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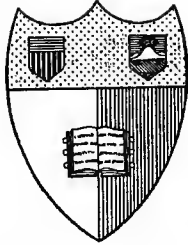
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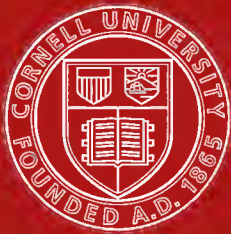


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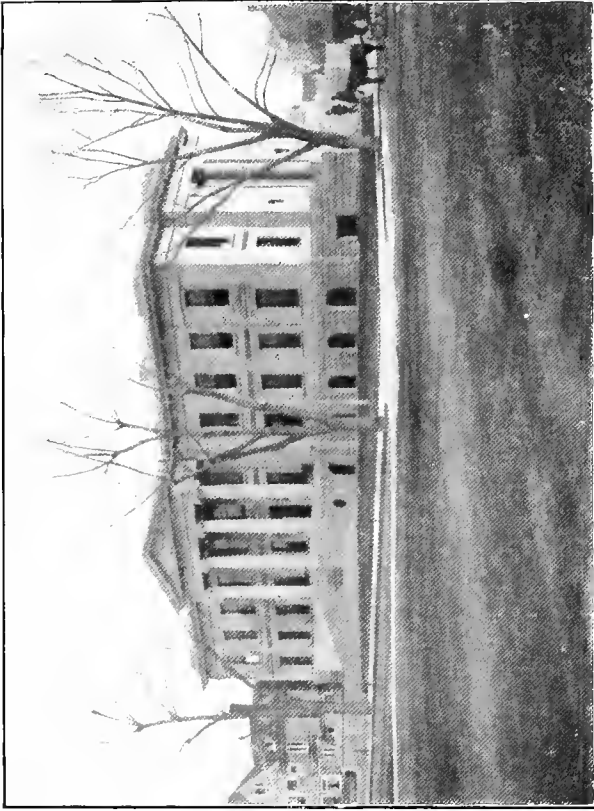


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CITY HALL, COLORADO SPRINGS, COLO.

BUILDING IN WHICH THE HEARINGS BEFORE THE BOARD OF ARBITRATORS WERE HELD

A
COMPILATION
OF THE
RECORDS
OF THE
COLORADO SPRINGS LIGHTING CONTROVERSY
WITH AN
INTRODUCTION AND EPITOME

BY

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LIGHTING CONTROVERSY, 1907,
ETC.

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PREFACE.

The controversy between the City of Colorado Springs, Colorado, and the Pike's Peak Hydro-Electric Company of the same city, has become memorable because it decided for the first time in a judicial way three questions of importance to those engaged in the business of electric lighting.

First: The meaning of the phrase "An arc light of standard 2,000 candle-power."

Second: The monetary damage accruing by the substitution of a 6.6 ampere series alternating-current arc lamp for "an arc light of standard 2,000 candle-power."

Third: The financial damage resulting from the failure to maintain the substituted lamps at their normal operating conditions.

The controversy is furthermore of unusual interest and value, because there was put on record, under oath, the opinions of many of the leading experts of this country on questions of lighting, arc lamps and illumination.

The important character of the questions settled, the permanent value of the opinions of the experts, the precedent established as to a fair and sensible method of settling an engineering controversy, the repeated requests for statements of the exact points involved, copies of the testimony, the arbitration agreement, the award, and the fact that the case was arbitrated under the statute—therefore no record of the findings appear in the law journals—all these considerations have seemed to demand that the history of the case be put in book form.

Following a general synopsis of the controversy by the editor, the matter herein has been arranged, for the most part, in the natural order of its introduction in the case. The Exhibits—those of the Plaintiff being numbered and those of the Defendant being lettered—have been grouped together seriatim, ahead of the testimony, for convenient reference. The testimony given at the Hearings is arranged in the order in which the Witnesses were heard; the Closing Arguments of the Attorneys, the Award

of the Arbitrators, and an Index conclude the subject matter of the book.

The Editor desires to gratefully acknowledge the cordial cooperation of the witnesses, attorneys and the two other arbitrators in the preparation of this publication.

HENRY FLOY.

New York City, January 2, 1908.

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Introduction and Epitome.

HISTORICAL RESUMÉ.

The street-lighting controversy between the City of Colorado Springs, Colorado, and the Pike's Peak Hydro-Electric Company arose over the interpretation of a clause in a City Ordinance. The Ordinance, known as the "Jackson Franchise," (see Exhibit No. 1) was granted by the City of Colorado Springs, September 8, 1898, for twenty-five years to one George W. Jackson, and by him assigned to the Pike's Peak Hydro-Electric Company. The franchise, aside from allowing the grantee to string wires, lay conduits, and exercise other rights within the city limits, gave him the use of the City's water supply, for the purposes of power generation—which has been developed to the extent of some 3,000 horse-power—in return for his completing certain constructions in connection with the water works of the City and furnishing to the grantor, for electric lighting, "arc lights of standard 2,000 candle-power" at the rate of \$66.00 per annum, and in addition some minor, free, electric service. Furthermore, any plant, erected by the grantee to supply the City, to become the property of the City at the expiration of the franchise.

Soon after the granting of the Jackson franchise, and until the grantee could begin furnishing light thereunder, the City of Colorado Springs entered into a contract for lighting its streets, on a moonlight schedule, with the El Paso Electric Company, using lamps, which in the wording of the contract (see Exhibit No. 22), "are commercially known as arc lamps of 2,000 candle-power." This contract, dated April 1, 1899, and running for five

years, was taken over by the Colorado Springs Electric Company, successors in interest to the El Paso Company. With the consent of the City, a new contract, dated September 5, 1901 (see Exhibit No. 23), was substituted for the one inherited from the El Paso Company, under which the Colorado Springs Electric Company agreed to supply lamps commercially known as "6.6 ampere, enclosed, arc lamp of the series, alternating system" to the City, on practically a moonlight schedule, for \$80.00 per year, a reduction of \$18.00 per annum, per lamp as compared with the price under the discontinued contract.

Finally, in February, 1905, after the Pike's Peak Hydro-Electric Company had completed part of its construction in connection with the water works, so that it could use the city water, had notified the City that it was prepared to carry out the terms of its contract with regard to lighting the City streets (see Exhibit No. 47), and after an informal conference in the store of one of the Aldermen, named Perkins (which was the subject of much controversy in the hearings before the arbitrators), the City Council, at a regular meeting, formally authorized (see Exhibit No. 46) the Pike's Peak Hydro-Electric Company to begin the use of the City's water and to inaugurate the lighting service to the City under the terms of the Jackson franchise.

The Pike's Peak Hydro-Electric Company having built its power plant outside of the city limits, and owning no wires therein, had arranged (see Exhibit No. 48) with the Colorado Springs Electric Company, whose contract was now being discontinued, to act as its agent, to light the streets of the City. It had also arranged to supply "en bloc" to the Colorado Springs Electric Company for its own use, all the electric energy generated at the Pike's Peak Company's hydro-electric plant.

The representatives of the Pike's Peak Hydro-Electric Company claimed that it was understood by the representatives of the City at the informal conference in Alderman Perkins' office, that among other things, the Pike's Peak Company would, through its agent, continue to employ the 6.6 ampere lamps and wires of the Colorado Springs Electric Company in carrying out its obligations to the City under the Jackson franchise, and one of the Company's witnesses testified that all matters arranged at the informal conference were incorporated in a Resolution passed at a regular meeting of the Councilmen held the same day or the day thereafter. This Resolution, however, contains no permit to substitute any other lamp or light for that called for in the Jackson franchise, and no conclusive evidence was introduced that showed the City understood or agreed that the 6.6 ampere lamp would be furnished and accepted as equivalent to the light called for in the Jackson franchise. On the other hand, the City acquiesced in the use of the 6.6 ampere lamps to the extent of offering no formal objection to their employment for fifteen months, during which period it paid for the lights in full.

Dissatisfaction with the grant of the Jackson franchise and its provisions had been evinced several times by the citizens or public officials of Colorado Springs between 1898 and 1907. In 1900, the City brought suit to test the validity of the franchise, but the United States Circuit Court of Appeals held it to be valid and not forfeited. Claims were made that the owners of the franchise failed to carry out important obligations and had wasted and polluted the city water. Early in 1906 the City Council called for a report and opinion from the City Attorney covering the whole question, which report, presented March 22, 1906, stated that in the opinion of the City Attorney, the Pike's

Peak Hydro-Electric Company had "never furnished or offered to furnish to the City any electric light of 2,000 candle-power each," had overcharged the City for service supplied and had forfeited every right granted under the Jackson franchise and "no longer has any right to use of the City water or any other of the City's property." Upon the advice of the City Attorney, the City refused to pay the lighting bills presented by the Pike's Peak Hydro-Electric Company, beginning June 1, 1906, with the result that the arbitration herein discussed was mutually agreed upon to settle that phase of the controversy between the City and the Company.

ARBITRATION ARRANGEMENT.

The State of Colorado by statute provides that civil cases of controversy may be decided by arbitration. The law covering the matter is so concise, sensible and withal establishes such a desirable precedent that it is worth quoting at length.

CHAPTER 26 OF ARBITRATION.

282. All controversies may be arbitrated.

That all controversies which may be the subject of a civil action, may be submitted to the decision of one or more arbitrators, in the manner and with the effect indicated in this act.

283. Written articles of agreement—bind.

In order to make future arbitration obligatory and binding upon the parties, they shall before they make their submission, make and subscribe a written article of agreement, in and by which they shall agree to submit all matters, or some particular matter of difference, to the arbitrators named, and to abide their award; and also, that the award, when made, may be filed by the successful party with the clerk of the District Court, as a basis of a judgment, and that an execution may be issued for its collection.

284. Oaths of Arbitrators.

Arbitrators shall not have power hereafter to act until they take and subscribe an oath, before some person authorized by law to administer oaths, to the effect that they will well and truly try, and impartially and justly decide the matter in controversy, according to the best of their ability, which oath shall be filed with their award.

285. Power of Arbitrators—issue subpoenas—administer oaths—quorum.

Arbitrators duly sworn and entered upon their duties, shall have power to issue subpoenas for witnesses, while a court of record in proper case may aid and enforce by attachment, and after a trial and hearing they shall decide the matters in controversy in writing, according to the very right of the matters. Any arbitrator may administer oaths to witnesses, and when there are three arbitrators, two of them may do any act which might be done by all.

286.

The party in whose favor any award shall be made, may file the same with the clerk of the District Court of the county wherein the matters were arbitrated, who shall be authorized to enter a judgment thereon, and if such award requires the payment of any sum of money, it shall be lawful for the clerk to issue an execution, out of and under the seal of the court for the collection of the judgment.

287. Fees of the Arbitrators—to be included in award and paid before delivered.

Arbitrators shall be entitled to receive from the parties in whose favor the award is made, three dollars per day for their services, and the amount of their compensation shall be included in their award and in the judgment entered thereon by the clerk. The arbitrators shall not be required to deliver their award to such successful parties until their said compensation shall have been paid.

288. Res Adjudicata applies—impeachment of award—setting it aside.

Whenever it shall appear upon the trial of an action at law, or the equity, or in any legal proceeding, in or before any court of competent jurisdiction, that the subject matter of such action, or proceeding, or any part thereof, or the defense thereto, or of any part thereof, has been submitted to and decided by arbitrators, according to the terms of this article, such matter, so arbitrated, shall be held to have been adjudicated and settled, and not open, either directly or indirectly, for review; but this shall not be construed to prevent an adjudication by arbitration from being impeached and set aside for fraud or other sufficient cause, the same as a judgment of a court of record, nor to prevent a party from relief on the ground of mistake, inadvertence, surprise, or excusable neglect, or in case of other judgment orders or proceedings of the court.

Preliminary steps looking to a settlement, in accordance with the statute, of the lighting controversy between Colorado Springs and the local Company, were first arranged in June, 1906 (See Exhibit No. 2), and the final Arbitration Agreement (See Exhibit No. 3) was signed January 30, 1907. Under this Agreement, Professor L. G. Carpenter of the State Agricultural College, Fort Collins, Colorado, formerly State Engineer, Mr. E. L. Elliott, Editor of the *Illuminating Engineer*, New York City, and Mr. Henry Floy, Consulting Engineer, New York City, were agreed upon by both parties as constituting a Board of Arbitration, which should hear the evidence offered and render a decision in final settlement of the whole question.

The Board of Arbitrators met February 1st, 1907, in the Council Hall at Colorado Springs and, after being sworn, immediately proceeded with the hearings. The City was represented by its Attorney, Judge William C. Robinson; the Pike's Peak Hydro-Electric Company by Honorable K. C. Schuyler of Denver, Colorado; and the Colorado Springs Electric Company, although only indirectly interested, by Honorable R. L. Holland, of Colorado Springs, Colorado. A host of well-known, capable and fair-minded experts were called by both sides and their more important testimony is hereinafter given in full.

Under the Arbitration Agreement, the City claimed that the Arbitrators should base their award, if any, upon the ratio of the candle-power of the lights furnished the City to 2,000 candle-power, the figure mentioned in the Jackson franchise. That is, it demanded as repayment \$16,952.21 out of the total \$19,943.79, which it had thus far paid on account of lighting furnished by the Pike's Peak Hydro-Electric Company, with a similar reduction on the bills presented and unpaid, basing its claim on the ratio

of 300 candle-power, the figure derived from tests on the street lamps made by experts, to 2,000 candle-power, the figure mentioned in the contract. Moreover, the City claimed that such basis of award had been agreed to by the Pike's Peak Hydro-Electric Company, quoting in substantiation the paragraphs "A" and "B" of Section "First" from the Agreement of Arbitration. Attorneys for the Pike's Peak Company maintained that the clauses referred to had been inserted in the Arbitration Agreement only as a claim of the City, which had not been assented to by the Company. Considerable acrimony developed over the interpretation of these clauses, which the Arbitrators ignored, because of the form of the Agreement of Arbitration itself, the contradictory statements made by the two parties to the Agreement and the little likelihood that the Pike's Peak Company would stipulate in advance, as a basis of award, the ratios of candle-powers.

The fuller statements of the claims of the parties to this controversy are best set forth in the verbal arguments presented at the conclusion of the hearings by the respective attorneys in their closing addresses to the Board of Arbitrators.

HEARINGS AND TESTIMONY.

All the hearings for taking the testimony of the witnesses were held in Colorado Springs. They continued for eight days without interruption, except for Sunday; morning and afternoon sessions being held daily, and in some cases, night sessions also. After the conclusion of the hearings, the Arbitrators conferred for one full day and then adjourned to await completion of the stenographic reports of the testimony of the experts and the

arguments of the attorneys; also requesting the attorneys to submit written briefs on the question of the City's being estopped from claims for rebates.

In reproducing the records of testimony given by the witnesses, questions to show their competency have been omitted, as in all cases the witnesses were accepted, and the brief statement given under the name of each, on page 29, is believed to be sufficient identification. All discussions of extraneous matters, such as time and place of adjournment, orders of procedure, semi-personal or legal exchanges of opinion, immaterial to the real subject of the controversy, have also been omitted.

In order to arrive at a clear understanding of the relations between the City and the various Lighting Companies operating in Colorado Springs, the contracts and the evidence of Messrs. Mac-Millan, Rouse, McIntyre, Taff, Dillon and Tripp should be read. The other witnesses were called mainly to secure expert testimony as to questions of light, candle-power, arc lamps, electrical measurements, etc.

At the conclusion of the testimony, the respective attorneys were requested to immediately make their closing arguments, no time being allowed for especial preparation. These arguments are given hereafter, in abbreviated form, both attorneys having kindly co-operated with the editor, by omitting all but their leading thoughts from the printed addresses, and this may have resulted in some lack of smoothness or continuity in their present form which was not apparent in the verbal arguments.

EQUITABLE ESTOPPEL.

After the conclusion of the hearings, the attorneys, for the

respective parties to the controversy, submitted written briefs on the question of equitable estoppel, which had been claimed by the counsel for the Pike's Peak Hydro-Electric Company and strongly urged during his verbal closing argument.

The subject of these briefs may be summarized as follows:

The Attorney for the Pike's Peak Hydro-Electric Company argued that the City was precluded from asking damages, past and future, on account of the light furnished, because of two circumstances:

First. The City, through its Mayor, with several Councilmen, at a conference in Alderman Perkins' office, January, 1905, received verbal notification of, and there accepted as satisfactory under the Jackson franchise, the furnishing of lights through the lines and lamps of the Colorado Springs Electric Company then in use (which had previously been approved by the City as satisfactory under the terms of a contract made with the Colorado Springs Electric Company, September 5, 1901), and therefore the City was estopped from thereafter claiming that the lights furnished, through those lines and lamps, were not in accordance with the wording of the ordinance.

References:

- "Estoppel and Res Adjudicata," by H. M. Herman, Sections 772-776.
1 Dillon "Municipal Corporations," pages 485-523.
15 "American and English Encyclopedia of Law," page 1028.
Bank vs. Bank, 50 N. Y., page 582.
Blair vs. Watt, 69 N. Y., page 113.
Arapahoe County vs. City of Denver.
30 Colorado, pages 13-20.
105 Federal, page 11.
122 Federal, page 322.
27 L. R. A., page 827.
Mills A. S., Sections 4487-8,4496.

Second. The City allowed the Pike's Peak Hydro-Electric

Company to continue to supply certain lights for a period of fifteen months, paying full price therefor without formal remonstrance, and that, therefore, the City was bound to continue the acceptance of such lights.

References:

- Austin vs. Bartholomew, 107 Federal, page 349.
- Easton and Mahon vs. New York R. R. Co., 24 N. J. E. reports, page 49.
- Argenti vs. City of San Francisco, 16 California, page 256.
- Kneeland vs. Gilman, 24 Wisconsin, page 39.
- Central Electric Co. vs. Street Lighting District No. 1, 58 Atlantic, page 1080.
- City of Atlanta vs. Gate City Gas Light Co., 71 Georgia, page 125.
- Gilbert vs. City of Manchester, 55 New Hampshire, page 303.

The City Attorney, in answer to the first claim of opposing counsel, argued that the contract between the City and the Company was made by an ordinance passed by the City Council and accepted by the Company, which contract required lights of a certain candle-power; that the meeting in Alderman Perkins' office was not and did not pretend to be a meeting of the City Council, but it was merely an informal conference between certain members of the City Council and certain representatives of the Electric Company, of which no record was kept; that nothing done at that conference could repeal or modify the terms of the ordinance contract. He further argued that at the said meeting neither the City nor an officer of it received notice or knowledge that the lights to be furnished would be of less than the power required by the ordinance, and that the letters addressed by the Company to the City Council about the time of this conference, and the formal action of the Council in response to those letters,

showed that neither party intended that any change should be made in the ordinance contract.

The City Attorney further contended that as the Company had not expended or parted with any money or other thing of value, or in any manner changed its position in regard to the matter involved, by reason of any delay of the City in objecting to the character of the lights furnished, therefore, the City was not estopped from now claiming that the lights did not fulfill the terms of the contract.

References:

- Bouvier's Law Dictionary.
- Blackstone, 3 com. 308.
- Abbot's Law Dictionary.
- 8 Cyclopedia of Pleading and Practice, page 10.
- Lower Co. vs. Lowden Co., 27 Colorado, page 267.
- Birch vs. Stepler, 11 Colorado, page 408.
- City vs. Kirk, 7 Colorado, page 419.
- Shuman vs. Seymour, 24 N. J. Equity, page 143.
- Strong vs. District of Columbia, 4 Mackay, page 242.

Answering the second claim, the City Attorney held that the City had changed its Council and nearly all of its other officers very soon after the beginning of service by the Company. That the new Council, with reasonable promptness after being organized, expressed dissatisfaction with the lighting, and as soon as it had proof that the lights did not fulfill the contract, withheld all payments to the Company, and hence, the City acted with such promptness that it was not barred by the principle of equitable estoppel.

References:

- Bigelow, page 569.
- Birch vs. Stepler, 11 Colorado, page 407.
- Araphoe County vs. Denver, 30 Colorado, page 13.

After seriously considering the matter, the Arbitrators concluded, as they were appointed by both parties to the controversy to get at the "real right of the matter" without too much regard for legal technicalities, as the statute providing for arbitration could hardly have intended a tribunal appointed thereunder to decide matters before it based on delicate, legal interpretations of what constituted equitable estoppel, and as the legal decisions quoted by the respective attorneys more or less contradicted one another, and certainly did not clearly establish an exact precedent to the case under consideration, that therefore they were safe in waiving the legal claim of equitable estoppel and deciding the case on its moral merits.

AWARD.

Each having received the stenographic records and having separately considered the attorneys' briefs, the arbitrators reconvened in New York City on March 21st, and held continuous sessions, daily, until March 29th, 1907, when they made a unanimous award, in favor of the City, to the amount of \$7,123.67.

In taking up the subject before them, the Arbitrators considered it under five heads, as follows:

I. "Does the phrase 'Arc lights of standard 2,000 candle-power each' mean an arc lamp giving 2,000 actual candle-power, or if not, what was the generally accepted meaning at that time?"

As all the experts agreed that the term, 2,000 candle-power light, could relate only to a direct, constant-current, series, open arc lamp taking not less than 9.6 amperes and consuming, approximately, 450 watts at the arc, the Arbitrators had little difficulty in concurring with them.

II. "Do the arc lights which the Company has furnished, when operated under normal conditions, come within the meaning of the phrase, 'Arc lights of standard 2,000 candle-power'?"

The uncontradicted testimony of the expert witnesses was to the effect that the lights furnished by the Company did not come within the meaning of this phrase.

III. "If the lamps furnished by the Company, when operated under normal conditions, have not fulfilled the requirements of the phrase 'Arc lights of standard 2,000 candle-power,' what is the extent of the overcharge, measured in dollars and cents, due to such deficiency?"

This was one of the most difficult questions to be answered by the Arbitrators. By reason of the form of the Arbitration Agreement, and because of the contradictory statements made by the two parties to said Agreement, the Arbitrators did not feel justified in making an award based on the ratio of candle-power of the two lamps under consideration, as the Attorney for the City claimed had been stipulated in the Agreement of Arbitration. The testimony of the witnesses showed that while the candle-power of the light called for under the terms of the franchise was very much in excess of the candle-power of the light furnished by the Company, yet the enclosed arc lamp had certain compensating advantages as compared with the open arc lamp. Consequently, the Arbitrators concluded that, in determining the "real right of the matter," candle-power alone could not fairly be considered by them in fixing the lighting damages sustained. The evidence adduced, indicated the 7.5 ampere, alternating, series, enclosed, arc lamp could be considered as giving a fair equivalent for the light stipulated in the franchise. The difference in candle-

power between this 7.5 ampere and the 6.6 ampere lamp of the same type was, according to the testimony of the experts, about 20 per cent., which figure the Arbitrators decided evaluated the damages due the City from the use of said lamps, operated normally, in place of the lamps implied in the ordinance.

IV. "Was the service which the Company actually furnished from the lamps in use, such as might reasonably be expected, and, if not, what was the overcharge, expressed in dollars and cents due to defective service?"

During a portion of the time covered by the controversy, the Company admitted that they operated their lamps below normal, but that as soon as practicable after their attention was attracted to the condition of affairs, they increased the current and operated their lamps above normal. In substantiation of this, they submitted station records (See Exhibits M, 1-25), from which, allowing proper deductions for line loss, etc., they figured the average wattage consumed per lamp. This computed wattage, however, did not agree with the wattage actually measured from a test made on each lamp on the city streets (See Exhibit J), the discrepancy being about $6\frac{1}{4}$ per cent. The Arbitrators therefore felt justified in accepting the Company's records of average wattage delivered to each lamp, less $6\frac{1}{4}$ per cent., as correct, and they determined the candle-power at said wattage by means of the curves made from tests by Prof. Matthews, showing the relation between candle-power and wattage. (See Exhibits Nos. 28 and 29.) Thus the candle-power furnished by the lamps on the streets, operating below or above normal, was determined from the station records of wattage, and said candle-power compared with the candle-power of a lamp operated at normal wattage, expressed in per cent., gave the means of determining the defici-

ency or excess of service supplied, compared with a normal lamp of this type. Consequently, the monthly amount due the Company under the terms of the franchise was first reduced 20 per cent. to secure the money value of the normal 6.6 ampere, enclosed arc light, which value was further decreased or increased by the percentage of candle-power the lamps in operation were below or above their normal.

V. "Was the City estopped from claiming any refund?"

Realizing that the point involved was a very important legal question which had not been brought to the front until the closing arguments of the attorneys, the Arbitrators called for written briefs from the attorneys. After carefully studying the briefs and informally securing disinterested, legal opinion on the technicalities involved, the Arbitrators concluded to ignore the legal claims, if any, and settle the controversy on its merits.

The Arbitrators did not feel that either party to the controversy was wholly and intentionally responsible for the continued use of the 6.6 ampere lamps for the first fifteen months or up to the time the City refused further payments therefore. The City had used and paid for the lamps during that period without protest and the Company had furnished a light inferior to what was required by the contract. Consequently the Arbitrators concluded both parties had been about equally in the wrong, and therefore, allowed only half,—10 per cent. instead of 20 per cent.—reduction in the lighting bills already paid, believing the responsibility should be evenly shared by both parties. During the period in which the City had refused payment of all bills and had formally protested against the use of the 6.6 ampere lamps, the Arbitrators concluded the Company had received ample notice, and since it had continued supplying a light inferior to the contract obligation

it did so at its own risk and hence they penalized it the full 20 per cent. for normal operation during this period.

CONCLUSIONS.

The Colorado Springs controversy again emphasizes the importance of having every business transaction fully and promptly recorded in writing, particularly when carried on with public bodies, which are continually changing their personnel. Failure in this particular was the flaw in the argument of the Pike's Peak Hydro-Electric Company, that the light from the 6.6 ampere, enclosed, alternating-current, arc lamp had been accepted as an equivalent to that required under the Jackson franchise. Any such interpretation of the franchise should at least have been incorporated in the Resolution passed by the City Council, January 16, 1905 (Exhibit No. 46). It will be noticed that this Resolution authorized several modifications in the service contracted to be rendered the City by the Electric Company, and if the Council intended accepting the 6.6 ampere, series, alternating-current lamp, as fulfillment of the contract, there should have been little difficulty in incorporating a clause in the Resolution legalizing this substitution.

The controversy illustrates the amazing neglect of bodies, constituted to represent the public, in determining important matters without proper expert advice. The Jackson franchise, anticipating the expenditure of several hundred thousand dollars for electric lighting, was drawn without complete knowledge as to what was desired or provided by its terms, with the too frequent result that the controversy, over the interpretation of the clause

in question, cost the City several thousands of dollars, besides dissatisfaction and ill feeling on both sides.

The advantages of having a technically educated tribunal to get at the "real right" of an engineering matter, without undue regard for purely legal points or procedure, are too apparent to need emphasis. The attorneys for both parties to the case were the only ones who felt called upon to apologize for their perfectly pardonable lack of knowledge of the terms and details involved, which they frankly did.

The Agreement of Arbitration was defective in the following:

(a) If it had been agreed, by both parties to the arbitration, that monetary award should be made on the basis of candle-power furnished, to that called for in the Jackson franchise, it was not clearly so set forth in the Agreement.

(b) The Agreement provided, only, for a settlement of damages for defective lighting up to the time of beginning the hearings. It made no provision for a decision or recommendation by the Arbitrators, as to the form of lighting to be furnished for the remainder of the life of the franchise. The result has been that up to the present, the City has absolutely declined to make further payment to the Company for lights furnished since January, 1907. The Company does not want to revert to the use of the old, open, direct-current arc lamp and has been unable to get the City representatives to commit themselves to the use of any other particular lamp, as satisfactory.

(c) The clause of the Agreement allowing either party to the controversy to introduce "all and every kind of evidence that it may desire, etc.," was too liberal. It resulted in repetition and undue prolongation of the hearings, which the Arbitrators were

powerless to prevent owing to this express stipulation in the contract under which they were appointed.

It has been made clear, as a result of this arbitration, that in the future American municipalities will not pay full price for inferior service. Usually lighting companies have not been accustomed to make any reduction from their bills unless street lamps are extinguished; but the Colorado Springs Award has demonstrated that a company is responsible for damages accruing from not keeping its lamps burning at normal brilliancy.

The controversy emphasized the recent development of thought in the art of lighting by distinguishing the relation between candle-power and illumination. The Arbitrators, in determining the "real right of the matter," were unwilling to consider only the candle-power—maximum, mean-spherical, or mean-hemispherical—in comparing the light of the franchise with that actually furnished. Although not wholly complete, the expert testimony indicated that, as ordinarily operated in America, the street illuminating service rendered by a 7.5 ampere, alternating-current, series, enclosed arc lamp was about as satisfactory as that by a 9.6 ampere, direct-current, series, open arc lamp.

The expenditure of money, time and energy involved in interpreting the Jackson franchise will probably never be all directly repaid the City of Colorado Springs or the Pike's Peak Hydro-Electric Company, but if the information and experience there evolved can indicate how to avoid in the future similar controversies over arc lighting contracts, the whole electrical fraternity has benefited immensely.

WITNESSES FOR THE PLAINTIFF.

- ADAMS, ALTON D.,
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 Member American Institute of Electrical Engineers.
- ARMSTRONG, J. R.,
 Professor of Electrical Engineering, Colorado College, Colorado Springs, Colo.
- BELL, LOUIS,
 Consulting Electrical Engineer and Electrical Expert, Boston, Mass.
 Member American Institute of Electrical Engineers.
 President Illuminating Engineering Society.
- MACMILLAN, K. M.,
 City Clerk of Colorado Springs, Colorado Springs, Colo.
- McINTYRE, W. H.,
 Ex-Member City Council, Colorado Springs, Colo.
- MARKS, LOUIS B.,
 Consulting Illuminating Engineer, New York City.
 Member American Institute of Electrical Engineers.
 Ex-President Illuminating Engineering Society.
 Member New York Electrical Society.
- *MATTHEWS, CHAS. P.,
 Professor of Electrical Engineering, Purdue University, Lafayette, Ind.
 Member American Institute of Electrical Engineers.
- ROUSE, VAN E.,
 Ex-Member City Council, Colorado Springs, Colo.
- SHEDD, JOHN C.,
 Dean of College Letters and Science, Westminster University, Denver, Colo.
 Professor of Physics, Colorado College, Colorado Springs, Colo., 1900-1907.
 Member American Physical Society.
 Member Illuminating Engineering Society.
- STRIEBY, WILLIAM,
 Professor of Chemistry, Colorado College, Colorado Springs, Colo.
- TAFF, GEO. A.,
 Consulting Engineer, Colorado Springs, Colo.
 Manager and Engineer Pike's Peak Hydro-Electric Company, 1902-1907.
- *Died at Phoenix, Arizona, Nov. 23rd, 1907.

WITNESSES FOR THE DEFENDANT.

- DILLON, E. P.,
 General Manager the Pike's Peak Hydro-Electric Company,
 Colorado Springs, Colo.
 Electrical Engineer, Colorado Springs Electric Company,
 1903-1907.
 Associate Member American Institute of Electrical En-
 gineers.
 Associate Member National Electric Light Association.
- HUMPHREY, C. W.,
 Consulting and Designing Engineer, Chicago, Ill.
 Engineer Northern Colorado Power Company, 1906-1907.
 Associate Member American Institute of Electrical En-
 gineers.
 Associate Member American Society Mechanical Engineers.
- LAWLER, J. C.,
 Electrical Engineer Colorado Springs Electric Co., Colorado
 Springs, Colo.
 Assistant Electrical Engineer Colorado Springs Electric Co.,
 1906-1907.
 Associate Member American Institute of Electrical En-
 gineers.
 Associate Member National Electric Light Association.
- RYAN, W. D'ARCY,
 Illuminating Engineer for General Electric Co., West Lynn,
 Mass.
 Associate Member American Institute of Electrical En-
 gineers.
 Member Illuminating Engineering Society.
- SCHUCHARDT, R. F.,
 Assistant to Electrical Engineer, Commonwealth Edison Co.,
 Chicago, Ill.
 Associate Member American Institute of Electrical En-
 gineers.
 Member Illuminating Engineering Society.
 Member Western Society of Engineers.
- TAFF, GEO. A.,
 Consulting Engineer, Colorado Springs, Colo.
 Manager and Engineer Pike's Peak Hydro-Electric Com-
 pany, 1902-1907.
- TRIPP, G. B.,
 Associated with Curtis & Hine, Colorado Springs, Colo.
 General Manager Colorado Springs Electric Company, 1901-
 1906.
 President Colorado Electric Light, Power and Ry. Ass'n.

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EXHIBIT NO. 1.

THE ORDINANCE OF COLORADO SPRINGS GRANTING A FRANCHISE TO GEO. W. JACKSON.

AN ORDINANCE, granting to George W. Jackson, his associates or assigns, the use of water power, right of way and the right to lay underground conduits and wire cables, to construct manholes and to erect poles and wires on the streets and alleys and upon the property of the City of Colorado Springs.

BE IT ORDAINED by the City Council of the City of Colorado Springs, Colorado:

Section 1. From and after the date of the passage of this Ordinance and for the full and complete period of twenty-five (25) years, George W. Jackson, of Colorado Springs, El Paso County, Colorado, his associates or assigns, shall have, and are hereby granted, the right, privilege and license to lay, construct and maintain underground conduits, cables and wires and to construct necessary manholes and make connections therewith (and outside of the fire limits of the City of Colorado Springs, as the same shall be constituted at the time of the passage of this Ordinance, to erect such poles, wires and appliances) as may be necessary for the transmission and sale to the City of Colorado Springs and the citizens thereof or others within or without the corporate limits of said city, of electricity for electrical power, and for the transmitting and conducting of other wires, cables and pneumatic tubes, in and through the streets and alleys of the City of Colorado Springs, or any extension or additions thereto, and as now described, or as the same may be hereafter described; and to operate the same for the purposes herein set forth, and the said George W. Jackson, his associates or assigns, shall have the right to rent space to others in said underground conduits if he shall desire.

PROVIDED, however, that no pole or poles or other fixtures shall be placed where the same will interfere with any gas lamp, electric light, or water hydrant, nor shall any such pole or poles be placed in a street except at the outer edge of the sidewalk, or in any alley except close to the line of the lot abutting on said alley, and then in such a manner as not to interfere with vehicles

passing through such alley, or with other necessary use of the same.

Section 2. Also from and after the passage hereof and during the period of twenty-five years thereafter the right to construct, maintain and operate on any land belonging to or controlled by the City of Colorado Springs, or which may hereafter be acquired by it, at points most feasible for the construction, maintenance and operation thereof, or upon land now acquired, or hereafter acquired, by the said George W. Jackson, his associates or assigns, and along, by and through the land and right of way of all streams, reservoirs, flumes, ditches, pipe lines and conduits, belonging now or hereafter to the water system of said city and controlled by it; pipe lines, conduits, power houses and plants for the purpose of generating by water power, and transmitting electricity to be used for electrical purposes, and the right to utilize and divert for the generation of such power all the water of any streams, ditches, flumes, pipe lines, conduits, and reservoirs, belonging to the water system of said city, or controlled by it now or hereafter; also the right during said term to construct, maintain and operate dams and reservoirs on said lands of said city, and to erect, construct and maintain on said lands of said city all necessary poles, wires and underground conduits, cables and manholes for the transmission, transfer and delivery of said electrical power and to take and use from said lands such earth, stone, and dead timber as may be necessary for the construction and maintenance of said power houses, reservoirs, plants and dams; provided, the use of said water shall neither diminish the flow thereof, nor pollute the same, and that all water diverted from the water system of said city shall be returned thereto by the said George W. Jackson, his associates or assigns, unimpaired; nor shall said water be permitted to be polluted by others owning, controlling, or having charge of the said power houses, plants and conduits.

PROVIDED, further, that the City of Colorado Springs hereby does and always shall reserve to itself the right and authority to determine and declare what constitutes pollution or waste of said waters.

PROVIDED, further, that the said City of Colorado Springs does not guaranty nor agree to furnish any specified quantity or flow of water from the water system belonging to the said city.

PROVIDED, further, that nothing in this franchise shall be construed as granting to the said George W. Jackson, his associates or assigns, the right to place any poles in any of the public parks of the City of Colorado Springs; and

PROVIDED, further, that this franchise is granted subject to the rights, if any, of The Manitou and Pike's Peak Railway Company, in a certain pipe line, by virtue of a certain contract be-

tween the City of Colorado Springs and the said railway company, dated September 22d, 1891.

AND PROVIDED, further, that nothing in this Ordinance shall be construed so as to conflict with any of the rights or privileges granted in a certain franchise to Irvine Howbert, Trustee, his associates and assigns.

PROVIDED, however, that nothing in this Ordinance shall be construed as permitting the said George W. Jackson, his associates or assigns, to do any act which will interfere with the successful operation of the gravity system of water works of the City of Colorado Springs.

Section 3. The said George W. Jackson, his associates or assigns, shall construct and maintain at their own expense from Lake Moraine to some point in the Town of Manitou, a twenty (20) inch water pipe of an approved make and of sufficient strength to stand the necessary pressure; said pipe to be subject to the approval of some competent engineer to be appointed by the City Council of the City of Colorado Springs; and its construction and installation to be under his superintendence, and subject to his approval; said pipe and the water therein shall be used by the said George W. Jackson, his associates or assigns, for the purpose of generating power.

PROVIDED; that the City of Colorado Springs shall during the term of this grant allow so much of the water of its water system to pass through the pipe lines constructed or acquired by the said George W. Jackson, his associates or assigns, as they shall desire, providing the same can be done consistently with the proper operation of its water works system.

Section 4. The privilege and license hereby granted and the construction of the said underground conduits and pole lines shall at all times be subject to such police power, reasonable dominion and regulations as the City Council of the City of Colorado Springs may by resolution or ordinance hereafter provide, and the said City Council of said city reserves to itself the right to require the said George W. Jackson, his associates or assigns, at any time to elevate or lower the wires connected with any pole line constructed hereunder at any place in said city to such height above the surface of the street as it may deem necessary, which right may be exercised by the said City Council by resolution prescribing the height of the lowest wire above the surface of the street in any specified locality.

Section 5. Before constructing any portion of the work hereby authorized, the said George W. Jackson, his associates or assigns, shall file with the City Engineer a plan showing the location and character of the proposed work, and all such work within the corporate limits of the City of Colorado Springs shall

be performed under the supervision of the City Engineer of the City of Colorado Springs.

Section 6. In every underground conduit constructed by the said George W. Jackson, his associates or assigns, and upon every pole erected, sufficient and necessary space shall be reserved for the fire departments and the police, telephone and telegraph wires now belonging to, or that may hereafter belong, to the City of Colorado Springs, and the fire and police departments by their representatives shall be allowed free access to said underground conduits and poles upon application to the said George W. Jackson, his associates or assigns, and shall be allowed facilities and privileges in putting in or taking out wires, equal in all respects to those of the said George W. Jackson, his associates or assigns.

Section 7. The said George W. Jackson, his associates or assigns, shall remove their pole lines and overhead wires within the corporate limits of the City of Colorado Springs, and shall replace the same by underground wires and conduits.

Section 8. Nothing in this Ordinance shall be construed as authorizing the said George W. Jackson, his associates or assigns, to lay such conduits or to erect such poles over or on any private property.

Section 9. The said George W. Jackson, his associates or assigns, shall within one year after the completion of the Strickler Tunnel and during the remainder of the term of this grant, furnish to the City of Colorado Springs such arc lights, of standard 2,000 candle-power each, as may be required by the city for the purpose of lighting its streets, alleys and public grounds at the rate of five dollars and fifty cents (\$5.50) per light per month, said lights to be used from sunset to sunrise during each and every day of each and every month; also, free of cost, such arc and incandescent lights as may be required by the said city not exceeding five arc lights of 2,000 candle-power each and 200 incandescent lights of 16 candle-power each, or the equivalent; also, free of cost, such electrical power, to be delivered at such points in the City of Colorado Springs, as the city may specify, as may be necessary for use by said city for municipal purposes, said power not to exceed fifty (50) horse-power; and will at all times during the term of this grant furnish to the said city such other power as may be required for municipal purposes at the same prices that are paid by the most favored customer of the said George W. Jackson, his associates or assigns. Provided, the said city shall give the said George W. Jackson, his associates or assigns, ninety (90) days' notice of its intention to use any of said power in excess of 50 horse-power, and the amount required.

Section 10. The construction of the power houses and

plants to be erected and installed by the said George W. Jackson, his associates or assigns, may be commenced at any time after the granting of this franchise, but shall be commenced within thirty (30) days after the completion of the Strickler Tunnel and the acceptance thereof by the City of Colorado Springs, and the same shall be properly installed and in such working order and condition that the owner, manager or controller shall furnish arc and incandescent lights and power to the said City of Colorado Springs, upon the terms and conditions hereinabove set out, not later than one year from and after the completion of the Strickler Tunnel and the acceptance thereof by the City of Colorado Springs; and that thereafter the said George W. Jackson, his associates or assigns, shall make any necessary provisions to insure to the city at all times, when required, sufficient power for the lights of the said city and power for its municipal purposes as hereinabove provided; and it is also provided that if the said George W. Jackson, his associates or assigns, shall fail to commence the construction of the plants and power houses within the time herein prescribed, or shall fail to furnish to the said city the said lights and power as hereinabove provided by and at the time designated, or shall at any time thereafter fail to furnish said lights and power as herein provided, then all the rights and privileges herein and hereunder shall and will become null and void, and the same shall revert to the City of Colorado Springs unless the said George W. Jackson, his associates or assigns, shall be restrained or enjoined by some bona fide proceeding in law or equity, or prevented by unusual casualty, fire, lightning, storms, or act of God.

Section 11. An electrical plant sufficient for generating the electricity for furnishing the lights and power required by the City of Colorado Springs, as provided in Section 9 hereof; also any transforming station, wires, cables and pole lines and other improvements, which may be built by the said George W. Jackson, his associates or assigns, for the purpose of transforming and delivering the electricity necessary for furnishing electric lights to the said City of Colorado Springs; also the pipe line to be built by the said George W. Jackson, his associates or assigns, hereinabove provided for, together with a right of way sufficient for maintenance, repairs, and renewals thereof, shall at the expiration of this grant revert to and become the property of the said City of Colorado Springs.

Section 12. The rights and privileges hereby granted shall continue for the period of twenty-five (25) years, and shall extend to all the avenues, streets, and alleys of the said City of Colorado Springs, and to all extensions of the same, and to all lands of the said city under the terms and provisions of this Ord-

nance and subject to the conditions and limitations herein contained.

Section 13. After the commencement of work hereunder there shall be appointed annually by said city a supervisor, whose duties will be to oversee, control and patrol and have full and complete authority over that part of the water works system affected by this grant, and it shall be the duty of said supervisor to prevent any pollution of the water of the water system of the city, and to protect the interests and property of the said city, and the said George W. Jackson, his associates and assigns, shall compensate the said city for the reasonable expenses of the said supervisor.

Section 14. This franchise is subject to the express condition that the said George W. Jackson, his associates or assigns, shall within the period of fifteen (15) months from and after the date of the passage of this ordinance, complete the Strickler Tunnel in accordance with the specifications in a certain agreement made and entered into December 27th, 1895, between the City of Colorado Springs, party of the first part, and Wilson and Jackson, of Chicago, Illinois, parties of the second part, and any extensions and modifications which have heretofore been made, or may be hereafter made thereto, and a failure of the said George W. Jackson, his associates or assigns, to complete said tunnel as above provided, within the time provided, shall render this franchise, and all the rights and privileges granted hereunder, null and void, and the same, together with all pipes, pipe lines, power houses, plants, underground conduits, pole lines and other improvements which may be built or erected hereunder, shall revert to the City of Colorado Springs.

Section 15. And the said George W. Jackson, his associates or assigns, shall, before they enter upon the enjoyment of the franchise and ordinance herein granted, execute and deliver to the City of Colorado Springs a bond in the penal sum of fifteen thousand (15,000) dollars, with surety to be approved by the City Council of said city, conditioned that they will assume all damages for personal or other injuries that may occur, either to private individuals or corporations, as well as to the City of Colorado Springs, holding the said City of Colorado Springs harmless from any damages from pollution or waste of water, electrolysis, or otherwise occasioned by the granting of this franchise or by their operations thereunder, or from any damages occasioned by the negligence or want of care on the part of the said George W. Jackson, his associates or assigns, in constructing and maintaining any of the plants or appliances herein provided for.

Section 16. It is further provided that if at the expiration of this grant, to wit: the term of twenty-five (25) years, it is de-

sired by the said George W. Jackson, his associates or assigns, to accept a new grant from the said City of Colorado Springs, of like and similar rights and privileges, and for a period which may then be agreed upon, a grant will then be given to the said George W. Jackson, his associates or assigns, in conformance with such conditions as the then City Council may then provide, and which they may then conclude to be wise and for the best interests of the City of Colorado Springs.

Passed September 8th, A. D. 1898.

(Signed) M. B. IRVINE, Mayor.

Attest:

(Signed) I. S. HARRIS, City Clerk.

[Seal of City of
Colorado Springs.]

STATE OF COLOADO }
COUNTY OF EL PASO } ss:

I, K. M. MacMillan, Clerk of the City of Colorado Springs, County and State aforesaid, do hereby certify that the above and foregoing is a true and correct copy of an ordinance entitled, "AN ORDINANCE, GRANTING TO GEORGE W. JACKSON, HIS ASSOCIATES OR ASSIGNS, THE USE OF WATER POWER, RIGHT OF WAY AND THE RIGHT TO LAY UNDERGROUND CONDUITS, AND WIRE CABLES, TO CONSTRUCT MANHOLES AND TO ERECT POLES AND WIRES ON THE STREETS AND ALLEYS AND UPON THE PROPERTY OF THE CITY OF COLORADO SPRINGS," passed September 8, 1898, as it now appears in the records and files of my office.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the seal of the City this thirty-first day of January, A. D., 1907.

(Signed) K. M. MACMILLAN,
City Clerk.

[SEAL]

EXHIBIT NO. 2.

PRELIMINARY ARBITRATION AGREEMENT.

AGREEMENT made this 12th day of June, 1906, between the City of Colorado Springs, party of the first part, and the Pike's Peak Hydro-Electric Company, a corporation of Colorado, (hereinafter termed the "Company"), party of the second part.

1. Any claim by the City for damages for waste of water by the Company in the past shall be submitted to arbitration under the statutes.

2. Segregation shall be made by the Company as speedily as practicable of Company's system and City's system according to plans to be approved by the City Engineer and the Company's engineer, or, in case of their disagreement, by engineer to be selected by the other two; these plans to cover return of all water, including vent water, to the City's system, and to be along the following general lines:

The Company will disconnect its twenty-inch pipe line from the City's fourteen-inch main and extend its twenty-inch pipe line to some convenient point in Ruxton Park, where it will construct a main intake of over a million gallons capacity, properly protected from pollution, so arranged that any overflow from said intake will pass into the City's fourteen-inch main near that intake.

Above that intake the Company will construct a sandbox, into which water will be conducted by City's fourteen-inch main from present intake on main Ruxton.

The Company will disconnect its eight-inch pipe in South Ruxton from the City's pipe and extend it to connect with said twenty-inch pipe extension, leaving unused by the Company the City's eight-inch pipe from its old or lower intake on South Ruxton down to connection with the City's fourteen-inch main, so that the City can take into its own system any water passing the Company's intake on South Ruxton.

The Company will collect any water escaping from the vent in its present twenty-inch pipe and deliver it by pipe to the City's system.

The expense of the umpire engineer, if required, shall be borne by the City and Company equally.

The engineers shall determine in like manner whether such segregation is being effected as speedily as practicable, the segregation to be completed in any event not later than September 1, 1907, and as much earlier as the engineers may determine to be practicable.

3. Any money claim of the City based on the contention that street arc lights are less than standard two thousand candle-power shall be submitted to arbitration under the statute.

4. The Company will build a pipe line to Lake Moraine as speedily as practicable, if and when required so to do by the Council, and according to plans to be approved by the engineer for the City.

5. The Company will furnish power for municipal purposes under Section 9 of the ordinance upon demand by the City,—construction by the District Court of El Paso County, Colorado, of that section to be made upon statement of facts to be submitted within thirty days, the decision of said Court to be binding upon the Company, and the Company thereupon, if so required by the City, to contract to furnish to the City at any time during the life of the franchise such power and at such rate as are provided by said Section 9 as so construed by the Court.

6. The Company will pay \$75.00 per month for expense of supervisor required by ordinance, or in lieu thereof will contribute \$100.00 per month toward compensation of any hydraulic engineer who may be placed in charge of the City mountain system.

7. And generally, the Company will comply with every clause and provision of the franchise.

8. Nothing in this agreement shall be deemed a waiver either by the City or the Company of any rights under the Jackson franchise.

IN WITNESS WHEREOF, the City of Colorado Springs has, pursuant to resolution duly passed and adopted by its City Council by concurrent vote of the majority of the whole number of members elected to said Council, caused these presents to be signed by its Mayor, and its corporate seal to be hereto affixed and attested by its Clerk, and the Pike's Peak Hydro-Electric

Company has caused these presents to be subscribed with its name by the hand of its President and its corporate seal to be hereto affixed and attested by its Secretary on the day and year first above written.

Executed in duplicate originals.

THE CITY OF COLOADO SPRINGS,
(Signed) HENRY C. HALL,
Mayor.

Attest:

(Signed) K. M. MACMILLAN,
City Clerk.

[SEAL]

of the City of Colorado Springs.

THE PIKE'S PEAK HYDRO-ELECTRIC CO.,
(Signed) G. A. TAFF,
President.

Attest:

(Signed) J. M. RIPPEY,
Secretary.

[SEAL]

of the Pike's Peak Hydro-
Electric Company.

STATE OF COLOADO ss:
COUNTY OF EL PASO

I, K. M. MacMillan, Clerk of the City of Colorado Springs, County and State aforesaid, do hereby certify that the above and foregoing is a true and correct copy of an agreement entered into the twelfth day of June, 1906, between the City of Colorado Springs and the Pike's Peak Hydro-Electric Company, as it now appears in the records and files in my office.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the seal of the City this thirty-first day of January, A. D., 1907.

(Signed) K. M. MACMILLAN.

[SEAL]

of the City of Colorado Springs.

EXHIBIT NO. 3.

AGREEMENT OF ARBITRATION.

THIS AGREEMENT OF ARBITRATION, made and entered into this thirtieth day of January, 1907, between the City of Colorado Springs, a municipal corporation organized and existing under the laws of the State of Colorado, party of the first part, and the Pikes Peak Hydro-Electric Company, a corporation, organized, existing and doing business under and by virtue of the laws of the State of Colorado, party of the second part, WITNESSETH: that

WHEREAS, on the 8th day of September, 1898, the City of Colorado Springs did duly pass and enact a certain ordinance entitled: "An ordinance granting to George W. Jackson, his associates or assigns, the use of water power, right of way, and the right to lay underground conduits and wire cables, to construct manholes and to erect poles and wires on the streets and alleys and upon the property of the City of Colorado Springs," and

WHEREAS, the party of the second part has become and now is the owner and holder of all rights and privileges granted by said ordinance to George W Jackson; and

WHEREAS, Section 9 of said ordinance is as follows, to wit:

"Sec. 9. The said George W. Jackson, his associates or assigns, shall within one year after the completion of the Strickler tunnel and during the remainder of the term of this grant, furnish to the City of Colorado Springs, such arc lights, of standard 2,000 candle-power each, as may be required by said City for the purpose of lighting its streets, alleys and public grounds, at the rate of five dollars and fifty cents (\$5.50) per light per month, said lights to be used from sunset to sunrise during each and every month; also, free of cost, such arc and incandescent lights as may be required by the said City for the lighting of the buildings belonging to the said City not exceeding five arc lights of 2,000 candle-power each and 200 incandescent lights of 16 candle-power each, or the equivalent; also, free of cost, such electrical power, to be delivered at such points in the City of Colorado Springs, as the said City may specify, as may be necessary for use by said City for municipal purposes, said power not to exceed fifty (50) horse-power; and will at all times during the term of

this grant furnish to the said City such other power as may be required for municipal purposes at the same prices that are paid by the most favored customer of the said George W. Jackson, his associates or assigns, PROVIDED, the said City shall give the said George W. Jackson, his associates or assigns ninety (90) days notice of its intention to use any of said power in excess of fifty horse-power, and the amount required."

WHEREAS, the party of the second part, since February 15, 1905, has been furnishing street lights to the party of the first part under said section, and has rendered certain bills for such street lights, which bills covering the period down to and including May 31, 1906, have been paid by the party of the first part; but for the period since May 31, 1906, have not been paid by the party of the first part, and the party of the first part now claims that the lights so furnished by the party of the second part have not been of the candle-power prescribed for street lights by said Section 9 of said ordinance hereinbefore set forth, and by reason thereof, that the party of the first part is entitled to re-payment to it of certain moneys in accordance with the claim hereinafter set forth, and also to reduction in the amount of the bills rendered by the party of the second part for the period since May 31, 1906; and

WHEREAS, the parties hereto have heretofore, in writing, agreed to submit the claims hereinafter set forth to arbitration in the manner provided for by Chapter 26 of the Code of Civil Procedure of the State of Colorado;

NOW, THEREFORE, in consideration of the premises, the parties hereto do hereby make and subscribe these written Articles of Agreement, and have agreed, and do hereby mutually agree, as follows:

FIRST. The particular matters of difference between the parties hereto, which are to be submitted to and decided by the arbitrators hereinafter named, are as follows, to wit:

A. The party of the first part claims that the party of the second part is indebted to it in the sum of Sixteen Thousand Nine Hundred and Fifty-two Dollars and Twenty-one cents, (\$16,952.21), on account of the claim of the party of the first part that the party of the second part has overcharged the party of the first part for street lights from February 15, 1905, to May 31, 1906, upon the following basis, to wit:

Total amount paid Pike's Peak Hydro-Electric Company from February 15, 1905, to May 31, 1906, on basis of lights supposed by the City to be of standard 2,000 candle-power each	\$19,943.79
Amount which City of Colorado Springs claims should have been paid by the City to the Pikes Peak Hydro-Electric Company during said time by reason of its claim that said lights were only 300 candle-power each...	2,991.56

Amount which City claims it was overcharged....\$16,952.23

Or, in case said computation should prove not to be exact, the money claim so submitted to arbitration is for the difference between the amount which the City should have paid for the street lights furnished during the period in question and the amount which the City did pay, said claim to be determined by the difference in candle-power between the lights so furnished and the lights required by said Section 9 of the ordinance.

Interest is also claimed upon the amount, if any, found due from the date when the respective amounts found due accrued until the date of the award, at the rate of eight per cent. (8%) per annum.

B. The party of the first part further claims that the bills rendered by the party of the second part for street lights furnished to the party of the first part since May 31, 1906, and the charges therefor down to the date of such arbitration are excessive in the same proportion; or in case such computation should prove not to be exact, the further money claim for overcharge so submitted to arbitration is for the difference between the amount which the City should pay for the street lights furnished since May 31, 1906, and the amount charged therefor by the Company, said claim to be determined by the difference in candle-power between the lights so furnished and the lights required by said Section 9 of the ordinance.

SECOND. The parties hereto agree to submit such particular matters of difference set out in paragraph First, to L. G. Carpenter of Fort Collins, Colorado; E. L. Elliott of New York City, and Henry Floy of New York City, as arbitrators; and hereby

agree that the said L. G. Carpenter, E. L. Elliott and Henry Floy shall be arbitrators to determine, pass upon and decide said matter; and the parties hereby agree to abide by the award made by a majority of said three arbitrators.

The hearings before said arbitrators shall begin February 1, 1907, and continue daily until completed.

IT IS EXPRESSLY AGREED AND UNDERSTOOD that the arbitrators hereinabove named shall hear all evidence offered by each party hereto and make their award therefrom. It is agreed and understood that either party may introduce all and every character of evidence that it may desire and that the objections of each party to the same on any and all grounds, whether of materiality, competency, relevancy or on special grounds, may and shall be considered as being made and exceptions taken at all proper places in the proceedings. This to the end that the taking of evidence may not be interrupted by the making or urging of objections and that the arbitrators may and shall be relieved from in any wise passing upon the validity or legality of any objection made to evidence.

IT IS FURTHER AGREED AND UNDERSTOOD that the said award of said arbitrators, when made, shall be filed by the successful party, with the Clerk of the District Court of El Paso County, as the basis of a judgment, and that an execution may be issued for its collection.

IT IS FURTHER AGREED AND UNDERSTOOD that said arbitrators shall allow interest at the rate of eight per cent. per annum on any sum or sums found due to either party hereto, and that such interest shall be computed from the time or times such sum or sums were overpaid, or should have been paid, as the case may be, until the date of making the award hereunder.

IN WITNESS WHEREOF the party of the first part has, pursuant to resolution duly adopted by the City Council, upon the concurrence of a majority of its members, caused these presents to be signed by its Mayor and attested by its City Clerk, with its corporate seal affixed, and the said party of the second part has caused the same to be signed by the hand of its Vice-

President, and attested by its Secretary and its corporate seal thereunto affixed, on the day and year first above written.

Executed in duplicate originals.

THE CITY OF COLORADO SPRINGS,

(Signed) HENRY C. HALL.

Mayor.

[SEAL]

of the City of Colorado Springs.

Attest:

(Signed) K. M. MACMILLAN,
City Clerk.

THE PIKE'S PEAK HYDRO-ELECTRIC CO.,

(Signed) G. A. TAFF,

Vice-President.

[SEAL]

of Pikes Peak Hydro-Electric Co.

Attest:

(Signed) A. RALSTON,
Secretary.

EXHIBITS NOS. 4—20 INCLUSIVE.

These exhibits consist of certified copies of the bills for lighting service presented by the Pike's Peak Hydro-Electric Company against the City of Colorado Springs from the month of February, 1905, to and inclusive of December, 1906, part of which had been paid in full.

Below is given, as an illustration, one of the bills rendered, being "Exhibit No. 4," for service during the month of January, 1906.

EXHIBIT NO. 4.

Colorado Springs, Colo., February 6, 1906.

M. The City of Colorado Springs,

Colorado Springs, Colorado.

To The Pike's Peak Hydro-Electric Company, Dr.

Office, 203 Mining Exchange Building.

To 236 Arc lights at \$5.50.....	\$1,298.00
1 arc, Boulder Crescent and West Park, installed Jan. 9, 1906, (22 days).....	4.03
1 arc, Cache La Poudre and Royer St., installed Jan. 11, 1906, (20 days).....	3.67
1 arc, Boulder and El Paso Sts., installed Jan. 16, 1906, (15 days).....	2.75
	<hr/>
	\$1,308.45

Approved.

(Signed) A. W. GRAY,

Street Commissioner.

O.K. (Signed) A. M. HOLDEN.

STATE OF COLOADO }
COUNTY OF EL PASO } ss:

I, G. M. Perry, City Auditor of the City of Colorado Springs, do hereby certify that the above is a true and correct copy of the bill rendered this City by the Pike's Peak Hydro-Electric Company, for January lights, with the item of bills rendered added.

(Signed) G. M. PERRY,

City Auditor.

Colorado Springs, Colo.,

February 2, 1907.

EXHIBIT NO. 21.

CONTRACT BETWEEN THE COLORADO SPRINGS
LOWE GAS AND ELECTRIC CO. AND THE
CITY OF COLORADO SPRINGS.

THIS AGREEMENT, made and entered into this seventh day of April, A. D., 1890, between The Colorado Springs Lowe Gas & Electric Company, a corporation duly formed and existing under the laws of the State of Colorado, party of the first part, and The City of Colorado Springs, a municipal corporation, party of the second part, WITNESSETH: that

WHEREAS, the City Council of the party of the second part did heretofore, and on the 24th day of March, 1890, duly enact an ordinance entitled "An Ordinance in Relation to the Colorado Springs Lowe Gas & Electric Company," whereby certain rights, privileges and franchises were granted to the party of the first part, including the right, privilege and license to manufacture and distribute gas for lighting, heating, power, manufacturing and other purposes, and to manufacture and distribute electricity for lighting, power and other purposes, as by reference to said ordinance will more fully appear; and,

WHEREAS, it was provided in and by the provisions of said ordinance, and as a condition of the grant of the rights-of-way, privileges and franchises therein mentioned, that within thirty days from the date of the passage thereof the said The Colorado Springs Lowe Gas and Electric Company should, under its corporate seal and the hand of its President or Vice President, enter into an agreement on its part with The City of Colorado Springs, of the other part, promising, covenanting and agreeing as hereinafter provided; and,

WHEREAS, it was further provided in and by section 9 of said ordinance that the Mayor of The City of Colorado Springs be and he was thereby authorized and instructed to enter into such contract with said Company as will by the section last referred to more fully appear;

NOW, THEREFORE, in consideration of the premises, and of the passage of the ordinance aforesaid, and of one dollar to each party in hand paid by the other, the receipt whereof is hereby acknowledged, the parties hereto do hereby covenant and agree with each other as follows:

1. The party of the first part hereby covenants and agrees that it will not charge the party of the second part, or any

person, bodies or corporations within the corporate limits of the City of Colorado Springs, more than two and fifty-hundredths dollars (\$2.50) per thousand cubic feet for illuminating gas; that the said party of the first part will, within a reasonable time from the date of this agreement, lay pipes and distribute and sell gas on any and all streets respectively in the City of Colorado Springs, so far as there may be any reasonable demand for such gas on said streets or any of them; that the party of the first part will, in all cases, be controlled and governed by the ordinances of the City of Colorado Springs then in force, relating to the manner of laying and distributing pipe, and of making and guarding excavations therefor; that the party of the first part will be responsible for any damage, either to streets, persons, or property, resulting from any act of negligence on its part; that the party of the first part will at all times furnish a full and sufficient supply of good gas of not less than 20-candle power, unless prevented by accident or other cause beyond its control, in which event said obstacle will be removed and overcome without unnecessary delay.

2. And said party of the first part further agrees that it will furnish gas to the party of the second part at not more than twenty dollars (\$20) per lamp per annum for each and every lamp supplied for the streets of the party of the second part; provided, however, that the party of the first part shall furnish all street lamps and lamp posts to the party of the second part of the kind required by the City Council of said second party, delivered on the grounds at cost; said lamps and posts to be the property of the party of the second part, and the cost and setting thereof to be paid for by the said party of the second part.

3. And the party of the first part further covenants and agrees that it will not charge consumers more than three cents per hour for each 16-candle power electric light, and will furnish said light to all persons residing on any street where its wires extend who shall pay promptly therefor, and will in no case discriminate as to rates charged between consumers in outlying districts and consumers in competitive districts of the City of Colorado Springs.

4. And the party of the first part further covenants and agrees that it will furnish the party of the second part, whenever so required, with not less than forty (40) arc lights, of what is commonly known as 2,000 candle power each for lighting the streets of the city for not more than \$125 per annum for each arc light, or will furnish not less than fifty (50) arc lights of the same candle power for not more than \$120 each per annum.

5. And the party of the second part, for and in consideration of the premises, hereby ratifies and confirms to and unto the party of the first part the rights-of-way, privileges and fran-

chises granted by the ordinance of the City of Colorado Springs herein above referred to, passed March 24, 1890, in relation to the manufacture and distribution of gas and electricity for lighting and other purposes.

IN WITNESS WHEREOF, the party of the first part has hereunto caused its corporate seal to be affixed, and these presents to be signed by its Vice-President and Secretary, and the party of the second part has caused its corporate seal to be hereunto affixed, together with the signatures of its Mayor and City Clerk in attestation thereof, the day and year first above written.

THE COLORADO SPRINGS LOWE
GAS AND ELECTRIC CO.,
(Signed) J. F. HUMPHREY,

Corporate seal of
The Colorado Springs
Lowe Gas and Electric Co.

Vice-President.

Attest:

(Signed) J. F. HUMPHREY, Secretary.

(Signed) L. P. LOWE, Treasurer.

CITY OF COLORADO SPRINGS,
(Signed) J. W. STILLMAN,

Mayor.

Corporate Seal of
City of Colorado Springs,
Colorado.

Attest:

(Signed) H. C. McCREERY,

City Clerk.

STATE OF COLORADO,
County of El Paso,

BE IT REMEMBERED that, on this 7th day of April, A. D. 1890, before me, the undersigned, a notary public, duly commissioned and qualified under the laws of said State to take the acknowledgment of deeds, etc., personally appeared J. F. Humphrey, Vice-President of the Colorado Springs Lowe Gas and Electric Company, and J. F. Humphrey, Secretary of said Company, to me, personally known to be the identical persons whose names are subscribed to the foregoing agreement in attestation thereof, and they in due form of law severally acknowledged that they were personally present at the execution of the foregoing agreement; that their signatures thereto are genuine; that the seal affixed thereto is the common and corporate seal of the said corporation; that the foregoing instrument was duly signed, sealed and delivered by, and as and for the act and deed of the said The Colorado Springs Lowe Gas and Electric Company, and by its authority, for the uses and purposes therein set forth.

IN WITNESS WHEREOF I have hereunto set my hand and affixed my official seal at Colorado Springs, Colo., the day and year aforesaid.

(Signed) JOHN DEWITT PELTZ,
Notary Public.

Notarial Seal of
John Dewitt Peltz.

My commission expires March 16, 1892.

STATE OF COLORADO, }
COUNTY OF EL PASO, } ss:

BE IT REMEMBERED that, on this 7th day of April, A. D. 1890, before me, the undersigned, a notary public, duly commissioned and qualified under the laws of said State to take the acknowledgment of deeds, etc., personally appeared J. W. Stillman, Mayor of The City of Colorado Springs, and H. C. McCreery, City Clerk of said City, to me personally known to be the identical persons whose names are subscribed to the foregoing agreement in attestation thereof, and they in due form of law severally acknowledged that they were personally present at the execution of the foregoing instrument; that their signatures thereto are genuine; that the seal affixed thereto is the common and corporate seal of the said corporation; that the foregoing agreement was duly signed, sealed and delivered by, and as and for the act and deed of, the said The City of Colorado Springs, and by its authority, for the uses and purposes therein set forth.

IN WITNESS WHEREOF I have hereunto set my hand and affixed my official seal at Colorado Springs, Colo., the day and year aforesaid.

(Signed) JOHN DEWITT PELTZ,
Notary Public.

Notarial Seal of
John Dewitt Peltz.

My commission expires March 16, 1892.

STATE OF COLORADO, }
COUNTY OF EL PASO, } ss:

I, K. M. MacMillan, City Clerk of Colorado Springs, county and State aforesaid, do hereby certify that this is a true and correct copy as shown on the records on file in my office.

Certified to this 15th day of January, A. D. 1907.

(Signed) K. M. MACMILLAN,
City Clerk.

Colorado Springs, Colo.,
Corporate Seal.

EXHIBIT NO. 22.

CONTRACT BETWEEN EL PASO ELECTRIC CO. AND
THE CITY OF COLORADO SPRINGS.

THIS AGREEMENT, made and entered into this 1st day of April, A. D., 1899, by and between the El Paso Electric Company, a corporation, hereinafter referred to as "the Company," party of the first part, and the City of Colorado Springs, hereinafter called and referred to as "the City," party of the second part,

WITNESSETH:

That for and in consideration of the monthly payments hereinafter provided, the said company hereby agrees to furnish electric light for the purpose of lighting the streets and parks of the City of Colorado Springs; such light to be furnished through electric lamps, which are commercially known as arc lamps of 2,000 candle power. There shall be furnished not less than one hundred and thirty-five (135) of such lamps, which shall be located in such places as shall be designated by the City Council of said City of Colorado Springs. More and other lamps of like capacity and character shall be furnished by said company to said city at such places as the said City Council may from time to time require and designate; but no light shall be required to be furnished at a greater distance than eleven hundred (1,100) feet from the said company's wire mains. Such lamps shall be lighted every evening, not later than one hour after sunset, and kept lighted until one hour before sunrise; provided, however, that upon moonlight nights said lamps shall not be lighted while the moon is shining. Cloudy nights shall not be considered moonlight nights, and upon all cloudy nights the said lamps shall be lighted. The moonlight schedule in common use for street lighting shall be observed as to the arc lights. If, for any cause, said lights, or any of them, are not lighted continuously for the time as above provided, there shall be deducted from the compensation agreed to be paid a pro rata share of such compensation for the time said lamp, or lamps, are not lighted.

The City of Colorado Springs agrees to pay to the said company for such lighting the sum of eight dollars and sixteen and two-third cents (\$8.16 $\frac{2}{3}$) per month for each and every lamp furnished to the said city by the said company; such payments to be made monthly, on the fifteenth day of each month.

It is mutually agreed by the parties hereto that this contract shall continue and be in force for a term of five (5) years from the 31st day of March, A. D. 1899. And it is further mutually agreed by the parties hereto that if, at any time during the term of this contract it shall become a well known and established fact in electric lighting that electricity can be produced and distributed for arc lighting by other and less costly processes than that at present known and used, that when such new process shall be known to be practicable as a proper and legitimate business method, fully developed and in general use, then, and in such case, the City of Colorado Springs shall have the right to demand of the said company a modification of this contract in such manner as will give the city an equitable benefit arising from such new process; the City Council of the City of Colorado Springs reserves the right to determine when such new method has been fully developed, established and in general use. Such demand, if any, for a modification of the contract to be made in writing, and in case of disagreement between the parties hereto as to the time and conditions of such modifications of the contract, the same shall be submitted to three arbitrators; one to be selected by the party of the first part; one by the then acting Mayor of said city, and the other by the two so chosen and named; the finding of the arbitrators to be final and conclusive on each party hereto as to all matters in difference thus submitted.

It is expressly agreed and understood by and between the parties hereto that, in case litigation should arise over what is known as the Jackson franchise, passed by the City Council of the City of Colorado Springs on the 8th day of September, A. D. 1898, and afterward, by the said City Council, repealed by ordinance, and said litigation should result in favor of the owner and holder of such franchise, and further should the owner and holder of such franchise furnish, or offer to furnish, to the City of Colorado Springs, lights as mentioned in said franchise, and according to the price herein stated, then, in that case, the City of Colorado Springs hereby reserves the right to terminate and end this contract.

And it is further mutually agreed by and between the parties hereto that, whereas, the City of Colorado Springs owns and controls a valuable water power from Ruxton Creek, which it may determine to use for the purpose of operating an electric lighting plant for the purpose of lighting its said streets and parks, now, if the said city shall, during the life of this contract, determine to put in, or cause to be put in, such electric plant so operated, then this contract shall cease and terminate as soon as such city plant is completed and put in operation, or caused to be completed and put in operation, by direction or permission of the said city.

IN WITNESS WHEREOF, the party of the first part has hereunto set its corporate seal and caused this contract to be signed by its President and attested by its Secretary, and the party of the second part has hereunto attached its corporate seal and caused these presents to be signed by its Mayor and attested by the City Clerk of the City of Colorado Springs.

Executed in duplicate.

THE EL PASO ELECTRIC COMPANY,
(Signed) C. H. WHITE,
Vice-President.

Corporate Seal of
The El Paso Electric Co.

Attest:
(Signed) O. L. GODFREY,
Secretary.

THE CITY OF COLORADO SPRINGS,
(Signed) J. R. ROBINSON,
Mayor.

Attest:
(Signed) I. S. HARRIS,
City Clerk.

Corporate Seal of
Colorado Springs, Colorado.

STATE OF COLORADO }
COUNTY OF EL PASO } ss:

I, K. M. MacMillan, City Clerk of Colorado Springs, County and State aforesaid, do hereby certify that this is a true and correct copy as shown on the records on file in my office.

Certified to this 15th day of January, A. D., 1907.

(Signed) K. M. MACMILLAN,
City Clerk.

Corporate Seal of
Colorado Springs, Colorado.

EXHIBIT NO. 23.

CONTRACT BETWEEN THE COLORADO SPRINGS
ELECTRIC CO. AND THE CITY OF
COLORADO SPRINGS.

THIS AGREEMENT, made and entered into this fifth day of September, A. D., 1901, by and between the Colorado Springs Electric Company, a corporation duly organized and existing under and by virtue of the laws of the State of Colorado, hereinafter referred to as the Company, party of the first part, and the City of Colorado Springs, hereinafter referred to as the City, party of the second part,

WITNESSETH: that

WHEREAS, heretofore, to-wit: on or about the first day of April, A. D. 1899, The El Paso Electric Company, a corporation organized and existing under and by virtue of the laws of the State of Colorado, and the said party of the second part herein made and entered into a certain contract for the furnishing of electric lights by the said The El Paso Electric Company to the said City, which said contract by its terms and limitations extends to and expires upon the 31st day of March, A. D. 1904; and

WHEREAS, The said party of the first part herein, so-called the Company as aforesaid, is the successor and grantee of the said The El Paso Electric Company, under the said contract and the rights and liabilities therein provided for and set forth; and

WHEREAS, The said company is desirous of modifying the said contract and of securing a further contract with the said city relative to the further furnishing and supplying of electric lights, and is further desirous of substituting a new and improved light for the light now in use and furnished under the said contract of April, 1899, and the said Company is willing, in consideration thereof, to make a certain reduction in the price of the lights as named and provided for in the said prior contract;

NOW THEREFORE, this agreement witnesseth that in consideration of the premises and of the mutual covenants and agreements herein contained, it is hereby, in lieu, place and stead of the said contract of April 1st, 1899, covenanted, contracted and agreed as follows, to wit:

1st. In consideration of the monthly payments hereinafter provided, the said company hereby agrees to furnish electric lights for the purpose of lighting the streets and parks of the said City of Colorado Springs, such lights to be furnished through

electric lamps which are commercially known as 6.6 ampere enclosed arc lamps of the series alternating system, the same to be in all respects equal in lighting power to the sample lamps of the kind above described, heretofore installed and exhibited by the said company in the streets of Colorado Springs for testing purposes.

2d. There shall be furnished not less than one hundred and sixty (160) of such lamps, which shall be located in such places as shall be designated by the City Council of the said city; more and other lamps of like capacity and character shall be furnished by the said company to the said city at such places as the said City Council may from time to time require and designate, but no lamps shall be required to be furnished at a greater distance than 1,100 feet from the said company's wire mains.

3d. Such lamps shall be lighted every evening not later than one hour after sunset, and kept lighted until one hour before sunrise; provided, however, that upon moonlight nights the said lamps shall not be lighted save as hereinafter specified, while the moon is shining; cloudy nights shall not be considered moonlight nights, and upon all cloudy nights the said lamps shall be lighted; the moonlight schedule in common use for lighting shall be observed as to all of the lights, save that, anything herein to the contrary notwithstanding, the company shall furnish light for thirty (30) of the said lamps for lighting the business portions of the said city from the hour of lighting thereof to and until the hour of eleven o'clock P. M. each and every night irrespective of the said moonlight schedule. If for any cause the said lights or any of them are not lighted continuously for the time as above provided, there shall be deducted from the compensation agreed to be paid a pro rata share of such compensation for the time the said lamp or lamps are not burning.

4th. The said city covenants and agrees to pay to the said company for such lighting to and until the said 31st day of March, A. D. 1904, the sum of six dollars and sixty-six and two-third cents (\$6.66 $\frac{2}{3}$) per month for each and every lamp so furnished to the said city by the said company; and from the said 31st day of March, 1904, to and until the 31st day of March, A. D. 1909, the said city shall pay for the said lighting the sum of six dollars and twenty-five cents (\$6.25) per month for each and every lamp furnished to the said city by the said company; all payments hereinbefore provided to be made monthly on the fifteenth day of each and every month.

