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OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

COURT ROOM NO. 2, TEMPLE BUILDING,

TORONTO, December 23rd, 1913.

The President, Mr. A. M. Wickens, occupied the chair.

Chairman,—

Gentlemen, if you will come to order we will start the business of the meeting. We have been delayed a few moments making arrangements in regard to the current for the lantern. The first order of business is the reading of the minutes of the previous meeting. Now, we have had some trouble getting the book out this month, and the same was only mailed to you this morning.

Mr. Baldwin,—

Although we have not yet received a copy of the book of proceedings, I move that the minutes of the previous meeting be adopted. Seconded by Mr. Cole.—Carried.

Chairman,—

The next order of business is the remarks of the President. I regret that we have had some trouble this evening in regard to the current for the lantern which has delayed us a few minutes.

I suppose this will be my last opportunity to sit at the head of this Club, and I therefore desire to say good-by, and thank the officers and members of this Club for the very hearty and cordial support that they have given me during my term of office.

We have had a fairly successful year; there is no man that belongs to this Club that has not got the worth of his money.

I consider that during the year we have had some very expert papers, and we have been causing outside people to talk considerably in regard to the good papers we have been securing.

You will remember at the last meeting we were to have had a moving picture exhibit and paper by Mr. F. N. Speller of the National Tube Company, showing the manufacture of steel tubing. This has now been arranged for the February meeting —the exact date will be given later—possibly it will be February 24th. This meeting will be held in conjunction with the Engineer's Society of Toronto University, and will probably be at the University. This will no doubt be a very interesting paper, as it will illustrate the manufacture of steel tubing, from the mining of the ore right down to the finished product. These pictures were taken right at the plant of the National Tube Company and were exhibited last summer at the American Railway Master Mechanic's Association Convention. I think that on account of failing to get Mr. Speller in the first place, his paper will be all the more appreciated when he does come.

The paper to be given at the January meeting, January 27th, will be by our esteemed friend and Past President, Mr. Geo. Baldwin, on the subject "Horticulture." This paper will include both branches, namely, flowers and vegetables, and will no doubt be very interesting to all as there is hardly a man that has not got a garden of some kind, and when you get the JOURNAL with his paper in it, you can keep it, and in the spring you will be able to look it up and find how to take care of your gardens.

I do not think I have anything more to say, except to thank you all for the loyal support I have had from the members during the year.

I will now call on the Secretary for the list of new members:

NEW MEMBERS

Mr. C. G. Spencer, Mechanical Engineer, Toronto Power Co.
Mr. C. G. Curry, Stores Inspector G.T.R., Brockville, Ont.
Mr. H. R. Hamer, Asst. General Foreman C.P.R., West Toronto.

MEMBERS PRESENT

T. J. Ward	Wm. S. Butler	K. A. McRae
T. B. Cole	Thos. Thompson	W. M. McRobert
James Wright	Chas. Russell	N. A. Davis
Geo. Baldwin	James Kelley	J. Boland
R. B. Murray	R. Pearson	E. A. Wilkinson
J. Callanan	A. R. Woodley	J. C. Donald
L. Salter	A. M. Wickens	G. D. Bly
J. W. McLintock	W. C. Sealy	Jas. Reid
A. J. Lewkowicz	H. G. Fletcher	J. Barker
T. McKenzie	J. Anderson	J. Dodds
W. McRae	W. H. Alderson	E. Logan
W. Kirkwood	C. H. De Grouchy	A. Hallamore

Chairman,—

Any reports from standing committees?—None.
Any unfinished business?—None.

Has any gentleman got anything to bring up under the head of new business?—None.

I might state that your executive committee took the matter up, at the last meeting, of having a winter entertainment, and it was decided that early in the New Year there will be an entertainment given which will most likely take the form of a dinner.

Mr. Helps, who is going to read a paper to us to night, is not quite ready, and I think that as this is election night, we might take up the matter of election of officers now.

At the last meeting a nominating committee was appointed, and they have nominated the following:—

For the office of Honorary President, Mr. R. Patterson, Master Mechanic, G.T.R., Stratford. If any gentleman desires to make further nomination, he is at liberty to do so, as this is not a permanent list.

Moved by Mr. G. Baldwin, seconded by Mr. J. Wright, that the nomination be closed.

Elected by acclamation.

For the office of President, Mr. Thos. J. Walsh, Chief Engineer, High Level Pumping Station, Toronto.

Moved by Mr. C. Russell, seconded by Mr. K. A. McRae, that the nomination be closed. Elected. (Applause.)

For the office of First Vice-President, Mr. Jas. Wright, Foreman Gurney Foundry Company, Toronto.

Moved by Mr. T. J. Ward, seconded by Mr. W. M. McRobert, that the nomination be closed. Elected.

For the office of Second Vice President, Mr. Jas. Herriot, General Storekeeper, Canada Foundry Company, Toronto.

Moved by Mr. H. G. Fletcher, seconded by Mr. R. Pearson, that the nomination be closed. Elected.

The next is the Executive Committee. This executive committee is composed of seven members, and the outgoing president is supposed to be one of these members, according to the by-laws. The committee have nominated:—

Messrs. Wickens, Scott, Pearson, McRobert, Baldwin, Cole, and Logan.

Mr. Baldwin,—

I would like to say that although I was on the nomination committee, that I did not have anything to do with putting my own name down on the executive list.

I would have liked to nominate someone else in my place, but however, if it is your wish that my name is to go forward, I will only be too pleased to do all that I can for the Club as I have in the past.

Moved by Mr. C. Russell, seconded by Mr. J. Wright, that the nominations be closed. Elected.

