ON THE SUBDIVISION AND DISTRIBUTION OF ARTIFICIAL SOURCES OF ILLUMINATION.

BY PROF. WILLIAM A. ANTHONY.

It is a well recognized principle that to illuminate evenly a given area by means of an artificial source, it is necessary that this source should consist of numerous small sources distributed over the area. In carrying out this principle it is usual to divide the area to be lighted into squares, and place a lamp in the center of each square as shown in Fig. 1 where each lamp is represented by the sign $\times$. In order to study the distribution of light by this arrangement of lamps I have computed the illumination at the central point of the figure due to the lamps situated upon the boundaries of each of the squares represented by the dotted lines, the illumination produced by the lamps on the smallest square be taken as unity. The following table gives the values up to the twelfth square, twice the number represented in Fig. 1, and corresponding, therefore, to an installation in which four times as many lamps are used.

I.	II.	III.	IV.	V.
1	1.000	1.000	4	4
2	.511	1.511	12	16
3	.312	1.823	20	36
4	.223	2.046	28	64
5	.174	2.220	36	100
6	.143	2.363	44	144
7	.121	2.484	52	196
8	.104	2.588	60	256
9	.092	2.680	68	324
10	.083	2.763	76	400
11	.075	2.838	84	484
12	.067	2.905	92	576

Column I gives the designating number of each square counting outward from the central point. Column II gives the illu-

mination at the center due to the lamps located on each boundary. Column III gives the total illumination at the center due to the lamps included within and upon each boundary. Column IV gives the number of lamps situated upon each boundary. Column V gives the total number of lamps.

It is seen from the table that the twelfth series which consists of 92 lamps gives at the center less than 7 per cent. as much light as the first series of four lamps, and contributes only about two and one-half per cent. to the total illumination at the center. This arrangement of the lamps does not give an even distribution of light over the entire area, as will be evident from a considera-

FIG. 1.

tion of the illumination upon the outside boundaries of the space. It is evident that the point B at the corner of Fig. 1 receives one-fourth as much light as it would do if it were the center of an area four times as large, and lighted by four times as many or 576 lights. But the illumination at the center of such an area as seen by the table is 2.905. The illumination at B is, therefore, $2.905 \div 4$ or .726, while the illumination at A from the sixth line of the table is 2.363. The illumination at B is then less than one-third that at A. At C the illumination is evidently but little more than half that at A. Points located between the center and

outside would be illuminated to an intermediate degree, but after leaving the outer boundary the illumination would rapidly approach that at the center of the figure. I am considering always points of least illumination in any region, that is, points situated as far as possible from any lamp. It is evident, therefore, that to obtain a uniform distribution of light, the lamps must be concentrated toward the outer boundary of the space instead of being placed at equal distances throughout, as in the figure.

But the most interesting question connected with this matter is: what is the effect upon the uniformity of the illumination of grouping the lamps in clusters or using larger lamps at fewer points? It is evident that whatever the candle power of the lamps or their distances apart in a distribution like that represented in Fig. 1, the *relations* represented in the table will remain unchanged. It is evident also that the illumination at the central point will be proportional to the intensity of the individual sources (if lamps are placed in clusters each cluster is to be considered as a source) and inversely to the square of the distance between the sources.

This illumination is, therefore, given by the formula

$$K \frac{s}{d^2} C$$

where K is a constant depending on the units employed, s the intensity of the individual sources, d the common distance between them, and C the quantity in column III of the table corresponding to the number of sources as found in column v.

Compare the illumination at the center of an area lighted by 576 lamps with that at the center of the same area lighted by the same lamps arranged in 144 clusters of four lamps each. If s and d represent the intensity and distance in the first case, $4s$ and $2d$ will represent the corresponding quantities in the second case. C in the first case is 2.905 corresponding to 576 sources. In the second case, for 144 sources C is 2.363. The relation sought is, therefore,

$$\frac{K \frac{4s}{4d^2} 2.363}{K \frac{s}{d^2} 2.905} = .813$$

The light at the central point with the fewer sources, is only 81 per cent. that obtained under the first arrangement. Other

points of minimum illumination will suffer in like manner. On the other hand, points near the clusters of lamps will be much more strongly illuminated than corresponding points near the single lamps of the first arrangement.

