and buildings or the nearest railway station, are often sadly defective. And even in cases in which measures were taken to give the necessary information in the daytime, the fact that such notices as had been erected became invisible during the evening was generally overlooked.... except by those who had occasion to search for them. More recently, however, the need for well-illuminated and prominent signs of this description has been more clearly realized, and there are now a number of cases in which such defects have been remedied; of these the illuminated signs adorning many motor-buses and those calling attention to the whereabouts of the Metropolitan Railway stations off the Strand are examples. There still remains, however, very much that might profitably be done in this direction, both in the way of providing directions as to the whereabouts of objects of interest, and also of illuminated explanation signs referring to streets, public buildings, &c.

FIG. 2.—Diffused Lighting by "Regina" Arc Lamps.

As soon as we enter any big building the same want is felt, and if the present arrangements are a very great improvement on those that were considered satisfactory in the past, there is still room for further progress. When entering a railway station, for example, there are always certain things we wish to know and very often want to know in a hurry. We ought therefore to be able to see at a glance where the booking-office is, where the train for a certain place is about to depart, &c., and everything possible ought to be done to cause such notices to strike our attention at once. Well-illuminated direction-signs pointing out the subways to various local stations, &c., are also essential and well repay erection if only by the amount of cross-questioning they save the employees of the company. In the multiplication of such illuminated notices in most up-to-date railway stations we see an illustration that the value of light, wisely used for this purpose, is receiving more attention than a short time ago. An instance of the erection of very convenient illuminated signs of this kind occurs at the Finsbury Park station of the G.N.R., where passengers coming up from the tube and preparing to mount the stairs to the Great Northern station are met by a series of signs which inform them where the next trains are to start from and where they are going. Such instances might be multiplied, but we are still in a process of transition. In one of the tubes which the writer has in mind, excellent direction-signs of this kind abound, but the clocks are not illuminated at all, and appear to the passenger jet-black against a background of diffused illumination.

In commenting on the use of direction-signs in this way, the writer has made special reference to the requirements of railway stations, but it need hardly be said that the same remarks apply to many large buildings where cloak-rooms, ticket-offices, refreshment-rooms, &c., have to be searched out by the visitor.

Although the subject of shop lighting and advertisement lighting generally is too big a subject to be more than briefly mentioned in this article, the application of scientific principles of drawing attention are in this case self-evident. There is no doubt that much more might be done in the way of making such displays striking by carefully studying the method of lighting applied. In this connexion it cannot be too clearly laid down that any effect that is merely disagreeably bright probably defeats its object by making it unpleasant for the passer-by to keep his attention fixed. As a result, his eye, after being involuntarily attracted, turns away in relief to something less wearisome. In shop lighting for instance, where the

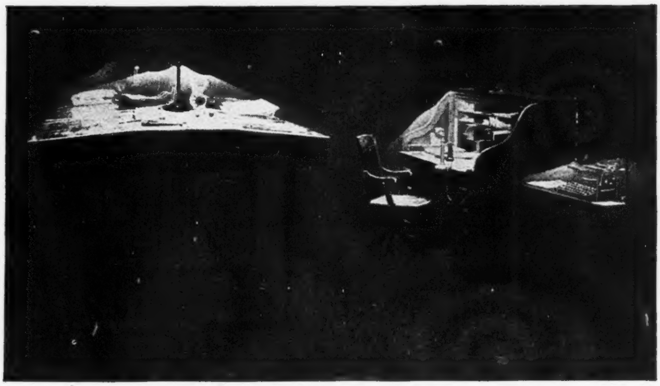


FIGURE 3.
Local Desk-Lighting with Sharp Contrast.

brightly illuminated window both acts as an advertisement in attracting attention and also serves the purpose of displaying goods when the prospective purchaser has arrived, it is generally agreed by those who have studied the subject that bright sources of light must be kept out of the line of sight of any one gazing into the window, and that the lights ought to be effectively utilized for illuminating the goods displayed. If the salesman elects to put some bright lights out of the line of sight above the window as an advertisement that is another matter.

An ingenious scheme now sometimes adopted is to cause the lights both to illuminate the contents of the window and also to illuminate a semi-transparent device bearing the name of the proprietor of the shop, as shown in Fig. 4. In such a case the same lights are used both for advertising purposes and for lighting the contents of the window, but in a legitimate manner without offending the eyes.

When we come to consider the best arrangement of lights for the display of the contents of the window we reach a very important subject that has hardly been adequately touched upon as yet. Considering the pains to which the stage-manager of a theatre is willing to go in order to interest the audience, it will be admitted that the shopkeeper, whose window may be regarded as a miniature stage, might achieve great results by exercising a little similar ingenuity, One question that has been frequently discussed of late is the advisability or otherwise of using a perfectly uniform system of illumination such as that aimed at in Fig. 5. This is a question which must be felt to depend very greatly upon the nature of the contents of the window. It might be supposed, for instance, that in this particular case, in which a series of hats, all apparently equally important, are illuminated, a diffused illumination is justified because the shopman has presumably no desire to attract attention to one hat more than another. On the other hand, in a case in which it is desired to call special attention to some special object within the window, it might be

FIG. 4.—Showing Lights utilized both to Light up Notices and to Illuminate the Contents of the Window.

advisable to secure this attention by accentuating the illumination of this object, and thus causing it to stand out among the general contents of the window.

Finally a few remarks may be made upon the general conditions that would seem to be necessary in order both to attract and to keep attention. In the first place we may emphasize the point made a few lines above, that though it may be necessary to make lighted signs brighter than their surroundings in order to attract attention, yet it is certainly inadvisable to restrain their brightness below that upper limit above which the eye is conscious of an impression of disagreeable dazzle in order to keep it. From this point of view, signs of the transparency variety would certainly seem to be preferable to those outlined in naked incandescent lamp filaments.

Also, attention may be called to one point that deserves greater notice than it has received at present, namely the value of colour as a means of attracting notice. As was explained at the commencement of the article, an object becomes indistinguishable from its surroundings when it resembles them exactly, both in colour and brightness. We may therefore often attract attention by making the colour of our sign quite different from anything in its neighbourhood. This would be particularly valuable for purposes of classification. It might, for instance, be settled that all municipal and official notices in the streets should be red or green as the case may be. We should then be in no danger of wasting attention upon an advertisement when we are inquiring our way to somewhere, and, indeed, the multiplication of illumination signs in our streets is proceeding so rapidly, that some such differentiation is already advisable in order to give prominence to certain important notices, among the many bright objects around them. In the same way if red light were invariably used for the illumination of clocks, we should soon fall into the habit of looking for the colour in a railway station or in any other circumstances in which the time is of paramount importance, and our attention would be immediately attracted by the unusual colour.

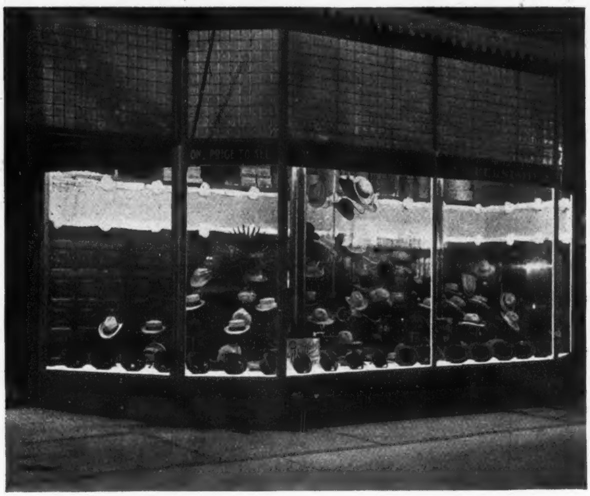


FIG. 5.—General Uniform Illumination.

We have already some illustrations of the use of colour in this way in the red lamps which indicate the whereabouts of the Fire Brigade or the doctor, and the white letters on a blue ground on the lamps outside the police stations.

The writer has abstained from referring to signs in which attention is attracted by alternately lighting up or extinguishing certain letters, &c. This method of attracting notice by alternation in brightness is of course very effective, but probably should not find application to the variety of signs with which we have mainly dealt. Signs of the purely advertising character form a special class by themselves apart from those intended to supply information. To many people the rapid fluctuations in darkness and brightness entailed by such signs are wearisome, and, as it must be confessed that their power of attracting attention demands a sudden change of this kind, one would hesitate to recommend a very general adoption of this method. The multiplication of flashing devices in our streets would tend to create a feeling of bewilderment and distraction, and would tend to render it difficult for attention to be attracted to notices which were really essential.

In any case our object in arranging the illumination with a view to attracting attention must be carefully borne in mind. We must in some way distinguish the important objects from their surroundings. It is even possible that in the future the relative prominence of illuminated signs will be a matter of definite privilege, and that in situations in which it is absolutely essential that public attention should be fastened upon a certain notice, the presence of other objects likely to encroach on the public attention, and render it possible for the important sign to be overlooked, will be forbidden. The general underlying principles of all such attempts to rivet attention are the same. It is only by means of light that an object is visible at all, and it is mainly by controlling this light that an object is brought into prominence or left in comparative obscurity.

Means of Preventing the Deposit of Moisture on Shop-Windows in Winter.

In the July number of *The Illuminating Engineer* (p. 595) attention was drawn to one qualification of illuminants intended for show-window lighting that is apt to be overlooked. In winter the cold window-panes are often obscured owing to the condensation of the moisture from the heated atmosphere within, and it therefore is best to avoid methods of lighting in which any considerable development of heat and moisture occurs in the processes of combustion.

The June number of *The World's Work* contains a reference to a preparation which, it is claimed, overcomes this difficulty. Windows coated with the preparation are said to remain quite clear, in spite of the difference in temperature inside and out, and the objectionable steaming does not take place.

Low Candle-Power Lamps and Sensitive Meters.

In a recent number of *The Electrical Times* attention is drawn to one point in connexion with electric meters that has arisen since the introduction of the new high-efficiency lamps. The starting-current of meters ought now to be kept down to a lower value than was formerly considered necessary, owing to the fact that lamps are now in use taking such a small current as to fail to be recorded by the meter at all.

For instance, on a 200-volt circuit a 30-candle-power tungsten lamp may have no effect on the meter, while on low-pressure circuits it would probably be difficult to find a meter capable of registering a single 6 candle-power lamp, unless assisted to do so by transformer losses. The consumer would therefore be at liberty to keep one light on for nothing.

Some Effects of Light, Visible and Invisible.

THE unfortunate experiences of Dr. Hall Edwards, and of many other early workers in the subject of X-rays, illustrate only too clearly how cautious should be the investigator of some new and untried form of energy, which may produce after-effects quite unsuspected at the time of the experiment. Unfortunately, too, these bad effects frequently only gradually reveal themselves when prolonged exposure has already done the mischief. Even to-day we are discovering new and peculiar qualities of these rays. Recently, for instance two French investigators, MM. Imbert and Marques, described a curious experience in their laboratory.

It was remarked that the hair and beard of one of their colleagues, long since turned completely white, were gradually returning to their pristine colour. Eventually this colour became even more striking than it had been originally. Subsequent experiments are said to have fully confirmed this remarkable effect; the change in colour was also apparently quite permanent. It is possible, therefore, that a cure for prematurely whitened locks is at length at hand; yet, in view of the ill-effects which may follow incautious exposure to these rays, one would hesitate to recommend its use, except under careful supervision.

During the last few years considerable attention has been paid to the physiological influence of another more frequently encountered form of radiation—the so-called "chemical" or "photographic" rays in the spectrum. Our eyes are only responsive to a certain range of frequency of the waves in the ether, which we call "light." Just as, in the case of sound, we recognize a certain number of octaves of musical sound, while higher or lower vibrations degenerate into mere noise, and eventually become inaudible, so, in the case of light, only the waves of a certain range of frequency are visible to the eye. They may, and do, however, possess other very vital properties by which they are readily detected in other ways. Rays which are of too high a frequency to be perceived by the eye, for instance, readily produce chemical action, and are thus perceived by the photographic plate in a camera. They even produce well-marked physiological changes, and the development of the methods of production and uses of this kind of energy forms one of the most interesting series of results of the last and the present century.

It is, perhaps, not generally known that sun-burning is now understood to be due, not to the mere heat of the sun, but to the photographic action of these invisible rays. This so-called photographic action is very curiously illustrated by the marking which follows small-pox. The discovery of this fact by Finsen led to the subsequent use of these rays for the treatment of skin diseases. Far back in the Middle Ages it was believed that, for some reason, it was beneficial to surround persons suffering from small-pox with red curtains. This impression was in some cases ridiculed by scientists, and it is only quite recently that it has been demonstrated that such curtains were really actually beneficial because they absorb the chemical rays. For the severe marking following small-pox was found to be actually due to a photographic effect — the disfiguring marks being permanently stamped or printed in on the exposed part by the chemical rays. If, however, such rays are carefully excluded from the patient until he is convalescent, the subsequent disfigurement is much less severe.

The discovery of this fact led Finsen to attempt to produce the chemical rays, or, as they are usually termed, "ultra-violet" rays, in greater quantities than they actually exist in sunlight. For this purpose he developed a very concentrated electric arc-lamp. By means of this apparatus he could readily produce all the effect of sunburn by an exposure of only a few minutes. At the present time it is a common experience of those who are constantly working with powerful arcs —searchlights and so on—to become sunburned in this way. Indeed, unless care is exercised the effect takes place with an emphasis which is distinctly uncomfortable, causing the skin of the part affected to peel off exactly as in cases of severe sunburn.

Afterwards the curative effect of exposure to ultra-violet rays of parts affected by various skin-diseases was discovered. The ultra - violet rays have long been definitely proved to exert a marked destructive action on bacteria ; it seems to be now regarded as very probable that these rays, even under ordinary circumstances, exert an important influence on the skin and blood. There has even been a suggestion that the inability of the negro to withstand the tubercle bacillus is due to the blackness of his skin, which absorbs ultra-violet light before it can do more than penetrate the very outermost layer of the epidermis.

As soon as the valuable qualities of ultra-violet light were generally realized, efforts were made to secure sources of light richer in energy of this description than the ordinary Finsen arc. The percentage of the total amount of energy put into the ordinary carbon arc light which actually comes forth in the form of ultra-violet light is very trifling—a mere fraction of 1 per cent. Naturally, therefore, the production of chemical rays in this way was very costly and inefficient. A distinct improvement was effected by employing iron electrodes, it having been found that incandescent iron-vapour is very rich in the required form of energy. More recently, electrodes of special chemical composition were utilized with yet more favourable results, but still the percentage of the desired form of energy generated was miserably low. But during the last two years a new and entirely different source of ultra-violet energy, which is said to possess wonderful properties, namely the mercury lamp, has come to the front.

The use of tubes of incandescent mercury vapour as a source of light—*for purposes of illumination*—is of older date ; a number of these lamps, shedding their characteristic curious green light, are to be seen in the streets of London to-day. In the case of these lamps the enclosing tube was made of ordinary glass, which very completely absorbs the ultra-violet rays. They were therefore of service for the generation of *visible* light only. But the discovery in Germany of varieties of glass which let through ultra-violet light revealed the possibilities of the mercury light in this direction. Lamps having tubes composed of these new quartz and other glasses are now actually constructed, and it is said that as much as 30 per cent of the power given to the lamp, as opposed to a mere fraction on the part of the sources previously mentioned, is actually available in the desired form.

Such lamps appear to be extraordinarily powerful. They are expected to prove of great service for medical purposes, such as the treatmen of skin diseases, the destruction of bacteria, and for sterilization generally. In this connexion it is interesting to learn that they have, apparently, a peculiarly deadly effect on small insects. It is said that a fly, when brought within an inch or so of the lamp, is killed immediately. The lamps are also regarded as of very great value for photographical purposes. One very interesting instance of their strong chemical action is as follows. The fading of carpets, and coloured objects generally, when exposed to bright sunlight, is now understood to be caused by the chemically disintegrating action of the ultra-violet element in daylight. For this reason we are told that the manufacturers of coloured goods in the north of Germany have found it necessary to send their goods south, to regions which are more liberally treated in the matter of sunshine, in order that the permanency of the colours employed might be effectually tested. But it is now suggested that this will be no longer necessary. The testing will be accomplished by means of the new mercury lamps, and that, too, in a mere fraction of the time formerly required.