Chairman,—

We now have only the Auditors, three to be elected; the committee name Messrs. F. G. Tushingham, D. Campbell, and G. Boyd. Are there any further nominations?—None. Elected.

The reception committee is in the hands of the incoming president, and he selects the members for this committee.

This finishes our election of officers for the year 1914.

Mr. Baldwin,—

As this is Mr. Wickens' last night in the chair, I desire to take this opportunity of moving that the heartiest vote of thanks of the members of this club be tendered to the retiring president for the able and courteous manner in which he has attended to the duties of his office during the past year.

Mr. T. J. Walsh,—

I take much pleasure in seconding that motion. I think the members of this Club owe a very hearty vote of thanks to Mr. Wickens for the capable manner in which he has handled the office of President during the past year.—Carried.

Chairman,—

I am sure I appreciate the vote of thanks, tendered me by the members.

I may say without any conscientious scruples that I have really enjoyed this year, as being president of this Club. My intercourse with the officers and members all year long, has been very pleasant. I never went to any member for any assistance in connection with anything we were undertaking but that they came right out and helped us along, and for that reason I think that any member who receives the office of President of this Club is sure of receiving very hearty support from the members.

I want to ask the members to give Mr. Walsh as hearty support as they have given me, and I am satisfied you will have a better year than this was.

Chairman,—

The next order of business is the reading of papers and the discussion thereon; we have with us to-night Mr. J. W. Helps, Late-Industrial Engineer of the Toronto Hydro-Electric System, who is going to read a paper on "Scientific Illumination" illustrated with lantern views. I shall now call on Mr. Helps.

NOTES ON SCIENTIFIC ILLUMINATION, HAVING SPECIAL REFERENCE TO INDUSTRIAL LIGHTING

BY J. W. HELPS, LATE-INDUSTRIAL ENGINEER, TORONTO HYDRO-ELECTRIC SYSTEM

The subject of this paper is at the present time receiving much attention, and very rightly so. It is not long since the man who even ventured to make use of this term was regarded as a faddist, and the pioneers in this department of industrial science got laughs and sneers as their principal reward,—or so it appeared at any rate. Now it is different: by contrast it may be mentioned in passing that the National Cash Register Co., of Dayton, Ohio, two years ago fitted up a laboratory at their works, and have spent some thousands of dollars in research work on this very question, thus indicating their appreciation of its importance to them.

Let it be understood that this is not a paper on the science of light. It will be necessary to refer to some of the properties and characteristics of light, yet light is not illumination but that which gives it. ' The problem for the illuminating engineer may be stated in general terms as follows: to obtain the illuminating effects desired in any case with the maximum economy, having due regard to the protection of the eyes from disagreeable or harmful effects, and to architectural and aesthetic considerations."—(Dr. C. H. Sharp.)

Bearing in mind that science is just another word for knowledge, it will be pretty well agreed that by the term "Scientific Illumination" we mean the use and application of light so as to secure the results above enumerated by the intelligent application of known laws. The study of this subject is essentially new: there never was a time in known history when man did not require light during the period between sunset and sunrise. On the other hand there never was a time when the need was so pressing as at the present, or when efficiency and economy were such important factors.

Again, when we say this is a new study, it does not mean that much has been added to the world's store of knowledge of the laws of nature concerning light—in fact very little is known now that was not known to somebody years ago. But that "somebody," whilst knowing much about light, had nothing to do with the task of applying light so as to produce illumination. Likewise, those whose work it was to provide illumination by artificial lighting paid little or no attention to what was known of the laws governing its application, much less to the structure of the eye.

During the last few—and particularly the last seven years however, there has gradually developed a school of students who have recognised the importance of connecting these things, and from this has evolved all that is now meant by the term "Illuminating Engineering." As to direct results of this, it may be said with a fair degree of accuracy that by applying the specialised knowledge thus obtained it is possible at the present time to get much better illumination than was possible five years ago, at about half the cost, and without the attendant injury to the eyes as was formerly the case where artificial lighting was much employed. To the merchant or manufacturer this means that his employés work at greater efficiency, producing better results than formerly; to the storekeeper it means that his store may be made attractive and his wares displayed better than ever before; to all concerned it means increased comfort, decreased eye strain, less headaches and other nerve troubles, and, in short, more congenial and hygienic surroundings. A subject, the study of which can secure such results, cannot be and is not now set aside as a "fad." It is deserving of much more attention than we can possibly give here. It can only lightly be touched upon in this paper, the main object of which is to direct special attention to it and to illustrate some of the means used and the results obtained.

It is not within the scope of this paper to go very much into the relative claims of the various light sources, whether gas, electric, acetylene or even coal oil lamps. Sometimes this amounts only to the question as to what is available, but where there is no such limitation, every illuminating engineer will select electricity, since electric light, besides being most hygienic is also the most easily controlled by reflectors, and for many other reasons.

A most interesting paper might be written on the subject of artificial lighting, going specially into the various forms of lamps which have been in use from time to time, leading up to the present methods of turning night into day. We would then be carried back to the clay bowl filled with oil into which twisted grasses were placed as wicks; then to the early candle, consisting at first of grasses around which grease was daubed. Slowly, slowly we could watch the trifling improvements in these lamps, including the development of the lantern, as they went about their work of filling the air with smoky fumes. Then we would be able to smile at the crudeness of those who first used petroleum in its crude state; we would watch the millions of gallons of this same petroleum being carried by miniature canals, into the rivers of the south as the quickest way of getting rid of what was considered a nuisance. We would then follow the early attempts to make use of this, bringing us to the introduction of the modern oil lamp, the light of which was for a time regarded as one of the world's great wonders.

One of the most important advances made at that time was the development of the Argand burner (1782), afterwards adapted to gas lighting.