If it be required that the illumination at no point shall be less in the second case than in the first, it will be necessary to increase the intensity of the sources nearly 25 per cent., or make the clusters consist of five instead of four lamps.

Again, suppose an area lighted by 64 sixteen c. p. lamps distributed as in Fig. 2. It is required to substitute 16 lamps of larger candle power distributed as in Fig. 3, and fulfilling the condition

FIG. 2.

FIG. 3.

that the minimum illumination shall be no less in the latter case. If x be the candle power of the larger lamps, we have:

$$\frac{x}{4 d^2} \times 1.511 = \frac{16}{d^2} \times 2.046$$

$$x = 64 \times \frac{2.046}{1.511} = 86.7$$

From which it appears that the total candle power must be increased $35\frac{1}{2}$ per cent. If the 16 candle power lamps consumed 3.5 watts per candle, the larger lamps to compete with them should consume less than 2.6 watts per candle.

It will be noted from the two examples given, that the loss from reducing the number of sources in a given ratio is less when the number is large. In other words, large lamps, or clusters of lamps, can be more economically used for large, than for small areas.

An inspection of the table will show, that while a given area may be lighted satisfactorily by 16 clusters of four lamps each, an area one-fourth as large, lighted by four clusters at the same distance apart, would not be as well lighted with six lamps to the cluster. It will be seen also that the larger the area, the further apart may lamps of the same candle power be placed. For example a room 40 feet square with 16 lamps 10 feet apart, is fully as well lighted as a room 16 feet square with four lamps eight feet apart.

Let us compare arc and incandescent lights on the same basis, that the minimum illumination shall be the same under both systems. First, I must say that the efficiency of arc lights has been greatly overrated. Instead of being ten times, it is rarely three times, and often only one and a half times that of an incandescent lamp.¹ This is for the naked arc. For indoor illumination, ground or opal globes are nearly always used, and these cut off fully half the light.² This leaves the efficiency at the most 1.5 times that of the incandescent lamp. The power required for a 16 candle incandescent lamp is 50 watts, and for a full arc lamp 450 watts. The arc lamp must, therefore, replace nine incandescents. Assuming that the lamps are distributed as described in this paper, the table shows that if four arcs take the place of 36 incandescents, their efficiency as compared with the incandescents must be 1.823, and with a relative efficiency of only 1.5, the arc lamps would not light the space as well as the incandescents. If 16 arcs take the place of 144 incandescents, the ratio of the efficiencies required is 1.56, and arcs at 1.5 are still not equal to the incandescents. If 64 arcs take the place of 576 incandescents, the ratio of the efficiencies becomes 1.42, and arcs at 1.5 would be an improvement on the incandescents. It comes then to this, that unless the area to be lighted is so large as to require about 500 incandescent lamps distributed uniformly over it, the use of full arc lamps requiring the same power, will leave some parts of the area less brilliantly lighted.

If we could make small arc lamps of the same efficiency as the full arc—by full arc I mean the so-called 2,000 candle lamp consuming about 450 watts—we could improve somewhat upon

1. See "Efficiency of Artificial Methods of Illumination." Dr. Nichols : *TRANSACTIONS*, vol. vi., p. 171.

2. "Loss of Light from Use of Globes with Arc Lamps." George D. Shepardson: *Electrical World*, vol. xxiii., p. 287.

the result as obtained above. But the fact that the mechanism of a small arc lamp costs just as much as that of a large one, and that *each* small arc will require as much care and attention as a large one, would place a limit upon the subdivision of the arc even if the efficiency could be maintained. And here I wish to enter a protest against the assumption that I often find in discussions of this subject, that the *so-called* 1,200 and 2,000-candle power arc lamps *are* 1,200 and 2,000-candle lamps. There is no 450 watt arc lamp in use that will measure 2,000-candles in the direction of greatest intensity, and compared with other artificial sources for general illumination, that is measured as other sources are measured, there is no 450 watt lamp that will give, when surrounded by a plain glass globe, 500 candles.