5th. It is further mutually agreed by the parties hereto that if at any time during the term of this contract, it shall become a well-known and established fact in electric lighting that electricity can be produced and distributed for arc lighting by other and less costly process than those at present known and used,

that when such new process or processes shall be known to be practicable as a proper and legitimate business method, fully developed and in general use, then, and in such case, the city of Colorado Springs shall have the right to demand of the said company a modification of this contract in such manner as will give the city an equitable benefit arising from such new process or processes. The City Council of the City of Colorado Springs reserves the right to determine when such new method has been fully developed, established and in general use, and for the purpose hereof it shall not be necessary for the said city to determine in advance, as a fact, that such less costly processes than now exist have been established and are practicable, but the said city may at any time on the bona fide belief that such new processes have become known and are practicable and are in general use, demand the arbitration hereinafter mentioned. Such demand, if any, for a modification of the contract, to be made in writing, and in case of disagreement between the parties hereto as to the time and condition of such modification of the contract, the same shall be submitted to three arbitrators, one to be selected by the party of the first part, one by the then City Council of the said city, and one other by the two so-chosen and named; the finding of the arbitrators to be final and conclusive on each party as to all matters in difference thus submitted.

6th. It is further mutually understood and agreed by and between the parties hereto that WHEREAS the said City of Colorado Springs owns and control certain valuable water-power plants which it may determine hereafter to use for the purpose of operating an electric lighting plant for the purpose of lighting its said streets and parks, or may hereafter acquire such a water-power plant for such purpose;

NOW THEREFORE, if the said city shall during the life of this contract determine to put in or cause to be put in or acquire such plant so operated, then this contract shall cease and determine as soon as the said city plant is completed and put in operation or caused to be completed and put in operation by the direction or under the permission of the said city.

7th. It is further expressly understood and agreed by and between the parties hereto that WHEREAS the Pike's Peak Power Company, so-called, is believed to hold a certain franchise, commonly known as the Jackson franchise, and the rights, if any, thereunder secured, passed by the City Council of the City of Colorado Springs, on, to wit, the 8th day of September, 1898, which said franchise was afterwards repealed by the then City Council of the said City by its ordinance, but under the said ordinance granting the said franchise, and notwithstanding the said repeal thereof, the said The Pike's Peak Power Company is supposed still to claim that under certain contingencies it may

have certain rights to furnish the City of Colorado Springs with electric light under certain terms in the said ordinance set forth;

NOW THEREFORE, in case the said The Pike's Peak Power Company or the owners of the said franchise, shall at any time during the life of this contract attempt to assert their said supposed rights and shall maintain the same by legal action duly instituted, prosecuted and defended, then and in that case the said City of Colorado Springs hereby reserves the right to terminate, annul and put an end to this contract, and the said city shall thereafter be relieved from any and all obligations of any kind or nature whatsoever hereunder.

This contract shall extend to and be binding upon the successors and assigns of the parties hereto.

It is further mutually understood and agreed that by the execution of this contract the said contract of April 1st, 1899, is hereby cancelled, abrogated and annulled.

It is further mutually understood and agreed by the parties hereto that this contract shall continue and be in force, save as hereinbefore provided, to and until the 31st day of March, A. D. 1909.

IN WITNESS WHEREOF the party of the first part has hereunto set its corporate seal and caused this contract to be signed by its vice-president and attested by its secretary, and the party of the second part has hereunto attached its corporate seal and caused these presents to be signed by its Mayor and attested by the City Clerk of the City of Colorado Springs.

THE COLORADO SPRINGS ELECTRIC CO.,

(Signed) WILLIAM P. BONBRIGHT,
Vice-President.

Attest:

(Signed) IRVING W. BONBRIGHT,
Secretary.

Corporate Seal of the
Colorado Springs Electric Co.

THE CITY OF COLORADO SPRINGS,

(Signed) J. R. ROBINSON,
Mayor.

Attest:

(Signed) K. M. MACMILLAN,
City Clerk.

Corporate Seal of
Colorado Springs, Colorado.

STATE OF COLORADO }
COUNTY OF EL PASO } ss:

I, K. M. MacMillan, City Clerk of Colorado Springs, County

and State aforesaid, do hereby certify that this is a true and correct copy as shown on the records on file in my office.

Certified to this 15th day of January, A. D., 1907.

(Signed) K. M. MACMILLAN,

City Clerk.

Corporate Seal of
Colorado Springs, Colorado.

EXHIBIT NO. 24.

This exhibit was an unsigned preliminary draft of franchise proposed to be granted George W. Jackson. It was practically the same as the copy of the franchise granted—Exhibit No. 1.

EXHIBIT NO. 25.

This exhibit was the original executed ordinance granted George W. Jackson and his associates and assigns, introduced in order to identify the copy of the same,—Exhibit No. 1.

EXHIBIT NO. 26.

SUMMARY OF TESTS ON ARC LAMPS USED ON THE STREETS OF COLORADO SPRINGS.

Test No.	Location.	Date.	No. IV.—Volts at terminals.			No. V.—Watts consumed in lamp.			M.H.
			Current.	Volts.	Watts.	Current.	Volts.	Watts.	
			III.	IV.	V.	VI.	VII.	C.-P.	
			II.			I.			
1.	Wood Av. & W. Espanola	June 2, '06, 11:00 p. m.	7.0	75.3	397	335	225	305	
2.	N. Corona & E. Columbia	June 3, '06, 9:15 p. m.	6.8	60.8	338	240	155	270	
3.	N. El Paso & Stillman	June 3, '06, 10:07 p. m.	7.1	88.2	440	385	275	240	
4.	N. Tejon & E. Cache la Poudre	July 5, '06, 9:25 p. m.	7.1	76.1	424	370	255	244	
5.	S. Wahsatch & E. Cimarron	Aug. 30, '06, 10:29 p. m.	7.0	73.7	436	385	270	270	
6.	Spruce St. & Center	Aug. 30, '06, 11:30 p. m.	7.0	69.1	410	355	240	240	
7.	Cascade Av. & E. Cache la Poudre	Aug. 30, '06, 11:59 p. m.	6.5	67.9	371	295	195	195	
8.	N. Tejon & Dale	Aug. 31, '06, 12:27 a. m.	7.0	71.9	424	370	255	255	
9.	N. Wahsatch & E. San Rafael	Aug. 31, '06, 1:00 a. m.	6.7	73.2	392	330	244	244	
10.	N. Weber & E. Uintah	Aug. 31, '06, 1:22 a. m.	6.7	43.4	240	43	35	35	
11.	N. Corona & E. Columbia	Aug. 31, '06, 1:47 a. m.	6.8	50.5	285	130	90	90	
12.	N. Tejon & E. Columbia	Aug. 31, '06, 2:10 a. m.	6.7	55.0	289	140	95	95	
13.	Wood Av. & W. Columbia	Aug. 31, '06, 2:27 a. m.	6.7	64.0	359	280	180	180	
14.	N. Cascade & Cache la Poudre	Aug. 31, '06, 2:51 a. m.	6.8	68.5	385	320	210	210	
15.	N. Tejon & E. Dale	Aug. 31, '06, 3:07 a. m.	7.0	71.0	420	365	250	250	
16.	S. Weber & E. Cucharas	Aug. 31, '06, 3:37 a. m.	7.0	64.0	379	310	202	202	
17.	N. Weber & E. Uintah	Aug. 31, '06, 4:28 a. m.	6.7	61.7	343	252	152	152	
Average			6.86	66.7	375.9	295	196	196	

Note.—Test No. 9, lamp marked "M"; test No. 10, lamp marked "J"; test No. 17, lamp marked "J."

EXHIBIT NO. 27.

COLORADO COLLEGE,

Colorado Springs, Colo., January 30, 1907.
William C. Robinson, City Att'y, Colorado Springs, Colo.:

Dear sir: Members of the Colorado College Committee on Street lamps, on the night of January 28-29, 1907, made the following power tests of lamps used on the streets of this city.

Location.	Hour.	Amperes.	Volts.	Watts.	Max. C.-P.	M. H. C.-P.	Outer Globes
W. Uintah St. & Wood Ave.	12 m'n.	6.93	79.6	446	388	280	O.K.
N. Columbia & Wood Ave.	12:19 a. m.	6.97	70	400	345	230	badly broken
E. Columbia & N. Weber	12:48 a. m.	6.96	75.8	450	390	290	broken
E. Columbia & N. Corona	1:11 a. m.	6.82	68.6	394	335	220	O.K.
E. Uintah & N. Corona	1:30 a. m.	7.02	73.8	438	382	272	O.K.
Cache la P. & N. Cascade	2:00 a. m.	7.14	79	466	402	307	O.K.
Average		<u>6.97</u>	<u>74.4</u>	<u>432.3</u>	<u>373.6</u>	<u>266.5</u>	

The volts in the above table mean volts at the lamp terminals; the watts mean watts consumed in the lamp. The maximum C. P. is read from the curve made from the Purdue tests; this is also the case with the last column which gives the Mean Hemispherical Candle Power.

J. R. ARMSTRONG,

J. C. SHEDD.

EXHIBIT NO. 28.

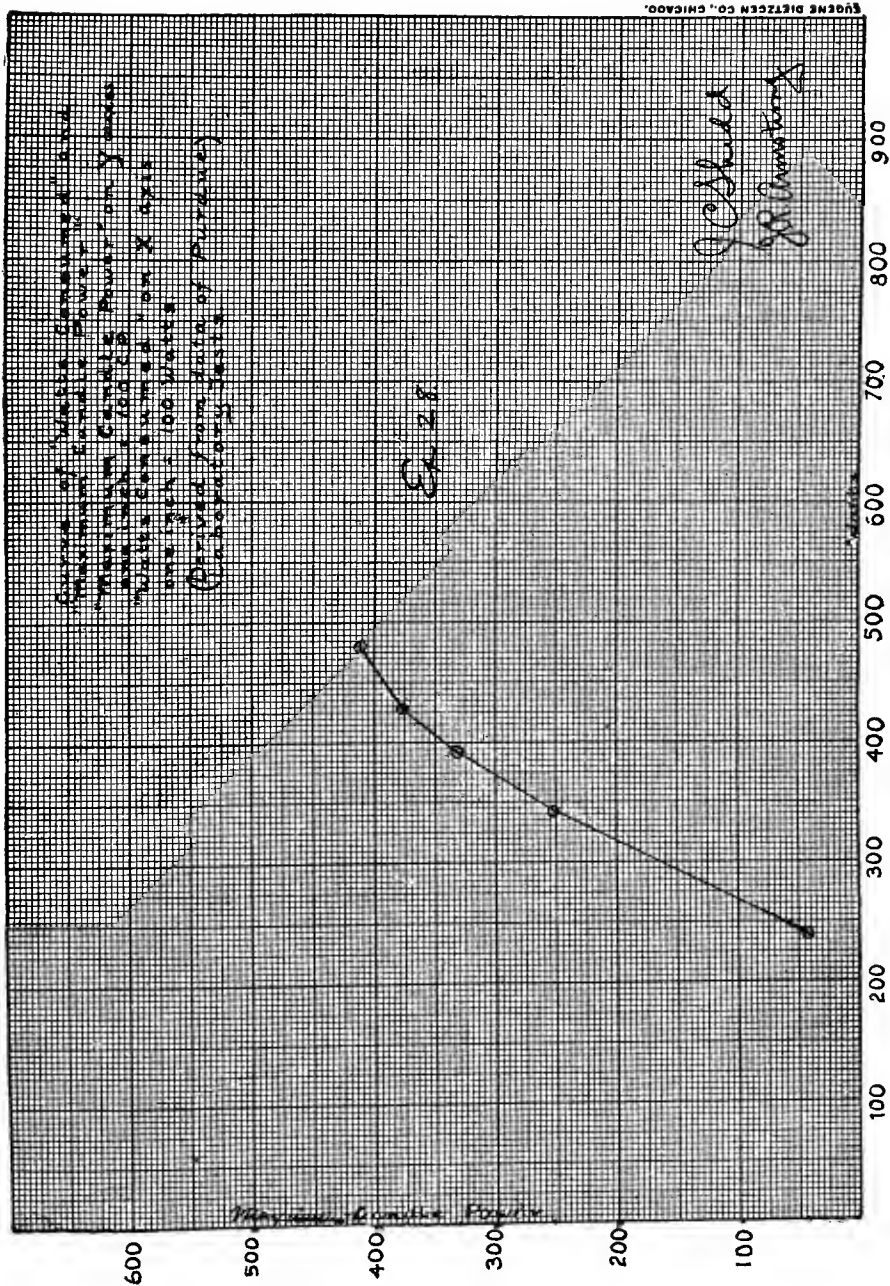


EXHIBIT NO. 29.

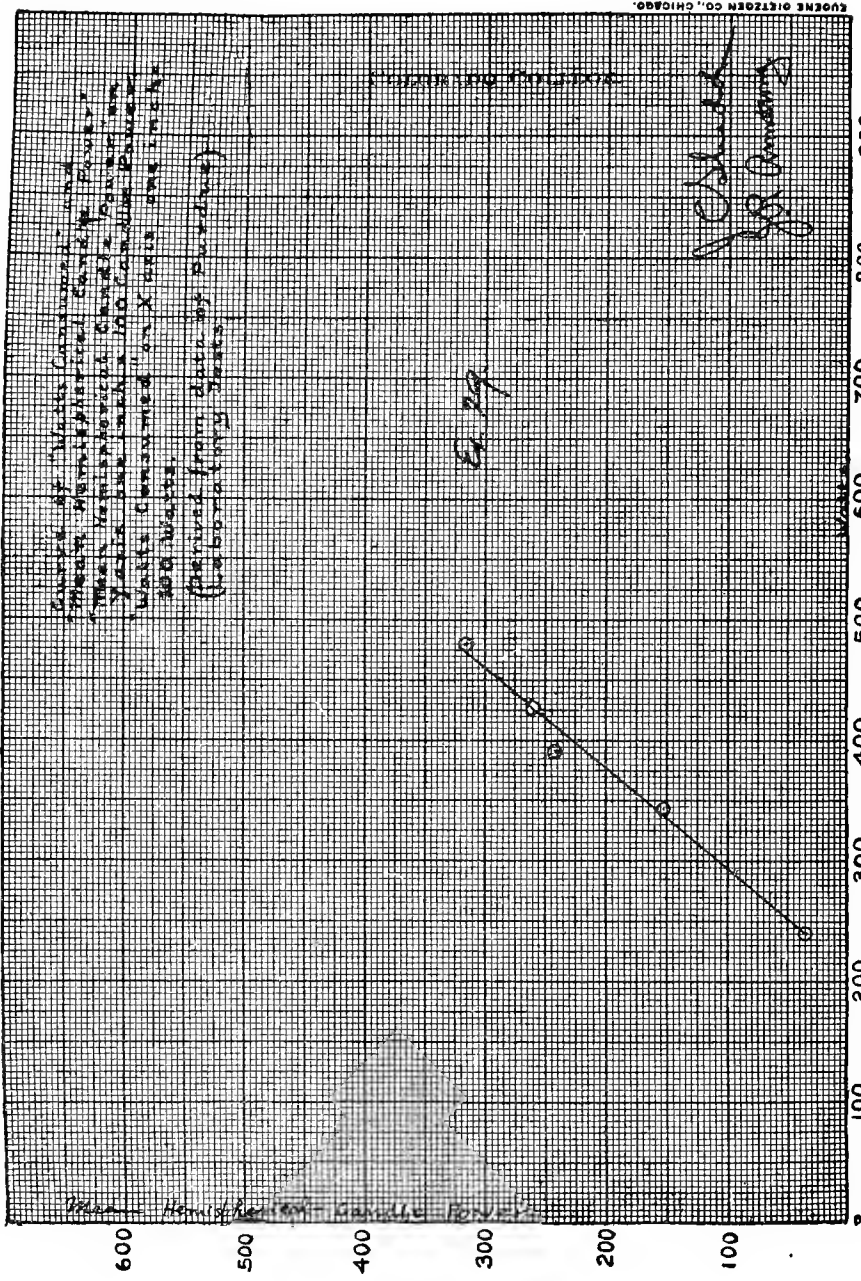


EXHIBIT NO. 30.

Colorado Springs, Colo., February 1, 1907.

M. The City of Colorado Springs,
Colorado Springs, Colorado.
To The Pike's Peak Hydro-Electric Company, Dr.
Office, 203 Mining Exchange Building.

To 253 arc lamps at \$5.50 each	\$1,391.50
To bill rendered Dec. 28, 1906	9,480.04
	<hr/>
	\$10,871.54

Approved.
(Signed) A. W. GRAY,
Street Commissioner.
O.K. (Signed) A. M. HOLDEN.

STATE OF COLORADO }
COUNTY OF EL PASO } ss:

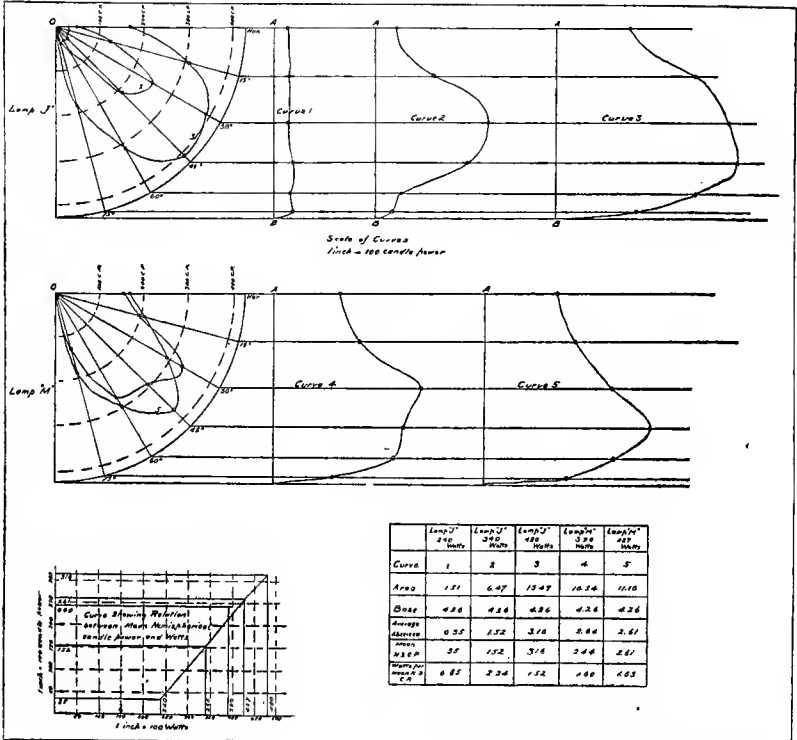
I, G. M. Perry, City Auditor of the City of Colorado Springs, do hereby certify that the above is a true and correct copy of the bill rendered this City by the Pike's Peak Hydro-Electric Company, for January lights, with the item of bills rendered added.

(Signed) G. M. PERRY,
Chief Auditor.

Colorado Springs, Colo.,
February 2, 1907.

EXHIBIT NO. 31.

Polar and Rousseau Curves.



These curves show candle-power readings on 6.6 ampere series lamps of the alternating-current, enclosed type under various power consumptions.

The upper figure gives the so-called polar diagram for the lamp marked "J" taken, Curve 1, when the power consumed in the lamp is 240 watts, Curve 2, 342 watts, and Curve 3, 480 watts. In this diagram the lamp is supposed to occupy the position "O" at the center of the radiating lines. The values of the intensity of the light, in candle-power, measured in different directions, is laid on lines lying at 0 degrees, 15 degrees, 30 degrees, 45 degrees, 60 degrees, and 75 degrees with the horizontal. These points are then connected by a curve as shown in the figure. Such curve is known as the distribution curve for the lamp.

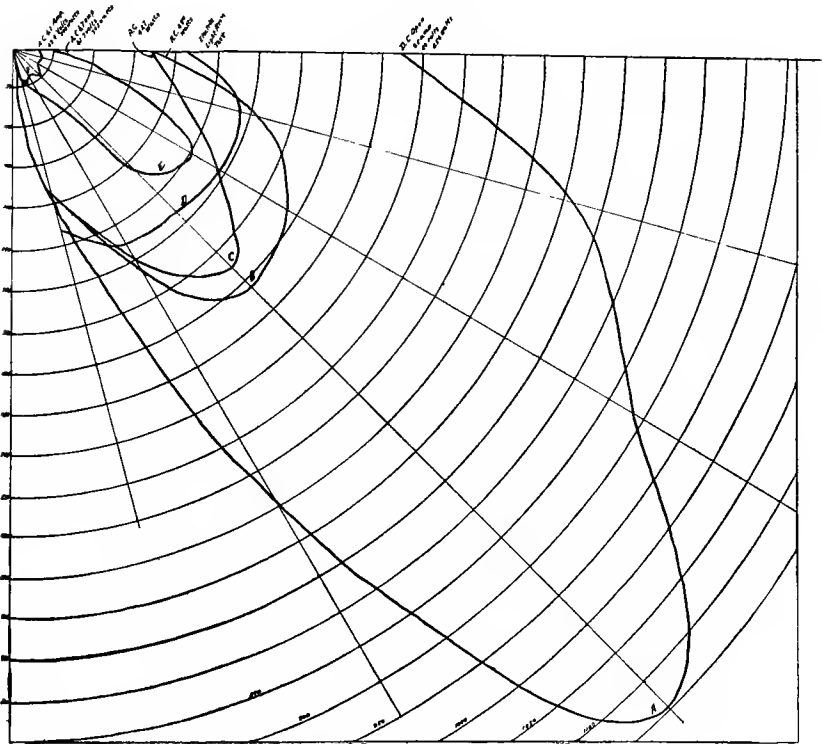
The diagrams to the right of the polar diagram show the same facts in a slightly different manner. The line AB here takes the place of the point "O," and the candle-power at the various angles is measured off to the right of this line. The curved line then shows the change of candle-power with the change of angle.

The lower figure refers to lamp "M" and presents the candle-power of the lamp at different angles for a power consumption of 392 watts, Curve 4, and of 427 watts, Curve 5.

The diagram in the lower left-hand corner is a candle-power consumption curve and is sufficiently labeled to be readily understood.

EXHIBIT NO. 32.

Polar Curves.



EXHIBITS NOS. 33 and 34.

These exhibits were an upper and a lower carbon from a direct-current series open arc lamp. These are illustrated by Figure 18-b of Exhibit B.

EXHIBITS NOS. 35 and 36.

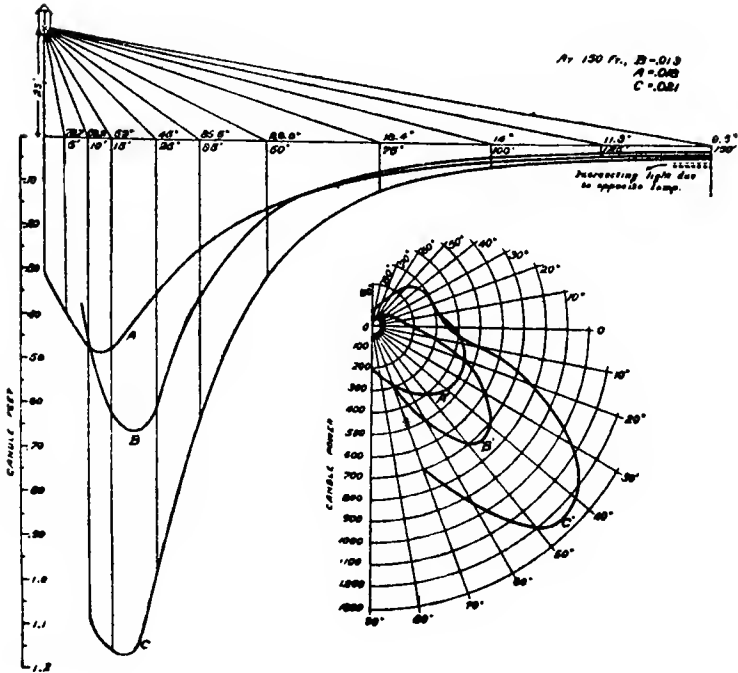
These exhibits were an upper and a lower carbon from an alternating-current series enclosed arc lamp. These are illustrated by Figure 18-a of Exhibit B.

EXHIBIT NO. 37.

This exhibit was a memorandum map of Colorado Springs introduced for the purpose of identifying the location of the lamps "J" and "M," on which measurements were made on the street by Professors Shedd and Matthews. Said lamps being removed to Purdue University for candle-power measurements.

EXHIBIT NO. 38.

ARC LAMPS — ILLUMINATION CURVES



Curves	A, A'	B, B'	C, C'
Type of Lamp	Series Alt. Enclosed. 6.6 Amps.	Series Cont. Cur. Open. 6.6 Amps.	Series Cont. Cur. Open. 9.6 Amps.
Volts { At Arc At Term	72 76	48.5 50	46 48
Watts, Actual	425	330	480
Globe	Inner, Opal Outer, Clear	Clear	Clear
Carbon	Electra Upper, Solid Lower, Cored	National Copper Coated	National Copper Coated
Arc In mean position for all tests.			

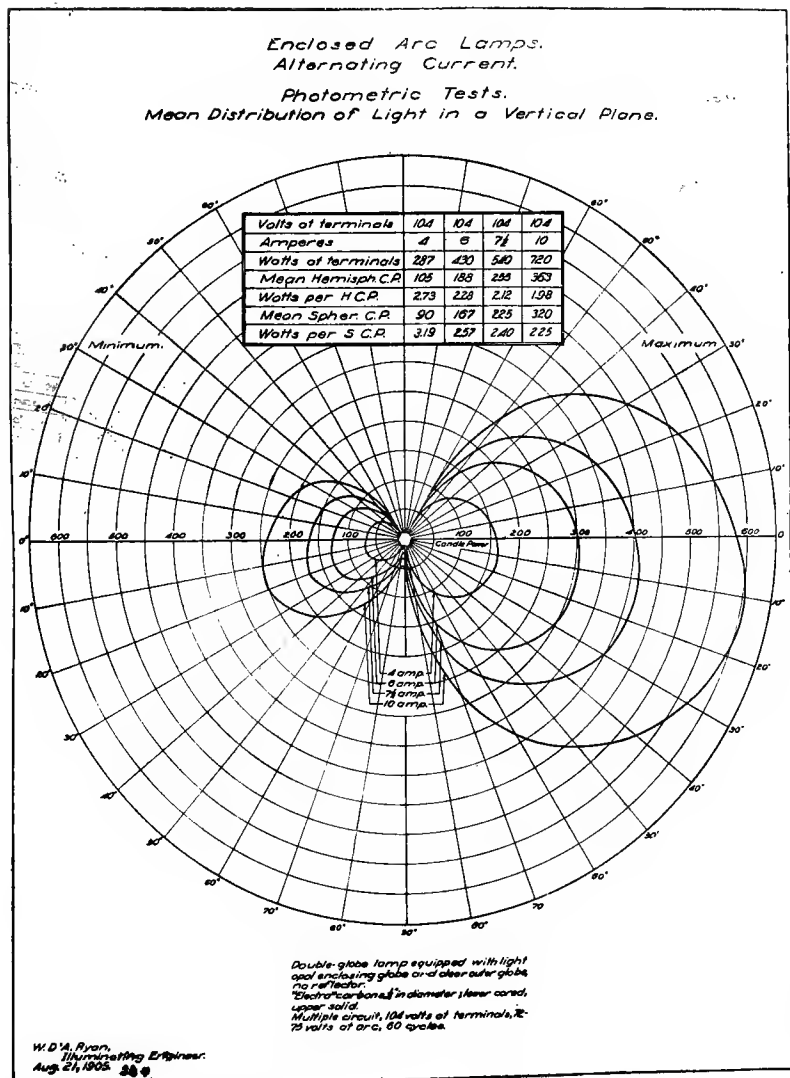
EXHIBIT NO. 39.

This exhibit was a series of free-hand sketches made on the blackboard by Mr. W. D'A. Ryan, of which no permanent record was made.

The information given is practically all covered by the testimony of Mr. Ryan in connection with Exhibits Nos. 31, 32, 38, 40, 41 and various Figures of Exhibit B.

EXHIBIT NO. 40.

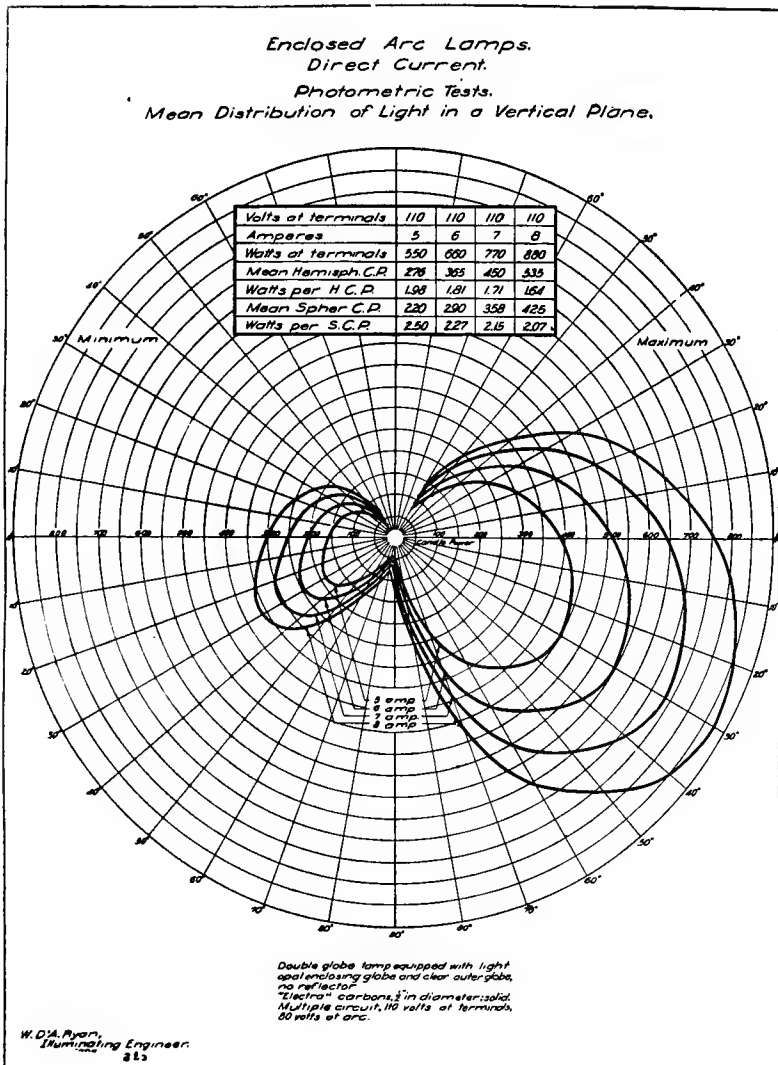
Polar diagram of A. C. lamps.



POLAR DIAGRAM.

EXHIBIT NO. 41.

Polar diagram of D. C. lamps.



A. C. ARC EXPERIMENTS.

EXHIBITS NOS. 42 AND 43.



Exhibit No. 42. Dics with 30% segments.



Exhibit No. 43. Diminution of light by rotating segments.

A. C. ARC EXPERIMENTS.

EXHIBITS NOS. 44 AND 45.



Exhibit No. 44. Diminution of light by stationary segment.

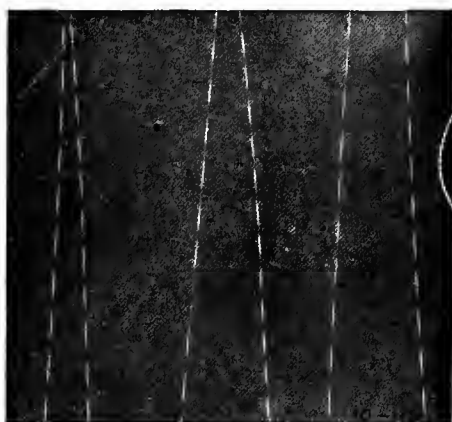


Exhibit No. 45. A. C. arc on rotating screen.

EXHIBIT NO. 46.

THE RESOLUTION OF THE CITY COUNCIL AUTHORIZING THE PIKE'S PEAK HYDRO-ELECTRIC CO. TO BEGIN THE USE OF CITY WATER AND FURNISHING OF LIGHT.

Extract from the Council Proceedings of January 16, 1905. Rec. 9, page 397.

Alderman Perkins introduced the following resolution which was read:

WHEREAS, the Pike's Peak Hydro-Electric Company, the owner by assignment of the franchise heretofore granted to George W. Jackson, his associates and assigns, has notified the City that it will soon be in a position to furnish the City the street lights and other lighting as provided for in said ordinance, and in the absence of extraordinary occurrence will be able to furnish said lights not later than the 15th day of February, 1905; and,

WHEREAS, the City has requested the Hydro-Electric Company to furnish all current which is necessary for lighting the new City Hall instead of the limited number of lights provided for in said franchise, which said request the said Company has granted; and,

WHEREAS, it will be necessary as soon as the said Company requests it for the City to turn the City water into the pipe line of said Company;

THEREFORE, BE IT RESOLVED, That the Chairman of the Water Committee or his duly authorized representative be and he is hereby authorized and directed to turn water into the pipe line of said company, at any time upon request of said company, and

RESOLVED, FURTHER, That the Council hereby accepts the arrangement heretofore suggested to and accepted by the said company, that said company furnish to the city the electric current necessary for the proper lighting of the City Hall building, in lieu of the free lights required under the Ninth Section of said franchise, the said arrangement to continue during the pleasure of the City Council, and

RESOLVED, FURTHER, That nothing in this arrange-

ment shall be construed as in any way modifying or impairing the validity or the obligations of said franchise, and

RESOLVED, That forthwith upon the commencement of operations by the said Hydro-Electric Company the city avail itself of the provisions of said franchise relating to the lighting of the streets of the city, and to notify the Colorado Springs Electric Company of the termination of the city's contract with it, all in accordance with the provisions of said contract.

Alderman Perkins moved, seconded by Alderman Holden, that the resolution be adopted as read. The Clerk called the roll of Aldermen upon the motion and the Aldermen each, upon their name being called, voted as follows: Banning, Dunbar, Hill, Holden, Patton, Perkins, Verner, yea. Absent, Mr. President. All the Aldermen present voting yea, the President declared the motion carried and resolution adopted.

STATE OF COLORADO }
COUNTY OF EL PASO } ss:

I, K. M. MacMillan, Clerk of the City of Colorado Springs, County and State aforesaid, do hereby certify that the above and foregoing is a true and correct copy of an Extract from the Council Proceedings of January 16, 1905, as recorded in Record 9, page 397, as the same now appears in my office.

IN WITNESS WHEREOF I have hereunto set my hand and affixed the seal of the City this fourth day of February, A. D., 1907.

(Signed) K. M. MACMILLAN.

[SEAL]

EXHIBIT NO. 47.**THE PIKE'S PEAK HYDRO-ELECTRIC COMPANY.****Main Office:****203 Mining Exchange Bldg., Colorado Springs, Colo.****Branch Office: Manitou, Colorado.**

Colorado Springs, Colo., January 12, 1905.

To the Mayor and City Council,

Colorado Springs, Colo.

Gentlemen:

Referring to the commencement of operations by the Pike's Peak Hydro-Electric Company, I desire to say that the company will very shortly be in a position to conduct the city's water through the pipe line and to commence the furnishing of the street lights and the other lighting for the city, in accordance with the provisions of Section 9, of the ordinance heretofore granted to George W. Jackson, his associates and assigns, under which the said Hydro-Electric Company is operating. Owing to the severe weather now prevailing, it is impossible to tell the exact date upon which the company will be in position to perform this service but the pipe is completely installed and there remains some calking to be done. As the water cannot be turned in the pipe in the first instance, except under favorable weather conditions, I beg to request that your council may take such action as it may deem proper in authorizing some one to turn the water into the company's pipe line when requested, the connection having been made, and in the absence of any extraordinary occurrence the company will be in position to furnish the city with lights as above stated not later than the 15th day of February, 1905.

Very respectfully yours,

(Signed) G. A. TAFF,

President,

The Pike's Peak Hydro-Electric Company.

STATE OF COLORADO
COUNTY OF EL PASO

} ss:

I, K. M. MacMillan, City Clerk of Colorado Springs, County and State aforesaid, do hereby certify that this is a true and correct copy as shown on the records on file in my office.

Certified to this 4th day of February, A. D., 1907.

(Signed) K. M. MACMILLAN,
City Clerk.

EXHIBIT 48.

NEWSPAPER CLIPPING OF CONTRACT BETWEEN
THE PIKE'S PEAK HYDRO-ELECTRIC CO. AND
THE COLORADO SPRINGS ELECTRIC CO.

THIS AGREEMENT, made and entered into this 31st day of January, A. D., 1903, by and between the Pike's Peak Hydro-Electric Company, a corporation organized and existing under and by virtue of the laws of the State of Colorado, party of the first part, hereinafter referred to as "The Power Company," and the Colorado Springs Electric Company, a corporation organized and existing under and by virtue of the laws of the State of Colorado, party of the second part, hereinafter referred to as "The Electric Company," WITNESSETH, that

WHEREAS, the Power Company is owner of a certain franchise granted to George W. Jackson by an ordinance passed by the City Council of the City of Colorado Springs, September 8, 1898, giving to the said Jackson, his associates or assigns, the right, among other things, to use the water of the water-supply system of the said City for the power purposes, and the said Power Company is about to construct the necessary works and plants for developing and utilizing the said water power and transmitting electrically the said power so developed to the City of Colorado Springs and other places, and is desirous of obtaining a market therefor; and

WHEREAS, the Electric Company is engaged in the business of supplying electricity for light, power and other purposes in the City of Colorado Springs and other places in the vicinity, and is the owner of a power-transmission plant located near Colorado Springs which is operated by steam, and of a distributing station and distributing system covering Colorado Springs, Colorado City, and other places in that vicinity;

NOW, THEREFORE, the parties above named have agreed as follows:

1. The Electric Company agrees to take from the Power Company, and pay for, at the price and upon the terms and conditions hereinafter specified, all of the electric power used by it from the time when the Power Company is ready to supply the same and thereafter during the continuance of this agreement, except an amount not exceeding an average of 175,000 Kilowatt-hours per month for not more than eight months each year, which it reserves the right to generate for itself.

2. The Power Company agrees to commence at once, and to proceed diligently with, the construction of the necessary works and plants for developing the said water power and supplying the said electric power to the Electric Company, and to have the same ready for delivering to the Electric Company (in addition to whatever power may be required to fulfill the terms of a contract with the Colorado Springs Interurban Railway Co. hereinafter referred to) an average of not less than one thousand one hundred and fifty (1,150) Kilowatts per hour, daily average, based on a load factor of fifty to fifty-five per cent., not later than the first day of October, 1903, and to supply to the Electric Company continuously from that time on during the continuance of this agreement, all of the electric power required by the Electric Company for use in its business, up to the full capacity of the said water power (less the amount of 175,000 Kilowatt-hours monthly, if the Electric Company elects to generate for itself that amount), subject only to the reservation specified in the next paragraph below. Should the Power Company be able to furnish electric power in excess of the capacity of said water power, whether generated by water, steam or otherwise, the Electric Company agrees, subject to the reservations herein expressed, to take from the Power Company all of the electric power it requires in its business during the continuance of this agreement, even if the power so taken exceeds the capacity of the said water power. Should the Power Company be ready to supply all the electric power required by the Electric Company, or such part of the same as to enable the Electric Company to dispense with one full shift at its main plant, at an earlier date than the first day of October, 1903, the Electric Company shall, upon thirty days' notice in writing of the Power Company's readiness to supply such electric power, take and pay for the same from such earlier date.

The term "load factor" as used in this agreement is the percentage which the average amount of power used constitutes of the maximum amount of power used during such period; for example, if the average consumption for twenty-four hours is one thousand kilowatts per hour, and the maximum consumption at any time within the twenty-four hours is two thousand kilowatts, the load factor would be fifty.

3. The Power Company covenants and agrees that it will not, during the continuance of this agreement, sell or furnish any current for lighting, power or any other purpose to any person, firm or corporation other than the Electric Company (except to the Colorado Springs Interurban Railway Company in case a contract is made between the Power Company and the said Railway Company in pursuance of negotiations now pending) for use in any territory in El Paso County, east of a line drawn through the most easterly point of the City of Manitou as at present con-

stituted, and, subject to the reservations specified in this paragraph, agrees to supply to the Electric Company so much of the total output of the Power Company, up to the full capacity of the said water power, as the Electric Company may require from time to time for use in its business, as and when required by the Electric Company. The Power Company reserves the right, however, to use for supplying its customers in the City of Manitou, for use only in said city and west of said city and its most easterly line, a maximum of ten per cent. of its average Kilowatt production from April 15th to October 15th of each year, during the continuance of this agreement, and the Power Company also reserves the right to sell or dispose of in the Cripple Creek District, or any other place west of the most easterly point of the City of Manitou, or any territory outside of El Paso County, for use only in said places, any surplus electric power it may have from time to time available above the requirements of the Electric Company at the time, including a sufficient reserve to provide for the usual and normal growth of the Electric Company's business.

The Electric Company agrees to furnish power to the Power Company in Colorado Springs at the same rate as the contract price plus line loss, the amount furnished by the Electric Company to the Power Company not to exceed ten (10) Kilowatts per hour. The amount so furnished shall not be counted in making estimates for minimum charge or discounts, and the power so delivered to the Power Company in Colorado Springs shall be used only by the Power Company for its own purposes, and shall not be sold or come into competition in any way with the Electric Company's business.

The Power Company covenants and agrees that in case a contract is closed between it and The Colorado Springs Interurban Railway Company for the supply of power to the said Railway Company, the price charged the Railway Company shall not be less than six and one-quarter mills per Kilowatt hour, and the said contract shall strictly limit the use of all power supplied by the Power Company to the operation of the Railway of said Railway Company, and lighting its property, and prohibit the use of such power for any other purposes.

And the Power Company further covenants and agrees that it will on or before the first day of June, 1903, assign the said contract to the Electric Company upon the execution of an agreement by the Electric Company to pay to the Power Company for all power generated by the Power Company and supplied to the Railway Company, in addition to the rates herein specified, one-half of the excess over such rates received from the Railway Company after deducting loss on such power which is fixed for the purposes of this agreement at five per cent.

The Electric Company is to receive the full compensation de-

rived from the said contract until the Power Company's plant is in operation.

4. All electric power supplied under this agreement shall be delivered at the eastern limit of the City of Manitou to transmission lines to be furnished by the Electric Company, and the Power Company agrees to provide and maintain, at its own expense, all generating plants, pole-lines, switchboards and other equipments, appliances and devices necessary for generating the said electric power and delivering it upon the lines of the Electric Company as above provided. All works, plants, pole-lines and other apparatus of the Power Company shall be of the best and most modern design and construction, and all transmission lines of the Power Company shall be equipped with two circuits of three wires each, for conveying said current, said circuits to be of the same size and carrying capacity as the circuits to be erected by the Electric Company extending from 8th Street, Colorado City, to the eastern limits of Manitou. All Power supplied by the Power Company shall be supplied in the form of three-phase, sixty cycles alternating electric current of the standard electro-motive force of 6,000 volts used by the Electric Company on its main transmission lines, and shall be at all times regulated for constant electro-motive force and synchronous operation with the generators of the Electric Company according to the best and most approved modern regulating appliances.

5. The Electric Company covenants and agrees that it will not sell or supply current for lighting, power or other purposes to any person or persons for use in the city of Manitou, except as it may be required so to do in fulfillment of its existing agreement with William A. Bell.

The Electric Company hereby agrees to pay the Power Company during the last five years of the term of the said contract with the said William A. Bell (the full term of the said contract being ten years from March 15, 1901) an amount computed monthly equivalent to the difference between the monthly receipts by the Electric Company under the said agreement, and the actual monthly cost (which shall be considered as six mills per Kilowatt-hour) to the Electric Company of the power delivered to the said Bell under the said agreement. The Electric Company further agrees that it will appoint as its representative to take readings of the meter or meters used for measuring the electric power supplied under the said agreement to the said Bell during the said last five years of the same, a person to be nominated by the Power Company, and will give such person so nominated by it and appointed by the Electric Company, all of the rights which are given under the said agreement with the said Bell to the representative of the Electric Company in regard to inspecting and testing the said meters.

The amount of electric power so furnished to William A. Bell

during the last five years shall not be counted in making estimates for minimum charge or discounts. A copy of the said agreement between the Electric Company and William A. Bell is annexed to this contract as Exhibit "A."

6. The Power Company covenants and agrees to give continuous and uninterrupted service to the Electric Company according to the best and most modern standards of engineering practice, and to maintain all of its plants, apparatus, transmission lines and appliances at the most efficient point of operation during the period covered by this agreement.

7. All power supplied under this agreement shall be paid for by the Electric Company monthly, and accounts for each calendar month shall be made up and settled on or before the tenth day of the succeeding month. When the average daily load factor for such calendar month is from fifty-seven per cent., and the monthly consumption does not exceed one million (1,000,000) Killowatt-hours, the rate shall be five and eighty-five hundredths mills per Killowatt-hour. When the average daily load factor for any month is greater than fifty-seven per cent., the rate per Kilowatt-hour is to be diminished at the rate of five one-hundredths of a mill, for each per cent. of increase in load factor up to sixty-two per cent., and when the average daily load factor for any month is less than fifty-seven per cent., the rate per Kilowatt-hour is to be increased by five one-hundredths of a mill for each per cent. of such decrease of load factor down to forty-five per cent. inclusive, but no account is to be taken in fixing the rate of any possible increase in load factor above sixty-two per cent. or any decrease below forty-five per cent.

In case the contract with the Colorado Springs Interurban Railway Company herein referred to, is executed, either by the Power Company or the Electric Company, then during its continuance, it is agreed that no reduction in price per Kilowatt-hour shall accrue to the Electric Company, for any increase in load factor, unless said load factor shall exceed eighty per cent. For any such excess above eighty per cent., a reduction in price shall be conceded to the Electric Company, as hereinbefore provided, for each per cent. of said excess up to and including eighty-five per cent.

When the amount of electric power received by the Electric Company exceeds an average of one million (1,000,000) Kilowatt-hours per month, for any year, a discount at the rate of five one-hundredths of a mill per Kilowatt-hour is to be allowed by the Electric Company upon the rates fixed, as above provided, for each hundred thousand (100,000) Kilowatt-hours per month so received by the Electric Company above the said amount of one million (1,000,000) Kilowatt hours per month, and proportionately for any fraction of one hundred thousand (100,000) Kilowatt-hours per month, provided, however, that the rate shall

in no event be less than five and fifty-five hundredths mills per Kilowatt-hour.

Provided also, that during such months as the Electric Company exercises its privilege to manufacture any part of the 175,000 Kilowatt-hours mentioned in Article 1 hereof, no rebate shall be allowed on account of load factor increase, until said load factor increase has reached sixty-four. Then from sixty-five to sixty-nine, both inclusive, a rebate shall be allowed of five one-hundredths of a mill per Kilowatt-hour for each per cent. of such increase, but no account is to be taken of any increase in load factor beyond sixty-nine.

During the life of the contract with the Railway Company herein referred to, the reduction in price upon load factor account, when the Electric Company is exercising its privilege of manufacturing power at its sub-station, shall be operative only between load factors of eighty-two and eighty-seven per cent.

8. The amount of power supplied by the Power Company and used by the Electric Company under this agreement shall be determined by suitable watt meters of some standard manufacture, to be furnished by the Power Company and placed in the Power Company's main distributing station in Manitou. All meters used for this purpose shall, before they are put in use, be tested in the presence of the engineers or other authorized representatives of both parties, in the Power Company's distributing station at Manitou on the transmission lines operated from its water power station, and under the same conditions of load and power factor under which they are to be normally operated, and thereupon the seal of both parties shall be applied thereto, and the said meters shall not be opened for inspection thereafter except in the presence of authorized representative of both parties, but the said meters shall at all times be open to the inspection of the Electric Company, or its duly authorized representative, in the presence of the engineer or other authorized representative of the Power Company. In case of any dispute as to the accuracy of the meters so used, or any of them, the Electric Company, or its duly authorized representative, shall be allowed to test the same at any time in the presence of the engineer or other authorized representative of the Power Company, and if the tests so made do not agree with those of the Power Company, the parties shall insist upon some competent electrician not connected with, or interested in, either party, to test the same, and his determination shall be binding on both parties, and all unsettled accounts for power measured by such meter shall be settled on the basis of such determination. If the parties fail to agree in the appointment of such electrician within ten days after either notifies the other in writing of its desire to have such appointment made, each party shall appoint one competent disinterested electrician, and the two so nominated shall make the test provided for, and

if they are not able to agree as to results, they shall appoint a third disinterested electrician, and the three shall make such test, and the determination of any two of the said three electricians so appointed shall be binding upon all parties, and all accounts for power measured by such meters from the time when the disagreement arose in regard to its accuracy shall be settled upon the basis of such determination. If either the Power Company or the Electric Company fails to appoint an electrician as above provided within ten days after receiving written notice from the other requiring such appointment to be made, the party so failing to appoint shall pay to the other, as liquidated damages, the sum of one thousand dollars (\$1,000) for each and every failure to make such appointment.

The Power Company shall furnish promptly proper facilities for all tests herein provided for, and the expenses of all such tests shall be divided equally between the parties hereto.

The Electric Company shall have the right to its option to furnish and install at its own expense in the Power Company's station at Manitou, and to connect with the Power Company's transmission lines, such additional meters as it may desire to use as a check upon the meters of the Power Company. The Power Company shall furnish all proper facilities for the installation of such meters (but without expense to it, all of the expense of installing and caring for the same to be borne by the Electric Company), and the Electric Company shall have free access to such meters at all times and be provided with proper facilities for examining and testing the same, but if such meters be installed, they shall at all times be subject to the regulations regarding testing and inspecting, as are above outlined for the meters to be installed by the Power Company.

9. The Electric Company agrees to pay to the Power Company (exclusive of the amount which may be due the Power Company upon account of power used by the Railway Company), a minimum of sixty thousand dollars (\$60,000) per year for the power supplied to it during the continuance of this agreement, commencing from the time when the Power Company has its works and plants completed and is ready to meet fully the requirements of the Electric Company for power up to the full capacity of the said water power (the Electric Company, however, to have thirty days' notice as provided above in case such works and plants are completed prior to the first day of October, 1903), provided, however, that the provisions of this paragraph shall not apply to any year during which the Electric Company shall require and be ready to receive power amounting, at the rates above specified, to the said minimum amount and the Power Company shall fail to apply the same, and for any such year the Electric Company shall pay only for the power actually received by it. If the price of the power received by the Electric Company amounts, at the

rates hereinbefore specified, to less than the said minimum sum for any year to which this paragraph applies, the balance required to pay such minimum sum shall be paid over by the Electric Company within twenty days after the accounts for such calendar year are made up.

10. Beginning October 1st, 1906, the Electric Company shall pay to the Power Company, in addition to the amounts above provided, the sum of four thousand dollars (\$4,000) each year during the continuance of this agreement.

11. It is understood and agreed that this contract is in no wise to be considered as a waiver by the Power Company of any of its rights under the said franchise granted to Geo. W. Jackson by the City of Colorado Springs, and that the Power Company may, at any time during the life hereof, and at any time after it shall be in position to furnish the lights and power herein referred to, demand of the City of Colorado Springs that it permit the Power Company to furnish to the City of Colorado Springs, and that the City purchase from the Power Company the lights and power provided for in, and upon the terms and conditions mentioned in Section 9 of the said Jackson franchise for the remainder of the term of said franchise; and it is agreed that, when the said City of Colorado Springs, voluntarily or involuntarily, permits the Power Company to furnish the lights and power as provided in Section 9 of said Jackson franchise for the remainder of the term thereof, the Electric Company shall assume and perform all of the obligations of the Power Company imposed by the said section, so far as such obligations relate to the supply of lights and power, using its own distributing system for that purpose, upon receiving an assignment from the Power Company in due form of all of its rights under the said Section 9, which assignment the Power Company agrees to make; but the Electric Company shall in no way assume any of the obligations of the Power Company to construct any works or plant for carrying out the provisions of such contract, or to turn over to the City of Colorado Springs any works or plants used for performing such obligations; it being understood between the parties hereto that the Electric Company shall assume the obligations as to supplying light and power of said Section 9 of the Jackson franchise when accepted for the remainder of the term thereof by the City as above provided, whether such acceptance on the part of the City is voluntarily enforced; inasmuch as the Power Company is by its counsel advised and now believes that the said Section 9 of said Jackson franchise of itself, and in connection with the other sections thereof, constitutes a binding contract obligating the City of Colorado Springs to purchase its street lights upon the terms and conditions therein mentioned, when and as soon as the Power Company shall be in position, and the water power shall have been sufficiently developed to furnish said lights, while the Elec-

tric Company is advised by counsel and believes that neither said section of itself or in connection with the other sections of said franchise constitutes a binding contract, but is merely an option on the part of the City of Colorado Springs. The provisions of this paragraph are understood by the parties, and are to be construed as in no way conflicting with or abrogating or modifying the obligations of either party under other parts of this agreement.

12. This agreement shall continue in force for the term of sixteen (16) years from its date, and the Electric Company shall have the right, at its option, to continue the same in force for additional term of seven years upon giving to the Power Company notice in writing twelve months prior to the expiration of the said original term, of its desire to continue the agreement in force for such additional term.

13. Neither party hereto shall be responsible, or liable for any default, failure or delay in carrying out any of the stipulations of this agreement when the same is caused by the act of God, labor strikes or an injunction or other Court order.

14. If the Power Company has not, by April 1st, 1903, prosecuted the work contemplated under this agreement to point sufficiently advanced to insure the delivery within the time herein limited of the required amount of power by the Power Company to the Electric Company, then and in that case the Electric Company may, at its option, notify the Power Company, at any time between April 1st, and May 1st, 1903, of the cancellation of this agreement, and such notice in writing, from the Electric Company to the Power Company, shall release both parties hereto from all conditions of this agreement. Provided, however, that if the Power Company has done sufficient preparatory work and has sufficient orders placed and accepted by reliable manufacturing concerns for deliveries at times early enough to insure the completion of the installation requisite to fulfill the terms of this agreement, such work and such orders so placed and accepted shall be deemed sufficient evidence that the installation will be made by the Power Company within the specified time.

16. This agreement shall extend to and be binding upon the successors and assigns of the parties hereto.

IN WITNESS WHEREOF, The parties named have caused their corporate names to be signed hereto by their Presidents and their corporate seals to be hereto affixed and attested by their Secretaries, the day and year above written.

(Signed) THE PIKE'S PEAK HYDRO-ELECTRIC CO.

(Signed) G. A. TAFF,
President.

Attest:

(Signed) S. T. HAMILTON,
Secretary.

(SEAL)

THE COLORADO SPRINGS ELECTRIC CO.

(Signed) P. B. STEWART,
President.

Attest:

(Signed) IRVING W. BONBRIGHT,
Secretary.

(SEAL)

EXHIBIT NO. 49.**THE PIKE'S PEAK HYDRO-ELECTRIC COMPANY.**

**Main Office: 203 Mining Exchange Building,
Colorado Springs, Colo.**

Branch Office: Manitou, Colorado.

Colorado Springs, Colo., January 12, 1905.

To the Mayor and City Council,
Colorado Springs, Colo.

Gentlemen:

Replying to the oral request of the lighting committee that the Pike's Peak Hydro-Electric Company agree to furnish the City, free of cost, all the electric current necessary for the lighting of the new City Hall instead of the limited number of lights provided for in the Ninth Section of the Jackson Franchise, I beg to say that I am authorized by the company to accede to your request and on behalf of the company I hereby accept said proposition on the understanding as stated by the committee that this agreement shall not be construed as in any way impairing the obligations or validity of said franchise, but shall be considered only as a fulfillment by the Pike's Peak Hydro-Electric Company of the obligations imposed by said Ninth Section of the said franchise relative to lights to be furnished free of cost, and upon the further understanding that this arrangement shall continue during the pleasure of the City Council.

Very respectfully yours,

(Signed) G. A. TAFF.

[SEAL]

STATE OF COLORADO }
COUNTY OF EL PASO } ss:

I, K. M. MacMillan, City Clerk of Colorado Springs, County and State aforesaid, do hereby certify that this is a true and correct copy as shown on the records on file in my office.

Certified to this 4th day of February, A. D., 1907.

(Signed) K. M. MACMILLAN,

City Clerk.

EXHIBIT No. 50.

This was a lead-pencil sketch of Rousseau diagrams, presented by Professor J. C. Shedd, practically duplicating the information contained in Exhibit No. 31. Not being considered valuable for preservation it was destroyed by the Arbitrators, after the conclusion of the hearings.

EXHIBIT A 1.

This exhibit was volume No. 105 of the "Federal Reporter," giving the opinion of Judge Sandborne in the case of the Pike's Peak Power Company vs. City of Colorado Springs, November 5, 1900.

This case arose from the attempt of the City to repeal the "Jackson Franchise." The United States Circuit Court of Appeals upheld the validity of the franchise and decided it had not been forfeited.

EXHIBIT A 2.

This exhibit was a volume of the proceedings of the National Electric Light Association of 1894 with particular reference, on page 282, to the resolution defining a 2,000 candle-power lamp, reading:

"RESOLVED, that in the opinion of this Convention what is ordinarily known as a two thousand candle-power arc lamp is one requiring, on the average, four hundred and fifty watts for its maintenance, the measurements being made at the lamp terminals, where no sensible resistance is included in series with the arc. In case such resistance is used, it must be excluded in the measurement of the voltage."

T. C. MENDENHALL,
W. A. ANTHONY,
GEORGE FORBES,
WILLIAM J. HAMMER,
EDWARD WESTON."

EXHIBIT B.

This exhibit was pamphlet No. 9,098 issued by the General Electric Company, being reprint of an article by Mr. W. D'A. Ryan, read before the Ohio Electric Light Association at Put-in-Bay, Ohio, U. S. A., August 20, 21, 22, 1901, entitled "Relative Merits of Open and Enclosed Arc Lights for Street Illumination."

Extensive quotations from this pamphlet were read into the expert testimony given by Mr. Ryan, and is therefore not here reproduced; the various illustrations in said pamphlet, to which reference is made in the testimony, are here shown.

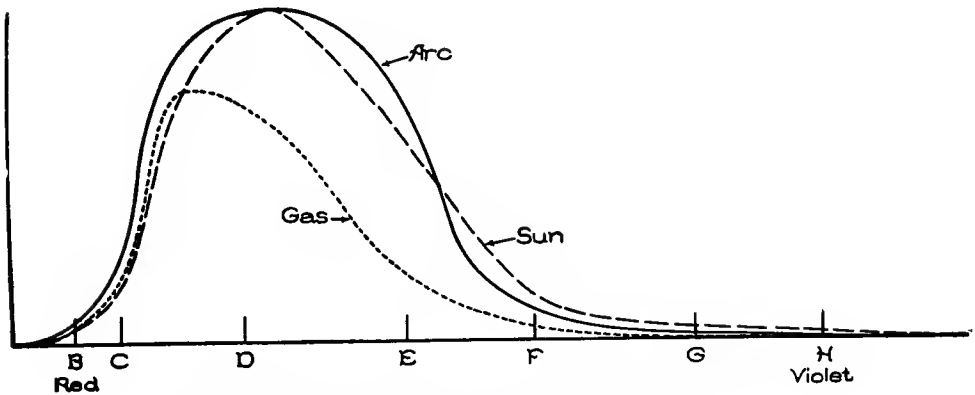


Figure 1—Comparison of sun, arc and gas lights.

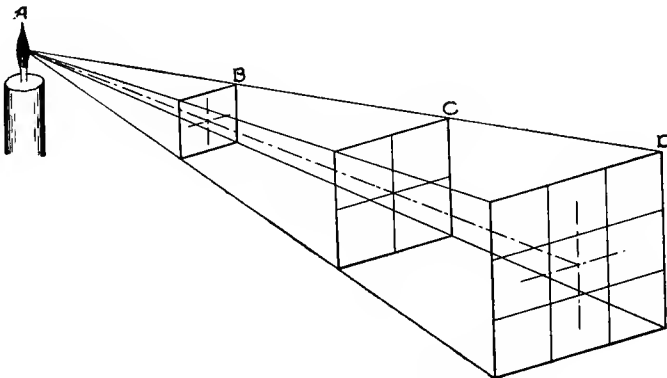


Figure 2—Law of inverse squares.

EXHIBIT B—FIGS. 3 AND 4.

Candle Power Curves.

Figure 3.

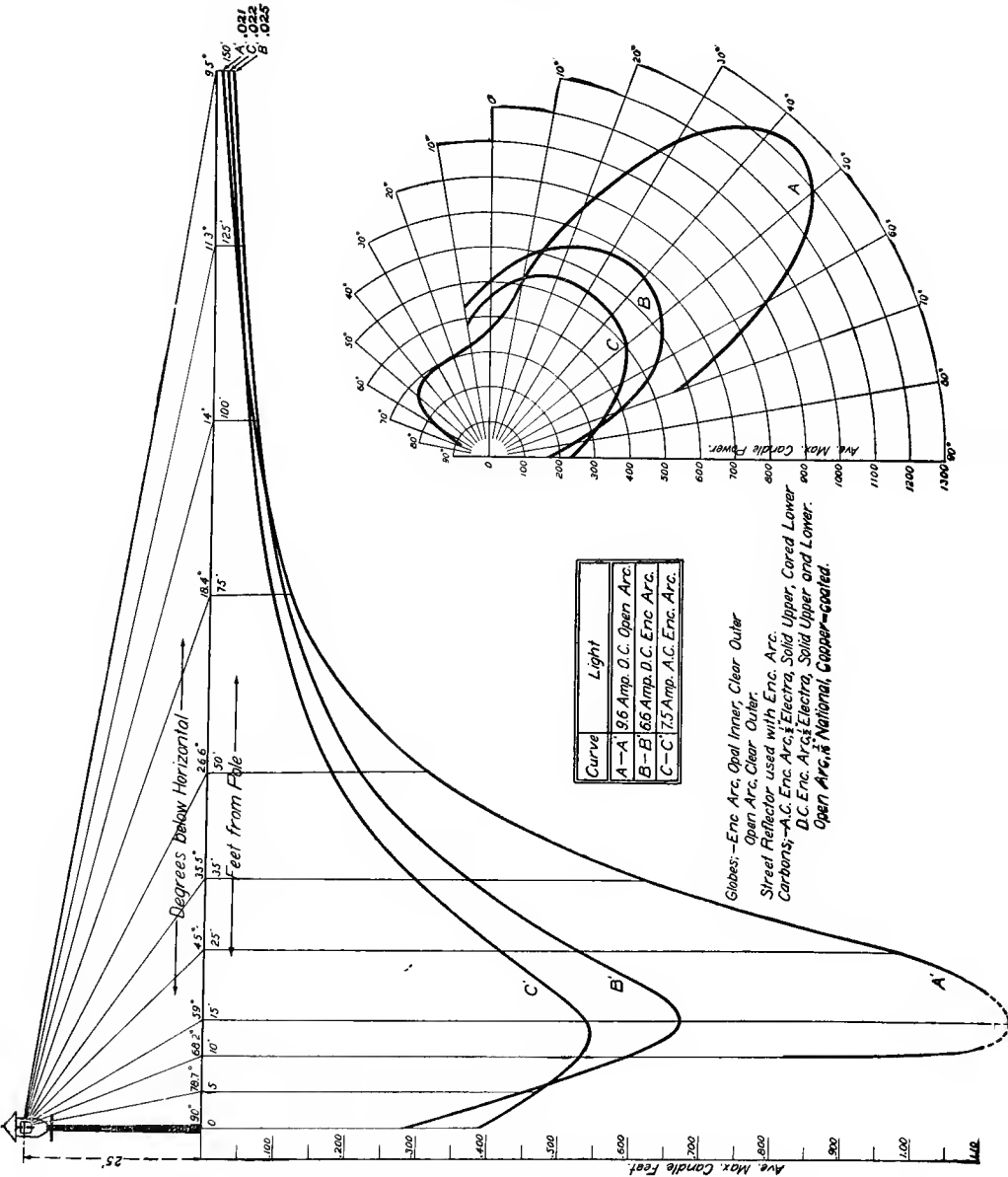


Figure 4.

EXHIBIT B.—FIGS. 5 A, 5 B.

Candle Power Curves.

Fig. 5A.

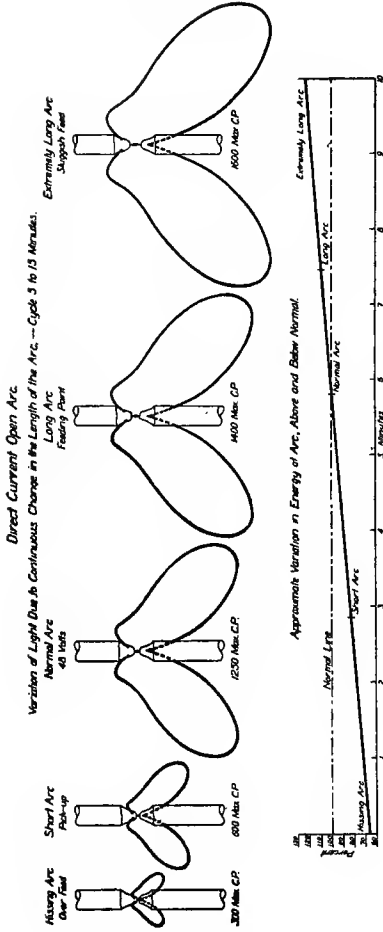


Fig. 5B.

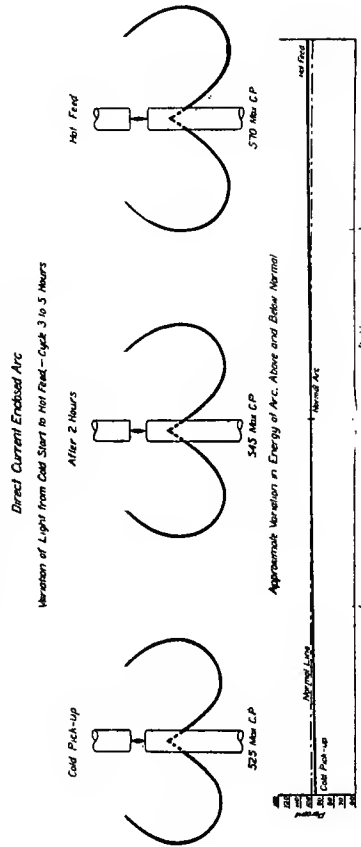
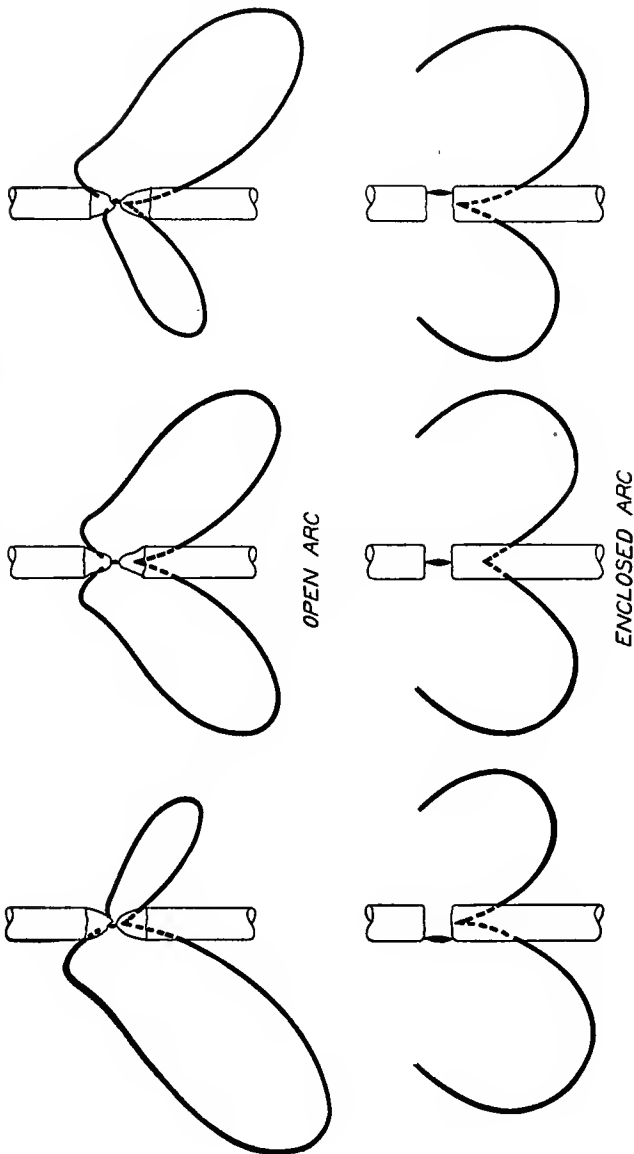


EXHIBIT B—FIGS. 6A, 6B.

Candle Power Curves.

Figure 6A.

Figure 6B.



*Variation in Direction of Light with Wandering of the Arc.
Length of Arc and Mean Hemispherical Candle Power Approximately Constant.*

EXHIBIT B—FIG. 7.

Light Distribution.

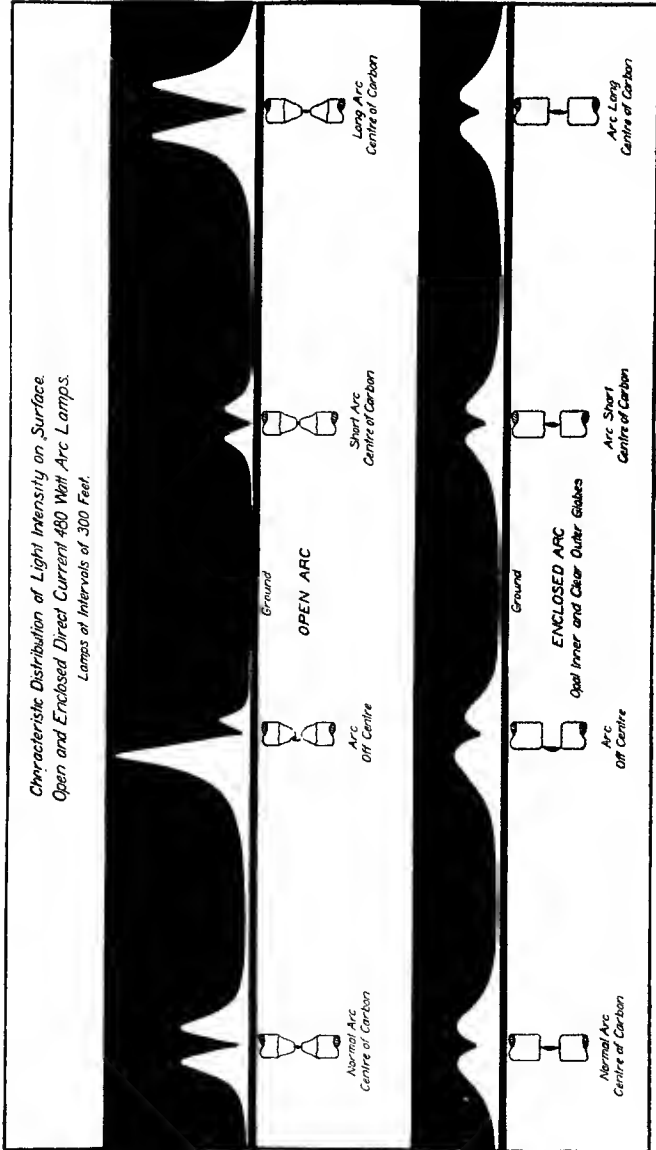


EXHIBIT B—FIGS. 8 and 9.
Light Fluctuation and Distribution.

Variation in the Mean Hemispherical Candle Power of Direct Current Open and Enclosed Arc Lamps.
Average Watts at Arc 460

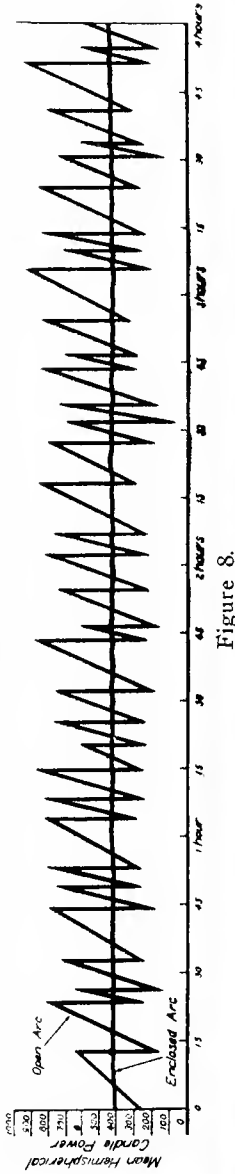
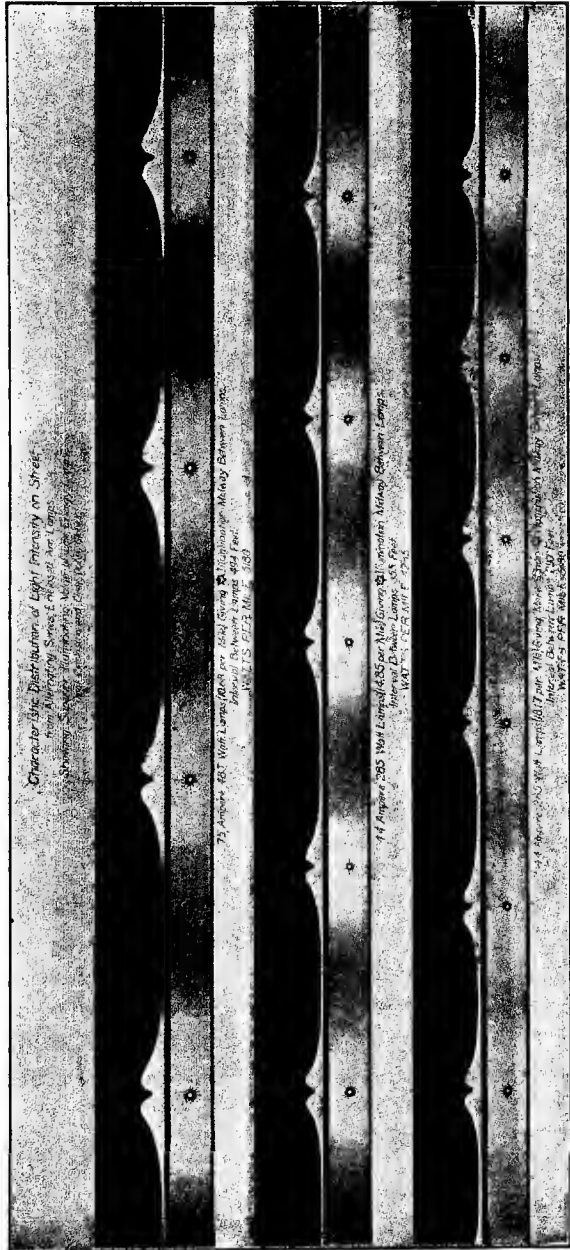


Figure 8.



Characteristic Distribution of Light Intensity on Street
in a City Street, Enclosed Arc Lamp
Showing the Effect of the Enclosure on the Light Intensity

75 Ampere, 600 Watt Lamp (Arc on 460 Watts) with 200 Ampere Mercury Arc Lamp
Interval Between Lamps 200 Feet
WATTS PER Ft. 1000

44 Ampere, 200 Watt Lamp (Arc on 460 Watts) with 200 Ampere Mercury Arc Lamp
Interval Between Lamps 200 Feet
WATTS PER Ft. 2000

44 Ampere, 200 Watt Lamp (Arc on 460 Watts) with 200 Ampere Mercury Arc Lamp
Interval Between Lamps 200 Feet
WATTS PER Ft. 2000

Figure 9.

EXHIBIT B—FIG. 10.

Luminometer Tests.