Then we would come to the next chapter, giving us the discoveries and accidents (for accidents played their part) which culminated in 1687, when Shirley suggested the possibility of using gas an an illuminant, little imagining how great and universal would be the usefulness of this product. Then, as this chapter develops, we will watch the streets of London, England, as they fill with an eager expectant throng, out to see the great sight of a street actually lighted by gas! This was in 1723, hydrogen being the gas then used, the idea being to see whether it was really possible to light the streets in this wonderful manner.

Then we will next have the patient thankless efforts to develop this as carried on successively by Hale, Clayton, Spedding, Murdock, Winsor, and others right through the eighteenth century,—none of them reaping much reward for their labours, many of them spending their all for the benefit of generations then unborn. But the chapter closes with a flourish as it shows us the picture of the Gas Works Clegg is building in 1807, and of Westminster Bridge, London, lighted by gas in 1813.

Chapter four would open at a little shop in St. Paul's Square, London. It is the year 1864. There were no electrical engineers then, for there was no such thing as electrical engineering. But the proprietor is gathering a few friends around in his wild delight to see the wonder he has evolved. For there, with a battery as the only then available source of electrical energy, he had given to the world the first arc lamp! But before our eyes have recovered from its glare, we find confronting us two other pictures, one of the wizard Edison, and the other of Swan, with the Atlantic between them but each working on the problem which eventually saw its solution in their hands in the introduction of the incandescent electric lamp.

Chapter five would take us back again to gas, and give us a glimpse at Aur von Welsbach experimenting with rare earths until at last he brings out his incandescent mantle, thus providing the lawyers of Europe and Americe with cases for many a day in the efforts made to infringe or preserve the patent rights; then the many improvements which have since been developed both in the manufacture and the means of using gas.

Just here we may well consider how the chain of events in the world's development links the work of one man with that of another. For the Welsbach mantle would never have existed but for the *apparently* less important invention by Bunsen of the burner (or more correctly, the principle) which still bears his name.

Chapter six would give us the birth of the Tantallum lamp, the general development of electric lighting, of the introduction of the Nernst lamp, the enclosed arc lamp, the flame lamp,—all very important developments. But history has now attained an accelerated speed and much which previously would have been considered important is now hidden in the deepest obscurity. Developments follow each other too rapidly to notice any but the very most important. There is the Mercury arc, the Moore tube, the Cooper Hewitt tube, and other devices. But all are eclipsed by the Tungsten lamp, whose wonderful development brings us up to the present day.

The article would be incomplete, however, without the seventh and last chapter reviewing the growth of the very study that the present paper has to introduce—Scientific Illumination.

So much then for the paper which *might* have been; so much for the attempts to find satisfactory "artificial light" so-called. When that paper is written, we will go into that matter further. For the present we will simply take it that we have got so far, and having so many available light sources, we want to know a little more about the best ways of using some of them so as to produce the best results. To this end we will confine our attention for the limited time at our disposal to consideration of a few points about the laws and characteristics of light, the structure and operations of the human eye, and the measurement and control of light and its distribution.

It is not possible to say what light really is, beyond stating that it is one of the great forces of nature, our knowledge being confined chiefly to its phenomena and the laws by which these are produced. Various theories have from time to time been put forward as to the mode by which light passes from one object to another or to the human eye, thus enabling us to see, two of which only are worth consideration. One of these is known as the "emission" theory, according to which small particles are emitted from the article seen; these are supposed to strike upon the eye and cause the sensation of vision. The other is known as the "undulation" theory. According to this all bodies and all space are pervaded by a thin and elastic fluid called ether; that light (or rather, vision) is caused by a vibratory or undulating motion imparted to this substance; that these tiny waves or undulations produce the sense of sight when they strike the nerves of the eye as do sound waves when they strike the nerves of the ear. The latter is the theory now generally accepted.

The velocity of light was first established by Rœmer, a Danish astronomer, in 1675, from observation of the satellites of Jupiter. He concluded that its velocity was 192,500 miles per second. Since then, however, it has been pretty well established that the actual velocity of light is 185,157 miles per second.

If we pass a ray of sunlight through a glass prism we get upon the screen a streak of light of a graduation of colours: violet, indigo, blue, green, yellow, orange, red. This is of the utmost importance. It is admitted by all that the best artificial light is that which approximates most nearly to the character of sunlight. We say that light is red when the red rays predominate; or by the blending of colours, when blue and yellow rays are most in evidence, we have green rays. What we call white light is really the effect produced by a correct blending of all the colours. By the application of this test, we can determine the value of any light source for purposes of ordinary illumination. It will be readily seen that although a light may be very bright, it may still be a poor illuminant, because of its colour composition. The Moore tube provides us with light which is almost absolutely the same as diffuse daylight. But this apparatus is not altogether suitable for commercial use. The following will give an idea of the character of some of the most generally known light sources. It may be well to notice that the yellow rays give the maximum light effect.

TYPE OF LAMP	COLOUR CHARACTERISTICS	REMARKS
Open arc	Bluish white (nearly white)	Somewhat unsteady; gives very strong shadows; brilliancy is bad for eyes Improved by the use of suitable glass globes
Enclosed arc	Bluish white (nearly white	
Flame arc	Generally yellowish	High intrinsic brilliancy. Colour depends upon treatment of carbons. Efficiency is highest when golden yellow.
A.B. Regenerative arc	Yellowish	Partially as other arcs above mentioned. Lights large areas.