It seems, therefore, that we have now at our disposal sources of ultra-violet energy far more powerful than were dreamt of a few years ago. That they will be invaluable for certain specified purposes can hardly be doubted. But we must also bear in mind the necessity for care on the part of experimenters, just as in the case of the X-rays mentioned at the commencement of the article. We would naturally suppose that ultra-violet light, which is credited with such wonderful powers in a curative direction, would also exercise marked influence upon the unprotected healthy individual. This seems to be the case. Fortunately it seems that the most injurious effects make their appearance relatively soon after exposure, and are therefore readily detected.

Ultra-violet light, as we have seen, produces "sunburn." In very great quantities even an exposure of a few seconds may produce a distinctly uncomfortable inflammation of the skin. Of much greater consequence, however, seems to be its effect on our visual apparatus. There are many cases on record where very serious inflammation of the eyes was experienced by those who had been working with powerful naked arc lamps. These bad consequences have been definitely traced to the presence of the strong ultra-violet element in the light from the arc lamp, originally remarked, as we have seen, by Finsen. It is significant that some of the most serious of these cases have occurred when arcs of very high power were being used for the purpose of drilling iron plates; luminescent iron-vapour, as we have remarked before, is exceptionally rich in ultra-violet rays.

Another instance of the effect of ultra-violet energy is afforded by cases of snow-blindness. The atmosphere of our earth is very effective in suppressing rays of this nature, and consequently sunlight, in the form in which it reaches us, only contains a comparatively small percentage of such energy.

On the mountains, however, the light from the sun is in a very different condition, because it has not suffered to the same extent owing to the intervening atmosphere. Moreover, the relatively strong ultra-violet element present is being constantly reflected hither and thither by the snow, and is thus able to enter the eye in directions very different from those in which it arrives in the ordinary course of events. It is therefore found that irritation, ultimately culminating in snow-blindness, is liable to occur if precautions are not taken to screen the eyes by suitable glass spectacles.

In all the cases the injury to the eyes is not felt immediately at the time of exposure, but only makes its appearance after a few hours have elapsed. Fortunately it seems to be fairly easy to guard against this injury by covering the eyes with thick glass goggles. But in the case of the extremely powerful sources which are now available, very special precautions are desirable, and special varieties of glass for the use of operators have been recently put upon the market.

It has even occurred to some engineers to raise the question whether the comparatively small quantities of ultra-violet energy present in ordinary illuminants, such as electric glow-lamps and incandescent mantles, may not be injurious. There is certainly a tendency in our modern illuminants towards higher temperature and consequently towards an increasing percentage of radiation of the character referred to. The present practical illuminants appear to yield but a very trifling percentage, but the older types, the candle and the oil-lamp, probably contained even less.

Schanz and Stockhausen (*Illuminating Engineer*, Jan., p. 70) have quoted the suggestion that cataract may be caused by the action of ultra-violet light on the lens of the eye, and have instanced the work of previous investigators who have observed a distinct turbidity of the lens under the action of the rays. However, common experience suggests that the danger of injury in this way is not very generally experienced.

One frequently hears vaguely expressed suggestions that the spectral character of the light given out by certain illuminants results in their being specially fatiguing to the eyes, and this is ascribed to the effects of ultra-violet light. There are, however, so many other factors that enter into the problem, and may individually be responsible for such effects—such as the concentrated brilliancy of the light for example—that it is mpossible to make any very definite suggestions on this point at present.

We must remember, too, that the glass globes which surround ordinary sources of light are all more or less effectual in destroying even such ultra-violet element as exists.

On the other hand, there is always the possibility of new illuminants (intended for ordinary purposes of illumination, but infinitely more powerful in this respect than any employed in the past) coming upon the scene. From the reports to hand at present it appears that the new Küch quartz tube lamp recently brought out in Germany is an example of such a lamp (*Illuminating Engineer*, January, p. 81), and it has been found necessary to surround the lamp with an envelope composed of glass of a special character capable of completely absorbing the dangerous rays.

It should also be borne in mind that when a person is working continuously by artificial light, effects which are in themselves comparatively trifling may, in the long run, have a cumulative result that is anything but insignificant.

J. S. D.

(*To be continued.*)

Illumination of Test-Type Charts by Artificial Lights.

(From the *Optical Journal*, June 11.)

Dr. Norman M. Black recently discussed the above question in a paper before the Academy of Ophthalmology, Louisville, Ky., U.S.A.

He explained that the conditions affecting daylight illumination differ so greatly at different parts of the year that some constant artificial illumination must take its place for the purpose of tests of visual acuity.

Of these he regarded electricity as the most convenient, as practically every city of sufficient size to support an ophthalmic surgeon was lighted by electricity; petroleum and illuminating gas and acetylene-gas were equally efficient from the standpoint of candle-power required, but less satisfactory to manipulate.

The committee appointed by the Ophthalmic Section of the American Medical Association to determine upon a standard of illumination for test-type charts would submit a full report upon this subject at the Chicago meeting next year.

Artificial illumination may be used in two ways, either reflected or transmitted. There was considerable difference in opinion throughout the United States as to the efficiency of these two methods, and an inquiry was circulated with the object of obtaining an expression of opinion from the leading ophthalmologists.

Sixty-two replies were received, and were classified as follows: 18 preferred reflected light, 9 preferred transmitted light, 5 used daylight only, 3 found practically no difference, 25 had had no experience with transmitted light, 1 had no opinion to offer. One question as asked was not answered.

A number of these replies are quoted, without, however, seeming to elicit any very conclusive evidence that either system is greatly preferable from the ophthalmological standpoint.

Dr. Black, however, quotes the statements of a number of American authorities to the effect that yellow light is best for the eyes, and is himself of the opinion that transmitted light is best for the illumination of test-types.

The Cost of the Lighting of the City of London.

(Extract from Report on Works executed by the Public Health Department of the Corporation of London during the year 1907.)

By Frank Sumner, M.Inst.C.E.

Gas Lighting.

UNDER this heading the report contains two complete tables showing the consumption, lighting-hours per annum, and annual and quarterly charge per lamp throughout the year in the streets of London.

From January 1st to June 30th the Gas, Light and Coke Co. supplied gas at 2*s.* 2*d.* per 1,000 cubic feet, this charge being subsequently increased to 2*s.* 5*d.* from July 1st to Christmas in the case of public lamps north of the Thames.

Incandescent Gas Lighting.

The number of gas lamps (including experimental lamps) paid for by the Corporation at the end of the year was 2,765, being a decrease of 39 during the year, accounted for by the removal of a number of lamps in the side-streets adjacent to the thoroughfares lighted by experimental electric lamps.

The size and character of these lamps (2,765) are set out in the following table :—

TABLE I.

Back Lamps.	Columns.	Brackets.	Lantern.		Ordinary Burners. (Cubic feet per hr.)									High pressure. (Cubic feet per hr.)						Spec'al.	Total.
			Sq.	Cir.	3	4·25	4·25 1/3	4·25 20	6⅜	7⅜	8·50	12·75	21·25	10	20	30	100	15	60		
66	555	2,144	2,678	87	10	1,972	71	477	1	39	56	5	1	42	45	8	1	1	6	30	2,765

In July two double burner incandescent gas lamps were fixed in Fore Street, by Red Cross Street, to better light the entrance to the public way through Cripplegate churchyard, in lieu of one electric arc lamp removed.

High-Pressure Incandescent Gas Lighting.

In January a double burner high-pressure lamp was fixed on the rest by Nos. 1 to 4, Lombard Street, in place of an electric arc lamp, and one electric light arc lamp at the corner of Lombard Street and St. Swithin's Lane was removed, for which an ordinary single burner incandescent lamp was substituted.

The number of defective gas lights observed and reported upon during the year was 2,278, viz., 1,843 ordinary and 435 high-pressure lamps.

The details of lighting defects in the ordinary incandescent lamps were as follows :—

Feeble lights..	1,485
Lights went out	12
Not alight during night ..	14
Total	1,511

In addition, 332 defects in the lanterns and burners were reported to the Gas Light and Coke Co., and rectified.

The details of the total defects observed in the ordinary lamps during the year are as follows (Table II.) :—

The readings of the meters attached to the public lamps in various parts of the City show that the full contract quantity of gas is given at those lamps, and I am of opinion that the contract quantity is given generally throughout the City, and that the regulators of the lamps are kept in proper condition.

The public gas lamps were lighted, in accordance with the general instructions in force for many years past, whenever fog or unusual darkness occurred. This happened on thirty-three days during the year, and entailed an additional cost of £219 2*s*.

Electric Lighting.

The lighting of most of the main thoroughfares of the City by arc lamps was continued throughout the year. The number of the older type electric lamps in lighting at the end of the year, at a cost of £26 each, was 400, being a decrease of 39, mainly accounted for by the substitution of the new and cheaper flame arcs, fitted up experimentally by the two Electric Lighting Companies, in November. These lamps were lighted on nine days during the year when fog or unusual darkness occurred, at a total additional cost of £43 12*s*. 11*d*.

The number of defective electric lamps observed during the year was 99. The returns of these defects are made daily to your engineer by the police; for which the City of London Electric Lighting Company were fined for each failure, the amount deducted from their account in fines during the year being £24 4*s*. 11*d*.

Removal of Arc Lamps.

During the year arc lamp "H 37" was removed from the east side of Adelaide Place, the light from the adjacent high-pressure gas lamp being sufficient to light this part of the thoroughfare.

In addition, the following arc lamps have been removed during the year, and gas lamps put up in lieu thereof :—

Rest by Nos. 1 to 4, Lombard Street.

Corner of Lombard Street and St. Swithin's Lane.

By No. 76, Cannon Street.

By No. 1, Fore Street, Cripplegate.

In Table III. is given the number of arc lamps in lighting on the 31st of December, with the annual cost of the same :—

TABLE II.

Defective Lights.			Defective Lanterns.							Total.
Feeble Light.	Light went out.	Not alight during night.	Bottoms.	Tents.	Sides.	Doors.	Dirty.	Protectors.	Burners.	
1,485	12	14	52	10	40	5	70	111	44	1,843

The total number of public electric lamps of all kinds in lighting on December 31st was 451, against 449 on December 31st, 1906.

Experimental Lighting.

In accordance with the Resolution of the Court of Common Council of July 25th, permitting the two Electric Lighting Companies, having statutory powers in the City, to experiment with the newest form of electric lamps for street lighting in the thoroughfares of Holborn, Holborn Viaduct, Old Bailey (part of), Farringdon Street, Newgate Street, and Cannon Street (between St. Paul's Churchyard and Dowgate Hill), the Charing Cross and Strand Electricity Supply Company proceeded with the lighting of their portion, viz., Cannon Street, by erecting 11 magazine "Flame" arcs, 5 of the "Oliver" type and 6 of the "Gilbert" make, centrally hung, being suspended over

TABLE III.

No. of Lamps.	Description.	Price per Annum. £	s.	d.	Company.
400	Original type	26	0	0	City of London E.L. Co.
1	"Oliver" flame arc at Lothbury ...	17	10	0	Ditto.
21	"Oliver" flame arc (experimental) ...	17	10	0	Ditto.
18	"Reason" enclosed arcs (experimental)	12	10	0	Ditto.
6	"Oliver" flame arcs (experimental) ...	17	10	0	Charing Cross Co.
5	"Gilbert" „ („) ...	17	10	0	Ditto.
Total 451					

the roadway by wires attached to the buildings on either side; these wires were subjected to a very severe test, by dead weight and a drop weight, considerably heavier than the lamp. The lamps were put into lighting on November 21st, and will be reported upon in six months' time.

The City of London Electric Lighting Company also proceeded with the carrying out of their experiment by substituting 21 "Oliver" flame arcs for a similar number of the original arcs, adapting the existing columns in Holborn, Holborn Viaduct, and part of Old Bailey, whilst in Farringdon Street 18 enclosed arcs of the "Reason" type were fitted up on special short columns in lieu of the 12 original arc lamps and columns in that thoroughfare. The installation of this area was completed by the 20th of November.

The maintenance cost of the "Oliver" flame arcs in the Holborn area is £17 10*s*. each per annum, being equivalent to the Charing Cross Company's charge in Cannon Street, and the cost of the enclosed arcs in Farringdon Street is £12 10*s*. each per annum.

A Restaurant Lighted with Holophane Globes.

THE illustration below represents an interesting and tasteful method of producing a uniformly distributed illumination over the tables in a restaurant in the United States.

The lighting is achieved by distributing incandescent lamps within Holophane globe reflectors, of the type described in *The Illuminating Engineer* for August (Fig. 3, p. 655).

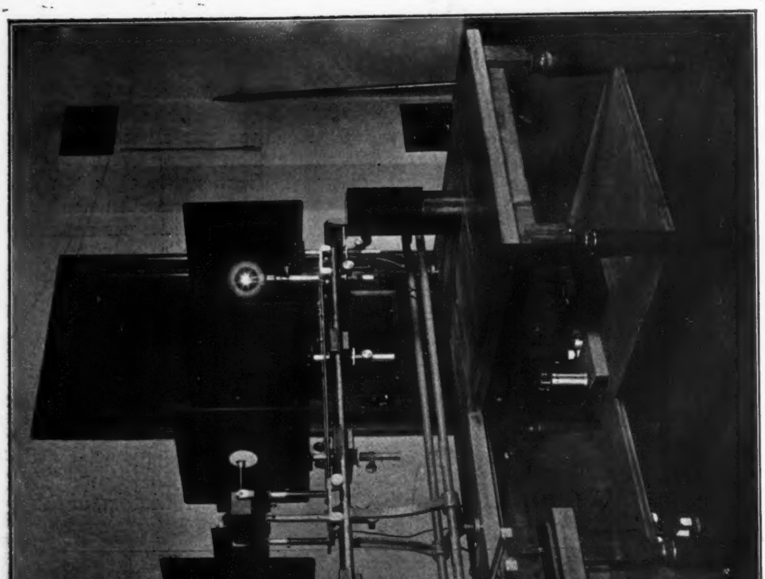


FIG. 1.—Standard Photometrical Bench, The Bureau of Standards, Washington.

SPECIAL SECTION.

Some well-known Photometrical Laboratories.

I. Photometry at the United States Bureau of Standards.

By Edward P. Hyde.

On July 1, 1901, in accordance with an Act of Congress passed the preceding March, the Bureau of Standards was established to supersede the old office of Standard Weights and Measures, which prior to that time, in a restricted way, had performed the functions of a national standards laboratory. By the terms of the Act the functions of the new Bureau were to "consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connexion with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests, and are not to be obtained of sufficient accuracy elsewhere."

From a humble beginning with a personnel of fourteen men, and with temporary quarters in the buildings of the Coast and Geodetic Survey, the Bureau of Standards has developed into an institution with a force of 110 employees, and occupying three new laboratory buildings situated on a 7½ acre tract in the north-western suburbs of Washington.

The work in photometry was inaugurated in the autumn of 1902 in one of the basement rooms of the Coast and Geodetic Survey building. For nearly two years it engaged the attention of only a single laboratory assistant; but in the spring of 1904 the photometric section moved to more commodious quarters in the new Mechanical Laboratory, and since that time the growth has been more rapid. At present the work is carried on by an associate physicist, two assistant physicists, a laboratory assistant, and a laboratory apprentice.

Equipment.—The photometric equipment consists of one standard photometer, one Matthews integrating photometer, one commercial photometer, one spectrophotometer, and various auxiliary photometric and electric apparatus, which will be described briefly in the following paragraphs.

The apparatus is mounted at present in two rooms $9 \times 6 \times 3{\cdot}7$ meters, and $4{\cdot}8 \times 4{\cdot}8 \times 3{\cdot}7$ meters respectively, but recently a third room $8 \times 5{\cdot}5 \times 3{\cdot}7$ meters has been assigned to photometric work. A special feature of all of the laboratory rooms is the provision that has been made for a partial control of the humidity. Each laboratory is provided with a coil of pipe through which cooled brine is made to flow, and by passing the air of the room over this brine coil by means of a fan, the humidity can be reduced greatly.

The Standard Photometer Bench (Fig. 1) is used in all work on standard lamps, and in the investigation of special problems. The photograph from which Fig. 1 is made was taken when the bench was set up for the investigation of Talbot's law, in which Nernst glowers, covered by cylindrical hoods, were used as sources. One of the hoods is shown in position; the other is sitting on the table beside the bare filament.