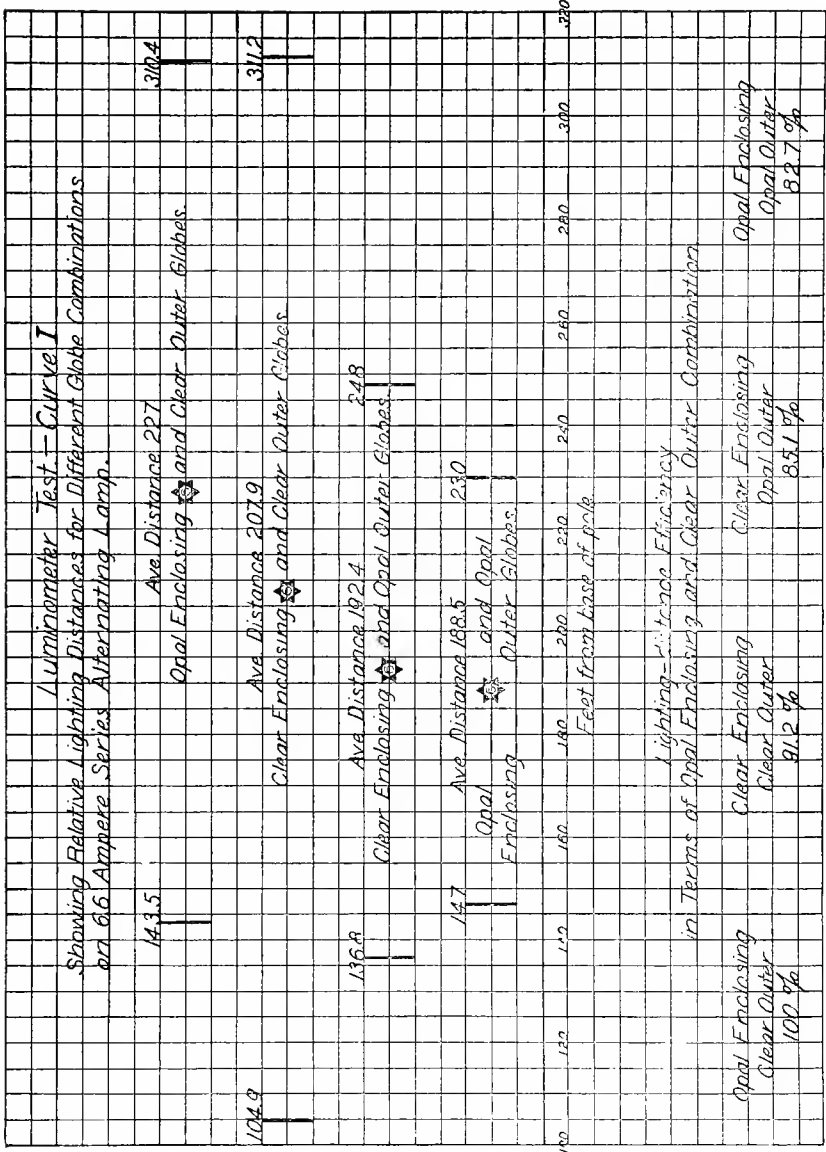


EXHIBIT B—FIG. 11.

Luminometer Tests.

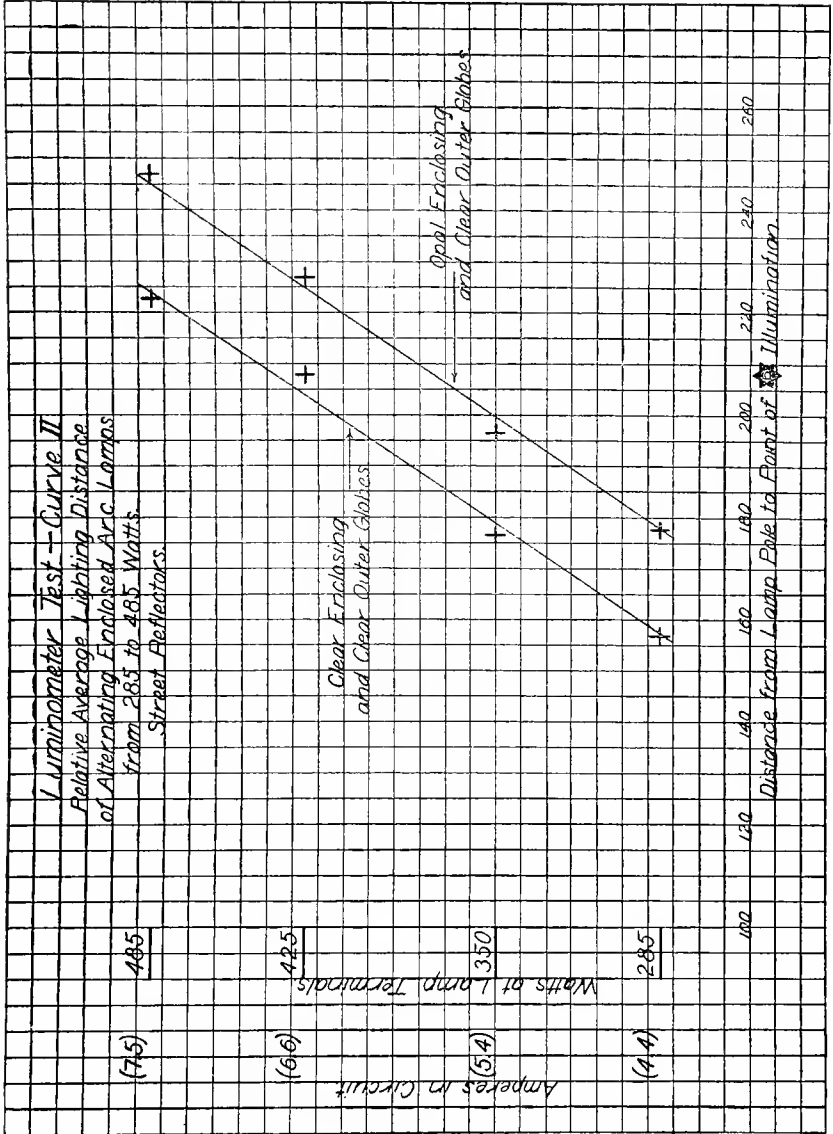


EXHIBIT B—FIG. 12.

Luminometer Tests.

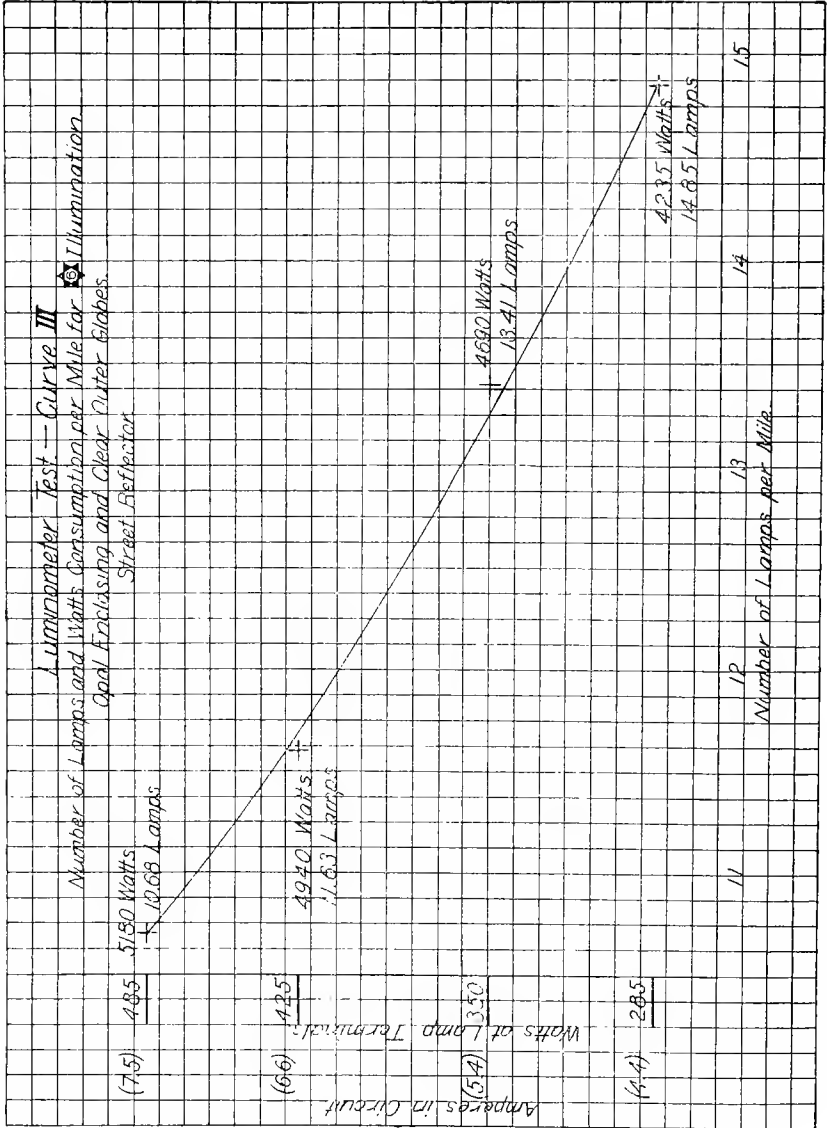


EXHIBIT B—FIG. 13.

Luminometer Tests.

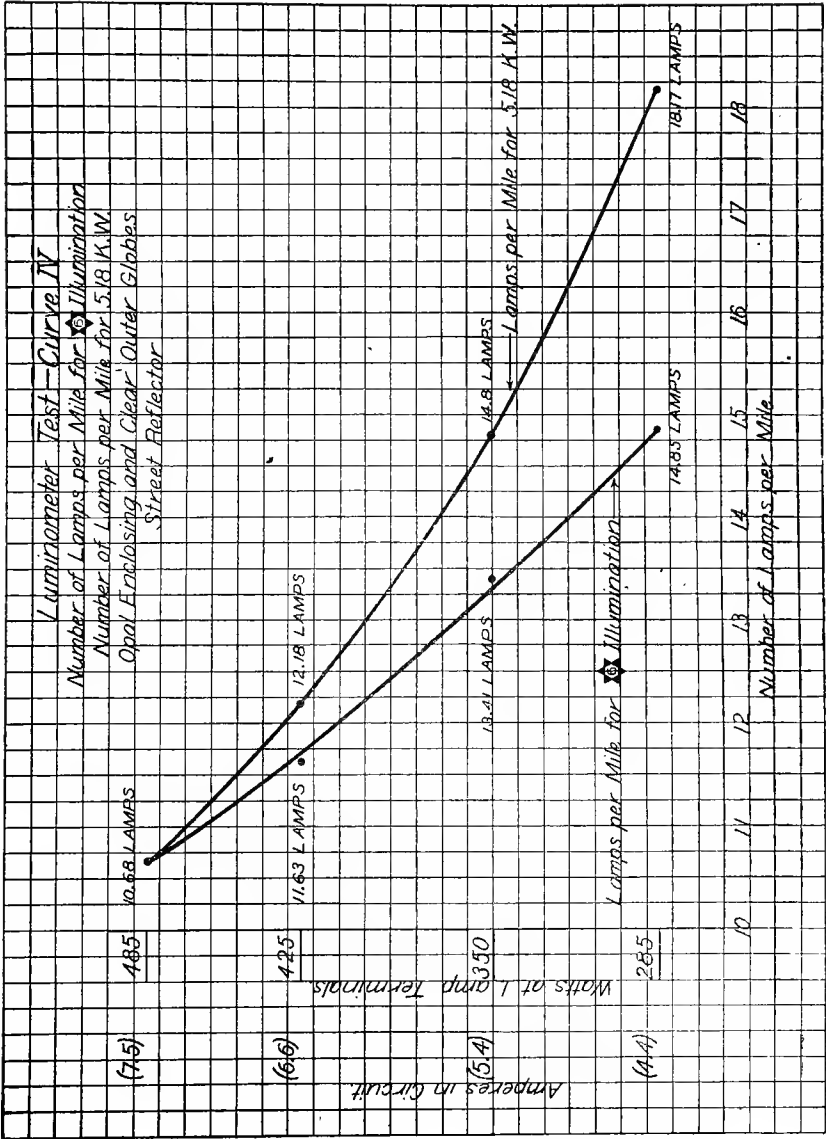


EXHIBIT B—FIG. 14.

Luminometer Tests.

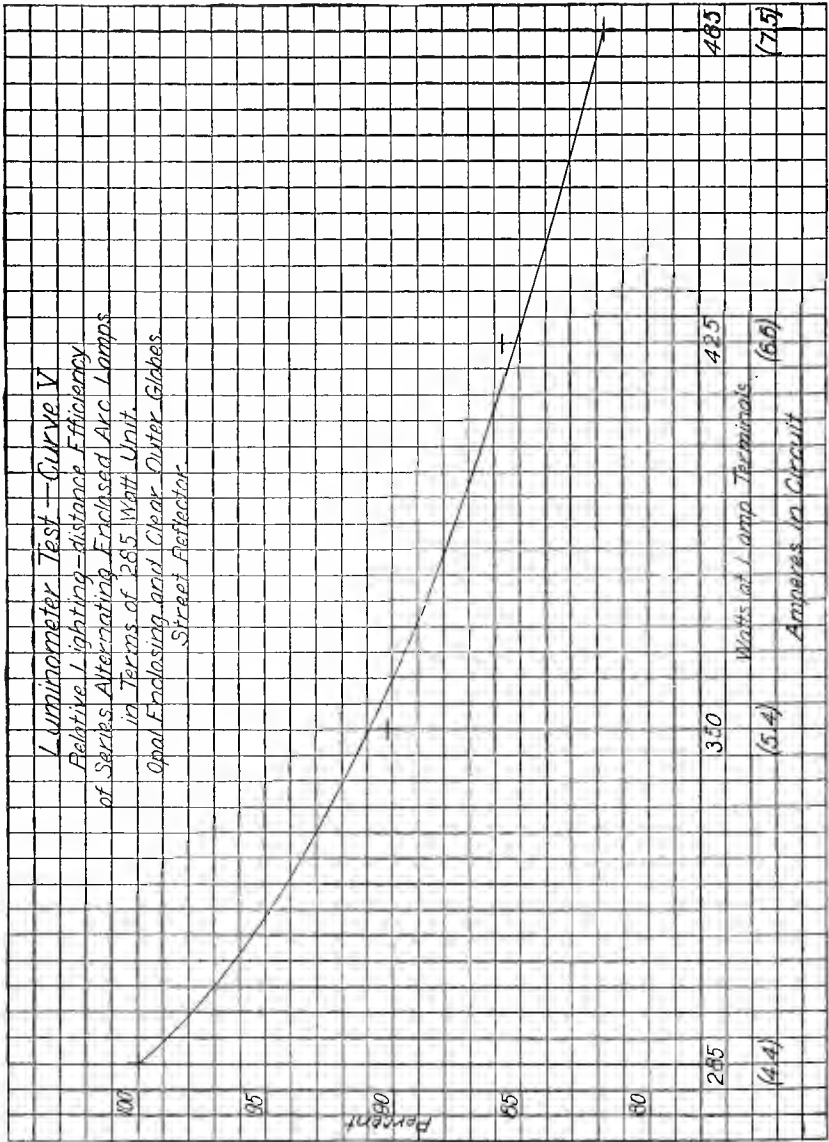
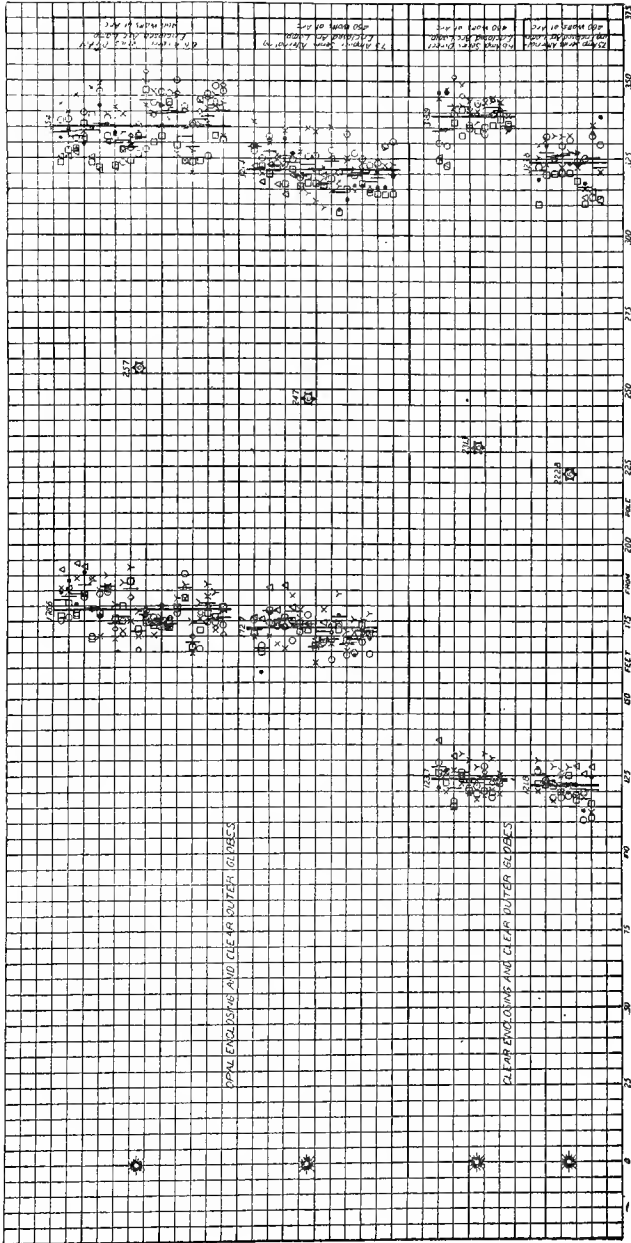


EXHIBIT B—FIG. 15.

Luminometer Tests.

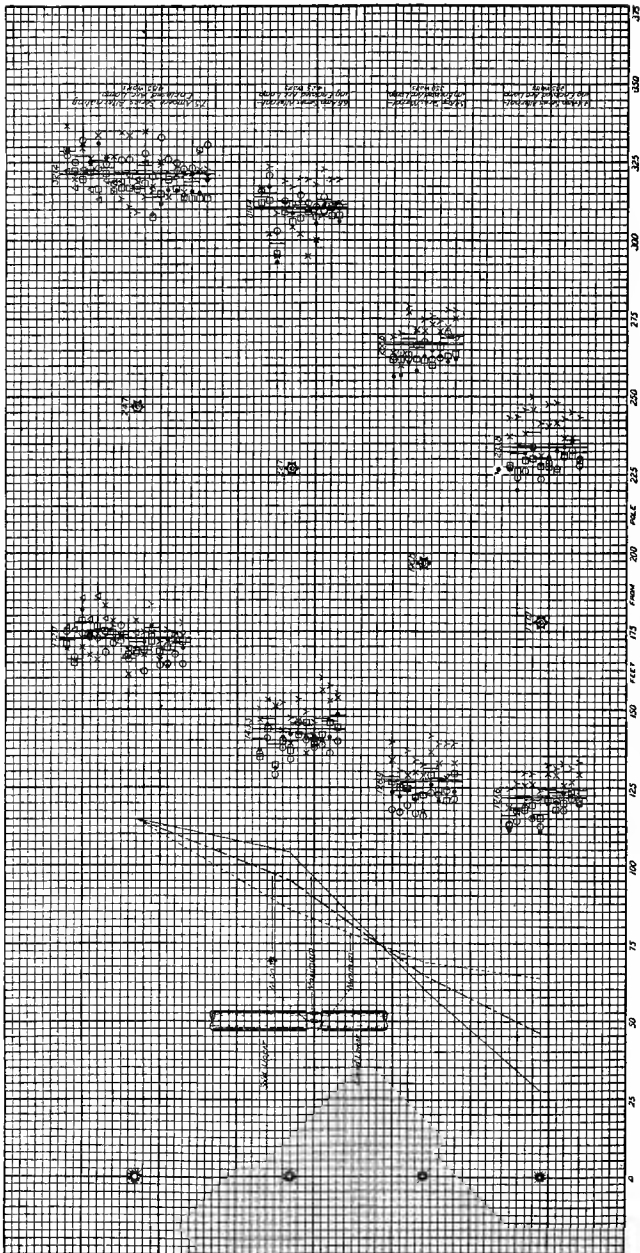


LUMINOMETER DIAGRAM
 Indicating That Alternating and Direct Current Arcs of Equal Energy will Illuminate Practically the Same Distance.
 (Advantage of Opal Enclosing Globe)

LUMINOMETER DIAGRAM.

EXHIBIT B—FIG. 16.

Luminometer Tests.



LUMINOMETER DIAGRAM
 Relative Lighting Distances for 7.5, 6.5, 5.4 and 4.4 Amperes Series Alternating Lamps—Opal Enclosing and Clear Outer
 Globes—Street Reflectors Arcs 25 Ft. Above Ground.

LAMP CARBONS.

EXHIBIT B—FIGS. 17 AND 18A, 18B.

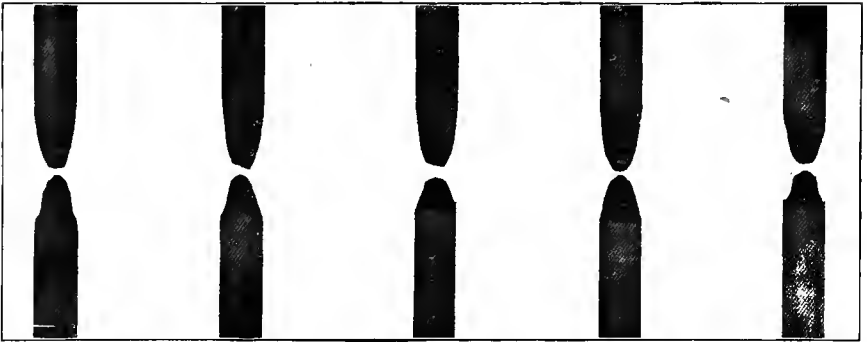


Figure 17—D. C. open arc.

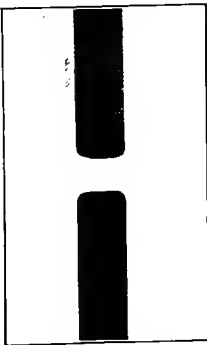


Figure 18A.
A. C. enclosed arc.

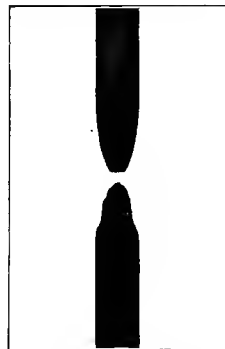


Figure 18B.
D. C. open arc.

CARBONS—SHADOWS.

EXHIBIT B—FIGS. 19 AND 20.

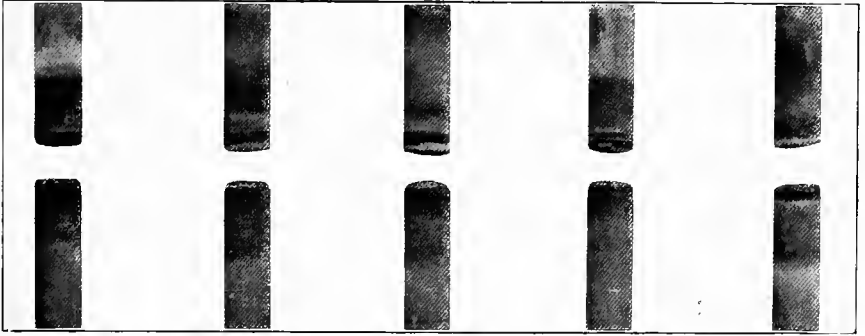


Figure 19—A. C. enclosed arc carbons.



Figure 20—Shadow zone, on short arc of a 9.6 ampere open lamp.

ARC LIGHT DISTRIBUTION.

EXHIBIT B—FIGS. 21 AND 22.



Figure 21—Distribution of light from an A. C. 6.6 ampere enclosed lamp.



Figure 22—Distribution of light from a D. C. 6.6 ampere enclosed lamp.

GLOBE—ILLUMINATION.

EXHIBIT B—FIGS. 23 AND 24.



Figure 23.
Inner globe, enclosed lamp.



Figure 24—A. C. 6.6 ampere lamps 400 ft. apart.

LUMINOMETER.

EXHIBIT B—FIGS. 25 AND 26.



Figure 25—Using Luminometer.

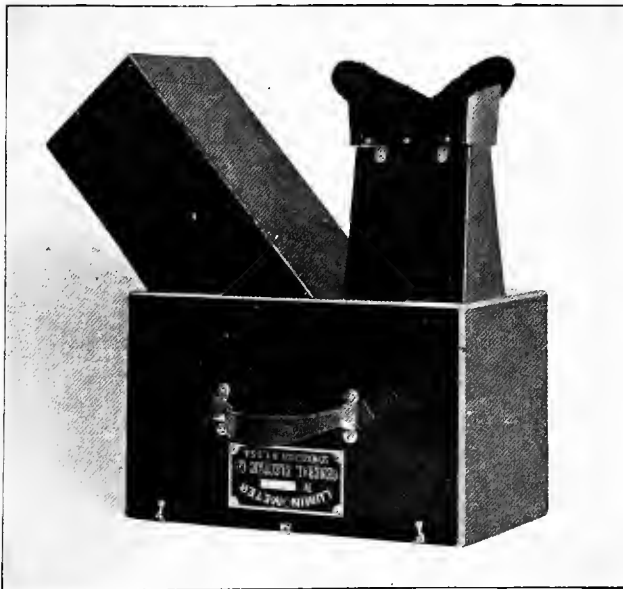


Figure 26—Luminometer.

EXHIBIT C.

This exhibit was a clear-glass, inner globe for the alternating-current, series, enclosed arc-lamp.

EXHIBIT D.

This exhibit was an opal-glass, inner globe for the alternating-current, series, enclosed arc-lamp.

EXHIBIT E.

Luminometer Card 1.

- 1 **Lord Methuen's Infantry**
- 2 **Would have been much**
- 3 **Protected against loss in their**
- 4 **Three battles if the howitzers had**
- 5 **Been added to his artillery, unlike navy guns**



6 Which are tied to every truck, they are almost as movable as ordinary field artillery.

- 7 **General Buller has been waiting for them day after day, when Ladysmith was exposed to a most scientific fire from the Boer artillery. The interruption of Lord Methuen's line of communications occurred yesterday**

- 8 **A railway culvert was blown up and the telegraph wires were cut by a party of raiders from the Free State frontier, possibly from Jacobel, and heavy firing was heard further north. The War Office betrays little uneasiness over this incident, and military men**

EXHIBIT F.

Luminometer Card 2.



A,—Fcl₁dkg cptdai grombu ufcwpc xitmsc jgfeb alnydols cxusgr tllv.
ytisre vinuli enorcy enkci₁t seisxo hegroe gegell oeyelb ismo.

B,—Motors jacket rice actor difficult crowded hence iota slide.
business pathetic appreciate nautical magnate possible china.

C,—Over 400,000 General Electric Arc Lamps in operation.
General Electric Motors for operating all kinds of machinery.

D,—Shtnon eerhty revede ussib lliwhe adotde siverx tsiles ehtg.
hocassa mnotso bwchsi fyojev obrevo nocsmo mmeegy dateen ehcs.

E,—Rallevia adicelle didez echacar hodes geroog lamanter fregando.
gurosa cinnusoel mibod erezzi vidalato mirato pomet toffelca.

F,—A discussion of the war fleets of several nations is not complete
without some mention of their powers of offence.

G,—Niniat nocret telwen aynapm occirt celela renegen ayradw nnyl.
thgiln oomela pehtyb piweiv ogthti raseor lemves dluown oyfi.

H,—Diphtheria power coffee dollars selecting can tonnage ancient.
procrastination easy useful photograph embark crescent fame.

EXHIBIT G.

This exhibit was an enlarged copy of City's Exhibit No. 32.

EXHIBIT H.

This exhibit was the "Proceedings of the National Electric Light Association" of 1894, pages 282-295, being the report of the Committee introducing the Resolution (see Exhibit A 2), afterwards adopted by the Association, defining a 2,000 candle-power arc lamp, with the discussion thereon, much of which is quoted in the examinations of Messrs. Matthews, Marks and Bell.

EXHIBIT I.

Curves showing sales of open and enclosed arc lamps, of all makes, 1895-1900, prepared by the General Electric Co.

EXHIBIT J.

Mr. W. D'A. Ryan's Report on the Arc Lights in Colorado Springs.

Colorado Springs, Colo., Sept. 15, 1906.
Mr. Geo. B. Tripp, General Manager,
The Colorado Springs Electric Company,
Colorado Springs, Colorado.

RE CITY LIGHTING CONTRACTS.

Dear Sir:—I have looked over the papers relative to your City Lighting Contract, and find that, in order to fulfill the obligations imposed by the Jackson Franchise, it may be necessary to deliver an average of 450 watts at the terminals of each lamp.

The situation, however, is rather peculiar, inasmuch as 6.6 ampere series alternating 430-watt lamps had previously been accepted by the City (after a practical demonstration) as being superior to the so-called standard 2,000 candle-power lamps which they replaced. I am not, however, in a position to express a legal opinion as to the bearing that this action would have on the later acceptance by the City of the contract as covered in the Jackson Franchise. I can say, however, that the 6.6 ampere lamp is generally accepted as a superior illuminant to the full open arc which it has replaced, and I attach hereto a partial list, consisting of several hundred cities which are now using the 430-watt lamp. The principal advantages of this lamp over the open arc are, better distribution, greater steadiness and uniformity of light and reliability of operation, which features you are familiar with.

I have made a careful inspection of the apparatus at the station, and have been over the lines and have familiarized myself with the methods employed by your men in making tests. The circuits were operated under normal conditions with a working complement of lamps. A carefully calibrated indicating wattmeter, voltmeter and ammeter were used. This method of testing eliminated all questions of power-factor and wattages at variable loads, etc. Before testing each circuit the lamps were warmed up and a record made of the condition as found. If abnormal, the adjustment was changed and a record made of the condition in which the lamp was left. A detailed list of these tests is attached hereto.

The following tabulation gives the condition of the lamps on each circuit as found and left:

AVERAGE ENERGY AS FOUND AND LEFT ON EACH CIRCUIT.

Test Extending from September 8th to September 15th, 1906.

Circuits.	No. of Lamps.	Amperes.		Volts.		Watts.	
		Found.	Left.	Found.	Left.	Found.	Left.
South St. Circuit..	39	7.02	7	74.2	77.8	458.7	473.3
West St. Circuit..	34	7.16	7.14	72.6	77.4	443	471.7
N. W. St. Circuit..	35	7	7	73.8	77.8	446	471
East St. Circuit....	35	7	7	80.5	80.3	472	470
S. E. St. Circuit...	43	6.97	6.97	78.4	83.2	444.3	470
North St. Circuit..	41	7.03	7.02	78.8	80.7	457.9	469.9
Av. all Circuits...	227	7.02	7.02	76.5	79.7	452.7	470.9

It will be observed that the lamps are consuming, on an average 470.9 watts directly after picking up. This would gradually increase on enclosed arc lamps from 5 per cent to 10 per cent up to the time of feeding. In other words, I found your lamps, directly after pick-up, running about 5 per cent higher than the contract calls for, and I question very much whether the General Electric Company would be willing to stand back of guarantees with the 6.6 ampere apparatus overloaded to this extent.

In addition to checking up the above tests, I have inspected the lights at night, and found that they were working very uniformly, but would strongly recommend that you replace the clear inclosing globes with light opal. This will still further improve your distribution without materially affecting the maximum lighting distance, and will eliminate the side rod and base shadows underneath the lamp; in other words, it will spread the light out more uniformly.

I note that your station equipment is complete with suitable instruments and testing transformer. All the apparatus appears to have been carefully kept up and is in first-class condition. I consider, however, that with six constant current transformers you should have at least one spare. While this apparatus is unusually free from breakdowns, at the same time an accident may happen, and with your present output it would be difficult to avoid an interruption of part of your service.

CANDLE-POWER—OPEN VS. ENCLOSED ARCS.

As there appears to be some confusion in regard to the candle-power rating of the different arc lamps under discussion; it might be well to explain that in the early days of arc lighting and at a time when arc lamp photometry was an unknown quantity the term 2,000 candle-power was unwisely arbitrarily applied as a trade name to designate a full arc., i. e., a lamp taking from

425 to 475 watts at the terminals. At the same time 2,000 candle-power was used to designate a so-called half arc taking 300 to 350 watts at the terminals. As a matter of fact, neither the wattage or the candle-power ratings are consistent, and bear no relation to the actual illuminating values of the lamps. As the science advanced and a full realization of the absurdity of these ratings became evident, an attempt was made to recede from what might be called an awkward situation by referring the matter to the International Electrical Congress of 1893.

Dr. T. C. Mendenhall, President of the Worcester Polytechnic Institute, in a report on the subject, stated that while they came to a unanimous agreement as to the definition of the ampere, volt and watt, which definitions were afterwards legalized by Congress, they failed entirely to agree on a unit of light, and declared that at present a satisfactory definition of this unit was impossible. Some of the American delegates at that Congress asked it to relieve them by defining a 2,000 candle-power lamp as being one operated by 450 watts, but the representatives of the other nations declared that they never made contracts in candle-power and that Americans ought not to be so foolish as to do so.

Finally the question was taken up in 1894 at the 17th Annual Meeting of the National Electric Light Association, a body whose actual membership included at that time 107 of the leading electric light and power companies in all parts of the country, with an associate membership of 112 other firms and individuals actively interested in the development of electric light. A special committee was appointed, its members being mostly professional men and in no way engaged or financially interested in electric lighting, to consider and report a definition of a 2,000 candle-power lamp, and, after a full discussion, the report of this committee was adopted by the Convention, without dissent. This definition has been universally accepted by electric light contractors, and has furnished the basis of nearly if not quite all contracts made since. The report, as adopted, was as follows:

"Recognizing the difficulty, if not impossibility of measuring with any degree of accuracy the illuminating power of the arc lamp, and the great necessity for a more precise definition and statement of the obligations of the producers of electricity for illuminating purposes to the consumer thereof; be it

"Resolved, That in the opinion of the Convention what is ordinarily known as a two thousand candle-power arc lamp is one requiring on the average four hundred and fifty watts for its maintenance, the measurements being made at the lamp terminals, where no sensible resistance is included in series with the arc. In case such resistance is used, it must be excluded in the measurement of the voltage."

Professor W. A. Anthony, long professor of physics and electrical engineering in Cornell University, past President of the American Institute of Electrical Engineers, etc., etc., in presenting the resolution defining the 2,000 candle-power arc lamp, at the meeting of the National Electric Light Association, said :

“When you come to absolute candle-power, everybody knows that a commercial arc does not give 2,000 candles. We cannot specify anything about the candle-power, and there is no use in bringing in anything on that point; because, if any city insists on having 2,000 candle-power, and insists on measuring the lamp to see if they can get it, you will find nobody to say that you are giving them 2,000 candle-power on the average.”

Professor E. L. Nichols, of Cornell University, a recognized expert in photometry of all kinds, says (Johnson's Cyclopaedia Article, Electric Lighting) :

“The candle-power of arc lights in general has been greatly overrated. For example, according to the system in vogue up to 1890, and used to some extent after that year, lamps were rated at 2,000 ‘nominal candle-power’, the mean spherical illuminating power of which was from 250 to 400 candles and whose brightness in the direction of the maximum was from 1,000 to 1,500 candles.”

In conclusion, aside from the question of accuracy, the mere reference to the candle-power of an arc lamp is of little use in determining its illuminating value without specifications as to the distribution and variation in intensity of the light. For example, the nominal 2,000 candle-power open arc lamp throws the maximum illumination at an angle of between 45 and 50 degrees below the horizontal, which produces a very bright circle on the street, leaving a dark zone in the center. The band of strong light is narrow and makes the space midway between the lamps appear very dark by contrast.

The mean spherical candle-power of the open arc lamp is higher than the enclosed taking the same energy, and the flux varies anywhere from 200 to 600 candle-power (with a maximum of about 1,200), depending upon whether the carbon has dropped to the hissing point or is drawing in an exceptionally long arc. This inherent defect is present in all so-called American clutch feed open arc lamps. The alternating enclosed arc lamp of equal energy delivers anywhere from 200 to 300 mean spherical candle-power (with a maximum of about 650) and the direction of maximum light is several degrees higher than the open arc, so that the illumination is spread to a greater distance down the street, and the objectionable shadows are eliminated, the eye

is not fatigued to the same extent by the high intrinsic brilliancy, and, while the maximum light is not so great, as previously stated, the average flux delivered over a period of, say, one year, is about the same, with the advantages mentioned.

In view of the fact that you made a practical demonstration comparing the open arc with the enclosed, it would seem to me unnecessary to go into further detail, except to say that you are, without any question, fulfilling the requirements of a contract calling for what is known as a standard two thousand candle-power arc lamp.

(Signed) W. D'A. RYAN,
Illuminating Engineer.

TESTS OF STREET ARCS.

Colorado Springs, Colorado, Sept. 8, 1906.

SOUTH STREET CIRCUIT.

	Location.	Volts.	Amperes.	Watts.	Remarks.
Found	Nevada Ave. and	79	7	500	
Left	Cucharras	79	7	500	
Found	Nevada	50	7	300	
Left	Vermijo	80	7	480	Stuck
Found	Weber	76	7	480	
Left	Cucharras	76	7	480	
*	*	*	*	*	*

Here follow similar figures of the tests made on 227 lamps in the streets, under Mr. Ryan's supervision, Sept. 8-15, 1907.

STATIONS USING 6.6 AMPERE SERIES ALTERNATING ARC LAMPS.

Albany, Ga., City of.
Anderson, S. C., Carolina Water, Light & Power Co.
Anniston, Ala., Electric & Gas Co.
Augusta, Ga., Railway & Electric Co.

* * * * *

Here follows a list of several hundred towns.

EXHIBIT K.

This exhibit was a list of orders received by the General Electric Company for 6.6 ampere, alternating-current, series, arc lamps up to February, 1904.

EXHIBIT L.

Attenda to Mr. W. D'A. Ryan's Report, Exhibit J.

STREET ARC LAMPS BROUGHT IN AND TESTED AT SUB-STATIONS SINCE THE ORIGINAL TEST IN SEPTEMBER. THESE LAMPS COULD NOT BE TESTED IN POSITION AT THE TIME OF THE REGULAR TEST.

Colorado Springs, Colorado, October 15, 1906.

	Location.	Volts.	Amperes.	Watts.
Found	Dale St.	78	7.5	480
Left	West of Cascade	80	7	460
Found	Bristol	80	7	480
Left	School	80	7	460
Found	West View	80	7	470
Left	Boulder Crescent	80	7	460
Found	Tejon	82	7	480
Left	Cache la P.	80	7	460
Found	Jefferson	67	7	400
Left	Nevada	80	7	460
Found	W. Huerfano	65	7	350
Left	Viaduct	80	7	460
Found	Seventh	50	7	300
Left	Bijou	80	7	460
Found	E. Huerfano	82	7	480
Left	Viaduct	80	7	460
Found	Second and	82	7	500
Left	Grant	80	7	460
Found	El Paso	82	7	480
Left	St. Vrain	80	7	460
<hr/>				
Total arcs brought in and tested, 10.				
Averages:				
	Found	74.8	6.75	442
	Left	80	7	460

EXHIBITS M, 1-23.

These exhibits were twenty-three monthly records, similar to the one herewith reproduced, from the month of February, 1905-January, 1907, inclusive, showing day by day the number of lamps in circuit, lamp hours, wattages and kilowatt output at the station, also the total for the month.

RECORD OF ARC LAMPS FOR MONTH OF FEBRUARY, 1905.

The Colorado Springs Electric Co.

Date	COLORADO SPRINGS				COLORADO CITY			TOTAL		NET Lamp Hours	K. W. HOURS.
	Number Hours Burned		No. Lamps in Circuit	Lamp Hours	Number Hours Burned	No. Lamps in Circuit	Lamp Hours	Lamp Hours	Lamp Hours Outages		
	HRS.	MIN.								HRS.	
	11	55	218	2598	4	30	157	2755	0	2755	
16	11	05	"	2415	4	30	157	2572	16	2556	1352
17	12	10	"	2652		0	0	2652	3	2649	1236
18	11	50	"	2579		15	8	2587	10	2577	1260
19	11	45	"	2561	1	15	43	2604	17	2587	1268
20	11	40	"	2543	4	0	140	2683	2	2681	1301
21	12	40	"	2761	6	0	210	2971	6	2965	1333
22	12	15	"	2670	7	0	245	2915	10	2905	1367
23	11	35	"	2524	6	0	210	2734	10	2724	1317
24	11	40	"	2543	7	30	262	2805	15	2790	1358
25	12	00	"	2616	9	0	315	2931	73	2858	1354
26	11	30	"	2469	11	0	385	2854	17	2837	1393
27	11	25	"	2488	11	25	391	2887	2	2885	1453
28	11	20	"	33419	72	25	2531	35950	181	35769	17310
Total	153	20	218	33419	72	25	2531	35950	181	35769	17310

EXHIBIT M 24.

This exhibit was a compilation based on Exhibits M 1-23, and is here reproduced in full.

MONTH	K. W. Hours Primary	K. W. Hours Secondary 9½	Line Loss Colo. Sigs. K. W. Hrs.	Line Loss Colo. City K. W. Hrs.	Total Line Loss K. W. Hrs.	K. W. Hours Lamps	Lamp Hours	Watts per Lamp	No. in Circuit.	No. of Lamps in Circuit
FEBRUARY, '05	17310	16270	1074	104	1179	15091	35769	418	403000	218
MARCH	41528	39050	2872	403	2775	36275	83768	429	"	220
APRIL	34716	32630	1925	338	2263	30367	68625	438	"	221
MAY	32214	30280	1826	291	2117	28163	64616	432	"	223
JUNE	28392	26680	1597	242	1839	24841	56989	432	"	226
JULY	30100	28300	1704	243	1947	26353	60959	428	"	227
AUGUST	34383	32300	1950	274	2224	30076	69014	432	"	230
SEPTEMBER	38490	36180	2140	304	2444	33736	78016	428	"	230
OCTOBER	45677	42910	2552	362	2914	39996	93140	425	"	231
NOVEMBER	47894	45000	2668	366	3034	41966	97060	428	"	232
DECEMBER	48230	45350	2848	372	3220	42130	103143	405	"	232
JANUARY, '06	48203	45310	2893	416	3309	42001	103736	401	"	234
FEBRUARY	42885	40320	2491	352	2843	37477	90038	412	"	236
MARCH	44438	41770	2491	437	2928	38842	92467	416	"	238
APRIL	39281	36920	2130	338	2468	34452	78124	437	"	239
MAY	35786	33630	2168	307	2475	31155	71880	434	426000	240
JUNE	31923	30000	2037	273	2310	27690	64836	427	"	241
JULY	30147	28330	2138	67	2205	26125	63192	414	"	241
AUGUST	33672	31630	2407			29243	68836	425	"	241
SEPTEMBER	42471	39930	3244			36676	75230	487	453000	241
OCTOBER	49503	46520	3209			43311	87490	495	"	242
NOVEMBER	51879	48730	3430			45300	92874	488	"	243
DECEMBER	56015	52630	3784			48846	100998	484	"	248
JANUARY, '07	54605	51340	3595			47745	99800	477	453000	249

EXHIBIT M 25.

Curve showing in graphic form the average watts, per lamp, per month figured from the station records, Exhibit M 24.

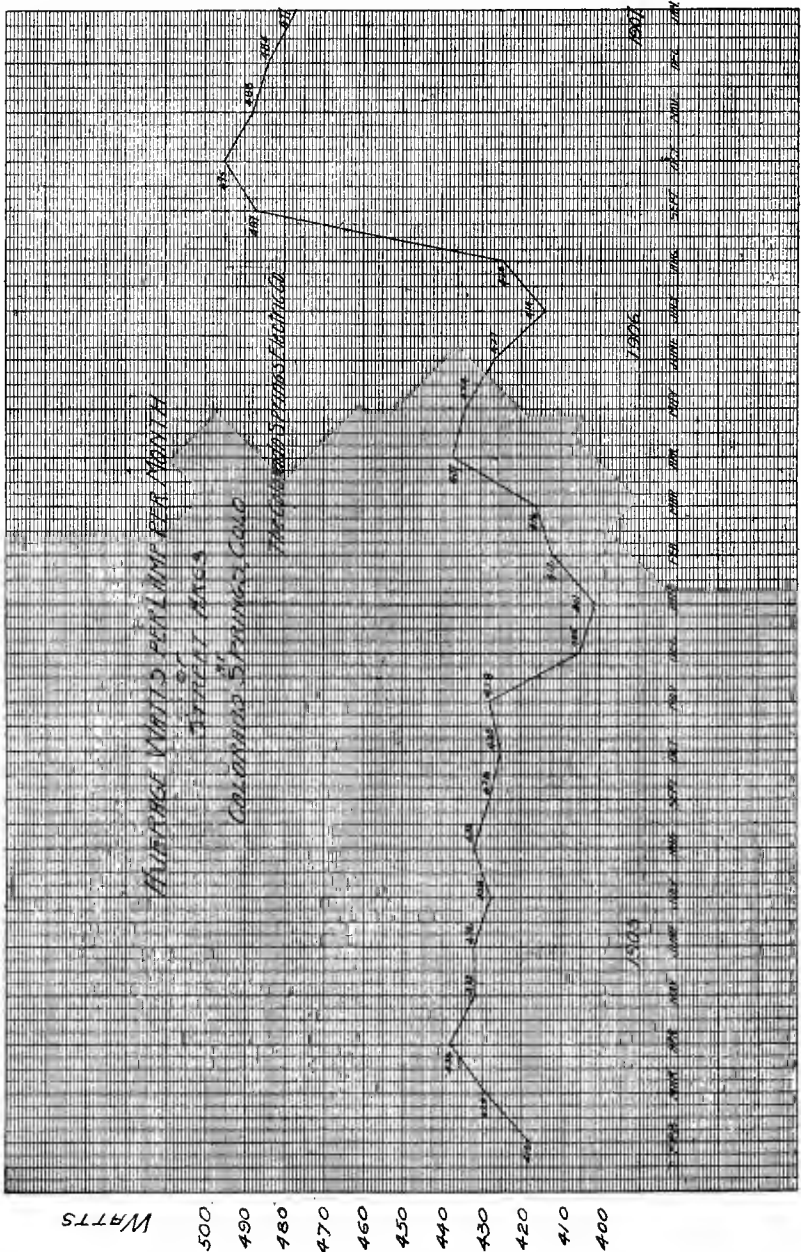


EXHIBIT N.

This exhibit was a volume, "The Art of Illumination," by Dr. Louis Bell, Edition of 1902, referred to during the author's examination.

EXHIBIT O.

This exhibit was a pamphlet, No. 9,124, published by the General Electric Co., "Light and Illuminating Engineering," by W. D'A. Ryan. It related exclusively to interior lighting, particularly by arc lamps.

EXHIBIT P.

This exhibit was a paper on "Illuminating Engineering," read by W. D'A. Ryan at the annual meeting, 1905, of the Ohio Electric Light Association."

EXHIBIT Q.

This exhibit was the Colorado Springs Electric Company's Inspector's original nightly reports and load sheet of Sub-station A, from which energy was supplied for lighting the streets of Colorado Springs for the month of August. This was simply introduced to verify the figures given in Exhibits M 1-23.

THE CITY OF COLORADO SPRINGS
 vs.
 THE PIKES PEAK HYDRO-ELECTRIC CO. } ARBITRATION.

The City was represented by **Wm. C. Robinson, Esq.**,

The Pikes Peak Hydro-Electric Company by **K. C. Schuyler, Esq.**, and

The Colorado Springs Electric Company by **R. L. Holland, Esq.**

The Arbitrators, consisting of Messrs. **L. G. Carpenter, E. L. Elliott** and **Henry Floy**, met in the Council Chamber of the City Hall, on the morning of February 1, 1907, and, after severally subscribing to their oath of office, organized by choosing **L. G. Carpenter** Chairman of the Board.

The Chairman announced the Board was ready to proceed with the hearings.

Mr. Robinson made a brief statement to the Board, offering certain Exhibits, which were identified and numbered.

Mr. Schuyler asked for an adjournment until afternoon.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT, AT 2.30
 P. M., FEBRUARY 1, 1907.

Mr. Schuyler made a statement of the position of the Pike's Peak Hydro-Electric Company and asked the Board to consent to allow one expert on each side to examine the expert witnesses.

Mr. Robinson objected to such procedure.

Chairman of the Board. "We will postpone our decision until the question arises. You may proceed with your testimony."

Mr. K. M. MACMILLAN, City Clerk, being duly sworn, and after identifying Exhibits Nos. 21, 22, 23 and 24, testified as follows, to wit:

Examination by Mr. Robinson.

Q. As City Clerk, have you in your possession the original contracts between the City and various electric light companies that now have, or have had, contracts with this City?

A. I have.

Q. Tell us if you can, what is Plaintiff's Exhibit No. 24?

A. Among the copies of Ordinances that have not been passed I found this in the files labeled "Ordinances for Water Power to George W. Jackson, etc."

Q. What is City's Exhibit No. 25?

A. It is an ordinance granted George W. Jackson and associates and assigns for the use of water, etc.

Q. Is that the original Ordinance?

A. It is the original. It has the official signatures on it.

Cross - examination by Mr. Schuyler.

Q. How long have you been City Clerk, Mr. MacMillan?

A. Since April, 1901.

Q. You were not connected with the city administration in September, 1898?

A. No, sir.

Q. Aside from having found this Exhibit No. 24 in the files of the City Clerk, have you no knowledge of its history?

A. No sir.

Witness excused.

Mr. VAN E. ROUSE, was next called and sworn, and testified as follows, to wit:

Examination by Mr. Robinson.

Q. Were you on the 8th of September, 1898, a member of the City Council of Colorado Springs?

A. I was.

Q. Did you participate in the discussion and proceedings at the time of the passing of what is known as the Jackson franchise on the date mentioned?

A. I did.

Q. Tell the Board, the best you can, what was the purpose and intent of the Council in passing that Ordinance, in so far as the amount of light to be received was concerned?

A. That Ordinance when present-

ed to the Council carried with it some conditions that the Council wanted to regulate as much in the interest of the City as possible. The question came up about regulating the price per light. The Council seemed, as a whole, of the opinion that we had been paying too much for light, and secondly, if we could get a reduction by granting that franchise, that it was one thing that it was proper to do. They asked for the insertion of a price of \$5.50 per month. It was the main request. Then the question as to the light to be furnished came right in on the same proposition. During the discussion the question as to the candle power of the lights then furnished by the Lighting Company came into the discussion. If I remember rightly, there was a committee that looked into the matter and reported to the Council as to what they considered the light power of the then existing lights. In view of the fact that we were getting a cheaper price and wanted to get a better light, the question of the candle power of the lights was pretty thoroughly discussed. The two questions seemed to be, the price of the lights and the candle power of the lights more than any other two points in connection with it. The impression of the Council at the time was that the City was getting light of about 1200 candle power. Upon that basis I took the position that the light furnished by the Jackson franchise Ordinance should be 2000 candle power lights. It seemed to be the general opinion of the Council, in their discussion, that we should have what the Ordinance called for—2000 candle power. I didn't know then, and I don't know now, what

it takes to make 2000 candle power. These two points were the two I was looking after. The other members of the Council had the same idea. These two points received greater consideration and discussion before the Council than any other.

Q. Do you remember anything having been said by any alderman to the effect, in urging the passage of the Ordinance, that under the Ordinance, the City would get more light for less money than they were getting?

A. Yes, sir, I used that argument myself.

Q. In favor of the passage of the Ordinance?

A. Yes, sir.

Q. I will call your attention, Mr. Rouse, to the changes shown in connection with the original copy of the Ordinance in Section 9, and ask you if you remember anything about that?

A. I don't remember about the change being made. I remember the discussion of the possibilities of the meaning of 2000 candle power.

Cross - examination by Mr. Schuyler.

Q. Mr. Rouse, how long have you lived in Colorado Springs?

A. About 27 years.

Q. What other points in the Ordinance were discussed there?

A. The argument used by some in favor of the passage of the Ordinance was that Mr. Jackson had had hard luck in the tunnel and lost money, etc., and that he should have a chance to recuperate.

Q. What other matters, aside from this of light and the price, that are embraced in that franchise, were specially considered?

A. One of them was the laying of a pipe line from Lake Moraine to Manitou. A parallel line.

Q. Did you vote for or against the franchise?

A. Against it.

Q. And fought it to the end?

A. Yes, sir.

Q. At that time the city thought it was using 1200 candle-power lamps?

A. That was the sentiment.

Q. Did anybody really know what 2000 candle power light was?

A. If he did, he knew more than I did.

Q. Your point was to get 800 candle power better light for \$66.00 per annum than you were then paying \$85.00 or \$108.00 per annum for.

A. Yes, sir.

Q. Do you know what is meant by the term "standard 2000 candle power"?

A. No, sir.

Q. In this Exhibit No. 25 the word "standard" is interlined, and the words "as commonly known" stricken out—don't you recollect that your mind was brought to this matter at the time of this discussion and that it was determined that the technical term was "standard," 2000 candle power, and that you erased "as commonly known" and interlined the word "standard"?

A. I don't know.

Q. Would you say that it did not occur?

A. That paper indicates that it did, but as far as I remember, I don't know.

Q. In Paragraph 4 of the contract with the Colorado Springs Lowe Gas and Electric Company, dated April 7, 1890, being Exhibit No. 21, clause No. 4 reads this way:

"And the party of the first part further covenants and agrees that it will furnish the party of the second part, whenever so required, with not less than forty arc lights, of what is commonly known as 2000 candle power each, for lighting the streets of the city for not more than \$125 per annum for each arc light, etc."

I will ask if that clause wasn't taken under consideration in the same manner that I mentioned in my previous question, and that it was determined to use the more technical term, "standard" 2000 candle power?

A. I couldn't say. I don't recollect any discussion of the technical term used.

Q. Don't you remember that the term "as commonly known" was stricken out, and the word "standard" inserted?

A. It must have been, but I don't recollect it. There was quite a talk about what we were paying for lights, and the service we were getting, and the City Council wanted to arrive at the best proposition possible in the then pending ordinance, or franchise, and that we would get as near 2000 candle-power as we could. Therefore, we supposed we were getting 2000 candle-power, as the ordinance called for that.

Q. You mean everybody in the council supposed that?

A. No, the people generally. That was what brought it up—the objection of the citizens to the degree of light.

Q. Were you a member of the City Council September 5, 1901.

A. I don't think so. I think my term expired April 17, 1899.

Witness excused.

Mr. W. H. McINTYRE was next called, and being duly sworn, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Were you a member of the City Council of Colorado Springs on the 8th of September 1898, when the so-called Jackson franchise was passed?

A. Yes.

Q. Can you tell the Board what was the intention of the council in respect to section 9 of that Ordinance providing for the candle power of the lights in the streets of this city?

A. I think the intention of the Council was to get all the light it could for as little money.

Q. What as to the power?

A. As near 2000 candle power as they could, I suppose.

Q. I call your attention to section 9, and to the part changed from type-writing to pen, and ask you if you recall that?

A. I don't know as I do specially.

Q. Do you know whether or not at that time there was any discussion that the lights then being used by the city were less than 2000 candle power?

A. I think there was a little. There was a little talk about their being less than that, but I don't know how much less than 2000 candle power. Perhaps 700 or 800 candle-power less.

Q. As you understand it, it was the intention of the Council to receive 2000 candle power?

A. As near as they could. I think Mr. Jackson told them—gave them that idea himself—that he would give them as near 2000 as he could. He was there and entered into the discussion several times himself.

Cross - examination by Mr. Schuyler.

Q. Do you remember the committee that was appointed by the City Council to look into this matter of light?

A. I do not.

Q. Did you know what constituted a 1200 or 2000 candle power lamp at that time?

A. No, sir.

Q. Were you enlightened by any investigation as to what it was?

A. I think not.

Q. I will ask you, Mr. McIntyre, if you remember these words were stricken out of that original paper, "as commonly known," and was that discussed, and the word "standard" used as giving the more technical definition?

A. I think there was some discussion. I think it was done at the suggestion of Mr. Jackson.

Q. It was in the course of that discussion that he said he would give you as near 2000 candle power as he could?

A. I think so. I think the members of the Council thought the word "standard" was a better word than the other. That it was probably better for the Council in order to get more light.

Witness excused.

PROF. JOHN C. SHEDD was next called in behalf of the City, being duly sworn, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Do you know the electric lighting system of this city?

A. *I am fairly well acquainted with it.*

Q. Please explain what system it is?

A. *At the present time the streets are lighted with a number of circuits radiating from what is known as a sub-station, these circuits being connected to what is known as tub transformers of General Electric Co. make. The transformers are energized by a circuit or circuits coming from the Pike's Peak Hydro-Electric Co.'s plant in Manitou. The lamps are those described as 6.6 ampere series alternating current enclosed arc lamps. There is also a circuit from the sub-station to the generating plant north of town, located at the coal mines; the purpose being to use either steam or water power, as the case may be.*

Q. Have you made any tests of the lights on the streets of this city as to the energy used and the candle power furnished?

A. *During the past nine months, approximately, I have been a member of a committee appointed by the College, at the request of the Mayor of Colorado Springs, to look into the matter of the lights used upon the streets of Colorado Springs.*

Q. As a member of the committee, did you assist in making some tests of the lights?

A. *Yes, sir.*

Q. Had you for some time prior to the making of those tests observed the lights on the streets of the city, and could you therefrom say that approximately the average condition of the lights on the streets were the same as when those tests were made?

A. *For about nine months previous to September last, at about which time the agitation with respect to the water system and the street lighting system was uppermost in the minds of the people, from about that time I have consciously observed the lights.*

Q. From such observations, could you say they were approximately the same as when you made the tests in June and September?

A. *I would say that during that time the lights appeared, as far as one could judge, to be of about the same quality, and therefore the nights upon which the tests were made were not exceptional in any respect. I speak here of the nights as a whole.*

Q. Professor Shedd, I will show you City's Exhibit, No. 26, and ask you if that correctly shows the results of the tests of the street lights of the city and the times.

A. *Yes, this is a tabular view of the tests made and the dates indicated.*

Q. And the lamps at the locations indicated?

A. *Yes.*

Q. Did you make tests of any other lamps besides what are shown here?

A. *Yes, on the nights of January 28 and 29, 1907, a number of other lights were tested.*

Q. Are the results of the tests made on the 28th and 29th of January, 1907, correctly shown on City Exhibit No. 27?

A. Yes, sir.

Q. Have you made any other tests than those shown by Exhibits Nos. 26 and 27?

A. On the afternoon of, I think, August 30, two lamps were taken from the circuits on the city streets and were transported, after being marked "J" and "M" for identification, to the laboratory at Purdue University and were there tested.

Q. Professor Shedd, I speak of you as being a member of the committee that made these tests, who were the other members of the committee?

A. On the part of Colorado College, Professor Strieby and Professor Armstrong and, later on in the summer, Professor Matthews of Purdue University.

Q. Who assisted at Purdue University?

A. Tests were made under the direction of Professor Matthews, director of the electrical laboratories of Purdue University, who was assisted by two of his men—Professor Topping and Mr. Lampke and myself.

Cross-examination by Mr. Schuyler.

Q. Did you first have your attention called to the condition of these lights in Colorado Springs about the first of January, 1906?

A. Thereabouts.

Q. When was your attention first specifically called to it and when

were you requested to represent the city?

A. In the spring of 1906.

Q. You followed that up by making these tests that you were employed to make by the city?

A. I wasn't employed. Our committee was requested to act from the College, and it acted as a matter of courtesy.

Q. They were requested by the Mayor?

A. Yes, sir.

Q. Was any member of the Colorado Springs Electric Company or the Pike's Peak Hydro Company present during the tests?

A. I think on one occasion one of them was present a part of the time. There was no test planned at which they were invited to be present.

Q. How many lamps are upon the circuit where you made the test?

A. As I understand the matter, there is more than one circuit.

Q. In sizing up the situation in this matter, would it not be fair to take into consideration the number of lights upon each circuit?

A. It would depend upon the purpose of the investigation. Our purpose was to determine what light was given by the lamps on the streets of the city.

Q. Would you in view of the conditions here think it necessary to take into consideration the number of lights on a particular circuit in making a test?

A. I don't see that it is. The lighting company might consider it so. They might consider the question of overload.

Q. You don't know how many circuits there are in Colorado Springs?

A. *No, sir, I do not.*

Q. Do you know how many lights are strung on a circuit?

A. *No, sir, I do not know. I only know that all those lights are not on the same circuit.*

Q. Why?

A. *Because I have a general idea of how the circuits of the city run.*

Q. You don't think it is necessary to know how many circuits or how many lights on a circuit, in order to arrive at the results tabulated in this statement?

A. *I didn't consider it necessary to know how many lights there were on a given circuit, or how many circuits there were in the city, or the exact location of the particular circuits.*

Q. If all the lights upon one circuit were increased or decreased, would that element have any effect upon the investigation?

A. *Our purpose was to determine the light given by the lamps; that was the sole object of the communication received from the Mayor.*

Q. Now what effect would there be on a given circuit having say 20 lamps by adding 25?

A. *In the constant current alternating system the "tub" transformer is designed to care for any added lamps up to the load limit of the transformer.*

Q. So that the whole matter can be relegated to and loaded upon the tub transformer?

A. *So far as my tests are concerned.*

Q. Now, Professor, aside from the tests down on Exhibits Nos. 26 and 27, which were made on June 2d and 3d, July 5th, August 30th and August 31st, January 28th and 29th—aside from those you never made any tests of those lights or any other lights than those named here, on the streets of Colorado Springs?

A. *Yes; that is besides those tests named I have not tested lights on the streets of Colorado Springs.*

Q. You state that your attention was not specifically called by the Mayor until a month or so prior to your first test, yet you say from January you noticed these lights, and you think just from your actual observation that the conditions were the same then as surrounded these lights at the time you made the tests?

A. *I do.*

Q. It is on your general trained observation that you rely for your statement that the conditions were the same?

A. *Yes, sir.*

Q. In other words, your testimony is that the conditions surrounding these lamps from January to April were the same as the conditions surrounding the lamps selected for the purpose of these tests at this time?

A. *Yes, sir.*

Q. And the Committee may take this as the result of your observation?

A. *It is the result of my observation.*

Q. How much of a deviation would your trained eye detect?

A. I don't know as I can evaluate it. On the night of one of our tests—during a part of the time—there seemed to be a falling off of the candle power of the lamps. We said it looked as if they were going down. After awhile we said it looked as if they were coming up. We were looking at the lamps for the distinct object of noting this very thing.

Q. Going up and down the street, what deviation would attract your attention?

A. I can't give you a numerical value of it. I don't think it would fall lower than 10 per cent. I don't wish to be asked to give specific figures. It might be 20 per cent.

Q. Now, did you notice any deviation in these lights, aside from the

one you have spoken of when making the test between March 1st and the time you made these tests?

A. More than once; I couldn't be able to state how many times; it was a matter of remark that the lamps were not as brilliant, as, for example, they are now.

Q. Did you pick out the nights when the lamps appeared to be below par to make the tests?

A. By no means. We set the dates ahead.

Q. But you did continue the tests this night when they appeared to be going down?

A. We were testing throughout the whole night.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT, AT 9

A. M., FEBRUARY 2, 1907.

PROF. J. C. SHEDD recalled to the stand.

Cross-examination Continued by Mr. Schuyler.

Q. When did you go to Purdue?

A. The afternoon of August 31st was the date on which the lamps were taken from the circuit, and I followed the lamps a day or two later, reaching Purduc on Thursday following that date.

Q. Two lamps were taken?

A. Yes.

Q. From what points were they taken?

A. You will find that in the tabular sheet, Exhibit No. 26. You will find one lamp marked "M" on the

margin. That is the one taken from North Wahsatch and San Rafael. The other lamp is marked "J" and was taken from the corner of North Weber and East Uintah.

Q. These were the only lamps used in making the tests at Purdue?

A. Yes, sir.

Q. Did you make any tests in the laboratory here?

A. None at all.

Q. Take Exhibit No. 26, test No. 1, upon June 2d. At that test Prof. Matthews was not present?

A. No, sir.

Q. Yourself, Prof. Armstrong and Prof. Strieby made that test?

A. Assisted by two students.

Q. At that time, and for the purpose of the question I wish to assume these facts: There were six circuits in Colorado Springs, and 241 arc lamps. On that night you examined one—only one lamp and on one circuit?

A. That is true.

Q. I ask you if it would be fair to arrive at the conditions of the other lamps on the circuit from an examination of one lamp?

A. Such a statement that the measurement of one lamp gave accurate information of all the lamps on a circuit or all the lamps of the city would be incorrect and has not been made.

Q. In other words, you do not intend this committee to gather from test No. 1 the idea that upon that circuit all the other lamps were of the same voltage and were consuming the same number of watts that existed at the corner of Wood avenue and East Espanola?

A. No.

Q. Then, I understand you take the position, that being true, an examination of one lamp upon one circuit would not give you any data as to the conditions of lamps upon other circuits, except as you got it from general observation, that is true?

A. That is correct.

Q. Does an examination of this one lamp give you any specific or accurate data as to the condition of the other lamps upon the same circuit?

A. If we read the current upon a given lamp, then, in the present system of lighting circuits in use on our streets, at that moment of reading

the same current will be present on that whole circuit.

Q. Aside from the possible presence of grounds on lamps and aside from possible local conditions peculiar to each lamp?

A. No, sir, aside from grounds only.

Q. But it doesn't give you any idea as to the voltage at other lamps?

A. No, sir.

Q. Well, then, can you fairly arrive at the watt consumption in all the lamps of a circuit by knowing simply the current of one lamp?

A. The only knowledge that the measurement of one lamp gives us with respect to other lamps on a circuit is with respect to the current through other lamps. Therefore, aside from the impression that you get visually with respect to the other lamps, you have no knowledge of the other lamps.

Q. The point is this, you state to this committee you don't want them to infer anything as to the other lamps except what you got from your visual observation; what visual observation did you make of the other lamps on that circuit?

A. I made this observation; they were burning.

Q. Where were the other lamps?

A. Up and down that street.

Q. Is that the only circuit found on that street?

A. I don't know; I know the lamps around that place are upon the same circuit, or presumably so.

Q. Then as a question of fact, you

didn't know the limits of the circuit, did you at that time?

A. No, sir.

Q. Then, so far as you know, you may have been seeing lamps that were upon other circuits?

A. That is true.

The purpose of our test was to determine the light of a given lamp. I confined myself to that problem. The information with respect to the circuits you speak of I do not regard as essential to it.

Q. I gather, then, at different lamps upon the same circuit there may be a very material difference in the voltage?

A. If there is a difference, material difference in the voltage, it indicates a lack of regulation upon that circuit. If the lamps are in good condition the measurement of one lamp is prima facie evidence of the condition in the other lamps; if that is deviated from, it is evident that the other lamps are not in the condition as the lamp tested.

Q. What is the standard of regulation; what should the adjustment be?

A. The lamp was shown and by, I believe, yourself is what is known as G. E. Co. 6.6 ampere alternating current lamp; it is 427 watt lamp, about 400 watts in the arc, and it should give 6.6 amperes in the lamp; the voltage is, approximately, 72 volts.

Q. These lamps you took East with you, their voltage was as found here in Exhibit No. 26, items 9 and 10?

A. The voltage on lamp M we tested to 73.2, the average of the test. Watts 392.

Q. Item 10?

A. 10 was tested twice; on the first occasion the volts were 43.4 on the second occasion 61.7 and the watts 240 and 343, respectively.

Q. Both on the same night?

A. Both on the same night.

Q. Tests on the same lamp differed in round figures 18 volts and 105 watts?

A. Yes, sir.

Q. Between 1.22 A. M. and 4.28 A. M. you got hold of some lamps which were not, according to your tests, adjusted to the capacity or in the way that they were designed to be adjusted?

A. We found no lights on that night so adjusted.

Q. You picked out a poor lamp to bring up here?

A. We selected one below and one above the average.

Q. But, you have stated, Professor Shedd, there is a certain standard for these lamps. How do you know, not knowing the lamps of a circuit or what other lamps are upon it, that the lamp you came across was not one that had something wrong with its particular adjustment?

A. I don't know.

Q. You didn't make any search to find out whether or not some peculiar condition effected this lamp which you examined as test number one on June 2d, which did not exist in the other lamps on the circuit?

A. We did this on that night; we tested as many lamps as the time of the night would permit; we went from point to point of the city in

order that we might not accidentally confine ourselves to one circuit; in so far as we did that, it was in order that we should get tests from different parts of the city.

Q. And get upon other circuits?

A. Yes, sir.

Q. But, I understood you to say, in starting this discussion, you tested on that night one lamp and one alone?

A. You are correct in that; I thought you were referring to other tests.

Q. You say you were testing for light; were you testing for light in the absence of having your photometrical machinery, or were you testing for energy?

A. In a test for light, the first step is to find the energy in the lamp.

Q. The result of your work upon the streets of Colorado Springs upon June 2d was summed up in watts?

A. The summing up of the information gained on these various nights was the amperage, voltage and wattage of the lamps.

Q. Professor Matthews didn't make any photometric tests in Colorado Springs, did he?

A. No, sir.

Q. The photometric tests were made in the laboratory in Purdue University?

A. Correct.

Q. The low condition of the two lamps you took away from here may have been due entirely to some failure to properly adjust these lamps?

A. No, sir.

Q. When you took these lamps off the streets here and shipped to Purdue, they were taken apart?

A. No, sir.

Q. You took the carbons out?

A. No, sir; not to my knowledge.

Q. Do you know the lamps were shipped just as taken off the street?

A. So far as I know.

Q. Do you know?

A. I didn't pack them.

Q. Go ahead?

A. After having gotten them at Purdue in shape for testing, the globes were cleaned and the lamps hung up; they were then tested for four conditions.

Q. Just a moment; that was a lamp, which when you measured it upon the streets of Colorado Springs had 6.6 amperes, 43.4 volts and 240 watts?

A. Yes, sir.

Q. And later the same night had 6.7 amperes, 61.7 volts and 343 watts?

A. That is the idea.

Q. All right now.

A. It was tested for the condition of 240 watts.

Q. That was your first test?

A. Yes, sir, photometric tests were made, the different amperage and volts being adjusted to the conditions found on the street. The lamp was first tested at 240 watts; it was next tested at 340 watts; it was also tested at 480 watts, which was entirely out of the range of our determination on the street.

Q. Let me ask you, while on this

lamp and this circuit, you don't know that the other lamps on that circuit at this time or any other time were not up to the standard prescribed by the General Electric Company; that is, 427 watt lamp?

A. Except as my visual impression led me. Now, the second lamp, "M," was found to be working at 390 watts and we so tested it. We also tested it for 427 watts, that being as you know the rated consumption for a lamp.

Q. May I ask you if the data contained in Exhibits 26, 27, 28 and 29 contain all of the data derived by you and your associates from the examination of these lamps and tests which are set out in Exhibits 26, 27, 28 and 29?

A. The documents which you have mentioned contain summaries of these tests.

Q. I will ask you to state how many different lamps in the City of Colorado Springs were examined by you and your associates upon which you made tests?

A. Taking summary sheet No. 26, there are the following pairs of lamps, that is, 2 and 11, North Corona and East Columbia; also 7 and 14; also 10 and 17; also 8 and 15. Those are the same lamps and, of course, therefore, are duplicates. The street tests were taken on four separate nights—June 2, July 5th and August 30 and 31?

Q. Professor Matthews was present on August 30 and 31?

A. That is correct. On the first night one lamp was tested; on the second, two lamps; on the third, one lamp; on the fourth, thirteen tests were made on nine separate lamps.

Q. Thirteen lamps?

A. Thirteen lamps out of a total of seventeen tests.

Q. Do you know you covered all the circuits of the city?

A. I don't know whether we did or not.

Q. You don't know whether the conditions here may not have existed in the lamp, which may have had some peculiar local adjustment, aside from your visual observation?

A. If some one should say to me that was his conclusion, I would be unable to convince him to the contrary.

Q. Will you explain item No. 4, on Exhibit 26, the light on the corner of Tejon and East Cache la Poudre?

A. On the night of July 5th an incident occurred, as follows: The committee was progressing with the test upon a lamp mounted on a pole at the corner of Cache la Poudre and Tejon streets; we were about half way through the readings, when a small wagon with two men drove up; the wagon bore the name C. S. Electric Company. One of the men alighted from the wagon and asked permission to view the test. We were mounted on a wagon ourselves. He forthwith mounted our wagon. He then explained they had not adjusted the pole lamps, but that they had adjusted those that could be lowered, such as those on Tejon street, south of us. He further said that he would climb the pole and fix this lamp. I suggested that he wait until our tests were through, so as not to break the continuity of that test. He stated, however, it would make no difference.

Q. Did you protest it would make a difference?

A. I said, "You had better wait until we are through, so as not to break in on our test." He went up the pole and fixed the lamp; then he inquired if the lights were not better.

Q. You had completed the first test?

A. No; we had not; we had taken about twelve readings, then I took two or three readings subsequent to his coming down.

Q. That throws a very great deal of light on two propositions; one in case of failure to adjust properly, a lamp may be deficient; second, that lamps are capable of receiving far greater voltage and consuming greater wattage than the standard calls for of 427 watts for a 6.6 amper lamp?

A. The incident illustrates that a lamp can be adjusted and in the particular case here, was so adjusted as to take a larger wattage than it was taking in the first place.

Q. How many pole lamps were there?

A. He told us the number: I think about a dozen.

Q. He stated to you the rest of the lamps which could be lowered had been adjusted?

A. He gave us to understand that the lamps that could be lowered had been adjusted. The party concerned said it was unfair for us to test lamps before they had been adjusted.

Q. We want you to now describe to us fully what you and your associates did when you went forth on

August 30, 1906, in the way of getting at the wattage, etc.?

A. Take the light on the corner of South Wahsatch and East Cimarron, Test 5. The parties present were C. P. Matthews, J. R. Armstrong, William Strieby, J. C. Shedd and V. T. Brigham.

The procedure was as follows: Mr. Brigham was installed at the ammeter, Mr. Armstrong was installed at the voltmeter, Mr. Matthews was installed at the wattmeter. The instruments were mounted on a small table in a wagon, of course, the whole being lighted by the light of the lamp under test.

Professor Strieby and myself were standing on the ground, then Professor Strieby, holding his watch first, gave five to ten seconds warning; then he said "read." The three parties read their instruments simultaneously, the first reading, for example, amperes, 7; volts, 69; watts, 460. That was repeated at half-minute intervals, five seconds warning being given.

Ten readings were taken, the last one being taken at ten o'clock, thirty-three minutes and thirty seconds. The summary you have in Exhibit No. 26 is the average for the current, the average for the voltage and the average for the wattage. On this occasion I figured it 7 for the amperage, 73.7 for the voltage and for the wattage, 436.

Q. You took ten readings on that night?

A. Yes, on that night, August 30th; on previous nights we had been taking fifteen readings at two minute intervals.

Q. How long after the lamp was turned on did readings begin?

A. *I think you may say about fifteen minutes to a half hour; at least fifteen minutes would elapse between the time we cut the lamp out to connect our instrument and cut in and began to take readings.*

Q. Now what scale ammeter did you have; tell us about that?

A. *Scale was zero to ten amperes, with Western standard portable A.C. and D.C. voltmeter, that read, I believe, up to 150 volts.*

Q. Where did you get the ammeter?

A. *The three instruments used that night were brought out here by Professor Matthews from Purdue.*

Q. Were the calibrations in all circumstances satisfactory to you?

A. *Yes.*

Q. When were they calibrated?

A. *These had been calibrated very shortly before the tests were taken. The instruments were secured, except the ammeter, for the purpose, in anticipation of these tests.*

Q. Now there was nothing in any information that you got from that test in Colorado Springs that enabled you to fill up columns six and seven, Exhibit No. 26, maximum candle power and mean hemispherical candle-power, was there?