TYPE OF LAMP	COLOUR CHARACTERISTICS	REMARKS
Tungsten	White	Has long life. Gives best results and lasts longest on Low Frequencies, or on D.C. if voltage is constant. Efficiency is very high.
Tantallum	Yellowish white	Colour is better than that of carbon lamps, efficiency less than Tungsten Filament is very strong, equal to mild steel. Best on low frequency.
Carbon	Very pale yellow	Requires about twice as much energy as Tantallum, and three times as much as Tungsten, per c.p. Good penetrative value, but now superceded by other lamps.
Gem	*Very* pale yellow	Better colour and much more efficient than carbon.
Nernst	Greenish white	Economic and steady, but a rather bad colour. Throws strong shadows; should be hung as high as possible.
Incandescent Gas	Greenish white	High brilliancy but low penetrative value, consequently poor distribution. Gives maximum light *above* the horizontal, if upright mantles are used.
Open flame Gas	Reddish yellow and violet	Unsteady. Very hard on the eyes, and very inefficient. Entirely superceceded.

One o: the strongest objections to gas lighting, and which is unfortunately not improved by the incandescent mantle, is the amount of poisonous fumes given off. These being heavier than air do not rise and remain at the top of the room, but sink to the floor level and by accumulation, if ventilation is not *very* well arranged, it rises to breathing height. It can be mitigated by drawing air from the lower part of the room instead of the upper. This, however, is ventilation, and our subject is illumination. It must not be overlooked that the Flame Arc may have a variety of colours, depending upon the chemical used in preparation of the carbons. The characteristics here given are those referring to the types and colours most generally used. Taken apart from any other consideation than that of the colour of the light, it will be seen that the naked or open arc and the tungsten lamp are the two sources from which we get the nearest resemblance to daylight effect, whilst the worst of all is the naked gas flame. From its effect upon the eyes and their power to see the violet or ultra-violet are the worst colour rays; blue ranks next, and green follows. "Why, no!" says somebody "Green is not hard upon the eyes. Go out on a summer's day and see how easy it is to the eyes when you are looking at the green grass and the green leaves; it seems to rest the eyes!" Granted. But let us see how this comes about.

It has already been said that white light is the effect produced by the correct blending of all the colours in the spectrum. One colour is said to be complementary to another when in combination with that other it produces white light. Thus red is complementary to greenish blue, yellow to indigo blue, and so on. Take two lamps, one giving a greenish blue light and one a red light, and, provided the lamps are of the right intensity, the result is neither red or green or blue, but a clear white light! So, in our little landscape view we have not only the green grass, but also the golden sunlight and the blue sky, and the result of the whole combination is nothing more or less than a clear white light.

The lesson which the Illumination engineer takes from this will need but very little argument now that this has been mentioned. Get from your light source a clear white light, and let your surroundings be of such colours as will blend without giving any preponderance of such colours as will be irritating to the nerves or injurious to the eyes.

The question of colour is one of the important items that has to be considered. Most of us have noticed occasions when we have gone into a room which seemed to have enough light, and yet we have found it difficult to see distinctly. One of the possible causes would be found in the character of the light as to its colour composition. The colours of surrounding articles lose some of their value by most forms of artificial light. We are all well aware that green will appear to be of a totally different shade when seen alternately by daylight and by gas light.

It may not be out of place at this point to recall what we mean by saying that articles have a certain colour. For instance, when we say an article is red, we really mean that it absorbs all the ray of light excepting the red rays, which it reflects,—a sort of automatic and natural form of light analysis and selection. A thing is said by us to be absolutely black when it absorbs all light striking upon it and reflects none. Likewise, when we say that something is white, we really mean that it reflects *all* the rays of light which fall upon its surface. Throw daylight upon it and it appears white; throw a yellow light, and it will appear yellow; and so on with any colours. But take a piece of blue cloth or other material and place it in the yellow light, and the blue will be difficult to recognise. Much could be said about this and many esperiments made did space permit. But it will be obvious that it is very desirable to *have the light as nearly like daylight as possible.* But a most important consideration is the effect of colours upon the nerves, and consequently upon the general health. Nobody knows when or by what argument a red light or a red flag was first adopted as the signal of danger: the choice of that colour came by instinct. Why does a bull become enraged by the waving of a red flag? Just for the same reason. It can now be fully demonstrated that there is real logic behind this, and that when the eye has to frequently see red colours the whole nervous system becomes distressed, and extreme irritation may result.

Many medical men have expressed themselves strongly on this question of the colour of the light that is used. Red is irritating, green very depressing. Professor J. R. McGrath, addressing the convention of illuminating engineers at Chicago last spring pointed out that care was necessary, not only in the selection of the right light source, but also in regard to the choice of shades and globes, adding "Gaudy lights in a living room have a more depressing influence upon the spirits than debts or indigestion. Red, blue, yellow, green, purple, or any other sort of tinged light globes diffuse rays that are conducive to sadness. If you want to chase the glooms and summon the joys, have white lights, but see that they are properly shaded." What applies to the home also applies to the office, store, warehouse or factory. The highest efficiency certainly is not reached by the worker whose eyes are wearied by light which is unsuitable. As one link will weaken a chain so will each and every single cause of inefficiency weaken the efficacy of a whole factory. We shall have more to say about the effects of incorrect lighting upon the eyes after we have considered the structure of the eye; but in passing it might be said that from the standpoint of efficiency—or if you like to put it another way, of *profit making*, the importance of good lighting cannot be overlooked. It is seldom indeed that the work of the illuminating engineer does not pay a handsome return for the amount which his services cost.

A little more than a year ago, the proprietors of a Toronto provision store were called to face the fact that their business was rapidly dropping off to an alarming extent. A business expert was consulted, and fortunately for them he was a man of the new school. He advised that an illumination man be called in. The store was re-painted, nearly everything being made white; a very fine, though not very expensive system of lighting by Tungsten lamps was installed. Trade immediately increased; in less than six months it had doubled, and they now have the finest business in that neighbourhood.