The bench is of the Reichsanstalt pattern, supplied with a Lummer-Brodhun contrast screen. By the use of a sufficient number of diaphragms covered with black velvet and suitably placed, stray light is excluded to such an extent that the leakage of light into the photometer screen is entirely negligible, although the walls of the room are of a light colour. The comparison lamp, on the right, is mounted on a carriage which is connected by means of adjustable links to the carriage supporting the photometer screen. The comparison lamp thus moves with the screen, remaining at a constant distance from it, so that the illumination on the right side of the screen remains constant during a series of measurements.

The standard and test lamps are placed successively in the socket on the left, and measured either stationary or rotating as occasion may demand. The horizontal rotator (shown in the photograph with the driving shaft disconnected) was designed and constructed at the Bureau. It has four rotating mercury contacts—two for current and two for voltage. The shell and the base of the socket are each divided into two parts, insulated from each other, to one of which the current lead is connected, and to the other the potential lead. In this way the voltage is measured on the base of the lamp, reducing greatly any error that may be due to a bad contact between the base of the lamp and the socket.

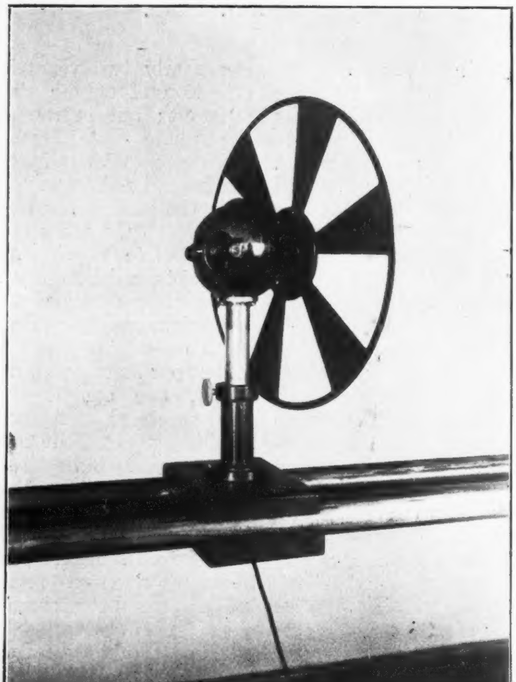


FIG. 2.—Rotating Sector Disc.

The sectored disc shown in the photograph is used, when rotating, to reduce the apparent intensity of a source by a known amount. In Fig. 2 it is shown on a large scale, mounted directly on the shaft of a small motor in the way in which it is generally used.

All of the electrical measurements are made by means of a potentiometer in terms of a Weston standard cell. The voltage of the lamps is reduced by a suitable multiplier, and current is determined by the fall in potential across a standard resistance. By means of a convenient multiple switch mounted in front of the potentiometer, voltage or current on either lamp can be determined quickly with an accuracy of one or two parts in 10,000. The galvanometer is mounted on the wall several feet behind the bench, but the spot of light is focussed on a graduated scale right behind the potentiometer, and at a convenient height for observation.

A new universal support and rotator recently constructed at the Bureau (Fig 3) may be mounted on one of the standard carriages belonging to the bench, for determining distribution curves around incandescent lamps. This instrument may be used either as a universal rotator, or as a universal lamp holder, since it is provided with two graduated circles in planes perpendicular to each other. A lamp may be set quickly to any latitude and azimuth, with an accuracy of a fraction of 1°. The axis of rotation is horizontal, making possible the use of mercury contacts. Any lamp from 4 c.-p. to 100 c.-p. can be measured, and many types of reflector shades and diffusing globes can be mounted with the lamps. By means of an adjustable counterpoise the instrument is always in equilibrium, and therefore free from mechanical strains.

In Fig. 4 is shown the Integrating Photometer for the direct measurement of mean spherical and mean hemispherical candle-power of incandescent lamps. It is of the Matthews pattern modified in theory and construction. It is 10½ft. high, and is provided with twenty pairs of mirrors. It is installed in a room by itself, and although the walls and floor are as nearly dead black as could be procured conveniently, black velvet has to be used freely in order to eliminate stray light. The black velvet was removed when the photograph was taken.

The instrument is provided with a Lummer-Brodhun contrast photometer screen. The test lamp is mounted in a special form of rotator which has two sockets—one upright and one inverted, so that the new types of lamps with weak filaments can be mounted and even rotated at a low speed. The comparison lamp is moved to and fro by means of a graduated steel tape on which the distance is read. Voltage is measured on a laboratory standard voltmeter, and current by means of a millivoltmeter and shunt.

The Commercial Bench (Fig. 5), set up in the same room with the Standard Photometer, is used principally in testing samples of lamps purchased by the Government departments. This bench was specially designed and constructed in the instrument shop of the Bureau. The horizontal rotator, mounted on the left, was purchased from the General Electric Company. It is equipped with the ordinary treadle for reversing the direction of rotation, so that lamps can be spun into and out of the socket. To the left of the horizontal rotator is a special end-on rotator made at the Bureau, for the purpose of determining the candle-power of lamps in the direction of the tip, since this is frequently specified in the purchase of incandescent lamps. This end-on rotator is driven by means of a belt running over a pulley on the vertical shaft of the horizontal rotator, so that both are driven by the same motor, and at the same speed, direct and reversed. Both rotators are provided with mercury contacts.

The comparison lamp is mounted in a fixed position at the other end of the bench, and the voltage on this lamp is adjusted until there is a balance against the standard lamp when the photometer screen is placed at 16 c.-p. or at the proper point on the scale corresponding to the candle-power of the standard lamp. The screen is moved to and fro over a limited

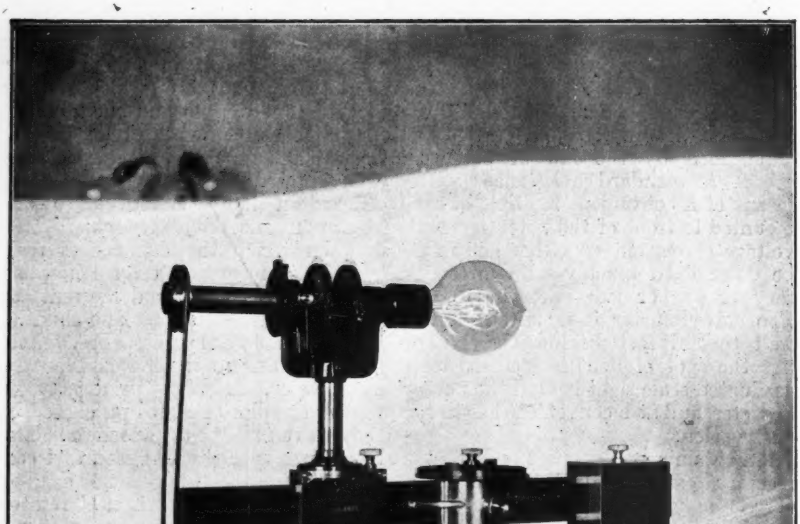


FIG. 3.—New Universal Support and Rotator for Glow-Lamp Tests.

distance by means of a belt operated by a wheel situated under the table, and in a convenient position for the hands of the observer.

A new feature of this bench is the multiple candle-power scale, which, in conjunction with a variable rotating sectored disc, permits of direct candle-power readings for lamps of all intensities, without moving the photometer screen over any great range of distance. One of the pieces of steel tubing forming the track is slotted, and within this tube is mounted a rotating drum graduated with five or six different candle-power scales, and operated by means of a thumb-screw. By turning the drum the desired candle-power scale can be brought beneath the slot. If 50 c.-p. lamps are to be measured, the variable disc is set to the proper angular opening and rotated, and the 50 c.-p. scale is used. The intensities of lamps in the neighbourhood of 50 c.-p. can then be read directly without moving the photometer any considerable distance from the central position. This latter feature is a distinct advantage, on the ground both of accuracy and of convenience. When lamps of a lower candle-power than 16 are to be measured, such as 8 c.-p. or 4 c.-p. lamps, the sectored disc is placed on the other side of the screen, between it and the comparison lamp.

The voltage measurements are made by means of a deflection potentiometer recently designed at the Bureau by Mr. H. B. Brooks. With this instrument the voltage can readily be adjusted to 0·1 volt or better in less time than it takes to make a corresponding adjustment with a voltmeter, and the accuracy of the instrument is much higher. The energy supplied to the lamp is measured on a Weston wattmeter. This instrument in connexion with a variable resistance controlled by the position of the photometer screen permits of direct readings of watts per candle. In series with the pressure circuit of the wattmeter are two resistance blocks bridged by a sliding contact fastened on the moving carriage which holds the photometer screen. The resistance in series with the pressure circuit of the wattmeter is always such for any position of the photometer screen that the watts are cut down in inverse proportion to the candle-power, so that the wattmeter indicates watts per candle directly.

In the new room which has recently been assigned to photometric work, another photometer bench will be installed within the next few months. The plans for this bench, which will be constructed in the instrument shop of the Bureau, are being drawn up now, but not sufficient progress has been made to warrant any description at this time.

The small amount of life-testing of incandescent lamps which the Bureau has undertaken in the past has been one on direct current, but a 40 kilowatt alternating-current generator has recently been installed for this work, and plans are now in progress to increase the capacity of the life-rack from 200 lamps to 500 or 1,000. The life-racks are not located in the laboratory rooms, but in a sepearate large room in the attic.

In addition to the several complete photometer benches which have been described there is much auxiliary apparatus which constitutes an important part of the equipment. A Brace spectro-photometer with a special form of variable sector made by Franz Schmidt and Haensch of Berlin from designs by Prof. Brodhun is provided for studying the spectral distribution of light from radiant sources. Flicker photometers of both the Simmance-Abady and the Franz Schmidt and Haensch forms have also been secured. An order has recently been placed for a large spectro-photometer of the Lummer-Brodhun type, together with a Lummer-Brodhun sectored disc, the opening of which can be varied and read while the disc is rotating.

As stated in previous paragraphs, the Bureau has a number of sectored discs of fixed opening, and two or three of variable opening of the ordinary form, ranging in opening from 0° to 180°. In addition to these there is one special variable-opening disc that was constructed by W. and L. E. Gurley upon designs furnished by the Bureau.

This disc is composed of two principal component discs, each having a fixed opening of 300°, and a number of very thin auxiliary discs whose only function is to close the gap formed between the two principal discs when these are moved over one another in such a way as to reduce the angle between their calibrated edges. Between 300° and 240° this fan-like set of very thin discs does not come into play, but when the angle between the calibrated edges of the two principal discs is made less than 240° the discs no longer overlap, so that there is an opening between the other edges. This opening is covered by the auxiliary discs. The total range of the disc is from 0° to about 300°. It is calibrated not only in degrees but in per cent. of total opening, and also in candle-power for use in the industrial photometry of incandescent lamps.

The standard lamps of the Bureau constitute an important part of the equipment. These include five Hefner lamps, two Vernon-Harcourt 10 c.-p. pentane lamps, one Carcel lamp, and a large number of incandescent lamp secondary and working standards.

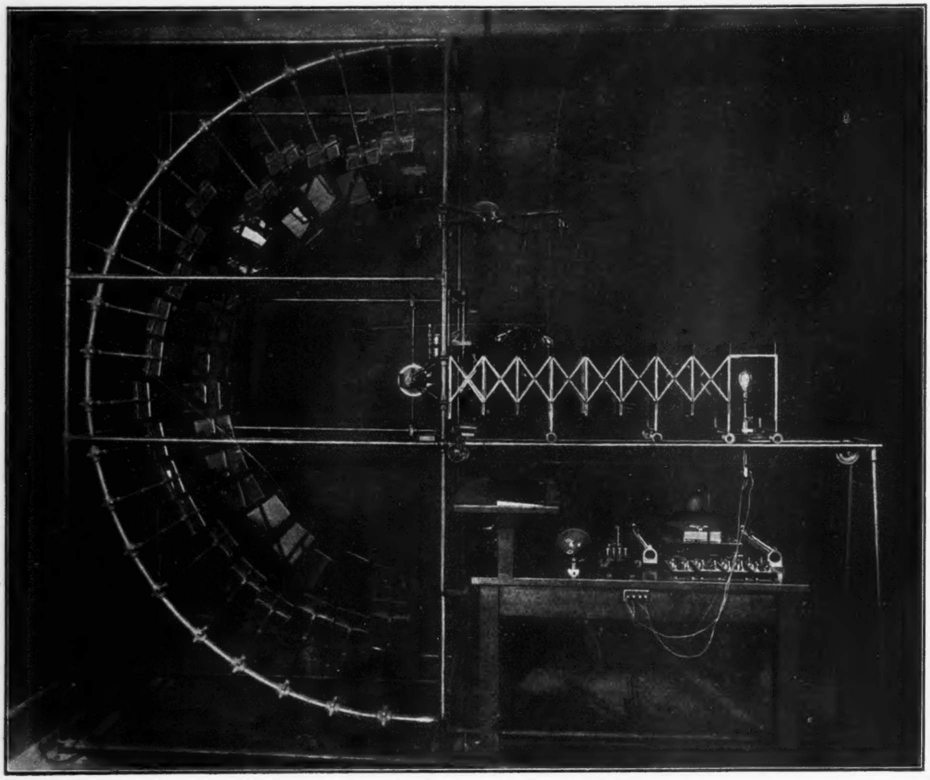


FIG. 4.—Matthews Integrating Photometer.

Testing.—The work in photometry may be classified roughly under two general heads: testing and investigation. An important function of the Bureau is to verify standard lamps for lamp manufacturers or testing laboratories. The Bureau does not undertake at present to supply standard lamps, or to season new lamps for use as standards, but if seasoned lamps are submitted they are standardized at a nominal fee.

The question is frequently asked, "What standard of candle-power is used at the Bureau ?" Although the Bureau has adopted a definite unit of candle-power, which it maintains through incandescent lamp secondary standards, it has not as yet adopted a primary photometric standard. This fact should be emphasized, as it is sometimes stated erroneously that the Bureau has adopted the Hefner lamp as the standard. Neither the Hefner nor any other lamp has been or will be adopted as a primary standard until the various lamps that have been proposed as standards have been investigated thoroughly. What has been done has been to adopt a unit of candle-power which bears a certain ratio (100 : 88) to the Hefner unit as maintained at the Reichsanstalt. At the time of the inauguration of the work in photometry at the Bureau this seemed to be the best way of arriving at the English parliamentary candle, which was supposed to be the common unit of candle-power in the United States both for gas and electric lamps. Inasmuch as the unit can probably be maintained constant through incandescent lamp secondary standards for an indefinite period, the adoption of a primary standard, though important, is not immediately urgent.

This distinction between a unit of light and a standard of light in terms of which the unit is expressed, has suggested the possibility of international agreement upon a common unit of luminous intensity for England, France, and the United States. The units in use in these three countries are so nearly alike that no serious results would follow a compromise by which all three countries would agree upon a common unit of candle-power. The suggestion is, that without in any way involving the question of primary standards, England, France, and the United States shall agree upon a common unit of candle-power which shall represent an average value of the units in the three countries. Each country will maintain this unit at its national laboratory in any way it may choose, *i.e.*, through pentane lamps, Carcel lamps, or incandescent lamp secondary standards, but by frequent intercomparisons among the various laboratories by means of incandescent lamps measured at each laboratory, the unit may be kept the same in the different countries.

It is probable that Germany would not be willing to change its unit by as much as 10 or 15 per cent., at least at present, but the ratio of the Hefner to the international candle could be determined and defined.

The adoption of a common unit of candle-power as distinguished from a standard lamp, suggests further a more complete differentiation of the functions of primary and working standards, and reduces the requirements demanded of each class of standards. On the one hand we should seek as a permanent custodian of the unit a primary standard, of which the only requirements would be a suitable colour, a suitable intensity, and exact reproducibility. It need not necessarily be simple, or inexpensive, or of great constancy over a long period of use. On the other hand, our working standards need no longer have the requisite reproducibility of a primary standard, but must remain constant after having been calibrated in terms of the unit. The seasoned incandescent lamp fulfils these requirements admirably for the photometry of electric lamps, but in the photometry of gas it is desirable to have flame standards that vary in intensity with changes in the atmosphere in the same direction and approximately to the same extent as the gas flame. It has usually been the custom heretofore to employ primary standards, such as the pentane lamp, in the photometry of gas, but is it not possible that a cheap and portable lamp might be found which would remain constant in intensity after having been calibrated, and which would be more convenient and more easily manipulated than the Harcourt 10 c.-p. pentane lamp ?