A. *The test that furnished us the direct evidence for that is given by the curves and belongs to the Purdue Laboratory tests.*

Q. Where did you get the curves?

A. *Why, from the tests we made in Purdue.*

Q. Professor, the papers marked "Exhibits 28 and 29," they are signed by J. C. Shedd and J. R. Armstrong?

A. *Yes, sir.*

Q. Are those the results of the sole work of yourself and Mr. Armstrong, or are they, also, results of Mr. Matthews' work; that is, the work of all of you?

A. *We all made the tests on which these two curves are based at Purdue; these particular curves were drawn by Mr. Armstrong and myself; they are the results of the Purdue tests.*

Q. Were globe and reflector used in making the test?

A. *The lamp was trimmed precisely as we found it on the street, inner globe and outer globe; it was mounted in that same manner, in the laboratory.*

Q. If you were a purchaser, would you be willing to take as a standard measurement upon which payment should be made, an expert test of one lamp, under the conditions you have testified, with visual observation for the balance, and pay for all lamps on that basis, where there are two hundred and forty-one lamps and six circuits?

A. *As I understand the question, it is this, if I were in a position to furnish arc lights for the city streets, under the system as we have it here, and the question came up as to establishing a standard or basis upon which payment should be made or received would I accept a basis as represented by these tests for such settlement. If I were selling light, as I understand the case to be here, I would be compelled in all fairness to accept some*

basis or test to determine what light was being furnished. Knowing, as I do, this make of lamps and because I consider the tests made upon two lamps, establishes a basis to determine the amount of light given, and the basis so determined is a fair basis therefore I would accept the average of those tests, although I might ask to have these tests duplicated or triplicated, as expert and a fair basis. This duplication or triplication would give, essentially, the same results. If I were selling light, I couldn't object to that basis as a basis of settlement; if I were selling power, I would object to that basis.

Q. You think it would only be fair to have the other lights taken into consideration?

A. Not as you state it.

Q. The other lamps of the circuit?

A. No, sir, I do not, because I think they are taken into consideration, because here we have two lamps taken and tested in the laboratory for their capacity to give light.

Q. You have answered that you would pay, would you buy on the basis you have stated?

A. If I would pay, I would buy on that basis.

Q. Why wouldn't you take the wattmeter at the plant showing the watts consumed?

A. Because there would be line losses, etc.

Re-direct Examination by Mr. Robinson.

Q. Professor Shedd, I want to ask whether or not the amount you

would have to pay under the contract would not that very largely guide you?

A. I should certainly scan the contract before signing it.

Q. You would be guided and governed by that?

A. Yes, sir.

Q. Now, when these tests were made, was there any person representing the city present?

A. Up to September 1st there was no person representing the city present or any of the parties except as they made themselves present with us.

Q. As you have heretofore described in one instance?

A. On the test of another evening there was a representative of the city as spectator.

Q. Tell the Board who that was?

A. That was the City Attorney.

Q. No one knew when you were going out?

A. No; they did not know when we were going out. May I make a statement?

The basis represented by these curves would be as a basis from lamps which have seen service; possibly, in fact, it is highly likely, that a test made upon lamps before issued from the factory in their new condition might give a different condition, but, this test we infer, in all fairness, in consideration of all the matters pertaining to it, represents the condition of the lamp in service; therefore, on that basis, I regard it as perfectly fair, with due allowance, it would probably tally up with the lamps in the factory.

Q. Who is the maker of the lamps used upon the city streets here?

A. *General Electric Company.*

Q. They are all practically the same?

A. *They are.*

Re - cross - examination by Mr. Schuyler.

Q. With reference to your voluntary statement, isn't it a fact that if the voltage and the current run the same it doesn't make a bit of difference whether the lamp is old or brand new?

A. *No, the gentleman is quite mistaken in that.*

Q. Tell us how.

A. *It would depend upon conditions of cleanliness of the globes; it could depend upon the quality of the carbons used in the lamps themselves.*

Q. But take the lamps in use on the street, if clean, using the same carbon and same voltage?

A. *That is what we did; we cleaned up the lamps, put back the old carbons, put back the old voltage, and we did realize the same conditions.*

Q. You mean when at Purdue?

A. *When we established this basis.*

Witness excused.

Board adjourned.

THE BOARD MET PURSUANT TO ADJOURNMENT, AT 2
P. M., FEBRUARY 2, 1907.

PROF. C. P. MATTHEWS, being first duly sworn on behalf of the City of Colorado Springs, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Are you acquainted with the electric light system used on the streets of this city?

A. I am.

Q. When, if at all, did you examine it?

A. I came here last August, the latter part of the month, and I looked over the system somewhat casually. I looked over the lights quite carefully, that being the thing which I was supposed to report upon.

Q. What character of lighting system did you find it to be?

A. What is known as a series alternating current 6.6 amperes constant current system.

Q. Did you make or assist in making a test of any lamps in use upon the street at or about that time?

A. I did.

Q. I hand you the City's Exhibit No. 26 and ask you to examine it and state what tests, shown on that Exhibit, were made in part by you?

A. Those tests bearing date August 30 and 31, 1906.

Q. Would that be this test 5 and the subsequent test?

A. Yes, sir.

Q. Does City's Exhibit No. 26 correctly show the result of those tests?

A. It does.

Q. I will hand you City's Exhibit No. 31, and ask you what that is?

A. These are the results of the candle-power measurements that were made on lamps designated as "J" and "M," taken from the streets of Colorado Springs and transported to my laboratory at Lafayette, Indiana, last summer.

Q. That correctly shows the light curves obtained by you from these tests?

A. Yes, sir.

Q. Were you engaged or retained by the National Electric Light Association to make tests of lamps?

A. I was. These tests extended over a period of four college years, and I think the years were '99, '00, '01, '02. The third report was presented in 1902, the last in 1903.

Q. Please state to the Court the maximum candle-power of the open arc direct current lamp, consuming 9.6 amperes, and from 45 to 50 volts, when operating in good condition?

A. I should suppose that it would be about 1,200 candle-power. This depends upon the quality of the carbon used to a large extent.

Q. Do you base your answer upon

your own experiments in testing the light of that lamp?

A. Yes.

Q. I will ask you whether or not you recently tested a lamp of that kind as to the candle-power?

A. I did, quite recently.

Q. What would you say is the maximum candle-power of the alternating current, series, enclosed 6.6 ampere arc lamp, such as in use on the streets of this city?

A. A liberal estimate would be 400 candle-power.

Q. Is that based upon your frequent tests of candle-power of lamps of that kind?

A. Yes, and upon the tests of others.

Q. What would you say is the mean hemispherical candle-power of a 9.6 ampere direct current open arc lamp?

A. In general terms, 700 candle-power.

Q. What would you say is the mean hemispherical candle-power of an alternating current enclosed arc lamp 6.6 amperes?

A. Making a very liberal estimate, as I just did in the case of the maximum candle-power, 300 candles would be liberal.

Q. And what would you say was the mean spherical candle-power of a 9.6 open arc direct current?

A. Somewhere about 450.

Q. What would you say was the mean spherical of a 6.6 ampere enclosed alternating current?

A. Soy 150 for that; of course, the total upper hemisphere is dark;

there is no light there at all, so that cuts it down very much on a spherical basis.

Q. Professor Matthews, can you base your testimony as to this candle-power upon tests made by yourself?

A. I can.

Q. As well as upon tests made by others?

A. Yes, sir.

Q. Professor, would you consider that the tests shown or the results shown by City's Exhibit No. 26 of these light tests, and which you participated in, would fairly represent the lights in use on the streets in this city on the dates those tests were made?

A. I would.

Q. I hand you Exhibit No. 1, and ask you to read Section 9.

A. Yes.

Q. I will call your attention to the phrase "such arc lights of standard 2,000 candle-power each," found in Section 9 of the Ordinance of September 8, 1898, and ask you, in the absence of any other agreement or understanding between the parties to said Ordinance at the time of its passage, what, in your opinion, is the meaning of that phrase?

A. I should say that called for the light from an old style, open, arc lamp, consuming 9½ amperes, 45 to 47 volts, approximately 450 watts at the arc, direct current.

Q. As I remember your testimony a few minutes ago, the maximum candle-power of such a light would be about 1,200?

A. Yes, I stated, I think, it might be more than that and it might be

less; the quality of the carbon being somewhat of a factor, but that is, I consider, a good, reasonable average value.

Cross-examination by Mr. Schuyler.

Q. Is not the 6.6 ampere, enclosed arc lamp very popular and being used in a great many cities of this country and recognized as superior to the old 9.6 open arc direct lamp?

A. In answering the first part of your question, it is used in a great many cities; as to its superiority, I don't admit that; I don't consider it superior to the 9½ ampere, open arc, direct current lamp as a light source.

Q. What do you think of its illuminating and distributing value?

A. I don't think it is superior in that respect.

Q. In what respect is it superior, in your opinion?

A. Chiefly in economy.

Q. Simply from a standpoint of commercialism?

A. Yes.

Q. It has been very generally or is being very generally accepted in this country, is it not, as superior in illuminating value?

A. Well, I think there are many who make such claims for it; those are chiefly interested in the exhibition and sale of the lamp, I think.

Q. Your employment, Professor, has chiefly been from the municipal side of this question, has it not?

A. Not altogether.

Q. Mostly so?

A. No, I have served for private light corporations quite a number of times.

Q. You are a strong advocate of municipal lighting?

A. No, oh, no.

Q. Well, the 2,000 candle-power lamp you have described, is generally considered throughout the country as being one which consumes at the lamp terminals 450 watts?

A. At the arc 450 watts, or as was stated in that Philadelphia resolution, 450 watts at the terminals when no sensible resistance is introduced. Of course, that is equivalent to 450 watts at the arc.

Q. Is this so-called Philadelphia resolution one generally recognized all over the country as being the proper definition of the so-called standard 2,000 candle-power light?

A. I think it is, so far as the 9.6 ampere open arc is concerned; I don't think it applies to the other kind of arc lamp.

Q. Wouldn't any lamp, however, which consumes at the lamp terminals 450 watts get this definition, generally speaking?

A. Not in my opinion.

Q. Isn't it a fact, that the subject of lighting and the capacity of arc lamps is considered from the standpoint of consumption of watts?

A. No. In the arc field, I should personally say, that is only one of the factors.

Q. Are contracts for lighting by street arc lights made, at all, upon the basis of actual candle-power in this country to-day?

A. Well, I don't know that they are not. I think it is not general to make them on that basis.

Q. Can you state a single case where they are made upon the basis of actual candle-power in the United States to-day?

A. I can't cite a case; that doesn't mean, necessarily, that I can't cite one on looking at my records.

Q. They are not of such frequent occurrence as to come under your attention and to impress your mind with a single instance, are they?

A. No, sir.

Q. So you would at least say to this committee, to be fair, that actual candle-power, in the United States, to-day, is not the basis taken into consideration in the making of contracts pertaining to these arc street lights?

A. I would consider—

Q. Then you concur fully in the rule established by the National Electric Light Association in 1894?

A. I understand that to be the definition of the 2,000 candle-power lamp as the term is commercially understood, but I further understand it to mean 450 watts of direct current, because that was the lamp which was in existence at the time this resolution was framed.

Q. Wasn't it also brought to your attention, that at the International Electric Congress of 1893 there was a discussion, the result of which Dr. T. C. Mendenhall made a report in which he said that while the Association came to a unanimous definition of ampere, volt and watt, which definition was afterward legalized.

they failed to declare a satisfactory unit of light, and some of the American delegates at that Congress asked it to relieve them by a definition of 2,000 candle-power light, it being one operated at 450 watts, but the representatives of the other nations declared that they never made contracts in candle-power, and that Americans should not be so foolish as to do so. You remember those circumstances?

A. Yes.

Q. That was followed by the National Electric Association, in 1894, defining for commercial purposes, the meaning of the term 2,000 candle-power light, wasn't it?

A. Yes.

Q. Now, in the year 1898, the date this contract was made, was the art in such shape or condition as to permit the electric fraternity to take actual candle-power as a basis for making an arc lighting contract?

A. I don't think it was.

Q. Or at the present time?

A. At the present date it is different; at the present date we know a whole lot about candle-power that we didn't know in '98 or '94.

Q. Even now, you are not in condition to make an actual candle-power-basis contract?

A. I think we are.

Q. You can't cite an instance where it is being done now?

A. No.

Q. On September 8, 1898, was there to your knowledge anywhere any such thing as a light for street

purposes giving actual 2,000 candle-power?

A. There were lights that would give 2,000 candle-power at certain instants of their operation, but not an average of 2,000 candle-power. I think they were especially powerful arcs, such as used in the tower system of lighting, which gave more than 2,000 candle-power.

Q. Was that for commercial uses upon streets?

A. Yes, sir.

Q. Where?

A. Detroit.

Q. What current?

A. About 30 amperes.

Q. What were the circumstances surrounding its use in Detroit; tell us fully?

A. Well, there were various cities that used the tower system of lights, where the arcs were placed on high steel towers. Those arcs took a larger current.

Q. How high were the steel towers, 150 or 160 feet, so as to get away above surrounding objects?

A. Yes.

Q. Those were special conditions, were they not?

A. Yes, the number of cities lighted by the tower system was comparatively small.

Q. Are you positive these Detroit lights were not 9.6 ampere lights?

A. No, sir, but knowing that certain of the tower systems used high current lamps, I inferred the Detroit lights were of the same current. I am not positive of that fact.

Q. I want to ask you, Professor, upon what basis you place your claim that the 9.6 ampere light, the old style direct open arc, is superior to the present 6.6 ampere enclosed lamp?

A. Well, it gives more light per watt of energy, and it gives, in spite of the claims to the contrary, a better distribution of light, not perhaps throughout the entire time, but in general a steadier distribution.

Q. As the arc moves from one side to the other, that lamp extends the light very much to one side, does it not, and leaves the other in a great shadow?

A. Yes, sir.

Q. The enclosed arc 6.6 does not do that to so great an extent, does it?

A. I think it does.

Q. What is the fluctuation or ratio of one type to the other?

A. I can't give you the numerical figure for it without looking it up in my reports, but I have published the figures.

Q. One other objection to the open arc lamp that is made is, there is a great variation in the candle-power of the arc, caused by the increased length of the arc from the picking up to the feeding point?

A. There is a very considerable variation.

Q. That is one of the objections made to it?

A. That is an objection to any arc lamp.

Q. It is greater in this style of lamp?

A. It may be somewhat higher in the 9½ ampere D. C. arc than it is in the other.

Q. There is another objection to that style lamp, which is caused by a wandering of the arc, due to, for example, a heavy draft of wind, isn't that true?

A. Well, the D. C. arc certainly wanders, so does the enclosed arc.

Q. Doesn't it wander more?

A. I don't think it does. It wanders in the enclosed arc as any man can see by looking at the arc; it is here, presently it is over there; it is the very wandering of this arc that keeps the carbons balanced for feeding. In the direct current arc you have a crater which tends to limit the wandering of that arc to a very small circle.

Q. Isn't it a fact that it sometimes takes the direct current open arc lamp from four to fifteen minutes to feed, that it takes the enclosed arc from three to four hours to feed?

A. The old style arc feeds more frequently than the new style, otherwise the carbon in the latter wouldn't last so long.

Q. Well, isn't it true when this feeding is going on so frequently in the direct open arc the light falls down then comes up again, flickers back and forth, suddenly decreases and comes up again?

A. That is true.

Q. Now, there are certain contentions made by certain persons, however ill advised they may be in your opinion, that the 6.6 ampere enclosed lamp is superior to the old open arc?

A. There are such, yes, sir, I have heard them repeatedly.

Q. But, I understood you to say the old lamp, in your opinion, is superior, and yet it has been falling off continually in use?

A. It has.

Q. When did you make your last test of such a lamp?

A. About two weeks ago.

Q. It was then you made this test Exhibit No. 32, about which you testified?

A. Yes.

Q. Of the old style 9.6 open arc lamp?

A. Only one of these curves apply to that. There are various other tests on this same sheet. The curve sheet, Exhibit No. 32, shows the distribution of light in the lower hemisphere from five different individual lamps, and also the combined result of a number of tests reported in my arc light report before the National Electric Light Association. Starting with the largest of the curves, A, we have the D. C. 9½ ampere open arc, next inward, B, is one of the Colorado Springs enclosed lamps run at 480 watts; curve C is one of these same lamps run at the normal wattage of 427; curve D is the mean of a number of tests on 6.6 ampere A. C. enclosed arc lamps of the series type, reported to the National Electric Light Association. Curve D is not the same contour as the others because the lamps tested in the N. E. L. A. tests were equipped with opalescent inner globes, whereas the Colorado Springs lamps were fitted with clear inner globes. Curve E is one of the Colorado Springs lamps run

at 342 watts, and curve F is still another of these lamps run at 240 watts.

Q. You have made these tests upon the streets of Colorado Springs and in your laboratory at Purdue, and you have represented the City's interest in making these?

A. I have.

Q. You were in the employ of the City?

A. Yes.

Q. At the time these tests were made, you were running the wattmeter, were you not?

A. I read the wattmeter originally and other instruments at different times and kept general survey upon the method of making the tests.

Q. Who was present at the time you took these photometric tests on these two lamps in your laboratory?

A. Well, besides myself, there were Professor Shedd, Professor Armstrong, and two of my own assistants.

Q. Now explain fully what you did from the time you started upon the tests?

A. On receipt of the lamps I had them unpacked and put in a safe place in the photometric laboratory; after these gentlemen from the West had come, I had the lamps put in working order. It is a very slight job, because nothing had been done to them to injure their operating features in any way; then they were hung up in the usual place in my arc light photometer, and the candle-power distribution obtained in the usual manner, which I have published time and time again. You

don't wish me to go into the details of the photometer, do you?

Statement by Mr. Schuyler.

Now, I would like to have Mr. Ryan ask you a few questions; he is an electrical engineer.

Mr. Robinson: We shall object to experts being permitted to examine. In the first place, it is unheard of in any court procedure; while this is not strictly court procedure, we are nevertheless proceeding along these lines; in the next place, perhaps the most substantial reason is, it seems to me, it gives to the experts on behalf of the defendant an undue advantage by permitting them to lay a foundation basis for their own testimony when that comes. A further reason is, that I think it is unfair to the expert witnesses themselves to be placed in that position; and it will, in my judgment, inevitably lead, unless controlled by the Board, to controversies between the experts, possibly not between Mr. Matthews and Mr. Ryan, but there are others coming along the same line.

Thereupon the Board ruled that Mr. Ryan might ask questions of the witness in order to expedite matters.

Counsel for the City then made the further objection that if Mr. Ryan acted as attorney they would then object to his being sworn as a witness.

Counsel for defendant then stated that Mr. Ryan, who was going to ask the questions, felt that since counsel for the City objected to his participation, that he didn't care to, and therefore the request was withdrawn.

Cross-examination resumed by Mr. Schuyler.

Q. Well, tell us the details of that photometric test?

A. *The arc lamp we tested was hung up in the proper place in the photometric room, equipped with carbons, globes and shades, etc., which belonged to it.*

Q. What kind of a photometer was it?

A. *The photometer used was a Lummer-Brodhun.*

Q. How many tests did you make altogether?

A. *Five.*

Q. How many readings at each point for each lamp?

A. *I have an automatic device for recording those readings, of which I have the record here. If there seems to be in any particular measurement a considerable variation, we naturally take more readings.*

Q. Did you pay any particular attention to the position of the arc at the time the readings were taken?

A. *I never do that. My method makes that unnecessary; I use a double mirror on each side of the arc.*

Q. Taking, now, Exhibit No. 32, explain to the Board why it is curve A swells out so much?

A. *Curve A swells out toward the horizontal because the carbon happened to be such that the crater formation was very indistinct and the arc wandered more than it would where there is a very marked crater formation. Wherever you get that feature, you always get horizontal readings strengthened. I am aware*

that is, to some degree, unusual. Sometimes different carcels of the same brand of carbon do not follow the same contour. That is due to the difference in quality and the method of burning the carbons themselves.

Q. Did you, in arriving at this, take the average of both sides or only of one side?

A. *I used two mirrors, one on each side, which automatically gave me the average of both sides of the arc.*

Q. What was the voltage of the lamp at that instant?

A. *Well, this test, of course, extended over some little time, and the arc was maintained very closely. By the way, I never undertake any open arc work except with a hand lamp.*

Q. Was the condition the same on the enclosed arc?

A. *No, you can't say that very well.*

Q. What were the conditions in making the photometric tests of the enclosed arc?

A. *We hung the lamps up as I stated, brought them to the operating condition at which we wished to make the tests, put the brown paper on the recording drum, then while a certain observer kept the power, voltage and current readings, the other observer made photometric settings. Whenever the latter gets a setting he presses the button, that is all there is to it. Suppose we start out with horizontal mirrors which will hereafter be designated as the right and left mirrors. Now, the light from the arc passes by way of the mirrors to a photometric screen, where it is balanced against the light from some*

other source of light known as the working standard. When a number of readings have been taken in a horizontal direction, these two mirrors are covered and the two mirrors next lower in the ring are uncovered. This process is repeated until the entire distribution curve, such as shown as this Exhibit No. 32, has been obtained. The readings thus far indicate only the relative candle-power in the different directions. The arc lamp is now removed and a standardized incandescent lamp put in its place. A second set of readings is taken on one of the sets of mirrors. With these two sets of readings it is possible to figure the candle-power of the arc without determining such troublesome factors as the reflection and co-efficient of the mirrors themselves or any other errors in the apparatus.

Q. Looking at Exhibit No. 32, I understood you to say you had maintained this by hand feeding at the maximum of the arc.

A. I don't understand what you mean by maximum.

Q. Probably I haven't the right word; you maintained it by hand feeding, what do you mean?

A. It is a hand-fed arc.

Q. As a general statement, under normal conditions, with a lamp allowed to feed up and down, how far down would it go?

A. As a matter of fact, the lamp which I made that curve on was not an automatic feed lamp at all; it was a special lamp I use for determining open arc candle-power.

Q. What would an ordinary 9.6 ampere lamp do under normal conditions of feeding?

A. Just about what that curve shows.

Q. Doesn't such a lamp go down to hissing point and then rise up?

A. Yes, sir, but in that connection a hissing arc, whether hand fed or automatic fed, is not a normal arc; if you are determining the candle-power of such an arc you should never make any reading when it hisses. In making such a curve I usually hand feed the lamp because it is so much easier to maintain conditions constant, 450 watts in the arc, 9½ amperes and 47 volts.

Q. What kind of carbons do you use?

A. I use the Columbia carbons.

Q. But an ordinary 9½ ampere light sometimes goes below the hissing point?

A. Yes, sir.

Q. Isn't that one reason why the enclosed lamp, 6.6 is superior?

A. I don't think it has much weight in that respect.

Q. Now, Professor, you have stated that these tests which you made upon these two lamps furnish a fair basis for all lamps of the city, did you not? Is that correct?

A. I don't remember whether I said that or not.

Q. If you did, is it true?

A. I think it is true. Because we took one of these 6.6 ampere lamps and tested it at various powers and adjustments. At each definite wattage we determined its candle-power, and then we plotted a curve with candle-power as ordinates and watts as abscissae. This curve comes out

practically a straight line, as Exhibit No. 29 shows. From this plot it is possible, thereafter, to determine the candle-power of any lamp of this type, operating under any wattage contained within the limits of these tests. I consider that method is thoroughly scientific and reliable.

Q. I will ask you to look at papers marked Exhibit No. 28 and Exhibit No. 29 and upon the latter we find the mean hemispherical candle-power is a straight line, but when we come to Exhibit No. 28, which shows the maximum candle-power, we find a droop in it; what is the explanation?

A. *A change in the shape of the distribution curve causes that. It is well known as you change the power expended in an arc, by changing the electrical quantities or shape of the distribution curve, the candle-power will change, change through very wide limits.*

Q. Take Exhibit No. 28; why does the curve droop down at the maximum?

A. *Well, I should want to take a little time to consider the theoretical reason for that.*

Q. Now, with reference to your tests upon these lights that they may be taken as a basis of the balance of the lights in the city, I will ask you if you know of any fairer way of getting at all the lights of the city at that time?

A. *I don't know of any fairer way of doing it within that time.*

Q. Is there any fairer practical way?

A. *Nothing more than to take more lamps in the way these were tested.*

Q. Wouldn't it be fairer to have taken all the lamps in the city and ascertained the condition of each?

A. *It would.*

Q. Isn't it also a fact, that it is a better way than the method you took, to ascertain from the wattmeter at the plant the entire number of watts consumed, and divide the number of hours and the lamps in service into the entire watt consumption, and thus accurately show the average terminal energy?

A. *That is a way to do it, yes, sir.*

Q. You think that would be a fair way to do it, do you not?

A. *It is a fair way. There would be some serious trouble in determining what such variable losses, as losses of the transformer, etc., would be; it would be a fair method, but not a very easy one I should say.*

Q. But, knowing the efficiency of the apparatus, isn't that, for practical purposes, a fair way for making measurements?

A. *Yes.*

Q. It's the average consumption that you use to determine the candle-power when you made this curve, isn't it?

A. *Oh, no; we determine the candle-power of the lamps separately with a given watt consumption.*

Q. But you take the watt consumption which you use as a basis, plotting the curve, using that as an arbiter, you apply it to other lamps?

A. *Yes, to determine their candle-power.*

Q. Different lamps upon the same

circuit may have a difference in the consumption of watts; there is quite a fluctuation?

A. Yes, sir.

Q. And the particular lamps you took for the purpose of your test may have been in a low condition by reason of adjustment?

A. Why, they evidently were; a 241-watt lamp is in bad condition.

Q. Is three per cent of the total number of lamps in a circuit a fair comparison?

A. In my judgment, it is, of a good type of lamp.

Q. But you didn't make an examination of the other lamps to find out whether their adjustment was up to the standard and were producing the results called for?

A. I examined, to see if they were all of the same type, however.

Q. What was the matter with this particular lamp you took to Purdue that produced only 241 watts? Was it a sticky dash pot or had the weight moved?

A. Well, I don't know, except it was giving about as much light as a 32 candle-power incandescent light; you could look at it without any discomfort at all. I called attention to that fact, "there is a lamp that is just barely going, that is all."

Q. Now, you took one lamp that was below the average and the other above?

A. Yes, sir, purposely so.

Q. Do you consider it fair to attribute to half the lamps in the city a 240-watt consumption?

A. That is not what we did.

Q. Did you keep the current constant with variable voltage in the laboratory tests?

A. We attempted to keep to the conditions of service, as nearly as possible, which would be a constant current.

Q. Well, did you make any inquiry of the Colorado Springs Electric Co. for information with reference as to the watt consumption as shown by the wattmeter?

A. No, sir.

Q. You didn't make any effort to go over the entire lights?

A. No, sir.

Q. Both of which methods you testified would be a fair basis for ascertaining the conditions of the lighting system?

A. Well, understand, I wouldn't have undertaken the method which you have brought out without bringing my own instrument to make station measurements.

Q. That is, you would want to put your wattmeter against the station's?

A. Yes, such a test would involve a month's time.

Q. Well, if it would take a month's time to make a fair test of a plant, how could you say an equally fair test is made by a couple of half days' work in your laboratory and a couple of half days' work out on the street?

A. Because that is a different way in which you do it; two things can be equally fair, and one can take a lot more time than the other.

Q. Can you explain how the curve, being mainly a straight line on

Exhibit No. 28, then makes a curve as it approaches the maximum?

A. Well, I have been thinking about that since your previous question on this matter. If you begin with a low wattage in the arc, as you increase the wattage you get a longer arc, and the light has some chance to get out; and so the mean hemispherical candle-power increases; but presently you reach a point where you get the carbons separated, and the instant at which the crater begins to cool a little and the arc changes between the carbon points, the light of the crater is absorbed, so you get a diminution in the maximum; after a while if you go on getting a still further length of the arc, you will presently reach a stage where the total light, the mean hemispherical, will fall off. There was at one time a 220-volt alternating arc, which gave very poor satisfaction to the public because the arc was so long, as somebody said, it was like a "blue streak in a bottle."

Q. Why doesn't this curve show in your mean hemispherical sheet, Exhibit No. 29?

A. I think you would find a little further continuation of this test would make that curve change also.

Q. Then, these are not consecutive curves?

A. They are only partially; they are segments; they are only through a very limited range of observation; they are consecutive as far as they go.

Q. How helpful is visual, casual observation of lights?

A. I don't lay any great amount of stress upon that, except where

the difference in the brightness of the source is considerable.

Q. How much difference would you be able to detect?

A. I don't know, because there are so many other various conditions, so many physiological facts wrapt up in it.

Q. Can you tell whether a 6.7 ampere arc, by looking at it as you pass down the street, is taking 6.7 amperes?

A. No, I don't think I can; you have to have them in juxtaposition. The eye has no memory, no retentive power.

Q. You don't mean by curve marked "A" on Exhibit No. 32, that if this light were in use on the streets of this city that this would be an average or constant curve?

A. No, sir, because the distribution curve shrinks on one side and grows on the other; that represents the average performance of a 9½ ampere lamp.

Q. Under ordinary operating conditions, with a 9½ ampere light, would this be the condition we find on both sides of that arc?

A. Yes, that represents the average candle-power on both sides.

Q. How much lower than this does it go?

A. I don't know; it is very hard to test a lamp under any particular condition of feeding, because obviously, it is suddenly changing through the inherent regulation of the lamp itself.

Q. You don't mean to give the broad idea that this curve represents what the average light would be do-

ing right straight along in picking up and feeding up?

A. Perhaps not, because the matter of feeding is eliminated from that curve.

Re-direct Examination by Mr. Robinson.

Q. In speaking a few moments ago of the method of examining lamps and testing their light-giving power by going to the station and measuring the current there, would you in that way take into consideration the variations that should be expected to be found in the lamps or in extra losses from grounds?

A. No, there would be variations due to these quantities which would not be accounted for.

Q. Wouldn't these losses be sufficient to make that method uncertain as to determining the light furnished by the lamp?

A. I think it might be. I am frank to say I never made any tests on that basis. There are variable losses, extremely variable with weather conditions.

Q. When you were measuring current at the station you could not tell what various losses were occurring along the line?

A. Correct; you would not know what to charge them to, whether to loss or to consumption in the circuit.

Q. Assume that there were some controversy between a company furnishing the light and the city that was paying for it, as to the quantity that was being received. If the company were informed in advance when tests were to be made, would it not be a very easy matter for it to increase the power?

A. It would.

Re-cross Examination by Mr. Schuyler.

Q. The wattmeter would tell the story?

A. The wattmeter would indicate the energy delivered, part of which would go into the lamps and part into other various losses, some of which are extremely variable.

Q. Which could be deducted from the wattmeter measurements?

A. It would be pretty hard to deduct some of the losses.

Q. Which ones, for example?

A. Leakage.

Q. Suppose you tested for leakage every so often?

A. That would tend to minimize the trouble.

Q. Bring it to a very low minimum, wouldn't it?

A. Yes, possibly so.

Witness excused.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT, AT 8 P. M.,
FEBRUARY 2, 1907, IN THE PHYSICS LECTURE

ROOM OF COLORADO COLLEGE.

Professor J. C. Shedd gave an illustrated lecture and was informally questioned by Mr. Robinson and cross-examined by Mr. Holland, in place of Mr. Schuyler, who was unavoidably absent.

Professor Shedd illustrated, by means of a lantern, the characteristics of the direct current arc, projecting upon a screen the image of the arc itself and clearly bringing out:

A—The positive carbon and its crater of high luminosity.

B—The negative carbon and its lower luminosity.

C—The increase and decrease of luminosity of the positive and negative carbons, respectively, when the current is reversed.

D—The shape of the positive and negative carbons.

Of particular interest was the application of Talbot's Law to the alternating arc, explained as follows:

It is, of course, apparent that the alternating arc is extinguished each time the current passes through the zero value, and such light as the lamp then emits must come from the heated carbon tips. It is also apparent that the current does not have a steady value during its period of flow in each half cycle, so that there must first be a rising temperature and then a falling temperature at the carbon tips. During a complete cycle this temperature wave would reach its maximum, for a given tip, when that tip is positive,

fall to the first minimum as the current passes through zero, rise to a low maximum with the reverse current, when the tip is negative, and fall to a second and lower minimum when the current again passes through zero.

It is probable that, for the small area of the crater, the highest maximum reaches the temperature of molten carbon, and that in the fluctuations of temperature lie explanation of the restricted area of the crater in the alternating current arc. The second maximum does not presumably reach much, if any, above the temperature of the incandescent lamp filament.

An added effect in prolonging the time of cooling results from the fact that the current upon falling to zero does not immediately begin to rise, but remains at zero until the E. M. F. reaches a value sufficient to make the current jump the air-gap. This effect must depress both of the minima to a point that they would not otherwise reach.

It is thus seen that the A. C. arc is extinguished for an appreciable fraction of each cycle and that the light received from it is of an intermittent character. Experiment also shows that the fall of temperature of the carbon tips is sufficient to cause the light from them to be intermittent also. This can be shown and measured in a very simple manner by taking a photograph of the arc in a moving camera. For this

purpose it is sufficient to rapidly move the camera up and down, or from side to side, pointing it the while at a street lamp fifty or more feet distant. In doing this it is best to select a lamp that has been newly trimmed and which has a clear inner globe, in order to get a sharp image of the arc. The trace obtained from an alternating current 6.6 ampere lamp on the streets of this city is shown in Exhibit No. 45. Of course, a direct current arc would give a continuous instead of a dotted line. On measuring this dotted line, on a photographic plate with a micrometer microscope of low power, the ratio of light to dark spaces is found to be about 70 to 30. Each light space is perceptibly intensified near the middle, the maximum point being nearer the front end. This would mean that the maximum temperature is reached a little in advance of the middle of the light period.

In applying Talbot's law, the ratio of 70 to 30 was taken. This assumes that the intensity of the light during the light period remains fixed at its maximum value, which would be approximately that of the direct current arc. This conclusion was reached by measuring the length of the light spaces and making a small allowance for the tapering ends. The value reached, if in error, is, I think, one favorable to the A. C. arc.

It now becomes possible to illustrate by means of the lantern the foregoing effect. To do this a disk was cut from pasteboard, as shown in Exhibit No. 42, having four teeth 27 degrees in width. The four thus cover 30 per cent. of the circumference. This disk, placed in the focal

plane of the lantern, shows, as in Exhibit No. 44. Part of the field is here seen to be illuminated by the full light of the lantern (using a D. C. arc) and part of the field is shadowed by the toothed wheel. If the lantern is properly focused and the disk is made to rotate rapidly, the effect shown in Exhibit No. 43 is obtained. The cutting down of the illumination by the presence of the teeth is strikingly shown.

The phenomenon here discussed is but one of the several that make the alternating current arc the less intense source of light than the direct current arc consuming the same energy, but it is apparent that this effect is responsible for a considerable part of the total.

For the sake of completeness, Talbot's law as given by Helmholtz may be quoted here. "If any part of the retina is excited with intermittent light recurring periodically and regularly in the same way, and if the period is sufficiently short, a continuous impression will result, which is the same as that which would result if the total light received during each period were uniformly distributed throughout the whole period."

The lights on the streets of this city may be said to give between 25 and 30 per cent. of the candle-power given by the old open arc lights. Whether this be estimated from the maximum candle-power of each lamp or allowance be made for the light thrown in all directions, the open arc lamp furnishes far more light than those now in use.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 9.30 A. M., FEBRUARY 4, 1907.

Mr. LOUIS B. MARKS, being first duly sworn on behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Mr. Marks, have you read section 9 of an Ordinance of this City of September 8th, 1898, referred to in this suit as the Jackson Franchise?

A. I have.

Q. I call your attention to that phrase, "Such arc lights of standard 2000 candle-power each," found in section 9 of the Ordinance of September 8th, 1898. In the absence of any agreement or understanding between the parties to said Ordinance at the time of its passage, what, in your opinion, is the meaning of that phrase?

A. It simply means the open type arc lamp such as was used at the time the Ordinance was passed, namely, the well known direct current, 9.6 to 10 ampere constant current open arc lamp consuming from 45 to 47 volts or thereabouts at the arc on an average, or practically 450 watts at the arc.

Q. Why would you say that, in the absence of any agreement or understanding to the contrary, that phrase meant the light from the lamp you described and operated as you have described?

A. Because that was the only lamp that was used at the time, generally speaking; the only open arc lamp in general use.

Q. If the phrase has that meaning, then how would you say that

that lamp should be operated, I mean as to its adjustment, etc., to give the light which is called for by that phrase?

A. A good carbon must be used and the lamp must be kept in good adjustment. I should say that a fair figure for the range of potential at the arc in open arc lamps of this type properly adjusted and maintained in good condition, would be from about say 45 or 46 to 50 or 52 volts at the arc. Occasionally a lamp will overfeed and drop below the lower limit of voltage I have stated. In that case the voltage drops below say 43 volts and you have what is known as a hissing arc.

Q. What I meant was whether or not, under that phrase and your definition of it and those conditions, the lamp described should be so adjusted as not to hiss or flame?

A. Yes, as nearly as possible.

Q. Please explain to the Board whether or not, and if so, how and why, the direct current open arc lamp gives more light than an alternating enclosed arc lamp such as in use on the streets here, when it is consuming practically the same number of watts at the arc?

A. I might preface my answer with the statement that watts at the arc are not a measure of light produced by any manner of means. The fact that one arc lamp consumes 450 watts does not mean that the lamp is capable of giving as much light as another lamp consuming the same power at the arc. I think that will

appear very clearly from the accepted candle power measurements of the open arc as commonly used in 1898 for example and as used to-day for that matter, and the enclosed 6.6 ampere constant current alternating series arc such as is used on the city's streets. The maximum candle-power of the so-called 2000 C. P. open arc I have found by numerous measurements to run up to about 1400 candle power or even more; but in some cases it is considerably less than that, say 1100 or 1200 candle-power when the arc is operated under good conditions. So that 1200 candle-power or thereabouts would be a safe figure, perhaps a low figure for the maximum candle-power of the open arc. Now the mean hemispherical candle-power of the open arc, that is to say, the candle-power below the horizontal plane passing through the arc, amounts to roughly from 600 to 700 candle-power. I believe Professor Matthews puts it at 700 or over, but quite a number of my own measurements show results as low as 600. The maximum candle-power of the 6.6 ampere A. C. series enclosed arc will probably not exceed about 400 is contrasted with 1200 of the standard open arc. The mean hemispherical candle-power of the enclosed arc of the type referred to will be approximately 300 as contrasted with 600 to 700 of the open arc lamp. Now, these measurements will give us some indication of the comparative candle-power value of the lamps, and if the distribution of candle-power of these two types of lamps is practically the same, then these measurements will give us a fairly good comparative value of the illuminating power of the two types of lamps for the purposes of street

lighting. From an examination of the curves of Professor Matthews I think it is very clear that the distribution of candle-power of the lamps used on the city's streets, namely, the 6.6 series A. C. enclosed arc lamp, is almost identical with that of the old open arc, commonly known as the 2000 candle-power lamp. This similarity of distribution is in some measure accounted for by the reflector that is used on the lamps in the city's streets, and by the character of the enclosing globes. So that when you come to size up the situation fairly and squarely, as I see it, you can't get away from the fact that the lamp on the street as now used is not giving you quite half the light that the old standard arc gave when it was properly operated, that is to say, the old open arc taking about 450 watts at the arc.

In making the comparison which I have just given it is only fair to state that in many cases, far too many, the old open arc, as commonly used on the streets, was not properly operated; in fact, if I were to make a selection to-day as between the old open arc as I have known it in many, many cases to be operated for street lighting and the enclosed lamp now used on the streets of this city, I should, unhesitatingly, select the enclosed lamp in preference to the old open arc. But, if the lighting company put its hand into its pocket, and kept its lamps right up to the mark, cleaned them regularly, adjusted them regularly when required, used only the best carbons that could be obtained for the purpose, and, in fact, spared no pains to operate the lamps under the best conditions, then

you would get the results upon which I based my original comparison.

Q You don't mean that extraordinary care should be taken, do you?

A No, I don't mean extraordinary care, but I do mean such care as would in many cases involve expenses which the lighting companies don't care to go to.

Q In that case the old lamp was more expensive to operate?

A That is it exactly. A more expensive instrument for the production of light.

Q Please give to the Board a comparison of operating the two types of lamps; by that I mean to keep them up in the proper condition. I am not asking for any extraordinary expense or care in either event, but such as should obtain in a properly operated plant of either kind?

A I think perhaps a good way to look at that would be to take the saving that has accrued to the lighting companies by the substitution of the enclosed arc for the open arc. A fair figure for the saving in the cost of carbons and trimming alone, to say nothing of the saving in cost of maintaining the lamps so far as the mechanism of the lamp goes, would be possibly from \$10.00 to \$15.00 per lamp per year; that is to say, in a system having 1000 arc lamps of the old type, a saving of from \$10,000 to \$15,000 a year in carbons and trimming alone could be effected by substituting the enclosed arc. That doesn't mean the company would be giving the same kind of light, however, as given by the old arc.

Q Would it then be that the enclosed arc alternating current, 6.6 ampere lamp, such as is used on the

streets here, could be operated for about one-third of the cost of the direct current open arc lamp?

A That is rather difficult to say. Of course the total cost of operating the arc lamp varies considerably with different conditions, but I would not care to say, nor could I give you that figure based upon the facts as taken from the lighting company's books.

Q No, I suppose one light company might stand more in that way than another, but what I am trying to get at is the proportionate cost of operating the enclosed A. C. lamp with that of the D. C. open lamp?

A In that case, I should say your figure was very low; the saving wouldn't be as much as that. Let us take a case of a city charging \$100 per lamp per year. Now, in that case, I certainly would not be prepared to say that the substitution of the enclosed arc for the open arc would save the company one-third of the operating expense.

Q I don't mean operating expenses, Mr. Marks; that, I take it, may include their office expenses and coal bills; I am speaking of the operation of the lamp itself, such expenses as you referred to a few minutes ago, trimming, carbon, maintenance of the lamp and the proper reasonable standard for light giving properties. Will there be a very substantial saving brought about? The alternating current enclosed lamp is a cheaper lamp to install, is it not?

A If you take into consideration the character of the city in which the lights are to be used, it may easily be in some cases that the series alternating constant current enclosed arc would be about the only lamp that a lighting company would consider as

practical to install, because of the expenses involved in the installation of other systems.

Q. Mr. Marks, I will ask you to explain the giving of light, the creation of light, the source of light and the light in the open arc direct current lamp?

A. *By passing a current of 9 or 10 ampere through a direct current series arc lamp you produce an arc which will give you practically the candle power that I have already named. Most of the candle power produced by the arc comes from the upper or positive carbon in which a more or less pronounced crater is formed by the normal operation of the lamp. The negative carbon assumes a rather pointed formation. The light produced is quite white in color, which is an important feature to be considered in comparing arc lamps of different types.*

Q. About what per cent of the light comes from the carbon tips themselves?

A. *A very small percentage comes from the tips; perhaps an eighth of an inch above the end of the positive carbon and below the end of the negative, the tips are heated white hot and do give considerable light*

Q. Could you say what percentage of the light comes from the arc itself?

A. *Oh, very small indeed, probably not over five per cent.*

Q. Then, is it not true that by far the larger part of the light comes

from the crater of the positive carbon?

A. *Yes, that is true.*

Q. And in the use of a lamp the positive carbon is the upper?

A. *Yes, that is the common practice in street arc lighting.*

Q. So, that the light coming from the carbon would naturally come rather below or on the lower hemispherical plane?

A. *Yes, that is an inherent feature of the direct current open arc; the crater acts as a reflector and throws the light down and out, which is a condition that you want for street lighting purposes particularly.*

Q. I will hand you a carbon marked "City's Exhibit No. 33," and one marked "City's Exhibit No. 34," and ask if those are samples of the negative and positive carbons of a direct current open arc lamp?

A. *Well, they have the same form of carbon ends as one would find in the open arc lamp.*

Q. Which of them would you say, I am speaking for the benefit of the record on that, is the positive carbon?

A. *I should say that the shorter one is the positive, the one No. 33, with a slight crater in it; the other, or longer one, is the negative carbon.*

Q. Please explain to the Board the distinguishing feature of the alternating current enclosed arc lamp; whether or not the carbons are heated in the same way as in the direct current open arc lamp?

A. *The carbons in the alternating*

current enclosed arc lamp do not show the same formation of points as those operating in the direct current open arc lamp, nor do they show the same character of the heating of the tips. In the A. C. enclosed arc lamp both of the carbon points become very highly heated, the upper one more so than the lower. In the very nature of things, the alternating current arc has entirely different characteristics from that of the direct current arc, whether of the open or of the enclosed type. While the light of the direct current open arc is distributed, for the most part, in one lobe below the horizontal plane passing through the arc, the light of the alternating current arc is distributed in two lobes, one half approximately going below the horizontal plane passing through the arc, and the other half going above this plane; that is to say, considering the alternating current enclosed arc lamp without the shade or reflector above the arc, the light from such a lamp would be about equally distributed up and down; one half of it would be used to illuminate the streets and the other half to illuminate the house tops. In ordinary operation the alternating current arc lamp is provided with a reflector to utilize these very rays that would otherwise be thrown up in the air and in some cases absolutely lost.

Q. Do I understand that the upper carbon in the alternating current enclosed arc lamp becomes very highly heated, reaches a greater temperature than the lower?

A. Somewhat hotter, yes; that is due to the natural tendency of the heat to rise, heating the upper carbon rather than the lower.

Q. That would probably be the only difference, the heat going up heating the upper carbon?

A. That is all.

Q. But as to the current?

A. So far as the action of the current is concerned, if the carbons were placed horizontally they would both be absolutely evenly heated.

Q. Is any crater formed on either of the carbon points in the alternating current enclosed lamp?

A. Only a very slight crater, in most cases imperceptible, particularly if solid carbons are used. The usual course in alternating current lamps is to use one solid and one cored carbon for the purpose of steadying the arc. In the cored carbon there is often a perceptible crater; the cored carbon may be either the upper or the lower.

Q. Do either of the carbons in the alternating enclosed arc lamp reach anywhere near the same temperature that the positive carbon of the direct open arc lamp reaches?

A. Probably not; I am not prepared to say as to the absolute temperature of the carbon tip, but am inclined to think that the temperature of the carbon tips of the direct current lamp would be naturally higher than that of the carbons of the alternating current arc, for the very reason that the direct current arc has an advantage of a continuous heat, whereas, in the alternating current arc there is heating and cooling going on continuously; the temperature of the carbon of the alternating arc would, therefore, naturally be somewhat lower.

Q. Now, I want to get a little closer to the cause of light, and put,

perhaps, a direct question. Is it not due to the high temperature reached by the carbon?

A. That is it exactly.

Q. So, that the higher the temperature in the carbon the greater might be expected the light produced?

A. Correct.

Q. Now, I think you have really answered this, but go now to the carbons and alternating currents. The current goes back and forth, alternates, as the word indicates; first one carbon is positive, the other negative, that is, the negative was formerly the positive?

A. That is correct.

Q. Is it not, therefore, a fact that there is an instant of time when there is no current passing through either carbon?

A. Yes, with 60 cycles this occurs 120 times a second.

Q. Is the point that you are now describing illustrated by a slide which was thrown upon a screen by Professor Shedd on last Saturday night, which is designated as the dot and dash illustration?

A. Yes.

Q. Then, if he could have taken photographs in practically the same way of the light from the direct current open arc lamp, it would have been one continuous light of white instead of a broken light as shown by the light from the alternating current?

A. Yes.

Q. Referring to some matters brought out in cross-examination of Professor Shedd as to the decrease

of the use of the direct current open arc lamp, what, in your opinion, was the cause of the decrease of the use of that lamp?

A. Too expensive to operate properly.

Q. Can you state where lamps of that character are being used at the present time, that is, in what cases and to what extent?

A. Well, they are being used to a considerable extent in the United States, and almost universally abroad. The enclosed arc has hardly gotten a foothold on the other side of the water. Now, I don't want you to infer from that that the open arc as used on the other side of the water is precisely the same kind of a lamp as the open arc lamp commonly called 2000 candle power that is used in this country.

Q. Could you give an estimate of the candle power of the open arc direct current lamps that are in common use in Europe?

A. Why, I should say that a good 10 ampere open arc lamp of the Bar-don type, which is a type that is very commonly used in Europe, would give about the candle power that I ascribed to the old 9½ to 10 ampere open arc lamp, assuming, of course, that the lamps to be in good condition and supplied with good carbons. In other words, there is no more reason why they should get a different candle-power with a 10 ampere lamp on the other side of the water than they should over here. The chief difference is in the mechanism of the lamp and in the care with which the mechanism is maintained.

Q. I wish you would state, Mr. Marks, in order to make it clear to

all persons, whether or not there is an enclosed arc lamp of a direct current as well as alternating current?

A. Yes, there is.

Q. State if you can why the enclosed arc lamp has not made greater progress in Europe?

A. In answering that question we must consider the conditions that obtain in Europe and in this country with reference to perhaps three points. First, the cost of labor on the other side of the water and in the United States; second, the cost of carbons; and third, the custom of the foreigner in so maintaining his lamps as to get the best results out of them. Now, as to the first point, the cost of labor; from investigations that I have made on both sides of the water I find that whereas in this country, particularly in the cities, a trimmer will get on the average about \$2.00 a day; on the other side of the water, on the continent of Europe, in places I have investigated, the average wage paid to a trimmer is about fifty cents a day or the equivalent, or about one-fourth of the expense of trimming on this side of the water. Now, take the question of carbons, the second point; the average central station pays for cored arc carbons about \$25.00 a thousand; small stations pay \$27.50 a thousand; some of the Edison Companies pay a few dollars less than the average figure that I have named. On the other side of the water the cost of carbons is less than one-third of this amount.

Now, taking these two points alone, the difference in the cost of carbons and in the cost of labor, it is very clear that the reasons that obtain for substituting the enclosed arc for the open in this country do not and did

not obtain abroad; in other words, the labor saving feature of the enclosed arc accounts to a very large extent for its remarkable introduction into the United States, and for the fact that it has largely displaced the old open arc type of lamp.

Q. About how often is it necessary to trim the enclosed arc alternating current lamp?

A. The carbons will burn 75 to 100 hours. Call it 100 hours as a fair figure for the lamps which run all night. As I understand it, the lamps in Colorado Springs are run on the so-called 4000 hour schedule. They probably trim them once a week to be on the safe side and allow some margin.

Q. About how often would it be necessary to trim direct current open arc lamps?

A. The double carbon open arc lamp, containing two pairs of carbons, one pair of which is automatically put into operation in the lamp when the other pair has burned away, gives approximately 13 or 14 hours life. That is to say, burning two pairs of carbons of about the same diameter as the carbons used in the enclosed arc you would get only 14 hours of life in the open arc as compared with 100 hours with one pair of carbons in the enclosed arc lamp.

Q. Then it would be true, as I understand it, that the carbon is consumed, if we may use the word consumed, much more rapidly in the open arc direct current lamp than in the alternating enclosed lamp?

A. Yes, the ratio of consumption would be about one to fifteen possibly; that is to say, an open arc lamp would consume fifteen times as much carbon as an enclosed arc lamp.

Q. And would that be caused by the higher temperature in an arc of the open arc lamp?

A. *In a measure, yes, but the chief cause is that the open arc is exposed to the oxygen or air in producing the light, which eats away the carbon very quickly.*

Q. Now, please explain the source of light that comes from the enclosed arc lamp alternating current along the same line that you have explained the source of light from the other lamp?

A. *In the alternating current enclosed arc lamp the light issues from the carbon points just as in the case of the open arc lamp, with this difference, however, that both of the carbon points in the enclosed arc lamp are highly heated and emit about the same amount of light, whereas in the direct current open arc lamp the bulk of the light comes from only one carbon, namely, the upper or positive carbon.*

Q. But, in the alternating enclosed lamp, do either of the carbon points become as highly heated or reach as high a temperature as the positive carbon in the open arc direct current lamp?

A. *They do not. There is one point to which I did not call attention, and which may perhaps not bear upon the present question, and that is that while in the direct current open arc lamps we have an intense white light, in the alternating current enclosed arc we have a decidedly violet light, which fact in itself accounts for a decrease in the luminous efficiency of the alternating current arc below that of the direct.*

Q. Can you state what proportion-

ate part of the light in the alternating enclosed lamp comes from the arc and what from the carbon points?

A. *A very small percentage, indeed, from the arc, but still a much larger percentage from the arc than in the case of the open arc lamp.*

Q. Referring to the use and to the styles of lamps and maintainance in Europe, is it not true that you found that one great difficulty in introducing the enclosed arc lamp was that it didn't give sufficient power to satisfy the users over there?

A. *Decidedly; on the other side of the water they poke fun at us and tell us that we have no idea of what good light by arc lamps is.*

Q. Now, in speaking of the cost of operating the two systems, is it not true that a very proportionate decrease in the cost would be had over there by using the enclosed alternating system we have here?

A. *Well, I would have to figure that out.*

Q. That is, wouldn't it simply be necessary for them to trim their lamps fewer times just as it is here?

A. *Yes, but you see the saving that they would effect in that way wouldn't begin to balance the increased illumination for the same money that they could get with an open arc.*

Cross examination by Mr. Schuyler.

Q. Mr. Marks, I understand you to say, then, that the term standard 2000 candle-power as used in September, 1898, in no sense referred to the actual candle-power?

A. *Yes, that is true.*

Q. So that how much else we may differ as to its actual meaning as applied to this case, it was then a general commercial or trade term used to designate a kind of light?

A. No, used to designate a very specific kind of light.

Q. But, a trade term to designate light, then?

A. A light.

Q. What I was trying to get at was, it was a trade term not to be taken in its literal significance?

A. Oh, no, not at all.

Q. Now, at the meeting of the National Electric Association, what was the light under consideration in making that ruling which I read to Professor Matthews yesterday?

A. You mean back in 1894, don't you?

Q. Yes?

A. Of course that was before we had any enclosed arc lamps, understand.

Q. That is, I understand that is your position?

A. No, that is the fact.

Q. I understand you to say you conceived one in 1893?

A. I happen to know when they were put on the market; there was no enclosed arc on the market when that resolution was adopted.

Q. What was the particular one under consideration?

A. The open arc lamp, now known and then known as the 2000 candle-power lamp.

Q. Well, the direct current lamp?

A. Yes, that is correct.

Q. Was any other kind discussed or considered in making that resolution?

A. Why, I don't know that there was any other kind considered; of course there were other lamps at that time.

Q. I meant that. Is your testimony that this ruling that was made refers to the direct current open arc lamp?

A. Yes.

Q. Were you at that meeting?

A. I think I was; I believe I read a paper at that meeting.

Q. Tell me, isn't it a fact that at that meeting it was decided and discussed and determined that what you were selling or what was being contracted for was not light in the sense of candle-power, because that was too indefinite but was simply the sale of power, that you were selling so much power?

A. That is just exactly what the light companies were trying to bring up.

Q. Isn't it a fact that was discussed at the meeting and talked about?

A. That is just the point; so much trouble arose on account of the dissatisfaction of the public with the light given by arc lamps that for their own protection the lighting companies passed a resolution stating that hereafter the light which is supposed to give 2000 candle-power, namely, the 9½ to 10 ampere direct series open arc shall be known as the 450 watt lamp.

Q. That was referring, you say, simply to the direct current open arc lamp?

A. I do.

Q. Well, the subject was determined, that thereafter in making contracts it should be recognized as the intention of the companies all over the United States that energy or power of a certain extent was being sold and not candle power, that is, so many watts; that was discussed and determined, was it not?

A. As I just stated, for their own protection the companies agreed that, wherever possible, they would enter into contracts that called for a given expenditure or power at the arc, or as you put it, watts at the arc.

*Q. Now, I am going to call your attention to the proceedings of that meeting and ask you if, in view of what I read, you are not mistaken in the position you have just taken? "Report of Special Committee on rating of arc lamps." Taken from the 17th Convention of the National Electric Light Association, Washington, D. C., February 18, 1894. Professor Anthony arose and spoke as follows: "Mr. President and gentlemen: The committee that was appointed * * * In regard to the alternating current arc lamps, Mr. Hammer, one of the members of the committee, had some data, which would seem to indicate that the Westinghouse Company had adjusted these lamps to use five hundred watts but still called them two thousand candle-power arc lamps. I suppose that would also be included under this resolution; that is, if you furnished an alternating current arc lamp with four hundred and fifty watts, it would be a two thousand candle-power arc lamp within the meaning of this resolution; and if you wish to furnish five hundred*

watts for the same thing, the customer cannot find any fault."

So, that the alternating current arc lamp as well as the direct current open arc lamp was under consideration at that meeting, and discussed, and supposed to be included in that definition, was it not?

A. I didn't so understand it.

Q. Well, in the face of the record, would you say that your individual recollection is better, or are these proceedings supposed to be the official record?

A. The proceedings you have read are, undoubtedly, the official record, but I think I am correct in saying,—I believe that the concensus of opinion of the central station men who attended that meeting would bear me out in saying—that what they had under consideration at that time, and the only thing they were talking about was the full arc, direct current, and these other things were extraneous matters.

Q. Well, you recognize the book which I read as the official record?

A. I recognize the book, but believe at that meeting I had a talk with Professor Anthony himself, and the gist of the whole thing was they were trying to get at a resolution for the old open arc.

Q. The Professor is the same gentleman who is speaking here when he says this resolution covers the alternating arc lamp?

A. Same man.

Q. Mr. Brophy said, and I will ask you if that wasn't the general consensus of opinion of that convention: "It is unfortunate that

the term two thousand candle-power was ever applied to an arc lamp. It has been in the past, and probably will be in the future, a source of trouble to all. You are furnishing power, and you should sell it as power." Is that true?

A. Absolutely true. That was the position that I took.

Q. You concur in that?

A. I do.

Q. I will ask you if from that time on in the United States when contracts of this character were made, whatever the trade designation of it, the thing that entered into them was that it was power that was being sold; wasn't that the consideration that always entered into it, whatever you may have called the light, the only thing they were selling was so much power?

A. When you were selling an open arc lamp and called it a 450 watt lamp, you referred to this so-called two thousand candle power arc lamp, but you did sell it as a 450 watt lamp.

Q. As consuming at the lamp terminals, 450 watts, exclusive of this resistance?

A. Yes, 450 watts at the arc. I might make my position on that matter still clearer. Some six months after that resolution was passed, I was requested to read a paper before the National Electric Light Association in 1895 in order to hammer in a little harder the fact that what the electric light companies were to do, for their own best interests, was to call the lamp a 450 watt lamp, and get rid of the candle power designation, which was so difficult to meas-

ure up; and I did hammer it in. I recall that at that time it was a very serious question as to whether the electric light companies could bring about the designation, 450 watts; they asked me to use my best efforts to help along the cause, as I was circulating pretty rapidly among the municipalities at that time. But, remember this, we were not talking about enclosed arcs; that is an entirely different proposition.

Q. Exactly. Then, while the same number of watts may be delivered, your position is there is a difference in the lamps, isn't it?

A. An entirely different question.

Q. Now, I want to ask you if it isn't and hasn't become the very general practice since the introduction of the enclosed arc lamp, to apply that term, two thousand candle power to the enclosed lamp?

A. Oh, I think it is a pretty fair statement to say in many cases; I don't know what proportion. But I hardly think it is fair to say that it is generally recognized that a 450 watt lamp is a two thousand candle power lamp; if you look at it in that way, I think you are mistaken.

Q. But, now, coming to another phase of it; while I understand you take the position that one style of lamp will give more light, I want to ask you this question: Isn't it a fact that it is generally recognized that the enclosed alternating current gives a better light?

A. Not at all, not at all.

Q. What is the advantage on the point of quality of the light, aside from the amount?

A. I think the quality of the light of the open arc is far superior to that of the enclosed.

Q. Now, as to the question of distribution and steadiness?

A. A good type of enclosed arc lamp, properly operated is, in my opinion, a better lamp, a far better lamp than the old open arc lamp that is ordinarily operated; but, in direct answer to your question, I would say that you can with an enclosed arc lamp obtain considerably better distribution of candle power than that obtained from the old open arc lamp, and also under ordinary conditions of operation the light of the enclosed arc will be considerably more steady.

Q. And less shadow?

A. Yes, less shadow.

Q. Isn't that quite an advantage to the public?

A. That is quite a decided advantage to the public; but bear in mind, when speaking of the enclosed arc, I am not speaking of the lamps that arc used on the streets of this city.

Q. Did you ever make any measurements, make any tests of these lights upon these streets?

A. No, sir.

Q. But for general purposes, you do say that, properly maintained, from the point of distribution and steadiness, there are advantages in the enclosed arc lamp?

A. Some types of the enclosed arc lamp.

Q. How many watts should that lamp take?

A. Which lamp do you refer to?

Q. The one you speak of as some type?

A. I had in mind when I spoke, particularly, the direct current series enclosed arc lamp, consuming roughly, 500 watts at the arc. I have had occasion to note, with a great deal of gratification, the results obtained from that lamp in the city of Boston.

Q. Isn't that 500 a general term; doesn't what you said apply equally well to the open arc 450 watt lamp?

A. No.

Q. Taking the same amount of current as the open arc, that is, 450 watts?

A. No.

Q. Running from 430 to 480?

A. No.

Q. That is not the one you refer to?

A. No.

Q. To what extent can you make a comparison and with what accuracy can you make observation, that is, visual, from the street, of the watts delivered at lamp terminals, that is, by looking at the lamp?

A. Oh, not a very accurate comparison.

Q. Do you agree with Professor Matthews in saying the eye is not retentive, has no memory of light, so you could a week later make a comparison of lights?

A. Well, I think Professor Matthews was quite right; but I might say this, that at the time at which I was very actively engaged with the open arc that I could, by going into

a town and looking at the lamps, tell whether they were using,—whether they had the circuit run up to, well, ten amperes. I don't think I could have told the difference between eight and nine, for instance.

Q. Could you come within ten to twenty per cent. of the watts?

A. No.

Q. Could you come into this city in January, say, and look at the lights, then late in September following, come back and observe a difference of from ten to twenty per cent., or anything of that kind?

A. I couldn't, unless you were working about at the ragged edge; that is, if you were at the point of unstable equilibrium, below which the lamps would be so unsteady that you couldn't help noticing their difference; but if the lamps were run at 450 watts,—along in there,—I don't think I or anybody else could tell the difference in illumination between a light taking 450 and one taking 440 or 460 watts.

Q. Could you tell the difference between a 6.6 and 7½?

A. I am inclined to think I could.

Q. You are not positive?

A. No, I am not positive of that.

Q. You don't rely upon that?

A. I don't rely upon my eye; but there is quite a big difference between a 6.6 and 7½.

Q. In making an actual test of one lamp could you rely upon mere visual observations to compare it with lamps upon other circuits?

A. Well, that would depend. I think probably if on one circuit the

lamps were very low, I would be able to point out, visually, which lamps were consuming less watts.

Q. They would have to be quite low?

A. They would have to be quite low; just what percentage of difference between the two I can't say. If you were trying to operate your lamps with 350 to 375 watts, just enough we will say, to make them go, then, if you dropped down a few watts you would probably notice a difference in steadiness.

Q. Isn't it a fact in this country, generally that, a 6.6 D.C. enclosed lamp in series takes about 450 watts on the average?

A. Why, I know in a number of cities they have been trying to cut down the watts a good deal.

Q. Can't you answer the question whether that is not generally true in the United States, isn't that the standard lamp of that kind?

A. Not to my knowledge, no.

Q. What is it?

A. I don't know as there is any standard on that.

Q. What is it?

A. Absolutely no standard on the enclosed arc lamp, so far as I know. Take the series circuit, the wattage would naturally be more than 450 watts to give a good light according to my notion; you would require about 500 watts to give you a light that was fairly comparable with that of the old open arc.

Q. At about, what do you mean; that is a relative term; do you mean up to five hundred?

A. No, not necessarily.

Q. Any where from 450 to 500, isn't that a fact?

A. I don't think it is a fact that a 450 watt enclosed arc lamp will give you a satisfactory enough light to displace the old open arc lamp.

Q. Hasn't it been generally conceded, not by compilation of electric companies, but from the voluntary acceptance of cities and citizens, the enclosed alternating arc is superior to the old?

A. No, I have never known of a case where it has been claimed that the 6.6 ampere enclosed arc lamp, as now used on the City's streets, is equivalent to the old 10 ampere open arc.

Q. That is what I asked you, where generally accepted by the public?

A. No, I am not talking about the public accepting a thing; the fact of their acceptance doesn't mean much to me, so far as the value of the light is concerned.

Q. You mean from an expert standpoint?

A. From an expert standpoint, or for that matter, from the company's standpoint. I don't think the manufacturing company that is selling the lamp, claims the 6.6 enclosed arc lamp, as now used, is equivalent to the old arc.

Q. How about a 7½?

A. A different proposition.

Q. Is that all right?

A. Taking the old open arc as it was run in a great many places I think it was a very fair substitute.

Q. You think it is a very fair substitute?

A. I was taking the old open arc as run in a great many places; I think it is a very fair substitute; in fact I will go further and say the present lamp in the street gives better results than many of the old open arcs as they were run.

Q. Isn't it a fact on account of an inherent defect in those direct current open arc lamps, American type, rod-fed lamps, it would have been quite impossible to keep them up to constant candle power?

A. No, I don't think it is a fact.

Q. What is the fact in that connection?

A. The fact is this. Let me preface my statement by calling the attention of the Board to the fact that there were two general types of open arc lamps used,—those known as the clutchfeed, and those known as the rackfeed lamps. In clutchfeed lamps the carbon carrying rod which engaged the clutch slipped through the clutch in the feeding of the lamp; whereas in the rackfeed lamps, the rod was provided with a rack; in other words the lamp was fed by clock work mechanism. Now, it was found in the operation of commercial circuits that with the clutchfeed lamps there was a tendency of the rod to stick in the clutch at times which would hold up the arc, that is to say, cause the carbons to flame, and at other times a slipping of the rod through the clutch which would cause the carbons to hiss and sputter.

It was extremely difficult, under ordinary conditions, without going to considerable expense, for the electric light companies to maintain these lamps in perfect working condition.

But I have run such circuits with clutchfeed lamps for a considerable period of time, and cared for the lamps as they should have been cared for to obtain fairly uniform results, without flaming on one hand or sputtering on the other, which were quite common in open arc lamps on commercial circuits, as ordinarily operated.

Now, referring to the other type of open arc lamps, namely, the rack feed type, while the same objections which I have named apply to this type of lamp as it was commonly used on commercial circuits, the lamp was capable of very steady and uniform operation. For a period of almost three years I, personally, operated a circuit of these rack feed lamps, and with some exceptions the regulation of the lamps was quite as good, if not better than that which we obtain to-day from enclosed arc lamps as commonly used.

Q. Now, I want to ask you if you could come to the City and distinguish between a 6.6 alternating current enclosed lamp burning 480 watts and a 7½ ampere burning 480 watts, by observation?

A. I don't think I could.

Q. I want to ask you if in this old type of 9.6 direct current open arc lamp, dust and rain didn't interfere with the maintenance of that lamp in a satisfactory form?

A. Yes, that was one of the objections to the old style of lamp. In many of the cities throughout the country they don't even take the trouble to put a casing on the outer globe, simply leave the globe open, permitting the rain and wind to af-

fect the arc; but with a suitable casing closing the globe, the deleterious effects of dust and wind would be minimized.

Q. Do I understand you to say as a general conclusion that the clutch feed lamp was inferior to the rack feed about which you spoke, more difficult to maintain?

A. I don't want to put it in just that way, because the old clutch feed type lamp, and for that matter the present clutch feed type of lamp has many advantages over the rack feed, in this that the clutch feed is a cheaper lamp and generally speaking it is a safer lamp to use; it doesn't get out of order as easily as the old rack lamp; that was the trouble with the old rack lamp, so the companies would not stand for it. But with care and attention and replacement of the parts that become worn, the companies could have operated them for quite a while.

Q. I asked what the general discarding of these lamps was due to?

A. The very faulty operation by the companies.

Q. As an electrical engineer, would you advise the City of Colorado Springs to go back to the 9.6 direct current open arc lamp?

A. I don't know just what position I would take in the matter. Probably if the City of Colorado Springs wanted to install a new system of electric lighting, I should be at their disposal at a certain amount per diem to advise on the question.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 2 P. M., FEBRUARY 4, 1907.

Mr. MARKS recalled to the stand.

**Cross - examination Continued
by Mr. Schuyler.**

Q. Mr. Marks, I want you to tell me if it isn't true that from the standpoint of the illuminating profession, its object is to secure a light giving the best distribution, the greatest steadiness, devoid of glare, that is as soft a light as possible and free from shadows, for street light purposes?

A. Yes, that is true, but of course we must always consider the question of economy in taking up matters of that kind.

Q. You said that in the enclosed arc lamp a greater amount of light came from the arc than in the other type we have been considering?

A. Yes, I said that.

Q. Isn't there a greater tendency in the enclosed arc lamp than in the open lamp to raise the maximum of light to the horizontal?

A. Yes, particularly if the arc is at the edge of the carbons.

Q. Isn't that true in any case?

A. It is true in a measure, but the main increase from such a cause would come about when the arc was at the edge of the carbons.

Q. Would it be a fair way for a lighting company, such as we have here under consideration, in order to determine what the lamp wattage may be, to take the total watt consumption at the plant, eliminate transformer loss, taking into con-

sideration the grounds and things of that character, and then to divide the number of lamp hours into the total number of watts consumed?

A. If they keep close track of those factors, and really know what they amount to, they certainly would get a very fair idea of the average watts per lamp, but that, of course, would not give them any idea of the watts in each lamp.

Q. That is, one lamp may fall to a low standard, we will say, and still other lamps upon that circuit be up to the standard?

A. Yes, that is true.

Q. Then that being true, would you consider it to be in any wise a fair test of what 241 lamps on six circuits in a city are doing to take one or two lamps on a certain day, ascertain their wattage, and thereafter removing those lamps, derive a curve outlining what those two lamps were doing, and then attempt to apply that as a general condition of the lamps all over the city?

A. Well, if they happened to select one of those two lamps from one circuit, and the other from another circuit, I think it would be quite fair to assume—in fact you couldn't assume otherwise—that all of the lamps on those two circuits were taking the same current as those lamps.

Q. How about the subject of volts?

A. With regard to the question of adjustment of lamps it goes with-

out saying that a man cannot definitely fix the voltage of one lamp from a measurement that he made of another lamp that he took from the circuit; but generally speaking, a man walking over the circuits of the town, and giving them a fair investigation, sizing up the circuits as it were, picking out for test a couple of lamps at random as representative of the conditions that obtained in the town, I think would probably give a pretty fair idea of the average conditions that existed at the time.

Q. Such a test wouldn't give the wattage extending over a period of a year and a half?

A. Decidedly not.

Q. And you wouldn't get the wattage on the particular circuit?

A. No, not on the entire circuit; but for the purpose of candle power measurements, the purpose for which these tests were made,—I understand you are referring to the tests about which testimony has already been adduced—I think the curves produced show a very fair average of what they found at that time.

Q. Upon those two circuits?

A. Well, wherever they were working.

Q. But I mean it would be limited to the circuit from which the lamp came?

A. Oh, yes.

Q. Isn't it a fact that the character of labor that it is possible to obtain in this country as compared with what it is possible to get in Europe, would have a good deal to do with the practicability of maintaining here that old system of 9.6 open arc lamps?

A. If you are willing to pay a man enough money, I don't doubt but you would get good skilled lamp trimmers; it is simply a question of expense.

Q. I will ask you if it isn't a fact that it would cost from \$40.00 to \$50.00 per annum for carbons alone to maintain European lamps in this country?

A. Well, it certainly wouldn't fall much below \$40.00.

Q. Might rise to \$50.00?

A. Possibly, assuming you paid for imported carbons; but if they ever got to such a point, I am inclined to think that our American manufacturers would get a move on and make satisfactory carbons over here for less money.

Q. And under present conditions it isn't recognized as practicable to maintain lamps at any such expense, in this country?

A. Well, I don't mean to imply that you would have to use the best foreign carbons to run series arc lamps.

Q. No, I didn't mean to imply that either.

A. If you ask me whether we could run series arc lamps and get good results with American made carbons, I will tell you yes, splendid results, and we don't have to pay any such price for them.

Q. Can you cite any instance where it is at present contemplated to install the open arc lamps?

A. No.

Re-direct Examination by Judge Robinson,

Q. One of the reasons for installing the 6.6 ampere lamp is due to the fact that it can be installed cheaper than the other, isn't it?

A. Yes.

Q. Speaking of the failure to keep in adjustment the 9.6 ampere lamp, direct current, something was said about the inherent faults of the mechanism of it; what can you say of the same lamp of the A. C. enclosed?

A. Oh, it has a few inherent faults.

Q. Does it cause it to get out of adjustment?

A. Very often; it has got to be carefully watched to keep it up to the mark; very carefully watched.

Q. Is it not a simple fact that in either kind reasonable care must be used to keep them up to the standard which they were intended to maintain?

A. Yes, that is so.

Q. I want to ask you about this famous National Electric Light Association; isn't it still endeavoring to find definitions for 2000 candle power lamps?

A. Yes, they are still at it.

Q. They are still considering the question of a proper rating and standardizing of arc lamps, are they not?

A. They are; they took up that question at their last meeting.

Q. Mr. Marks, is there any way whereby the candle power of the lamps out on a street circuit can be measured at the station, with reasonable fairness?

A. No, there is no way of getting the actual measurement of candle power of a lamp except by measuring the candle power at the lamp.

Re-Cross Examination by Mr. Schuyler.

Q. Isn't it a fact that the heavy cost to the lighting companies, of maintaining the open arc, direct current lamps, has brought about their disuse, because the cities themselves have not been able to afford, and cannot afford payment for them, at reasonable prices?

A. No, I certainly don't know that to be true, and I don't believe it is true.

Q. When the old style direct current, open arc lamp was in use, the prices prevailing for street lighting were very much higher, were they not?

A. Yes.

Q. Very often, and generally, as high as \$150 per light per annum?

A. I think I have known of cases as high as that.

Q. Isn't it a fact that at the time when that lamp was in the height of its glory in this country, that is, in most use, that the standard price for it was about \$18 a month, \$216 per year?

A. I don't know; in some places the price was a great deal lower than that.

Q. Don't you think that the present 6.6 ampere light tends very strongly in the line of giving better distribution, greater steadiness and softer light, devoid of glare and shadows?

A. Well, as I said before, if you

take an open arc lamp of good type, provide it with suitable carbons, and operate it under good conditions, and place it properly with reference to the lighting of the streets, I think that so far as the candle power delivered is concerned, you will beat the 6.6 ampere lamp out every time, completely; I think a fair proportion for the relative candle power delivered would be about two or two and a half to one in favor of the open arc. I don't mean by that, for one moment, however, that the old open arc as commonly used, was better for street lighting purposes than the present enclosed arc, even of the type used here on the streets which I consider one of the poorest types of enclosed arcs.

Q. You were kind enough this morning to say that you felt that this system here, 6.6, was kept up well.

A. I didn't say it was kept up well. I told you about my impression when I looked over the lamps here the other night. I judge from the reports that it has not been kept up very well. From my observations here these last few evenings I consider it is first-rate for a 6.6 ampere system.

Q. Did you pay any attention to this slight zephyr that swept through the city here last Friday?

A. Yes; that was very hard on arc lamps.

Q. And that would be pretty hard on open arc lamps?

A. It would be harder on them, yes.

Q. Don't you consider that \$66 is a very low rate for street arc

lighting, all night, with no moon-light service?

A. Regardless of any question of cost of labor, or what part of the country, and so on, I think it is low for an average rate.

Re-Re-Direct Examination by Mr. Robinson.

Q. Now, Mr. Marks, if you would base the rate of \$5.50 per month per light upon the fact that it is a part of the contract between the City and the Company, under which the Company used the City's water system to generate its currents, and that part of the current which was used in the street lighting, and for which \$5.50 per month was paid, was less than one-tenth of the entire current generated, would you then think \$5.50 a low rate?