Similar things could be said of factories; numbers of cases could be cited showing that the factory output has been increased by the simple matter of having the illumination corrected. There is nothing very wonderful about this; it goes without saying that a workman will accomplish more work and do better work if he can see clearly what he is about. Of course most men will think that what they have is the best thing, or at least is good enough. The answer to this is that even a blind man will in time become quite satisfied with his lot. But let him once see the daylight and all this satisfaction will be gone!

After the question of the colour of the light has been considered, there are other points of importance to be watched. Three such stand out prominently because they touch the errors most commonly met with, particularly in factories and warehouses. The first of these might well be expressed under the word "glare." "I want a good light," says the workman. "Oh yes," says the foreman or superintendent, "we need a good light here." And then, to meet that need they install some light source having a great brilliancy and giving a good blaze of light. Now, if you are anxious to be laughed at, just try to tell those people that they are making a mistake!

Of course it will be at once admitted that there must be sufficient light to ensure sufficient illumination, also that of course some operations require more light than others. But it is good illumination that is required, not brilliancy of light. A common place illustration will demonstrate this point. Take a newspaper out into the bright sunlight of a July day, and try to read; you will soon give up the attempt because of the strain upon the eyes. But take that same paper out into the daylight on a dull December day, and you will find that you can read quite easily although there is not nearly so bright a light. This is the consideration which has made indirect lighting become so popular during the last two or three years. It, however, is not suitable for factory illumination as a rule, although it is suitable for the office or the store, for home, hotel, and church lighting.

The same fault—"glare"—is very commonly met with in another form. As a rule, the carpenter at his bench, the compositor at his case, the fitter at the vise, the cutter at his table and the draughtsman at his board, each insists upon having his electric lamp right down close to his work, whilst the clerk and manager go one worse by having desk lamps. It will be asked—what else can you do? There you come right to the work of the illuminating engineer, since nearly every case has to be treated upon local conditions. The point is though that all these can be fully met. In general the position for the lamp in factory, warehouse or almost any industrial uses is not near the work but near the ceiling. Even this must be varied sometimes, though. Indeed with regard to industrial lighting generally, it may be said that there are no fixed rules, because the local conditions vary so much

Then there is the question of uniformity in distribution. The prevalent practice is to place a lamp in such a position that it will cast its light upon certain places, leaving other places in semi-darkness. This is one of the errors to be guarded against. What is really required is that the room itself shall be properly lighted.

The reasons for all these things will be seen and readily understood if we make a brief study of the human eye. Since the sole object in illumination is to enable us to see, it will be worth while for us to consider the structure of the organ of vision, and the method by which we see.

Take the front view of the eye. The black centre is of course the pupil and the coloured portion around it the iris. Though the pupil appears to be black, it really is colourless. It is the tubular space through which the rays of light pass. The action and in fact the whole purpose of the iris is of the first importance in connection with the subject we are now considering. When we enter a place where the light is very poor, the iris expands. After a while we find that we can readily see articles which at first we could in no wise discern, the reason being simply that the iris has expanded and allowed more light rays to pass into the eye. Just the opposite result occurs when we are subjected to too bright a light. The iris now contracts in order to exclude some of the superfluous light rays.

But before we go further with this let us look a little further at the structure of the eye. It must be admitted that it is not within human capacity to fully comprehend how the nerves convey the impressions of the light waves to the brain giving us what we call sight.

The outer surface of the eye is covered with a transparent cushion called the "cornea." Here the rays are a little "refracted" or slightly changed as to their course. Then the light rays pass through the pupil, the size of which is controlled by the involuntary muscles of the iris, after which they pass through the "crystalline lens" (this being to the eye just what the lens is to the camera). The picture is then made upon the sensitive surface at the back of the eye called the (retina) corresponding to the film or plate in the camera. The retina is really a portion of the optic nerve spread over the back of the eye, and the optic nerve itself conveys the impression to the brain.

We have already said that a bright glaring light is an error to be guarded against, and the truth of this will be readily apparent. Let us now come back to the iris and the pupil. As we have seen, when the light is too bright, the iris adjusts itself so that much of the superfluity of light is excluded, and of course might as well not have been provided so far as its usefulness goes; it is sheer waste. But this is only part of the story. The action of the iris is only intended to serve the conditions found in nature, and consequently its action is limited, and when there is a superabundance of light, too much is admitted to the eye and causes a form of paralysis in the nerve itself, besides being a very prolific cause of various nerve troubles the connection of which with the lighting in use might easily be overlooked. If this trouble is allowed to continue, the sight becomes impaired and permanent injury occurs.

Again: we do not look at the sun when we wish to see, but at the article upon which the sun's light is shining. Even then, though, if the rays of light are directly reflected into the eye, we find it almost impossible to see. Either the light must be diffused or must have been softened by repeated reflection, or its effect is to partially paralyse the retina.

The lesson from this in the application of artificial lighting is obvious. The light source should be placed above or in some way beyond the line of vision, and so situated that whilst it will illuminate the article or area which we wish to see, there will be no possibility of rays of light entering the eye directly. And if the articles at which the eye is directed are of a bright, glossy surface, it will still be necessary to have the lamp in such a position that the light is not reflected from the article directly to the eye.

Again: as to uniformity of illumination: suppose a bench to be well lighted, and the surrounding room in semi-darkness. The pupil, whilst we are looking at the bench, contracts. But we cannot possibly keep the eye still for any long period—it is always moving. And when the semi-darkness of the room is encountered, the pupil expands. It will be obvious that the pupil is called upon to expand and contract at a rate far greater than nature ever provided for, and becomes weak and partially fails to respond. This is another frequent cause of permanently impaired vision. Good eyes are as necessary as good lamps, and the importance of assisting the eyes scarcely needs to be emphasised.