In a linear distribution, as in street lighting, the arc is at a still greater disadvantage. Remembering that nine 16-candle incandescent lamps can be run with the power required for one 450-watt arc, it is seen that the arcs must be nine times as far apart as incandescents consuming the same power, and to give the same minimum illumination must be 81 times as intense, or about 1,300 candle power. But in no arc lamp as used for street lighting, do the rays proceeding toward the most distant points to be illuminated, reach more than one-fourth this intensity. In my way of thinking, the location of arc lamps at intervals of 1,000 to 1,600 feet as they are often seen in pretentious country villages and suburban places is an entire waste of money. A little spot 50 to 100 feet in diameter under each lamp is brilliantly lighted, while the more distant points are in darkness all the more profound from the loss of sensitiveness of the eye when in the strong light. Incandescent lamps at intervals of 100 to 200 feet, which could be run by the same power, would give a far better illumination.

Of course, in deciding between the use of arc and incandescent lamps in any special case, there are other questions to be considered besides that of the power required to operate. Practical questions of installation may outweigh all others. The considerations of these is foreign to this paper. The question I have considered is purely one of efficiency, and in treating that question I have assumed that every part of a space to be lighted, *needs* the same amount of light. I have omitted from the consideration all effects of reflection from ceilings, walls, or reflectors purposely provided, as these are too various and depend too

much upon the conditions in each special case to be introduced into a general discussion. My main object has been to point out to just what extent the general illumination of a space is affected, other things being equal, by the use of large in the place of small sources using in the aggregate the same power, and I trust the figures and illustrations I have given may be found useful in considering the special cases that may arise.

Vineland, N. J., April 28th, 1894.

DISCUSSION.

MR. NELSON W. PERRY:—I would like to ask in regard to the statement that no 450 watt lamp will give, when surrounded by a plain glass globe, 500 candles, what it means? There have been so many thousand measurements of the intensity of arc lamps that have almost universally shown an intensity in the plane of maximum illumination between 750 and 1250 and even more, that it would seem that they could not all be wrong. Most of these measurements were made with lamps without globes probably. Now, if we assume 1000 c. p. as an average of all of these determinations without globes, we must assume that Prof. Anthony's statement if true must mean that clear glass globes cut off at least 50 per cent. of the light in order to bring it down to 500. This of course is absurd.

PROF. ANTHONY:—I think you misunderstood the statement there. The statement is in the direction of the most distant point to be illuminated.

THE PRESIDENT:—Is that made by the short arc or the long arc?

PROF. ANTHONY:—The long arc 450 watt lamp. That is in the direction of the farthest point to be illuminated. It would be not more than ten degrees from the horizontal line. The illumination of any arc lamp in that direction is very small.

MR. KENNELLY:—While the figures that Prof. Anthony gives are no doubt true in the open air, without moon or star light; that is to say where there is no reflection; yet within doors the circumstances of reflection from walls and ceilings, would so far modify the practical conditions of the problem, that the conclusions to be drawn from the paper will surely undergo great modification in consequence; and while no doubt the general proposition is true that to get the most uniform and the least minimum illumination at any point, you should place a thousand candles in 1,000 candles and not have it in one lamp, still the effect of reflection from walls and ceilings, will so far modify any preconceived notions that we may have upon what should be the best luminous distribution, that everything would largely depend upon the particular circumstances of each case.

THE PRESIDENT:—I must confess to considerable surprise at the figures reached by Prof. Anthony. I do not doubt but that as a careful scientific man he has the facts of actual measurement to warrant the correctness of these conclusions. I would say, though, that such a very small economy of light for an arc lamp is quite at variance with the experience I have had in the matter, and is absolutely inconsistent with our ideas of the relations existing between temperatures and the power of emitting light. The temperature of an arc is immensely higher than that of an incandescent filament at any temperature at which it would be practicable to run the filament, and to get so astoundingly small an economy out of an arc lamp shows that there must be either

some peculiarity of measurement, or something wrong in our preconceived ideas as to the relation which ought to exist between candle power and temperature. I do not think it fair to measure the light giving power of an arc in a horizontal direction and base conclusions on that. It is fair enough to take that in an ordinary gas flame or in an incandescent light where this direction is far from being its position of least efficiency. I do not think it is fair to take it in the case of an arc light. I was particularly induced to ask whether you were running with the long arc or the small arc since it struck me at first that possibly the error might come from the shading of the positive crater by the projection or nipple on the negative carbon. The figures surprise me very much. I feel sure that it will be quite a surprise to those interested in arc lighting in the country to learn, if I am correct in my understanding, that you do not get more than one and one-half times out of the arc than out of the incandescent. Still, if true, it is very well worth learning.