A. Under those circumstances it might be a very high rate.

Question by Arbitrator:

Q. In regard to the relative merits of alternating lamps and direct current lamps for illuminating the streets, in which illumination would you rather drive a horse or an automobile; that furnished by the open arc lamp with clear globe, as it was commonly installed, or the present system that is used here now?

A. Taking the open arc as it was used in a great many cases, the lamp hung low, near the ground, I would choose the enclosed arc with opalescent globe,—not, however, such as is used here—every time; but if you mounted the open arc at a proper height, to give you the fairly wide distribution that you desire, in which case the difference between the maximum and minimum illumination of the street would not be so great

then I should say that the advantage in favor of the enclosed arc would not be so great.

Q. Getting at it from the illuminated engineering standpoint entirely, unless the direct current lamp were furnished and fitted with a diffusing globe of some kind, the shadows would be much sharper, would they not?

A. No, not very much sharper, if you used a small carbon. Of course you know that there is no arc, or at least so far as I know there has been no arc that has been more abused than the old open arc lamp. It has been hung on circuits and allowed to run itself; furnished with carbons that were unfit for use in any decent electric lamp; unclean; and as a result of such practice the open arc has gotten a very bad name. There is undoubtedly an advantage in favor of the enclosed arc, used with opal globes, from the standpoint of intrinsic brilliancy of the light, which would count for something in street illumination under the conditions which you name. I don't want to go into any fine spun theories or bring in technicalities, but a good deal would depend upon the speed of the automobile you are talking about; if you come along in an automobile at a speed of a few miles an hour, why that is one thing; while if you spin along at a forty mile gait, that is another.

Q. I had reference to an ordinary kind of driving?

A. Well, as used along the country roads, the old open arc lamps hanging, as they often were, low, were certainly unsatisfactory from that point of view, and in such cases if they were replaced by an enclosed arc lamp, of the proper kind, using opaline globes, an advantage would be gained.

Q. In the alternating arc lamp doesn't the reflector, to a considerable extent remove the shadows that were objectionable in the open arc?

A. To some extent, yes; but after all, if you put a reflector over the old open arc, it would serve quite the same purpose. If you will examine Professor Matthews' curve of the open arc, in evidence here, (and my own experience verifies his results) you will find that with the lamp operated in this way, you would practically cut your shadows below the arc, if you used the reflector at the proper point. In the alternating current enclosed arc lamp, although you have a reflector you must remember that the arc itself is very often in the center of the carbon tips; the tips burn to square ends; that means that you are going to have a very marked shadow underneath the lamp. If you will look out in the streets of this city you will find that the shadow underneath the arc in this alternating current system, even with the reflector, is at times worse than that which you will find under direct current arc lamps, operated in the way that I have stated.

Witness excused.

Mr. ALTON D. ADAMS, being first duly sworn, in behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Mr. Adams, have you read Section 9, of an Ordinance of this city, passed on the 8th of September, 1898, and the one involved in this controversy?

A. I have.

Q. I will call your attention to the words "such arc lights of standard 2000 candle power each" as found in that Section 9, and ask you, in the absence of any agreement or understanding between the parties to said Ordinance at the time of its passage, what in your opinion is the light called for by those words?

A. My opinion is that the light called for by those words is the light given and delivered by an open arc lamp, operating with a direct current of 9.6 to 10 amperes, and 45 to 50 volts.

Q. That would be in your opinion the technical interpretation of the words, as defined and distinguished from the plain English?

A. Exactly; those words, 2000 candle power, had come to have a special meaning in the art at and before the time to which you call my attention, and that meaning was an open arc lamp, taking about the amperes and volts mentioned; that is, from 450 to 500 watts, and nothing else, in my opinion.

Q. What would you say would be the maximum candle power of the light which you have described?

A. The maximum candle power of one of the lamps that come under that general description, may be varied between very considerable limits,

by different sizes and qualities of carbon, and by different adjustments of the lamp itself; but replying as nearly as I can to your question, I will say that 1200 candle power is a fair, conservative estimate for the maximum light-giving quality of a lamp of that type; that is, the intensity of light emitted in the direction where it was the greatest.

Q. What in your opinion is the maximum candle power of the alternating current enclosed arc lamps, taking 6.6 amperes, such as are in use upon the streets of this city at this time?

A. Again, in the statement of a maximum candle power, it can only be stated provisionally; but I should say that 400 candle power was a fair medium figure for the maximum for a lamp of that type.

Q. Will you explain to the Board the sources of light in the direct current open arc lamp; whether it comes from the carbons, and if so, how?

A. The principal source of light from the open arc lamp is the heated ends of the carbons, and furthermore nearly all of that light, perhaps ninety per cent. of it, comes from the heated end of what is known as the positive carbon, which is usually, but not necessarily, the upper carbon, but it is necessarily the carbon from which the current flows, and the carbon into which the current flows being known as the negative carbon, usually the lower one; the arc itself has but little light-giving power in the ordinary open arc. The reason that the upper carbon gives the great body of light that the lamp affords is that the temperature of the carbon point is very materially higher at the end of the positive carbon where the crater

is formed than it is at the end of the negative carbon where the point is formed, opposite to the crater on the positive carbon. Of course the greater temperature to which you raise the carbon, the more light is emitted per square inch. You get so much light per unit of square surface, heated to a certain temperature; and the crater of a positive carbon is heated to a temperature so much greater than that of the negative carbon that it succeeds in throwing out most of the light of the lamp.

Q. Speaking of the 9.6 and 10 ampere direct current open arc lamps, tell the Board something about the use of that lamp to-day?

A. Well, the direct current open arc lamps, called the 1,200 candle-power and the 2,000 candle-power lamps, were of course for many years the only lamps in general use for street lighting. At the present day they have been displaced in a very large number of plants. It is perhaps correct to say that in the majority of plants they have been displaced with one form or other of the enclosed arc lamp. The Gas and Electric Light Commissioners of Massachusetts compile each year from sworn reports a large amount of statistics with reference to the electric light stations operating in the State of Massachusetts. Their figure for the number of enclosed arc lamps as reported by the companies in use in that State on June 30, 1899, was 4,300; that number includes the lamps used in so-called commercial lighting, and on the streets. The report of the same Board for June 30, 1900, gives the number of open arc lamps in use by the electric companies of Massachusetts as 11,367, and the number of enclosed arc lamps of all types,

both direct and alternating, was 11,988. The report of the Gas and Electric Light Commissioners of New York gives the number of open arc lamps for use on the streets in New York State in the year 1905 as 9,298, showing, as I understand the figures, that that lamp still occupies a very important position in numbers in the lighting field.

Q. Please state what in your opinion is the cause of the change from the open to the enclosed lamp?

A. The great cause of the change, in my opinion, is the fact that the enclosed arc lamp, and particularly the alternating current enclosed arc lamp, can be operated more cheaply than the open arc lamp. There is also a difference in the matter of the cost of the plant, but the greater difference comes in the constant cost of operation, which is very decidedly in favor of the enclosed alternating arc lamp. The companies have naturally wanted to cut down their expenses as much as they could, and they have selected, as I believe, with very little knowledge or demand on the part of the public for a different type of illumination, the alternating enclosed arc lamp, because it could be operated more cheaply. There is an abundance of quotations that might be made from the proceedings of the Electrical Association in which these reasons that I have just given, have been reiterated again and again by electrical men themselves as the moving causes for the substitution of the enclosed alternating arc lamp for the direct current open arc lamp.

Q. Can you furnish anything of that kind from the General Electric Company?

A. I could make a quotation of

that kind from Professor Elihu Thompson, the great electrical engineer and inventor of the General Electric Company. It is a statement in a paper published by the National Electric Light Association, as a part of the proceedings of its Chicago Convention in 1903, entitled "Notes on the Enclosed Arc." It reads; "The economy of light production in the enclosed arc lamp cannot be expected to approach that of the open arc, and for several reasons. For a given energy in the arc the current is smaller, and the arc flame longer, with higher voltage. This means that more of the energy goes into the flame, as compared with that which heats the carbon ends. The crater surface is therefore smaller, and as the arc flame itself is a poor source of light, as compared with a hot solid carbon surface, the increased arc length in the enclosed arc contributes but little to the illuminating power." "The lower efficiency in relation to the open arc (he is speaking now of the enclosed arc) is shown to be unavoidable, but must be taken as compensated for by the longer burning without retrimming, lessening the cost of carbons, as well as the labor and inconvenience."

Q. Do you know of any instance where the 6.6 ampere alternating enclosed arc lamp has been substituted for the old 9.6 ampere direct current open arc, in the same contract?

A. I know of no such instance.

Q. Do you know of any instance where the 6.6 ampere alternating current enclosed lamp has been substituted for what was termed the old half arc direct current, open arc?

A. I don't happen to recall any such instance.

Q. Did you ever know of a case where a party or company had a contract which required the light of the 9.6 ampere direct current, open arc, where he or it attempted to fulfill that contract by the light of the 6.6 ampere alternating current enclosed arc?

A. I never did.

Q. Do you know, or have you known of any arc lamps of actual 2,000 candle-power?

A. Well, I have tested direct current open arc lamps using 30 amperes. I did that back in the eighties, in the Brush factory, but candle-power measurements of arc lamps in those days were very scattering; I don't know what they measured, but I should think that possibly 30 ampere open arc lamps in good operative condition, with proper size carbons, and all that sort of thing, might have measured up, probably 2,000 mean spherical candle-power.

Q. So the maximum would be beyond that?

A. Oh, yes, the maximum would be far beyond that.

Q. Haven't you known of lamps of that kind being used for lighting streets?

A. Though not positive, my recollection is that in one or more of the early plants some of the 30-ampere open arc lamps were used in connection with towers—and by towers I mean very tall iron masts or poles, constructed as they usually were of boiler iron, that ran up to a height of a hundred feet or more.

Cross-examination by Mr. Schuyler.

Q. But this 2,000 candle-power lamp was not in any sense, or was not in any general sense, used for street lighting?

A. No, it never was in any general use.

Q. Was it known as a commercial 2,000 candle-power lamp?

A. Oh, no; the lamp that has always been known generally as a 2,000 candle-power lamp, is the lamp taking about 450 watts of direct current at the open arc, and no other.

Q. The measurement of what was being sold and contracted for in the way of lighting purposes, was power measured in watts, was it not?

A. No, sir; it was the light given by a lamp taking a certain power. of a certain kind of current.

Q. You said, as I understood you, that the light under consideration by the National Association when this matter was defined, was the direct current, open arc lamp?

A. It was so.

Q. Did they not also consider the alternating current lamp?

A. The alternating current lamp formed no part of that resolution. Because somebody probably got up and made some remarks about it, that doesn't put it into the resolution.

Q. If, Professor Anthony, in making the statement concerning this resolution, said that the alternating current arc lamp, which was adjusted to use 450 watts, was included in this resolution, that this is the best official record of the understanding had at that time, when the matter was under specific discussion in that convention; isn't that true?

A. As nearly as I can answer that question is to say that the remark of any one member of the committee, or any one attendant on that convention, could not pass or fix a resolution, or put anything into it.

Q. On page 283 of the Proceedings we find that discussion without contradiction; the President then put the question, on page 294, and it was adopted after he had made this statement, he being a member of the committee?

A. My recollection of the state of the art at that time, was that one company was tinkering away in its factory, trying to bring out an open arc lamp, operated with alternating current, and I am unable to bring myself to believe that the body of men in that convention who adopted that resolution, ninety-nine out of a hundred of which had probably never seen an alternating arc lamp, or tried to operate one, had any idea that when they passed that resolution that they were saying that an alternating arc lamp, using 450 watts, was the same thing as the old familiar time-worn lamp operated with 450 watts with direct current. I will say, moreover, that Professor Anthony, in this connection, referred to the Westinghouse Company having adjusted these lamps to 500 watts.

Q. But certainly there was nothing in this resolution that specifically referred to the direct current open arc lamp, was there?

A. That is true, but in giving you my understanding, and as an expert, I have to base that understanding on the conditions at the time, and understand those words with reference to the conditions under which they were used.

Q. But this volume is the official record of what took place, is it not?

A. I believe it to be so.

Q. And the whole theory of that convention was to eliminate the designation of lamps as 2,000 and 1,200 candle-power, and to get down to the proposition, as Mr. Brophy stated it, "that the sooner you sell your light as power, the sooner this trouble will end," meaning by "trouble" the difficulty arising from those terms of 2,000 and 1,200 candle-power?

A. I believe that the adopting of that resolution was to aid in bringing about a state of practice, as to arc light contracts, in which the contracting companies, the lighting companies, would agree to sell the light developed in a particular type of lamp, that is, in the open arc direct current lamp, by a certain amount of power. I don't think it is accurate to say that the resolution meant merely to bring about a condition where they would sell so much power, and call it light, because it is conceivable, and entirely possible to use

450 watts in a lamp and not get much of any light.

Q. Well, isn't it a fact that this 6.6 ampere light, enclosed arc, is coming into general use; that comparisons were made in many cities all over the country for actually placing lamps of one type as against the other lamps?

A. I think there was some of that done.

Q. And don't you remember, that at those times the cities very generally accepted the 6.6 ampere light as a preferable light to the old type?

A. No, sir, I do not.

Q. You cannot name an instance?

A. No.

Q. Do you remember the time of a general rate all over the country of \$150 per annum for arc lights?

A. There never was any such general rate all over the country.

Q. You say they didn't get \$150; tell us what they did get?

A. They got all sorts of prices.

Witness excused.

Mr. LOUIS B. MARKS, being recalled in behalf of the city, testified as follows, to wit:

Examination by Judge Robinson.

Q. Mr. Marks, there was some question asked you on cross-examination concerning the invention of the enclosed arc lamp; please state to the Board who invented that?

A. *I am the inventor.*

Q. And I think some statement was made that the lamp was being developed, or had been developed by the General Electric Company; is that true?

A. *Oh, certain forms of the arc lamp were improved, but all of the lamps which they put upon the market are put upon the market under the Marks patents.*

Q. And the lamp has been developed under the patent issued to you?

A. *They acquired the patent since the early work of development.*

Q. Yes, but it is the patent issued to you as the basis of it?

A. *Yes.*

Q. Does that apply to all enclosed arc lamps?

A. *It applies to all commercial enclosed arc lamps.*

Cross - examination by Mr. Schuyler.

Q. There were a great many people about this same time claiming a patent on the enclosed arc lamps, were there not?

A. *Why, there were some that I discovered later on that claimed anticipations, but the General Electric Company took about three years' time to look into those anticipations and found there was nothing in them, and purchased the basic patent for quite a considerable sum of money.*

Q. The patent that you had, was it on the mechanism of the lamp or was it on the enclosing globe?

A. *The patent covered the method of operation, which was necessary for the successful operation of all types of enclosed arc lamps.*

Q. But mechanically this lamp isn't like the one that you had a patent on.

A. *In effect it is; the general principle of the lamp is about the same.*

Witness excused.

DR. LOUIS BELL, being first duly sworn in behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Dr. Bell, have you read Section 9 of an Ordinance of this city, passed on the 8th of September, 1898, and which is involved in the controversy on hearing?

A. I believe I have, yes.

Q. I will call your attention to the phrase, "such arc lights of standard 2,000 candle-power each," found in Section 9 of the Ordinance. In the absence of any agreement or understanding between the parties to said Ordinance at the time of its passage, as to the meaning of that phrase, what in your opinion is the meaning of the words quoted?

A. In the absence of any understanding regarding any special meaning to be put upon that phrase, there was but one thing to which at that date its terms could possibly apply: that was the direct current open arc, taking about 9.6 amperes, at roughly 45 to 50 volts. That was the only form of arc lamp in general use at the time to which such phraseology could by any possibility be properly applied.

Q. And that you would say would be the technical interpretation of the words as distinguished from the plain English of them?

A. Yes.

Q. What would you say, is the maximum candle-power of the light from the lamp which you have described?

A. It was never, I think, up to its rating of 2,000 candle-power, which was a purely nominal value,

but in point of fact gave somewhere about 1,200 candle-power in the direction of the maximum intensity.

Q. What would you say was the mean hemispherical candle-power of a light of that kind?

A. Somewhere about 600; I use the term a little indefinitely, because the quantity itself is a most variable one.

Q. Are you acquainted with the 6.6 ampere alternating current enclosed lamp that is now in use in the streets of this city?

A. Oh, yes.

Q. What would you say was the maximum candle-power of that lamp?

A. That, like the maximum candle-power of the lamp just referred to, is a more or less variable quantity, but I should say in the vicinity of 400 candle-power.

Q. And what would you say is the mean hemispherical candle-power of that lamp?

A. Somewhere in the vicinity of 300; perhaps that would be a rather liberal estimate than otherwise.

Q. How does the 6.6 ampere alternating current enclosed lamp compare with the 9.6 open arc direct current lamp, as a light-giver?

A. As the figures just stated would indicate, it is considerably inferior to it.

Q. Dr. Bell, have you heard quoted during the hearing of this matter a certain resolution passed by the National Electric Light Association, in 1894?

A. Yes, several times.

Q. Have you any personal knowl-

edge of the agitation which led up to the passage of that resolution?

A. I have.

Q. Please tell this Board what that was?

A. Owing to the fact that the so-called 2,000 candle-power lamp gave, as I have indicated, considerably less light than its reputed rating, there were frequent difficulties between those supplying and those using such lights, regarding the question of candle-power. Contracts were drawn, generally, in terms of this so-called 2,000 candle-power arc, or its smaller brother, the half arc, so-called, rated at 1,200 candle-power. Difficulties of this sort became so numerous that there was a strong feeling on the part of electrical engineers, and on the part of the companies supplying the light, that a different basis of contract should be found; a basis which would be at least definite in the specification of what was to be delivered, and which would quite reach, once for all, the alleged 2,000 candle-power humbug.

Q. Was that 2,000 candle-power a humbug?

A. Yes, it was. I personally took an active part in this agitation, particularly as editor of the Electrical World. I took up the matter with many of the members of the National Electric Light Association and I think I was perhaps the first one to publicly advocate making a contract for arc lighting by rating the lamp on watts consumed instead of on an entirely fictitious value of the candle-power. The matter finally came to a head at this convention referred to, in the resolution which has been read, following up two or three years of good,

hard education of the profession and business, toward a sounder basis of contracts; and at that time the resolution finally took form. I need hardly say that at that time nobody had anything seriously in mind as a commercial arc except the open arc direct current arc lamp, to which preference has been made. There were in 1894 no alternating arc lamps in this country which had passed beyond the stage of dismal and rather hopeless experimentation. I knew them well, such as they were, from personal observation and experience. The only alternating arc system which by any stretch of courtesy could be considered at all even fairly in experimental use was one developed by the Westinghouse Company, which used two carbons, somewhat smaller in cross-section than the carbon brushes used on dynamos at the present time; the carbons were perhaps two or two and a half inches wide, between which the feeble, intermittent light of the open alternating arc glowed at times. These lights were run in an experimental way, and soon abandoned.

In 1894, then, there was but one lamp in the minds of the National Electric Light Association; there was but one kind of lamp in general commercial use, to which this resolution could possibly have applied, and that was the open arc lamp of the ordinary kind then manufactured and sold, taking about 9.6 amperes and 45 to 50 volts, to-wit, 450 watts, at the arc.

I may further state that if any one had had the temerity to formally put the suggestion of alternating arcs in the body of that resolution, I know that it could not have been gotten through the National Electric Light Association in a month

of Sundays; everybody was using direct current arcs, and most of the members, I think, looked with something akin to horror at the doing of anything which would disturb the equilibrium of their business.

Q. Was it possible for the Association to have had in mind the lamps and currents being used to light the streets in this city now?

A. Absolutely no.

Q. Isn't it true, Dr. Bell, that the National Electric Light Association was composed chiefly of the producers of electricity, rather than the consumers of it?

A. *The full membership was composed practically entirely of those who were in the business of producing and selling electricity. It was then very largely composed of stations of moderate capacity, inasmuch as the Edison Company, which controlled lighting in many of the large cities, had an organization of its own, and desired to take no part in the deliberations of the National Electric Light Association, and did not do so.*

Q. Do you know approximately how many lighting companies there were in the United States at that time, which would have been eligible to membership in the National Electric Light Association?

A. *No, I cannot state that; a good many more than were in it.*

Q. If the Electrical World should have stated at about the time of the passage of this resolution in 1894 that there were 2,000 companies in the United States that were eligible for membership in the Association, and that there were actually but 150

members of it, would you take that to be correct?

A. *I should think it was.*

Q. Then is it not true, that the resolution was passed by a majority of the membership interested, practically 150 out of a total of 2,000 companies in the United States?

A. *On the statement just made I should judge that to be correct.*

Q. Now, isn't it true that the passage of that resolution was really caused by electric lighting companies having executed contracts which they found it practically impossible to fulfill?

A. *I wouldn't like to go so far as that; this question had either never been raised, or had been amicably settled, but there was a very strong feeling for the guarding of future contracts, and getting the business on a more definite basis with regard to wording contracts; I am not aware that those who were specially active in passing the resolution were in any trouble themselves under the terms of existing contracts. I rather think not.*

Cross-Examination by Mr. Schuyler.

Q. I ask you as an electrical engineer if you would advise the City of Colorado Springs at this date to put in the old type of 9.6 ampere direct current arc lamp system?

A. *I decline to give an opinion in any way. I have no objection to discussing the question, but what advice I would give a client is not a part of this issue, and I would rather beg to be excused, unless the Court desires.*

Q. Will you explain that to us—the conditions militating for and against such a system at this date?

A. *The 9.6 ampere open arc lamp, when properly run,—and by properly I mean run as it has been run in this country, and may be run again in some modified form—*

Q. Not as it is being run now, however?

A. *I am not prepared to say it is not being run as well in some places as it ever was—gives, in my opinion, a good deal more effective service under favorable conditions than the 6.6 ampere A. C. arc. By that I do not mean that the open arc has not had its own troubles, just as the enclosed alternating arc has, nor that it is itself free from all objections as a street illuminant; it does, however, when properly handled, give a tremendous amount of light, compared with the ordinary 6.6 ampere alternating current arc, as the figures which I have cited already sufficiently indicate. The 6.6 ampere alternating arc, when properly run, is unquestionably a good light for such power as there may be in it. It has certainly practical and commercial merits which have brought it into prominence; as a street illuminant, barring cases where arcs must necessarily be hung very low on account of overhanging trees, and similar exceptional conditions which may at times arise with respect to the employment of any illuminant, the 9.6 ampere open arc certainly out-classes in its general effectiveness, purely from the standpoint of the persons who are receiving light, the alternating arc in question.*

It is perfectly true that the alternating arc has been a very useful

illuminant, indeed; it very likely will continue to be so; but it simply has not got the light-giving power of the light in question, and when it has been used to supersede the open arc, I think there has generally been a new arrangement whereby a new light was furnished at a new price, under a new contract.

Q. Would you advise, at this date, any city to put in the 9.6 ampere direct current open arc light; and if so, under what conditions would you or would you not, and if so, when?

A. *I certainly would, under certain conditions. If a city is fairly clear of trees, so that it can hang its arcs in reasonably advantageous positions, and if it is reasonably sure that the operating company will take hold in good faith and make good with whatever arcs it chooses, and the citizens want to get a powerful illumination in the streets, making brilliant lighting, I should have no hesitation in saying that as against a 6.6 ampere A. C. light on equal spacings, they would do better to use the 9.6 ampere open arc. On the other hand, my preference would be, if the case of choice arose in a city, to use neither of these lights for the purpose of brilliant illumination, but rather the direct current enclosed arc, such as we are using in Boston, which takes 500 watts, per contract, with a minimum requirement, I believe, of 480, per lamp.*

If I were going to use the 6.6 ampere A. C. arc, I should want the privilege of putting in a good many more of them, and spacing them rather closely, particularly in a city that has a good many trees. Where they are willing to pay enough to get proper illumination on the street,

these lamps will do and are doing admirably.

Q. What do you say as to the 7½ ampere alternating current enclosed arc?

A. *The 7½ alternating current arc is a different proposition altogether from the 6.6 ampere; it is a very much more effective light.*

Q. Wouldn't you recommend a 7½ ampere alternating current enclosed arc in preference to the old type of 9.6 ampere direct current open arc under similar conditions?

A. *From experience I feel perfectly sure that the high power D. C. enclosed arc lamp can successfully replace the 9.6 ampere open arc as a street illuminant, light for light. Personally, I prefer it on account of its steadiness. If I were going to put in the 7½ ampere alternating enclosed arcs to replace the 9.6 ampere open arcs—which we did in my own town of Brookline—I should be disposed to do very much what we did, space them somewhat nearer, but I should feel that I was getting a thoroughly good light, and one which, with a little care, could successfully replace the open 9.6 ampere arc, with improvement in steadiness.*

Q. Isn't it a fact that the entire endeavor of the illuminating engineering profession has been toward securing the greatest steadiness of light, and the best distribution of it, devoid of glare, and, as far as possible, of shadows?

A. *That is certainly a very important feature of our work in interior lighting. In exterior lighting, of course, the question of diffusion, if the lights are properly placed, is not as important; but I will say with*

perfect frankness that I prefer the enclosed arc on the question of steadiness, and would not and do not hesitate to recommend its use.

Q. Now, wouldn't an opalescent globe on an A. C. arc lamp increase its efficiency?

A. *A globe can't increase the efficiency of an arc light, but it would improve the distribution undoubtedly.*

Q. And, of course, the candle-power?

A. *Its useful candle-power, somewhat; not to any extent that I should consider important—that I would consider a factor.*

Q. Did you make any tests of those lights here in Colorado Springs?

A. *No.*

Q. Just had a visual observation of them?

A. *Yes.*

Q. Can you tell the difference by visual observation between an A. C. arc lamp using 7½ amperes at 480 watts, and a 6.6 ampere, consuming the same amount?

A. *The eye has no effective memory, but if you had the lamps up side by side, you would find the difference mighty quick.*

Q. Without them side by side, could you walk into a city and tell when they were both carrying the same voltage or the same wattage?

A. *I could come pretty near it, I think; it would simply amount to this, that if the lights of the 7½ amperes happened to be down a little in voltage, you might not be able to tell the difference between one light*

and the other, but if you had two streets, one with one lamp and one with the other, you can tell the difference very quickly.

Q. How much of a difference?

A. A very appreciable difference; the 7½ ampere lamp has quite a whiter light than the 6.6 ampere, worked at a higher voltage.

Q. Now, can you make a test of one lamp in a city, on one circuit, and call that a fair test as to all the lamps in the city, when there are perhaps four or five other different circuits?

A. I think I should try to get a chance to test quite a few more than one lamp.

Q. Wouldn't this be a very fair way to get at the average of what the lamps in this city are doing—if the company knows the efficiency of the machinery of its plant, and can determine with reasonable certainty the transmission and the transformer losses, the grounds and similar matters—to take the entire number of net watt hours delivered and divide it by the total number of lamp hours and thus determine the service in the city?

A. Assuming that the station instruments were correct, and that the losses you mention were only normal, the test you mention would give a very good idea of the average watt consumption per lamp. It would not tell you how good the service was in point of uniformity of adjustment in the relation between the amperes and the lamp, and the volts in the lamp, and matters of that kind. You might have a circuit giving the most admirable service, and a circuit giving what you would call "rank"

service, both of which would show the same wattage on the meter.

Q. And isn't it perhaps a more fair test even, to take every lamp in the circuit and ascertain its individual condition, and what it is doing?

A. That test should be made by every operating company. It gives a very good idea of what it is doing.

Q. Would you as an electrical engineer take the test of one or two lamps at a particular time as indicative of the condition of a whole system of lamps, consisting of 241, for a period of twelve or fifteen months previous, and as controlling for eight or ten months, subsequent to that time?

A. According to my observation, a great many things can happen on a circuit in a period of a couple of years, and I would hesitate very much, from any test made at any particular time, to say what would or might have been going on on this circuit for the last six months, and would be likely to go on in that circuit, provided opportunity for change were granted, during the next six months.

Q. I don't want to refer to it too often, but you referred to the temerity of anyone to incorporate anything in the N. E. L. A. resolution of 1894 with reference to an alternating arc lamp?

A. Yes.

Q. I want to ask you if it isn't your recollection that Professor Anthony did have the temerity to say if you furnished an alternating current arc lamp with 450 watts, it would

be a 2,000 candle-power lamp within the meaning of this resolution?

A. I think that he would have been more cautious in advancing that statement if it had been so embodied that the Association had to vote on it.

Q. The vote was taken afterward?

A. The vote was taken afterward; that was the individual expression of opinion of one member of the committee, and I regarded it, to deal with the facts as they then existed, as a bouquet thrown to the Westinghouse Company, that was trying to get out an alternating arc system, which they hoped might come to something, but which didn't.

Re-direct Examination by Mr. Robinson.

Q. Isn't it a fact that in every instance that you know of where 6.6 ampere lamps have been substituted for 9.6 ampere lamps, that it was necessary to put in more of those lamps in order to secure proper illumination of the streets?

A. Yes, but in point of fact the substitution is sometimes made for the purpose, or with the result of cutting the electric light bill, and the additional lights, for the further lighting of the city, installed as time goes on.

Q. If you had a contract embodying the words that I read to you from the ordinance of September 8th, 1898, would you consider it possible for that contract to be filled by the producer of the light, with the system and apparatus that is used on the streets in this city in practical operation?

A. No, sir.

Re-cross Examination by Mr. Schuyler.

Q. You are referring to the street part of this system; is that the idea?

A. I am referring to the street part of the system, and the standard lamps which are used in the system.

Q. You are not referring to the plant at all?

A. Oh, no, I don't understand the question to refer to it.

Q. Well, what would you say about the 7½ ampere light being able to fulfil the terms of that franchise?

A. It would come very much nearer to fulfilling it than the system referred to.

Q. The 7½ ampere A. C. is better than the open lamp, on account of steadiness and distribution, and those matters that we have discussed?

A. I should hesitate to call it a better lamp. I think the lamp that you could definitely call better, which would appeal to the mind of anybody as being a more effective light, is the D. C. enclosed; but as I said, the A. C. arc lamp, run on an honest full 7½ amperes, and about 72 volts to the arc, would come pretty near fulfilling the bill, light for light, with the old open arc.

Q. Upon what basis is the charge made and collected for light?

A. On the basis of service.

Q. Well, don't you take the number of watts, and make the bill on that?

A. The bill is generally not made on the wattage. Contracts are generally put out in something of the following form;

the company undertakes to furnish a certain specified arc, operated under specified conditions, and taking specified voltage, for a certain price per year, or per night, per light. In a recent case with which I am acquainted the contracts for arc lights are now, I am glad to say, drawn on this specified basis, which specifies not only the number of watts, but the amperage of the lamp, its character, and the service which shall be rendered under the contract. That, I think, is the usually accepted form to-day.

Q. Do we understand that the effect of what you state is that a 7½ ampere lamp, properly kept up, and honestly run, was a fair substitution, lamp for lamp, for the old type of 9.6 ampere lamp?

A. An alternating enclosed arc lamp, which takes not less than 7½ amperes of current, at an effective voltage of 72, is a good enough lamp, in most cases, perhaps all cases, to replace a 9.6 ampere open arc lamp, for the purpose of street illumination. The question as to whether one could or could not replace it, under any given conditions of the contract, etc., I will not attempt to deal with, because that is a legal matter; but as to the lamp—that is the only alternating lamp, and that is the minimum in current, which I consider in any way capable of substitution, lamp for lamp, with what we would all agree in calling comparable results.

Question by Arbitrator:

Q. You replied to the question as to what lamp was meant in 1894 by the standard 2,000 candle-power lamp, as being the 9.6 ampere, with 42 to 45 volts at the arc; would the same answer apply in 1898?

A. Absolutely and exactly the same. I happened in the course of some litigation where I was acting as consulting engineer, to look up the state of the art at exactly that epoch, and there was not at that time anything whatever which could be considered as a lamp in use sufficiently beyond the experimental stage to justify its possible consideration under such a contract.

Re-cross Examination Continued by Mr. Schuyler.

Q. Isn't it true that the rating "standard 2,000 candle-power light," whatever might have been true at that time, has since been generally applied to the 480-watt alternating current light?

A. At times doubtless by the manufacturer and the agent, and, as a matter of fact, at the present time you do find it applied to the old open arc, the enclosed 6.6 ampere D. C. arc to which I have referred, the 7½ ampere alternating arc, and the 6.6 ampere enclosed arc. It is also true, curiously enough, that you find that same lamp at times rated as 1,200 candle-power, in quite a number of cases; but I don't think that any of these ratings have any serious bearing on the issue at the present time.

Q. And you say that, that rating applies to all these lamps without any distinction, at six and nine years after the epoch in question; how about two years ago; the same?

A. Why, since the practical abolition of the candle-power rating, and the pinning of contracts down to service, people have fallen into extremely loose ways of rating; rate lamps pretty much as they please. For example, I know of one case of a city,

in which the 6.6 ampere alternating were substituted for the old half arcs, and they gave excellent satisfaction, but in later years the whole question of candle-power dropped out of sight, and these same arcs were rated to the public as 2,000 candle-power, although they had been substituted for half arcs; so the whole thing now is so loose and irregular, and the contracts for candle-power are so utterly obsolete, that people rate about as they please, so long as the terms of the contract are lived up to.

But the change from candle-power rating has been a gradual one, and as the technical, legal, contractual importance of the candle-power rating has disappeared, why, people have simply paid very little attention to it, and rate it pretty much as they please, and nobody has paid any attention; it has dropped out of sight, and I don't consider that the rating of a lamp at one candle-power or another has any essential importance.

Q. The candle-power rating was rather fictitious, anyhow, wasn't it?

A. The candle-power rating of the old days, as I have indicated, was wholly fictitious.

Re-re-direct Examination by Mr. Robinson.

Q. The question asked you was about a 7.5 ampere light that might be substituted for some other; now, is that a size of lamp in itself?

A. It is.

Q. That isn't the same thing as a 6.6 ampere lamp, with 7.5 amperes running through it?

A. No, sir, it is a distinct and individual lamp, and takes a distinct and individual transformer to run it; it is a separate commercial article.

Q. How long has candle-power been used as a unit for the measuring of light?

A. I should say that the candle-power has been the legal, and the only legal standard of light in English speaking countries since the early days of using gas.

Q. Been something like a hundred years, hasn't it?

A. Well, in that vicinity.

Q. That is for measuring light; when you want to measure power you use something else, don't you?

A. Certainly; yes.

Q. But when you measure light you still use the candle-power as the standard?

A. You have to go back to the candle-power.

Q. By your reference to contracts now measured by watts, and other specifications, do you mean that a party holding a contract has the privilege of changing it and meeting his obligations under the contract by measurement in watts and volts?

A. Oh, so far as I know, all changes of that kind have been accompanied by a changed contract, generally a changed rate, and possibly changed conditions.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 9 A. M., FEBRUARY 5, 1907.

DR. BELL recalled to the stand.

Re-re-direct Examination Continued by Mr. Robinson.

Q. Dr. Bell, referring to some of your testimony of yesterday, in which something was said about a comparison between a 7.5 A. C. enclosed lamp and a 9.6 D. C. open lamp, I will ask you what general comparison you can make to the Board as between the light given by these two lamps?

A. As I indicated yesterday, a 7.5 ampere alternating enclosed arc is quite a different proposition from a 6.6 ampere alternating enclosed arc. The light given by it lies between that given by that of a 9.6 open arc and a 6.6 ampere alternating enclosed arc. I should say that a 7.5 enclosed alternating lamp, taking not less than 72 volts at the arc, would give a mean hemispherical candle-power not far from 400, and its maximum candle-power would lie correspondingly higher, between 500 and 600. Of course, the distribution of a 7.5 ampere alternating lamp is similar to that of the 6.6 ampere and different from that of the open arc, but the relative actual light-giving power of the arc, to which I understand you refer, is about as I have stated.

Q. Would the light of a 7.5 A. C. enclosed lamp be anything like a fair substitution for the light of a 9.6 D. C. open arc lamp?

A. In point of quantity the figures already given would show that the 7.5 ampere alternating arc was materially inferior to the 9.6 ampere open arc. Of course, one must under-

stand that the alternating arc lamp has some advantage of distribution that makes it, relatively, a slightly better light than the absolute candle-power would indicate.

Q. In your judgment, would it be reasonable and fair to require the company in this case to install such apparatus as would give the light described in the Ordinance?

A. I do not see how, as a general proposition, that could be denied; if the Ordinance required a certain thing, I should say, as a matter of fact and equity, that the Company might be required to install that thing.

Q. And to operate such as to furnish what it agreed to?

A. Of course, that goes without saying.

Q. Would it be impracticable, by reason of extraordinary expense, for the Company to supply such apparatus that would give the light required by the Ordinance?

A. Why, no, I should not think that from a practical standpoint it was unreasonable to require the Company to do that, because, although the light of a 9.6 ampere arc lamp would, unquestionably, cost the Company more than the present light, still it wouldn't cost it an amount so excessive that it should be considered unreasonable. Many such lights are in use in various places, and their cost, although higher than that of the alternating system of equal candle-power, is not to be regarded as extraordinary.

Re-re-cross Examination by Mr. Schuyler.

Q. In your last answer you were speaking of a 9.6 ampere direct current open arc lamp system?

A. Yes.

Q. Isn't it a fact that shadows from the old arc are very dense?

A. Why, at times they are; the globes are liable to get dirty; that is one of the well known and generally admitted disadvantages of the old open arc.

Q. Isn't the shadow due to the lower carbon and not to the globe, and therefore always present?

A. There is a shadow due to the cutting off of the light by the lower carbon, but this exists also in any form of arc lamp to a certain extent. I think the main trouble from shadows in the old open arc is an accumulation of dirt in the globes; they are very apt to gather up dirt and insects and what not, and the form of the old open arc lamp was not as skillfully designed as lamps which have been put out in recent years. There is no question whatever, that on the average the old open arc gives denser shadows than the modern enclosed arc.

Re-re-direct Examination by Mr. Robinson.

Q. You haven't examined the present lamp globes on the street to see whether their outer globes fill up with insects, have you?

A. Well, I have observed the dirt in the lower part of the globes, as I have been walking under them at night, but I can't say what their average condition is.

Q. Isn't that accumulation of dirt in the outer globe very nearly as much in this kind of lamp as in the old kind?

A. No, I don't think that the access to the enclosed lamp of modern design is as great as in the case of the average open arc; the dirt can't get in quite as readily as it used to in the earlier forms of open arc, but it does get in and does produce shadows.

Re-re-cross Examination by Mr. Schuyler.

Q. Isn't it a fact, that one of the chief points of the enclosed arc is that it keeps out insects.

A. The chief point is the great economy of operation on account of less trimming.

Witness excused.

MR. ALTON D. ADAMS recalled to the stand.

Examination by Mr. Robinson.

Q. Mr. Adams, yesterday it was arranged you were to present some statistics as to the use of the 9.6 D. C. open arc and the 6.6 A. C. enclosed arc; what have you got to-day on that?

A. I have some figures here, purporting to show the number of open and enclosed arc lamps in use for street lighting throughout the United States in 1902. Of course, these figures do not refer exclusively to the 9.6 ampere direct current open arc lamp and to the 6.6 ampere enclosed alternating current lamp, because there are other types of both open and enclosed lamps, so that the figures which I shall give in reply to your question, refer to all types of open and all types of enclosed arc lamps in use on the streets in the year 1902. The bulletin which I hold in my hand, which purports to come from the General Electric Company, is dated February 25, 1904, bulletin No. 4284. In the introduction of this bulletin there is a brief sentence which, if you and the Court will allow, I think I will read, as follows: "The use of the term candle-power in connection with arc lamps is strongly condemned, and though used in previous bulletins on this subject, it is here omitted, the watts at lamp terminals being substituted." The force of that statement, of course, is to show that, up to 1902, the description of arc lamps was commonly given in terms of candle-power in the electric field, and the General Electric Company, in issuing bulletins, descriptive of such lamps, used

that method of describing lamps in use.

This bulletin, as I have stated, gives the number of open and the number of enclosed arc lamps in use throughout the United States for street lighting purposes as far as the bulletin is complete. These are the results for the entire United States.

The number of enclosed lamps, as shown by the bulletin, was 31,718, and the number of open arc lamps, as shown by the bulletin, was 302,185, all in use for street lighting. I might say in further answer to your question that a part of these enclosed arc lamps were of the direct current type, in fact, the bulletin states here that seventy-three cities used the enclosed arc lamps, or having them on the streets, were using these of the direct current type.

Q. Do you know, of your own knowledge, whether the open lamp is in use in Worcester, Massachusetts?

A. Yes.

Q. Would it be practical for a company to instal such a plant of machinery and such apparatus as to furnish the light which you have testified was called for by this ordinance?

A. Why, undoubtedly; the thing is being done in hundreds of central stations to-day; I don't see anything impractical about it.

Q. Only it costs more?

A. It costs more to furnish a 9.6 open arc lamp and operate it well, than it does to furnish an enclosed 6.6 alternating current arc lamp and operate that well.

Cross - examination by Mr. Schuyler.

Q. You would advise the City of Colorado Springs to go back to the old style 9.6 direct current open arc?

A. That particular question is very difficult to answer without explanation. I certainly would advise the City of Colorado Springs, if it is entitled to the open arc 9.6 ampere direct current lamp to insist on having that lamp installed on its streets, in preference to the lamp that it now has. It is a decidedly better thing.

Q. Let's eliminate for a moment the question of a contract. Would you, in the present state of electric lighting, advise the City of Colorado Springs, from a practical engineering standpoint, to put in the 9.6 old style current open arc lamp?

A. The advisability on the part of the City of accepting any lamp, in the absence of a contract, must

depend, in my judgment, on the price at which the lamp is offered, and if the City could get a 9.6 ampere open arc lamp supplied and operated properly on its streets at no greater cost than the 6.6 ampere alternating current enclosed lamp, I should, unqualifiedly, advise the City to accept the 9.6 ampere open arc lamp.

Q. Did you ever use an illuminometer?

A. I never used the instrument you mentioned; I have observed lamps in use.

Q. A visual observation?

A. Yes.

Re-direct Examination by Mr. Robinson.

Q. Do you know what an illuminometer is?

A. No, sir, I don't; I don't remember.

Witness Excused.

Mr. GEORGE A. TAFT, being first duly sworn on behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Please state to the Board the proportionate part of the whole current generated by the use of the City water-power, which has been used to light the streets of the City?

A. *It ranges from 10 to 15 per cent.*

Q. And the remainder of the current is disposed of to other parties, is it?

A. *It is, in Colorado Springs and the town of Manitou.*

Q. What position do you occupy with the Pike's Peak Hydro Electric Company?

A. *I am its vice-president, engineer and manager.*

Q. And have you been an officer of the company and manager of it since it began to furnish light to the streets of the City since February, 1905?

A. *I have.*

Q. What, if any, plant, wires, lamps, poles, transformers, implements, or machinery of any kind has the Company inside the corporate limits of the City?

A. *None.*

Q. Is any part of its plant anywhere on ground of the City?

A. *There is not.*

Q. Then, is it not true, that if the City is receiving any benefit, income or recompense of any kind for the use of its water system that benefit, pay or recompense is through this street lighting arrangement or contract?

A. *Partly. The price named in the contract for street lighting when the contract was made, as I believe, was a little better than one-half of the price that was paid by the City for such lights; further, there is reserved a certain quantity of power that the City uses and additional lights for this City building.*

Q. That is true, the City is receiving the light for this building free, under that contract?

A. *It is.*

Q. Now, can you think of anything else it is receiving under contract?

A. *Nothing that I know of.*

Q. What is the capacity of your plant in kilowatt hours per month?

A. *The capacity of the plant varies per month; it has an output throughout the year of eight million kilowatt hours.*

Witness excused.

PROF. J. R. ARMSTRONG, being first duly sworn on behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Did you ever assist in making any tests of the power in the lamps on the streets in this City?

A. *I have.*

Q. I hand you City's Exhibit No. 26 and ask you if that shows the result of the tests, as to the location and date, current, volts and watts, as assisted in by you?

A. *It does.*

Q. I hand you City's Exhibit No. 27 and ask you if that shows the result of tests, aided by you, so far as location and time, amperes, volts and watts go?

A. *It does.*

Cross - examination by Mr. Schuyler.

Q. During the tests what instrument did you hold?

A. *A rotation of reading was used, through some of the tests fifteen readings were made; if at first I held the watt-meter, the next five readings I held the volt-meter, the next five readings I held the ammeter.*

Q. Professor Matthews supervised these tests after he got here, did he?

A. *He was anxious to be sure that things were correct, and when we started our readings we had both Professor Matthews' instruments, as well as the college instruments, and we carefully checked through together.*

Q. Who did supervise the tests?

A. *That is hard to say; perhaps Dr. Shedd took more leadership; when Professor Matthews was here he oversaw things more.*

Witness Excused.

PROF. WM. STRIEBY, being first duly sworn on behalf of the city, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Did you assist in making some tests of street lights of this City in June, July and August last year?

A. I did.

Q. I will ask you if you were a member of a committee of the college that was requested to make tests of these lights?

A. I was.

Q. Were you at that time in the employ of the City?

A. We were requested by the City; there was no employment, that is, for a sum of money; the services were given gratuitously.

Q. Now, I will ask you to state to the Board how the readings of the instruments were made?

A. Three men were stationed upon a wagon underneath the lamp, which was lowered in all of the last tests, to within a few feet of their heads; there were three instruments on a table, which the three men were reading; there were two persons on the ground near by to record the readings as they were given. I held the watch and gave the time. When everything had been made ready, the time for the readings to begin was announced by the statement, "get ready," meaning that there were five seconds before the reading was to begin. At the end of the five seconds after the "get ready" announcement was made, I said "read"; each one was supposed to read his instrument at that time; I would then

call off, say, the wattmeter, Mr. So-and-So, your data, and he would call aloud his reading, and I would record and the other would record, and I would call back the reading aloud so he and the others should hear it; then the next instrument in turn was taken and the same practice was gone over, and the third one, so at that time three readings were made simultaneously, each one called off in turn and the data was put down in two books, one carried by myself and the other by another gentleman. After waiting a suitable interval of time, which was, in the earlier tests three minutes, and then two minutes as the work progressed more easily, and finally in the last test one minute, the readings would be taken again and so on through the test. For the earlier tests there were made five readings by each gentleman at each instrument, then the man who had the volt-meter perhaps took the ammeter, changing around so each had a different instrument; the readings would be all repeated five or more times, then a change would be made again, so that the man who had the voltmeter at one time had the ammeter at the other, changing to the wattmeter at the last time. Three series of five readings would make a total of fifteen readings in all. In the tests on August 30 and 31 there were about ten readings made instead of the fifteen, and in that case the same gentleman remained at the instrument during the ten readings.

Q. About how long a time would elapse after the lamp was out until it would be cut in again, prior to the taking of the readings?

A. The light would actually be

out, I should say a couple of minutes.

Q. About how long would it be after you cut the lamp back in until you began to take readings?

A. It was somewhat variable; my recollection is that it was something like ten minutes.

Q. How would you say, from your experience and observation of the lights on the streets, that the lights which were tested at these times compare with the general condition of the lights of the City?

A. So far as my observation went, they seemed to be about the same as they had been for some little time previous.

Q. Did you gentlemen attempt to pick out lamps that were an average indication of the whole system?

A. The endeavor was to make such a selection of lamps all over the city as would give a fair knowledge of what they were doing; no attempt to pick out all the bad lamps or all the good lamps, but simply to pick out lamps here and there. L

Q. I will hand you City's Exhibit No. 26, and ask you if that shows the result of the test which you have described as to the location of the lamp, date, current, volts and watts?

A. It does.

Q. Can you explain to the Board the peculiarities of test No. 4, and how it happens that one reading on that lamp varies so much from the other, although taken at practically the same time?

A. In that case the test had proceeded until there were thirteen read-

ings made, when a man drove up and climbed the pole, and made some adjustment, or did something to the lamp, and after that time the readings as shown in the following test were different from those that had preceded it.

Q. What did this man say about the lamps and your testing?

A. When he came down from the pole he came over and sat by me and I asked him why he had changed and interfered with the lamp, and he said, "because it would not be fair to take the readings of the lamp until it had been changed, because the pole lamps had not been adjusted, and that it was only fair that the readings should be taken after adjustment."

Q. Do you know who the man was?

A. I did not know him.

Q. Did he say in whose employ he was?

A. I understood him to say that he was in the employ of the Colorado Springs Electric Company.

Q. In making the tests did you notice the physical condition of the lamps?

A. There were, in a number of cases, such defects as broken and very dirty globes, and dirt in the globes.

Cross - examination by Mr. Schuyler.

Q. Please tell us how many watts were consumed in the voltmeter?

A. I simply took the readings that were given to me and recorded them; I acted as clerk entirely.

Q. How about the wattmeter?

A. Same thing.

Q. Did you have both sets of instruments, those that Professor Matthews brought from the East and those that Professor Shedd had in the test at the same time?

A. We took—I think we tested both sets and made records, but they seemed to read alike, so we cut out one set and read with Professor Matthews' instruments.

Q. You are positive that you did not have two sets of instruments connected in at the same time?

A. Yes, sir.

Q. Your conclusion that the lights

around the city were of the same character as the one you tested was based on your visual observation?

A. Just as any one else would that had no special qualification for that.

Q. By whom were you called upon to take up this task?

A. First called upon by Mayor Hall, of this city.

Q. And acted thereafter at his request?

A. Yes, sir.

Witness excused.

THEREUPON THE CITY RESTED ITS CASE.

BOARD ADJOURNED.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 2 P. M., FEBRUARY 5, 1907.

Mr. W. D'ARCY RYAN, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. Would you be kind enough to explain your luminometer?

A. *The luminometer might properly be called an unscientific instrument designed specially for demonstrating to members of city councils and other people interested in the values of different exterior illuminants, what their various lighting values would be.*

This instrument is so extremely simple that it has proved a very valuable instrument in investigations of different lights; that is, in a practical way, eliminating the scientific subject and putting it on a more commercial basis; a basis where anyone can realize exactly what is happening with the light.

Q. Have you made any practical use of the instrument yourself?

A. *Yes; for a period of about a year, I had anywhere from five to twelve men at work, frequently the entire night, making tests.*

Q. Over what period of time have tests of that or of other character, for the purpose of comparing the efficiency of lights, been conducted by you?

A. *About seven years, and tests are still continued on different classes of illuminants. The tests referred to were the first that made a real, practical comparison of values of various open and enclosed arc lamps.*

Q. Prior to that time, was there any recognized definite method of making accurate comparisons of arc lamps?

A. *No, none whatever.*

Q. Will you give some idea of the development of the illuminating enterprise in this country; that is, of street lighting?

A. *When I entered the field, some twelve years ago, the lamps commonly used in this country were of the open arc type. Later developments introduced alternating lamps, first the open multiple series lamps, of the Thompson 1893 type, which were antedated by an alternating lamp run on a series transformer known as the ribbon feed. Development of the enclosed arc lamp occurred about 1895-1896. At that time, from 1896 to 1898, through that period, the enclosed lamp was rapidly introduced; the production of the open arc soon began to drop, and the enclosed arc predominated until the annual production of the General Electric Company at present is 100,000 enclosed arc lamps, and we do not make any of the open type; in fact, it would be practically impossible to get the supply parts.*

Q. How with reference to other manufacturers of open arc lighting apparatus?

A. *The same history. The Brush Company has gone through the same cycle, and is not doing anything now.*

Q. Some witness has stated here that no other lamp than the 9.6 ampere was in use in the year 1898. I

will ask you if you have any book or discussion of that subject to support your own recollection, and if so, to read such parts as may be material?

A. I have here a paper read in June, 1898, by H. A. Wagner, "Proceedings of the National Electric Light Association," twenty-first convention, Chicago. The paper was on the subject of general distribution from central stations by alternating currents. Page 135 reads;

"It seems now to be the universal opinion among Edison station men that the enclosed arc, long burning lamp is destined to replace all the old forms of arc lamp. We will therefore consider this type of lamp only. Fully as well burning lamps of this type are now made for alternating current. They are also about as free from noise as the direct current lamps." And on page 161; "Arc lamps have been familiar to us on alternating current circuits for some time, and the alternating current, enclosed, long burning arcs are now numbered by the thousands. Street lighting is still, however, in most places done on the direct current series system, and even the largest machines yet built for this purpose are very small in comparison with our large direct connected generators."

Q. That was a fair statement of the condition of the art as to the old open type arc, and the enclosed arc, in the year 1898?

A. Yes.

Q. Will you please state generally the reasons which have conduced to the passing of the old style open arc, 9.6 ampere direct current light?

A. In the first place, the outages and poor service rendered were a constant source of complaint by the various towns and cities. Owing to inherent defects which cannot, or could not be overcome, it was practically impossible to operate those lamps in what might be called a satisfactory manner. On the testing racks in the factory we could not keep the lamp closer than from five to seven volts by crocusing the rods and putting them in their very best condition; when they were placed in the streets, subjected to the atmosphere, the change of temperature, wind, dust, rain and other things of that sort, lamps put out in what would be considered perfect condition, and cleaned as far as it was possible to clean them at the pole, by the trimmer, would in many cases vary as much as fifteen volts or more.

Q. On whose part did those complaints arise?

A. Sometimes from the city; sometimes from the electric lighting companies. In many cases the electric companies were obliged to pay for outages, and the outages were tremendous. Among many stations I might say the lamps were not kept up as well as they might be, but even when they were kept up as good as it was possible to keep them, still the lamps were unsatisfactory.

Q. But you do not attribute the passing of the lamp then to the failure of the central stations to operate them to the best of their ability?

A. I don't think that is the case. There may have been certain cases of that kind, but it was not the general situation.

Q. But rather to the inherent de-

fects in the lamp itself, which prevented better service?

A. Coupled with the fact that it was an expensive lamp to operate, and there was a demand by the various cities for reduced rates. Further than that, the enclosed lamp was early recognized as an illuminant, superior to the open arc.

Q. Now, Mr. Ryan, please analyze the report, Exhibit B, and give a comparison of the different qualities of diffusion of light, and kindred matters.

A. I will pass over the "Theory of Light," and the "Law of Radiation," given in the first part of the pamphlet, and read a few words on the photometric subject from page 4. "Photometric measurements are usually made by placing a light to be measured opposite some standard light, and moving a screen between them to a point where a greased spot on the center of the screen disappears; this indicates that the light on both sides of the screen is equal. The intensity of the light being measured may be read directly from a scale laid out in accordance with the law of inverse squares.

For measuring arc lights it is usual to employ a photometer with a crane at one end, which permits the lamp to be raised or lowered so as to obtain light at different angles, the light being reflected to the screen on the photometer bar by a suitable mirror. There are also other satisfactory methods.

In the measurement of incandescent lamps it is customary to rate them in horizontal candle power. Measurements of such lights are easily made, but with arc lamps it is a difficult problem, as the light varies

enormously in different directions, and at different intervals of time.

There are many ways of expressing the candle power of an arc lamp. Some take the average of the light thrown in all directions, namely, mean spherical; others the average of light in the lower hemisphere, or over a selected number of degrees, such for example, as from the horizontal to sixty degrees below. Then again we may use the average of the maximum readings or minimum readings, or the mean average of all readings, but the usual way to refer to the candle power of an arc lamp is by its maximum, notwithstanding that this actually means less, as far as the value of light is concerned, than any other comparison which might be employed.

Of course it is well known that the so-called 2000 candle power direct current open arc lamp, taking about 10 amperes at 48 volts, does not give the candle power at which it is nominally rated. It is possible, however, to get a freak reading of 1700 or 1800 candle power, when the crater is all exposed on one side of the carbon, but the average maximum candle power is about 1250 at an angle of 45 degrees."

Q. May I interrupt you to ask if there has at any time been an actual 2000 candle power lamp or light of the arc kind?

A. Nothing commercial, in general use for street lighting. "By referring to candle power curves, (Exhibit B) Figure 3, the distribution of light from an enclosed arc lamp will be readily observed. These readings represent the average maximum of the different lamps equipped commercially as they should be in

service, that is, with the proper globes, reflector, etc.

The leading characteristics of the open arc lamp is a long narrow lobe of light. In contrast we have the enclosed arc with a short full lobe, the advantages of which are shown in illumination curves, Figure 4."

In Figure 4, B represents the direct current enclosed arc, taking the same voltage and energy as the direct current open, shown in A. By looking at the curves you will gain the impression that there was considerable more light from A than C or B, due to the fact that the polar curve always gives a wrong impression. It is difficult for one who is not used to reading these curves to get away from the impression, in a curve of this kind, or a curve similar to Professor Matthews', of an exaggerated idea of the value of a high candle power lamp. The effect of curve A is to produce a very bright spot on the ground near the pole; the effect of C or B is to raise the illumination and throw it out towards the horizontal. You do not in that illustration see what happens when A feeds, at which time there is a tremendous difference in candle power; as a matter of fact it is about cut in two, falling way below the curve A, owing to the peculiarity of the diagram it gives an impression of the situation different from that which really exists.

Q. Now what about the curves C and B, which I understand represent enclosed arc lamps, as distinguished from curve A, which is the 9.6 ampere open arc lamp?

A. Curves C and B have the maximum at a high angle, or near the horizontal; they do not put the strong

illumination on the ground near the pole; when an enclosed arc lamp, either of these represented by C or B, feeds it doesn't drop its candle power to anything like the same extent. In other words, if we consider candle power, we must introduce the time element; it is not what a man can do with a lamp in the laboratory, under fixed conditions, but what will that lamp do if allowed to feed as in the ordinary course of its operation; that is what we must get at.

Q. I want to ask you, what is the object in lighting; to bring a greater amount of light to the horizontal plane, or to incline it to the angle represented by curve A?

A. To raise the illumination towards the horizontal. In the illumination of a street, the object from an illuminating engineering point of view is to throw the light as far away from the lamp as possible, and cut down the strong light near the pole. Curve A will naturally throw its maximum light at a point near the ground, possibly within thirty or forty feet of the pole, with a very dark shadow in the center. The lamp, B, while not giving as much light near the pole, gives more light at the distant point.

Q. Why does it give more light at a distant point?

A. Because its illumination in higher angles is relatively stronger. Its curve crosses the other curves out toward the horizontal. The curves A, Figures 3 and 4, represent a fixed condition; that is to say, for 48 volts at the terminals. You will observe that curves C and B, between the horizontal, and ten degrees below, give a higher candle power than the

lamp represented by curve *A*. It is quite possible to obtain momentary candle power even above the limit represented by *A*, but just after the lamp represented by curve *A* feeds, its candle power falls far inside the enclosed arc curve. Referring to Figure 5A, you have the open arc lamp as it starts, giving, if the lamp is in good condition, somewhere around 600 candle power maximum. When it reaches 48 volts at the terminals, it should be giving about 1250; then if it is in very good condition, the lamp should feed; just before feeding it would probably go somewhere between 1400 and 1600 candle power as a maximum. That feed constantly takes place at intervals of anywhere from four to ten minutes.

Q. At the time of feeding what is the effect upon the light?

A. You have a tremendous variation in the candle power which is represented by the curve in Figure 8. In the same Figure 8, it will be seen that the enclosed arc light doesn't go through the variation. It picks up at intervals anywhere from half an hour to possibly four hours, and then it drops its candle power just an instant and is back again to the same value. Aside from some mechanical trouble, which might occur incidentally to any piece of machinery, the A. C. lamp should continue to give about the same total light flux, over a period of an hour or a week, as the case might be. You have, however, some variation in light, due to the wandering of the arc from side to side; that is a defect which exists in the open arc, only more exaggerated. See Figures 6A and 6B. I might state that

the variation shown for the enclosed arc lamp is greater than that which actually exists in the recent lamps.

Q. Will you describe the exaggeration that is found in the open arc lamp?

A. With the arc on one side, the other side is screened by the crater, and you obtain an effect shown in either of the outside diagrams Figure 6A. When the arc is in the center, you have two lobes of equal size; when the arc feeds the lobes are smaller than those shown, so that you have, over a period of time, large lobes and small lobes. The result is the light on the higher side is naturally exaggerated, as shown in the top illustration, Figure 7, which represents the open arc; the bottom one the enclosed arc. The light section representing the intensity of the light on the street at any given point.

Q. Does that mean there is no light, practically speaking, at the point between the D. C. lamps?

A. On the weak side, yes.

Q. Now how often does that condition of an absolute disappearance of light on the weak side of the direct current, open arc, 9.6 ampere lamp, occur?

A. It depends entirely upon conditions; wind, rain, humidity and dust. As a general thing you might expect any open lamp to do that four or five, perhaps ten times a night, depending on its adjustment.

Q. Now take the second row of illustrations, Figure 7, and explain to what they refer.

A. They represent similar conditions for the enclosed arc. You have first on the left at the bottom,

the normal arc; second, the arc off center, and third, the short arc, and fourth, the excessively long arc. You will observe that the difference between the short arc and the long arc is practically nothing; it is very small, and therefore the light is better distributed.

Q. In other words, the enclosed type of lamp illustrated by the second diagram is a superior illuminant to the old 9.6 ampere, which varies in the manner shown in the upper diagram?

A. Yes, superior because it is whiter, and there is an absence of shadows; but of course the other lamp gives more candle power.

Q. Now look at the Figure 8, and explain it.

A. That jagged curve is intended to further illustrate the feeding of the 9.6 open arc lamp. If we take the mean hemispherical candle power of the open lamp, we find that starting somewhere about 250, in say fourteen minutes it increases up to about 600, then it drops down to about 150; then it climbs up about 750; then in a few minutes drops down again; this goes on at from four to fifteen minute intervals.

Q. What is the horizontal line running through Figure 8?

A. That represents the mean hemispherical candle power of the enclosed arc lamp.

Q. Now please proceed reading from Exhibit B., on page 7.

A. "The 10 ampere open arc lamps burn with a very short arc, approximately one-eighth inch. About ten per cent. of the total light comes from the arc, five per cent. from the heated

carbon tips, and the remaining 85 per cent. is emitted by the crater on the end of the positive carbon.

The intensity of the light in any given direction is approximately proportional to the amount of the crater area visible from any point in that direction. When the arc is in the center of the carbons and burns normally, the largest portion of the crater is visible at an angle of 45 degrees; hence the greatest light in this direction.

At 70 degrees below the horizontal the lower carbon practically intercepts all the light from the crater, throwing a shadow on the ground directly beneath the lamp. This shadow, in conjunction with those cast by the side rods, forms one of the principle objections to the employment of open arc lamps for street illumination."

Q. Some witness testified that the shadow of the enclosed arc lamp was greater than that under the open arc; is that so?

A. No, the shadow under the enclosed arc lamp is very much less, even with a clear globe; with an opal globe it entirely disappears.

Q. So that you take a contrary position upon that point?

A. Absolutely. "In contrast to this we have the enclosed arc lamp, a long arc burning in air, which is practically free from oxygen. Although most of the light comes from the crater, still a greater percentage is emitted directly by the arc itself, owing to its length. A large portion of the crater's area is visible over a wider vertical angle, and the crater is not so concave as in the open arc; hence less concentration and better distribution of light.

In open arc lamps two distinct variations in the light arc constantly taking place. One is caused by the increased length of the arc from the picking up to the feeding points, thus making a great variation in the mean spherical candle power and watts at arc at different intervals of time. (Fig. 5A) The other variation is caused by the wandering of the arc, due to the non-homogeneity of the carbons and drafts of wind. (Fig. 6A) In strong winds the variations may become so rapid as to produce flickering of the light. These variations cannot be controlled satisfactorily.

In the enclosed arc lamps there is very little change in the length of the arc at any time. (Fig. 5B) The principle variation in the light is caused by the travel of the arc over the flat carbon ends. When the arc is in the center of the carbons we have equal lobes of light on opposite sides. When the arc travels to the edges of the carbons, the lobe of light on one side becomes enlarged, while the lobe on the opposite side is reduced. (Fig. 6B.)

Now I would like to state that the curve shown in Figure 4, is the average maximum illumination, which means merely an average of the highest readings, exclusive of the freaks. What I mean by a freak is that it is quite possible to obtain a reading anywhere from 700 to 1000, and possibly 1200 candle power, under certain conditions, from an enclosed arc lamp, but that is an absolute freak, and should not be included in the results, and is not so included in these results. I have obtained from open arc lamps freaks up to about 1800. Let me continue reading:

"Notwithstanding this, the mean spherical candle power of the lamp remains practically constant at all times. (Fig. 7.) Furthermore, the variation in the light referred to can be greatly reduced by the use of an opal enclosing globe which becomes luminous all over, and obliterates the shadows which would otherwise be cast by the side rods and the lower carbon. Even if we use a clear enclosing globe, the shadows are not so strong in contrast as those of the open arc."

Q. Just a moment. What effect does an opalescent, enclosing globe, Exhibit D, have upon candle power?

A. It reduces the candle power slightly, and improves the distribution, illustrating very beautifully that you can cut your candle power down and improve your lighting. For example, we will assume that with a clear enclosed globe a ray of light from an arc lamp starts off at an angle of 35 degrees below the horizontal; that is, the maximum ray will strike not so very far from the pole, while the ray that should naturally go to the great distance passes through the clear glass with small absorption; by introducing the opalized glass this same ray is partly absorbed; but it will be compensated for by re-radiated light from other portions of the globe made luminous by rays which with a clear globe would strike near the pole. You actually lose in candle power, but you change the character of the distribution, and raise the maximum a little nearer the horizontal. For instance, you may take light of a certain given candle power and do very excellent illuminating work, while with a lamp of twice, or possibly

three or four times that power, you may not do so well if the candle power is not in the proper direction.

Q. And in which direction is the candle power of a 9.6 as compared with the enclosed arc?

A. It is about 45 degrees below the horizontal for the 9.6 open arc and somewhere around 30 to 35 degrees for the enclosed arc, and with the opal globe you probably pull that up near 30 degrees.

Q. That is below the horizontal?

A. Yes, and by putting on an opal globe you will bring it up somewhere around 25 to 30 degrees; depends on the density of the globe; the greater the density of the globe, the higher you raise the plane.

Q. That is now 25 to 30 degrees below the horizontal for the enclosed arc as against 45 degrees below the horizontal for the open arc?

A. Yes, the enclosed being equipped with an opal globe.

Q. And which is the more favorable angle from the standpoint of illumination?

A. The higher angle; if you could place it at 10 degrees, you would be very much better off than you are now. Let me read again:

"If candle power curves (Fig. 3) are carefully analyzed, it will be observed that all candle power ratings, either maximum, mean spherical, or averages, through any selected angle, will be of little service in determining the commercial illuminating value of different lamps. We therefore turn to the illumination curves (Fig. 4) as being a more satisfactory solution of the problem. These curves show the intensity of the illumination which will fall upon objects on the

street normal to the rays of light at different distances from the base of the pole to the light intersecting point midway between lamps 300 feet apart. The light from the 480 watt direct current open arc lamp is superior to the 480 watt direct current enclosed lamp in the vicinity of the pole. At a distance of about 100 feet, however, the curve showing the illumination of the open arc indicates less intensity, and from this out to the light intersecting point the enclosed arc gives a stronger illumination. This illumination is made still more effective by the absence of the strong glaring light in the immediate vicinity of the lamp. This is an important consideration which can be better appreciated if we call to mind the lag between the time we step indoors on a bright sunny day and the time required for the eyes to adjust themselves to the proper vision of the lesser interior illumination.

When we walk through the brilliantly illuminated area which borders the shadow zone of an open arc lamp to the dimly lighted area between lamps, we experience precisely the same effect, and we would be obliged to stand at the latter point several minutes before we could fully appreciate and use to the best advantage the amount of light present."

One case came to my attention where a man was killed in the shadow of an arc lamp by an electric car; the shadow was so dense that the man was not seen by the motor-man.

Q. What do you say with reference to the problem suggested by one of the Arbitrators to the preference you would have in driving an

automobile or carriage toward or under these respective light conditions?

A. There is no question but that it would be very much safer to drive under the enclosed arc lamp. It is extremely difficult to drive under any kind of an arc lamp, but I have heard, on different occasions, where chiefs of fire departments have said they could drive faster, and could make their hose connections better at the hydrants, under enclosed arc lamps, as frequently about the time they were ready to make the connection, down would go the arc of an open lamp, and they would have to depend on their lamps or lanterns.

Q. Proceed reading, Mr. Ryan.

A. "It is therefore clearly evident that a source of light, which gives a strong illumination over a narrow angle covering the ground near the source, is to be regarded as inferior to an illuminant which projects more light to the light intersecting point, while the light in the vicinity of the lamp is more subdued. Briefly we can sum up the characteristics of the open and enclosed direct current lamps, as follows:

Open Arc Lamp. The mean spherical candle-power and the energy required at the arc are variable at different intervals of time between the picking up and feeding points.

Fluctuation of the light, due to wandering of the arc, in very marked, also the flickering due to the wind and non-homogeneity of the carbons.

Dense shadows are cast by the lower carbon and side rods, and the intensity of the light in the vicinity of the pole is objectionably strong, while the light at the light intersecting point midway between lamps varies through wide limits.

Enclosed Arc Lamp. The mean spherical candle-power and the watts at arc remain practically constant at all times between picking up and feeding points.

There are no shadows cast by the carbons or the side rods, and the light in the vicinity of the lamp is subdued, while the average light midway between lamps is slightly stronger than the open arc, and is not subject to so wide a variation.

The direct current enclosed arc lamp of 480 watts is superior from an illuminating point of view to the direct current open arc, consuming approximately the same energy."

Q. Please explain the illustrations Figures 20 and 21?

A. Figure 20 is the illumination from a 9.6 ampere series D. C. open arc lamp on short arc, showing the shadow zone, with an opal globe; that is a night photograph. You will observe that outside of the black circle you have a brilliant ring; just beyond that everything is in darkness. You will observe that the buildings practically disappear. The black line on the left indicates the side-rod shadow, which you have no doubt often observed swinging across the street, very frequently frightening horses.

Q. Is the illustration, Figure 21, a correct illustration of the absence of shadow with the 6.6 ampere enclosed arc light?

A. Equipped with an opal globe; with a clear globe there would be a faint shadow, but nowhere of the same degree as is indicated in Figure 20; there wouldn't be one-fifth the intensity.

Q. Proceed reading.

A. "Direct Current vs. Alternating Enclosed Arc Lamps. We have so far confined our attention to the relative merits of the direct current lamps, both open and enclosed. We will now contrast the two enclosed arc lamps, namely, direct current and alternating current, each consuming approximately the same watts at arc. Referring to candle-power curves (Fig. 3), it will be observed that the direct current lamp gives slightly more light than the alternating.

In illumination curves (Fig. 4), we also note that the direct current lamp gives more light at the light intersecting point; the difference is not so great, however, but that it may be nearly, if not entirely, compensated for by the better distribution of light from the alternating lamp, the latter having a more subdued light in its immediate vicinity, which increases the relative effect of the light at a distance by reduced contrast.

Carrying efficiencies back to the generator shaft would in many cases throw the balance in favor of the alternating arc, but the efficiencies of different plants are so greatly modified by local conditions that the watts at lamp terminals form a more satisfactory basis to work from."

Now I would like to say in that connection that the advantage of the alternating enclosed arc, where it pulls up to practically the same illuminating value as the direct current enclosed, is due to the fact that the minimum readings, which are not shown in Fig. 4 are higher; they never fall quite so low as in the direct current lamp, and the characteristic is more near spherical.

Q. Proceed.

A. "Globes. The light from the

arc is subject to such wide variation that it is practically impossible to operate a photometer with sufficient accuracy to determine the relative values of various globe combinations.

This subject, however, I have been enabled to investigate with considerable accuracy with a luminometer, a simple instrument which I have devised for comparing the strength of illumination at points distant from the source.'

At this point I wish to state that the variations are so great in the arc light, in the open arc particularly, due to different causes, that we found it very difficult to arrive at any satisfactory conclusions as to their relative illuminating effects. I should like to explain the luminometer, which is merely a box with some cards printed in different sized type. The method of using this instrument is to place a card in it, such as Exhibit E, and go to a distance from a lamp to be observed, and gradually work back towards the light until the character of the card selected can be read. In using the instrument a difficulty arose due to the fact that if one knew what he were reading the memory would help him see, which was a very serious situation where actual measurements were to be obtained. To obviate that I had a series of cards printed with letters of no particular meaning, such as Exhibit F.

For our tests a lamp was so arranged that it could be turned around to bring the arc on the same or opposite side of the observers. Complete switch-board, all the necessary instruments and various lights of different colors for signals were had. Five men would go into the field, each with a luminometer, including

myself. When we were ready a signal would be given; say for maximum rating, the lamp would be turned so that the arc would be in the direction of the observers; they would go to a point where it was impossible to see the characters, and gradually work back slowly until a reading could be obtained, at which point a stick with a number on it would be placed on the ground, representing the lighting distance when the arc was turned around towards the observers.

Occasionally there would be freak readings, and after some investigation or experience, it was possible to avoid the freaks. Again the observer would approach the lamp, and then recede taking readings. In one case your eyes are going from darkness to light and in the other case they are going from light to darkness; one to compensate for the other. Strange to say, the sticks would get placed in just about the same spot, approaching or receding from the light, which was rather unexpected.

The next observation would be with the lamp reversed, with the arc on the opposite side of the carbon tips. In order to prevent the men from carrying any impression, the sticks were removed after each reading was noted.

Those tests were carried on not only to cover this series of results, but they were carried on for practically a year, and they still continue. If we found a lighting distance of 300 feet on one reading and 200 feet on another, we would average the two, and give the average result as the real lighting distance.

Q. Is there any better device, so far as you know, to find out what the lamps are doing?

A. I don't know of anything that will give as uniform results, although we found great difficulty with the open arc, as the lighting distance would be 100 feet on one reading, and probably 600 feet for the next, showing the tremendous variation in the light from this lamp.

Q. That is work in the laboratory, or where?

A. That is out in the field.

Q. This was under practical conditions?

A. Under practical conditions. Tests were conducted on the various classes of globes to obtain their lighting distances; that is shown by Figure 10. The 6.6 ampere series alternating lamp has an average lighting distance of 227 feet; with an opal enclosing and a clear outer globe, the variation is from 143 to 310; that is a variation due to the wandering of the arc; and I would refer to the point I made earlier, that the opal globe while absorbing some light, by changing the character of distribution actually gave you a greater lighting distance; two opal globes give you a smaller variation, but the density is so great then it would hardly do for general street lighting. It is safe to say for the opal enclosing globe there is a gain of ten per cent. lighting distance, compared with the clear globe.

Q. How with reference to some other style of lamp?

A. The direct current open arc varied so much that we could not make any definite readings; its candle-power varies between 200 and 600 feet.

Q. Whereabouts then, can the

Board of Arbitration put their finger upon the mean spherical candle-power limit?

A. It depends upon the weather, etc.; the conditions that would obtain this week of the total flux delivered, might be entirely different next week. Will you refer to luminometer diagram Figure 15. There you see that the enclosed arc lamps, direct current and alternating current, taking an equivalent energy, with the opal and the clear globes, give very little difference in the maximum candle-power, but the minimum is reduced, due to change of characteristics due to a change of globe.

Question by Arbitrator:

Q. Have you found that it made any difference whether an observer was near-sighted or not; would that same ratio hold?

A. No, the ratio would not hold; it is necessary to select your men, and calibrate every man; we calibrated the men every other night on these comparisons.

Q. What do you mean by calibrating a man?

A. I mean we took an intensity of about .006 candle foot of illumination as a minimum; if a man can not distinguish the characters with that illumination, we consider him defective and do not use him. After you select a set of men it is simply the results that will obtain, as illustrated in Figure 15, which is the most remarkable illustration of accuracy, I have ever observed in any lighting measurements of this class. Each man is represented by a different character; for instance, my readings are represented by an x, and you will observe they are nearly all on the right hand side of the average, show-

ing a little personal difference in observation.