This brings us right to the question of the control of the light. It will reasonably be asked: "How are you going to see if you do not have the light near to your work?" The answer brings in the next part of our subject—Reflectors. With an electric lamp of nominally 16 candle-power, it will be observed that quite a large proportion of the light given strikes out at an upward angle, and the maximum light is given in a horizontal plane level with the centre of the filament of the lamp. Its minimum is at a point immediately below the centre of the lamp. It is said to be giving 16 candle power, but that light is given at the very point where it is of the least use. The same difficulty occurs with every form of lamp when used without a reflector. With *correct* reflectors, it is possible to make use of all this otherwise wasted light by directing it to the plane to be illuminated. Without a reflector we had at a point immediately under the lamp, six candle power, whereas now *with* a reflector we have thirty-six candle power.

One of the most important developments in connection with this subject is that of the scientifically designed reflector. Care must be taken, however, to use the right kind or type for the actual conditions that exist, a decision which cannot be got at by any rule of thumb method. It is possible for an illuminating engineer to decide upon the correct amount of illumination necessary and then to select such reflectors as, with the proper spacing of the lamps at the proper height, will give just the desired results with great efficiency and economy.

The results to be obtained from reflectors are now figured out in cold mathematics. For most industrial purposes, of course, those made of steel are to be preferred, and in all these, whilst the details vary with different makes, the principles of all are the same, though no two makes or types will give the same results. In most of these the reflecting surface is of white enamel or (in one or two makes) of matt aluminum, either of which is very efficient. Some makers have at times adopted mirrored glass as a reflecting medium, but most engineers of repute object to its use—for many important reasons.

Light, when it strikes upon a reflecting surface, is reflected off from that surface at a similar angle but in an opposite direction to that line in which it came. The important thing then in the design is to have the *shape* of the reflector such that the light will be reflected to a given area and direction, with the least possible waste. It must be remembered that the intensity decreases as the area increases and *vice versa*. If all your light is confined to an area of four square feet and has an intensity of twenty candles, you will find that if you increase the area to forty square feet you have reduced the light intensity to two candles. But observe that the *total* result is the same in either case, i.e., 4 x 20=80, and 40 x 2=80. This would in fact in either case be described as a total of eighty "lumens."

The forms of glass-ware now being manufactured as adjuncts to lighting are, of course, in the words of the auctioneer—"too numerous to mention." They all resolve themselves, however, into a direct classification, as follows: (a) Ornamental glassware; (b) Direct reflectors; (c) Prismatic reflectors; (d) Diffusing glassware. With regard to the first it naturally occurs that the question is merely how far it is intended to carry the idea of ornamentation and how much are we prepared to sacrifice lighting efficiency in order to obtain it? It must be confessed that in far too many cases the aesthetic or ornamental consideration is carried much too far. This has been partly dealt with in connection with the question of colour earlier in the paper. (b) This class also includes a great variety of reflectors. It includes all those glass reflectors excepting class (c) where the main idea is reflection and not ornamentation. They may be made ornamental in design merely as a secondary consideration. Unfortunately no fixed rules can be given for the proper selection, important as this is. The two principal considerations should be (1) efficiency, depending upon the shape and material of the reflector; (2) suitability, considering the area over which illumination is to be provided and the photometric curve of the reflector in question.

(c It would be nearly correct to refer to this class as "refractors" instead of reflectors, since their high efficiency is largely due to their refraction of light rays. These are becoming increasingly popular, and are regarded by all authorities as representative of the highest grade. Their usefulness is, however, often curtailed by injudicious use, for these, more than others require care in selection. There is one point which must be emphasised; always be sure that you get the genuine "Holophane" goods when considering glass reflectors of this class. There are many imitations much like them in appearance but generally little value. Indeed, whilst prismatic reflectors can be obtained to meet nearly every need, we are bound in honesty to acknowledge that the "Holophane" reflectors have this class "all to themselves."

(d) Diffusing glassware has come into much use during the past two or three years, chiefly as the result of the adoption of large Tungsten units. One of the most usual forms of employment is by way of a globe surrounding the lamp; another form occurs where a bowl is placed beneath the lamp. Various kinds of glassware are used—sanded glass, opal, opalescent, and translucent glass like that known as "Alba," "Moonstone," etc. The purpose here is to diffuse the light by breaking up the rays and scattering them equally in all directions. This is particularly useful where ceilings are low and the lamp otherwise would come within the line of vision.

The main point to consider with diffusing glassware is the efficiency. Some forms absorb as much as 60% of the light, leaving only 40% for use, whilst others absorb only about 14%.

To go into the various uses of the many principal types of reflectors would be to go far beyond the intended scope of this article. Before closing, however, we would emphasize these points as of the first importance:

(a) The entire abolition of naked gas flames where gas must be used;

(b) The careful shading of *all* bright lights;

(c) The avoidance of *too much* brilliancy or "glare";

(d) The general use of Tungsten lamps;

(e) Care in selecting the right size of lamp to get proper distribution with economy;

(f) The proper spacing and height of lamps;

(g) The use of *carefully selected* reflectors.

Volumes have been written, and many more could be written, on this interesting subject—a subject which becomes increasingly interesting to those who take the pains to study it. The most that the writer hopes to achieve in the present instance is to direct attention to its importance and value, particularly in connection with industrial concerns. It is hoped, however, that some of the suggestions herein briefly suggested will prove of some use to those who have exercised such patience as to follow it through, and that to some extent it will help to promote "good lighting."