MR. STEINMETZ:—I think the figures are not very far from true. When the 2,000 candle power arc light got this name, it was given to it because if everything is adjusted carefully, as it can be done in the laboratory, then the maximum intensity is about 2,000 candles, but the spherical intensity is only little more than one-third as high, that is, 700 candles, and taking into consideration, that a part of the light is shaded off by the glass globe, we get not very far from 500 candles as the mean intensity of the covered arc. Still from another side you can approach the same result:

The brilliancy of the arc is that of boiling carbon. The brilliancy of the incandescent lamp filament, that is, the candles per watt, is less. But, increasing the temperature by raising the voltage, increases the brilliancy, until the carbon filament evaporates. Now, immediately before this, the brilliancy must be about the same as that of the arc. Photometric tests of incandescent lamps at seven to eight times their rated candle power give brilliancies of from 1 to 1.2 candles per watt, and seem to point towards a maximum value of about $1\frac{1}{2}$ c. p. per watt. The spherical brilliancy of very large arcs was observed as 1.5 to 1.7 candles per watt.

The above stated data of 2,000 maximum or 700 spherical candles for the ordinary 450 watt arc gives a brilliancy of 1.55 candles per watt, so that, estimating the light absorption of the glass globe as 30 per cent. we get the figures given by Prof. Anthony.

Hence the name "2,000 candle power arc" only refers to the maximum intensity of the naked arc in the most favorable direction. A more proper way to rate arc lamps would be, not by the candle power, but by the watts consumed. I think that is quite extensively done now.

MR. CLAYTON W. PIKE:—I understand Prof. Anthony's

figures are about 500 candles spherical when the glass globe is on.

I remember making a number of experiments on 1,200 candle power lights without any globe, of the spherical intensity, and in every case we ran below 450 candles. If we change from the 1,200 to the 2,000 and also bring in the correction for loss from the globe, we shall find those figures correspond very closely with Prof. Anthony's. I have done that on a sufficient number of arc lights to enable me to feel sure that those figures are correct.

PROF. ANTHONY:—If I may put a figure on the blackboard:—(making a sketch, Fig. 4) measuring the intensity of the light from an arc lamp at various angles from the horizontal downward, we obtained results which when plotted on a system of

FIG. 4.

polar coördinates gives a curve like *a, b, c, d*, where *o a, o b, o c*, etc., represent the intensities in those directions. The maximum intensity occurs at 45 or 50 degrees below the horizontal, and from that point toward the horizontal it decreases very rapidly, until along the horizontal the 450 watt arc will rarely measure more than 300 candles. It is usual to take as the mean intensity of the arc light the mean intensity in the lower hemisphere because it is the lower hemisphere that we wish to illuminate in all ordinary use of the lamp. Since the light in the upper hemisphere is extremely small, the mean intensity for the lower hemisphere is much greater than the mean intensity for the entire sphere, but even in the lower hemisphere the mean intensity is not above 500 candles.

THE PRESIDENT:—At what height did you estimate the average height of the arc?

PROF. ANTHONY:—These are candle power measurements made on a photometer. The horizontal intensity would be a horizontal line.

THE PRESIDENT:—You are not considering then the question of illumination at all?

PROF. ANTHONY:—In this case, in determining the candle power, we simply measure it on a horizontal line as so many candles and so on as you go down. At 45 or 50 degrees there is a maximum, and the measurements will sometimes run to 1,500 or 1,700 candles. On good 450 watt long arc lamps I never obtained but one measurement out of thousands I have made, as high as 2,000 candles.

THE PRESIDENT:—That probably is near the crater, say, on one side.

PROF. ANTHONY:—Very likely.