Examination Continued by Mr. Schuyler.

Q. Now as to the practical part of the instrument?

A. It would hardly do to place that instrument in the hands of one who had had no experience with its use, and ask him to see if he couldn't find the same lighting distance we found; he might see to read with a certain degree of ease; the next man would see to read with a still greater degree of ease, or would strain harder to read the type, and of course would get dissimilar results; for instance, they would perhaps take a few readings, and establish a certain degree of ease of reading, and then go out and check up lamps without any trouble, but not make scientific readings, like ours. In the case of our tests the men were trained to it.

Q. Have you made any luminometer tests of the lights in this city?

A. I took some maximum and minimum readings here and I went to Denver and checked the open arc.

Q. What do you say as to the results of your luminometer tests in this city?

A. The lamps were working normally here.

Q. And what do you say as to the Denver 9.6 old style direct current open arc lamps?

A. They were working a little better than usual, but were going through the ordinary changes. In two or three instances where I was within 25 feet of the lamp, I couldn't read the luminometer card, and again I got beyond the 400 foot mark a few

times. Nothing out of the ordinary developed.

Q. What have you to say about Prof. Shedd's experiments, at last night's session?

A. The professor merely illustrated the fact that once every alternation there is momentarily no current flowing in the alternating current lamp, at which time the light is actually out; which is admitted, but during the period that the A. C. arc is burning it is brighter than the continuous current arc taking the same energy; so that the illuminating result amounts to about the same thing.

Q. I understand your position to be then that a candle-power in the neighborhood of the horizontal is much more effective for illuminating purposes?

A. Much more effective for street illumination; from say, five degrees below the horizontal down to about 20 degrees below the horizontal is the most useful for the purposes of street lighting.

Q. And that a lamp which tends to throw candle-power toward the horizontal of much less candle-power may be more effective than a lamp of greater candle-power, tending to throw it away from the horizontal?

A. That is the exact situation, and one of the reasons why the enclosed arc lamp, giving less total candle-power, is considered a superior illuminant, and is replacing the open arc lamps.

Q. Mr. Ryan, you have heard the testimony with reference to the tests made by Professors Shedd, Streiby, Armstrong, and Matthews, upon the

streets of the city of Colorado Springs, represented in figures by Exhibits Nos. 26 and 27. I wish to ask you as an electrical engineer to express your views upon the fairness of those tests as determining what the other lamps in the city of Colorado Springs were doing at those respective times?

A. Answering the question exclusive of the question of candle-power I should say it was a very small number of lamps to take as an average to figure up the output of the entire plant of that size.

Q. By taking a lamp or so in one or two circuits can you in any way determine what is being done upon the other circuits?

A. I don't see how you can.

Q. Would you then call that test so made, in any sense a fair test as representing the average of what the entire system of lamps in the city of Colorado Springs is doing, or was doing at those respective dates?

A. No, I don't see how you could do that.

Q. State your reasons why it wouldn't be fair?

A. Because conditions vary in the lamps to a certain extent. The enclosed arc lamp has the natural defects of mechanism incidental to all pieces of machinery, no matter how well made, and wind storms, or other reasons might produce some injury to the lamp, or change its condition from perfect; a little off adjustment, might throw one a little high and another low; if it so happened that they obtained a lamp in either the high or the low condition, then it would either give you an impression

that the lamps were doing better than the average, or doing worse than the average; and I should hesitate to accept a "snap" test of this kind to represent the condition of that plant even for one year.

Q. Would it, in your judgment, be in any sense, a fair basis for computing or measuring the amount of money to be paid for or received by a party, covering any period of time?

A. I hardly think so; no.

Q. And wouldn't it be equally true, not only as to the months previous to the dates those were made, but also as to each night on which the tests were made?

A. It would more nearly give you an idea of the particular night, but still I don't see how you could accept it as indicating what was happening to 241 lamps on different circuits.

Q. If you accompanied tests of this character by visual observation of what lamps were doing, as you went up and down the streets, would that aid in any way the accuracy of the test, and make it applicable to general conditions?

A. Visual observation is a very treacherous thing. For instance, the streets of this city I should say were somewhere from 250 to 300 feet wide. These streets are relatively wide; the buildings are very dark, and the illumination here would probably seem much less brilliant to the ordinary observer or even a keen observer than the same illumination would compare in some other city, where the streets were narrow, and the buildings of a somewhat lighter character. That is a general statement of the condition.

Q. Do you know the streets in Brookline?

A. Yes.

Q. Do you think that under your statement that Dr. Bell, being accustomed to those streets, might be deceived by the brilliancy of the lights in those streets?

A. I don't know how much he would be deceived, but I personally couldn't carry an impression from one city to another; although I will say that Brookline has the advantage of narrow streets.

Q. Is visual observation in any way considered by the profession as an element of testing lights?

A. No.

Q. Is it to be depended upon in any degree for the purpose of ascertaining accurate data with reference to what lights are doing?

A. No.

Q. How frequently should one check the condition of arc lamps, to ascertain what they are doing?

A. I should say it would not be necessary, under ordinary conditions, to take them oftener than once a week, or once every other week; and if you wanted to learn accurately what they were doing, you would have to test them.

Q. How many lamps would you take into consideration?

A. You should test at least a third.

Q. Is there another method of testing?

A. Yes, record your energy at the station through suitable meters, and deduct the losses. Of course, in or-

der to do this a daily record would be necessary, and a test for grounds.

Q. From your knowledge of the Colorado Springs plant would you say that would be a practical method of getting at what the lamps were doing in this city?

A. I would.

Q. Express your views upon Exhibits Nos. 28 and 29.

A. It is hardly fair to take tests of this kind where a limited number of readings have been taken, and criticise them, because even with the best of apparatus, and the greatest of care, you will get big differences. I think they are clearly representative of the laboratory condition of the lamp, taking its full amount of wattage. If tests were carried on sufficiently far to arrive at a true character, Figure No. 29, the lower part of that curve would have a shorter bend. Aside from this, they look very good.

Q. Do you think the conditions adopted were laboratory and not practical?

A. I think it is a question of the laboratory and not practical conditions.

Q. Look at the paper marked Exhibit 32, or the enlargement of that, marked Exhibit "G", and state what it represents?

A. A series of candle-power curves.

Q. Will you please explain the curve marked A, and the peculiarities of that curve as you see them?

A. Curve A shows a fairly good characteristic of the 9.6 ampere open lamp, and is fairly representative of

what it should do, except from the horizontal down to 30 degrees, where it is off; and this is the most critical part of the curve. It shows that it has not been carried far enough, that is all. Furthermore, it is very bad to jump fifteen degrees at the critical point. For instance, if you have a reading every five degrees below the horizontal, five, ten, fifteen, twenty, twenty-five and thirty, then the error which evidently occurred on that curve would have been found, and the large swell of the curve between zero and thirty degrees would have disappeared. But that is not of any great significance, except to show the great difficulty of obtaining correct curves even with the very best apparatus, and with observers of experience who do their best.

Q. Where on the curve is the hissing point?

A. Between two hundred and three hundred candle-power; but the hissing point can better be expressed in volts; about 37 volts in the so-called standard lamps of the American class, using the solid carbons.

Q. And what would you say as to the 9.6 old style dropping below the hissing point?

A. It does so if it is not in good condition; if a storm comes up you will find lots of them down below the hissing point.

Q. Which tends to render the candle-power still more variable?

A. Yes. I think it is a very good illustration of how we deceive ourselves by looking at a polar curve. In Exhibit No. 32, A appears to give a tremendous candle-power as compared with B, but if you will

compare the candle-power of A and B as given by Professor Matthews, you will find that there is no such actual difference.

Q. On the other hand, do curves B and C do justice to the candle-power of the enclosed arcs?

A. *They do justice from a laboratory point of view; if you compare the maximum of A and the minimum of A, and consider the time element, and take your curve B and treat it likewise, then you will find that while the one falls far below and sweeps above its average candle-power, the other, though apparently less, has more uniform candle-power, with the net result that the total light delivered by each places them on a very fair basis of equality, provided they both take the same amount of energy.*

Q. So, if a lamp on the city streets takes the same amount of

power, it is on a practical illumination equality with the 9.6 old style direct current open arc lamp?

A. *That statement would have to be modified within certain limits. For instance, you could have a current so low and a voltage so high that the amount of light that you would get for a given amount of power consumed would not be anything like what you obtain from the present lights that you have, or from the open arc lamp; but they are on a fair basis of equality, if you maintain your current somewhere between 7 and 7.5 amperes, but not below, and the lamps are properly equipped. As far as illuminating value is concerned, a 6.6 ampere enclosed arc lamp is regarded quite generally over this country as a superior illuminant, take it year in and year out, to the 9.6 ampere open arc, known as the 450 watt lamp.*

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 9 A. M., FEBRUARY 6, 1907.

MR. RYAN resumed the stand.

**Direct - Examination Continued
by Mr. Schuyler.**

Q. Mr. Ryan, referring to the point that we were discussing before the last adjournment, I ask you if you desire to further discuss that proposition?

A. I think the way that it was stated may be misleading. A distinction must be made between a light which could fairly be considered over a period of time the equivalent of the open arc lamp, standard 2,000 candle-power, and a lamp which could fairly be substituted on the 450-watt basis of the N. E. L. A. resolution. In the latter case a voltage limit should be set at about 80 to 85 volts, to prevent very low currents, and excessively high voltages being used.

Q. In the record of last night you spoke of maintaining your current somewhere between 7 and 7.5 amperes?

A. I prefer to substitute the voltage limitation rather than the current limitation. The current limitation which I had in mind last night was to place the two enclosed arc lamps, namely the 6.6 ampere and the 7.5 ampere alternating arc on practically the same basis of illumination.

Q. Has candle-power ever been the basis of measurement for the sake of arriving at amounts to be paid and received in street lights?

A. I do not know of a single case where candle-power has been

used as a basis in the art of street lighting.

Q. Isn't it a fact that the term "candle-power," being in its character such a variable and uncertain quantity, has simply been used to apply as a sort of designation to different types and classes of arc lamps?

A. Yes.

Q. What was the proper basis of measurement for commercial arc lighting, upon which to base charges, back in the period between 1895 and 1900?

A. I think the most common form was the selling of a lamp, with a trade name of standard or nominal 2,000 candle-power, it being understood that the lamp should consume an average of 450 watts at its terminals.

Q. Then it was the energy consumed that was the basis, as I understand it?

A. Yes.

Q. To which the designation "candle-power," the mere name, was applied?

A. Yes, the only tangible limitation.

Q. Yesterday you stated that in the 9.6 ampere light, the old style, the variation in the mean spherical candle-power was such that in practical working it was impossible for the Board to put their finger upon any correct mean spherical candle-power over a period of time. On the other hand, you stated that the

enclosed 6.6 arc, of the character we have here possesses, over a period of time, quite a constant condition, from which you could figure an average continuous, and quite accurate, mean spherical candle-power?

A. Not quite accurately in either case; owing to the smaller degree of variation in the enclosed arc lamp, I think there is no question but what you can arrive at a much closer idea of the average illumination delivered, than you can from the open arc, but I don't think with what knowledge we have at the present day on the subject, that it would be logical to try to draw a contract based on candle-power. The bulge near the horizontal, Exhibit No. 32, on curve A, appears quite insignificant, but being in a critical part of the curve, it would probably be fifteen per cent. or more in the reduction of the total flux of that lamp. I also stated that the point should be anchored at five degrees intervals over the critical range. My curves show ten degrees. I would not even take these curves, that I have spent years working over, to get the best results, and use them as a basis.

Notice the curve B, and curve C; two alternating current lamps, one taking 427 watts, the other 480; they have entirely different characteristics. If the true average or characteristics of those curves could be obtained by carrying tests to a sufficient extent, you would find the characteristics the same.

You notice that curve C has a characteristic about the same as the open arc lamp; that is physically impossible. Curve E returns on itself; that is a condition which could not exist with an enclosed

arc lamp under those conditions taking 340 watts.

This merely shows that, as stated yesterday, with the best of apparatus, the most careful observers, observers of reputation—like Professor Matthews—that you cannot make candle-power curves that are sufficiently close to use as a basis for selling the light. My curves are open to the same criticism, and everybody else's in the same category, whether they are made in this country or in Europe. This applies to arc lamps.

Q. May I ask if the curves that you speak of as having been making over a period of years, and after great labor, and which still have proven futile for the purpose of determining correct candle-power curves, were, to speak scientifically, carried to a better conclusion, than those which were introduced by the plaintiff's witnesses in this case?

A. Yes; because they represent several hundreds set of tests. Prof. Matthews' curves, if carried on far enough, would very soon give you the true characteristic of the lamp under a fixed laboratory condition, but they do not take in the time element, and without this time element it is impossible to determine the average candle-power that is delivered.

Q. Was this condition true of the art in September, 1898?

A. Yes.

Q. It was also understood that the mean spherical candle-power varied in such a way as, in practical working, to make impossible any basis upon which to make a charge?

A. It was true then and it is true even at the present time.

Q. Now, if under any possible conception of this matter a candle-power was to be considered as a basis, would you take into consideration the maximum candle-power or mean spherical candle-power?

A. If we could arrive at a basis, the mean spherical candle-power would be the logical, the fairer one to use.

Q. Now, we have had some discussion as to foreign conditions under which the 9.6 open arc direct current lamp is used. What do you say as to the practicability of applying foreign conditions of operation to this country?

A. The foreign conditions are entirely different. They make very delicate lamps on the other side, which require the greatest of care in order to keep them running. Labor is cheap, cost of carbons relatively low, cost of current relatively high. In this country labor is high, carbons are high, cost of current relatively low. It would be practically impossible, for anything like a reasonable price, to maintain these foreign lamps in this country; lamps of the Siemens Halske type, or of that order.

Q. Mr. Ryan, I hand you the report of the special committee on the rating of arc lamps in 1894, at the meeting of the National Electric Light Association, and which has been read, and ask you to state to what, in your opinion, that rule applies?

A. It has always been and it still remains my impression, that this resolution was drawn to cover any lamp that consumed 450 watts. For instance, to show that it certainly extends beyond the mere question of

one type of lamp, we have the following statement embodied in the resolution; "The measurements being made at the lamp terminals, where no sensible resistance is included. In case such resistance is used, it must be excluded in the measurement of the voltage."

That suggests at once that they must have had in mind other lamps aside from series lamps, because the ordinary series lamps of the street type do not include any form of resistance. In the second place, the question of alternating current lamps was introduced at that meeting, and inasmuch as they did not specifically state direct current, they must have intended to include the alternating current. Furthermore, aside from the Westinghouse experiments at that time, the General Electric Company were well along with the development of what was known as the Thompson '93 class of lamps, comprising direct and alternating current, multiple and series types. While these lamps were not on the market in 1893, there was no secret about the development that was going on, and the committee would undoubtedly have known something of the future development. Furthermore, it does not seem reasonable to suppose that the committee would spend time on covering an existing condition, without looking into the future. It is perfectly clear in my mind that the committee certainly must have intended to include 450 watt lamps of the future; particularly as their intention was to avoid misunderstandings and disputes over contracts. Now, this resolution does not in any way deprive the consumer of anything that he had before. It is not an attempt to cut down what he had before, but to give him something

with a name; with a rating, that could then and in future years be actually measured. If they did have the future in mind, there is no question but that the 450 watt rating is good for any class of lamp that may come out.

Q. Mr. Ryan, taking the language by itself, what do you say the term "standard two thousand candle-power light" as used in the Jackson franchise means?

A. A lamp consuming an average of 450 watts at its terminals.

Q. You mean any lamp that would do that?

A. Any arc lamp, alternating or direct current.

Q. For street lighting purposes?

A. Yes.

Q. What was the character of the membership of the National Electric Light Association in the year 1894?

A. It consisted of 107 representatives of the leading electric light and power companies in all parts of the country, with an associate membership of 112 other firms and individuals actively interested in the development of electric light.

Q. What conditions have the illuminating profession been attempting to bring about in arc lighting?

A. Reduction in intrinsic brilliancy; diffusion of the illumination, and the utilization as far as possible of stray light; ten times the amount of illumination would give poor illumination or light if it is in streaks or intensified at one spot, and weak at the other.

Q. I will ask you to look at Ex-

hibit I, and state what that represents?

A. That represents the sale of the enclosed arc lamps for the year 1895, up to and including 1900; also the sale of the open arc lamps through the same period. It shows that the open arc lamp reached its maximum at 1897, and in 1900 it was very much below its maximum; about 1901 and 1902, there was just a very few sold.

Q. What in 1895?

A. Yes, in 1895 about 2,500 sales of enclosed arc lamps for that year.

Q. And for the year 1898, what was the sale of the enclosed arc lamps?

A. About 34,000.

Q. And what in the preceding year?

A. Nearly 13,000.

Q. Mr. Ryan, did you make tests in September, 1906, of the lights in Colorado Springs, the results of which are embodied in Exhibit J?

A. Yes.

Q. In that report you say, "I question very much whether the General Electric Company would be willing to stand back of guarantees with the 6.6 ampere apparatus overloaded to this extent." Mr. Ryan, may I ask you who does the matter of overloading affect; the public or the company that is running the lamp?

A. The company that is running the lamp.

Q. Is there any betterment of the service in that situation?

A. None whatever; the lamps may deteriorate a little more rapidly, and would cause expense, which

would fall on the operating company.

Q. Now, have you some specific figures as to candle-power?

A. Yes.

Q. We have discussed it in the abstract; will you please give the precise figures that you have, and explain to what conditions, laboratory or practical, they apply?

A. These candle-powers were taken under a fixed wattage, precisely as Professor Matthews' test was taken.

A. C. enclosed 6.6 ampere lamp, maximum 480, mean spherical 195, mean lower hemispherical 345, watts 430; A. C. enclosed 7.5 ampere lamp, maximum 550, mean spherical 235, mean lower hemispherical 410, watts 450; open A. C. 9.6 ampere lamp, maximum 1,250, mean spherical 370, mean lower hemispherical 550, watts 450; D. C. enclosed 6.6 ampere lamp as sent out from the factory, maximum 650, mean spherical 300, mean lower hemispherical 435, watts 450.

Q. Those are under fixed laboratory conditions?

A. Yes.

Q. Now, following up your figures, what do you find?

A. You will see by those figures that the open arc lamp as made, is credited initially with a higher candle-power than the alternating arc lamp taking the same energy; the direct current enclosed open arc is also credited with a higher candle-power than the alternating enclosed arc taking the same energy, but I will state that even with the same energy, the illuminating values of the two lamps are on a reasonable basis of equality.

Q. That is under practical operations, the apparent difference there in candle-power reduces itself to a practical equality?

A. Yes; there is some difference between the two lamps; there is no question about that; they have different characteristics.

Question by Arbitrator:

Q. Where do these figures come from; from your own light measurements?

A. Yes, they are my own measurements, extending over a period of five to six years. Now, these are merely the fixed conditions of the laboratory, and cannot form a basis for contract; the time element is not introduced there, and cannot be.

Examination Continued by Mr. Schuyler.

Q. Does your report, Exhibit J, cover every lamp in the city?

A. I think not; it covers 227 lamps; I understand you have 241.

Q. And each circuit was considered?

A. Yes.

Q. Well, did you make any tests of lamps brought into the sub-station?

A. No, I did not.

Q. Will you turn to that portion of your report which is headed "Stations using 6.6 ampere series alternating arc lamps," and state what that refers to?

A. That is a partial list of stations where they have substituted the 6.6 ampere series alternating lamp for the open arc, direct current

so-called 450 watt lamp. I don't know the form of contract in those cases; they have accepted those lamps as a substitute for the 9.6.

Q. Which system, the 6.6 A. C. enclosed or the 9.6 D. C. open, in your opinion, is the most generally used in the United States to-day?

A. There are about a thousand installations; this list gives something like 700 installations, and they are practically all 6.6 ampere.

The United States census for 1900 contains 423 cities having a population of 10,000 or more, and of these 240 have adopted the General Electric Company's enclosed arc street lighting system. Of the total, there are 26 stations using 7.5 ampere, and 699 using the 6.6 ampere lamps.

Q. In the purchase of gas light or incandescent light, is it based upon candle-power, or on what basis?

A. In buying light of incandescent lamps, you buy so many watts, and if you buy gas you buy so many cubic feet of gas; you may use a lamp standardized at so many candle-power, but what you buy is watts, and you buy so much gas, and that is what you pay for.

Q. In your opinion, what is the fair basis for the Board to consider this subject upon, in the way of measurement and charges made?

A. I don't see what you can base it on aside from energy; you certainly cannot base it on candle-power.

Q. Energy as expressed in watts?

A. Yes.

Cross - Examination by Mr. Robinson.

Q. Mr. Ryan, how did it happen that you came here, and in whose interests are you here?

A. As I understand it, I came at the request of the Hydro Company, but I don't know who the official was.

Q. And your salary from the General Electric Company would continue during such service?

A. Undoubtedly.

Q. And your expenses be paid by them?

A. I don't know; the question hasn't been raised; I don't know that either the General Electric Company or these people would raise any question about it.

Q. Now, who is George B. Tripp, to whom you made this report, marked Exhibit "J"?

A. He was the General Manager, as I understand it, at the time, of the Colorado Springs Electric Company.

Q. And who is the Colorado Springs Electric Company?

A. I don't know, sir.

Q. What have they to do with this controversy, if you know?

A. Nothing at all—I don't know.

Q. Do you know whether or not the Colorado Springs Electric Company is lighting the streets?

A. No, sir; I don't know this instant who is lighting the streets, so far as the companies are concerned.

Q. Well, you made an examination?

A. Yes.

Q. For the Colorado Springs Electric Company?

A. *I don't care who it was for; I examined the condition, and reported upon it to Mr. Tripp.*

Q. But the Hydro Company didn't say anything about tests to you?

A. *I don't think so; Mr. Tripp was the gentleman that I met here.*

Q. Were you in the employ of the General Electric Company in 1901, when you read the paper marked Exhibit "B", Mr. Ryan?

A. *Yes.*

Q. Do you remember of any other papers that you read before societies while in the employ of the General Electric Company?

A. *Yes, several of them.*

Q. And while you were on a salary by the company?

A. *Yes.*

Q. And to which meetings the company paid your expenses?

A. *Undoubtedly.*

Q. Did not the General Electric Company print this Exhibit "B" and circulate it?

A. *Yes, but I have not embodied anything in the paper which might be considered for purely commercial purposes.*

Q. Wasn't it one of the purposes of writing this paper, marked Exhibit "B", to show the superiority of the apparatus of the General Electric Company?

A. *After the superiority had been determined, yes; had the superiority not developed, that paper would not have been printed.*

Q. Referring to some of the last testimony given in chief, isn't it true that electric light companies sell light on the basis of a certain price per hour for a 16 candle-power lamp, in many cases?

A. *A certain price per hour, yes; there are some obsolete contracts of that sort. An up-to-date plant sells exclusively on a watt hour basis; and when they do sell on the basis of 16 candle-power, that is simply the name of a lamp; it is understood that the lamp is not maintained at 16 candle-power, but will gradually drop back until it may get down to 12, or even 10.*

Q. That is understood by the company?

A. *Understood by everybody that uses it; don't you know that an incandescent lamp depreciates after it has been burned for a certain length of time?*

Q. I don't know that when I am paying for 16 candle-power lamps I am only getting ten or twelve?

A. *That is all you are getting and sometimes less.*

Q. Well, I am a worse victim than I thought I was. Do you mean now to tell this Board that it is the common custom of lighting companies to swindle their customers in that way?

A. *That is not swindling; it is a well known fact.*

Q. If they sell 16 candle-power lamps, and deliver ten for the sixteen, isn't that swindling?

A. *No, sir.*

Q. That is all right in electric lighting matters?

A. It is the same thing in gas matters. You can't obtain an impossibility.

Q. I can ask that the contract with my opponent be fulfilled, can't I?

A. You buy a 16 candle-power lamp, so rated, and when it is new it is a 16 candle-power lamp; that is what you buy and pay for; after that lamp is put in service it gradually depreciates; there is no attempt to make customers believe that that lamp will not go down; you must realize that every lamp depreciates until you have to put in a new one; you cannot maintain the candle-power indefinitely. You may buy a 16 candle-power incandescent lamp, rated at $3\frac{1}{2}$ watts per horizontal candle. That lamp has a mean spherical candle-power of 4.24 watts per candle. After the lamp burns 500 or 600 hours you have a mean spherical candle-power of anywhere from 5 to 6 watts per candle, and if the lamp still continues to burn after it has run 80 per cent of its initial value, the electric companies tell you that it would pay you to throw the lamp away and put in a new one. If you allow it to continue in use and it doesn't break, it will consume 6 or 7 watts per candle; so that it is all the time changing, and it is impossible to make a definite contract on the amount of candle-power delivered over a period of time. It is true of gas; it is true of incandescents, and it is true of the arc, only it is harder to locate the arc than it is the others, on account of its peculiar variations.

Q. Now, speaking of the incandescent light, Mr. Ryan, and the depreciation of that, as I understood it from the blackening of the globe—

possibly some depreciation in the filament?

A. Yes.

Q. It is continuous?

A. Yes.

Q. And that cannot be restored, if at all, without taking the filament out and putting in a new one; getting a new lamp?

A. Correct.

Q. Well, that condition doesn't apply to street lamps, because you can clean them up every night?

A. You are now comparing one variable of the arc with the incandescent lamp, viz., the variable due to the dirt on the globe; that has nothing whatever to do with the other variables.

Q. How large is that variable?

A. The variation of the useful light of the arc lamp due to a deposit after one week's run, should not exceed 5 per cent. Of course, the distribution would be somewhat changed; perhaps for the better.

Q. Does not that blackening of the globe in the arc tend most to reduce the illumination at the horizontal point?

A. No, sir, above the horizontal.

Q. Now, is it not true that in 1898 many of the large electric companies sold their product, not by the watts, but by the lamp hours, based on their alleged 16 candle-power lamps?

A. I cannot recall any such cases; there may have been some.

Q. Is it not a fact that many of the companies that used meters for

their own production, billed out their incandescent product in lamp hours?

A. They had all kinds of ratings in the early days for incandescents.

Q. Was the lamp hour one of them?

A. That might have been one of them; there were several.

Q. You spoke of the Thompson lamp of '93?

A. Yes.

Q. And the ribbon feed lamp?

A. Yes.

Q. Were those constant potential lamps?

A. The ribbon feed was a lamp run from an individual constant current transformer, on a constant potential circuit; and the Thompson '93 embraced the alternating and direct current circuits of all classes.

Q. Can you state in what places and in what numbers this Thompson lamp was used for public street lighting; speaking especially of it in its alternating current series form?

A. At that time I was on what is called the expert course, and I knew very little about where any were being placed. I knew they were going out from the factory quite lively.

Q. So you don't know where those lamps were used?

A. No.

Q. Can you tell the Board when the General Electric Company stopped making the 9.6 ampere open arc lamps?

A. It was a production that fell off gradually. I cannot give you the precise date. Exhibit "I" gives

a pretty good idea of what was taking place.

Q. But as I understood you yesterday, you said that the General Electric Company had stopped making them?

A. Yes.

Q. When did they stop making them?

A. I can't tell you exactly, but possibly if some central station or some lighting company required some new lamps, they might make up a small batch.

Q. Now, are any other companies than the General Electric Company making the 9.6 open arc lamp?

A. I don't know. The Brush lamp is also made by the General Electric Company; occasionally we see some repair work going.

Q. You don't know, then, whether any company in the United States is manufacturing the 9.6 open arc lamps?

A. I will not say they are not making any; to the best of my knowledge the lamp is obsolete.

Q. Isn't it true that the General Electric Company makes and lists the 9.6 Brush arc generators for the operation of these lamps?

A. They are making the Brush arc generator to operate enclosed arc lamps, but not open lamps; they are made for low current, 5 and 6.6 amperes, but we are not supplying generators of 9.6 amperes.

Q. Well, don't they list, and aren't they selling, or aren't they willing to give quotations on the 9.6 ampere Brush arc generators?

A. I presume if any one wished

the 9.6 ampere machine, there is no question but what they would wind one for them, and it might appear in some of our catalogues, but I don't know of their selling any.

Q. You won't say they don't list them?

A. I wouldn't say that, because our catalogues are very extensive, and we like to supply our customers with supply parts.

Q. I will ask you whether or not the 9.6 ampere Brush arc generators, listed by the General Electric Company, are intended to operate open arc lamps or enclosed?

A. If you find any listed at the present time they are intended for open arc lamps, because we are not running any enclosed arcs at that current.

Q. Now, can you tell the Board when the General Electric Company put out its first tub transformer?

A. It states in Exhibit "K", last page, "that since the introduction of the system in 1898, orders have been received," etc., so I presume it was in 1898, although I cannot depend

upon my memory to state definitely that that is right.

Q. The best information you can give is that it was in 1898?

A. Yes, judging from that Exhibit.

Q. Does Exhibit "I" include the sales for enclosed multiple, as well as series lamps?

A. Yes, I think it does, although I wouldn't swear to it.

Q. Then if it is true that the first tub transformer was sold in 1898, then the enclosed lamps sold prior to that time, as shown on Exhibit "I", must have been the multiple lamps?

A. If we assume that the enclosed arc lamp was not introduced before 1898, I say I must reserve a little liberty on that, because I cannot exactly remember. It wouldn't be on there if it wasn't in service. I would also like to state that there may be many lamps sold, but not listed, because this list was made up from statistics immediately obtainable.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 2 P. M., FEBRUARY 6, 1907.

MR. RYAN resumed the stand.

**Cross - Examination Continued
by Mr. Robinson.**

Q. Mr. Ryan, yesterday you read from page 153 of the proceedings of the National Electric Light Association of 1898, an article by Mr. Wagner. I will ask you now to begin where you left off and read the entire paragraph and then tell us whether or not the arcs referred to were constant potential, and not constant current arcs?

A. Yes. But at this time there was a general impression that the difference between the alternating and direct current enclosed arc was as great as the open arc, due to the fact that extensive tests up to that date had not been made. It is a well known fact that there is quite a decided difference between the open A. C. arc and the open D. C. arc; that is due to the peculiarities of the arc itself. In one case you are using cored carbons, and in the other case sometimes both cored, sometimes one cored, and sometimes both solid. There is no question, however, but what the difference between the enclosed arcs is not so great as the difference between the open arcs. Furthermore, my figures which I gave you this morning show that the direct current enclosed arc is more efficient.

Q. I will ask you, then, whether or not Mr. Wagner, in the paper which you have read, did not refer to the enclosed alternating arc?

A. He undoubtedly refers here to the enclosed multiple lamp. There

is no dodging the question that the direct current enclosed arc, carrying 450 watts, undoubtedly does take more energy per candle than the open; there is no question about that, but as far as the illuminating value of the two lights is concerned, there is not very much difference.

Q. I understood that you said you used from five to ten men in making your luminometer tests, working nights, for about one year, and that you worked with them a large part of the time yourself?

A. Yes.

Q. Were you with the men for the purpose of directing them, to prevent errors in readings by the instrument?

A. I was there to see that error was not introduced, and to watch all the points.

Q. An instrument which would require you to be present to avoid errors in its readings would hardly be trustworthy, would it?

A. Every light-measuring instrument is open to that objection. The errors that I have mostly in mind related to lamps, voltage, current, etc.

Q. Now, is that instrument in anything like general use?

A. I presume 25 or 30; at one time I would not permit them to go out, because I felt it would only be a source of misunderstanding.

Q. Now, were the test readings with the luminometer, about which you testified yesterday, made with

the sized type shown by Exhibit "F"?

A. Yes.

Q. What fraction of candle-foot have you taken as necessary to read this type in your tests?

A. Six thousandths; that is not clear reading; it is the making out of a character.

Q. I understood from the tests that you could read the letters?

A. You could just make the characters out.

Q. And that you could see that type at what distance?

A. That is recorded in the Exhibit there; about 225 to 250 feet.

Q. Well, didn't you say that you could read that type, or see that type, at 600 feet?

A. With the open arc, yes.

Q. That was the old 9.6 ampere lamp?

A. Yes, I have seen freak readings of that kind.

Q. Now, about how high was the arc above the ground?

A. I do not confine myself to any particular height, but in the tests referred to the height was about 25 feet. Occasionally the arc will come up to a point where you would possibly be getting a freak of 1,800; it isn't impossible to get freaks of about 2,000 candle-power.

Q. Now, will you please compute the candle-power given by the arc in that direction from those figures?

A. Did I confine my statement to the type, or was my statement not confined to the test here in this Exhibit?

Q. Oh, no; I asked you about the print on Exhibit "F"; that was the one you used; you said you could see that print 600 feet, from a 9.6 open arc, direct current, sometimes; the candle foot intensity being six-thousandths?

A. You could not get any such result unless you had a freak reading. At that distance you must have over 2,000 candle-power to give .006 candle feet.

Q. Please state how you computed that?

A. That is, the square of the distance, multiplied by the intensity of illumination, gives me the candle-power intensity.

Q. Wouldn't you take the intensity as equal to the candle-power, divided by the square of the distance?

A. Inversedly, yes; that is what I am doing.

Q. Wouldn't the candle-power be 2,160?

A. I think that is right; about 2,000 candle-power is what I figure it.

Q. Wouldn't you say that according to that data, it would give 2,160 candle-power?

A. Well, that is what it figures.

Q. Yes, now, from that data what was the angle below the horizontal at which this 9.6 open D. C. arc, according to measurement, gave 2,160 candle-power?

A. 2.4 degrees below the horizontal; somewhere in that vicinity.

Q. Now, I wish you would plot that point on this Exhibit "G"?

A. The point would come midway between the horizontal and 5 degrees below.

Q. Now, where would that come out extended on the map to 2,160 candle-power?

A. If those figures are correct, it would be at the distance given, about 600 feet.

Q. Well, can you put that point on that plat?

A. No.

Q. Because there isn't enough paper there?

A. That is one reason.

Q. You can't get it on that plat because the plat isn't large enough, is it?

A. No, it should be entirely reconstructed.

Q. Now, as you cannot plat that point that we have described upon this Exhibit, because there isn't room enough on it could you have platted the remainder of the curve to scale, coming from the point 2,160 candle-power?

A. I don't understand your question.

Q. What we want, Mr. Ryan, if you will give it, will be the approximate distribution of light when you come to that point, 2,160 candle-power?

A. Now, you cannot introduce freak readings into this question of candle-power. This curve would be entirely a distorted curve; on one side there would be no light, and on the other side it would be very nearly on the horizontal.

Q. Mr. Ryan, did you use the

luminometer to compare light sources?

A. Yes.

Q. Can you anywhere compare two lights which are not simultaneously present?

A. Not very well.

Q. In what units is illumination measured?

A. Foot-candles, or candle-feet.

Q. What is the relation between foot-candles and candle-power?

A. Candle-power is an intensity; foot-candles takes into consideration distance.

Q. Well, the exact relation, mathematical relation?

A. Why, you include distance in the question of illumination.

Q. Can you give the formula of it?

A. "The intensity of light from a fixed source varies inversely as the square of the distance."

Q. How do you get illumination curves?

A. By calculating from the candle-power curves.

Q. Now, near the top of page 12, of Exhibit "B", I read: "It is practically impossible to operate a photometer with sufficient accuracy to determine the relative values of various globe combinations." Is that true?

A. Yes, that is correct.

Q. Is that confined to globe combinations?

A. No, sir; in computing these candle-powers, you are taking the arc into consideration.

Q. On what do you base your illumination curves in Figure 4?

A. On candle-foot curves made up by applying the inverse square law.

Q. Does the illumination curve for the 6.6 ampere A. C. enclosed lamp cross at any point that of the 9.6 ampere lamp, open?

A. Yes, at about 10 degrees, see Fig. 4.

Q. But that curve is of a 7½ ampere lamp. I was talking about the 6.6 ampere. Please refer to Exhibit 38, and I will ask you if you recognize the curves as shown there?

A. Well, yes, those are my curves.

Q. Now, then, does the curve of the 6.6 alternating current enclosed, cross the curve of the 9.6 direct current open?

A. Just about the horizontal. This curve only shows the light at 150 feet from the lamp, up to this distance curve A does not cross curve C, in this Exhibit; had the distance been carried out 500 or 600 feet to about the point that we were discussing, then the curves would have crossed; but this Exhibit does not signify the fact that this open curve is going to stay on the outside when that lamp feeds; curve C will dwindle to a little curve away within A. Going back to my statement of yesterday, consider the time element, then your average curve will naturally fall outside. If we could properly estimate the average characteristic, taking into consideration the time element of both of these lamps, you would find that the alternating arc shown in curve A would average outside of the characteristic of the open arc C, over a period of

time, taking into consideration how the lamps would work, day in and day out, in actual service.

Q. You made those curves?

A. Yes.

Q. They are correct?

A. They are correct for laboratory conditions.

Q. As near as a skilful man could get them?

A. They cannot be considered as representing the amount of flux delivered over a period of time, but merely as giving some idea of the general characteristic of the lamp. I do not know of any possible way whereby I can produce curves so that I could say to you, this will represent the amount of candle-power that we can guarantee to deliver over a period of time. I wish we could, but it is impossible to do so on account of fluctuations, which are not at all constant.

Q. The fluctuations go above and below the line you indicate?

A. Yes.

Q. And that would indicate the general condition, wouldn't it, as well as anything?

A. On Exhibit "G," A represents the distribution of light from a 9½ ampere, 48 volt arc, which may climb up a couple of volts more before it feeds, but the chances are it will feed somewhere in that vicinity; then it may drop 5, 7 or more volts; wherever it goes to, the time required for it to climb from that point to feeding point is possibly five times more, in some cases, than the time required for it to go from the point where the curve is made,

to the point where it will drop back. Therefore, there is absolutely nothing to average from.

Q. In Exhibit "B", I read, "For measuring arc lights it is usual to employ a photometer," etc. "There are also other satisfactory methods." Was the photometer test one of those considered as a satisfactory method?

A. There are various satisfactory methods of taking candle-powers; but they do not include the time element.

Q. Can't you take one moment of time, and from it get a representation of the entire time; and isn't that what you do in your curves; and if that isn't the fact, then what in the world are the curves for?

A. We take several hours of time, weeks of time, trying to arrive at a characteristic; but that characteristic is not a characteristic that you could take and state that that is the candle-power that we will deliver to you on the contract basis. It is absolutely out of the question, and cannot be done.

Q. Now, you stated, as I understood, that Professor Matthews' laboratory at Purdue University is well equipped for photometric tests?

A. I think it is.

Q. And I understood you also to quote with approval Professor Nichols as authority on photometric questions?

A. Yes.

Q. I understood you to say yesterday that the D. C. 9.6 open lamp was rejected in this country chiefly because of inherent defects in it; is that right?

A. That was one of the causes.

Q. If it was true the lamp was retired from service generally and chiefly upon the ground of inherent defects, why is it almost exclusively used for lighting in European countries to-day?

A. They do not use the American open arc at all in Europe.

Q. I didn't say American; I said the D. C. open arc lamp; now, why is that?

A. With the European lamp the situation is so different I do not think we can make a comparison.

Q. It is simply the way the lamp is manufactured; in other words, it is the fault of the manufacturer, and not the fault of that kind of light; now, isn't that true?

A. No, it is not that exactly.

Q. Isn't the direct current open arc lamp system chiefly used in European countries for street lighting to-day?

A. Yes, but I think I explained that. Operating expenses of such a very expensive mechanism would require such a tremendous amount of care that it would increase the price from \$200 to \$250 per lamp per year.

Q. Referring to the test which you made of the lamps on the streets of the city in September of 1906; what preparation, if any, was made for those tests?

A. I don't know what particular preparation was made; they were testing the lamps when I arrived. I merely went over the circuits and checked up some of the results to see what they were getting, and how they were testing, and whether or

not they were correct in their methods.

Q. Then you didn't make these tests yourself?

A. I made quite a number of them.

Q. What instruments did you use for testing?

A. They were General Electric Company's instruments. Volt-meter, ammeter, and watt-meter.

Q. That wasn't a recording ammeter on the street, was it?

A. No.

Q. Will you briefly describe the test that you made of lamps on the streets?

A. The various instruments were properly connected to the lamp, which was turned on, after the circuits had been warmed up with a full complement of lamps in a series. Within a couple of minutes after the switch was turned, readings were made and recorded. Then the lamp was tested with pick up voltage, by locking the carbon and sliding the lamp down to directly above the feeding point, without changing the feeding point, due to a change of position of the carbon; an observation was made, but the observation recorded was the lower observation, and not the higher one, when it would be five to ten per cent. higher than the one recorded in Exhibit J.

Q. Were the readings made on the various instruments simultaneously?

A. Yes.

Q. And how many times repeated for each test?

A. A reading was taken, and if

the lamp was found to be out of adjustment, it was readjusted. It might take two or three observations to get it right, or it might take a dozen. I might state that the lamps were provided with lead weights for adjustment, which weights, in my opinion, were the cause of the decided difference in wattages of the different lamps, which under normal conditions would not exist. The lead weights have given us trouble elsewhere and are being replaced by iron which do not loosen up.

Q. Did you find quite a good many of these lamps out of adjustment?

A. That report shows that some were high, and some were low.

Q. Then you took the lamps and put them in adjustment, and then took the readings from which you made this report?

A. No sir; the readings first recorded show how the lamps were; that shows precisely the condition of the lamps. The second reading shows how the lamps were adjusted and left.

Q. So that one of the purposes, at least, of the test was to leave the lamps in adjustment, wasn't it?

A. Most assuredly.

Q. Now I call your attention to the summary of your report that gives the volts, the average of the six circuits as you found them was 76.8, and as you left them, 79.7?

A. Yes.

Q. So that you increased the voltage there by about three volts in the average of all the lamps in the city?

A. Correct.

Q. How long did it take to make the test of each of these lamps?

A. Anywhere from five to ten to fifteen minutes after the instruments were in, and they were adjusted.

Q. Could you testify as to how many personally you saw read?

A. I don't remember; possibly somewhere around 25 or 30 lamps. I went around with the wagon sometimes, with the men; I would leave—let them go for a while, and then go back again to see that they were continuing in their work properly.

Q. Were the men out practically all night making their tests?

A. I do not know. I made checks with them in the day time; I did not do any testing at night.

Q. Oh, these are day tests?

A. Day tests, with a load put on the same as at night, under precisely the same condition.

Q. Well, it is a fact that the load was put on for the purpose of making these tests?

A. Yes.

Q. Then it was not a service test at all, was it?

A. No sir, only I wish it understood that the conditions of load were the same as at night, although it was not what you would call a service test.

Q. Do you know what the night run was?

A. I was told.

Q. I am not questioning your good faith; but do you know that thing yourself?

A. I could not swear to the fact

that they did run the same, but I have no reason to believe that they would try to deceive me as to what they were doing at night as compared to what they were doing in the day time, because they were anxious to find out what condition they were in; and they certainly could not find it out by giving me a false condition to run on.

Q. If you, as an engineer, should test 17 lamps taken at random on several city circuits, and found the wattage varying from 240 to 440, with eleven of the number running below 400 watts, should you consider that first-class service was being given?

A. I should say that there was something radically wrong with the lamps. If they varied that much, they must be out of adjustment.

Q. Referring to your testimony of yesterday, is it not a fact that the wandering of the arc off the center is infrequent, and not a part of the normal operation of the open D. C. arc lamp?

A. On a calm night, if the carbons are in good condition, it ought not to get very far off the side, but if there is a little bit of wind, it would be apt to chase over.

Q. Now, is it not a fact that in the A. C. enclosed lamp the wandering of the arc from side to side of the carbons, and all over their terminal surfaces, is a part of the normal operation of the lamp, as shown by the uniform way in which the ends of the carbons are smoothed off?

A. Yes. I would like to explain that notwithstanding the range that that covers in wandering about is

greater than the open arc, the change in the luminosity due to that wandering is not to be compared to the variation you get in the open arc due to the wandering.

Q. I believe you stated yesterday that the average maximum of the enclosed arc was given by curve C in Figure 4 of Exhibit "B." Now, do I understand that this average maximum is derived from the photometric readings taken when the arc is quite over to one side of the carbons?

A. Yes.

Q. Would that not be represented by the larger lobe of Figure 6A?

A. Yes, it would.

Q. And when the arc had passed to the other side of the carbons, you would obtain what you would properly call the average minimum, wouldn't you?

A. Yes.

Q. Have you the average minimum curve which would properly correspond to the average maximum of Curve C in Figure 3?

A. No, sir, it is not here.

Q. Have you that curve for alternating enclosed lamps?

A. Not here, but the ratio is three to one.

Q. Now, wouldn't the combination of these two curves, the maximum and minimum, give the proper average or normal curve?

A. It will give you the results I read this morning, which take both sides into consideration.

Q. Now, referring to that Figure

6 A and B again; have you similar curves for the distribution with the arc central?

A. I think not, except in that book.

Q. That would be the central one?

A. Yes, in Figure 6 B.

Q. Well, is this Figure 6 B, with the arc central, substantially correct?

A. Yes; you will please understand though that these curves are merely diagrammatic; they do not represent the variation at all.

Q. From this maximum and minimum data, how did you obtain the mean lower hemispherical candle-power of the 6.6 alternating current enclosed lamp, or any other lamp?

A. I took the candle-power at angles of 10 degree intervals below the horizontal, weighted each with a zone factor and then averaged the figures resulting therefrom.

Q. Can you sketch that for us on the board?

A. I will explain it by reference to this Exhibit G. Assume that the illumination on the horizontal is 300 candle-power; then we will call the candle-power 310, for example, ten degrees below. These are merely figures for illustration, and bear no relation to a candle-power curve. Of course, these points are ordinarily located before the curve is drawn; we are doing this backward, so to speak. Now, in order to obtain the mean spherical candle-power, we will take the illumination at each point, completely around, weight it with the zone factor, which integrates for the relative areas over which the light is spread. We next take both sides,

the high and the low, so as to be fair, and average the two; this gives us the mean spherical candle-power of the light; it also gives us the maximum and the minimum, and shows how much the lamp varies due to the travel of the arc. In order to obtain the lower hemispherical candle-power, disregarding any reflector on the lamp, we merely go through the same process in the lower hemisphere. To get the mean lower hemispherical candle-power with reflector raises the question how efficient the reflector will be. This introduces another variable. We generally take the light in the upper hemisphere and deduct about twenty-five per cent. for loss from the reflector; these figures that I have given you are approximated on that basis, and it seems to me to be about as fair a way to get at it as we can.

Question by Arbitrator:

What do you mean by the zone factor, Mr. Ryan?

A. It is the ratio between the areas of horizontal bands of equal width surrounding a sphere.

Cross-examination Continued by Mr. Robinson.

Q. Please look at Figure 8 of Exhibit B; how was the data for that line obtained, and from whom?

A. That is just an approximate curve for illustration.

Q. Well, did you intend to make it quantitative?

A. I did, yes, just approximately.

Q. In your direct examination, referring to Exhibit No. 45, you said that the A. C. enclosed lamp gave a brighter light at the time the bright

spot was made in the line, than any other lamp consuming the same energy, and that the extreme heat, at the time the bright spot in the line was made, carried the light over the dark point; will you explain that?

A. An A. C. arc lamp, to take the same arc wattage as a D. C. lamp, would naturally have a higher current, and the higher current density would assist in compensating for the dark area during the change of direction in the current.

Q. Didn't you say that at the light moment the temperature was higher, and carried the light over the dark spot?

A. What I had in mind to imply was that, by using a higher current density, there was more brilliancy than there would be if he used the same current density; it would be equivalent to the experiment performed by the Professor.

Q. What would be the effect of having the current density higher?

A. It would tend to increase the efficiency of the arc.

Q. That is, the amount of light given out?

A. Yes.

Q. And why?

A. Because it would enlarge the crater, and there would be less chilling effect around the crater surface.

Q. You are speaking now of the alternating enclosed arc?

A. Yes. The volatilizing point is equal for the same grade of carbon in either the open or enclosed lamp.

Q. Is the curve for the 6.6 A. C. enclosed series arc in Figure 3, Exhibit B?

A. No, sir.

Q. Page 11, Exhibit B, reads: "We will now contrast the two enclosed arc lamps, namely, direct current and alternating current, each consuming approximately the same watts at arc. Referring to candle-power curves (Fig. 3), it will be observed that the direct current lamp gives slightly more light than the alternating." Now, the alternating current there was 7.5 amperes, was it not?

A. Yes, it was.

Q. And the enclosed was 6.6 amperes?

A. Yes.

Q. But you don't say that in that paper?

A. I said here, consuming approximately the same energy; the 6.6 ampere enclosed D. C. consumes approximately the same wattage as a 7.5 ampere A. C. enclosed lamp.

Q. I know they do, Mr. Ryan, but now, neither the reading from which you have read this morning nor the figures to which you refer, neither

of those things gives the lamp that is in use here on the streets, does it?

A. No, sir.

Q. Will you state approximately the difference in the cost of operation of the 9.6 D. C. open arc and the 6.6 A. C. series alternating?

A. The figures that I have are for the old style system 9.6 ampere open arc lamp, compared with a corresponding system, which is the direct current enclosed arc lamp. Annual operating expense, open arc, trimming \$5.40, carbons \$5.50, globes 20 cents, repairs \$2.00; total, \$13.10. Enclosed lamp, trimming \$2.40, carbons \$1.20, outer globes 20 cents, inner globes 45 cents, repairs \$1.00; total \$5.25. Saving per lamp per year, \$7.85. Now, I understand that the cost of maintaining the alternating lamp is somewhat higher than the direct current enclosed lamp, because the lamp is of shorter life, has to be trimmed a little more frequently, and the repairs would probably run a little higher. I don't know just how much, probably not over \$2.00.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 9 A. M., FEBRUARY 7, 1907.

MR. RYAN recalled to the stand.

Re-direct Examination by Mr. Schuyler.

Q. What is Exhibit No. 40?

A. This set of curves is the final summing up of five or six years' work. It covers a range of current from 4 to 10 amperes; gives the mean hemispherical and spherical candle-powers with other data, and it is probably, without doubt, the nearest or closest approximation of what would be expected from lamps of that type, at a fixed voltage and a fixed wattage, of any curves that have ever been made.

Q. Explain what Exhibit No. 41 is?

A. I would like to call attention to the general shape of the curve of the direct current, enclosed arc. It will be observed that a larger proportion of the light from this lamp is naturally below the horizontal than in the case of the alternating arc, which, barring the question of reflectors, would naturally make that lamp appear a more brilliant illuminant because the light more nearly approaches the open arc, that is, the maximum strikes the ground near the pole. The general impression gained would be that it was considerably brighter than the other lamp. It will also be observed that the minimum in the alternating lamp does not fall proportionately so low as it does in the direct current, and that the alternating distribution is more nearly spherical; the curve is rounder. If any comparisons are

to be made between these illuminations of the open arc and the enclosed arc on a candle-power basis, these curves more nearly represent what you should expect to find than any data heretofore given, although you will find practically no difference, except that these are for multiple lamps, while the other data is for the series lamp.

To obtain the lower hemispherical candle-power, with reflectors and clear globes, from these curves, first add 10 per cent. to the mean spherical candle-power, to compensate for the light lost in absorption of the opal globe, with which these tests were made. Then deduct the difference between the mean spherical and the lower hemispherical from the mean spherical candle-power and the remainder represents the upper hemispherical candle-power, from which about 25 per cent. should be deducted to cover loss in the reflector; what remains should be added to the lower hemispherical candle-power of the lamp without reflector, and you then have the lower hemispherical candle-power with reflector.

Q. Are curves in both Exhibits Nos. 40 and 41 made with opal globes?

A. Yes. I might state that reflectors are being designed to change them entirely, so you cannot bank very much on those maximums, because different reflectors will give you different results; but they fairly represent the total flux delivered.

Q. You haven't any curves of the series lamps?

A. No, sir, but they will give the same relative values.

Q. There is no 9.6 ampere?

A. No, these are all enclosed arcs; enclosed alternating and enclosed direct. You will observe from the characteristics of the two sets of curves presented that the turning down of the light from the upper

hemisphere from the direct current lamp wouldn't help out nearly so much, because there is so much more light; so when you place a reflector on both lights that way, then you bring the lamps more nearly to a basis of equality; there still exists one thing in favor of the direct current, but as to the question of distribution, I think there is not a great deal of difference.

Witness excused.

MR. C. W. HUMPHREY, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. Are you acquainted with a resolution passed by the National Electric Light Association, which has been referred to here?

A. Yes.

Q. To what, in your opinion, did that resolution refer?

A. I have always looked at that resolution as referring to any arc consuming 450 watts at its terminals, as meaning a 2000 candle power lamp.

Q. In 1898, Mr. Humphrey, the City of Colorado Springs granted to George W. Jackson, his associates and assigns, a franchise, the language of which, so far as it is material here, is as follows:

"During the remainder of the term of this grant said Jackson and his assigns shall furnish to the City of Colorado Springs such arc lights of standard 2000 candle power each, as may be required by said city for the purpose of lighting its streets, alleys and public grounds;"

Taking this language alone into consideration, from the practical standpoint of your experience, what is the meaning of the term "standard 2,000 candle-power arc light" as therein used?

A. I would consider that as meaning any arc lamp for street illumination that would show a consumption of 450 watts, at its terminals.

Q. Will you explain your opinion as to the relative merits of the 9.6 ampere D. C. open arc lamp, and the

6.6 ampere A. C. enclosed arc lamp, in practical operation?

A. I have always considered that the A. C. 6.6 arc was a better light as far as distribution was concerned, and gave a better quality of light, than the 9.6 ampere D. C. lamp.

Q. How with reference to the subject of shadows?

A. It is comparatively free from shadows.

Q. What is the condition of the 9.6 direct current open arc?

A. Sometimes there is nothing else but shadows.

Q. Explain what the practical operation of the 9.6 lamp is, as to variation?

A. From my observation of them, there is always more or less flickering of the light, and it is very unsteady; it may be very bright at one time and very dark at another; light on one side, and dark on the other side. It depends a good deal on the condition of the weather. Take a stormy night, when the snow and wind can get into the globe, it gives very poor results.

Q. In your opinion, what is the possibility, from a practical standpoint, of measuring the candle-power of such a light?

A. I have never heard of its being done and have never attempted it myself.

Q. Would you, as a practical man, say that it was possible to be done, in practical operation?

A. I suppose the candle-power could be measured at certain instants, but not over any length of time; it

would be no criterion of the performance of the lamp.

Q. Is the 9.6 ampere lamp increasing or decreasing in use?

A. It is rapidly falling off in use. In fact, it is very hard to get repair parts or new lamps at all at the present date.

Q. To what cause do you attribute the falling off in the use of that lamp?

A. Why, everybody, of course, is trying to obtain better light, better illumination, and as time goes on, and a better lamp comes into the market, the people are anxious to obtain it; and it has been considered that the 6.6 ampere alternating arc is much superior to the old 9.6 open arc, and in the majority of cities they have been very glad to have the companies change over to the alternating arc. I would say that that is the principal reason for the increased use of the 6.6 over the old 9.6. In fact, I understand that some of the companies have discontinued the manufacture of those lamps entirely.

Q. From the standpoint of practical operation, was there any inherent defect in the 9.6 ampere lamp?

A. Yes, the lamps are very hard to keep in repair; in fact, to keep a 9.6 ampere lamp in good repair requires the services of more than an ordinary trimmer; he must be an expert in that line; the alignment of coils and armature must be perfect; the rod that feeds the carbon must be perfectly straight, free from dirt, grit, and this has to be polished with crocus cloth, and any slighting of this work will cause the lamp to flame, give poorer service, sputter,

etc. The rod sliding up and down with the carbon is exposed to the elements, and no man can get around to that lamp frequently enough to keep this rod clean; and in the case of a sleet storm, or anything of that kind, it is bound to become clogged, dirty, greasy, gritty. We have always had a lot of trouble with operating our D. C. lamps.

Q. Comparing climatic conditions here and in the east, which would you say was the more favorable to the operation of the 9.6 lamps?

A. Why, I believe the east is a little more favorable to their operation, although we used to have a great deal of trouble with them there at Madison.

Q. In your experience what has been the basis of measurement upon which to predicate a charge for service of arc lamps?

A. Wattage measurement.

Q. What do you say as to the practicability and fairness of basing such charges upon a candle-power basis?

A. I never knew of its being done.

Q. What are the reasons that militate against it?

A. Because no lamp can be guaranteed to give a certain candle-power; and if it has a candle-power assigned to it there is no assurance that this will be the candle-power it will always operate at.

Cross-examination by Mr. Robinson.

Q. Mr. Humphrey, do you know when the resolution was passed to which counsel has called your attention?

A. I believe it was in 1898.

Q. Do you believe it was in 1898?

A. I wouldn't be sure as to the date; I know I have read it, and heard about it a great many times.

Q. Well, what was your occupation, Mr. Humphrey, in 1894?

A. I was a student at the High School in Waterloo, Wis.

Q. Would you tell this Board that you had any experience whatever with arc lamps in 1894?

A. I had not.

Q. What were you doing just previous to last May?

A. I was engineer for the Denver Gas and Electric Company.

Q. Now, from whom did the Denver Gas and Electric Company last buy new open arc lamps and dynamos?

A. I have been with the company about six years, and during that time no new arc lamps, open arcs, have been purchased; there were some second-hand ones purchased, as nothing else could be procured at a reasonable price.

Q. Do you know whether or not they attempted to buy any?

A. There were inquiries made of the General Electric Company.

Q. What was paid by the company for the second-hand arcs they did buy?

A. Two dollars apiece.

Q. Do you know of your own knowledge of any company that has substituted the 6.6 ampere enclosed alternating series lamp for the 9.6 ampere direct current open arc lamp, within the last few years?

A. I don't recall right now any that have changed, although I have heard of several.

Q. Did I understand you to say, Mr. Humphrey, that in Denver you sold your product by watts?

A. That is the basis, yes.

Q. The arcs?

A. The rate on arc lamps is based on so much a year.

Q. I suppose the kind of arc is specified, is it?

A. I don't remember how the contract reads; they are the open 9.6.

Question by Arbitrator:

Q. They are still in use there?

A. Yes, although they have several other forms of illumination there; the last installed were enclosed alternating arcs.

Q. In Denver?

A. Yes; there were 125 enclosed multiple alternating arc lamps installed on Sixteenth street recently.

Examination Continued by Mr. Robinson.

Q. How many to the block?

A. I think there are eight.

Q. How long are the blocks?

A. The blocks are about 450 feet; I wouldn't swear to those figures.

Q. Were those lamps installed in the place of the 9.6 open arc lamps?

A. Yes; the 9.6 arc lamps are still hanging on that street; these other lamps haven't been lit as yet, but as soon as they are lit, their expectation is to take these 9.6 arc lamps down.

Q. How many of the 9.6 lamps were there in the block?

A. One on each end of the block.

Q. Then in place of the two of the 9.6 ampere there will be eight of the others?

A. Yes.

Re-direct Examination by Mr. Schuyler.

Q. What is going on on Sixteenth street in Denver?

A. Sixteenth street is the retail district of Denver; they are striving to make it one of the best illuminated streets in the world. There is a great deal of strife in Denver in regards to lighting, both decorative and street lighting. In fact, they have put in a good many incandescent and Nernst lamps on the

streets, and Sixteenth street will be the principal lighted street in the city and the best illuminated.

Q. Well, was the intention to try and get the same amount of light by the use of eight 7 ampere enclosed alternating arc lights in a block, as was formerly given by a 9.6?

A. Oh, no.

Q. What was the idea?

A. They were trying to get a uniform illumination along that street nearly equal to the illumination found under the arc lamps; they are trying to eliminate those circles entirely.

Witness excused.

MR. J. C. LAWLER, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. Have you at any time assisted at or supervised any tests of the lamps on the streets of this city?

A. Yes.

Q. When was that, Mr. Lawler?

A. We tested the lamps on the streets at different times; the last time was in September of 1906.

Q. Was that the occasion when Mr. Ryan was in the city?

A. Yes.

Q. Please explain to the Board how those tests were made?

A. We arranged a switchboard, which contained a volt-meter, a watt-meter, and ammeter. The switchboard was placed in a wagon, and we would drive up under a lamp, which would be lowered to a convenient distance from the wagon, and connected so that the current voltage and watts of the lamp would be indicated on these instruments.

The lamp was, of course, turned off during the time of making the connections, and turned on as soon as the connections were made.

I had with me at different times three or four men besides myself.

The ammeter was watched all the time to see that it was carrying proper amperage. After the lamp was turned on I watched the watt meter, to see what the wattage would come up to. If it ran up to 500 watts, I would not take that as a reading, but would turn it off and turn it on again. It might happen that the clutch wouldn't work right

maybe the carbon would be out of place, and after trying the lamp several times with the lamp burning for a minute each time, to see that it settled down to what appeared to be its normal wattage, I would say, "Now," and two men would read the ammeter and volt-meter, respectively, at the same time I read the watt-meter. That was what we called a "found" condition. If the lamp was too high or too low, I would generally try and find out the reason by removing the outer case and looking for places binding, or for a loose joint, or a slipped weight; and if any new parts were needed we put them in and adjusted the lamp, and would leave it generally between 460 and 470 watts on the pick-up. A record was made of the final readings, and kept as showing the "left" condition. The average running would be from 6-8 per cent. higher.

Q. Well, how generally over the city did you make the tests?

A. All over the city; there were a few lamps which we couldn't get at, due to local conditions; possibly the wagon couldn't get under the arc because of a ditch or something of that nature.

Q. What did you do with those lamps?

A. They were brought into the plant, and a new lamp was taken out. These lamps brought in were tested under the same conditions as they had been on the line.

Q. Does Exhibit "J" show the true results of the tests which you made of the lamps?

A. Yes, except of the lamps

tested at the station. It is the report which I got up at that time.

Q. How many readings did you make at a time?

A. We only kept a record of one reading, as we found the lamp, and that reading was recorded at what I would call, from my experience with arc lamps, as the normal reading.

Q. And how did you arrive at the normal conditions?

A. By trying the lamp several times; then if it came to the same point each time, we took that reading, and if different results were not consistent with each other, we found what seemed to be the normal condition of the lamp, as the average of what it would be at the pick-up.

Q. And this normal reading was the result of several readings to get at what the lamp was doing; is that it?

A. Yes; that is the only reading which was placed on record.

Q. Will you state what is Exhibit "L"?

A. These are the results of the lamps which were brought into the plant and there tested.

Q. And are these accurate results of the readings there made?

A. They are.

Q. What conditions, as compared with the street tests, were those made under?

A. Exactly the same conditions, so far as the lamp was concerned.

Q. Now, what preparation, if any, at the plant, was made in anticipa-

tion of the making of these tests upon the streets of the city?

A. We simply turned on the lamps.

Q. Any changes in conditions at the plant?

A. No, sir.

Q. Any variance in the machinery?

A. Not in the least. I called up by telephone a great many times to see that their instruments and apparatus were under exactly normal conditions, and checked up with ours on our wagon.

Q. What do you say as to the accuracy of the meters employed by this company since February 15th, 1905, so far as they have come under your observation?

A. I have been able to keep all meters within one per cent. of correct.

Q. Were you present at a test made by Professor Shedd in the laboratory at Colorado College last Saturday evening?

A. I was.

Q. What have you to say with reference to the correctness of that test, as showing that the light from an alternating current lamp was 30 per cent. less than that of the light from the direct current arc lamp, carrying the same amperage?

A. I don't consider that as correct by any means.

Q. For what reasons?

A. Because the mean effective amperes from an alternating current is what is equivalent to the same amperes flowing from a direct cur-

rent. An ammeter measures the mean effective amperes on alternating currents, and if an ammeter on an alternating current with unity power factor shows 7 amperes, and the same on direct current of 7 amperes, the power consumed is exactly the same thing, but there is a slight difference in the light, due to the efficiency of the carbons. It requires more heat to raise a body to a certain temperature from a lower temperature than it does to maintain it at that temperature; and as an alternating current lamp is coming off and on, it requires a slight amount more of heat to raise it to that incandescent temperature, than it does to maintain it at that incandescent temperature after it has once been obtained.

Cross-examination by Mr. Robinson.

Q. Who went with you when you made these September tests of the lamps on the street?

A. They were all employes of the Colorado Springs Electric Company.

Q. Were they electricians or the ordinary employes of the company?

A. Two of them were electricians.

Q. Can you tell the Board why the Colorado Springs Electric Company was having the tests made?

A. To find out whether the lamps were doing what we thought they were doing.

Q. Is it true that the Colorado Springs Electric Company is furnishing the street light on the streets of this city?

A. That would be a detail of management as to who was furnishing the light; we are attending to them.

Q. Well, don't you know that the Colorado Springs Electric Company owns, or has charge of the lamps on the streets of this city?

A. They have charge of the operation of them, and have always taken care of them.

Q. Isn't the current coming from the stations of the Colorado Springs Electric Company?

A. The current that feeds the arc lamps comes through one of our stations.

Q. That is, your company buys the current from the Hydro Electric Company, and distributes it in the streets?

A. That is what I have supposed to be true; I don't know that it is.

Q. Were those September tests made in the daytime or the night?

A. Those tests were made in the daytime.

Q. The current was turned on the circuits for that purpose, was it not?

A. Yes.

Q. And as I understood you, when you went to a lamp you attached it to your instruments, and then did more or less in the way of adjusting it?

A. We went to the lamp, and after taking the wattage and the measurements we wanted, we then made adjustments.

Q. If the first measurements that you got didn't satisfy you, weren't in your opinion correct under the circumstances, then you adjusted the lamp to get what you would term the normal condition?

A. Yes.

Q. Or the condition which you wanted?

A. Yes, the condition which seemed proper.

Q. Were you personally present at each of the tests that are shown in Exhibit "J"?

A. Yes.

Q. Did Mr. Ryan supervise these tests?

A. No, not entirely.

Q. Well, at what time did Mr. Ryan appear in the matter, if at all?

A. He appeared soon after we started making these tests; half a day, or something like that.

Q. Did Mr. Ryan bring any instruments with which to make the tests on the streets?

A. He ordered an instrument while he was here, I believe.

Q. What instruments were used when you began the tests?

A. They belonged to the Colorado Springs Electric Company.

Q. Were they ordered for the purposes of these tests?

A. They were ordered for testing arc lights, and I think they are used now on a regular board.

Q. When these tests were made in September, is it not true that your company knew that the city had made some tests on the streets?

A. Yes.

Q. And at this time didn't you go out and test the lamps in behalf of the owners?

A. Yes.

Q. And because of the tests which the city had made?

A. No.

Q. When was a complete test of all the lights made by the company prior to September?

A. Every lamp on our system has been tested before Colorado College ever thought of testing an arc lamp.

Q. When were they tested, Mr. Lawler?

A. When they were put up.

Q. When did the company send out and make a general test of the lights on the street prior to September?

A. We never tested them all practically at the same time; nor have we ever tested every lamp in town, on the street, with instruments; however, we have a man that does nothing else but look after these lamps at night time.

Q. Could you mention another time when tests were made on the street lights with instruments?

A. Some I recollect were made last spring; I think it was last April.

Q. How many lamps did you test at that time?

A. We tested six or eight lamps, and it began to rain.

Q. Was that test at night with instruments?

A. Yes.

Q. With the same instruments you have heretofore described?

A. No, the tests we are now

speaking of were made with Weston instruments, which you lay on a table; for the later tests, when we went out prepared to test every lamp in town, we arranged a switchboard for convenience.

Q. Were the September tests made with switchboard instruments?

A. Yes, they are the back connected type.

Q. Have you the calibration cards for those instruments?

A. No, sir.

Q. Have you the record of the tests which you made last April?

A. I might be able to find it; I didn't try to keep any record of it. The test was merely to find out how they were burning at night time, compared with how they were burning in the day time.

Q. Then it wasn't for the purpose of determining the candle-power of the lamps?

A. No, sir; we have never paid any attention to the measurement of candle-power.

Q. How do you get at the light, then, aside from candle-power?

A. By watts.

Q. How do you determine candle-power from watts?

A. I never determined it.

Q. I will show you a copy of Section 9 of the Jackson franchise, and ask you if you know whether or not it is under that section that your company is furnishing street lights?

A. I have always understood that it was.

Q. Well, will you point out to the Board any part of that contract wherein this company of yours is furnishing watts to this city?

A. "Such arc lights of standard 2,000 candle-power each," arc lights of standard 2,000 candle-power are lamps consuming 450 watts. Ever since I have known anything about arc lights, or been acquainted with electric works at all and paid any attention to the subject, it has always been my opinion that a 2,000 candle-power arc is one that consumed 450 watts.

Q. Referring to these tests of September, did the conditions which you obtained at the lamp when you took the readings reproduce service conditions?

A. They certainly should, for that point, at the pick-up.

Q. Then you mean to say that the conditions at the lamps when you took your tests, and made your readings, were the same conditions, although in the day time, that the lamps were in at night, when they were supposed to light the streets?

A. Yes, sir.

Q. If that is true, then please explain how it happened that the voltage at these lamps was considerably less when you found them than when you left them?

A. On an average of all the circuits, the voltage was left about 2½ per cent. greater than what we found it.

Q. Didn't you leave it greater on every circuit than you found it, except on the east circuit; isn't that true?

A. The report would seem to in-

dicating that out of all the lamps which I raised and lowered, the average raise was $2\frac{1}{2}$ per cent.

Q. Isn't it a fact that the average shows that the voltage per lamp was raised from 76.8 to 79.7?

A. I presume the figures are correct.

Q. What is the normal rated current of the 6.6 ampere lamp, in use here on the street?

A. They are marked 6.6 ampere.

Q. What do they run at?

A. The ammeters show about 7 amperes.

Q. Do you know how long the machines down at the plant have been running at 7 amperes?

A. No, sir, I don't.

Q. Do you know whether or not that was changed during last summer?

A. I couldn't say; it isn't in my department.

Q. I understood you to say that you didn't consider the test made by Professor Shedd at Colorado College last Saturday evening, as being correct by any means?

A. Yes, as I understand it.

Q. Now, how do you understand it?

A. I understood him to state that an alternating current lamp carrying the same amperage, I believe it was, only gave about 70 per cent. of the light which a direct current lamp would, for the reason that an alternating current lamp was going out sixty times a second.

Q. Would you say that the tem-

perature of the carbons was the same with direct current as with alternating current, with the same wattage?

A. I don't know; I am not a laboratory man enough to measure the temperature of carbons; it is a point there of making actual measurements.

Q. Does not a greater temperature cause a greater light?

A. I presume that it does.

Q. You don't know whether carbons would reach a greater temperature with direct current than with the alternating current lamps?

A. I don't know.

Q. Do you know what is the shape of the current curve in the arc of the alternating current?

A. It is likely to have a difference under different conditions but ordinarily it is a sine curve.

Re-Direct Examination by Mr. Schuyler.

Q. When, with reference to the time of the readings embraced under the column "found," were those adjustments to which you referred made?

A. The adjustments were made after those results given in the "found" column were obtained.

Re-Cross Examination by Mr. Robinson.

Q. Was any representative of the City present at the making of these tests in September?

A. Certain city employes witnessed the tests, but whether they witnessed the tests in the capacity

of representing the city or not, I don't know.

Q. Do you know whether or not the City was notified that you were going to make the tests?

A. *They were not notified by me, or to my knowledge.*

Q. No one, so far as you know, representing the city, pretended to go around with you and make the tests?

A. *No.*

Witness excused.

MR. E. P. DILLON, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. How long have you been with the Colorado Springs Electric Company, and in what capacity?

A. For four years, as electrical engineer.

Q. Are you acquainted with the apparatus and lighting system of the company?

A. I am.

Q. Please explain the arc lighting system employed for lighting the streets since February 15, 1905, the number of lamps in use and number of circuits?

Statement by Mr. Robinson.

I think the time has come when it should be stipulated in the record that the Colorado Springs Electric Co. is furnishing light on the streets of this city. The point being that if the Colorado Springs Electric Company is not furnishing this light, such testimony as it is now proposed to introduce is incompetent, as the contract of the City is with the Pike's Peak Hydro-Electric Company.

Mr. Schuyler: The point simply is that the Colorado Springs Electric Co. is the distributing agent for the Pike's Peak Hydro-Electric Company, and certainly the acts and conduct of the agent can be shown in behalf of the principal.

Mr. Robinson: If you say they are your agent, and you assume responsibility for their acts in this record, well and good.

Mr. Schuyler: I do not see how one can have an agent and not assume responsibility for his acts.

Mr. Robinson: But we deny it is a fact that they are your agents.

Arbitrator: Has there been any evidence in the case to show that the Jackson franchise has been assigned to the Hydro Company?

Mr. Robinson: I think so, yes. It is stipulated in the article of agreement.

Mr. Schuyler: There is no desire, however, to conceal anything; I thought this entire matter was covered by the agreement. Before we get through, we will have upon the witness stand Mr. Taff, through whom we will develop the exact relations existing.

We have the privilege of offering such evidence as we may please, and we reserve the right to plead our case as we please. The details of our agreement with the Colorado Springs Electric Company makes no difference. We acknowledge this Company to be our agent for the purposes of this hearing.

Mr. Holland: While the Colorado Springs Electric Company is not a party to this suit, and is only incidentally interested in this controversy, there is not now and there never has been any assignment of any of the rights of the Jackson franchise to the Colorado Springs Electric Company, which is the distributing agent of the Hydro Company.

Arbitrator: Taking the statement of counsel that the question of agency will be proven afterwards, it seems to us that the testimony about to be offered is relevant.

Examination continued by Mr. Schuyler.

Q. Now, Mr. Dillon, please explain about the number of lamps in

use, circuits, etc., since February 15, 1905?

A. The system in the streets of Colorado Springs is known as the constant current alternating enclosed arc system. The transforming device — tub transformers — through which the energy to the lamps is supplied, is located in Sub-station A of the Colorado Springs Electric Company. The circuits are regular series circuits; the lamps being 6.6 ampere constant current enclosed, of General Electric Company make, equipped with clear outer and inner globes, and shade reflectors. On February 15, 1905, the lamps in Colorado Springs were supplied through five circuits, each operated from a tub transformer. In Colorado Springs there were 218 lamps, and in Colorado City 35 lamps on these circuits. At that time the same recording wattmeters measured the energy supplied to the lamps in both cities. On July 9, 1906, the transformer supplying Colorado City arc lights was moved to Sub-station B, and thereafter that city's record was registered on its own wattmeter in Sub-station B. At the time of this transfer, the arc lamps in Colorado City had been increased to 38, and in Colorado Springs to 241, which arrangement continued into September, 1906, at which time an additional tub transformer was installed at Sub-station A, making six in all, when the circuits were rearranged, making six circuits in Colorado Springs.

Q. What do you say as to the efficiency of this system as compared with that of other companies in other states?

A. It compares very favorably with them; if anything, we expend

a little more effort than the average station in keeping our system up to good operating condition.

Q. State the practice of your company with reference to the maintenance of the lamps, their inspection, testing, etc.?

A. We have a regular inspector who makes several trips nightly over the entire arc lighting system, starting any lamps that may be found not burning, repairing, if possible, any lamps that may be found in poor condition, such as not drawing an arc, or flickering badly, or replacing a broken inner globe, re-trimming the lamp in case the carbons have burned out before their regular time. He makes a daily report, which is sent to me, of the number of lamps started each night, and the time that each lamp was started, and the cause for the lamp being out. If any lamps are found not burning, or burning very poorly, he determines the cause, if possible, and attempts to correct it, and he reports that lamp as burning, but in poor condition, or out, and the reason for it. If it is impossible to repair a lamp on the street, at night, he reports it to the proper department, which changes the lamp, bringing in the poor lamp to be fixed. The inspector only depends on his visual observation as to the condition of the lamps. I am frank to say that a lamp may vary from fifteen to twenty per cent. and not be perceptible, although he is trained to do nothing else than to investigate these arc lamps. He does not get to every lamp in the city each night, because it isn't necessary. He goes to a point where he can see every lamp on the street and if he sees a lamp out of order, he goes to that

lamp and investigates the condition and repairs it if possible. The line work is investigated principally by the "trouble department," which consists of two men, whose entire duties entail their traveling about the city in answer to trouble calls, of which, of course, the majority are from residences or stores. Before going out every day, they test every arc circuit for an open or a ground. If they find anything of the kind, they immediately hunt the trouble, and they are the ones who also change the lamps on the order of the night inspector.