Chairman,—

Gentlemen,—We have heard Mr. Helps' very exhaustive and carefully prepared paper, and I only regret that we did not get the proper current so that the views could have been better shown on the screen.

I feel sure Mr. Helps has gone into this matter thoroughly to find the easiest colour to the eye for illumination purposes, etc., and will only be too pleased to answer any questions which you may have to ask him.

Mr. McRae,—

Mr. Chairman, one thing I would like to ask the speaker is this: what form of light does he consider the best, direct, indirect or semi-indirect.

Mr. Helps,—

Mr. Chairman, if the gentleman who asked that question will give me some information as to the size of the walls, the height of the room, and the colour of the walls, I will endeavour to answer his question fully.

Generally speaking, for the home, or in fact in almost any place of that description, indirect lighting is suitable, although it requires about 60 per cent. more wattage than the direct system.

Mr. McRae,—

The building I had reference to was an office building, with nearly white walls, 12, 14 or 16 feet high and large offices.

Mr. Helps,—

Under these conditions, I think indirect lighting would possibly be better than direct lighting. It gives illumination without glare; that is one of its great features. I did not give it more than a passing reference in the course of the paper because it is not very suitable for factory or general industrial lighting, in which most of the gentlemen present are interested.

Mr. W. S. Butler,—

I am sure Mr. Helps has gone into the subject of scientific illumination quite thoroughly. There is one thing in connection with indirect lighting which is sometimes overlooked. Very often in a room with a low ceiling there is too much light thrown on the ceiling and when you look at the ceiling the iris closes up and makes the pupil of the eye small, and when you look down at the parts of the room which are not so brightly illuminated the iris of course expands; it makes the pupil of the eye larger which throws a constant strain on the eye. This is one of the things you have certainly got to guard against. When you are using indirect lighting, it is very necessary to consider the conditions which you are working under. One of the best systems is the semi-indirect system of passing lighting through a glass bowl and splitting it up in all directions, and at the same time throwing a portion of the light on the ceiling. This gives a very desirable light and effect.

I think that the great trouble with most lighting systems are that they are designed by people who know little or nothing about the Science of Illumination.

I have in mind an incident which I should like to relate, as it bears on this subject.

Some time ago one of the churches in this city had a new lighting system installed which was supposed to be perfect; it was very good with the exception of the lights under the gallery. They used the Holophane shade throughout the entire installation. The Holophane shade is the most scientific shade in the world. I went to this church and was very surprised to see that although the light was very good in some parts of the church, there were spots underneath the gallery which were almost dark. I called up the minister of the church next morning, and asked him what was the matter with it, and he said, "I don't know; I know there is something wrong with it. Do you think you could tell me?" "Well now," I said, "I don't know." He said, "Come down and have a look at it." So I went down, and saw in a moment what was the matter with it. As I said before they used the Holophane shade; under the gallery they used type F or Focusing shade, and type E or Extensive shade up in the dome. "Now," I said, "if you will reverse these, bringing the extensive type E shade down below the gallery and put the focusing type shade up in the dome, you will get much better results." However, he took my advice and reversed them; he is now having good results. As I said, this is the great trouble: people in selecting shades, select the shade which pleases them regardless of efficiency.

Mr. Helps,—

In regard to Mr. Butler's remarks, I might state that the question of indirect lighting fixtures giving a glare is a question of the design of the fixture. I had to abbreviate somewhat and so did not say much about "Holophane." I consider that the Holophane glassware is in a class by itself. There is nothing in the world to compare with it. For scientific reasons, Holophane glassware is the best in the way of prismatic reflectors that this world has ever produced. There is, however, a great deal in what Mr. Butler has said in regard to the choice of the *correct form* of reflector. It is highly important.

What is known as semi-indirect lighting is a mixture. It is a case of mixing indirect lighting with direct. Some of the light is thrown on the ceiling and reflected down into the room, whilst some is permitted to pass down through a translucent glass bowl, which causes a breaking up of the light, sending it off hither and thither. As a matter of fact, it is not very efficient. It relieves the eyes.

I would like to relate to you an incident which has just come to my mind. Some time ago I was given the task of designing the lighting system for a church.

I used a special form of Holophane glassware, and on the first Sunday evening the work was not quite completed. The people said there was not near enough light. "Oh!" I said, "the work is not quite completed,"—there were a few screws to go in, etc. On the following Sunday, they were quite cheerful to see the improvement in the light. They called me up on Monday and told me the light was much better. I told them th there was something to be done yet. The following week, the could not wait until Monday morning, but called me up Sunday night, and said that the light was just perfect. Two months later they were wondering whether they didn't have too much light. I need hardly say that they were getting the same amount of light all the time.

The walls were about thirty-eight feet high and a special type of Holophane glassware was used. Thus we had good illumination without the glare. But popular prejudices often count for a while.

Mr. G. D. Bly,—

Which is the best, direct current or alternating current? and then second, I find the electric light very irregular; when we want illumination in our rooms, houses, etc., the voltage is usually down, but when you get up at 1 or 2 o'clock in the morning and turn on the light, it is unusually bright, and the whole house is lit up almost beyond your imagination. Is it not possible to regulate this voltage so as there will not be this great variation. Take the Hydro along the streets: one night the streets will be well lit up, and the next the lights will be very dim.

Mr. Helps,—

In reply to the question, which is the best, direct current or alternating current, I think the only question is which have you got. You can get precisely the same illumination from either. Under some conditions special attention has got to be paid to details; some lights have to be enclosed, and others shaded. It is important that we impress the necessity of proper care of the eyes. The bright light striking the eyes (as for instance right in this room the glare of the light is right in your eyes) should not be; the lights should be shaded in some way, or better still, kept out of the line of vision.