THE PRESIDENT:—I do not yet see why you call that the maximum intensity. That is not the maximum intensity; else I do not understand. The horizontal line—did I understand you to call that the maximum intensity?

PROF. ANTHONY:—No. At some 45 degrees below the horizontal, is the line of maximum intensity. At the horizontal line it would not be more than 300 candles.

THE SECRETARY:—Then the practical efficiency of the lamp would depend very largely on what purpose that lamp was intended for. If it was intended for the illumination of a park or any large open space, it might be well to have it up at a certain height, while for practical purposes, if the illumination was required on a horizontal plane opposite the arc it would be comparatively inefficient. So that the practical result will have to depend largely on the purpose for which the lamp is designed.

MR. FRANCIS R. UPTON:—A little apart from the subject of arc lamps, I would like to say, that I am very glad to see that Prof. Anthony has made an effort at the distribution of light, which, as I understand, is the title of this paper. A number of times I have had that subject brought before me, and I know that it is one of the most puzzling subjects which can be presented. The conditions vary so, as Mr. Kennelly mentioned, about ceilings and walls, that the question of proper distribution of light is one which it is very difficult to answer in general terms. There is one point in distribution which I have noticed, which probably many of you have observed: that is the fact, that in the illumination of a given space, the whole aim should be not to spot the lighting, so that the eye will not lose its sensitiveness by being dazzled by a bright spot. It is well known to those who have to do with lighting, especially with the incandescent lamp, that rooms can vary two or three-fold in their rate of illumination; that is the absolute rate of illumination without being

noticed if the eye has only darkness to compare the light with. I wish Mr. Stieringer were here, as he is a master of the art of illumination. He put in practice one of the most successful illuminations in this country; that was at the exposition at Louisville some years ago. At that place he distributed his lights with the power to prevent anybody from putting an arc lamp in the building, or from using any light, grouped in clusters, near the ground. The result was that he was able to illuminate a large exhibition building there, so that it looked brilliantly lighted with a very low grade of absolute illumination, because there was no one spot which your eye looked at which made the rest look dark. I feel that there is great room for some good means for determining illumination in distinction from determining the candle power of the light giving body. There appears to be no good unit for illumination that is thoroughly reliable for this purpose, and I think that a discussion of the general lines that Prof. Anthony has made in this paper, adds to the knowledge of what is meant by the distribution of light, and I find it very interesting. I think, probably many of you have perceived, in going along a street at night and looking into the various stores and seeing how much the illumination varies, by reason of the mode of placing the lights in those places, how much more use can be made out of lamps well placed than out of lamps poorly placed.

THE PRESIDENT:—I suppose the photometer you used absolutely prevented any reflection from the ground. You simply measured the horizontal ray. You had probably a shield or screen or something to prevent any other light from coming in except from that direction.

PROF. ANTHONY:—Those measurements such as I have shown on the board are made in the photometer room—a blackened room.

THE PRESIDENT:—Consequently you would lose all possible advantage of what you get in actual practice—illumination of objects from light thrown from the ground. I cannot believe in only one and a half times the efficiency of the arc light over the incandescent. It is contrary to my experience. I think there is something wrong in the method. However, I certainly shall know in a little while whether I am wrong or not.

MR. R. O. HEINRICH:—It is rather surprising that so little attention has been paid to the very important and eminently practical questions considered by Professor Anthony. If we would simply make a distinction between luminosity of a source and illumination produced, such perplexing questions as the actual candle power of a "2000 candle power" arc would be of very minor importance.

On account of the complication of conditions the illuminating effect of a combination of sources of light, such as met with for artificial illumination, is almost beyond mathematical computation. A practical and successful solution of such problems can be ob-

tained only through a vast number of observations and measurements.

The requirements of actual practice are two-fold: First: A uniform illumination should be attained, one which comes nearest to the ideal illumination of diffused daylight. Second: A definite intensity of illumination should be assumed as necessary either for the performance of certain work, such as reading, writing, drawing, sewing, etc.; for general indoor illumination in theatres, halls, etc., and for outdoor and street illumination.