In addition to the testing of secondary or working standards the Bureau undertakes to do a certain amount of commercial testing for various departments

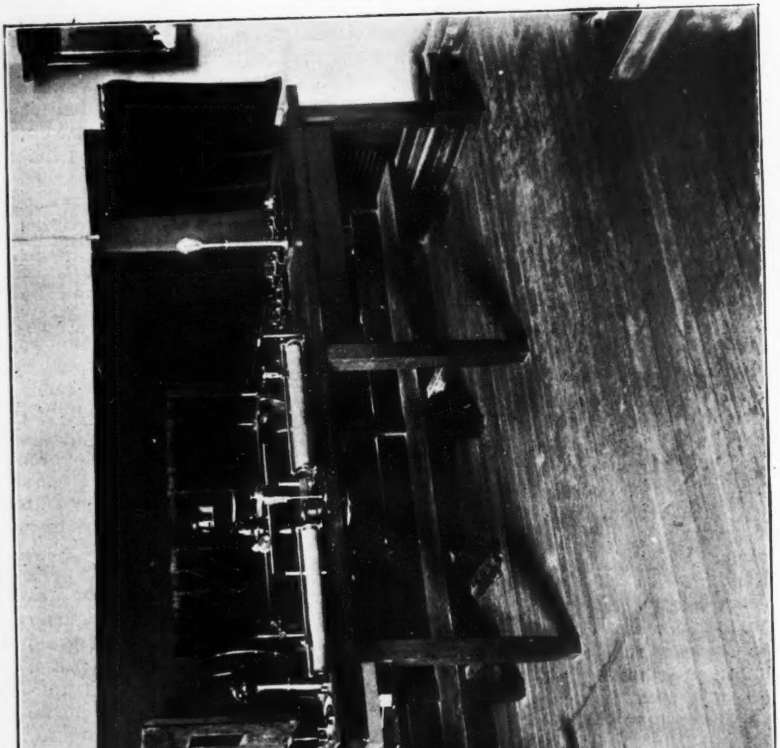


FIG. 5.—Photometrical Bench for Commercial Testing.

of the Government. and for private firms or individuals in cases of dispute, or where authoritative results are especially desired. It is prepared at all times to make special tests whenever these are practicable, to render assistance in the development of the proper methods of measuring luminous sources and illumination, and to aid as far as possible both the manufacturer and the consumer in preparing suitable specifications for the purchase of lamps.

It has been seen that the present equipment of the Bureau is designed for the most part for the testing of electric incandescent lamps. Although no work has been done thus far on arc lamps, and little work on the photometry of gas and oils, it is hoped in the course of time to broaden the work so that there will be facilities for measuring any kind of luminous sources. The photometry of incandescent lamps has been developed first because there seemed to be more demand for it.

Investigation.—Not the least important part of the work is the investigation of problems in photometry. This includes the study of standards (primary, secondary, and working), the development of accurate methods of photometric measurement, and the investigation of physical laws upon which the science of photometry depends. The scope of the work is therefore very broad, and the best results can be accomplished by maintaining a proper balance between investigation and testing. The one makes possible continual improvements in the other, and this in turn suggests fertile fields for further investigation.

The results of the investigations at the Bureau are published in the *Bulletin* of the Bureau of Standards, and also at times, usually in abstract form, in some of the technical journals. Each paper printed in the *Bulletin* is published separately in the form of a reprint, which may be obtained upon application. A list of the papers published up to the present time, containing in a few words a statement of the nature or results of each investigation, has recently been issued. The following list of papers in photometry has been copied from this source, the numbers referring to the order of publication in the *Bulletin.*

Papers on Photometry.—No. 12. On the 'Theory of the Matthews and the Russell-Léonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities.' The accuracy of these instruments in measuring lamps with various simple polar distribution curves is investigated. The method is given for computing the best arrangement of any given number of mirrors to obtain relative values between lamps having different distribution curves.

No. 20. 'The Use of White Walls in a Photometric Laboratory.'—If proper black velvet screens are employed on a photometer bench the leakage of light into the photometer due to the diffuse reflection from white walls is shown to be so small as to be negligible.

No. 26. 'Talbot's Law as Applied to the Rotating Sectored Disc.'—The apparent intensity of a source, before which a sectored disc is rotating rapidly is found to be proportional to the total angular opening of the sectored disc for all angles between 288° and 10°.

No. 30. 'An Efficiency Meter for Electric Incandescent Lamps.' — By means of a variable resistance in series with the pressure circuit of a wattmeter and controlled by the position of the photometer screen, the wattmeter is made to indicate watts per candle directly.

No. 43. 'On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method.'—A study of the errors incident to this method, due (1) to the distortion of the filament on rotation, and (2) to the inability of the eye to estimate accurately a badly flickering illumination. By the use of a single stationary mirror accurate measurements of mean horizontal candle-power can be made even with badly flickering lamps.

No. 50. 'A Comparison of the Unit of Luminous Intensity of the United States with those of Germany, England, and France.'—A number of seasoned incandescent lamps were carried abroad and measured in authoritative laboratories in the three countries named. The ratios of the units obtained through them are compared with the ratios generally accepted, and with those obtained in other recent investigations.

No. 51. 'Geometrical Theory of Radiating Surfaces with Discussion of Light Tubes.'—Assuming Lambert's cosine law and the inverse square law to apply to infinitesimal surfaces, the errors incident to applying them to finite surfaces are deduced for several simple cases. From a consideration of the case of an infinitely long, uniformly bright strip of finite width a theory of light tubes is developed.

No. 61. 'An Explanation of the Short Life of Frosted Lamps.'—The rapid decrease in candle-power of frosted lamps is due, at least partly, to the increased absorption of the carbon film deposited on the inner side of the bulb. Owing to the diffuse reflection at the frosted surface a relatively large part of the emitted light is compelled to traverse the absorbing carbon film three or more times before finally emerging. Results of confirmatory experiments are given.

No. 63. 'On the Determination of the Mean Horizontal Intensity of Incandescent Lamps.'—A continuation of a previous investigation on this subject (see Reprint No. 43). Other types of lamps are studied, and the methods and results of similar experiments by Uppenborn are discussed.

No. 72. 'A Comparative Study of Plain and Frosted Lamps.'—The various effects of frosting the bulbs of carbon filament incandescent lamps are studied as changes in (1) absorption, (2) distribution, and (3) life.

1. New lamps show an absorption of only 2 or 3 per cent., which increases rapidly as the lamp burns.—2. The distribution of light around frosted lamps depends on (*a*) the distribution curve of the bare lamps, and on (*b*) the shape of the bulb.—3. The theory advanced in a previous paper (see Reprint No. 61) to account for the short life of frosted lamps is further substantiated. Readings are given of the temperatures of the bulbs of plain and frosted lamps, both new and old.

An International Unit of Candle-Power.

(*Electrical World*, March 28th.)

At the convention at Boston last June a sub-committee of the Illuminating Engineering Society was formed to study the possibility of agreement upon an international unity of luminous intensity. Later the American Institution of Electrical Engineers, and the American Gas Institute, co-operated with this committee, and a final report was adopted in February, and is to come before the Illuminating Engineering Society very shortly.

The report advocates the establishment of one single unit of intensity throughout America, to be maintained by the Bureau of Standards, who will also issue sub-standards. The question of international agreement is also discussed, and it is suggested that in future a unit should be adopted, which shall be 2 per cent less than that now maintained at the Bureau of Standards at Washington. This change is advocated on the ground that such a unit is estimated to differ by less than 1 per cent. from the anticipated international standard.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Further Remarks on the Injury to the Eyes caused by Ultra-Violet Light.

By Prof. Birch-Hirschfeld.

(*Zeitschr. für Augenheilkunde*, xx. vol. i.)

The author gives an account of five cases, closely examined during the course of two months, which illustrated the injurious action of the mercury-vapour light on the eye. Though the influence of such rays is serious, their recognition is hindered by the fact that such organic changes as are produced only give rise to slight subjective experiences, and therefore demand special methods of study.

1. Among these cases may be mentioned first the case of a student of twenty-five years of age who worked for the sessions with an 8–9 amp. Heraeus lamp, with unprotected eyes. He suffered repeatedly from sensations of watering, burning, and pressure on the eyes, and noticed, after being dazzled, a tendency to "see yellow," and obscuration of objects directly gazed at. One day, after working for a quarter of an hour in the immediate neighbourhood of the lamp, he suffered from severe electrical ophthalmia, and also subsequently discovered that his sense of colour was affected. In the right eye there appeared to be central and in the left paracentral relative scotoma, especially for the colours red and green.

2. A young man who had worked daily with unprotected eyes for several months at photographic work involving copying by means of the Uviol lamp. After several weeks he began to experience pain and burning sensations in both eyes, accompanied by a diminution in visual acuity; he also discovered that he could distinguish colours, especially red, yellow, and green less successfully than hitherto, and this was confirmed on examination.

3. Another worker in the same room, twenty-three years old, had experienced similar unpleasant sensations, and complained of diminished powers of distinguishing colours, particularly red and green tones. On examination. colour-disturbances in the field of view of both eyes were found to exist.

4. A third worker in the same room had copied by the aid of the Uviol light for about one year; in this case the left eye was proved to be insensitive to red and green.

5. This patient had carried out spectroscopic research with the Uviol lamp for several hours a day for several months. He, too, complained of pressure and burning sensations in the eye, and found difficulty in distinguishing colours. On examination a spot was found in the lower inner region of the field of view of the right eye, insensitive to red and green.

From the consideration of these cases Prof. Birch-Hirschfeld comes to the conclusion that the rays from the mercury-vapour lamp, besides causing trouble to the membranes at the back of the lens, may also give rise to injury by acting directly on the retina itself.

F. Schanz.

Arc Lamps for Photographic Work.

An interesting example of arc lamps intended for photographic purposes is exhibited at the electrical exhibit in the Machinery Hall at the Franco-British Exhibition.

In order to secure the predominance of the valuable ultra-violet radiation a long arc is desirable. In the present instance, therefore, a special type of flame carbons are employed and an arc no less than about 3½ inches in length is obtained.

The Meeting of the British Association.

The Annual Meeting of the British Association for the Advancement of Science is this year to be held in Dublin. The proceedings will open on Wednesday next, September 2nd, when an address will be delivered by Mr. Francis Darwin, F.R.S., the new President of the Association.

On the Injury that may be Caused to the Eye by Ultra-Violet Light.

By Dr. F. Schanz and Dr. K. Stockhausen.

(*Elektrotech. Zeitschr.*, Aug. 13, 1908.)

In addition to the account of the demonstration kindly sent us by Dr. Schanz and referred to on the last page, mention must be made of the paper by the same author recently read before the Verband Deutscher Elektrotechniker, and dealing with the same subject.

Dr. Schanz recapitulates the results quoted in the former article, and explains the considerations which render the use of a type of glass opaque to ultra-violet light desirable. For greater detail on these points we refer readers to our abstract in the January number of *The Illuminating Engineer* for the present year (p. 70). Briefly the author narrates how the researches of Widmark, Birch-Hirschfeld, Schulek, &c., have shown that the inflammation of the eyes following excessive exposure to arc-lights, &c., may be ascribed to ultra-violet rays, and that snow-blindness, and possibly also cataract, may be due to the same cause. Ultra-violet light must therefore be

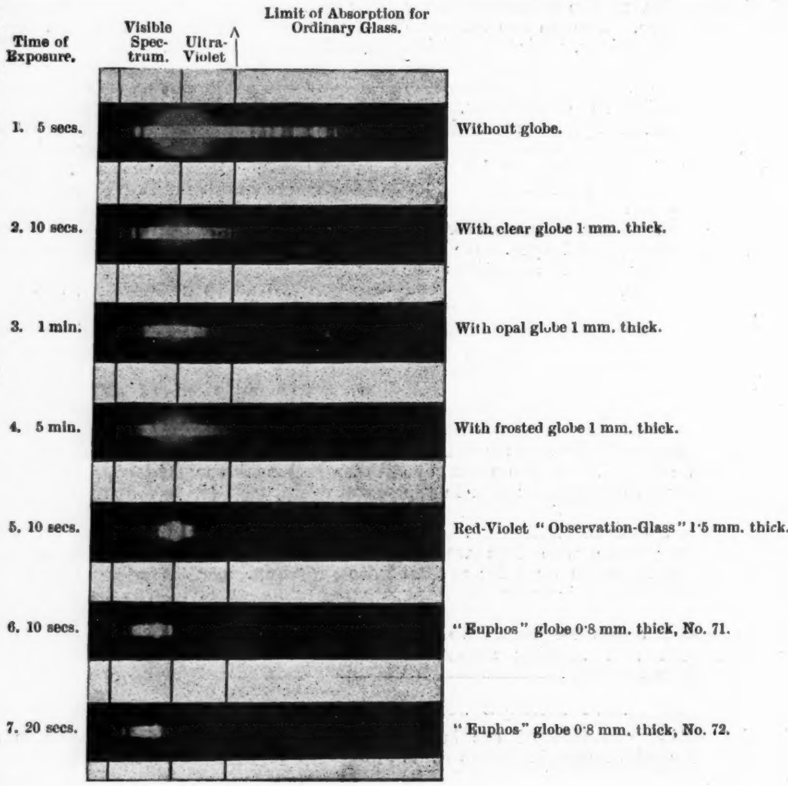


Fig. 1.—Electric Arc Lamp.

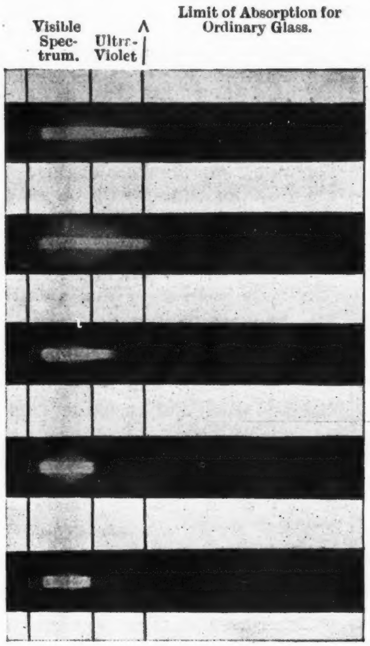


FIG. 2.—Nernst Lamp. Exposure 20 min.

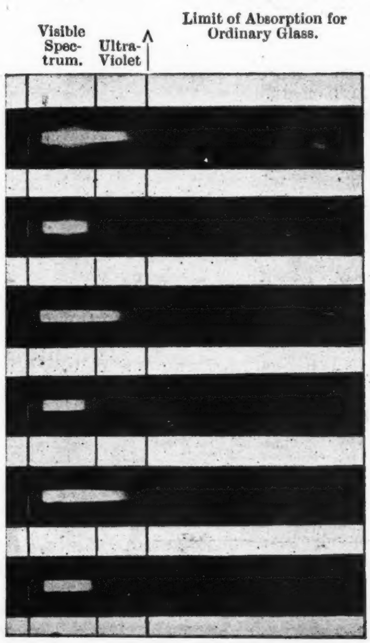


FIG. 3.—Metallic Filament Lamp. Time of Exposure 20 min.

regarded as harmful, and excluded from the light yielded by practical illuminants.

Yet the increasing temperature of incandescence of modern illuminants favours the production of such radiation, and the globes ordinarily in use have been shown by the author to transmit just those rays which he regards as most serious. Hence the value of the "Euphos" glass, which is opaque to this radiation.

Figs. 1, 2, and 3 furnish an interesting verification of the relative action of "Euphos" and ordinary glass in suppressing ultra-violet rays. Fig. 1 refers to photographs of the spectrum of an electric arc. It will be seen that the extent of the active spectrum in the case of the unscreened glass far exceeds that obtained when the various glasses are in use. Even the red "observation-glass," however, while shortening the spectrum considerably, does not entirely exclude the ultra-violet rays. The "Euphos" glass cuts off all ultra-violet light entirely, and the author also claims that it only absorbs about 2 to 3 per cent of the visible spectrum.

Figs 2 and 3 illustrate the effect of the "Euphos" glass in the case of various metallic filament lamps and the Nernst lamp respectively.

A Demonstration of the Effect of Ultra-Violet Rays in causing Reflex Action of the Eyelids, and Fluorescence of the Eye-Lens.

BY DR. F. SCHANZ.

(Demonstration before the Opthalmologische Gesellschaft of Heidelberg, 1908.)

DRS. SCHANZ AND STOCKHAUSEN have previously referred to the fact that ordinary glass only absorbs the less penetrating ultra-violet rays, and mentioned their attempt to devise a special glass to absorb all ultra-violet rays completely (see *Illuminating Engineer*, Jan., 1908).