The arc transformers are supplied from the primary, the 6,600-volt transmission system, as distinguished from the distributing system. All the energy passing from the main bus-bars of the sub-station into the arc lighting system is measured and integrated by two General Electric high torque induction watt-hour meters, connected to the arc system by series and shunt transformers. One of the regular practices of the company is the keeping of a system of records of the generation and distribution of power. We have an accurate hourly record of the number of kilowatts output from our plants.

The integrating wattmeters referred to are a part of our switch-board equipment, and this method of measuring the arc lighting system has been in use as long as I have been with the company. These wattmeters are in use simply for the purpose of maintaining an accurate record of how much energy has gone into the city arc lighting system. Similar wattmeters measure how much has been expended in the constant potential lighting system and how much in the 500-volt power.

At Sub-station A the readings are taken at twelve midnight daily, entered in the proper sheet, which is computed by an employe who is specially delegated for that purpose, and the records kept at the office of the Company.

Q. How continuously during the period from February 15th, 1905, until date, has this system of inspection and condition of machinery which you have testified about prevailed?

A. It has prevailed for the entire time—it is a matter of everyday operation of the system.

Q. What do you say as to the correctness of the meters?

A. We check the meters frequently with our standards in the meter department. We consider a test on a wattmeter to be "O. K." if within one per cent. of correct. We base our output on a commercial basis. We do not pretend to and cannot maintain laboratory conditions on our switchboards. One of the meters tested in May, I believe, was shown to be 5 per cent. fast, but due to the peculiar connection and the peculiar operation of two wattmeters in measuring three-phase power, this meter only registered 20 per cent. of the entire power recorded, and reductions of 5 per cent. on this meter have been made on the records of the meter, which we have at hand. Later tests showed that this same meter was 4.5 per cent. slow, but we have not added to our records to account for this, as the compilation which I have at hand was made for the purpose of developing evidence in this case, and we were disposed to be absolutely on the safe side.

Board adjourned,

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 2 P. M., FEBRUARY 7, 1907.

MR. DILLON recalled to the stand.

**Direct Examination Continued
by Mr. Schuyler.**

Mr. Dillon, what do you say as to being able to ascertain the transformer and the line losses during the period from February 15th to the present time?

A. I think that could be done within very fair limits, knowing the size and length of wire in the circuits, and the efficiency of the transformers, together with the fact that we test our lines daily for trouble, and also coupled with the fact that in this extremely dry atmosphere we are not greatly troubled with leakages from grounds, except on extremely wet nights. We have kept our system very free from grounds, except on very rare occurrences. We can deduct the efficiency of the transformer from the watts measured by the primary, and from that deduct the line losses for the hours burned, and knowing the outages, we can get a very clear idea of what the lamps, on the average, are consuming, especially as this computation has been made over a period of two years. It is not a test for any instant, but it is an average condition of operation.

Q. Is it in any sense a laboratory test?

A. Not in any sense, it is a practical operating test. The wattmeters are on the high tension circuit supplying the transformers; there are no individual wattmeters on the individual transformers.

Q. Mr. Dillon, I hand you Exhibits "M 1" to "M 25" inclusive, and I will ask you if they were made by you, or under your supervision?

A. They were made practically under my supervision; partially by me personally.

Q. State what these various exhibits represent?

A. Beginning with February 15th, 1905, to July 9th, 1906, they show in order under the head of "Colorado Springs," the number of hours burned, the number of lamps in circuit, the lamp hours; under the head of "Colorado City," the number of hours burned, in hours and minutes, number of lamps in circuit, etc., under the head "Total" is the sum of Colorado Springs and Colorado City lamp hours; the lamp hours outage; net lamp hours service and kilowatt hours recorded on the wattmeters at that date; this is shown by each month giving the totals. The July one, the sheet "M 17," gives the Colorado City record up to and including July 9th, at which time the Colorado City arc lighting circuit was moved to another sub-station. The later sheets, to "M 23," give the records for the two cities separately.

Q. What is Exhibit M-24?

A. Exhibit M-24 is a summary of the foregoing exhibits, from February, 1905, to and including January, 1907. That shows first the kilowatt hours in the primary, in the next column the kilowatt hours in the secondary, allowing 94 per cent as the average efficiency of the transformers. The efficiency guaranteed

by the General Electric Company is very close to 95 per cent., and we have used 94 per cent. to be perfectly safe and fair. The figures in the column headed "Line Loss," we have obtained by taking the number of feet of wire in the circuit, which is No. 6 B. & S., and using the value of 0.4 ohm per thousand feet as the resistance, which multiplied by the number of thousand feet times the square of the current, gives us the well-known C^2R line loss. This multiplied by the number of hours that the current was flowing in the wire, will give the kilowatt hours loss for the circuits. This quantity deducted from the secondary K. W. hours output of the transformers, gives us the net kilowatt hours of the lamps, which divided by the total lamp hours per month, gives the average watts per lamp for that month. During the time the circuits were not separated the line loss of Colorado City as distinct from Colorado Springs was taken into consideration.

Q. Please explain Exhibit "M-25?"

A. It is a graphical curve, showing the average watts per lamp per month from February, 1905, to and including January, 1907. The value, as found from the summary, Exhibit M-24, the average watts per lamp per month, is located above the appropriate month indicated on the bottom of the sheet; then the points are connected by lines making a curve, showing graphically the variation.

Q. What are the average watts per lamp per month throughout the periods?

A. I have not drawn an average

curve, but from computation it is approximately 437 watts.

Q. That is, 437 watts were delivered per month, per lamp, throughout the whole time?

A. Yes.

Q. During December, 1905, January and February 1906, there is a drop in the curve; please explain that?

A. This is very probably due to the lamps getting out of adjustment resulting in each lamp taking slightly under its normal wattage.

Q. What do you say as to the improvement in that condition as shown by the curve?

A. It is due to the fact that beginning in February and during the next few months we had a considerable disturbance in the way of snow storms, trouble on the lines, etc., necessitating changing the lamps frequently; perhaps 15 or 20 lamps a day would be reported as out of adjustment, with the result, there was a general change in the system through bringing lamps in and repairing them and sending them out again, thus bringing up the average wattage consumed by the lamps.

Q. Would you record that as a usual or unusual condition?

A. It is a condition that cannot be avoided in practical operation. There is no likelihood that any central station in America operating street lamps, would have discovered it any earlier than we did.

Q. How about removing the bad condition after it was discovered?

A. They certainly could not have done it any sooner, in my opinion.

Q. Referring to August and September, 1906, explain fully why the wattage goes up to 490-495?

A. Up to about May 1st, 1906, the Company had perfect confidence that it was giving the light called for by the contract. About that time considerable agitation arose regarding the arc lamps, and as we preferred to be fair in our dealings with the public or individuals, about that time we boosted the amperage on the constant current transformers so as to run from 7-7.2, perhaps an average of 7.1, with the idea of doing everything we could to be perfectly fair in the matter. To be perfectly sure our lamps were doing what we thought they were doing, we started some tests, I think it was on the night of June 14. Owing to the unsettled condition of the weather at that time, the tests were somewhat interfered with, and we found difficulty in covering the entire system, which we knew would be necessary to get an exact idea of what our lamps were doing, so we abandoned the night tests. A day or two later we started day tests, measuring the volts, amperes and wattage of the lamps; this showed us they were a little below adjustment, and before leaving a lamp, the crew making the test would adjust the lamp to normal wattage, attempting to have it consume 450 watts or better shortly after pick-up. We soon found, owing to the loaded condition of our circuits at this time, which we had no reason to believe was serious previous to making these tests, that the capacity of the transformers was insufficient to maintain the 7-7.1 amperes and bring every lamp on the circuit up to 450 watts. We therefore discontinued these tests

and immediately ordered another tub transformer about June 20th. Notwithstanding our effort to get immediate shipment, we were unable to get the new transformer until early in September. A day or two after it arrived, one of our old tub transformers burned out and the new one was placed in service, while the burned-out one was being repaired. Then the repaired transformer was put in service and five circuits changed over to six circuits on September 7, 1906. This change left a considerable margin on the "tubs," as they were only carrying a fair load, and we immediately started another series of tests to bring the lamps up to where we wanted them. The results of this change shows in the increase in the average watts per lamp, per month, after August.

Q. This result was owing to your getting a new transformer?

A. As the result of having the capacity necessary to supply that much load.

Q. Was there any objection to the lamp service given prior to this agitation early in April, 1906?

A. Absolutely none that I know of.

Q. Do you, of your own knowledge, know of any arrangement between the Hydro Company and your Company concerning these lamps in this city?

A. No, that is a question of management.

Q. Do the figures given in Exhibits M 1-24 inclusive, and the curve illustrate reasonably fairly what the lamps have been doing during that

period, February 15, 1905, up to the present time?

A. I consider that they do, from a practical standpoint.

Q. At the time of the agitation, was anything left undone by you that could reasonably be done to meet the objections?

A. By no means. We proceeded as rapidly as we could.

Q. You spoke of some tests in September. Are they illustrated by Exhibit "J"?

A. Yes, that is an accurate report of the tests made.

Q. What had you to do with these tests?

A. They were made under my supervision. I was personally present at a great many of them.

Q. What preparation was made in the plant for these tests upon the streets?

A. No unusual preparation. We simply ran the circuits in the daytime with the full complement of lamps on each circuit, burning the same as the circuits were operated at night; our idea being to arrive at the same condition that would obtain at night when the lamps were actually in service on the streets for illuminating purposes.

Q. How nearly did you arrive at these conditions?

A. I consider that we duplicated them.

Q. There is a separate test shown by Exhibit "L"; please explain it?

A. We have a number of lamps on the top of poles; some at places where it would be impracticable, if

not impossible, to take such a test as we were making, with the wagon equipped for testing purposes. Therefore, these lamps were brought into the sub-station testing room and there tested.

Q. There appears to be two columns, one the condition of the lamps when found and the other when left. What do these terms mean?

A. When placed on the test rack and with a current passing through them the same as on the line when in service, the wattage of these lamps duplicated that consumed when in service. Under the head of "Found" is given volts, amperes and watts, the readings taken a few minutes after the lamp was started on test, no adjustment of lamp ever being made until after the reading recorded under the head of "Found" had been taken; then if the lamp was not in normal condition, the necessary repairs or adjustments were made and the consumption of the lamp in volts, watts and amperes was recorded under the head of "Left," being the condition we left the lamp at the pick-up point. We went further and brought the lamp to feeding point so as to get an idea of the average performance of that lamp in watts consumed; however, that does not show on the record here.

Q. How many readings did you take?

A. We would probably take four or five readings to ascertain the record for the "Found" condition. Then after the lamp was properly adjusted, we would take another set of readings to ascertain the "Left" condition. There was no definite number of readings taken, as it was

unnecessary, there not being much fluctuation in the lamp.

Q. What place has candle-power as a basis upon which to predicate charges for service, or has it had no such basis in commercial electric lighting since you have been in the engineering profession?

A. I do not consider that candle-power is a tangible quantity on which to base any contract, and I have never personally known of a case where candle-power was sold by an electric lighting company.

Q. How about the sale of light as light?

A. I know of no case where light was ever sold as light.

Q. What is the basis upon which it has been and is being measured?

A. In the electrical lighting field it is absolutely a question of wattage; the amount of energy measured in watts necessary to produce good illumination.

Q. What do you say as to the relative merits of the 9.6 open and the 6.6 enclosed alternating arc at 450 watts?

A. For a given energy the desirable feature to be obtained is illumination, and, personally, I consider the total flux of light thrown off from the enclosed A. C. lamp consuming 450 watts, to be very superior to the general illumination from the 9.6 open arc lamp consuming the same energy.

Q. Taking the language of Section 9, of the Jackson franchise, by itself, what meaning do you think is proper to give to the words "such arc lights of standard 2,000 candle-

power each," construed as to the time when the franchise was based?

A. In the lighting field the standard 2,000 candle-power arc lamp is a well-known misnomer, and in the electrical fraternity such lamp is considered as an arc lamp consuming 450 watts at its terminals with no appreciable resistance in the circuit, and any arc lamp consuming 450 watts, within the reasonable limits of performance as to amperage and voltage, would come within that definition.

Q. If I have failed to bring out any point in your direct examination, you are at liberty to state it.

A. In making some luminometer readings with Mr. Ryan when he was here last September, on the 6.6 ampere lights in this city, we found the maximum and minimum readings not to vary a great deal; that is, we did not have to go much closer to the lamp for the minimum, when the arc was on the opposite side, than for the maximum reading, when the arc was on our side. At the same time, we found that by replacing a clear inner globe with an opal globe our maximum was cut down a trifle, but our minimum was increased, so that we didn't have to go as close to the lamp to make a reading as we did with the clear inner globe. I also happened to be in Denver when Mr. Ryan was there, and we similarly examined the 9.6 open arc lamp on the streets there, and found we could get a maximum considerably in excess of that obtainable from the lamp in use in Colorado Springs; but frequently—on four or five lamps—we had to go within 25 to 30 feet of the lamp to read the luminometer card, after the lamp had fed. Frequently, it

was a matter of from one to three minutes before the arc would pick up so it made any illumination of the street, and until that time there was a dense black shadow under the arc. These tests clearly indicated to me that the steadiness of the enclosed arc lamp made it far superior as an out-door illuminant compared with the open arc lamp; and from general observation, we felt the Denver system was well maintained from a practical operating standpoint, and have since been informed that they take great care in the maintenance of their lamps.

Question by Arbitrator:

Q. Do you remember about how far that Denver distance compared with the lamp as used here?

A. I haven't those figures with me at present; it was more or less of a relative investigation; not an investigation of actual distances, because, personally, I was not familiar enough with the luminometer to place my records on a scientific basis at that time; it was simply a relative comparison. I should say that there was a difference of probably 60 to 75 feet between the maximum and minimum of the enclosed arc lamps, while with the readings we got in Denver—I will admit the point of feeding, with practically no light, was a "freak" condition, yet with us that happened frequently with the open Denver lamps—there was a difference probably of 300 or 400 feet between the maximum and the minimum.

Examination Continued by Mr. Schuyler.

Q. Why hasn't candle-power been

made a standard upon which to predicate a charge?

A. There are a thousand and one meanings to candle-power. All of them have a different, a very different value; and by whatever means you arrive at candle-power, no definite basis on which to make a charge of candle-power can be obtained.

Cross Examination by Mr. Robinson.

Q. Did I understand you that there were a thousand and one meanings for the term candle-power?

A. I used that expression in a relative form; there are a great many.

Q. Enumerate all you know?

A. Well, there is the horizontal candle-power.

Q. Horizontal?

A. Another one is mean spherical.

Q. There are five that have been in evidence in this case: horizontal, mean spherical, mean hemispherical, average maximum and average minimum; now, do you know any more?

A. I don't actually know of any more.

Q. Do you say that you never knew of candle-power being sold?

A. Not on a basis of delivered candle-power.

Q. I will show you, Mr. Dillon, Section 9, referred to by counsel, and ask you if you find that contract calls for watts or lights?

A. It doesn't call for watts.

Q. Doesn't it call for light measured in candle-power?

A. No sir.

Q. Do you think the term "Arc lights of standard 2,000 candle-power each" doesn't mean light measured in candle-power?

A. No sir; not in my interpretation of it.

Q. You don't find any words in there on light or candle-power?

A. We all know that the standard 2,000 candle-power lamp is purely a trade name.

Q. If a man contracted, according to the terms of that contract, and wanted to use candle-power, couldn't he do it?

A. He could use all the candle-power he wanted, but he would not be contracting for candle-power.

Q. He would be contracting for light, wouldn't he, measured in candle-power?

A. He would be contracting for so much energy to be converted into light.

Q. Does he say energy?

A. No, it doesn't say so.

Q. But a man cannot be prevented from contracting for light or candle-power if he wants to?

A. He cannot buy light as candle-power; it cannot be sold as such.

Q. Would not that statement be very much like saying that a man can't do what he has done?

A. He can't buy in candle-power.

Q. Don't you know these experts have been measuring candle-power

and describing it to this Board for the last three or four days?

A. They have been telling about measurements of it.

Q. Showing that it can be measured?

A. Certainly.

Q. Then why do you say it cannot be measured?

A. Because no kind of tangible candle-power is asked for in the contract.

Q. No tangible kind?

A. No sir; candle-power is only one of half a dozen meanings.

Q. Don't you know that where candle-power is used lamps are measured in their maximum candle-power?

A. No sir.

Q. Don't you know that Mr. Ryan says so?

A. I know that such power can be determined.

Q. Can't a man enter into a contract and designate maximum candle-power?

A. He certainly can.

Q. He can make a contract in mean spherical or mean hemispherical candle-power if he wanted, could he not?

A. Yes, if he wanted to.

Q. Why do you understand the term "2,000 candle-power light" to mean a lamp consuming 450 watts on the average?

A. The only definition I know of defining such a lamp is the one adopted by the National Electric Light Association in 1894.

Q. Do you know what kind of a lamp that resolution referred to?

A. In my opinion, it would refer to any arc lamp consuming 450 watts at its terminals.

Q. At the time of the passage of that resolution were there any other than the D. C. open arc lamps in use?

A. I cannot say. It would refer to any lamp consuming that energy and operating within the proper limits of arc lighting.

Q. So, if a 9.6 D. C. open arc lamp consumed 450 watts, that would fulfill the definition?

A. Yes.

Q. If a 6.6 A. C. enclosed lamp with the current run up to 7 or $7\frac{1}{2}$ amperes, consumed 450 watts, would that fulfill the definition?

A. I certainly think it would.

Q. Doesn't the 9.6 ampere open lamp give a greater mean spherical candle-power than the 6.6 ampere enclosed?

A. The only evidence we have had showing the light from a 9.6 open arc lamp, is when it is operated under fixed and constant conditions consuming 450 watts. There is no way of getting at the average illumination from that lamp under practical operating conditions.

Q. Doesn't the average include the question of time?

A. Certainly, in watts it does.

Q. Now, when you fix the limit in laboratory service at 450 watts and test it at that, doesn't time come within the definition?

A. It certainly does not; it repre-

sents the average condition of an open arc lamp in the laboratory.

Q. There is no difference how it fluctuates within reasonable limits if the average is 450 watts?

A. Yes, if the fluctuations were such that within reasonable limits the lamp averaged 450 watts, I think it would come within the definition.

Q. Have I understood you correctly to the effect that if you put 450 watts of energy through any arc lamp under normal conditions, that would fulfill the definition of a 2,000 candle-power lamp?

A. I think so.

Q. It would not make any difference, then, whether the lamp was operated by an alternating current through an enclosed lamp or a direct current through an open arc?

A. I think not.

Q. Do you know what arc lamps were in common use for street lighting in 1894?

A. I do not.

Q. You think there were some, but you don't know what kind?

A. As a matter of fact, I do not.

Q. Do you know what were the proper limits of current and voltage in 1894 for a lamp?

A. I do not know of personal knowledge what they were using.

Q. Is not the extent of your knowledge based upon your interpretation of the Resolution of 1894?

A. I have always understood and been taught that the object of the Resolution in 1894 was to arrive at some tangible basis on which to determine street lights, and that it, at

that time, referred to the open arc; and I have been taught, and from other sources of observation been of the opinion that any arc lamp consuming 450 watts at the terminals, with equivalent illuminating power, as an illuminant would come within the meaning of that definition.

Q. Do you think a 2 ampere at 225 volts would do that?

A. I should not think it would.

Q. That would give 450 watts, wouldn't it?

A. Yes.

Q. Then the mere consumption of 450 watts in an arc lamp would not of itself comply with the definition, would it?

A. I don't think I have at any time so stated.

Q. What would you say as to a 4 ampere D. C. lamp with 112½ volts at the terminals?

A. I am not familiar with the lamp.

Q. Wouldn't that consume 450 watts?

A. It would.

Q. Mr. Dillon, referring to Exhibit "M 25," as I understood you to say that the drop as shown in November was caused by some failure of adjustment in the lamps?

A. Very likely.

Q. Well, would practically all of the lamps be out of adjustment and cause the decrease shown?

A. They might be.

Q. Do you know what the wattage consumption of the lamp is, as given by its manufacturer, which you

are using, and from which this record was made?

A. According to the manufacturer's data the lamp would consume under those conditions 430 watts at the terminals.

Q. And what at the arc?

A. According to the General Electric pamphlet the watts at arc are 400, and watts at terminal are 427.

Q. Now, does Exhibit "M 25" show the watts at the terminals or the watts at the arc?

A. Watts at the terminal.

Q. Now, how did the difference come on this sheet, in the month of August?

A. There might have been a little increase in the average current. It would be difficult to account exactly for all those fluctuations; it is an average for a month, you understand, and the extreme rise from July, through July and August, to the point arrived at in September is due to the fact that the lamps were tested in the early part of September, and additional apparatus installed, so that we had the necessary station capacity and apparatus for maintaining these lamps at the wattage which we wished.

Q. Isn't it true, Mr. Dillon, that you increased the wattage of the lamps because of the objections that had been made on behalf of the city?

A. I so stated. Previous to the time of the objections we felt that we were acting in good faith in giving them the lamp to which there had never been any objections made.

Q. Isn't it a fact that the tub transformer which you described was burned out by the company

boosting those lights, because it learned that the city was testing them?

A. There is no way in the world to prove that.

Q. I am asking you about that.

A. That is not my opinion; it was an incident in the operation of the street lights of this city.

Q. Isn't it a fact that you were boosting the lights at that time?

A. We were not boosting the lights at that time, no, sir.

Q. Didn't that transformer burn out about the first day of September?

A. Yes.

Q. And doesn't your curve there show that you, at that time, were putting the power up pretty high?

A. Remember that the point which represents September, is the average watts per lamp, consumed for the month of September, during which month I have admitted that the average wattage of the lamps was increasing during the month. To my knowledge there was no change made in the amperage, on the circuit, or in the adjustment of these transformers at that time.

Q. What was the amperage, if you know, on the 15th day of February, 1905?

A. 6.6, as near as we could adjust the transformers to it.

Q. When did you increase the amperage above that?

A. As I stated, I think it was in May, 1906.

Q. So that from February, 1905, to May, 1906, the amperage stood as

near 6.6 as you could operate the plant?

A. Certainly.

Q. And in May, 1906, to the best of your recollection, you increased it to what figure?

A. 7 to 7.2 ampercs.

Q. And you have maintained it at that point since as nearly as possible from a practical standpoint?

A. Yes.

Q. Now, if the amperage was increased to 7.2 in May, 1906, and has remained there practically ever since, what was done to cause the increase in the energy in August and September of that year?

A. The lamps in September were individually tested, and properly adjusted to take an increased wattage.

Q. Now, does that mean that you boosted the amperage in May, and boosted the voltage in September?

A. In September we made a general adjustment of the system. The voltage in many cases was changed at the lamp. In some cases it was reduced.

Q. Must not the average voltage have been greatly increased in order to get the curve which you have shown?

A. It would seem so, yes.

Q. A part of that increase was caused by your adjustment of the lamps?

A. Certainly.

Q. Then, prior to that time, practically all of your lamps were out of adjustment, were they not?

A. They were out of adjustment on the 450 watts basis, yes.

Q. Well, then, prior to about August 15th, you were not fulfilling the contract, according to your own interpretation of it; is that right?

A. We were not able to at that time. Our apparatus did not have sufficient capacity to deliver the wattage. We were then doing all we possibly could to get the apparatus and as soon as it was obtained we made the changes.

Q. I understood you to say that the illumination of the 6.6 A. C. enclosed lamps is equal to that of the 9.6 D. C. open lamps; is that right?

A. I would consider that the former is superior for street purposes to the latter, as an all-around, day-after-day illuminant.

Q. I show you figures which I took down from Mr. Ryan's testimony, showing the maximum candlepower of the A. C. 6.6 ampere as 480; the maximum of the D. C. enclosed 9.6 ampere as 1,250; the mean spherical of the 6.6 enclosed, 195, and of the 9.6 D. C. 370; the mean lower hemispherical of the A. C. 6.6 enclosed, 345, and of the D. C., 550, and ask you whether or not you would take these figures as being correct?

A. I would certainly take them as being correct for the conditions under which they were taken.

Q. You spoke of the circumstances under which they were taken; do you doubt the sufficiency of those figures to show the maximum spherical and lower hemispherical candlepower of the two lamps described?

A. In their laboratory tests, it is certainly correct.

Q. Then you don't think they are worth very much in practice, do you?

A. I don't think you can make a test on a lamp in practice like that; I never have tried it myself, and I don't believe it is possible.

Q. Then you think it isn't worth very much in practice?

A. No.

Q. Don't you think they could be made from data gathered from lamps in service?

A. I don't think that you can make an actual photometry test of a lamp in service on the street.

Q. Then what is your opinion of the way in which a street arc light should be measured?

A. By watts at the arc consumed.

Q. As to its value to a city; you would rate it by its power to give illumination?

A. No.

Q. Would you rate it by watts, without any regard as to whether it gave any illumination?

A. That certainly would make a difference, but I wouldn't rate it by anything other than the watts it consumed.

Q. But you would compare them as to which gave the better illumination?

A. Certainly.

Q. Then illumination would be a factor which you would consider in comparing one lamp with the other, to determine which was the better?

A. Under actual service conditions.

Q. Now, tell us in what units illumination is measured?

A. I don't know exactly.

Q. Can you tell the Board the connection between foot-candles and candle-feet?

A. No; in fact, I am not familiar with the subject.

Q. Can you tell it how they can measure illumination without considering candle-power?

A. I don't believe they can.

Q. I understood you to say that the flux of light from the A. C. 6.6 series enclosed lamp is greater than from the 9.6 open D. C. lamp; is that right?

A. Why, that is my understanding, that it is superior over a period of considerable time; not on your laboratory basis, but as a lamp is found installed on the street.

Q. If you could get the average of the conditions as found on the street, you would get the same thing, wouldn't you?

A. If you could, yes.

Q. So that the average flux of light from the smaller light is greater than the average flux of light from the larger lamp, which we have described, according to your view of it?

A. I think so, under operating conditions. I use that term, flux, as not purely technical, but as to the general reliability for service of the two lamps as compared.

Q. Isn't it a fact that the excess in the flux of light of one lamp over the other determines superiority?

A. No. What I may have called the total flux I mean relates to the

general conditions of the burning of the two lamps; that is, that one lamp burns along steadily and the other is up and down, burning high and very low.

Q. Mr. Dillon, how did you compute the lamp hours in your report?

A. I took the number of lamps in service actually on the circuit, multiplied that by the number of hours that the circuits were burning, which gave me the total lamp hours.

Q. Did you base your figures on a sunset and sunrise schedule?

A. Yes, commonly known as such.

Q. Well, what do you mean now by that?

A. It is recognized as approximately 4,000 hours a year.

Q. Well, did you make your figures on 4,000 hours?

A. Yes; I mean it is a very small fraction of one per cent. short.

Q. Referring to the plant, have you a wattmeter on each of the arc circuits?

A. No, sir.

Q. How many wattmeters have you connected with the arc system?

A. Two in service constantly.

Q. Those two measure the total watt hour output on the arc system?

A. They do in Colorado Springs.

Q. From July 9th, 1906, the two wattmeters measured the current for Colorado Springs alone, and separate from Colorado City, did they?

A. Yes.

Q. What information with respect

to individual circuits did your wattmeters give?

A. They gave information with regard to the whole system only.

Q. And none as to the individual circuits?

A. No.

Q. Then any one of these circuits might get out of service without any wattmeter stopping to record that?

A. It could; but our station records or log would also show that.

Re-direct Examination by Mr. Schuyler.

Q. Do you, of your own knowledge, know anything of the arrangement, if any, made between the Hydro-Electric Company and the City of Colorado Springs, as to the conditions which should prevail in the operation of these street lamps—this street lamp system—between February 15th, 1905, and, say, September, 1906.

A. I do not.

Q. After that time in your opinion, were the lamps being operated in accordance with the Jackson franchise contract?

A. Beyond any question.

Re-cross Examination by Mr. Robinson.

Q. Were the lamps consuming 450 watts at the arc or at the terminals from September, 1906, down to the present time?

A. Our records show that they were very much in excess of 450 watts at the terminals, on the average.

Q. If the Jackson franchise called for 450 watts of energy, then you think you were making full compliance with it?

A. No.

Q. What were you doing?

A. I think we were supplying an arc lamp consuming 450 watts at the terminals, running 7 to 7.5 amperes, somewhere around there; that is generally accepted, according to the general meaning of the term, as the standard 2,000 candle-power lamp.

Q. And because you think it was generally accepted, then are you prepared to say that that operation was fulfilling this franchise?

A. I think we were delivering the equivalent of the standard 2,000 candle-power arc.

Witness excused.

MR. R. F. SCHUCHARDT, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. Mr. Schuchardt, please state when in your recollection or knowledge the enclosed arc lamp came into use.

A. *I don't know the exact time, but I do know that in 1898 they were in use, and fairly well perfected, and they had then been in service for about two years.*

Q. Taking the language alone into consideration, what in your judgment is the meaning of the phrase in the Jackson Franchise "such arc lights of standard two thousand candle power each," as therein used?

A. *The only interpretation to place on that is the one placed by the definition, an authentic definition, both by the International Congress, and by the National Electric Light Association of America, which defined such a lamp as a lamp consuming 450 watts at the terminals. The term "two thousand candle power" as used all this time is a misnomer, because the lamp in question was not actually giving two thousand candle power in any direction; nor was any lamp at that time doing so.*

Q. To what extent, if at all, in connection with arc lamps, does or has the Chicago Edison Company sold light on the basis of candle power, or adopted that as a measurement upon which to predicate a charge for service?

A. *Neither the Chicago Edison Company, nor any other company that I know of, has ever sold arc light by candle power.*

Q. Is such light sold as light, or has it been within your experience?

A. *It is sold by wattage; by power consumed.*

Q. What, in your opinion, as an electrical engineer, has the basis been upon which charges for service should be predicated?

A. *The only equitable basis would be power; that is, kilowatt hours. It is the only thing about the lamps that can be definitely measured.*

Q. Why is it that you cannot arrive at a definite basis of candle-power; what is the reason for that?

A. *Because candle power, unless very clearly defined, might mean almost anything with regard to the light from the lamp.*

Q. From your experience, can you give the Board some practical illustrations of the illuminating values of the open arc and the enclosed alternating lamp consuming 450 watts?

A. *All of the old work in my city, like in many other cities, consists of series open arcs. There are many of them in the city of Chicago. The early installations, for street lighting, consist entirely of open arc lamp systems. All of the new installations are alternating current systems, the lamps taking, I think, approximately 450 watts. I have had occasion at times to make comparisons. I have tried to read certain sized type at a given distance from these lamps. I remember particularly a comparison made by me in Milwaukee and Chicago, where the porch of a house in each city is about 120 feet from the corner street lamp. In Milwaukee, the corner lamp is a 9.6 ampere open arc, in the other, Chicago, it is 6.6 ampere alternating current series enclosed lamp.*

I have tried to read a certain size type on each of these porches. In the first case with the open arc, I succeeded when the arc was on the side toward the house, but when it travelled to the other side I could not make out anything on the page. On the Chicago porch I did not find this extreme and violent fluctuation, and had no trouble in reading the type almost the entire time. The enclosed alternating is a far better street illuminant than the open arc, has a better distribution; and the intrinsic value of the light source, compared with the open, is far less in the enclosed lamp, hence you have a far easier effect on the eye, while the general distribution is far superior to that coming from the other lamp. In fact, the two lamps are epoch-making illuminants in the history of street lighting. The old open arc is being supplanted by the superior illuminant, the enclosed lamp. The fact that people who still maintain series open systems have trouble in getting repair parts, is sufficient evidence of the truth of what I have just stated.

Q. Is there anything in the construction or method of operation of the 9.6 ampere direct current open arc lamp that contributes to difficulty in practical measurement of candle power?

A. *The extreme variation of the light; the fact that due to the construction of these lamps the rod sticks frequently, causing jerky light, works very much against the accurate determination of the candle power, and such tests as have been made were under laboratory conditions.*

Q. Would such laboratory conditions prevail in practical operation of the lamp?

A. *They would not.*

Q. Suppose four gentlemen measure the wattage of two lamps, upon two different circuits, out of a total of 241 lamps and six circuits in operation upon the streets of a city, thereafter remove said lamps to a laboratory and make a candle power curve upon the data so secured, would that test in your opinion be a fair illustration of what all the lamps in the city, upon all of the circuits, were doing at that time?

A. *It would not.*

Q. Would it in your opinion be in any way a fair representation of what the lamps had been doing for a period of fifteen months previous to the test?

A. *I cannot conceive how that could be.*

Cross-examination by Mr. Robinson.

Q. A test upon one lamp would give you the current on that circuit?

A. *Yes, if the lamp is tested in its circuit.*

Q. You spoke of some lamps being in use in Chicago, as the 6.6 A.C. enclosed?

A. *The lamp, I believe, is a 7 or 7.5 ampere of the General Incandescent Co. make.*

Q. Do you know whether or not the lamp to which you have referred is the commercial 6.6 or the 7.5 lamp?

A. *I don't think it is either.*

Q. Is it some special type?

A. *It is a standard lamp built by the General Incandescent Co., but I don't know what it is rated at, but*

my recollection is that it is 7 or 7.2 ampere.

Q. What is the globe used on that lamp?

A. Either a very light opalescent or a clear inner globe.

Q. With a clear globe, is it not true that the intrinsic brilliancy of the enclosed arc is objectionably high?

A. At the beginning of the run it may be, but the inner globe becomes coated very rapidly with a light deposit, which makes it slightly opalescent in effect.

Q. Have you ever made any test of the flux of light in the street?

A. No sir, not of the flux of light.

Q. Referring to the lamp which you have described as being in Milwaukee, do you know the amperage at which that lamp is run?

A. It is supposed to be a 9.6 ampere lamp; what the exact amperage is I don't know.

Q. Do you know what repair it is kept in?

A. I do not.

Q. Referring now to the resolution of 1894, I understood you to say, possibly it was a slip though, that the resolution referred to was passed by the International Congress as well as by the National Electric Light Association?

A. My recollection was that such was the fact; but I wish to say that I have refreshed my memory and find that I am mistaken so far as the International Congress is concerned..

Q. Now, don't you know that, as a matter of fact, in 1894, the lamps then in use were the 9.6 or the 6.8 D. C. lamps?

A. Those lamps were in use; and there were also alternating current lamps in use.

Q. In 1894?

A. In 1894.

Q. Where were they?

A. In the discussion preceding the adoption of this resolution by the National Electric Light Association, the chairman of the committee, Professor Anthony, said that it was his intention that the alternating lamp should also be included in this ruling. This, I think, is sufficient evidence that the alternating current lamp was at that time in use.

Q. All you know about that is what you have read?

A. Yes.

Q. You referred to some enclosed lamp being in use, to your knowledge in 1898?

A. Yes.

Q. Were they or were they not constant potential lamps?

A. The lamps referred to were constant potential.

Q. Were they D. C. or A. C. lamps?

A. The lamps I had in mind, were all D. C., but I saw A. C. lamps in service at that time also.

Q. Isn't it a fact that the decrease in use of the open arc and the increase in the use of the enclosed arc is chiefly due to the lessened cost of the latter?

A. From the standpoint of an illuminating engineer I will say most positively no. It is an index of the modern trend in illuminating engineering.

Q. Which gives the greater maximum candle power?

A. Unquestionably the open arc.

Q. Which gives the greater mean spherical?

A. I believe the open arc.

Q. Which gives the greater mean lower hemispherical?

A. The open arc.

Q. Which gives the greater minimum?

A. The upward ray of both is

zero. Answers to these questions are very misleading, however, because the use of a lamp has no relation to its maximum lower hemispherical or of its minimum candle power. The condition which determines illuminating value is the distribution of the light; that is, what the candle power is in the useful directions, and the answer to that question is the reason for the adoption of the enclosed arc lamp.

Q. Then which of those two lamps gives the better distribution of light?

A. The enclosed arc lamp, unquestionably.

Witness excused.

Board adjourned.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 7.30 P. M., FEBRUARY 7, 1907.

Statement by Mr. Schuyler.

May it please the Board in further support of the position of the Pike's Peak Hydro-Electric Company, I wish to offer in evidence certain portions of the work on the Art of Illumination, by Dr. Bell, published by the McGraw Publishing Co. in 1892, page 2; also chapter 7 and pages 144-156. I call the Board's attention specially to the tracing between the figures 49 and 50, as shown in the two figures, on page 150.

Arbitrator: As I understand, this evidence has been before the Board in a number of forms; what is the object of this?

Mr. Schuyler: To show a very material change in the views of the witness. I simply want the Board to have this before it, as we desire to have these declarations of the witness who was upon the stand in behalf of the City, and without it being read into the record, we don't know how the record would be complete.

I also desire to offer the entire chapter 11, without reading it, upon Exterior Illumination, page 250, also pages 336, 335, 337, 338 and 339—I think you will find matters that are peculiarly relative, and not brought out from this witness before.

MR. GEORGE B. TRIPP, being first duly sworn in behalf of the defendant, testified as follows to wit:

Examination by Mr. Schuyler.

Q. Upon coming to Colorado

Springs as manager of the Colorado Springs Electric Company, in October, 1901, what did you find as to the condition of the street lamps, and arrangements made with reference to them?

A. I found that the system at that time being used was the direct current lighting system, and that a new contract had been made between the City and the Electric Company, and the latter was simply waiting until the apparatus had been received in Colorado Springs before the new system of alternating current arc lamps could be installed. I had the new apparatus installed during the month of December, 1901.

Q. Now, what apparatus was that?

A. The apparatus consisted of General Electric so-called tub transformers, and the incidental switch-board and other apparatus that goes with that system, together with the complete complement of 6.6 ampere arc lamps.

Q. And how with reference to the equipment we now have upon the streets?

A. That equipment is the same.

Q. From December, 1901, on, was there ever any objection made by the City of Colorado Springs to this service furnished through those lamps?

A. Not officially. I only heard of objections through the medium of the newspapers.

Q. Had there been any objection up to the 15th day of February, 1905?

A. *Not that I can recollect.*

Q. These newspaper comments that you speak of were within the past year?

A. *They were.*

Q. Do you remember, on or about February 15, 1905, when the change was made from the 1901 contract, and the order of the Council was made to turn the water into the pipes of the Pike's Peak Hydro-Electric Company?

A. *I do.*

Q. Were there any conferences between you and the representatives of the City, and of the Pike's Peak Hydro-Electric Company, prior to that time?

A. *There were.*

Q. With reference to that matter?

A. *Yes.*

Q. And with reference to street lighting?

A. *Yes.*

Q. And with reference to the lighting of the City Hall?

A. *Yes.*

Q. Now, where and when was the conference or conferences between such representatives?

A. *Such a conference took place during the month of January, in 1905, at the office of Mr. L. C. Perkins, at which time Mayor Harris, Aldermen St. John, John Hill, Perkins, Holden, Verner and Dunbar were present; there were six, to my recollection. There also were present at that meeting Judge Babbitt, Mr. Taff and myself.*

Question by Arbitrator:

Q. How many members of the Council were there?

A. *Eight; six there, and two absent.*

Examination Continued by Mr. Schuyler.

Q. Who was Judge Babbitt?

A. *Judge Babbitt represented the Pike's Peak Hydro-Electric Company's interests at that meeting.*

Q. And was there any officer of that company present?

A. *Mr. Taff.*

Q. And yourself?

A. *As representing the Colorado Springs Electric Company, yes.*

Q. State what agreement or arrangement was at that time entered into between the parties there represented, with reference to the turning over of the lighting to the Pike's Peak Hydro-Electric Company, especially the street lighting?

Statement by Mr. Robinson.

Just a moment. I don't propose to put in an objection, but simply in the interest of saving time. That contract as between these parties is an Ordinance; we call it a contract. Now, if I understand what they are attempting to do, it is to show that at a meeting between men who were aldermen, on the one side, and representatives of these two companies on the other, some agreement was made which would change this Ordinance. As a question of law, they could not make any change in the Ordinance. I simply state that if this point is brought up, it will require a great

deal of time to go into it on our side.

Arbitrator: That may be the case, but they had better proceed, and we will consider your objection afterwards.

Mr. Schuyler: So far as the legal point raised by counsel is concerned, it certainly lays the foundation for what is known in law as equitable estoppel. Answer the question, Mr. Tripp.

A. The general conditions were discussed at that meeting with reference to the time when the Hydro Company would first begin to supply light to the City, and also when the City would allow the turning on of the water into the mains of the Hydro Company, making it possible for them to generate electricity therefrom. A resolution was discussed and outlined at that time, which was finally passed at a subsequent meeting of the Council. The question particularly was asked by one of the aldermen present as to whether there would be any change in the apparatus, poles, lines, arc lamps, etc., on the streets which had been operated by the Colorado Springs Electric Company when the Hydro Company began its operations; and that matter was fully explained that there would be no change in the poles, lines, arc lamps, etc. The other matter of the lighting of the City Hall was also discussed. It seems that the original Jackson franchise provided for furnishing without charge a limited number of incandescent and arc lamps, and in lieu of that the councilmen preferred that, on the Hydro Company's suggestion, the complete lighting of the City Hall be made without any question as to the number of lights therein.

Q. Were there at that meeting any aldermen who were aldermen of this city at the time that the 1901 contract was adopted, whereby the present system was installed in lieu of the old 9.6 ampere system?

A. Mr. St. John was the only one.

Q. Prior to this, had you had any conversations with city officials concerning the matter?

A. I had.

Q. Just state what they were?

A. The general question came up as to the arc lighting system, and whether the City could be inconvenienced or not, and I affirmed that there would be no cessation of light in any particular on account of there being no change contemplated in the apparatus, either overhead or in the plant itself; that the Colorado Springs Electric Company were simply to act as the distributing agent of the Hydro Company.

Q. Was that the relation which came in force after February 15th, 1905?

A. February 15th the Colorado Springs Electric Company ceased to bill the City of Colorado Springs for arc lighting, and the Hydro Company began its charges, and began billing the city at the franchise rate.

Q. After this full discussion of the situation with reference to continuing to operate this same system under the new arrangement, what objection or dissent was made, if any, by either the Mayor or any representative of the City, councilmen or otherwise?

A. There were no objections that I heard anything about.

Q. Upon, or in reliance of what understanding did the Hydro Company then continue to give this street lighting after that time?

A. *They lighted the streets of the city under the Jackson franchise, through the Colorado Springs Electric Company as their distributing agent.*

Q. And in accordance with the suggestions at this meeting?

A. *Exactly.*

Cross Examination by Mr. Robinson.

Q. You spoke of a meeting, as I understood, in Mr. Perkins' office?

A. *I did.*

Q. Was that a meeting of the City Council?

A. *Not in regular formation; it was a meeting of the councilmen, and the Mayor, together with representatives of the Hydro and Colorado Electric Companies.*

Q. Simply a meeting of the representatives of the two companies with certain gentlemen who were members of the City Council, was it not?

A. *Yes, but they met for a specific purpose, and preliminary to a meeting of the City Council.*

Q. But it was not a meeting of the City Council?

A. *Oh, no, certainly not; not in a store room.*

Q. And I believe you said that at that meeting a resolution was discussed, which was afterwards passed by the Council?

A. *Yes.*

Q. Do you recognize Exhibit No.

46 as being the resolution to which you refer?

A. *Yes.*

Q. Mr. Tripp, will you please state to the Board what the arrangement was between the Colorado Springs Electric Company and the Pike's Peak Hydro-Electric Company, as to furnishing lights for the streets of this city?

A. *That was simply, as I have stated before in my testimony, that the Colorado Springs Electric Company should be the distributing agent for the Hydro Company.*

Q. Are you connected with the Colorado Springs Electric Company, Mr. Tripp?

A. *No.*

Statement by Mr. Robinson.

I will now call on counsel for the Colorado Springs Electric Company, and the counsel for the Pike's Peak Hydro-Electric Company to furnish a copy of the contract between those Companies, under which lights are being furnished to the streets of this city.

Mr. Schuyler: We object to the introduction in the record of that contract; first, because it is entirely unnecessary under the issues of the case, and because it is taking into the record here a matter of private contract between these companies that is entirely unnecessary for the Arbitrators to arrive at a correct understanding of the situation; we having admitted that we are here furnishing these lights, and ready to submit to a judgment of the Board, as we have admitted that we are the responsible parties, and as the witness has already testified that the Colorado Springs Electric Company was the distributing agent, anything

in this contract throwing light on the matter could possibly arise. That is the position of the Hydro Company.

Mr. Holland: In behalf of the Colorado Springs Electric Light Company, I will say that we are not a party to this arbitration; whatever rights these parties may have, it is to be by reason of a contract which has been entered into between the City and the Hydro Electric Company, and cannot possibly have any jurisdiction, directly or indirectly, over the Colorado Springs Electric Company.

Mr. Robinson: Then I understand from both of you, representing your respective companies, that you decline to furnish a copy of that contract?

Mr. Schuyler: We submit to the Board whether it is material or not.

Q. Then, Mr. Tripp, I will hand you Exhibit No. 48—

Mr. Schuyler: Just a moment, if the Board please. We wish a ruling.

Arbitrator: Proceed, Judge Robinson.

Examination continued by Mr. Robinson.

Q. Mr. Tripp, I will hand you a paper marked Exhibit No. 48, and ask you to look at it, and state whether or not, to the best of your knowledge and belief, that is a copy of the contract between the two corporations described?

Mr. Schuyler: We make the same objection; but I understand it is allowed to go in.

Arbitrator: It is submitted as evidence, which we feel we have no occasion to rule out; the question of calling for other documents not here is another proposition.

Witness: May I ask the Board a question?

Arbitrator: Certainly.

Witness: This is not a copy that I would be very familiar with on account of its length, and the signatures are printed there; this is in a newspaper form. I think it would hardly be fair to ask me to swear absolutely that that was a copy.

Q. I didn't ask you that, Mr. Tripp; I asked you to the best of your knowledge and belief.

A. Then I prefer to read it. (Witness reads paper.) That apparently is a copy of such contract. As to whether it is an exact copy of the contract, I couldn't say.

Re-direct Examination by Mr. Schuyler.

Q. To whom did the City send requests for additional lamps since February 15th, 1905, if you know, and while you were in charge of the Colorado Springs Electric Company?

A. To the Colorado Springs Electric Company.

Q. And what kind of lights were asked for?

A. Why, the specification—there was no real specification to the order; it was simply, "We hereby request that an arc light be installed at the intersection of such and such streets," and signed by the chairman of the Street Committee. Those orders would be written in the office of the Colorado Springs Electric Company, and the chairman of the Street Committee would drop in at some time and sign them.

Q. How frequently has that happened since February 15th, 1905, approximately?

A. Why, I should say monthly.

Witness excused.

MR. GEORGE A. TAFF, being first duly sworn in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. What was your employment when you first came here?

A. I came here as engineer for the Colorado Springs Electric Company.

Q. How long did you continue as engineer for the Colorado Springs Electric Company?

A. From April, 1900, until November, 1901.

Q. What kind of a street lighting system was in vogue here when you came, and during the time you were with that company?

A. The direct current, open arc system, with 9.6 to 10 ampere lamps, Thompson type, operated from Thompson arc generators.

Q. After coming here, do you remember a time when the question of changing the system came up, from the old style 9.6 to the new type of lamp, the 6.6?

A. I do.

Q. About when was that, Mr. Taff?

A. Some time in the spring of 1901.

Q. State the circumstances surrounding that matter?

A. Early in the summer of 1901, the Colorado Springs Electric Company ordered a small tub transformer, and about 25 lamps of the alternating current type, for the purpose of having the same placed on the streets in the City of Colorado Springs, to demonstrate their supe-

riority over the direct current open arc lamps, then in use in the city.

Q. And after placing such lamps, what took place with reference to inspections of them, and exhibitions of their respective merits?

A. As engineer for the Company, I spent considerable time on the streets in the evening, accompanied by the aldermen, inspecting the new light, and comparing it with the old open arc that had been in use here for some time.

Q. How were those 25 lamps placed with reference to the other lamps?

A. They were placed on corners 500 feet apart, directly opposite those occupied by the old open arc, for the purpose of allowing a comparison being made between the two forms of light.

Q. That is, upon an opposite corner?

A. The opposite side of a block.

Q. And what was done by you and the aldermen with reference to examining these lights, and their respective merits, and how frequently?

A. We were out nearly every night, discussing the feature of illumination, comparing them in a number of ways.

Q. Just explain to the Board what ways those were that were adopted?

A. I cannot recall now the conversation that took place; but I do recall specifically how we arrived at a conclusion as to the quality of the new lamp.

Q. Please state that?

A. At the intersection of Platte

Avenue and Tejon Street, there was an open arc, direct current lamp, one of the old type; and at the intersection of Nevada Avenue and Platte we had one of the alternating current arc lights placed. During the conversation at the time referred to, I suggested that we walk down midway between the two lamps, and be in a position to examine the lamps from practically the same distance. We found that the shadow formed by the alternating current enclosed arc lamp, that is, the shadow to the west of the observer, was very much sharper and stronger than the shadow to the east, that caused by the screening of the rays from the open arc light. With that point brought up, we spent considerable time discussing it, and I believe that is the last evening I spent on the street in company with the aldermen.

Q. Now, after that, what expression was made by the representatives of the City to you with reference to the new lights?

A. When the examination or inspection of the shadows came up, one or more of the aldermen stated that that convinced him the new light was a more powerful light than the old one, or something to that effect; they were satisfied the new light was a better light than the old one; and some time shortly after that a contract was entered into between the City and the Colorado Springs Electric Company for the placing of the new form of light on the streets as a substitute for the old arc light.

Q. What do you say as to the difference between that lamp which you were then exhibiting and the present lamps on the street, if any?

A. They are the same lamps.

Q. After leaving the Colorado Springs Electric Company, what connection did you have with the Pike's Peak Hydro-Electric Company?

A. I was manager of that company, although not exclusively employed. I gave that company such of my time as was necessary.

Q. Under whose direction was the pipe line and plant at Manitou built?

A. Under my direction; I was the engineer for the company.

Q. At what time was it that the water of the City of Colorado Springs was turned into the pipe line of that plant?

A. On February 2, 1905.

Q. About that time, do you remember any conference had with officials or representatives of the City of Colorado Springs, concerning the turning of the water into the pipe line, and the lighting of the City of Colorado Springs?

A. I do.

Q. Where was such conference, and when?

A. That conference was held at the office of Mr. Perkins, one of the aldermen, some time in January, 1905.

Q. State who were present, if you recollect?

A. There were present at that meeting Mayor Harris, Aldermen St. John, Dunbar, Perkins, Holden, Hill and, I believe, Verner.

Q. Of how many was the City Council composed at that time?

A. Eight, I believe.

Q. And what kind of a meeting was this and for what purpose?

A. It was a meeting of the aldermen, for the purpose of considering the notice from the Pike's Peak Hydro Electric Company that they were ready to furnish lights to the City of Colorado Springs under the terms of the Jackson franchise, and for the purpose of considering the application by the same company for an order to turn water through the pipe line.

Q. State to the Board what agreement or understanding with reference to the street lighting was at that time talked of and entered into by the representatives of the various parties present?

A. The principal question under discussion was the furnishing of street lights by the new company, and as to how they were to be furnished; and the question came up as to whether the change of lighting by the new system and the new company, would involve an interruption in the street lighting service, and we assured them that would not occur, inasmuch as we had made arrangements with the Colorado Springs Electric Company to furnish the lights through that company and through the system then on the streets, and that in making such change there would be no interruption in the lighting service.

Q. Were any of the aldermen in that Council also councilmen when this demonstration of the relative merits of the two lights was made, back in September, 1901?

A. Alderman St. John, I believe, was the only one present at the meet-

ing, although Mr. Banning was also a councilman at the time referred to.

Q. What did you gather as to their wish with reference to the Hydro-Electric Company using those same lamps, the same system?

A. I understood it to be acceptable, and no objections were offered when it was explained how the street lights were to be furnished; that matter had been evidently discussed for some little time previous to the meeting in Mr. Perkins' office, but not by myself. Mr. K. R. Babbitt counsel for the Hydro-Electric Company, had, I believe, carried on some discussion with the different members of the Council.

Q. After that time, Mr. Taff, what objections were made, if any, by any representative of the City of Colorado Springs to these lights, to the Pike's Peak Hydro-Electric Company?

A. No objections directly to the Pike's Peak Hydro-Electric Company and none that I heard of in any form until the Spring of 1906.

Q. Did you then receive any objections officially?

A. I did not. The only official evidence we have received, was a bill from the City, asking a refund of some \$16,000 on lighting bills rendered from that period up to May 31, 1906.

Q. What outside agitation, not the official, was brought to your attention concerning the Hydro-Electric Company's affairs?

A. The newspapers reported certain doings at the city council.

Q. During this time, what atti-

tude did the City assume toward the Hydro-Electric Company, and in its water supply?

A. A very antagonistic attitude. On numerous occasions turned off the water, and shut down the plant without notice.

Q. How many times did the Pike's Peak Hydro-Electric Company resort to the courts by way of injunction in the Spring of 1906?

A. I can't recall now, but I believe several times, in order to protect the property.

Q. And has the Pike's Peak Hydro-Electric Company at any time received requests from the City of Colorado Springs to install additional street lights?

A. Very recently; in the past six weeks we have received requests from the Chairman of the Street Committee to install in all, I should say, nine or ten lamps.

Q. In reliance upon what understanding has the Pike's Peak Hydro-Electric Company continued the street illumination of this City since February 15, 1905?

A. On the understanding or agreement reached at the meeting of the council in Mr. Perkin's office.

Cross-examination by Mr. Robinson.

Q. Was that a meeting of the city council of this city, Mr. Taff?

A. I believe so.

Q. Was there any clerk present?

A. Not to my knowledge.

Q. Any record made of the proceedings that you know of?

A. I understand there was; as to whether it covered the exact language as used at that meeting, at that particular time, I couldn't say.

Q. Wasn't it, Mr. Taff, just a meeting of two or three of you gentlemen representing the electric companies, and some of the men who were aldermen in the city?

A. It was a meeting of the city council and its Mayor, as I was notified, called for the purpose of discussing the features we have just related, and for convenience they met at Alderman Perkins' office.

Q. You understood that it was a meeting of the city council, did you?

A. I believe it was; I so understood it, and I have had no notice to the contrary since that date.

Q. I hand you Exhibit No. 46, and ask you if to the best of your recollection that resolution was passed after the meeting to which you refer?

A. I believe that is their way of expressing the sense of the meeting referred to; I believe it refers to that meeting.

Q. I hand you Exhibit No. 49, do you recollect sending that communication to the City?

A. I cannot recall it.

Q. I hand you Exhibit No. 47, and ask you if you recognize that as being a copy of a letter which you wrote to the City concerning the furnishing of street lights, and the turning on of the water?

A. I recall this communication.

Q. I understood you to refer to some incident when the trial lamps

were on the street, and one of the alderman expressed himself as satisfied with the light; who was that alderman?

A. I cannot say now which one of the number did the talking, or expressed themselves as stated.

Q. Can you state who any of those persons were?

A. I cannot.

Q. In the conversations between you and any of the aldermen of the city concerning the change of light, was there any representation made as to the new light, or what would be its characteristics?

A. I believe we explained to the aldermen as clearly as possible, that the new form of lamp was to be an alternating current enclosed arc lamp, of the type known as 6.6 amperes capacity.

Q. What was said about candle-power?

A. Nothing that I know of; in fact I will say now that in none of my discussions so long as I have been connected with electric construction, have I used the term candle-power.

Q. You never claimed then that the candle-power of the new lamp was equal to the candle-power of the old lamp?

A. I claimed the light was superior to the light then on the street.

Q. In your direct examination, Mr. Taff, I understood you to say that you had had no notice of any objections to the light being furnished on the streets of this City, until a bill for about \$16,000 was rendered to you?

A. That was the official notice I referred to.

Q. Prior to that you had known that there were objections, had you not?

A. Such as I saw in the papers regarding resolutions introduced in the City Council, and the very strong statements made by the City Attorney on that subject.

Q. Isn't it true, that you were present here in this chamber at at least two meetings of the City Council when this matter was under discussion, and long before you received any bill for \$16,000 or any other sum from the City?

A. I was present in this council chamber at no meeting to my knowledge where the lighting question was discussed. I was present when a discussion was on concerning the waste of water by the Hydro-Electric Company.

Q. You remember the agreement between the City and the Hydro Company dated June 12th, 1906?

A. I do.

Q. Now for some months prior to that time, had you not had various meetings with committees of the City Council and the Mayor, looking to an adjustment of the difficulties between the City and the Company?

A. I attended one or two meetings, in the private office of Mayor Hall, looking to the adjustment of the differences; but that was on the so-called waste of water by the Pike's Peak Hydro-Electric Company; at which meetings we agreed, in order to satisfy certain members of the City Council, that we would make some changes in the mountains. I

cannot recall of any meeting prior to June 12th, where the question of arc lights was discussed.

Q. You remember to have addressed the Council regarding these matters at least once, don't you?

A. I addressed this Council some time in February, 1906, particularly and specifically on the charges made by the Water Superintendent.

Q. And you addressed various communications to the City Council in regard to the controversy, did you not?

A. I believe I did.

Q. Do you remember that there were several resolutions introduced in the Council concerning the charge that the Hydro Company was not fulfilling its contract, and several reports made by aldermen or commit-

tees, along in the fall and winter of 1905 and 1906, concerning the matter?

A. I cannot recall that; in fact the first communication or action by the City Council that I recall was along in March of 1906.

Q. If I call your attention, Mr. Taff, to the fact that a report to the City Council was made by the City Attorney about March 22, 1906, would that recall to your mind that for some months prior to that time the question of the differences between the City and the Hydro-Electric Company had been agitated in the City Council?

A. I cannot recall now of anything of that kind being agitated; it may have been; I do remember a resolution being introduced looking to the repeal of the Jackson franchise.

Witness excused.

MR. R. F. SCHUCHARDT being recalled in behalf of the defendant, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. Mr. Schuchardt, will you please state to the Board if the National Electric Light Association has at any time since 1894, when it adopted this resolution which has been under discussion here, changed it or

modified it in any particular to the present time?

A. I am not aware of any such change.

Q. How often does that Association meet?

A. That Association meets once a year, I believe.

Witness excused.

THEREUPON THE DEFENDANT RESTED HIS CASE.

BOARD ADJOURNED.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 9 A. M., FEBRUARY 8, 1907.

MR. K. M. MACMILLAN being recalled in behalf of the plaintiff in rebuttal, testified as follows, to wit:

Examination by Mr. Robinson.

Q. Mr. MacMillan, have you in your possession as City Clerk of this City the record of the meetings of the City Council covering December, 1904, and January and February, 1905?

A. I have.

Q. Will you please produce them and read to the Board the record of all the proceedings concerning the Hydro-Electric Company matters that you find in the record of the City Council during the three months mentioned?

A. This is from Record 9, page 396; a communication from G. A. Taff, President of the Pike's Peak Hydro-Electric Company, (reads letter, Exhibit No. 47), also a communication submitting a proposition to furnish the said city free of cost all electric current necessary for lighting the new City Hall, Exhibit No. 49. Communication ordered placed on file.

Mr. Schuyler: What date was that, Mr. MacMillan?

A. That is a meeting held on January 16th, 1905. Alderman Perkins introduced the following resolution, which was read. I read from page 397: (reads Resolution, Exhibit No. 46.)

Q. Outside of what you have

read, and the reference on pages 397 and 398 about a bond furnished, do you find the record of any other matter concerning the resolutions between the City and the Pike's Peak Hydro-Electric Company, concerning the use of water or the furnishing of lights?

A. Not in the periods mentioned in your statement.

Q. Did you ever attend a meeting of the City Council in the office of Alderman Perkins, in January of 1905?

A. I did not.

Q. Was there ever such a meeting held there?

A. No.

Q. I will ask you whether or not you were City Clerk during January of 1905?

A. I was.

Q. And was it a part of your duty to attend a meeting of the City Council?

A. It was.

Q. As such Clerk or otherwise do you know of any meeting of the City Council ever having been held in the office of Alderman Perkins?

A. No, I do not.

Q. Do the records of the City Council show any meeting held at that place?

A. They do not.

Witness excused.

PROF. J. C. SHEDD, being recalled in behalf of the plaintiff in rebuttal, testified as follows, to wit:

Examination by Mr. Robinson.

Q. One of the witnesses for the defense, I believe, Mr. Ryan, cited Professor Ed. L. Nichols as authority to sustain a claim made by that witness in this case. Can you give us anything from Professor Nichols as rebuttal of the testimony of that witness?

A. Yes, I desire to cite the following letter of November 24, 1906, from Dr. Nichols himself;

"The question of the interpretation of the term 2,000 candle-power as applied to arc lamps is a very old one. I do not know in how many instances consumers have been able to hold electric lighting companies to the letter of the law, but it is my impression that the term has been recognized as a merely nominal one. It was introduced for the purpose of deceiving the public, and has been known as a fake expression ever since. There is no ordinary arc light of 2,000 candle-power on the market, and never has been; but the city is undoubtedly entitled to lamps giving such light as can be obtained from a properly constructed and regulated mechanism employing 10 amperes of current at not less than 45 volts. This at least the contracting company could be held to under a system of inspection on the part of the city. I should hold further that if the company subsequently changed over from direct current open arc lamps to enclosed arcs, they were not entitled to charge at the same rate per lamp, since the latter are much cheaper to maintain, as has been shown, and they afford less light

than the open arc lamp. If these enclosed arc lamps are upon alternating current circuits the light obtained from the same would be materially less than in the case of the direct current enclosed arc lamps and probably not more than from 60 to 70 per cent of an open arc lamp consuming the same energy.

"It has been a matter of common practice on the part of electric lighting companies to persuade their customers to change from the open arc to the enclosed arc, and to insist that the latter were an improvement from the point of view of light production. Owing to the fact that the light from the enclosed arc appears to come from the entire surface of the bulb instead of from the arc itself, this lamp presents to the eye the appearance of a more powerful source than in the case of open arc lamps with clear glass globes, but the measurement of the illumination at a given distance in the two cases shows that this is deceptive. It would perhaps be unreasonable for a consumer to object to enclosed arc lamps, but he should be given the advantage of the very great saving in the annual cost of maintaining such lamps as compared with the open arc.

"I do not think that a deposition from me on this subject would be of much value, because I have not personally made tests and could only quote the very valuable measurements by Matthews and others, which are to be found in the literature of electric lighting. Yours very truly, Edward L. Nichols."

Q. Some of the witnesses for the defense referred to the tests made by the committee as "snap" tests

Please explain the conditions of the tests to the Board?

A. I infer by the comment of Mr. Ryan that he invited a comparison between the tests by the college committee and the tests as participated in by himself. I would say first, that with respect to the instruments used, it is unheard of when standard Weston instruments are available, as the defendant shows they were, to use switch-board instruments for any tests that are to be presented before a Board, unless, of course, the purpose of the test is clearly understood. In the second instance, it is very important in making tests to divorce the observer from the test; that is, his judgment should not enter into the tests. The college committee took readings by the watch, at stated intervals, and took a large number of those readings, in some cases as high as fifteen, and the readings were taken simultaneously upon a signal. This divorced the observer from the test, making him merely a recording instrument to set down what he saw. Now, in the case of Mr. Ryan's tests, the instruments were watched, and when they got the reading they considered to be a proper reading, they set it down. They set down but one reading, although they may have watched the instruments for five or ten minutes. In the college tests they set down every reading that was signaled for. Those readings were all recorded, and their average was entered up. The comparison is obvious. I think the defendant has in its testimony clearly shown that the purpose of their test was to make an adjustment of the lamp; the purpose of the college test was to determine ab-

solutely what was going on at that particular interval or period of time.

Q. A criticism was made, by Mr. Ryan, I believe, of the polar curves furnished by Professor Matthews; what have you to say in response to that?

A. Mr. Ryan made the criticism with respect to Mr. Matthews' curves, stating that they lead to a false impression with respect to a comparison between curves lying in toward the center with those lying out toward the edge; therefore this Rousseau diagram, Exhibit No. 50, has been prepared. Personally, I do not share the objection to the polar diagram, and I think that the Rousseau diagram makes the contrast even greater, if that is possible. This curve A on Exhibit 50 gives us the 9.6 ampere lamp as tested by Professor Matthews, operated at $9\frac{1}{2}$ amperes. B gives us the 6.6 ampere enclosed A. C. lamp operated at 480 watts, with the same current that it was found to be operated with upon the streets of the city, 7 amperes. C gives us the same type of lamp, with 427 watts, operated with the street current of 7 amperes. Curve D gives us the National Electric Light Association tests with the opal globe. That perhaps might be shoved to the right 10 per cent. if a clear globe were used; the distribution would be a little changed; in that case the distribution would become essentially what the curve B is; curves E and F give the city lamp operated at 342 watts and 240 watts respectively. I would point out also to the Board that not only is the maximum shown here, but the area of the curves gives directly the mean lower hemispherical candle-power.

Q. I understood Mr. Ryan, in behalf of the defendant, to claim that the time element should be included in the testing of the lamps, and I understood him that it was not included in the tests that you gave. What have you to say to the Board about that proposition?

A. It is unquestionably true that lamps in operation fluctuate over a considerable range. If we say that a lamp is operated at 450 watts, we do not mean that a lamp, throughout an hour, or even throughout ten minutes, is consuming 450 watts, but that it fluctuates, sometimes being above that value, sometimes being below that value. The average condition of the lamp throughout that period of time is that of a lamp fixed at 450 watts. The word "average" is itself a recognition of the time element. Therefore, if we wish to determine what a lamp is doing at a given power consumption, for example 450 watts, we will keep it at that constant 450 watt consumption, and measure its distribution. That is what was done in this case. It is very important, if possible, to arrive at a method by which this average shall be automatically given. Thus from a minimum distribution curve or a maximum distribution curve, such as Mr. Ryan presented to us, it is impossible to state whether the minimum occurred 1-10 of the time, and the maximum 9-10, or in other words, it is impossible to get the correct proportion; therefore, a method, if possible, that will show this or give us the average is of very great importance.

Now, I would like to point out to the Board that the method adopted in making our laboratory tests shows precisely this character. Let us consider the arc lamp as hanging mid-

way between my hands; we put two mirrors, one on each side, the two mirrors being symmetrically arranged; the photometer will be directly in front of me at a proper distance. Now, it will be quite apparent that as the arc fluctuates from side to side, that if it be on the left, for example, that that left-hand mirror will get an illumination which is determined by what we may call the maximum distribution curve, and the right-hand mirror, shaded as it is by the carbons, will get an illumination which corresponds to the minimum curve, and that both these illuminations are made upon the photometer simultaneously, the direct rays being screened, and the setting of the photometer in this way gives us the minimum and maximum curves automatically, averaging the two conditions.

If the arc be in the center, and we have a distribution approximately the same on both sides, then these two mirrors will throw up on the photometer an illumination corresponding to that condition, and it averages that condition, and shows all variations due to the fluctuating of the arc. Therefore, the curve described by Mr. Matthews is itself that average curve which Mr. Ryan was so anxious to get, and upon which he places so much stress; but the statement that he made regarding it, that that average curve should be itself averaged with the minimum curve is erroneous, because the averaging has already been done by the photometer. If he were to desire such an average, he must take the maximum distribution curve, and the minimum distribution curve, and then his average would be the curve which is here presented. Of course, there are fluctuations due to lamp conditions;

due to the conditions where the lamp is not staying at 450 watts. That is taken care of in this manner; we are told that the average consumption of the lamp is 450 watts, and therefore if we determine the condition when the lamp is at that average consumption, we have allowed for fluctuations above or below the average. The purpose of the committee was to determine the candle-power of these lamps; they clearly understood that for them to get the candle-power of each and every lamp, for each and every night, would be impossible, and they determined, first, from the early tests, the type of lamp used universally through the city; having done that, they then determined the service conditions under which those lamps were operated, showing that they were operated, for example, at 7 amperes, or at a given number of volts; they then took samples of those lamps, taking two of them, and took them to the laboratory, and carefully determined the variation between the watt consumption of the lamp and the candle-power of the lamp; keeping the lamp at that constant current which it is holding under service conditions. Somewhere about fifty different readings were taken on a given lamp in a given condition; and then those readings were carefully worked out under well-known methods, and the average candle-power for that test arrived at. This then resulted in two curves. Exhibit No. 28 is a diagram showing the relation between watts consumption and the maximum candle-power. In making this we eliminated one factor which obtains on the streets; the globes were clean. Diagram Exhibit No. 29 gives the relation between watts consumption and for switch-board work, but when we

mean hemispherical candle-power. Now, with the diagrams taken from two lamps representative of this type and system, we can say with reasonable accuracy, for a given watt consumption, what the candle-power may be. Let me illustrate my point: the average maximum candle-power per lamp, extending over the year and a half is 360, based on 437 watts, the average energy consumption as figured by the defendant. With respect to hemispherical, they were giving during this period 260 candle-power. Now, within the last six months they have boosted these lamps to average 472 watts; that means that the maximum candle-power was boosted up to 400 candle-power as a maximum, from 360; and their mean hemispherical candle-power was boosted up from 260 to 311 mean hemispherical.

Therefore, we have here determined a scale by which the maximum candle-power or the mean hemispherical candle-power of a lamp may be determined, and we have done that with great accuracy and fairness.

Cross examination by Mr. Schuyler.

Q. Professor Shedd, do you know what watt-meters are down in this station?

A. Yes.

Q. Now, you referred to a meter for which the Weston should have been substituted at the switch-board?

A. I don't think I did; I have no criticism to make with respect to the instruments on the switch-board are making street tests we should use the very highest grade of instruments available. Now, the Weston instruments represent that type.

Witness excused.

DR. LOUIS BELL being recalled in behalf of the plaintiff in rebuttal, testified as follows, to wit:

Examination by Judge Robinson.

Q. Dr. Bell, at the last session of the Board some matter from a publication written by you was put in evidence. I will ask you to state to the Board your position on the matters brought out in evidence?

A. *It is a little awkward, your honors, to be cited as it were by both sides as an authority. I beg leave to, in connection with any and all statements made in my book or any other publication, to ask you to bear in mind the fact that we are dealing with a very swiftly changing art. If the Board will pardon me for a personal explanation — within twenty years past I have personally had the good fortune to be in at the dawn of three great changes in electrical engineering—so swift has been the change in the art with which we are dealing. I mention this without the slightest idea of self aggrandizement, merely to show how rapid these changes are, how fast we have to learn in order to keep up with them and how close the application in following any given branch has to be. As compared with the time involved in legal actions this is extremely short, which may account for any misunderstanding on the part of counsel. For example, the art of electric lighting arose, and the art of electric railroading came into being during the time that passed between the beginning and the end of the litigation of the Berliner transmitter patent.*

In connection with my direct testimony which was given in this case,

as regarding what was meant by the light of the Jackson franchise, Section 9, I testified substantially that the lamp under consideration was an open arc taking about $9\frac{1}{2}$ to 10 amperes, and a corresponding number of volts, to get somewhere around 450 watts.

I would call the attention of the honorable Board to the statements which are made with respect to this light in the book in question. On page 248, I think is a full and substantially correct statement as to what is meant by the two thousand candle-power or arc as follows:

“For years open arc lamps have been classified as 2,000 candle-power or ‘full arc,’ and as 1,200 candle-power or half arc lamps, but these alleged candle powers are never obtained even in the direction of maximum illumination. The former arc lamps taking about 9.5 to 10 amperes, and 450 to 480 watts, the latter 6.5 to 7 amperes and 325 to 350 watts. Their actual maximum intensities are, respectively, about 1,200 candle-power and 700 candle-power, located at about 45 degrees below the horizontal plane. Reduced to mean spherical measures their ordinary intensities are about 600 and 300 candle-power respectively. In the horizontal plane these intensities fall to about 350 candle-power and 200 candle-power.”

Now beside that chapter on exterior illumination, and the one on arc lamps already in evidence and before the Board, I will refer to the chapter on Standards of Light, at page 335, and will read from that page:

“The rivalry between makers of arc lamps did not tend to depreciation of their intensity, and so it came about that an open arc taking about 450

watts was rated at 2,000 candle-power, while a similar arc of about 325 watts was rated at 1,200 candle-power."

These arc intended to be and obviously are to any one reading the book the same things which are referred to in the paragraph on page 248. I don't think there could be the slightest hesitation of anyone in reading the book as a whole in coming to that conclusion.

"While it is possible that some experimenter at an especially favorable moment may have obtained these intensities in a single direction, it is certain that the ratings were very soon regarded as merely conventional."

I may interpolate that that was the cause of the difficulties in the early state of the art, and the approximate cause of the famous N. E. L. A. resolution of 1894.

"They have long since been relegated to the category of merely commercial designations, the rating bearing no more precise relation to the thing than does the term "best" as applied to flour or other commodities.

When an individual or municipality contracts for a 2,000 candle-power arc light, the thing bought, received, and paid for is an arc light taking about 450 watts of electrical energy, and such is the general understanding of the term as interpreted at various times by the courts. There is not nor has there ever been, in commercial use in this country, or elsewhere, an arc lighting system using lamps actually giving anywhere near 2,000 candle-power, either as maximum zonal intensity or as mean spherical intensity."

That, I think, covers the citations

which bear directly on this question of 450 watts. If there were the slightest doubt in my mind, or in the mind of this Board, about the proper connection of these citations as meaning as they did, and as they must in the mind of anyone carefully reading the book, I would state, as an additional reason, that at the time this book was written, which was in the summer of 1901, in 1898, and in 1894, which are the three dates which are here to be considered, the only thing which was ever known in the art as a 2,000 candle-power lamp, and so generally understood, was the open direct current arc, taking about 9.6 amperes and 450 watts; as one of the instigators of the 450-watt definition, I think I am justified in saying it without being misunderstood. The 2,000 candle-power light, as I have stated, was in 1894 and 1898, and clear up to the date of this book, the only particular thing which was commonly used in street lighting, and which was commonly understood as being the thing referred to whenever a 2,000 candle-power arc light was mentioned.

It is perfectly true that since the publication of this book, and in some increasing degree, the ratings which would apply in candle-power have been loosely transferred to other types of lamp than this open arc. That was not true, however, in 1901 or 1902, at the time the book was issued. The book was written in the summer of 1901, and published under date of 1902. At this time the change was becoming more or less rapid toward the use of the alternating arcs.

As more and more of the new systems come into use, people get a little careless in their ratings, and especially they do not rate the new

type of lamps at any given candle-power at all. They follow, very properly and wisely, the procedure which had been brought to bear by the National Electric Light Association, and, I think, by all those that have had the interest of the art at heart, to get away from a purely candle-power rating; but they did not rate at that time and do not rate now in watts, so far as I know, in commercial series street arc lighting systems. The thing sold in modern contracts is service of a particular thing; and to put my position absolutely on record in that regard, I will read my judgment of the matter at the date of this book, which I have not seen any reason to change since. Page 269:

"Contracts for arc lighting should never be drawn on the basis of a nominal candle-power. They should clearly specify the kind of arc to be installed, the amount of energy to be taken in each arc, and the kind of shades to be used. The nature of the fixtures should be specifically designated, whether pole tops, brackets, mast arms, or cross suspensions. These and the location of the lamps should be designated by some one familiar with practical street lighting, following the general line of the data which have here been given. The hours of lighting should be distinctly stated, with rebates for failure to provide continuous light within these hours."