It matters little for these considerations what the "candle power" of a source of light amounts to; for the conception of a definite illumination, this expression is without meaning. It is necessary under the above considerations to express the intensity of illumination in its own distinct unit.

Little has been done towards the universal adoption of such a unit, although the "metre candle" was proposed for the purpose more than ten years ago by Prof. Leonhard Weber, W. H. Preece, and Mr. Wybauw, the latter proposing the name "lux" for this unit.

On the authority of Dr. H. Cohn (Breslau) 50 metre candles are sufficient to permit reading with the same facility as in diffused daylight. He considers 10 metre candles as a minimum illumination from a hygienic standpoint, for the purpose of reading. Wybauw (*Mésure et répartition de l'éclaircissement. Bull. de la Soc. Belge d'Electr.*, 1885) considers 15 to 25 metre candles or "lux" as necessary to permit a fluent and prolonged reading of a newspaper, and holds that a minimum of one metre candle should be required for street illumination.

Assuming such or similar values based upon a unit of illumination, all controversy as to candle powers would be at an end. Contracts for the illumination of reading rooms, halls, streets, squares, etc., should specify a required minimum illumination in some such unit as above referred to, and it would then rest with the expert engineer to accomplish this with the least possible amount of mechanical energy converted into light.

Actual measurements would soon convince us in what bungling way illumination is generally carried out. Prof. Anthony's remarks in reference to the lighting of pretentious country villages and suburban places are very pertinent; they would apply equally well to the illumination of our city streets and squares if it were not for the illuminated shop windows which somewhat mitigate the contrast between superabundance of light and darkness.

In connection with this matter I may be allowed to make reference to Professor L. Weber's portable photometer, which is especially adapted for making measurements of the intensity of illumination. This photometer seems little known on this side of the Atlantic, and I therefore give a sketch of its general arrangement. See Fig. 5 and 6.

The apparatus consists of a tube A about 30 cm. long, which

can be moved up and down, and swung in a horizontal plane on the upright *c*. The standard light *s*, a benzine lamp, is contained in a lantern fastened to the right end of the tube *A*. Within the tube *A* a circular plate of opal glass can be moved from or towards the light *s*; its distance from *s* is read in centimetres on the scale *s* by means of an index fastened to the pinion *p*. At right angle to tube *A* a second tube *B* is fastened. This tube can be rotated in a vertical plane, and its position in reference to the horizontal is read on the graduated circle *c*. A rectangular prism contained in tube *B* in its axis of rotation receives light from the opal glass plate in tube *A* and reflects this light towards

FIG. 5.

the eye piece *o*, so that the right half of the field of vision is illuminated by this light, the left half is illuminated by the light entering the tube *B* at *g*.

In making measurements, the tube *B* is pointed towards the source of light to be measured. This light has to pass through a square box *g* in which may be inserted one or more opal glass plates, in order to diminish the intensity of the light and thus to make it comparable with the standard light. The apparatus permits the measurement of light in the shape of a flame as well as the measurement of diffused light.

Since the measurement of diffused light interests us most at present, a short description of the method will not be out of place.

A white screen, the surface of which is absolutely without lustre, furnished as part of the apparatus, is placed in a convenient position, either horizontal or vertical, or at any desired inclination towards the source of light.

The photometer having been located at a convenient distance from the screen, the tube B is pointed to the center of the screen. The distance of the photometer from the screen can be varied within very wide limits, the only restrictions being that the field of vision receives no other light than that emanating from the screen. The necessary precautions for adjustment having been observed, the opal glass plate in tube A is moved until both halves of the field of vision appear equally illuminated. The distance r of this glass plate from the standard light at the

FIG. 6.

moment of equal illumination is read on the scale on tube A in millimetres, and the intensity of illumination on the white screen is calculated from the formula.

$$I = \frac{10000}{r^2} K.$$

The constant K is previously determined as follows:

A standard candle is placed exactly one metre distant from the white screen and the tube B of the photometer is pointed towards the screen, so that the center of the screen, which is marked by a cross, is seen in the center of the field of vision. As indicated in the sketch, the photometer must be so placed that the eye looking through the eye piece sees nothing but the

white screen. The angle of inclination under which the screen is observed may be varied within wide limits without influencing the result, it should however not exceed 60° from the normal to the screen.