In the present instance the author allowed a stream of ultra-violet rays to fall upon the eye of an animal, when it was observed that the eyelids were sharply contracted together. It was also shown that the eye exhibited a bright green fluorescence under the action of these invisible rays.

It was shown further that neither of these effects was interfered with by interposing a sheet of ordinary glass 18 mm. in thickness, but, on the other hand, both immediately ceased when a strip of the special "Euphos" glass was used.

Drs. Schanz and Stockhausen have found that ordinary glass is effective in absorbing the very short wave length ultra-violet rays less than about 300 $\mu\mu$. But unlike "Euphos Glass," it allows rays between 300 and 400 $\mu\mu$ to pass, and Dr. Schanz's experiment, referred to above, is intended to show that it is just these latter rays that produce the most marked physiological effects, for they are able to penetrate through the eye-lens, and after bleaching the fluorescent material therein, act upon the retina itself. The disturbances of colour-vision recorded by Prof. Birch-Hirschfeld are caused under these conditions.

Need We Fear the Influence of the Ultra-Violet Rays of Modern Illuminants on the Eye?

BY DR. VOEGE.

(Abstracted from the *Elektrotechnische Zeitschrift*, Aug. 13, 1908.)

IN this article Dr. Voege regards the question of the effect of ultra-violet light on the eye from an entirely different standpoint from that of Dr. Schanz. He remarks on the need for a comparison between the ultra-violet element in sunlight and artificial lights. Our eyes have been gradually developed and adapted to daylight, and we are therefore led to inquire why, if the intensity of ultra-violet light prove to be stronger in the case of natural daylight conditions, it should be considered necessary to use special absorbing glasses in the case of artificial lights.

It is an undoubted fact that exposure of the eye to sources of very great intrinsic brilliancy is injurious; but the author is doubtful whether this injury is to be ascribed solely to the ultra-violet element; on the other hand it may be admitted that the serious action of the ultra-violet rays from the mercury quartz lamp has been clearly demonstrated.

In order to compare the ultra-violet element in daylight and various artificial illuminants Dr. Voege has carried out the following experiment. He arranged to produce two exactly similarly shaped patches of light formed by daylight and the source of light under test, and altered the intensity of either until the brightness of the two patches appeared to the eye to be about the same. He then introduced a photographic plate, and obtained a negative of the bright image, thus comparing not the *brightness* but the chemically active ultra-violet intensity of the two patches of light. The plates used in these experiments were developed under exactly the same conditions, the exposure and strength of the developer being so selected that the blackness of the negative could be regarded as roughly proportional to the intensity. The appearance of the two patches of light *a* and *b*, divided by a vertical line, will be understood from Fig. 1.

Naturally a quartz lens, which transmits ultra-violet light, was used to produce the image. Provision was also made for the insertion of a piece of clear glass, 2 mm. thick, so as to cover the upper half of both patches of light; this, as will be seen in Fig. 1, divides the image horizontally. It was also possible to introduce a solution of Nitroso-dimethyl aniline in the course of the rays. This liquid has the property of strongly absorbing light of wave-lengths lying between 0·5 and 0·37 μ, but of transmitting light from the H and K line as far as about 0·2 μ.

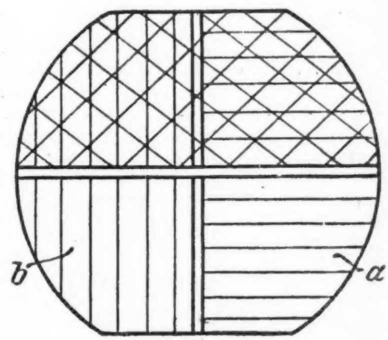
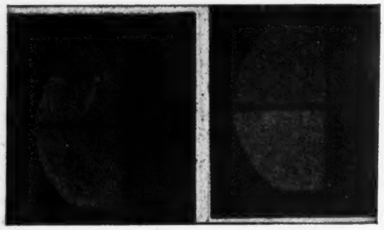


FIG. 1.

In Fig. 2 is shown a negative photograph illustrating the relative ultra-violet intensity of diffused daylight and light from the Nernst lamp, and an incandescent gaslight respectively. It will be seen that the right half of the image, corresponding to the Nernst lamp, is much the *lighter*. For a given physiological brightness, therefore, a surface illuminated by diffused daylight appears to be much richer in ultra-violet rays than one illuminated by the Nernst lamp. The same holds good for the incandescent mantle.

In the case of all the other artificial lights examined in this way, including the incandescent gas light, miniature arc lamps, and carbon and metallic filaments, a result in the same direction was obtained—with two exceptions. These two exceptions are the quartz mercury-vapour lamp (without glass globe) and the Regina arc-lamp, both of which are known to be exceptionally adapted for photographic copying processes. Fig. 3

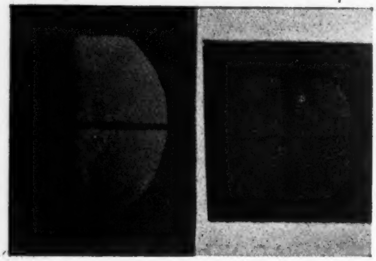


Incandescent Gas Burner. Nernst Lamp.

FIG. 2.

shows a result obtained with the former. Even in these cases the difference between daylight and the artificial light becomes but slight, if by daylight we understand light from the blue sky.

From the foregoing experiments, therefore, Dr. Voege concludes that in the case of all ordinary artificial sources of light, and as far as illuminated surfaces are



Compared with Diffused Daylight. Compared with blue sky.

FIG. 3.—Quartz mercury-vapour lamp.

concerned, the eye will be subjected to *less* ultra-violet energy when a given brightness is obtained. Naturally we may present to the eye an excess of ultra-violet energy if we are dealing with far too brightly illuminated surfaces. In the same way, possibly, injury to the eyes from ultra-violet light may be caused by looking straight at a brilliant unshaded artificial light. But, if we screen direct light from the eyes, and thus imitate natural daylight conditions, there would seem to be no reason to fear danger from reflected ultra-violet light from illuminated surfaces. Probably in many cases where fatigue is experienced the feeling may be attributed to the *want of uniformity* of the illumination.

We must, however, recognize that it is extremely difficult to avoid sometimes looking direct at artificial sources of light as usually arranged. On the other hand, we are also apt virtually to gaze directly at the sun, by receiving its rays direct from highly reflecting and sparkling surfaces (*e.g.*, mirrors, windows, placid water, &c.). Dr. Voege, therefore, next

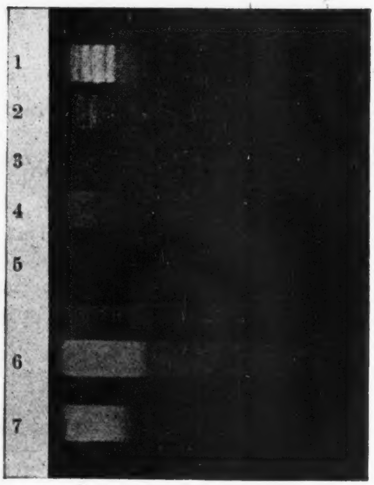


FIG. 4.

raises the question whether gazing for a short time at artificial sources of light may be expected to prove more injurious than receiving the rays of direct sunlight, and whether the ultra-violet element is stronger in the former case than in the latter. To test this point he arranged to take a spectro-photograph of a number of sources placed behind a narrow slit, all the photographs being developed, under exactly the same conditions, and the exposure being 5 seconds throughout.

The sunlight was imposed on the slit by reflection from a silvered mirror. The distances of the artificial lights were fixed at 40 centimetres in the case of glow-lamps and incandescent mantles, 60 centimetres in the case of small arc lamps, and 100 centimetres in the case of the larger arc-lamps. This selection of distances is to some extent arbitrary, but it is hardly to be expected that any one who is not actually engaged in manipulating these lamps would look at them at shorter distances away than these.

The results of this experiment are shown in Fig. 4.

The numbers correspond to the following sources of light:—

1. Regina arc-lamp with no outer globe, 6 amps. 108 volts. Distance away 60 cms.

2. Carbone-Flame arc lamp (yellow light), 12 amps. 45 volts, 2,000 H.K., with opal globe. Distance away 100 cms.

3. Incandescent gas light, 75 H.K. Distance away 40 cms.

4. Nernst lamp with clear globe, 32 H.K. Distance away 40 cms.

5. Just-Wolfram lamp, 40 H.K. Distance away 40 cms.

6. Direct sunlight in July, 10 o'clock in the morning.

7. Sunlight transmitted through clear glass plate 2 mm. thick.

It can easily be seen that the spectrum of the direct sunlight extends far further into the ultra-violet than that of any of the artificial lights—even the Regina arc. Experiments with a somewhat wider slit and a 40-second exposure led to the same result, the spectrum of a white surface illuminated by direct sunlight again proving to be both longer and more intense than that of a flame arc-lamp.

On the whole, therefore, there seems no reason to believe that the light from a 2,000 H.K. flame arc at a distance of 2 metres from the eye exerts greater action upon it than a white surface illuminated by brilliant July sunshine, which our eye is often compelled to contemplate for 40 seconds or more without serious injury.

On the other hand, it is possible that the reason why a flame-arc appears to the eye so unpleasant at night may lie in the fact that the background is in this case relatively extremely dark in comparison with the source itself, the eye being mainly fatigued by the *contrast.* In the case of sunlight the contrast between a bright object and its illuminated surroundings is relatively trifling.

However this may be, the author fails to find any justification for the fear that artificial sources are likely to injure the eye through excess of ultra-violet energy over that in sunlight. On the contrary, the percentage of ultra-violet light is almost invariably greater in the latter case, and the use of special protective glasses in the case of artificial illuminants may be regarded as unnecessary.

Hygienic Regulations Affecting the Use of Petroleum for Illumination.

A RECENT number of the *Moniteur du Pétrole Roumain* contains an account of the methods of testing and generally supervising the use of petroleum for lighting purposes, suggested by a commission selected by the refiners of Roumania.

Petroleum destined for illuminating purposes is defined as the fractional distillate between 120° and 300° C. Liquid coming over near 110° C. must not occur in samples intended for purposes of illumination, while products between 110° and 130° C. must only form 5 per cent of the total distillate; at least 80 per cent of this total distillate should consist of products distilling below 270° C. Other proposed regulations are that the specific gravity of the oil at 15° C. should not exceed 0·820, and that it should comply with specified conditions as regards colour, flash-point, &c.

Sanitary inspectors will undertake the testing of petroleum at the works, and there will also be qualified supervision of the conditions under which it is in actual use.

Regulations are also to be imposed governing the permissible location of refining works and the sanitary conditions under which the petroleum is treated; the refuse-water of refineries must be disposed of in such a way as to avoid all possibility of contaminating surface or subterranean water in the neighbourhood.

White versus Black Letters in Printing.

In a recent number of *The Illuminating Engineer* of New York, Mr. A. J. Marshall made the suggestion that, from a physiological standpoint, it would be preferable for books and magazines to be printed in *white* upon a *black background* instead of in the ordinary way.

We give below a paragraph printed according to the system recommended by Mr. Marshall.

Naturally in such a case as this, the influence of custom is very strong, and one would ask for very distinct evidence of improvement in making such a radical change as that suggested. It is also open to question how far the mere fact of a certain amount of light continuously entering the eye (provided it is not above the upper limit of desirable brightness), can be regarded as responsible for eye-fatigue in reading.

In making this suggestion Mr. Marshall argues that the feeling of tiredness resulting from prolonged reading is partially due to the amount of light entering the eye. If, therefore, the plan of printing in *white* upon a black background were adopted, we ought to be able to see with equal distinctness, but the amount of light coming from the page to the eye would be very greatly reduced, as the letters on a printed page occupy but little room compared with the blank space. This, Mr. Marshall thinks, should render the operation of reading less tiring, while there is also a possibility that it may be psychologically preferable for the portion of the page, on which we desire to concentrate our attention, to be lighter than its background instead of darker.

Probably the continuous effort of accommodation of the eyes, and the actual mental effort of receiving and analyzing the impression conveyed by the printed matter, are much more influential factors, though, of course, *insufficient illumination* adds to the effort of reading, and *too bright* illumination dazzles the eyes of the reader.

As regards the purely optical side of the question there does not seem to be universal agreement among opticians. At present it is, of course, more usual for black type on a white ground to be used in tests, though some opticians have expressed themselves in favour of the reverse arrangement.

In an ordinary magazine, however, where more or less shiny paper is inevitable, another aspect of the question presents itself. Direct reflection from such paper is always inclined to be a nuisance, and it may safely be asserted that with white letters on a black ground the effects of such reflection would be much more noticeable.

The suggestion receives a more practical stamp than would otherwise be granted to it owing to the present commercial difficulties by which the paper trade appear to be faced in the United States. Almost all white paper is prepared from wood pulp, and the supply of this material is inclined to fail. The manufacture of such paper, in any case, makes serious demands on the existing forests of spruce and pine, which are alone serviceable for this purpose, and an agitation has recently been set on foot for the removal of the duty on foreign wood pulp. Moreover printing-ink seems to resist all bleaching actions so effectually as to render white paper that has once been used of no value for subsequent use *de novo*.

Paper manufacturers are therefore inclined to favour the suggestion that newspapers should be printed in white upon black paper in future. It seems to be agreed that black paper can be produced at a much cheaper rate, being capable of being manufactured out of all sorts of old stock and refuse, and the production of a serviceable white ink is also looked upon as feasible.

Effects of Light upon the Eye.

BY DR. H. H. SEABROOK.

(From the *Transactions* of the Illuminating Engineering Society, February, 1908.)

DR. SEABROOK commences his paper with a brief summary of the nature and functions of the different portions of the eye, and then proceeds to consider the action of different varieties of light on the retina.

Experience has long ago shown how intense sunlight can injure, or even destroy, the retina, and the experiments of Brücke in 1845, and, subsequently, of Donders, Chardonnet, and Birsch-Hirschfield, have shown that such effects are mainly caused by the ultra-violet constituent in daylight. An exposure to powerful sources of ultra-violet energy for only half an hour may damage the cells of the retina, and with repeated exposures the lens of the eye may become permanently opaque. Of visible rays, those of *short* wave-length, the blue and the violet, are most influential. Disintegration of the pigment cells in the retina is a minimum in yellow light. At present there seems no reason to suppose that heat rays cause damage of this nature, though they may give rise to discomfort.

Dr. Seabrook next refers to the well-known trouble that may follow incautious exposure to arc-lights These severe effects are mainly due to concentration of energy on the eye. In practice the eye rests itself by constantly altering its position, and so receiving the bright image on different portions of the retina.

When, however, it is unable to do so, owing to the ubiquitous glare, exhaustion of the exposed portion of the retina is apt to occur. Modern illuminants are tending to grow continually more brilliant, and probably the old original kerosene burner is, from a physiological point of view, the safest of all.

Dr. Seabrook therefore recommends the use of amber-coloured diffusing shades, on the ground, firstly, that the intrinsic brilliancy of many illuminants must be diminished, and, secondly, that such yellow shades at once enable the eye to receive the variety of light to which it is best adapted and prevent the passage of objectionable rays of low wave-length.

Finally the author refers to the many disputed points and apparently contradictory conclusions reached by different workers in the subject of visual optics.

In discussion of the paper Dr. Louis Bell remarks that it was well known that *yellow* light is the most efficient in producing the sensation of light, and therefore also presumably most effectual in producing photo-chemical action in the retina; hence it seems a little surprising to learn that the most vigorous chemical action is caused by violet and ultra-violet energy.

It seems to be generally believed that the blue end of the spectrum is harmful; yet we must remember that natural light — daylight — contains a stronger violet and ultra-violet element than most artificial illuminants, and therefore it seems premature to decide that such light in moderate intensities is injurious. Dr. Bell also suggests that light of any colour, but especially monachromatic light, must tend to be injurious if it strikes the retina in excess. Very possibly even yellow light, the strong element in many flame arcs, for instance, might be injurious under certain conditions.

Prof. Clifford refers to the necessity for scientific consideration of the many disputed points referred to in the paper. Many people believe the mercury lamp to be restful to the eyes because it contained no red element. This, however, is in disagreement with the contentions of Dr. Seabrook. Prof. Clifford thinks that if the mercury lamp is really restful, this fact must be ascribed to some other cause than the absence of red rays. With reference to this point, Dr. Seabrook remarks that no doubt the low intrinsic brilliancy of the mercury lamp has much to do with the question.