As to the effect on the eyes of alternating or direct current; the point is one which has never been completely settled. The effect of the variation would be to tax the iris or the pupil of the eye; when it is too rapid to take that effect, say for instance a 25 cycle lamp, where the changes are at the rate of over 5,000 per minute, the iris is not sufficiently sensitive to take any notice of it.

In regard to the light being brighter at 2 o'clock in the morning than during the evening: this is largely a question of voltage regulation which should be attended to at the central station. It may be perhaps accounted for in another way. Bear in mind the fact that at 2 o'clock in the morning, when the nerves are at repose, even a match light would seem very bright.

Mr. McRae,—

Mr. Chairman, I would like to ask through you, Mr. Chairman, why is it that on the streets of Toronto they have three lamps of say 60 watt on the lamp post and two of 60 watt under ground. Why do they have these two lamps under the ground?

Mr. Helps,—

If I were to try and fully explain that question, it might be said that I was trying to get back at somebody. Anyway, when the Toronto Hydro Electric System was in the making a certain man set out to do some designing. Well, he made some mistakes, and so in many places where one would expect to find lower voltages there is only 550 volts provided. If you are using five lamps, each requiring 110 volts that is all right. But the powers that be at present seem to think it is all right to put three on the top of the pole to light the street and two underground—where they cannot be seen

Mr. McRae,—

I might say, my reason for asking that question was: My manager asked me one day to explain it to him, and I didn't know the reason.

Mr. Helps,—

I have noticed it myself. It seems to me to be not the most sensible thing in creation to put three on the post and two underneath the ground. If you have got to use them, surely they could be so arranged that the five could be put on the post. It certainly looks like hiding your light under a bushel.

Mr. Butler,—

I think it was a very fortunate thing in connection with the 25 cycle which came into force just at the time that the tungsten lamp was being perfected.

Had the engineers who designed that system known that the Tungsten lamp was going to be the lamp that it is to-day, I very much doubt if these engineers would have advocated the use of 25 cycle. 25 cycle is not at all suitable for small units and it is impossible to use large lamps in all installations.

Mr. Helps,—

I am afraid I must disagree with Mr. Butler.

Had they known that the tungsten lamp was coming into use the one system that they would have adopted would have been the 25 cycle It so happens that low frequency is far better for Tungsten lamps than higher. If you have a perfectly even voltage (and you seldom get that) direct current is slightly better. This is well illustrated in Foster's "Electrical Engineer's Handbook" if anyone cares to take the trouble to look that up. The results are all right if the conditions are right. Not under the conditions, however, that Mr. Butler has been in contact with. Mr. Butler is very well acquainted with a system of illumination which is in my mind very bad. You have that very fact in certain institutions in this city where Mr. Butler has seen the 25 cycle lamp in small sizes (25 watt) placed immediately over a reading table. The whole system of illumination is in my opinion much at fault. Now, then, do away with these conditions and get your illumination system and details brought up to a high and correct standard of efficiency, and you may search a long time before you will find the awful flicker.

Mr. Bly,—

In our homes the women insist on having a four or five light fixture in the rooms for ornament, and we must use a 10 or 16 Watt lamp. When we sit down to read the light vibrates considerably, and it is very unpleasant. Before we had the Hydro we were not subject to these vibrations. The Toronto Electric Light Company went into this and they so arranged the switches in the office that they could change from the direct to the alternating current without the clerks knowing it. I do not know whether it was done at noontime or not, but it was so arranged that they could light with the direct current and then with the 25 cycle alternating current, and they found that when they put on the 25 cycle, the clerks became restless and could not stay at their work.

I think when the Hydro-Electric came to Toronto, it was the worst thing possible for the people.

Mr. Helps,—

The answer to that is this: the Pearson Co., who are really the owners of the Toronto Electric Light Company, went to the expense of securing the very best engineers from all over this continent, to advise them as to the best way to re-arrange their equipment so as to bring it up to the most modern condition. This of course being only a year ago was after the Tungsten lamp came. The result was that 25 cycle is the supply they have adopted as their standard.

The very difficulty in regard to vibration of the light was explained by Mr. Bly. Is it to be a question of ornamentation or proper scientific illumination?

Mr. Bly,—

It is my contention that the citizens of Toronto are compelled to throw away the fixtures which they have bought and installed for others to suit the current which the Hydro-Electric Company will supply at the expense of our eye-sight.

Mr. Helps,—

If Mr. Bly will kindly let me see the fixtures in question, I will endeavour to show him how to remedy the trouble.

Chairman,—

I think we have got this thing very well thrashed out, and I am sure we have been all delighted with Mr. Helps' very interesting and exhaustive paper.

Mr. McRae,—

I move that the members of this Club tender a very hearty vote of thanks to Mr. Helps for the very interesting and instructive paper which he has read before the Club this evening. Seconded by Mr. Bly. (Applause.)

Mr. Helps,—

I thank you very much for your vote of thanks, and I think that the pleasure has been all mine. I only regret the trouble we had getting current for the lantern, and the views were not as plain as they would have been had we had the proper current.

The meeting adjourned at 11.15 p.m.

NOTICE

Change in Date of February Meeting

The regular February Meeting will be held on

FEBRUARY 5th AT 8.15 P.M.

In conjunction with the University of Toronto Engineering Society, in

Convocation Hall, Toronto University

When a paper will be read, illustrated with Motion Picture Exhibit, by Mr. F. N. Speller, Metallurgical Engineer, National Tube Co., Pittsburgh, Pa.

Subject:

"THE MANUFACTURE OF STEEL TUBING"

A full attendance of Members and Friends is requested.

Take either College or Bloor car.

C. L. WORTH,
Secretary-Treasurer.