Equal illumination of both halves of the field of vision having been obtained by means of adjusting the opal glass plate in tube A, the constant c is found by calculation ;

$$K = \frac{r^2}{R^2}$$

Since r is read in millimetres and R is made 1 metre or 10000 millimetres, 10000 instead of 1 must be taken in the formula for calculating the intensity of illumination in metre candles.

A second method permits of measurements of diffused light without the intervention of the screen, but for further details I must refer to the description of the apparatus by Prof. Weber, *Elekrotechnische Zeitschrift*, vol. v. p. 166.

Since the whole apparatus can easily be taken apart and packed in a box about 24 x 8 x 12 inches, it recommends itself extremely well for out-of-door work. In this case the benzine lamp might well be replaced by a small incandescent lamp, provided this lamp is standardized before and after each set of experiments. I have found such miniature lamps very convenient, and quite sufficiently constant in candle power for several hundred observations.

THE PRESIDENT:—If there is no further discussion, we will go on with the next business. I understand that Mr. Wurts has notified the Secretary that it would be impossible for him to read his paper on "Discriminating Lightning Arresters and Recent Progress in Means for Protection against Lightning," to-day. Meanwhile, Mr. Hammer has asked the privilege of the floor to explain a matter in connection with the consideration of rules adopted by the National Electric Light Association for electrical construction and operation.

MR. W. J. HAMMER:—Mr. President and gentlemen—Secretary Porter of the National Electric Light Association has sent me for distribution some of the copies of the Standard Rules for electrical construction and operation recently adopted at the convention at Washington of the National Electric Light Association, and on behalf of that Association and as chairman of the Committee on Standard Rules I wish to bring these rules before the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, and I make the motion that the chair appoint a committee, preferably of five, who will examine these rules with a view of recommending their endorsement by the INSTITUTE. And in connection with this motion I would like to ask that this be taken up as a special matter on Thursday.

I wish to say one word in this connection, and that is that these rules are the result of a very large amount of work by gentlemen connected with a number of committees which have had

this matter in charge for years past. Some years ago there existed an infinite variety of rules issued by the different insurance companies, boards of trade, electric light companies, experts and others, which rules have gradually disappeared or been incorporated in a set of rules issued by the National Electric Light Association. These rules have been issued with very slight modifications by the International Board of Fire Underwriters, the National Board of Fire Underwriters, and the Local Board of Fire Underwriters without, however, giving any credit to the original source, which is the National Electric Light Association. Various efforts have been made to have one single set of rules go out. It is my hope and that of others that before this year expires some action will be taken which will bring about this long sought for result, and as these rules that are issued by the National Electric Light Association are to all intents and purposes the same ones which are issued by the Board of Fire Underwriters, with very slight modification, I would recommend that this committee be authorized to examine into these rules with a view to recommending their endorsement by the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. This will be a step in the right direction. There will be undoubtedly certain things open to criticism. But these rules are in the hands of a permanent committee that are intending to make them the standard rules and keep them up to date, and the endorsement of the INSTITUTE, as a representative body of scientific men interested in matters of this character, will assist this good work and I feel sure that with this endorsement by the INSTITUTE, before the year is out or before another year comes, there will be but one set of rules which will be satisfactory and which will receive the endorsement of the National Electric Light Association, the Boards of Fire Underwriters, the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS and all other bodies. It is with this end in view that I have asked the privilege of bringing the matter before the INSTITUTE, and I make the motion that the chair appoint five gentlemen to report upon this matter and bring it up before the meeting on Thursday.

[The motion was carried.]

THE PRESIDENT:—The Chair appoints as the committee, Mr. Hammer, Mr. C. P. Steinmetz, Mr. A. E. Kennelly, Mr. Edward Weston and Mr. N. W. Perry.

The Secretary made some announcements respecting invitations and the meeting then adjourned until the following day.

Tuesday evening the members attended an informal reception given by the Engineers and Manufacturers of Philadelphia, under the auspices of the "Engineers' Club" and the "Electrical Section of the Franklin Institute," at the Manufacturers' Club.