Dr. A. E. Kenelly refers to the increase in the amount of light now considered necessary in interiors. Dr. Seabrook, he remarks, commented on the effects of red and violet rays, but little information seems to be available as regards the action of the intermediate portion of the spectrum. Yet this may probably also be injurious if present in sufficient quantity. In examining the effect of different illuminants, therefore, we must distinguish between bad effects due to improper location of light-sources and bad effects due to peculiar colour. Many draughtsmen use the mercury lamp without being troubled in any way by the violet constituent in its spectrum, and Dr. Kenelly therefore doubts whether we are yet justified in believing these rays to be necessarily injurious. On the other hand, he is in agreement with the wisdom of avoiding prolonged exposure to light of any very unusual colour.

Mr. R. C. Ware remarks that in his experience strong red light does produce a feeling of positive discomfort. In this connexion Prof. Clifford contends that a distinction ought to be made between the purely physiological effect of breaking down cells in the retina, &c., and the psychological impression of discomfort arising from certain kinds of light.

Dr. Seabrook, in reply, points out how difficult it is to discriminate between these two effects, the retina of the eye being in reality an offshoot of the brain. It is hard to say, for instance, exactly why the bull is irritated by a red colour. As a matter of fact, however, investigators had come to the conclusion that red rays, though capable of causing discomfort, are not responsible for actual changes of tissue in the eye.

Dr. Seabrook also emphasizes the fact that sunlight itself is a very variable quantity, and must not be taken as a standard, under all conditions, of what light should be. Very bright sunshine may easily produce ill-effects, while the light in mountainous regions, which is specially rich in ultra-violet light, is still more apt to do so.

In further discussion of this paper some important points are raised by Mr. P. S. Millar. He, too, questions Dr. Seabrook's contention that chemical or short-wave rays are responsible for injury to the eyes, except when present in very exceptional quantities. He also draws attention to the fact that much of the eye-trouble at the present day arises from our using our eyes more, and testing them more severely. Much of the defective vision found among school-children is due to improper use of the eyes between the ages of seven and nine years. Such defects are therefore often not directly chargeable to the nature of modern methods of illumination.

Eyesight and Artificial Illumination.

By Dr. J. T. Krall.

(From the *Transactions* of the Illuminating Engineering Society, March, 1908.)

This paper bears upon the same aspects of the subject as that of Dr. Seabrook, abstracted above. Dr. Krall, while admitting the injurious influence of ultra-violet light in excess, thinks that the ill effects of modern sources depend mainly upon excessive brightness rather than anything peculiar in their radiation. He does not share the views of those who have freely condemned the electric light, believing that this kind of light, *wisely used*, is not only harmless, but one of the very best of modern illuminants. Nor does he agree with those who feel that the higher degree of illumination of surfaces attainable by the modern illuminants, as compared with that of the old candles, kerosene lamps, &c., is necessarily bad.

On the contrary the older lamps yielded too weak an illumination to enable us to carry out our present arduous work with comfort. It is, however, very essential that our brighter modern sources should be properly shaded. In the concluding portion of his paper the author gives a useful résumé of experimental work on the subject of ultra-violet light and its effects. One interesting instance of this effect is the prevalence of cataract among glass-blowers; this is attributed to the continual exposure to the ultra-violet rays given out by the glowing masses of clay and sand. Another is the effect of snow-blindness in high altitudes.

What is Light?

By P. G. Nutting.

An exceedingly interesting and valuable communication dealing with the physiological basis of light-perception by Mr. P. G. Nutting, of the Bureau of Standards, appears in *The Electrical World* for June 27th. We are still extremely ignorant on many points in connexion with the fundamental problems concerning the actual formation of the sensation of "light" in the eye, and might, indeed, echo the unconsciously humorous answer of the school boy, "Light, as I understand it, is very little understood."

Mr. P. G. Nutting's article deals mainly with the results of the complex nature of our methods of perceiving light and colour at low and high intensities. It is now

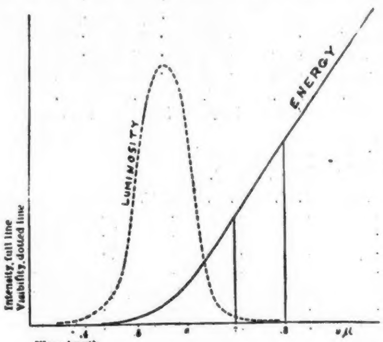


Fig. 1.

believed that at very low illuminations the eye acts in a profoundly different way from that characteristic of high illuminations, and makes use of an entirely different set of minute organs on the retina. At high illumination we utilize small organs known as "cones," at low illuminations a quite distinct variety known as "rods." Consequently the quality of light best adapted to certain purposes is very different in the two cases.

One question that goes to the very root of the theory of light production is the amount of energy the eye must receive in order to experience a certain sensation of brightness. Indirectly, suitable curves of energy radiation and luminosity of a certain illuminant enable us to calculate the mechanical equivalent of light.

Fig. 1, for instance, represents the energy and luminosity curves of a carbon filament glow-lamp as determined by Coblentz.

One evident uncertainty in calculating the mechanical equivalent of light accord-

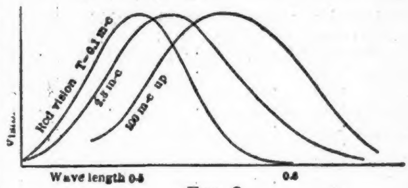


Fig. 2.

ing to the usual definition is that of deciding exactly what range of wave length we are going to term luminous. We can easily see from Fig. 1 what a great difference in the result would be occasioned by taking the upper limit as $0{\cdot}8\mu$ instead of $0{\cdot}7\mu$. The total light is hardly affected, but the energy is enormously increased.

These problems, however, are enormously affected by the order of illumination employed—on whether we are working with weak light, and so depending on "rod-vision" or with a strong light, in which case we utilize "cone-vision." Intermediate sensations take place by the aid of both the rods and the cones in the eye. Thus Table I. gives some values of the distribution of luminosity in the spectrum, corresponding to

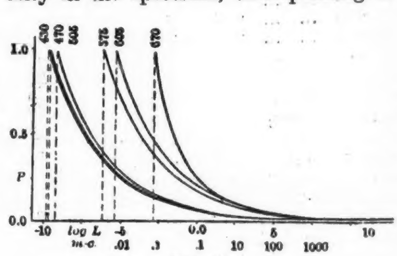


Fig. 3.

rod-vision, or cone-vision, or both combined.

Some curves derived from this table are shown in Fig. 2.

The general behaviour of different eyes, not known to be abnormal in any way, is broadly the same. Thus Koenig gives the data shown in Table II. on rod-vision for ten different observers.

On the whole it appears that rod-vision is paramount for illuminations below 0·1 candle metres, while cone-vision is predominant for 100 candle-metres and upwards.

In Table III. are given some values of the mechanical equivalent in candles per watt for different wave lengths :—

identical for all colours. As the illumination is reduced the sensibility is reduced also, but at different rates in the case of the different colours, the red being naturally the first to die out, because the rods appear to be practically blind to this end of the spectrum.

In conclusion the author emphasizes the need for carefully preparing a complete tempered scale of light radiation, including all wave lengths and all intensities. Though the broad lines on which such an investigation should proceed are now mapped out, many requisite data are missing. Naturally any attempt to decide on a primary standard of light must include a consideration of all these physiological phenomena.

TABLE I.

ROD AND CONE VISION.—VISIBILITY AT VARIOUS INTENSITIES.

Intensities.	·00024	·00225	·036	·575	2·30	9·22	36·9	147·6	590·4 m-c
Ratio to Proceeding		9·38	16	16	4	4	4	4	4
λ = ·430	·047	·057	·076	·060	·063	·057	—	—	—
·450	·23	·21	·21	·20	·14	·10	·085	—	—
·470	·50	·46	·42	·42	·36	·19	·16	·13	—
·490	·85	·78	·75	·70	·63	·40	·28	·25	·24
·505	·99	·99	·98	·94	·88	·63	·50	·45	·40
·520	·97	·96	·94	·99	·97	·85	·72	·69	·67
·535	·75	·76	·76	·83	·98	·98	·91	·88	·87
·555	·36	·42	·47	·54	·83	·97	·99	·99	·99
·575	·12	·17	·20	·26	·58	·85	·97	·98	·98
·590	·045	·059	·095	·15	·42	·71	·88	·92	·92
·605	·015	·022	·044	·10	·28	·54	·71	·079	·79
·625	—	—	·022	·05	·17	·05	·42	·52	·54
·650	—	—	—	—	·057	·11	·15	·18	·23
·670	—	—	—	—	—	·038	·050	·055	·058
λ max	·511	·511	·511	·515	·529	·545	·560	·565	·565
Constant κ	461.	466.	445.	395.	254.	221.	214.	198.	197.
Vo/13 =	1·08	1·16	·94	·74	·31	·48	1·07	1·00	1·00

TABLE II.

VISIBILITY AT LOW INTENSITY (ROD VISION).

Wave length.	A. B.	E. H.	F. D.	R. R.	E. B.	A. K.	A. H.	E. K.	F. H.	X. P.
·430	·015	·10	·038	·062	·064	·059	·047	·069	·31	·089
·450	·074	·30	·14	·25	·21	·21	·23	·23	·47	·01
·470	·27	·64	·31	·50	·47	·49	·50	·49	·74	58
·490	·57	·90	·58	·74	·80	·60	·86	·69	96	·84
·505	—	1·00	·85	1·00	1·00	1·00	1·00	1·00	1·00	·99
·520	1·00	·96	1·00	·85	·98	·99	·98	·87	·90	1.00
·535	·78	·77	·85	·64	·74	·77	·75	·66	·71	·81
·555	·45	·47	·49	·33	·41	·42	·36	·38	·44	·47
·575	·20	·20	·25	·12	·17	·17	·12	·14	·21	·13
·590	·085	·076	·15	·051	·067	·061	·045	·071	·10	—
·605	·035	—	·09	·022	·026	·022	·015	·024	·048	—
λ max	·518	·507	·521	·504	·512	·511	·511	·506	·502	·514

TABLE III.

Wave length.	Watt cm².	Meter-candles.	Meter-candles, watt/cm².	Candles, watt.
·620	·000162	64	390,000	3·1
·566	·000042	64	1,520,000	12·1
·566	·000036	61	1,700,000	13·5
·595	·000123	182	1,480,000	11·8

Another factor which varies with the illumination, and has been exhaustively studied by Koenig and Brodhun, is the photometric sensibility, the reciprocal of which is the minimum charge of illumination that the eye is capable of detecting at different intensities. Their results are shown in Fig. 3. Briefly it appears again that at high illuminations the photometric sensibility is practically

CORRESPONDENCE.

The City Lighting.

SIR,—It has afforded me great pleasure to read Mr. Voysey's report on the public lighting of the City of London, published in the July issue of *The Illuminating Engineer*. The thoroughly practical investigation that Mr. Voysey conducted and the excellent manner in which he has plotted the results reduce to a small compass, that is readily observed and grasped, information that must have taken a very long time, and a vast expenditure of patience to collect. One regrets that such a systematic examination should be confined to the comparatively narrow limits of the City; in the many miles of streets comprising greater London all sorts and conditions of public lighting are to be found, where the local authority is also the electric lighting authority I doubt whether any lighting inspector exists, or if he does he is not allowed to act, for many of the street arc lamps are run much below normal candle-power, are frequently very badly placed, and not sufficiently well adjusted to do public service, whilst the globes are usually dirty and sometimes broken. The incandescent gas light has now made people accustomed to a big white light, so that whereas fifteen years ago electrical engineers were afraid of blinding people with too strong a light, the gas people have now broken the ice, and it is no longer necessary to hide an arc light inside of a thick opal globe on which dirt has been allowed to accumulate unnoticed.

In regard to the central suspension of street arc lamps, some experiments, which I helped to carry out whilst acting as assistant engineer to the Italian Edison Company in Milan twenty years ago, proved conclusively that equal illumination of the streets could be obtained with thirty per cent less lamps placed centrally than if placed along the kerb lines, and those who know Milan will remember that all the main thoroughfares are lighted in that way. In this country there has always been the difficulty of obtaining the sanction of property owners for the attachment of supports to the fronts of buildings for the purpose of carrying the lamps, in a few places—as in Oxford Street—central standards have been fixed, but it is questionable whether the additional lighting efficiency secured by their central position is not more than counter balanced by the consequent reduction by perhaps fifty per cent of the amount of traffic which can now pass along the road; in the City the accumulated wisdom of age has secured the privilege of compulsory attachment to buildings for public lighting purposes, and it is a most valuable asset in connexion with the scheme.

I am, &c.,

CHAS. A. BAKER.

Whitehall Club, S.W.

The Testing of Gas Burners.

To the Editor of 'The Illuminating Engineer.'

August 7th.

SIR,—I have read with great interest, in your last issue, Prof. Morris's article on gas burner tests, a subject which I find engrossing. I note without surprise the great increase of efficiency obtained with the Keith burner when it was removed to another gas supply.

The fact is that burners in general are not only sensitive to change of pressure and calorific value, but also even more so to changes in the composition of the gas, whether entirely coal gas or partially water gas. At present, if good results are to be obtained, burners must be run on the right pressure, with gas of the right calorific value, and with gas of the right composition, according to the design of the burner, and changing over to any other gas supply may reduce the efficiency by one-half. Comparative tests between burner and burner are quite misleading unless the burners are tested on the supply on which they are to be used, and the tests must then be only considered as applicable to that particular supply.

Truly the position of the gas-burner manufacturer is not a happy one. If the efficiency of gas lighting is to be raised to something like the claims of its partisans, steps must be taken to standardize the conditions. Burners can then be marked for use under certain specified conditions, and the consumer discouraged from using burners not suitable for his particular supply.

The first thing to take in hand will undoubtedly be the pressure. The Gas Light and Coke Co. supply me with gas varying in pressure from 2 to nearly 4 inches, measured at the meter, and this is one of the most up-to-date companies in existence.

When the supply pressure is standardized and maintained constant by means of governors fixed with the meters, it will then be time to attend to the internal piping. Why should not the amount of gas passing through a pipe in a house be subject to rules such as electric light installations have to conform to?

After the pressure has been standardized, attention must be turned to calorific value and composition of a gas. These cannot be entirely standardized, as the best sort of gas to manufacture depends so much upon local conditions, but burners might be designed and marked for various sorts of gas just as electric lamps are marked for various voltages.

When all this is done, the burner with a gas regulator and air-regulator, bad enough singly and abominable when combined in the same burner, and which the consumer never properly adjusts, will become a thing of the past.

I note that Prof. Morris finds in one instance that the increase of pressure of 1 per cent is accompanied by an increase of light of ½ per cent only. On looking up various tests carried out on domestic burners I find that I have obtained various values ranging from 0·5 per cent to 3·60 per cent increase for each increase of 1 per cent in pressure from 2 inches.

Yours faithfully,

LANCELOT W. WILD.

Meeting of Lamp Testers.

A MEETING of all the lamp inspectors in the employ of the electrical testing laboratories was held in New York on July 6th, 7th, and 8th, inclusive. The following papers were presented and discussed :—

- 'Visual Inspections of Electric Lamps,' by C. E. Currier.
- 'The Best Procedure in Lamp Inspection,' by C. H. Stephens.
- 'The Selection of Life Test Samples,' by H. E. Allen.
- 'The Effect of Varying Test Quantity upon Rejections,' by W. F. Teneyck.
- '"Bugs" in Photometry,' by E. L. Peck.
- 'Lamp Inspections at Purchasing Companies' Storehouses,' by W. J. Bray.
- 'The Criterion of Lamp Value,' by A. W. Minty.
- 'The Value of Laboratory Tests,' by W. H. Robinson.
- 'The Functions of a Lamp Inspector,' by Geo. H. St. John.
- 'The Responsibilities of a Lamp Inspector,' by L. J. Lewinson.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

AMONG the contributions of the month dealing specifically with ILLUMINATING ENGINEERING may be mentioned that of **J. R. Cravath** (*Electrical World*, N.Y., Aug. 1st). The author points out the importance of this subject to the electrical contractor, and makes a number of suggestions with regard to the functions of shades and reflectors. It is not easy to form a really satisfactory definition of the "efficiency of illumination," though the percentage of the total light generated that is cast directly upon a plane 30 in. from the floor is sometimes so defined. This, however, leaves out of account the desire of the consumer to spend a certain amount of light on his walls and ceiling.