It is perfectly true that some stations, particularly large Edison stations, supply commercial arc lamps on a special arrangement of wattage, but in every case the nature of the lamps is understood between the customer and the seller.

As regards the citations made from

this work with respect to intrinsic brilliancy, and general desirability of diffusion, and so on, I have no quarrel to make. I would merely ask the Board, in considering the bearing of any of these statements, to simply read through carefully the statements made.

Now, to further clear up the fact which I mentioned concerning the rating of these modern arcs; at times the 6.6 alternating lamps are now—within the last few years—rated for popular consumption, so to speak, at 2,000 candle-power, although the contracts on these very lamps are stated in watts, and kind and amount of current specified, but never in watts alone.

I can hardly show that point better than by reference to Exhibit K in this case, which purports to be a partial list of stations where 6.6 ampere series alternating lamps have been used, and have successfully replaced the 9.6 ampere open arcs supplied on 2,000 candle-power.

Reports based on affidavits, as I found them in the office of the Massachusetts Gas and Electric Light Commissioners, show that in Brockton these lamps are rated as 1,200 candle-power.

The next city cited in the list is Cambridge, Massachusetts. In that city, to my knowledge, some few years ago the change referred to was made, and in its sworn reports Cambridge rates its lamps as 6.6 ampere; not as 2,000 candle-power.

In the city of Chelsea, the change was made from 6.6 ampere open arcs, and not from the full arcs of 2,000 candle-power. That change was made at the instance of the city itself, changing from 1,200 candle-power to this enclosed light. I think

they were wise in doing so; but in later years that lamp has appeared under the guise of a so-called 2,000 candle-power light. There you have the same lamp rated both ways; the old rating as 1,200 candle-power has been changed deliberately to a nominal 2,000 candle-power.

Holyoke, Massachusetts, which rates its light in amperes only, is a municipal plant, consequently contracts do not exist.

In Lowell, Massachusetts, the change was made, but the lamp installed there was the $7\frac{1}{2}$ ampere A. C. lamp, although it is not so stated in the Exhibit; and this is rated as a 2,000 candle-power light.

Salem Electric Lighting Company rates its lamps in amperes only.

Taunton, Massachusetts, is a municipal plant, and in its sworn statements holds its lamps at 1,200 candle-power.

I may say that each and every one of the Massachusetts cities cited, either has a different rating from that given in the Exhibit K or simply rates its lamp as 6.6 amperes.

I want to refer to one other city, Toledo, Ohio, Railways & Lighting Company, is cited as one of the cities where the change has been successfully made. There happens to be in the proceedings of the National Electric Light Association of May, 1904, 27th convention, Volume 2, page 309, a statement direct from the company thus cited, appearing in the question box of that convention:

"No. 9. When it is proposed to change from 9.6 ampere open street arcs to the alternating current enclosed system, is it commercially advisable to offer the 6.6 ampere or the 7.5 ampere lamps?"

I emphasize these words because

categorical information regards illumination was asked for, and this is the answer which the Toledo Railways & Light Company put in, the signature being apparently that of the company:

"Our experience is that illuminating power of 6.6 ampere enclosed arcs is not equal to a 9.6 ampere open arc. Would suggest a 7.5 ampere lamp if equal illumination is desired."

That throws light on still another of these cities. At the same time, on the previous page, and the same page, under No. 9, a number of other replies to this question came in, all substantially to the same effect.

I need only say in concluding that the enclosed arcs which have been referred to in testimony in this case as existing prior to 1898 were almost exclusively constant potential direct current arcs. We had yesterday testimony from a distant witness to the effect that in 1898 there were a great many enclosed arcs in use. It was immediately pointed out that those were D. C. enclosed arcs, constant potential.

Examining this Exhibit "I," it is very clear that there were enclosed arcs in use prior to 1898, but those arcs were of the kind that I have stated.

There is one thing further I would mention, and that is that a number of the statements made in my book you will please consider as based upon the then existing information regarding the details of performance of these various arcs; some of it being derived from commercial experience which I thought then to be reasonably sound, but which I should hesitate now to take at its face value.

Q. Some evidence was given on

behalf of the defendant that light was not sold for light on a candle-power basis. Will you please state what you mean in regard to light sold as such?

A. For many years the customary way of selling electric light supplied through so-called 16 candle-power incandescent lamps, was by the lamp hour. Even after the introduction of meters it was not unheard of to find a company actually measuring the current and supplying it to the customer on the basis of lamp hours. The lamp hour basis, flat rate contract so-called, is a common contract even now.

Cross-examination by Mr. Schuyler.

Q. Since the resolution of 1894, when this standard 2,000 candle-power was defined to be a certain number of watts, however we may define the lamps to which it applies, the selling of electric light has been on the basis of current delivered, hasn't it; that is, watts?

A. No, sir, it has been, as I have plainly stated in this case, and repeat now, the sale of a particular thing furnished to the city, with specified service; and while it is perfectly true that the watts at the lamp have been part of the description in many cases, there were many candle-power contracts like this one in use long after that date; the wattage is only one element of the description, and it has been in recent contracts specifically understood what current was to be furnished, and what service was to be given.

Q. So far as the purpose of charge was concerned, watts were the

specific thing upon which the charge was based?

A. It certainly was not. The thing which was sold was the service through a particular lamp, with a specified number of watts which should be furnished in that lamp, so as to hold the company up to its mark.

Q. Do you know of a single instance where light was sold as light, and the measurements of it for the purpose of predicating the charge was candle-power?

A. The sale of light as light was known in the incandescent lighting field; it was a familiar thing; but as regards arc lights, in later years, I will say such measurement has decreased.

Q. Do you know of any instance where arc lighting has been sold as light, since 1894?

A. If you mean for regular city service on the basis of a guaranteed candle-power delivered, I should say no.

Q. Do you know in the world's history, of any arc light bill rendered on the basis of candle-power delivered?

A. Within my knowledge of the electric lighting art, I cannot recall any such instance.

Q. Has the National Electric Light Association resolution ever been changed to your knowledge?

A. I do not know of any change that has been made.

Q. I am not quite clear as to your position as to when the enclosed arc lamp did come into use.

A. The enclosed arc lamp, as a

direct current, constant potential lamp, came in about 1895, and it gradually crept into more and more extended use.

As regards the constant current series enclosed arc, the first lamps that I have been able to discover went into use in the city of Boston, in the latter part, I think, of 1897; they had been in tentative use by Mr. Gilbert, manager of the Boston Electric Light Company, for possibly a

year before. I think they had a few of them out on the street in the very last days of 1896; the change was in 1897 or 1898. As regards the alternating enclosed series lamp, here under consideration, that lamp was in tentative use in Hartford in the latter part, I think, of 1897, and it gradually came into more general use during the years 1898 and 1899.

Witness excused.

THEREUPON THE PLAINTIFF FINALLY RESTED ITS CASE.

MR. W. D'A. RYAN, being recalled in behalf of the defendant in rebuttal, testified as follows, to wit:

Examination by Mr. Schuyler.

Q. In regard to Dr. Bell's reference to your candle-power curves, do they take into consideration the variation due to the fluctuating of the arc, and do they cover the time element?

A. *The main point in regard to the time element hasn't been fully brought out. From the tests that I have made, I think it is fair to state that a ten per cent. reduction, for time element, on enclosed arcs, is quite proper, and 33 1-3 per cent. for open arcs; so if it is a question of testifying to the mean spherical or lower hemispherical candle-power, it is quite proper that that time element should be considered. If the maximum is considered, I cannot give you the time element, because it is so great; but it is fair for the mean spherical or lower hemispherical, to take a 33 1-3 per cent. reduction for the open arc, covering that time period, and a 10 per cent. reduction for the enclosed; that is, in taking into consideration the extreme variations of light which take place with the mechanical conditions of both lamps in good shape.*

Now, in regard to the curve in Exhibit "B", it is true, as the Doctor states, that the curve may be misleading, but it is an average maximum curve and it is so stated; at that time we took the extreme average maximum; just the highest readings that we could get. I have stated that this is not good practice, where

actual candle-power is desired; these curves should show what we get at the low state as well as the high, and I have shown in the next page the explanation of this curve.

In reference to the list of central stations, Exhibit "I", I may state that I obtained that from our commercial department in good faith. I asked them to give me a list of the stations where the 6.6 alternating enclosed arc had replaced the so-called standard 9.6 lamp. This was the list presented, and I am very sure it was given to me without any intention of it being used in testifying by me or anybody else; I don't think they knew what I wanted it for at that time.

The Doctor made the statement that the 6.6 ampere lamps were used to replace others, but that a greater number of lamps were used, the lamps being placed closer together. As a matter of fact, in nine cases out of ten you put one on each corner, and if you can afford it you put one in the center; but of the thousand cities using the 6.6 ampere, they seem to use the same spacing.

Cross-examination by Mr. Robinson.

Q. Were your curves made by the double-mirror method?

A. *No, sir, they were made by a better method. Fifty readings, as mentioned by Professor Matthews, are not sufficient; we take a few in order to see if things are running smoothly, then we take 500 readings on a point; that is the way we make our tests.*

Q. Do you know of any instance

where a 6.6 ampere alternating current enclosed series lamp has been substituted in a contract which called for a 9.6 D. C. open arc lamp, at the same price?

A. I am not posted on prices.

Q. You travel over the country, and have a large knowledge of these things, don't you?

A. I cannot recall a case of that kind, just now.

Witness excused.

THEREUPON THE DEFENDANT FINALLY RESTED ITS CASE.
BOARD ADJOURNED.

THE BOARD MET, PURSUANT TO ADJOURNMENT,
AT 3 P. M., FEBRUARY 8, 1907.

Thereupon the attorneys for the plaintiff and defendant respectively argued the case in behalf of the parties as follows:

INITIAL SUMMING UP AND ARGUMENT FOR THE
PLAINTIFF

By

MR. W. C. ROBINSON.

May it Please the Board:

It is probably a new experience to most of us to try a case of this kind. I deem it would be rather a waste of your time, to say nothing of my own, if I attempted to explain many of the very intricate features that have been brought out in the testimony of the witnesses, for I am confident that you have all understood it as they went along, much better than I understood it myself. Owing to the brief time that was given to us for preparation of our closing argument, and the lack of knowledge of details in many of these matters, I want to say that in the argument of the evidence I expect to go but little into the details, and that where I omit matters which may be really important, I don't want the Board to think because I have omitted reference to them, that I have therefore intended to neglect them or ignore them, or that I consider them as of no weight. My omissions must not be taken as confessions. In the Article of Agreement, we attempted to put in a limitation concerning objections to evidence that counsel for both sides thought would be of benefit to the Board, and would hasten the trial of this case. We have found in actual practice that it did not aid you, but rather, perhaps hindered you, possibly annoyed you a little sometimes, but it was our intention to aid and not to hinder the Board.

I shall take up first, and very briefly, the actual wording of the Jackson Ordinance. In this connection I want to call your attention to the language of the lighting contracts that the City had both prior to the passage of the Jackson Ordinance, and subsequent to the passage of that Ordinance, and also to the beginning of operations under it, because the terms used in those contracts may aid you in finding the true meaning of the terms used in the Jackson Ordinance. I will read just a paragraph from the fourth section of a contract dated April 7th, 1890, Exhibit No. 21:

"And the party of the first part"—that is the Company—"further covenants and agrees that it will furnish the party of the second part, whenever so required, with not less than forty arc lights, of what is commonly known as 2,000 candle-power each, for lighting the streets of the city for not more than \$125.00 per annum for each arc light, etc."

I call attention to the words of this description: "arc lights of what is commonly known as 2,000 candle-power." The terms "candle-power," "arc lights" and "commonly known as 2,000 candle-power."

Then from a contract dated April 1st, 1899, Exhibit No. 22, part of the second paragraph of the instrument: "Such light to be furnished through electric lamps, which are commercially known as arc lamps of 2,000 candle-power."

Calling attention further to the use of the terms: "lamps which are commercially known as arc lamps of 2,000 candle-power each."

Now I refer to the Ordinance that is involved in this controversy. All of it taken together, gives light upon the Section 9 which is directly involved. And I might say, following out a well-known rule of law, that no part of a statute is to be construed alone; rather all parts of a statute are to be considered when construing any particular part of it.

I will turn to Section 9, and read, and we will bear in mind the conditions shown in the whole contract, that Jackson was a contractor, constructing a tunnel through the mountains for the City's water system, and that neither party was an electrician.

"Sec. 9. The said George W. Jackson, his associates or assigns, shall within one year after the completion of the Strickler tunnel and during the remainder of the term of this grant, furnish to the City of Colorado Springs such arc lights of standard 2,000 candle-power each, as may be required by said city for the purpose of lighting its streets, alleys and public grounds, at the rate of five dollars and fifty cents per light per month, said lights to be used from sunset to sunrise during each and every day of each and every month; also, free of cost, such arc and incandescent lights as may be required by the said city for the lighting of the buildings belonging to the said city not exceeding five arc lights of 2,000 candle-power each, and 200 incandescent lights of 16 candle-power each, or the equivalent; also, free of cost, such electrical power, to be delivered at such points in the City of Colorado Springs as the said city may specify, as may be necessary for use by said city for municipal purposes, said power not to exceed fifty horse-power, etc."

If you will examine Exhibit No. 25, which is the original Ordinance as passed by the City Council, you will note the changes that were made in Section 9. You will see that the Ordinance was in typewriting, and beginning with the third word in the fourth line it was originally written, "such arc lights, 2,000 candle-power each, as commercially known, as may be required, etc., etc." You will see that the words "as commercially known" were erased, and that the words "of standard" were added in ink before the figures 2,000. It is clear from the notations on the margin that these changes were made during the consideration of the Ordinance, so it seems that before passing the Ordinance the City Council deliberately changed the phraseology from "such arc lights, 2,000 candle-power each, as commercially known, as may be required, etc., etc." so as to read "such arc lights, of standard 2,000 candle-power each, as may be required, etc., etc." It can not be doubted that these changes are material and we must assume that the City Council had some purpose in making them. It will be noticed that the phrase "as commercially known" was used in a former light contract, held by the City, to describe the character of the lights to be furnished and the evidence

showed that there had been some discussion as to whether or not those lights fulfilled that contract. In the other light contract to which I have referred, the phrase used to designate the character of the light was "commonly known as 2,000 candle-power."

I know not what view you may take of this point, but in my mind there is no doubt that the City Council intended by these changes to more clearly and definitely describe the character of the lights to be received by the City, and I believe that the language means, and that we are justified in claiming, lights of 2,000 actual candle-power, or, in other words, lights of the power of 2,000 standard candles. The Ordinance was first written without the words "of standard," and those words were added; it was first written with the words "as commercially known," and those words were erased. If the purpose of these changes was not what I have indicated, then I hope counsel will explain to you the purpose which the City Council had in making them.

A little further down, where Mr. Jackson agreed to furnish some lights for the city building, they were described as arc lights of 2,000 candle-power each. There is no qualifying word in that at all.

I now want to discuss the distinction between light and power,—a feature that has continually been brought out by the defendant. After describing the lights that are to be furnished for the streets and the buildings, the Ordinance says, "also free of cost such electric power." You will notice that heretofore it had been "lights" all the time. Now they begin using the word "power"; "also free of cost such electric power, to be delivered at such points in the City of Colorado Springs as the said City may specify, as may be necessary for use by said City for municipal purposes, said power not to exceed fifty horse-power."

Now you will notice that they have divided that contract into two parts. One part of it is for lighting, and the other is for power. It seems to me that this division is significant, and it does show that this City was contracting, in that part of it, for light, and I insist that it was "light" that this City was buying, and that this "light" was to be measured in "candle-power."

Now, taking up this Ordinance again, if you do not agree with me that it required 2,000 candle-power actually, then it seems to me that you must agree with me that that ordinance required a first-class service. Perhaps I would be justified in calling it a gilt-edged service. If not what the words say in English, then what the art knew as its best. I don't mean extraordinary, practically impossible, but what the lighting art knew as its best service.

Now, it seems to me that that cannot be avoided. That City and that contractor, it seems to me, must have both understood that a high-class lighting service was required, and was promised to be delivered.

By reading the contract as a whole you have found what it was or had been the evident intent that the City should receive in the way of the lighting of its streets, for a period of twenty-five years, and that then there should revert to the city a lighting plant, which would belong to it. And you have it in evidence before you that there is not a wire,

not a lamp, not a pole, not a dollar's worth of property, that has ever been placed under that contract where it will ever revert to this City; that the plant that was used to generate the power that was described in there, is upon land owned by the Company and is under a heavy mortgage, while all of the poles, wires, lamps and other apparatus used to distribute current and create light belong to another corporation; and that outside of the lights for this building and these street lights, at \$5.50 per month, of whatever character they are, that those are the only things that this City has obtained for the use of its water-power for twenty-five years, and all that it is likely to ever receive; a contract that in my judgment to-day could be sold for \$250,000. As to harshness, in my judgment the liberality of it, and the value of it, is nowhere else equaled in all the West. Instead of being a harsh one, even if construed as we have construed it, it is one of extraordinary liberality. Even without what is in it to-day, it is in evidence before you by Mr. Rouse that the City gave to Mr. Jackson a present of \$10,000 on the same transaction.

I want now to consider for a moment the real effective clause in the Arbitration Agreement; I will read the last sentence of paragraph A of "First":

"Or, in case said computation should prove not to be exact, the money claimed so submitted to arbitration is for the difference between the amount which the City should have paid for the street lights furnished during the period in question, and the amount which the City did pay, said claim to be determined by the difference in candle-power between the lights so furnished and the lights required by said Section 9 of the ordinance."

Pardon me if I read part of that again, and call attention to the terms light and power:

"Said claim to be determined by the difference in candle-power between the lights so furnished and the lights required by said Section 9 of the ordinance."

In that I submit there is not a reference by inference, intimation, or any other way, that this City was buying anything but light, and especially do I claim that the Board is required to base its award upon the difference in candle-power, and not upon the difference in watts, nor—and I use this term with some little limitation—nor upon the difference in illumination. The ordinance said lights and candle-power; the arbitration contract says lights and candle-power; and our claim is to be determined by the difference in candle-power between the lights so furnished and the lights required by Section 9 of that ordinance.

Now, what are the lights required by Section 9? If your Honors do not agree with my claim that we are entitled to lights of 2,000 actual candle-power, but do agree with my claim that we are entitled to a first-class light, let us construe the words of this section by their meaning at the time they were used in 1898 and we find from the evidence that

we are entitled to the light that would come from a 9.6 ampere, direct current, open arc lamp, operated in a proper condition and in a proper manner.

Then if we are entitled to that light, what is that light, measured, not in watts, but as the contract says, in candle-power. Fortunately, there is not much disagreement between the most skilful and learned witnesses that have appeared on both sides of this case, and the evidence of the defense says that it is 1,250 candle-power. That is one value about which I am sure there will be no quarrel on our side.

Now I will read just a little more than Mr. Ryan read from his paper, Exhibit B, beginning on page 1:

"The source from which we receive our daylight, namely, the sun, is at an enormously high temperature. Any artificial source, to produce a white light of the same relative effectiveness, should also be at a very high temperature. It is a well known fact that the temperature at the crater of an electric arc is much nearer the sun's temperature than any other artificial heat.

"In the case of ordinary candles or gas flames, the temperature is comparatively low and the percentage of short waves is too small in proportion to the long waves. We therefore get a predominance of red, yellow or green.

"Colored objects, when viewed under such lights, suffer greatly in comparison to their daylight appearance.

"The spectrum of the arc very closely approximates that of the sun, hence its superiority in quality over other artificial illuminants.

"It is also a well established fact that the higher the temperature of the source, the greater the efficiency of the illuminant. In this respect the electric arc excels all other commercial lights."

Then comes the discussion on "Law of Radiation," and a little later the "Photometric tests of Arc Lights," from which I will re-read part of that quoted by Mr. Ryan:

"There are many ways of expressing the candle-power of an arc lamp.

"Some take the average of the light thrown in all directions, namely, mean spherical; others the average of the light in the lower hemisphere, or over a selected number of degrees, such for example, as from the horizontal to 60° below. Then again, we may use the average of the maximum readings, but the usual way to refer to the candle-power of an arc lamp is by its maximum, notwithstanding that this actually means less, as far as the value of light is concerned, than any other comparison which might be employed.

"Of course, it is well known that the so-called 2,000 candle-power direct current open arc lamp, taking about 10 amperes at 48 volts, does not give the candle-power at which it is "nominally" rated. It is possible, however, to get a freak reading of 1,700 or 1,800 candle-power, when the crater is all exposed on one side of the carbon, but the average maximum candle-power is about 1,250 at an angle of 45°.

"By referring to the candle-power curves, the distribution of light from an enclosed arc lamp will be readily observed. These readings represent the average maximum of the different lamps equipped commercially as they should be in service, that is, with the proper globes, reflector, etc."

Then Mr. Ryan proceeds with a description, which I shall not read, but I specially desire to call your attention to the fact that he gets practically the same light curves, which he frankly acknowledges as his, shown in this exhibit that the City has produced in this case

Now, in this article, I didn't think the author was quite fair with his public.

There are, in my judgment, but two light sources involved here; the light from the 9.6 D. C. open arc, and the light from the lamps which are in use in the street, the 6.6 A. C. series enclosed lamps. No one can reasonably deny that at least we are entitled to the light of the lamp first described, and there is no possible doubt but what the light that we are getting is being furnished by the 6.6 A. C. enclosed series lamp.

Now, this document and these curves were put in evidence by the defendant, and referred to on page 11 as follows:

"We have so far confined our attention to the relative merits of the direct current lamps both open and enclosed. We will now contrast the two enclosed arc lamps, namely, direct current and alternating current, each consuming approximately the same watts at arc. Referring to candle-power curves, it will be observed that the direct current lamp gives slightly more light than the alternating."

But the alternating lamp to which he refers is the 7.5 ampere and not the 6.6 ampere, and the curve which he gives is not that of our alternating lamp here, but the 7.5 ampere alternating, a larger lamp, which is, as in evidence before you, a larger and a better, and an entirely different proposition, than the lamp which is in service on the streets.

We have from Mr. Ryan the statement that the usual way to measure the candle-power of a lamp is by its maximum, while the curve which we have given you, made by Professors Shedd and Matthews, is not a maximum curve, but it is an average curve. We take the small lobe and the large one at the same time, and bind them together, and get the average of the two.

Now I desire to run briefly over how our various tests were made. There came before you Professors Shedd, Matthews, Streiby and Armstrong; they showed you with what painstaking care they went out to make these tests; how they were requested, but not employed to do so by the City, to get as scientific men what the facts were.

They showed to you how they took reading after reading, the great care and labor they used in making these tests, and have brought to you the results of their tests. Then Professors Shedd and Matthews took the results of these tests to the laboratory of Purdue University, and there putting the lamps in the condition of actual service, they got for you what may be called—and I use the term without exact accuracy—a measuring stick or curve by which to measure these others. It seems to me that it would have been impossible for the City to have done more to learn what the conditions actually were.

Now, let us take up the tests made by the other side. They were

made by employes of the Colorado Springs Electric Company, in daytime, with the current turned on the lamp or the circuit for that purpose, and I think I am justified in saying that they were made in view of the controversy between the Company and the City, and without impugning for a moment the good faith of any man connected with that test, I submit it to the Board to say whether or not the evidence shows that it was made with anything like the painstaking care with which the other tests were made, or that it was made by men who possessed anything like the degree of skill and experience that was possessed by these gentlemen of national reputation who made the tests which we have brought to you.

The value of the two tests, the weight of that testimony, is for you, gentlemen, to determine.

Now, there isn't a syllable of testimony that the Pike's Peak Hydro-Electric Company tested any lamps, or owned any lamps, or anything else, within the city. The evidence came from tests by the employes of the manufacturer of this light on the streets. It is shown by the contract that the Hydro Company sells its current to the other concern, and the other concern distributes it through the streets. I think it very much a question in your minds how I could consider any testimony along that line as material. The tests that came before you from that side of the fence came from the company that was really operating the system, and which is, if we may read their contract correctly, liable for any deficiency in it. Therefore, that must be considered in weighing their testimony, for a court or a jury is always entitled to know the interest which a witness may have in the subject about which he testifies.

Now, it was solemnly stated in this room by counsel for both these companies that one was the distributing agent of the other. Let me also call your attention to Sections 2 and 3 of the contract, Exhibit No. 48, from which you will see that the evidence shows that these tests come from a source that has an interest in these tests. They took the tests in the daytime, turning on the current for that purpose. The professors took their tests under operating conditions, when neither party knew that they were to be taken. How utterly senseless it would have been to have informed the Company when tests were to be made appears from the evidence in that when making their tests an employe of the Colorado Springs Electric Company discovered them, and went up the pole and adjusted the lamp; and you saw the results in the figures of the Exhibit No. 26.

Now, there can not be a more suggestive thing, it seems to me, to this Board as to what this Company had been doing, than the curve Exhibit M 25, put in by them, claiming to show the watts they had been using in these lamps. Note the great variations in it, and how it had gone up in a very marked degree about the time that these tests were all made. Also how they are boosting that lamp beyond the point its maker claimed it should be run at. That is their evidence, and it seems to me it isn't possible for it to be construed otherwise than that they were aware of the fact that they were not fulfilling the contract,

But there was another thing that I wanted to discuss, and that is that question of watts. As I understand the contention of these gentlemen, it is that if they put 450 watts, average, through any lamp, that they have fulfilled that contract. Now, you will bear in mind that I insist that it is light that we are after, not watts; the ordinance and the contracts all say light, and candle-power; light, light, all the time; and then they distinguish light and power. Now, gentlemen, if it is watts that they are to furnish,—for they admit they are not furnishing the light,—if it is watts they are to furnish, then suppose they put 450 watts through a lamp that gives no appreciable amount of light, then they would fulfill their contract.

Now, I ask you the question, is it power that we were wanting on these streets, or is it the light? Suppose, in the progress of this wonderful art in the next few years, a mechanism would be discovered whereby with the expenditure of 200 watts they could make a light equal to that which we are now entitled to, do you suppose that we could force them to put 450 watts through their new mechanism? If they furnished the light, couldn't they say, "We have furnished all the light the contract calls for, and it is none of your business how many watts it takes to do it?" Why, most certainly they could.

But if their theory is correct, then we could turn that thing right around, and if the art increases as it has done in the past, and leads to a mechanism that gives the same light with less expenditure of energy, we could force them then to expend that energy, without regard to the light it furnished.

Now, on the resolution of 1894!

There were at that time, I believe, about 2,000 electric lighting companies in the United States. Of course, there were, as we may reasonably suppose, 2,000 consumers; therefore, there were 4,000 parties to electric lighting contracts. There were about 150 of the 2,000 companies represented at that meeting; and now to say that those 150 gentlemen could meet down there, and by a certain resolution bind the other 1,850 lighting companies, and the 2,000 consumers, and us here, that would be an astonishing thing. No resolution that those gentlemen made, however skilful and able they may be, could bind this City.

CLOSING ARGUMENT FOR THE DEFENDANT.

By

MR. K. C. SCHUYLER.

May it please this Honorable Board:

By the Code of Civil Procedure, which you have had before you as a guide of your conduct, you will observe that the statute which enters into and becomes a part of this contract requires as an essential of what you shall do that you determine this matter according to the very right of the situation. The whole theory and idea of arbitration is to avoid any legal technicalities and difficulties which may stand between the parties, and exact justice, and, by allowing disinterested men of sound business judgment and common sense whom the parties may select to weigh the difficulties that exist between them, to secure a decision which shall do even-handed justice between the parties, free, as I say, of those technicalities.

With that as the foundation-stone upon which we shall proceed, I desire to present to you our reasons why the defendant here owes the plaintiff absolutely not one dollar.

The whole controversy arises out of the Jackson franchise, and while as one of the elements for your consideration, a proper construction of it is to be determined, there are other matters equally essential, and not only equally essential, but the moving factors, which must control your best judgment against any decision here in favor of the plaintiff.

My friend has spoken in his introduction of the harsh contract which is being enforced against the City by reason of the Jackson franchise. As I said before to this Board, it has been an old neighborhood quarrel, with results invariably in favor of the Company, and never has the City attempted to discuss a matter connected with this franchise but what, like Banquo's ghost, the decision of the United States Circuit Court of Appeals of this Circuit (105 Federal Rep., page 1) rises to defeat them. In that case, the Court, speaking through Mr. Justice Sanborn, said:

"Neither Jackson, or his assignee, the appellant, is doing any wrong, or violating any rule of law or of equity in their dealings, and the case presents no equitable ground for depriving them of the rights and privileges which were granted to them under the contract, and which they have fairly earned by the substantial completion of the great work they undertook."

And so, may it please the Board, not only in the time of Jackson was it true that he had acted in good faith and good conscience under this franchise, but peculiarly is it true to-day that the Pike's Peak Hydro-Electric Company has acted in good faith, equity and good conscience in this matter.

While I do not desire this argument to be in any wise a legal argument, I simply want to present matters which will enable the Board to understand how, in order to arrive at the very right of the matter, in justice they should consider the situation.

There are three or four contracts to be considered, not only the Jackson franchise, but others, and particularly the one down in Mr. Perkins' office; and I desire to call your attention to the language which Judge Sanborn,—sitting on the bench of the Eighth Circuit Court of Appeals of this circuit,—used with reference to what the duty of a court was when considering the matter of the fair construction of a contract:

“The purpose of a written agreement is to evidence the terms upon which the minds of the parties to it meet when they make it. Hence the true end of all contractual interpretation is to ascertain that intention, and when it is found it prevails over verbal inaccuracies, inapt expressions, and the dry words of the stipulations. The court should, as far as possible, put itself in the place of the parties when their minds met upon the terms of the agreement, and then, from a consideration of the writing itself, its purpose, and the circumstances which conditioned its making, endeavor to ascertain what they intended to agree to do.” Vol. 121, Fed. Rep., 611.

Counsel for the City started out with the emphatic proposition that they were entitled to 2,000 actual candle-power; then followed that up by the statement that if they were not right about that, then they were entitled to this 9.6 ampere lamp. What was the condition back at that time? On the streets of this city, at the very time the Jackson franchise was passed, the 9.6 ampere light was being burned. That was the one that was furnished, and these councilmen who went upon the stand told your Honors that what they then wanted was to get a better light; that there was considerable talk of dissatisfaction. Now it seems to me that a fair way to interpret the meaning of the words “as commercially known,” would be that the lamp as commercially then known was unsatisfactory and they wanted to obtain something better. Do you think they wanted to obtain the old 9.6 lamp, which these gentlemen on the witness stand said was then unsatisfactory, and creating adverse discussion in this city? No; they wanted to move forward, as my friend Dr. Bell says, in the progress of the illuminating art and secure a better light.

Now let us go a step further. Counsel for the City called attention to two contracts, one of which provided that these lights, the old 9.6 ampere, should be paid for at \$125.00 per annum; another at \$106.00 to \$108.00 per annum; but he didn't call your attention to a contract which we think is of considerable importance here, which recites, that: Exhibit No. 23.

“WHEREAS, the company is desirous of modifying the contract, and is further desirous of substituting a new and improved light for the light now in use and furnished under the contract of April, 1899; therefore, they agree to take down this present system which the City has,

and substitute a better light than these old 9.6 ampere lamps,"—which our friends here have all agreed upon this witness stand is an obsolete light, and now rapidly decreasing in use, and as Dr. Bell in his book said, "as rapidly as the companies can afford to make the change."

And it was under those circumstances, with those conditions, with this light having been used for four years, while the City had held Jackson and his assigns up from performing the terms of the Jackson franchise, and while the illuminating art was advancing,—it was under these circumstances that the Pike's Peak Hydro-Electric Company, upon February 15th, 1905, entered into the contract to continue to use this system, to the nature of which I shall presently more fully address myself.

By that time certainly the City had placed a practical interpretation themselves upon what they thought was the standard 2,000 candle-power light, for anybody can see that with these lights upon the street they adopted a franchise seeking to secure a light which the councilmen say would be better. This Board will very readily see that the object of the City Council in 1898 was, as these gentlemen upon the stand said, to secure light; they didn't like these old lamps; they wanted something better, and when they had the first opportunity, after seeing what the comparison was between the present lamps and the old 9.6 ampere system upon the streets, they snapped it up and put the stamp of their approval upon it in a written contract.

The Arbitration Agreement sets up the claim which is made by one party against the other, which is to be arbitrated. The Arbitration Agreement sets up the issues as tendered by the City to its opponent; the City by its claim tells what the other party may be expected to meet, but the Agreement does not contain the position to be taken, or contemplated to be taken by the Company. I gather—but I cannot conceive that counsel was serious in it—that because in this claim there is the phraseology: "said claim to be determined by the difference in candle-power between the lights so furnished and the lights required," that he seriously hopes to fasten upon us an agreement that the matter is to be so determined. The point is that the Arbitration Agreement only sets out the claim, and the basis upon which the claim is predicated.

The City's claim is set forth in paragraph "First" of the Agreement, and everything in that paragraph is therefore a matter in dispute, and the City by this agreement advises us that it makes its claim, and that if this isn't enough they want more; and they give us notice that they base that claim to be determined by their contention, that the difference in candle-power is the point upon which they rely. This is an issue tendered by the City to the Pike's Peak Hydro-Electric Company; it advises us that they claim \$16,952.00 upon the following basis, to wit: setting it out; or in case that isn't enough they want more; and they advise us that their contention is that it is to be determined upon the basis of the difference in candle-power.

The whole fight between the City and the Company is as to whether or not candle-power or watts control.

Now with the Company claiming as its position that it don't owe a dollar of the money, that it is watts upon which you are to base your judgment, it is very clear that the arbitration contract simply is the statement of the claim of the City, and the basis upon which they hope to maintain it. You will search the contract in vain to find any statement by us that we don't owe a dollar and that our position is that the question must be determined by watts; and yet you gentlemen from the circumstances of the matter know that when this agreement was signed, this controversy, which you are now to determine, was based upon these issues, which had been the subject of discussion for months.

Paragraph "Second" clearly shows that the parties thereto agreed to submit these particular matters in dispute to the Board; so that in addition to the matters in dispute which are outlined in the Agreement, so long as the Hydro Company can in any way produce matters calculated to defeat the claim, it is apparent that its position and contentions are not set forth in the Agreement at all, but we are arbitrating the claim which the City makes against us, and its basis.

Now we deny that we owe any money; we deny that their basis is correct; and in addition we bring before the Board what is just as binding as an absolute release, executed under the seal of the City. These are the three positions that we take; and you will find none of them in the arbitration agreement, because its intention is to bring before the arbitrators the claim of the City, and the contention upon which it is based. So much for a preliminary statement.

Now, of course, it isn't necessary to waste time discussing the proposition that the term "standard 2,000 candle-power" has any relation to 2,000 actual candles. The first expert witness who arrived upon the stand for the City negated that idea completely.

Now let us get down to the consideration of this light question. Certain it is that every witness, expert in character, who went upon this witness stand, said that the object of the illuminating engineering profession to-day was to secure better illumination.

What is it that the people and tax-payers of the City of Colorado Springs want? Do they want light, as counsel says, or do they want the old 9.6 ampere lamp with its intrinsic brilliancy, confining itself to a small circle, with a dark shadow underneath; a spluttering, flickering light, going up and down; a lamp which their own city council, in the year 1901, discarded as being an obsolete lamp?

Now, finally, we got Dr. Bell to admit that arc light was not, since 1894, measured as light; and in addition to his admissions certainly we had the testimony of our witnesses that light has not been, cannot be, and is not, sold as candle-power, actually.

Now my friend has gone to some length in his remarks to tell us of the very fair tests that were made upon these street lights. These tests are those of which Mr. Marks said it would have been much fairer to have examined a greater number of lights or, preferably, all the lamps in the city. But over and above it all you are invited to rank against our tests, and the recording watt-meters at the plant, the testimony of

the expert, Professor Shedd, whose eye was sufficiently calibrated to enable him to tell by visual observation the condition of all the lamps upon the city streets, he having tested one.

All of the experts agree that measurements made at our plant by the integrating watt-meters indicated what the lights were doing, if the losses could be determined. And we have brought before you not only the condition of our plant and machinery, but if your honors please, we have placed before you data disclosing the exact condition of these lamps, as shown by practically correct watt-meters, month by month, day by day.

My argument is that the Jackson franchise means, and I think we have sustained it in principle, a light which consumes 450 watts, and the progress of illuminating engineering is toward obtaining light well distributed, and not merely fictitious candle-power.

We have from this witness stand, expressed by our witnesses, five opinions, that that term "standard 2,000 candle-power" refers to any lamp that gives or consumes 450 watts at lamp terminals.

We think the basis that you should adopt would be to take these watt-meter measurements and figure the difference between what the watts per month show there and the 450 watts that we think we should have delivered. We don't think that under any circumstances this Board can take a candle-power measurement. It has not been done in the past. How can this Board assume to do it for the first time here, and take as a standard of measurement that which has never been recognized as a basis upon which to found a charge.

And so we say to you take the 7.2 ampere light at 450 watts as a compliance with the Jackson franchise, and independent of other considerations, charge us with the deficiency in wattage, but under no circumstances can you use candle-power.

Having shown you, and corroborated it by Dr. Bell's book, that it is the illuminating value that counts, and that this enclosed A. C. lamp run at 7 to 7.2 amperes is the superior in illumination to the obsolete illumination of 9.6 ampere open arc, we ask you to take not 450 watts turned into any old mechanism, but 450 watts turned into a mechanism that produces a better illumination.

Our testimony stands uncontradicted that in practical operation the 9.6 ampere lamp varies from 200 to 600 mean spherical candle-power. How you gentlemen can be fair and base a charge upon such a variable is more than I can tell.

I regret that it is not within my powers to discuss curves and hemispheres, and average maximums, and average minimums, and luminometers, and parachromoscopes and hemichromoscopes, and other sundry terms and instruments; but it does lie on my mind deeply, as a matter of common sense, after hearing all these matters, that if you are going to get at the very right of the matter, and if from the testimony you believe, as I think you must, that this light produces in practice a far superior illumination, it seems to me that, independent of anything else,

you must discard candle-power, which cannot serve as a basis of measurement for charges, and adopt current, when you know that that current is being honestly and fairly supplied.

No matter what you may think of candle-power, no matter what you may think of the luminometer, no matter what you may think of Dr. Bell's book, and his explanations of it, and no matter what you may think of the very scientific manner in which the City has worked up this case, and presented it, I want to present to you the reason why, if you want to follow the Code provision, and get to the very right of the matter, that you must dismiss this case out of court.

There is a principle of the law that is as old as the hills themselves, that one man cannot by his acts or conduct induce another one to take a certain position, and then take advantage of his own act, and claim damages on account of it; and not only does the principle apply to men in their individual transactions, but it is especially applicable to municipal corporations in the situation the City of Colorado Springs is to-day.

Now municipalities have some limitations. They must act through their officers, and in governmental acts of a certain character, which are not necessary to be construed here, those officers alone can bind them; but if this City, in the course of its dealings with the holder of a franchise from it, has induced him or it, the corporation, to take a certain position, or has assented that he may take a certain position, its mouth is irrevocably closed to question anything surrounding that situation.

Now let me just call your attention to what the doctrine known as that of "equitable estoppel" is. This is from Anderson's Dictionary of Law:

"What I induce my neighbor to regard as true is the truth as between us, if he has been misled by my assertion."

The vital principal is, that he who by his language or conduct leads another to do what he would not otherwise have done, shall not subject such person to loss or injury by disappointing the expectations upon which he acted.

"The meaning is not that equitable estoppels are cognizable only in courts of equity, for they are commonly enforced in actions at law."

The City of Colorado Springs, on September 5th, 1901, contracted for these so-called better lights. They recognized the first time they had a chance to do so that these lights now attacked were better lights. Now they went along for four years, practically without any objection, and then what happened? When the Hydro-Electric Company, the long-suffering successor of a long number of long suffering predecessors, got ready to turn the water into its pipe line, the subject came up of the street lights, and they had a conference, and the Mayor of the City was there, and six Aldermen of the City were there; and my friend says because it wasn't a council meeting, as a technical proposition, the City didn't consent to these proceedings.

It don't make any difference whether they met as a city council or

not. The representatives of the city, and the Mayor, charged by the statutes of the city with the enforcement of all the ordinances, did meet with the representatives of the Company. I would refer you to Section 4487, 2nd Mills, and 4488 and 4496, 3rd Mills. Well, they met, these six Aldermen, and Mr. Taff of the Hydro-Electric Company, and the representatives of the Colorado Springs Electric Company, and the attorney for the Pike's Peak Hydro-Electric Company; they met and discussed this matter, not only then, but as individuals they had discussed it before and agreed that these lights now on the streets should continue when the Hydro Company turned the water into the pipes; that there should be no interruption in order to make any change; and that they should have the price named in the Jackson franchise, of \$5.50 per month, and that the same system should be used.

From that time on until the official bill was received late in August of 1906, over a period of fifteen months, and just before the current was boosted the Pike's Peak Company relied upon the acquiescence of those gentlemen, and upon the understanding had there.

The Colorado Springs Electric Company had nothing to do with it, except as the distributing agent.

Not one of the six Aldermen was put upon the witness stand to tell you that Mr. Taff or Mr. Tripp had not told the truth? No. And why not? Because they told the truth.

With regard to the resolution, Exhibit No. 46, let me dispose of that. The wording, as Mr. Taff explained, was probably "the way the City chose to put it." When they said that they would avail themselves of the street lights called for by the Jackson franchise, take the situation of the parties, as Judge Sanborn says you must, what did they, at that time, understand and agree would be a compliance with the Jackson franchise?. While this resolution is in no sense binding upon Mr. Taff, or varies the understanding that he then had, and which none of them ever could afterward say he did not earnestly and confidently rely upon, it is evident that that understanding enters into the resolution, and would control it, no matter if the Company were in no wise a party to it.

The Jackson franchise, in paragraph 10, says this:

"It is also provided that if the said George W. Jackson, his associates or assigns, shall fail to furnish to the said city the said lights and power as hereinabove provided, then all the rights and privileges herein and hereunder shall and will become null and void."

Tell me if, on February 15th, 1905, you gentlemen had been in the situation of this Company that had expended \$300,000.00 or more in the construction of a plant and knew that the 6.6 ampere lamp, run at 430 watts, was not the standard 2,000 candle-power lamp, and realized that when you didn't furnish that kind of a lamp, which is a mere incidental expense as compared with \$300,000.00, you would run the risk of forfeiting your franchise absolutely, unless you had some understanding to the contrary, what would you have done? There is the situation

surrounding the parties, and to say that the Pike's Peak Hydro-Electric Company didn't rely upon this understanding is to put them in the position of saying that they knowingly imperiled the franchise under which they got the power to operate their plant. They have gone ahead with this system which they frankly confess to you now was maintained at 430 watts, only because they understood that was proper. Do you believe that knowing that their franchise,—the only valuable, central thing that enables them to do business,—would be jeopardized by their furnishing this system of lights without an understanding, don't you believe that was the first thing they inquired into? Do you think they would let it go without an understanding? Never.

The decision of Judge Sanborn says that the City is operating in its contractual private business capacity as to this matter. Now referring to the acts of the officers, remember that the Mayor was present, and had charge of all these ordinances, and I consider that his action in consenting to this matter, and entering into an understanding upon which the Company's representatives were induced to rely, that alone ends the matter so far as the City is concerned. This point about the regular city council meeting has nothing to do with the matter. Their act in permitting this matter to go along, in paying for lighting for fifteen months, that act of itself,—disregard the meetings, disregard the talk which induced this line of conduct,—that alone shuts the mouth of the City on this proposition.

"Any positive acts by municipal officers which may have induced the action of the adverse party, and where it would be inequitable to permit the corporation to stultify itself by retracting what its officers had done, will work an estoppel." I Dillon on Mun. Corp., 485.

Now take this in connection with the other, or take it by itself: P. 523, Dillon.

"The assent of a municipal corporation to the variation or modification of a contract need not necessarily be expressed by the formal action or resolution of the common council; but it may be implied from acts relating to the contract work subsequent to the date of the contract."

Don't let the following sentence deceive you at all:

"But where the contract is made by ordinance in the prescribed statutory mode, it can only be repealed or annulled in the same manner."

This was neither a repealing or annulment of the Jackson franchise. It was simply a construction which these gentlemen chose to place upon the franchise as to what they would be willing to accept as a compliance with Section 9, at the price therein stated.

I call your attention to a decision in 122, Federal Reporter, at page 322, where it is held that the modification of a contract, or a waiver of conditions found in a contract, found to be prejudicial to its interests, can be made by a municipal corporation by implication.

I call your attention to a decision found in 27 L. R. A., at page 827:

“A city which has for many years recognized and accepted a water-works system as fully complying with a contract, cannot afterwards repudiate such recognition and claim damages for failure to comply with the contract.”

I also wish to call your attention to a matter closer home, asserting the general principle we urge. I refer to a case found in the 30th Colorado Supreme Court reports; a decision of Mr. Justice Gabbert in which he says:

“The defense of equitable estoppel may be asserted against a municipal corporation when the character of the action and the facts and circumstances are such that justice and equity demand the corporation should be estopped.”

Can you gentlemen, under the uncontradicted testimony of Mr. Tripp and Mr. Taff, that the Pike's Peak Hydro-Electric Company relied upon the acts, words, conduct, of the municipality, to continue this present system of lights, can you decide that candle-power rating should apply to these lamps, and the city should have been furnished with the old obsolete 9.6 ampere lamp?

I don't believe that you gentlemen are going to hold to any such technicality as that to constitute a meeting, a clerk must be present in the room to write down the proceedings provided it is against the solid justice of the thing. After these men, in Mr. Perkins' office, accepted these lamps as being the system through which the electricity should flow, then when they did come together in a meeting in which neither Mr. Tripp or Mr. Taff was present and adopted a resolution in which they said that nothing could impair the validity of the franchise, and that they availed themselves of the lights provided for by the franchise, they nevertheless put into the resolution, as Judge Sanborn would say to you, every fact, every circumstance, that surround the making of it, it all entered in and became a part of it.

Having adopted this resolution, what did they do? Followed it up by ordering each month from this Electric Company lights to go on this system. Can you discard that act, and that conduct, in considering whether or not under the law this City should in equity or justice to be here before this Board of Arbitrators.

I anticipate that you gentlemen must see that while there are some points here about candle-power, and visual observation, and luminometers, and wattage, it is unnecessary to dispose of them because there is the other controlling point of estoppel that disposes of the whole case.

However, as a last word from our side upon this subject of the expert testimony, I think that when you put yourselves in the position of this city council in 1898, you won't believe that with all the development that has been going forward since, that what these gentlemen had in mind was to keep to that same old lamp.

The City is here before you. What it wants to get at, is whether the Jackson franchise is being complied with. Why should you hesitate to resort then to that construction which says to the citizens of this city—your franchise upon this witness stand has been defined to mean a lamp of this character at 7 amperes? I appeal to you not only on the basis of engineering, but on the basis of common sense, not to relegate this city back to a system which Dr. Bell says every city is discarding as rapidly as it can.

We claim that we have maintained the position that when this light is running at 7 amperes, or better, we are within the Jackson franchise.

Don't be deceived for a minute by this trouble about cost. That has nothing to do with the matter. We either are complying with the franchise, or we are not; and you gentlemen are now in the position where you can choose for this city, between this lamp which has been demonstrated to give the practical results that the citizens need, and an obsolete lamp which the city council in 1901 discarded as being inferior to this light.

Now, briefly summarizing. The agreement of arbitration brings to you the chance to do the absolutely just thing between the parties. It presents the issue which has been tendered by the suit. Our reply to it is given by the evidence, which is that we deny that we owe any money; we deny their claim that the difference in candle-power is the correct basis; and we assert that the acts and conduct of their officers amounts to an estoppel, which throws every other contention into the shade, but which must bring you gentlemen to the very right of the matter; that is, that this company undoubtedly,—certainly until a demand was made upon them, until some formal objection was made to them that these lights were not what the City wanted, had a right to rely upon this situation, and that the City is estopped.

We urge upon you that candle-power, in no sense of the word, is the basis upon which you can measure anything, because it is too variable, under the testimony. You cannot take a laboratory condition and apply it to a street; that has been brought out. If you cannot do that, can you do otherwise than base a charge upon practical conditions? If there were any questions here about measurement, wattage is the only thing, and we have shown you why we operated that lamp as we did.

Confident, therefore, of the absolute justice of our position, from whatever view-point taken, and that we are entitled to favorable consideration at your hands an account of all of the circumstances, I submit this case to you, thanking you at the conclusion, as at the beginning, for your very kind and patient consideration of me and the company in your hearing of this matter.

**FINAL SUMMING UP AND CLOSING ARGUMENT FOR THE
PLAINTIFF**

By

MR. W. C. ROBINSON.**MAY IT PLEASE THE BOARD:**

We have heard quite a little here tonight in the way of a plea for equity and justice. One of the first maxims of equity that is taught to the young lawyer is that "He who comes into a court of equity must come with clean hands." This maxim is based on Holy Writ, for therein, in effect, it is asked, "Who shall stand in the places of the Most High?" and the answer is given, "he that hath clean hands and a pure heart." So we may say that when this defendant comes here pleading for equity, as distinguished perhaps from law, it should be required to come with clean hands in order to have its plea heard. With the evidence before you of what was required of this defendant, of what it has done and of what it has failed to do under this franchise, it seems to me that if there ever was a pair of dirty hands uplifted in any tribunal we have seen them here.

Of all the obligations assumed by Jackson or his assigns, we find only that the tunnel was completed; that free lights have never been furnished for any of the buildings except this one; that no street lights were furnished until about four years, instead of one year after the completion of the tunnel; that the lights were only of about 400 candle-power; that there has never been a pole, wire, lamp, or any apparatus erected in the city under the franchise; and that there is nothing whatever to revert to the city on the expiration of the franchise.

It has appeared to you by some evidence, but chiefly by counsel's statements, that almost from the time of the passage of this Ordinance the city has been fighting it. He stated to you in effect that time after time the city had tied the defendant's hands by injunction, but he probably did not mean to say that, for it is not true. The city has never tied the defendant's hands by injunction. Those writs have come from the other side. There has been litigation, and city council after city council has had trouble with the successive owners of this franchise, and the evidence before this Board shows that there was abundant cause for the trouble.

Counsel cites the decision of Judge Sanborn, in the U. S. Circuit Court of Appeals, as forever upholding this franchise, but he knows full well that that decision was based on the then facts as they were presented to the court at that time and that the facts of the case are not the same today. Nearly every benefit to be received by the City and which Judge Sanborn recited as the considerations moving to the City for the rights granted to Jackson have failed, and I have no doubt

that he would be the first to repudiate the claim that his decision could be taken as upholding this franchise under the present conditions.

Now, I want to take up for a moment that wonderful contract, probably the most wonderful contract ever presented by an attorney to any tribunal, the alleged contract made down in Alderman Perkins' office when some of the Aldermen met some of the representatives of the two electric companies. According to counsel's theory, as I understand it, they changed an ordinance of the City, for we must remember this contract was made by an ordinance. If he don't know it, you certainly do, that the business of a City Council can not be transacted at a mere conference between some of its members and other persons. An ordinance can not be amended, altered or repealed in such a manner. They claim that at that meeting this Ordinance was changed so that instead of requiring lights of standard 2,000 candle-power each, it requires any kind of a lamp that consumes 450 watts at the terminals. And now, what was the record of that conference or talk? Read the letters of Mr. Taff, representing the defendant company, to the City Council, Exhibits Nos. 47 and 49, in which he says particularly that his company will "commence the furnishing of the street lights and other lighting for the City, in accordance with the provisions of section 9." That is, in accordance with section 9 of the franchise ordinance, and then they come in here and say that that section has been changed.

Now, what did the City Council do after the receipt of those letters? The record of its proceedings on January 16th, 1905, Exhibit No. 46, shows its action on the matter, and one paragraph of the resolutions is as follows: "Resolved, further, that nothing in this arrangement shall be construed as in any way modifying or impairing the validity or the obligations of said franchise." You will see that the City Council did not intend that the obligations of that franchise should be modified or impaired. In both of the letters from the Company, and in the formal action of the City Council on the subject, they specifically provide that what they are doing should not modify or impair the obligations or validity of the franchise. There is not the slightest intimation that any of those terms had been changed, but on the contrary, there seems to have been great care taken that nothing should be understood as having changed the terms of the Ordinance in any respect. These letters, and these resolutions, so particular in this respect, were written and passed within a few days after the famous meeting in Alderman Perkins' office, and, according to some of defendant's witnesses, as a result of that meeting; and yet, when these men are caught in this matter, they come in here and attempt to claim that the Ordinance was changed at that meeting and so as to lessen the obligations of the defendant.

You will remember that in 1901 the Colorado Springs Electric Company, not the defendant, was lighting the streets with the old 9.6 D. C. open arc lamp, and in that year made a new contract with the City, at a lower rate per light and with an extension of time, and substituted the new 6.6 A. C. enclosed arc, and that that new contract had no connection whatever with the defendant Company or with the Jackson franchise.

Counsel has stated, in effect, time and time again, that the City was dissatisfied with the old light, repudiated the old lamp, wanted a better, a new and improved light, etc., etc. The purpose of this argument must have been to induce you to believe that in 1901 the City deliberately accepted the 6.6 A. C. enclosed arc as a substitute in a contract for, and as superior to, the 9.6 D. C. open arc, and as a fulfilment of the terms of the Jackson franchise, and that the City repudiated and threw out the old lamp. But you will notice that the Colorado Springs Electric Company was not operating under the Jackson franchise; that it never claimed to own or to have any interest in that franchise, and that franchise was in no possible manner involved in the transactions of 1901. We further see by this contract of 1901, Exhibit No. 23, that it was the Company, and not the City, that "repudiated" the old lamp, and that described the new lamp as "a new and improved" light; that the Company voluntarily offered to furnish the new light at a less price than the old, although its contract still had several years to run at the higher rate. The City never accepted the new lamp as a substitute for the old lamp in any contract, as counsel would have you believe, but at the solicitation of that company the City made an entirely new contract with it, whereby the City obtained the light of the new lamp at a less price than it was then paying for the old light; a matter in which the Jackson franchise was in no manner involved.

Let me now take up the doctrine of equitable estoppel, which the defendant seeks to interpose against the City. It must be borne in mind that the contract between the City and this Company was made by an ORDINANCE, a point of very great importance, and the claim of the Company now is, as I understand it, that this contract was changed at the informal meeting in Alderman Perkins' office between some of the Aldermen and some of the representatives of the two electric companies. At page 532 of Dillon on Municipal Corporations, it being the same page from which counsel read, the author says: "But when the contract is made by ordinance in the prescribed statutory mode, it can only be repealed or annulled in the same manner." That is, when a contract is made by an ordinance, it can be repealed or annulled only by an ordinance. Counsel may say that the Ordinance was not repealed or annulled in Mr. Perkins' office, but only changed and modified. If they can thus change and modify this Ordinance, so that it requires only a 400 candle-power light instead of a 2,000 candle-power light, they certainly could continue to modify and change until there would be nothing left except the title. Now, counsel claims, as I understand him, that because these members of the City Council at that famous meeting in Mr. Perkins' office, when he says a new contract was made, did not object to the lights being furnished through the present lamps, that the City is now estopped from denying that these lights fulfill the requirements of the Jackson franchise.

Now, it is claimed that the Aldermen present made no objection, when they were informed that lights under the Jackson franchise would be furnished through the wires, lamps and other apparatus then on the

streets, and that thereby the City acquiesced in and agreed to the lights thereafter furnished through that apparatus. No claim is made that these aldermen were informed or ever knew that the lights to be furnished were of only 400 candle-power or of any less power than that required by the franchise. On the other hand, no claim is made that this defendant was ignorant of the fact that the lights which it proposed to furnish were of only 300 or 400 candle-power instead of standard 2,000 candle-power.

Before finally passing the question of light and watts, or light and power, I want to call your attention to the bills put in to the City by the defendant. For instance, the bill dated February 6, 1906, calls for 232 arc lights, and I believe that every bill is worded in the same way. They have been billing the city for arc lights and not for watts or for lamps. It would seem that this idea that they are selling the city power to be measured in watts was an afterthought. By what right does the defendant read watts and power into this contract? The contract says light and candle-power, and it does not say watts or power.

Counsel has deemed it necessary to indulge in some sharp criticism of Prof. Shedd. I am quite willing to leave the character, learning and honesty of Prof. Shedd for your consideration, and without any fear that they will be injured by anything that counsel can say; but I submit that Prof. Shedd did not say that having tested one lamp, he could, by visual observation, whatever counsel means by that, tell the condition of all the lamps. He did say, in effect, that having carefully observed all the lamps, he could form an opinion that they were all of about the same power.

Now, let us consider the defendant's right to substitute the new lamp for the old, or rather the light of the new lamp for the light of the old lamp, in a contract calling for the latter. Has such a thing ever been done? Mr. Ryan, no doubt, in an honest effort to advance the interests of his employer, came here to testify in this case for the defendant, but he could not tell you of a single instance where this small lamp had been substituted for the old lamp in a contract calling for the latter. And I can recall no instance where the new lamp superseded the old lamp at the same price. It must be clear to the Board that the old lamp, when operated properly, as is shown by its operation in Europe, gives more light than the new lamp. The new lamp can be purchased and operated at a smaller cost, that is admitted, but it does not seem that they have ever been able to substitute the new for the old at the same price, and so far as we have been able to learn this is the first time that any one has ever attempted to do so. The maker of the lamp does not claim that it is capable of taking the place of the old lamp. The small lamp is undoubtedly a good one for the purpose for which it is made, but the point is that we did not contract for that kind of a light, and the little lamp can not fulfill the requirements of the other. And as a legal proposition, you can not substitute one thing for another in this contract without our consent. It does not lie in their mouths to say that this lamp is as good an illuminant as that one, and, therefore,

they can substitute it. That is a matter of opinion, and they have no right to make the substitution, even if the small lamp was as good an illuminant as the other. To illustrate: If I bought from one of you a black horse weighing 1,500 pounds, and you came to me with a white horse weighing 1,510 pounds, and said to me, "This is just as good a horse as you bought of me," you could not compel me to take the horse and pay the price. I didn't buy a white horse from you at any price.

Now let me summarize the claim of the city. We claim:

1st. That we are entitled to a light of 2,000 candle-power, according to the ordinary meaning of the words used in the Ordinance.

2nd. If we are not entitled to a light of 2,000 candle-power, then, under a technical meaning of the terms used in the Ordinance, we are entitled to a light equal to the light given by the 9.6 ampere, direct current, open arc lamp, when operated in a proper manner and a proper condition, and that such light would be of not less than 1,200 candle-power.

I think that I am fully justified in saying that all of the testimony on the point shows that the light that we have received has not exceeded 400 candle-power. That would be the maximum. If we are entitled to lights of 1,200 candle-power, at \$5.50 per month, and we have received only 400 candle-power, then we are willing to pay 400-1200 of \$5.50 per month. As we did not contract for lights of 400 C. P. at any price, we are not legally obliged to pay anything for them, but we do not care to take advantage of our legal rights on that point. We are willing to pay for what we have received, but nothing more.

Please allow me to again try to impress on your minds the point that our contract calls for lights, and for lights measured in candle-power, and that it does not call for watts, or power, or lamps. You may not agree with my claim that we are entitled to lights of 2,000 candle-power, but I do not see how it is possible for you not to agree with the claim that we are entitled to at least 1,200 candle-power lights. Let us take that certain quantity, as shown by the testimony of Professors Matthews and Shedd, Dr. Bell, Mr. Marks and Mr. Ryan. I believe that none of the defendant's witnesses testified that the present lamp did or could produce that amount of light. Even their boys who testified so learnedly about the meaning of the famous resolution of 1894 did not make that claim. So far as I can recall, no witness put the power of this lamp claims it was being operated at more than 400 candle-power. Thus we may say that under the great weight of the testimony we are entitled to at least 1,200 candle power and that we have received at most 400 candle power.

Now, in closing, we claim that for \$5.50 per light per month, we are entitled to lights of at least 1,200 candle-power; that we have received lights of not more than 400 candle-power; and we ask you to settle the claims between the City and the Company on a basis which will cause us to pay not more than 400-1200 of \$5.50 per light per month,—that is, on a basis that will cause us to pay for nothing more than we have received. If this basis seems unreasonably low and unremunerative to

the Company, and probably destructive of its business, let me call your attention to the facts that have appeared before you. The Company is using the city water system as its only source of power. It has no other power plant. According to the testimony of an officer of the Company, from 10 per cent. to 15 per cent. of the total amount of current generated by this water-power is used for our street lights. From 85 per cent. to 90 per cent. of it is sold to other consumers. Undoubtedly, any honestly organized and honestly managed company would be glad to have the use of that water-power and pay for it by furnishing free lights for our buildings and streets.

If you will consider all these facts, all the conduct of this Company, how much it has received and how little it has given in return. I am sure that it will lie in your hearts to feel and in your mouths to say that the course of this City towards this defendant has been marked by extreme liberality.

THEREUPON THE BOARD FINALLY ADJOURNED THE
HEARINGS.

STATE OF COLORADO }
 COUNTY OF EL PASO } s.s.:

ARBITRATION BETWEEN THE CITY OF COLORADO SPRINGS AND THE PIKES PEAK HYDRO- ELECTRIC COMPANY.

Award of the
 Arbitrators.
 L. G. Carpenter.
 E. L. Elliott.
 Henry Floy.

The findings herein set forth constitute the award of the Arbitrators named in, and acting by virtue of an Agreement of Arbitration entered into on the 30th of January, 1907, by and between the City of Colorado Springs, hereinafter called the City, and the Pikes Peak Hydro-Electric Company, hereinafter called the Company, copy of which is attached hereto.

The matters in controversy presented to the Arbitrators arise from a franchise granted to one George W Jackson by the City of Colorado Springs, under date of September 8th, 1898. This franchise, on the one hand, granted to the said Jackson, for a period of twenty-five years, certain rights to use, under certain restrictions, the water supply of said City for generating electricity, and also to maintain a system for the distribution of electrical energy in said City. The said Jackson, on the other hand, was to complete a water works contract which he had previously undertaken, and was to furnish electrical energy to the City under certain conditions. This franchise came into possession of the Pikes Peak Hydro-Electric Company by assignment, and the said Company began to furnish arc lights to the City on February 15th, 1905, through the Colorado Springs Electric Company as agent.

The particular provision of this franchise relating to the controversy before the Arbitrators is contained in Section 9, which reads as follows:

"The said George W. Jackson, his associates or assigns, shall within one year after the completion of the Strickler Tunnel, and during the remainder of the term of this grant, furnish to the City of Colorado Springs such arc lights of standard 2,000 candle-power each as may be required by the City for the purpose of lighting its streets, alleys and public grounds, at the rate of \$5.50 per light per month, said lights to be used from sunset to sunrise during each and every day of each and every month."

The City claims that the arc lights furnished by the Company are not in accordance with the provisions of the franchise, as stated above, and therefore a reduction should be made in all bills rendered by the Company to the City, whether paid or unpaid. In answering the claims set forth by the City in the Agreement of Arbitration, the Company made the contention that the City was estopped from claiming damages or rebates, at least until June 1, 1906, by reason of the fact that the City paid its bills in full to that date, and on other grounds which were duly set forth by Counsel. Both parties presented arguments and briefs on this point.

The hearings were held before the Arbitrators in Colorado Springs, continuing from February 1st to 9th, inclusive, the City appearing as Plaintiff, and the Company as Defendant, both represented by able Counsel. An unusual number of expert witnesses of high character and acknowledged reputation were examined, all of whom showed an evident intention to give wholly unbiased facts and opinions.

The provisions of the Agreement of Arbitration that all evidence should be admitted led to a volume of testimony which proved in a way an embarrassment of riches. The case appeared to be of more than local interest and of wider importance than the mere money involved. These conditions necessitated a careful study and protracted consideration of every phase of the question, which, however, has enabled the Arbitrators to reach a unanimous conclusion.

Analyzing the several claims made by the two parties to the controversy, the matter has been considered under the following heads:

I. Does the phrase "Arc lights of standard 2,000 candle-

power each" mean an arc lamp giving 2,000 actual candle-power, or, if not, what was the generally accepted meaning at that time?

II. Do the arc lights which the Company has furnished, when operated under normal conditions, come within the meaning of the phrase "Arc lights of standard 2,000 candle-power?"

III. If the lamps furnished by the Company, when operated under normal conditions, have not fulfilled the requirements of the phrase "Arc lights of standard 2,000 candle-power," what is the extent of the overcharge measured in dollars and cents due to such deficiency?

IV. Was the service, which the Company actually furnished from the lamps in use, such as might reasonably be expected, and if not, what was the overcharge expressed in dollars and cents due to defective service?

V. Was the City estopped from claiming any refund?

Considering the above questions in detail:

I. "Does the phrase 'Arc lights of standard 2,000 candle-power each' mean an arc lamp giving 2,000 actual candle-power, or if not, what was the generally accepted meaning at that time?"

On this question the experts on both sides unanimously agree that at the date of the granting of the franchise, namely: September 8th, 1898, there was no arc light in use for street lighting purposes of 2,000 actual candle-power and therefore the phrase cannot be taken literally. The testimony of all the experts, however, shows that there was one particular type of arc lamp, namely: a direct, constant-current, series, open arc lamp taking 9.6 amperes and consuming 450 watts at the arc which was generally accepted at that time as complying with the meaning of the phrase.

II. "Do the arc lights which the Company has furnished, when operated under normal conditions, come within the meaning of the phrase 'Arc lights of standard 2,000 candle-power?'"

The Arbitrators have no difficulty at reaching a conclusion on this point since the uncontradicted testimony of the expert wit-

nesses was to the effect that the lights furnished by the Company did not come within the meaning of this phrase.

III. "If the lamps furnished by the Company, when operated under normal conditions, have not fulfilled the requirements of the phrase 'Arc lights of standard 2,000 candle-power,' what is the extent of the overcharge measured in dollars and cents due to such deficiency."

In arriving at an answer to this question, the Arbitrators encountered many difficulties arising from the present imperfect state of the commercial photometry of arc lights, the meagreness of evidence on some points, the variance of expert testimony on other points, the difficulty of selecting a satisfactory standard of comparison, and of estimating, on a dollar and cents basis, the difference in arc lamps of such widely varying characteristics.

The experts generally agreed that candle-power measurements alone do not fully express the effective values of arc lamps for street lighting, and that while the lamps used fell short of meeting the requirements of an "arc light of standard 2,000 candle-power," they had some compensating advantages.

After carefully weighing such evidence as was presented, the Arbitrators reached the conclusion, everything considered, that twenty per cent., in the present case, is a fair estimate in dollars and cents of the deficiency of the lights furnished by the Company as compared with "arc light of standard 2,000 candle-power," both types considered as operating under normal conditions.

IV "Was the service which the Company actually furnished from the lamps in use, such as might reasonably be expected, and, if not, what was the overcharge expressed in dollars and cents due to defective service?"

The Company admitted that during a portion of the period involved in this controversy, its lamps were not operated under normal conditions, and placed in evidence a complete set of station records covering the entire period. From these records it appears that during a portion of the time the lamps were operated below their proper wattage, and for another portion of the time above their normal wattage. There appeared to be a dis-

crepancy, however, between the wattage delivered at the lamp terminals, as computed from the station readings, and the wattage as actually measured by tests at the lamps. During the month of September, 1906, measurements were made of the exact wattage of every lamp in the City, which provided data for determining, within reasonable limits of error, the actual amount of this discrepancy in wattage. The discrepancy thus determined proved to be $6\frac{1}{4}\%$, which has therefore been used as a correction constant for reducing the station wattage. The corrected wattage thus obtained was used to determine the candle-power from the data given in Prof. Matthews' tests, made on lamps taken from the City circuits. These candle-powers compared with the candle-power of a lamp operated at its normal wattage (430) were expressed in per cent., which gave the means of determining the deficiency or excess of service supplied, compared with a normal lamp of this type.

V. "Was the City estopped from claiming any refund?"

The Arbitrators requested briefs upon this question from counsel on both sides, which were carefully considered.

The Arbitrators reached the conclusion that there was no intention on the part of either party to evade the obligations of the contract. The good intention of the Company, could not, however, be held as justification for an actual deficiency in service, which has been shown to exist. On the other hand, the fact cannot be overlooked that the City should have been advised in regard to a matter of such importance, before accepting the service furnished by the Company, or at least before having allowed it to continue for so long a time without protest. For these reasons the Arbitrators consider that the responsibility is divided between the Company and the City for the period to June 1, 1906, and therefore conclude that the reduction on account of overcharge for this period should be figured on a basis of 10% in place of the 20% taken after June 1, 1906.

The percentages as given under III, IV and V have been used in computing the results which go to make the total award, the tabulated figures are shown on the sheets attached hereto.

CONCLUSIONS.

The monetary claims made by the City were:

1. Claim for a refund on bills paid prior to June 1, 1906;
2. For a reduction of bills for service rendered from June 1, 1906, to February 1, 1907.

After careful consideration of all facts presented in evidence, and for the reasons given above, the Arbitrators make, in accordance with the Agreement of Arbitration, and under authority of the statutes of the State of Colorado, the following award:

1. That the Pikes Peak Hydro-Electric Company shall refund to the City of Colorado Springs the sum of \$4,612.12.

Interest on these overcharges computed at 8% to April 1, 1907, amounting to \$519.34, is awarded the City, in accordance with the stipulations of the Agreement of Arbitration.

2. That the bills of the Pikes Peak Hydro-Electric Company against the City of Colorado Springs for service rendered from June 1, 1906, to February 1, 1907, shall be reduced by the amount of \$2,056.43.

Interest on the bills thus corrected, due the Company, computed at 8% to April 1, 1907, is \$307.22, which amount is awarded to Pikes Peak Hydro-Electric Company in accordance with the stipulations of the Agreement of Arbitration.

3. That in accordance with the statutes of Colorado the Arbitrators declare that the statutory fee of three dollars per day for each Arbitrator amounts to \$243.00, which amount is awarded to the City of Colorado Springs to be paid by the Pikes Peak Hydro-Electric Company.

L. G. Carpenter

E. L. Elliott

Henry Flay

PART I.
BILLS PAID BY THE CITY.

TABLE.—Tabulation to determine amount of overcharge by the Pikes Peak Hyrdo-Electric Company against the City of Colorado Springs on bills for services from February, 1905, to June 1, 1906, and the amount to be refunded (Column I) with interest thereon (Column J) to April 1, 1907.

EXPLANATION OF HEADINGS.

- Column A.—Months wherein service rendered.
 Column B.—Amount of bills as presented and paid.
 Column C.—Average wattage per lamp from the station records.
 Column D.—The amounts in Column C reduced by correction obtained from September measurements.
 Column E.—The candle-power corresponding to the wattage of Column D.
 Column F.—Per cent. the candle-powers in Column E are of the normal candle-power of the lamp.
 Column G.—The percentage in Column F reduced by an additional allowance of 10%, giving the percents of the bills which should have been paid.
 Column H.—The difference between the percents in Column G and 100%, being the amount of overcharge expressed in per cent.
 Column I.—The overcharge for the month, being the amount of the bills in Column B multiplied by the per cent. in Column H.
 Column J.—The interest on the amounts in Column I at 8% computed to April 1, 1907.

TABLE 1905.

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Feb.	610.50	418	392	218	82.6	74.3	25.7	\$156.90	26.15
March	1226.50	429	402	230	87.1	78.4	21.6	264.92	42.39
April	1232.55	438	411	241	91.3	82.2	17.8	219.39	33.63
May	1245.45	432	405	234	88.6	79.7	20.3	252.83	37.09
June	1253.82	432	405	234	88.6	79.7	20.3	254.53	35.63
July	1254.00	428	401	229	86.7	78.0	22.0	275.88	36.78
August	1310.90	432	405	232	87.9	79.1	20.9	273.98	34.60
Sept.	1287.00	428	401	228	86.4	77.8	22.2	285.71	34.28
Oct.	1295.90	425	398	225	85.2	76.7	23.3	301.94	34.22
Nov.	1298.00	428	401	229	86.7	78.0	22.0	285.56	30.46
Dec.	1298.00	405	380	204	77.3	69.6	30.4	394.59	39.46

TABLE 1906.

Jan.	1308.45	401	376	199	75.4	67.9	32.1	420.01	39.20
Feb.	1321.47	412	386	211	79.9	71.9	28.1	371.33	32.18
March	1328.43	416	390	216	81.8	73.6	26.4	350.71	28.06
April	1335.40	437	410	240	90.9	81.8	18.2	243.04	17.82
May	1337.42	434	407	236	89.4	80.5	19.5	260.80	17.39
								<u>\$4612.12</u>	<u>\$519.34</u>
	<u>\$19943.70</u>								

SUMMARY OF TABLE I.

Total amount of bills presented and paid by the City . . .	\$19,943.79
Total amount to be refunded to City by the Company . . .	4,612.12
Interest on the amounts to be refunded	519.34

Total amount to be paid the City on account of overcharges and interest to June 1, 1906. \$5,131.46

PART II.

BILLS, PAYMENT WITHHELD BY THE CITY.

TABLE.—Tabulation to determine the amount by which the bills of the Pikes Peak Hydro-Electric Company against the City of Colorado Springs for services from June 1, 1906, to February 1, 1907, should be reduced, the amount of the bills after reduction (Column I) to be paid by the City and the interest thereon (Column J) to April 1, 1907.

EXPLANATION OF HEADINGS IN TABLE.

Column A.—Months wherein service rendered.

Column B.—Amount of bills as presented but payment withheld.

Columns C, D, E, and F, see Table I (same).

Column G.—The amounts in Column F reduced by 20% per paragraph III, the difference in the lights.

Column I.—The amount of the bills in Column B multiplied by the percents in Column G, giving the amount of the bill to be paid by the City.

The difference between the amounts in Column I and Column B will give the amount of the reduction of the bill presented.

Column J.—Eight per cent. of the amounts in Column I, being the interest due the Company by the City to April 1, 1907.

TABLE 1906.

A.	B.	C.	D.	E.	F.	G.	I.	J.
June	1342.00	427	400	228	86.4	69.1	927.32	55.64
July	1342.00	414	388	213	80.7	64.6	866.94	46.24
August	1342.00	425	398	225	85.2	68.2	915.25	42.71
Sept.	1347.50	487	457	296	112.1	89.7	1208.71	48.35
Oct.	1350.80	495	464	304	115.2	92.2	1245.44	41.52
Nov.	1358.50	488	457	296	112.1	89.7	1218.57	32.50
Dec.	1376.60	484	453	291	110.2	88.2	1214.16	24.28

TABLE 1907.

Jan.	1391.50	477	447	284	107.6	86.1	1198.08	15.98
	<u>\$10,850.90</u>						<u>\$8794.47</u>	<u>\$307.22</u>

SUMMARY OF TABLE II.

Amount of bills presented by the Company and unpaid. \$10,850.90
 Amount of reduction in bills. 2,056.43

Amount to be paid to the Company by the City. \$8,794.47
 Interest on the payments withheld. 307.22

Total payment to the Company for services from June
 1, 1906, to January 31, 1907, with interest. \$9,101.69

FINAL SUMMARY.

Refund to City, per Table I. \$4,612.12
 Reduction from face of bills after June 1, per Table II. 2,056.43

Total. \$6,668.55
 Interest due City, per Table I. \$519.34
 Interest due Company, per Table II. 307.22

Excess of interest due City. 212.12
 Arbitrators' fees 243.00

Award to City \$7,123.67

SUMMATION OF THE ACCOUNT BETWEEN CITY AND
COMPANY TO FEBRUARY 1, 1907.

Total of bills presented for service from June 1 to
 February 1 unpaid, as per Table II. \$10,850.90
 Total Award to City. 7,123.67

Difference due Company to balance accounts to Feb-
 ruary 1, 1907, from City \$3,727.23

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