It is, in fact, essential to use some light in this way; otherwise the contrast between the brightly illuminated table and its sombre surroundings becomes unpleasant. It is for these reasons that opaque prismatic reflectors are preferable to enamelled opaque ones. By suitably designing the former we can arrange for any desired percentage in the light to pass upwards. Mr. Cravath remarks that it is usually advisable for 25 to 35 per cent of the light to be used in this way.

E. L. Elliott writes upon the LIMITS OF ART IN FIXTURE DESIGN. Such design must be a perpetual compromise between the æsthetic and utilitarian considerations, but a want of knowledge of the principles of illumination often leads to the design of globes which do not distribute the light satisfactorily, even though a trifling alteration in design might accomplish this end without impairing their artistic merits.

Among common faults in such lamps, Mr. Elliott mentions the use of coloured glasses which absorb a great deal of light without distributing it effectually.

In many cases, indeed, only a narrow circle of light is produced, and all the surrounding region is left in darkness.

Perrot (*T.I.E.S.*, June) discusses the principles of CHURCH LIGHTING, illustrating his contentions with some interesting illustrations. Here, again, we find a recognition of the necessity for satisfying both the æsthetic and practical conditions. The difficulty is intensified in ritualistic churches on account of the symbolic significance of decorations employed. Even here, however, modern sources of light have found useful application to meet the requirements of special occasions, judging from the photograph of some Christmas decorations.

In the discussion of this paper there seemed to be a general recognition of the desire for a subdued illumination, and inverted systems of lighting were mentioned with approval.

Marshall and Rolph (*Illuminating Engineer*, N.Y., July) contribute an article on the ARTIFICIAL LIGHTING OF SCHOOLROOMS. The article is illustrated by photographs showing the position of the desks and the various lights used, and also diagrams indicating the intensity and distribution of light.

It is interesting to find that in this case the authors recommend the use of enamelled opaque reflectors, on the ground that a more perfect diffusion can be obtained in this way.

A recent number of *The Electrician* contains a well illustrated article. describing a novel system of inverted lighting by Osram lamps, in use at the Inns of Court Hotel, Holborn.

E. W. Weinbeer (*Elek. Anz.*, Aug. 2) describes some graphical constructions for determining the shape of reflectors designed to provide a uniform ground-illumination.

A recent number of the *Elektrotechnische Zeitschrift* contains the complete paper by **Drs. Schanz and Stockhausen** on the EFFECT OF THE ULTRA-VIOLET RAYS IN ARTIFICIAL ILLUMINANTS ON THE EYES, and also an article by **Dr. Voege** on the same subject.

Schanz and Stockhausen take the view that ultra-violet rays, in excess, are actually known to produce serious injury to the eyes, and mention a number of cases recorded by Prof. Birch-Hirschfeld where this has been the case. Dr. Schanz has also demonstrated their effect on the eyes of an animal (*Z. f. B.*, Aug. 20), in causing contraction of the eyelids and fluorescence of the lens.

The authors therefore propose to surround artificial illuminants with a special variety of "Euphos" glass which *completely* absorbs ultra-violet energy. Some spectro-photographs are given which show that ordinary glass fails to absorb these rays completely but that "Euphos" glass does, and that without absorbing more than 2 to 3 per cent of the visible spectrum.

Dr. Voege, on the other hand, describes a series of experiments intended to show that, for a given brightness, daylight is richer in ultra-violet rays than all the artificial illuminants examined with the exception of the Quartz mercury-vapour lamp and the Regina-arc lamp; and these are specially designed with a view to the production of these rays. Therefore he sees no reason why absorbing glasses should be considered necessary in the case of artificial sources and not in the case of daylight. This matter has given rise to some very lively discussion before the German Institution of Engineers, and further details may be expected shortly.

Among other articles of interest we may mention that by **Herlt** on the progress of illumination in Turkey. Orientals, he remarks, are content with extremely dim daylight-illumination in their interiors, and also seem to dislike, or at least to see no reason for, any but the feeblest artificial lights.

Hence we find that in Turkey the oil-lamp reigns supreme, and difficulties are put in the way of gas and electric lighting, which have as yet made but small progress. Acetylene is tabood as too dangerous.

Among contributions of a more photometrical nature, attention may be drawn to the discussion of the recent paper by **Dr. Steinmetz** on a NEW PRIMARY STANDARD OF LIGHT. The suggestion is that such a standard should be formed by the mixture of three monochromatic lights in a given proportion. It also seems to be assumed that it would be possible to define the standard light by merely specifying the amount of energy of each constituent.

In the discussion the chief difficulty suggested seemed to lie in the actual measurement of the energy of a narrow band of light. Apart from this, one could suppose that the usual physiological difficulties are only postponed, and not conquered; and it also seems undesirable to select a primary standard differing so markedly in spectral composition from ordinary daylight.

In the course of the discussion, an interesting declaration is attributed to Dr. Steinmetz, to the effect that he believes the mechanical equivalent of light to be much higher than is commonly supposed to be, in fact, as high as 50 candles per watt.

Fery (*Jour. de Physique*, Aug.) describes an attempt to form a direct-reading photometer which seems to have been carried further than is usually the lot of such instruments. A thermo-couple arrangement, on similar lines to the Radio-micrometer, is utilized; the radiation, however, passes through a graded screen of copper acetate solution. This is said to absorb the energy in the different regions of the spectrum in such proportions as to produce what is virtually the same curve of sensitiveness as that of the eye.

As an example of the correctness of the instrument the author gives some measurements of the efficiencies of various glow-lamps which approximate to the values usually accepted.

Electric Lighting.

The prospects of the metallic filament lamps, as usual, receive attention. Several papers have been read on the subject in the United States, and it seems to be generally accepted that there is no danger of their causing inconvenience to the supply companies.

It is, indeed, generally recognized that the supply companies, who are themselves controlling the sale of lamps to contractors, should take pains to let them understand both the possibilities and present disadvantages of the tungsten lamps. Much interest has been aroused by the issue of a 100 volt 20 to 25 watt tungsten lamp in the United States.

The articles by **Duschnitz and Schmidt** in the *Elek. Anzeiger* are continued in more recent numbers of this journal. Mention may also be made of a general article (*Elek. Anz.*, Aug. 16) reviewing in an up-to-date manner the PROGRESS OF ELECTRICAL ILLUMINANTS. The writer refers to the advantage of long-burning hours enjoyed by the enclosed carbon arc-lamp, the limit of which, however, he fixes at 300 hours.

He also gives some interesting particulars of a new form of Blondel flame-arc, with upright carbons, which will burn for twenty-four hours without recarboning, and can be run three in series on 110 volts.

The recent papers by **Wedding** and **Remane**, mentioned in the last review, have now been reprinted in full. Wedding's paper contains the results of a very RECENT SERIES OF TESTS ON METALLIZED TANTALUM, AND WOLFRAM LAMPS. In contradiction of Remané's previous suggestions, he believes that the future of the metallic filament lamps will lie in the production of one for 220 volts and 16 c.-p. upwards. He also hints that in future the battle between gas and electricity is likely to be fought out mainly on cost of maintenance and general convenience, rather than cost of energy.

Remane's more recent paper contains a series of tables and diagrams designed to prove the superiority of HIGH CANDLE-POWER OSRAM LAMPS—which are now made to yield as much as 400 H.K.—over the SMALLER ARC LAMPS. Much discussion turned on the possibility of running such lamps successfully, two in series on 220 volts, and their capacity to withstand shock and overrunning. Remané cites a case in which a railway collision occurred, and practically the only things left intact afterwards were the osram lamps in the carriages!

B. Walter (*E. T. Z.*, July 16) criticizes the results recently obtained by Hirschauer with regard to the EFFECT OF CHANGE OF PRESSURE ON NERNST LAMPS. He described some tests on the subject, and finds that the result depends very greatly indeed on the iron resistance in series with the glower. On the average a 5 per cent change in P.D. produced a 12 per cent change in candle-power. Cases were met with, however, in which changes of 30·8 per cent and 45·7 per cent occurred.

Freeman (*Elec. World*, N.Y., Aug. 15) describes some extremely interesting experiments on the "overshooting" of tungsten lamps. He obtains simultaneously records of the intensity of the light yielded by carbon and metallic filament lamps and oscillographic tracings of the growth of current when the lamp is switched on.

The results show very clearly the difference in the behaviour of the current in the two cases, an "overshooting" only occurring in the case of the metallic lamp. Another interesting illustration exhibits pulsations in the light from a tungsten lamp on an alternating P.D. taking place simultaneously with the reversal of current.

MISCELLANEOUS.

Under this heading particulars may be given of one or two papers which, while not bearing very directly on electric lighting or problems of illumination, are yet of interest.

W. Coblentz (*Bull. Bureau of Standards*, May) and **A. Pfluger** (*Ann. der Physik.*, No. 9, 1908) have carried out some interesting researches on the character of the RADIATION FROM THE NERNST FILAMENT and the QUARTZ MERCURY-VAPOUR LAMP respectively.

Coblentz, among other researches, traces the alterations in the distribution of energy in the spectrum of the Nernst filament with rise of temperature, and shows that they are not in accordance with the black body law. In general there appear to be a series of bands at low temperatures which eventually coalesce and the filament shows marked evidence of selective radiation. **Pfluger's** experiments are likewise designed to study the distribution of energy in the spectrum of the mercury lamp, and he seeks to deduce some general law governing its radiation.

W. S. Grippenberg (*Phys. Zeit.*) describes a new method of forming light-sensitive selenium cells by the sublimation of selenium vapour upon a suitable non-conducting surface.

GAS-LIGHTING, &c.

Few contributions to the subject of gas-lighting dealing specifically with problems of illumination have appeared during the last month.

Of considerable importance, however, is the decision on the part of the **Edinburgh and Leith Gas Commissioners** to REDUCE THE CANDLE-POWER OF ILLUMINATING GAS FROM 20 TO 14. Very recently the candle-power of the gas supplied was as high as 25, but it was stated in the evidence that only about 15 per cent of the gas supplied is used for flat-flame burners, so that illuminating, as compared with calorific value, must be considered relatively of little importance.

Another matter of some interest in the gas world is the high figure for the UNACCOUNTED-FOR GAS, occurring in the report of the Gas Light and Coke Co. The increase amounts to no less than 122 million, making the unaccounted-for gas for the present year 7½ per cent of the total gas generated.

In reality it need not, of course, be assumed that all this gas is necessarily lost, and there are various items of uncertainty affecting its measurement at the works and the meters; but still the exceptional increase for the present year is causing some concern.

A novel and interesting METHOD OF INCANDESCENT GAS-LIGHTING is being exhibited at the Franco-British Exhibition by the **Buisson-Hella Co.**, and is described in a recent number of the *Journal of Gaslighting.* The "bushlight"—it can hardly be termed a mantle —consists of a cluster of rods of 0·8 mm. in diameter and 25 to 30 mm. in length, which are made of rare earths and incandesce in the usual way.

Though, of course, brittle to the touch, they are said to withstand vibrations extremely well and to resemble mantles of the ordinary variety in efficiency. The filaments can be twisted in the plastic state into any desired shape; it is also stated that the colour of the light yielded by them can be controlled by altering their chemical conposition.

Lux (*Z. f. B.*, Aug. 14) gives the results of some tests on several "BENOID" BENZINE AIR burners. The figures vary from 1·2 to about 1·5 litres per H.K.-hour, according to the type of burner, and the practical manipulation of the gas-generating apparatus is stated to have given satisfaction.

Though the calorific value of the gas (3,300 g. cal. per litre) is somewhat less than that of ordinary illuminating gas, a higher flame-temperature is attained than in an ordinary gas-burner, and a whiter coloured light, as was proved by spectroscopic study. The radiant efficiency is likewise higher, presumably on account of this higher temperature.

Meyer-Liegnitz (*J. f. G.*, Aug. 14), describes a new form of MECHANICAL MANTLE TESTER, which serves to compare the resisting power of mantles to vibration.

The RELATIVE MERITS OF COMPRESSED-AIR AND COMPRESSED-GAS INSTALLATIONS are again under discussion. On the whole it is contended that the former system is preferable, though it may not be desirable to remove existing high-pressure gas systems in actual operation.

The necessity for a special meter for high-pressure gas is cited as a drawback, and the effect of a leak is stated to be injurious to the trees or shrubs used to line the streets.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Cravath, J. R. Illuminating Engineering (*Elec. World*, N.Y., August, 1908).
Devaux, E. Observations sur la communication de MM. Broca et Laporte (Bull. Soc. Int. des Electricians, July, 1908).
Elliott E. L. The Limitations of Art in Fixture Design (*Illuminating Engineer*, N.Y., July).
Féry, Ch. Photomètre à Lecture Directe (*Jour. de Physique*, Aug.).
Gaster (L.) Illumination and Hygiene (*Jour. of the Society of Arts*, Aug. 21).
Hammer (W. J.), Ein neues Selenphotometer (abstr. *Elek. Anz.*, Aug. 2).
Herlt, G. Das Beleuchtungswesen in Türkei (*J. f. G.* Aug. 1).
Johnstone, G. A. A New Source of Illumination (*Elec. World*, N.Y., Aug. 15).
Lerche. Der Stand des Beleuchtungstechnik und die Beleuchtung im Post u. Telegraphbetriebe (*Archiv. f. Post u. Teleg.*, 1908, Nos. 8 and 9; *Ann. der Elektrot.*, No. 8, 1908).
Loring, G. The Electrical Contractor's Opportunities in the Illuminating Field (*Elec. World*, N.Y., and *Elec. Rev.*, N.Y., July 25).
Marshall, A. J., and Rolph, T. W. Artificial Lighting of Schoolrooms (*Illuminating Engineer*, N.Y., July).
"Multipolaris." Lamp-posts (*Illuminating Engineer*, N.Y., July).
Perrot, E. S. Church Lighting (*T. I. E. E.*, June).
Schanz and Stockhausen, K. Die Schadigung des Auges durch Einwirkung des Ultravioletten Lichtes (*E. T. Z.*, Aug. 13).
Schanz, F. Demonstration des durch ultravioletten Strahlen zu erzeugenden Lidschluss-Reflexes und der durch diese Strahlen veranlassten Fluorescenz der Linse (*Z. f. B.*, Aug. 20).
Voege. Ist durch das ultraviolette Licht der modernen kunstlichen Lichtquellen eine Schädigung des Auges zu befurchten? (*E. T. Z.*, Aug. 13).
Weinbeer, E. W. Die graphische Konstruktion der Reflektoren (*Elek. Anz.*, Aug. 2).
The Electric Lighting of the Union Station, Washington, U.S.A. (*Elec. World*, and *Elec. Rev.* N.Y., Aug. 1).
Discussion of Paper by Steinmetz on 'A Primary Standard of Light' (*Elec. World*, N.Y., Aug. 15).
Reflected Lighting with metallic filament lamps (*Electrician*, Aug. 14).

GASLIGHTING, ETC.

Celle. Fernzündung der Strassenlaternen (*J. f. G.*, Aug. 8).
Grey, J. E. The Hygiene of Burning Gas (*Progressive Age*, Aug. 1, *Am. Gaslight Jour.*, Aug. 3).
König. Die neuesten Fortschritte im Gasfach (*J. f. G.*, Aug. 14).
Lux, H. Untersuchung eines Benoid gas apparatus (*Z. f. B.*, July 30 and Aug. 10).
Meyer-Liegnitz. Glühkörper-Festigkeitsprüfer (*J. f. G.*, Aug. 14).
Edinburgh and Leith Commissioners' Provisional Order, to reduce candle-power of gas to 14 (*G. W.*, Aug. 1, *J. G. L.*, July 28).
Public Lighting by High Pressure Gas in Berlin (*J. G. L.*, July 28).
The Mitchelite Petrol-Air Gas Apparatus (*J. G. L.*, July 28).
The "Hella Bushlight," rod filaments for incandescent gaslighting (*J. G. L.*, Aug. 4).
Pressgas oder Luftgas (*J. f. G.*, July 25; see also *J. G. L.*, Aug. 25).
The Illumination of Political Banners (*Am. Gaslight Journal*, Aug. 3).

MISCELLANEOUS.

Coblentz, W. W. Selective Radiation of the Nernst Glower (Bull. Bureau of Standards, U.S., May).
Gripenberg, W. S. Ueber die Anwendung von Selendampf zur Herstellung von Lichtempfindlichen Zellen (*Phys. Zeitschr.*, Aug. 1).
Pflüger, A. Die Gesetze der Temparaturstrahlung und die Intensitätsverteilung im Spektrum der Quecksilberlampe (*Ann. der Physik*, No. 9).

ELECTRIC LIGHTING.

Duschnitz, B. Metallische Leuchtfäden in der Fabrikation und in der Praxis (*Elek. Anz.*, Aug. 9, Aug. 20).
Editorial. The City Lighting (*Elec. Engineer*, Aug. 7).
The Problem of the Small Consumer (*Elec. Rev.*, July 31).
The 25-Watt Tungsten Lamp (*Elec. World*, July 25 and Aug. 1).
Ennsbrunner, A. Die Quarzlampe (*Elek. u. Maschinelle Betriebe*, 1908, Nos. 6 and 7; *Ann. der Elektrot.*, No. 7, 1908).
Freeman, J. S. Conclusive Evidence of the "Overshooting" of Tungsten Lamps and other interesting Phenomena (*Elec. World*, N.Y., Aug. 15).
Freeman, W. W. The Status and Commercial Possibilities of High Efficiency Lamps (*Elec. Engineering*, Aug. 20, abstract).
J. W. B. Daylight Saving: Influence of the Proposed Changes on the Electric Lighting Industry (*Elec. Engineer.*, Aug. 21).
Ladoff, J. Recent Progress in the Voltaic Arc (*Illuminating Engineer*, New York, July).
Long, F. W. Electric Street-Lighting (*Jour. Inst. of E. E.*, London, Aug., 1908).
Remané, F. Vergleich von Betriebskosten kleiner Bogenlampen und hochkerziger Osramlampen, complete paper and discussion (*E. T. Z.*, Aug. 20).
Seelman, M. S. Introducing the Tungsten Lamp (letter, *Elec. World*, N.Y., July 25).
Schmidt, J. Ueber elektrische Strassenbeleuchtung deren Systeme und ihre Rationellität, (*Elek. Anz.*, July 26, Aug. 2, 6, and 23).
Wagoner, W. W. Street-Lighting with Metallic Filament Lamps in Series (*Elec. Engineering*, Aug. 20, abstract).
Walter, B. Einfluss von Spannungsschwankungen auf die Helligkeit von Nernstlampen (*E. T. Z.* July 16).
Wedding, W. Neuere Errungenschaften in der elektrischen Beleuchtung (complete paper, *E. T. Z.*, July 30).
Denver Convention Illumination (*Elec. World*, N.Y., July 25; *Progr. Age*, Aug. 1).
Electric Light Display at Seattle (*Elec. World*, N.Y., Aug. 15).
The Lighting of Cotton Mills (*Elec. World*, N.Y., Aug. 15).
Die elektrische Beleuchtung und ihre Entwicklung (*Elek. Anz.*, Aug. 16).
Lampe à Filament Metallique "Phillips" (*L'Electricien*, Aug. 8).

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. B.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

The International Electrical Congress at Marseilles.

THE congress is to be held at Marseilles on September 14th to 20th of this year, and will deal with many general, technical, commercial, and administrative proplems.

An interesting programme of papers has been issued, among which we note the following two papers in the fourth section which are of special interest from the standpoint of illuminating engineering:—

M. A. BLONDEL Rapport sur les procédés d'éclairage électrique.

M. F. LAPORTE Rapport sur les spécifications et la photométrie des lampes électrique.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

14,851. Metallic filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.
14,852. Titanium filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.
14,853. Metallic filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.
14,867. Incandescent lamp filaments. July 13. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
14,910. Protective covers for glow lamps (C.S.). July 14. (I.C. June 1, 1908, Germany). Siemens-Schuckertwerke G. m. b. H., Queen Anne's Chambers, Broadway, Westminster.
14,912. Tungsten filaments for incandescent lamps. July 14. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand. (From Westinghouse Metallfaden Glühlampen Fabrik G. m. b. H., Austria.)
14,961. 14,962. 14,963. } Metallic filaments for incandescent lamps. July 14. W. Majert, 4, South Street, Finsbury, London.
14,982. Arc lamp, with inclined carbons (C.S.). July 15. Veritys, Ltd., and F. S. Worsley, 11, Burlington Chambers, New Street, Birmingham.
15,030. Incandescent lamps. July 15. F. Wilkins, 6, Lord Street, Liverpool.
15,057. Metallic filament lamps. July 15. W. Majert, 4, South Street, Finsbury, London.
15,079. Decarbonizing metallic filaments (C.S.). July 16. H. Aron and A. Geiger, 77, Colmore Row, Birmingham.
15,080. Metallic filaments for incandescent lamps (C.S.). July 16. H. Aron and A. Geiger, 77, Colmore Road, Birmingham.
15,116. Arc Lamps. July 16. L. Shaw, Clun House, Surrey Street, London.
15,328. Soldering metallic filaments to their electrodes (C.S.). July 20. S. Marietti, 72, Cannon Street, London. (Addition to 14,483/08).
15,346. Mounting and feeding carbons in arc lamps. July 20. S. C. Mount and Beck Flame Lamp, Ltd., 27, Chancery Lane, London.
15,979. Lamps. July 28. Van Raden & Co., Ltd., and M. Metz, High Street Chambers, Coventry.
15,994. Shade devices (C.S.). July 28. C. W. Frauenlob, 4, Corporation Street, Manchester.
16,151. Arc Lamps. July 30. The Jandus Arc Lamp and Electric Co., Ltd., and A. D. Jones, Hartham Works, Hartham Road, Holloway.
16,311. Lamp holders. August 1. F. W. Russell, Prudential Buildings, Albert Street, Nottingham.
16,695. Incandescent lamps. August 8. Cutler, Wardle & Co., Ltd., and W. Wardle, 55, Market Street, Manchester.
16,797. Arc lamps (C.S.). August 10. T. J. Rensing, 24, Southampton Buildings, London.
17,140. Carbons for flame arc lamps. August 14. S. Paterson and C. H. Tubbs, Birkbeck Bank Chambers, London.

II.—GAS LIGHTING.

14,790. Gas lamps. July 13. G. Helps, Izons Croft, Ausley, Atherstone.
14,835. Inverted incandescent lamps. July 13. A. E. Podmore and J. Thomas, 256, Croxted Road, Herne Hill, London.
14,979. Gas harp pendants. July 15. A. Raybould and A. E. Seymour, 9 Fleet Street, Birmingham.
15,143. Gas pendants and burners. July 17. G. Helps, Izons Croft, Ausley, Atherstone.
15,217. Inverted incandescent burner protecting the mantle from shock. July 18. H. Pullen, 24, Listerhills Road, Bradford, Yorks.
15,263. Gas lights. July 18. H. F. Boughton and A. Cruickshank, 276, High Holborn, London.
15,549. Manufacture of incandescent mantles (C.S.). July 22. S. Cohn, 11, Southampton Buildings, London.
15,630. Illuminating apparatus for intermittent signs (C.S.). July 23. R. Ullrich, 7, Southampton Buildings, London.
15,644. Incandescent burners. July 23. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
15,845. Converting pendant with upright incandescent burner into one with inverted burner (C.S.). July 25. (I.C. Feb. 11, 1908, Germany.) F. Heuer, 19, Holborn Viaduct, London.
16,074. Inverted burners (regulating air and preventing back lighting). July 29. J. Dittrich, 15, Ampton Street, Gray's Inn Road, London.
16,278. Lamps (C.S.). July 31. W. E. Lake, 7, Southampton Buildings, London. (From Aurora Illuminating and Mantle Co., U.S.A.)
16,351. Automatically lighting or extinguishing gas lights. Aug. 1. G. Robson, 18, Southampton Buildings, London. (Addition to 20,109/07.)

16,364. Chronometers for lighting or extinguishing burners (C.S.). Aug. 1. C. Gagliazzo, 111, Hatton Garden, London.
16,645. Mantles. Aug. 7. W. G. Potter, 18, Fulham Place, London.
16,979. Support for gas lanterns (C.S.). Aug. 12. J. Gunning, Birkbeck Bank Chambers, London. (Addition to 2,960/08.)
17,007. Inverted incandescent mantles. Aug. 13. F. Nemerovsky, 55, Market Street, Manchester.
17,125. Incandescent lamps. Aug. 14. G. King, 65, Chancery Lane, London.

III.—MISCELLANEOUS

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

14,809. Candle lamp (C.S.). July 13. J. R. Churchill, 22, Abbeyfield Road, Sheffield.
14,989. Lamps and apparatus for burning carburetted air. July 15. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
15,337. Acetylene generator and torch (C.S.). July 20. A. F. Jenkins, 19, Farringdon Street, London.
15,691. Electric and other lamps. July 24. W. H. Dee, W. Dee, and F. J. Edginton, Criterion Works, Bow Street, Birmingham.
15,878. Lamp burners with detachable cones. July 27. F. Sherwood, 11, Burlington Chambers, New Street, Birmingham.
16,331. Illuminated advertising devices (C.S.). Aug. 1. F. W. Bundy, 8, Portugal Street, Lincoln's Inn, London.
16,448. Combustible mixtures for producing actinic light (C.S.). Aug. 4. C. Bethge, 111, Hatton Garden, London.
16,458. Incandescent burners for petroleum or petroleum spirit (C.S.). Aug. 4. J. Daugarou, 118, Holborn, London.
16,602. Incandescent petroleum lamps (C.S.). (Aug. 6. I.C. Nov. 8, 1907, Italy). G. Bas, 33, Cannon Street, London.
16,952. Method of lighting lamps (gas, oil, or candle). Aug. 12. A. H. Hathaway and E. D. Round, 15, Mansel Road, Smallheath, Birmingham.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

16,503. Attaching tungsten filaments in glow lamps (C.S.). I.C. May 6, 1907, Germany. Accepted July 22, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
16,719. Arc lamps for signalling and for search lights. July 22, 1907. Accepted July 29, 1908. G. Forbes, 24, Southampton Buildings, London.
17,059 Arc lamps. July 25, 1907. Accepted July 29, 1908. E. R. Grote and M. V. Ely, trading as Foster & Co., Worple Road, Wimbledon.
17,346. Holders for incandescent lamps. July 29, 1907. Accepted July 29, 1908. R. T. Preston and H. E. Theobalds, 77, Chancery Lane, London.
17,661. Switch for series lighting. Aug. 2, 1907. Accepted Aug. 12, 1908. H. J. Dowsing, 24, Budge Row, London.
17,718. Arc lamps (C.S.). I.C. Aug. 2, 1906. Accepted Aug. 12, 1908. Deutsche Beck-Bogenlampen G. m. b. H., 27, Chancery Lane, London.
18,053. Filaments for incandescent lamps. Aug. 8, 1907. Accepted Aug. 12, 1908. R. Jahoda and Electrische Glühlampenfabrik "Watt," 7, Southampton Buildings, London.
18,573. Controlling electric lamps or signs (C.S.). Aug. 16, 1907. Accepted July 22, 1908. J. Cole, 1, Broad Street Buildings, Liverpool Street, London.
19,157. Filaments for lamps. Aug. 26, 1907. Accepted Aug. 12, 1908. O. Imray, Birkbeck Bank Chambers, London. (From Glühlampen-Fabrik "Union," G. m. b. H., Germany).
19,672. Metallic filaments for glow lamps (C.S.). I.C. Aug. 2, 1907, Germany. Ges. für Verwertung Chemische Produkte, m. b. H., 55, Chancery Lane, London.
20,619. Holder for incandescent lamps. Sept. 17, 1907. Accepted July 22, 1908. C. M. Escaré and C. Damey, 9, Osborne Road, Thornton Heath, Surrey.
23,043. Arc lamps (C.S.). Oct. 18, 1907. Accepted July 22, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
4,762. Electrodes for arc lamps (C.S.). I.C. March 1, 1907, Germany. Accepted Aug. 12, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
6,229. Arc lamps for theatrical stages, &c. (C.S.). March 20, 1908. Accepted July 22, 1908. T. J. Digby, 37, Essex Street, Strand, London.
7,328. Arc lamps (C.S.). I.C. Aug. 2, 1907, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
9,479. Supporting hooks for lamp filaments (C.S.). I.C. May 3, 1907, Germany. Accepted July 29, 1908. W. Schäffer, 31, Bedford Street, Strand, London.
9,501. Arc lamps (C.S.). May 1, 1908. Accepted July 29, 1908. H. Baggett, 88, Chancery Lane, London.
12,682. Arc lamps (C.S.). I.C. July 15, 1907, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
16,534. Refractory conductors (C.S.). I.C. August 7, 1907, U.S.A. W. D. Coolidge, 83, Cannon Street, London.

II.—GAS LIGHTING.

16,213. Gas lamps and burners. July 15, 1907. Accepted July 22, 1908. R. J. Russell, 275, High Road, South Tottenham, London.
17,442. Inverted incandescent burners. July 30, 1907. Accepted Aug. 6, 1908. F. Turner, 77, Chancery Lane, London.

20,330. Inverted incandescent burners. Sept. 12, 1907. Accepted July 29, 1908. W. Cross & Son, Ltd., and J. Kirby, 24, Temple Row, Birmingham.
20,933. Gas illuminated "flash" advertisements. Sept. 20, 1907. Accepted July 22, 1908. D. Assersohn, 7, Southampton Buildings, London.
27,455. Inverted incandescent lamps. Dec. 12, 1907. Accepted July 29, 1908. S. J. How and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
2,572. Mantles for incandescent lighting (C.S.). Feb. 5, 1908. Accepted July 29, 1908. M. Weickert, 37, Essex Street, Strand, London.
7,309. Controlling gas supply to lamps at a distance (C.S.). I.C. July 23, 1907, Germany. G. Himmel, 18, Southampton Buildings, London.
9,362. Suspending device for gas lamps. April 30, 1908. Accepted Aug. 12, 1908. W. H. Clupperfield, 149, Strand, London.
10,233. Incandescent mantles (C.S.). May 11, 1908. Accepted Aug. 12, 1908. A. Simonini, 332, High Holborn, London.

III.—MISCELLANEOUS.

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

16,599. Reflectors, for search lights, &c. July 19, 1907. Accepted July 22, 1908. The Hon. C. A. Parsons, G. G. Stoney, and E. Bennett, 18, Southampton Buildings, London.
17,716. Petroleum and like lamp burners. August 2, 1907. Accepted August 6, 1908. T. Andreasen, 4, South Street, Finsbury, London.
28,495. Lamps. December 27, 1907. Accepted July 22, 1908. Clarke's "Pyramid" and "Fairy" Light Co., Ltd., S. B. Clarke, and H. Clarke, 24, Southampton Buildings, London.
3,159. Suspension device for incandescent bodies (C.S.). I.C., February 20, 1907, Germany. Accepted July 22, 1908. F. Frey, 231, Strand, London.
3,947. Mantle rings, burner nozzles, insulators, and other incombustible articles for gas and electric fittings (C.S.). February 21, 1908. Accepted July 29, 1908. A. A. Lines, 33, Chancery Lane, London.
8,010. Acetylene burners (C.S.). April 10, 1908. Accepted July 29, 1908. D. J. Van Praag, 18, Southampton Buildings, London.
10,225. Lantern holders (C.S.). I.C. June 6, 1907, U.S.A. Accepted August 6, 1908. C. W. Leaning, 53, Chancery Lane, London.
15,746. Long distance lighting (C.S.). I.C. July 25, 1907, Germany. J. Lafitte, 111, Hatton Garden, London.
17,148. Automatic ignition and extinction of lamps (C.S.). I.C. August 16, 1907, Sweden. E. A. Fagerlund, 18, Southampton Buildings, London.

EXPLANATORY NOTES.

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

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

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

Accepted.—Date of advertisement of acceptance.

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

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

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

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

TRADE NOTES.

We have received from the *Linolite Co.* some particulars of the "Tubolite" reflector, accompanied by an intimation that two new patterns have been introduced; also that a substantial reduction is to be made in the price of the fitting, which will in future be sold at 7*s.* 9*d.* per foot.

We have also to acknowledge, among other publications, the receipt of an illustrated list of lamps and fittings from the *British Westinghouse Co., Ltd.,* some particulars of recent types of searchlights from *Messrs. Siemens Bros., Ltd.,* and an illustrated catalogue of oscillographs from the *Cambridge Scientific Instrument Co, Ltd.*