MITLibraries
Document Services

Room 14-0551
77 Massachusetts Avenue
Cambridge, MA 02139
Ph: 617.253.5668 Fax: 617.253.1690
Email: docs@mit.edu
http://libraries.mit.edu/docs

DISCLAIMER OF QUALITY

Due to the condition of the original material, there are unavoidable flaws in this reproduction. We have made every effort possible to provide you with the best copy available. If you are dissatisfied with this product and find it unusable, please contact Document Services as soon as possible.

Thank you.

Due to the poor quality of the original document, there is some spotting or background shading in this document.

530.49
T6

MASS. INSTITUTE OF TECHNOLOGY
10 OCT 1903
LIBRARY.

LIBRARY OF ELECTRICAL ENGINEERING

A Photometrical Study of the
Enclosed [illegible]

In presenting this thesis we extend our sincerest thanks to Dr. R. R. Laurence, under whose supervision it was conducted, for his kindness, courtesy, and valuable suggestions, and to him it is gratefully dedicated.

— List of Photographs —

PART I

	PAGE
Frontispiece	
Incandescent Light Room	5
Switch Board; Incand. Lt. Room.	7.
Sleeker Photometer	18
Summer Brodhun Photometer	33
Bureau Photometer	44

PART II

Arc Light Room	75
Switch Board; Arc Lt. Room.	87
Arc Lamps Tested	95

59735

Draughts, Plots, and Diagrams

	PAGE
Wiring Diag. of Incand. Lt. Room	9
Draught of Flicker Photometer	17
Draught of "Summer-Brodhun"	32
Plot for Jacques Lamp, cored carbons	107
Rousseau's Diag., Jacques Lamp	108
Plot for Jacques Lamp, uncored carbons	118
Rousseau's Diag. Jacques Lamp	119
Plot for Gandusee Lamp, cored carbons	129
Rousseau's Diag., Gandusee Lamp	130
Plot for Gandusee Lamp uncored Carbons	139
Rousseau's Diag., uncored carbons	140
Plot for Helios Lamp, cored carbons	149
Rousseau's Diag. cored carbons	150
Plot for Helios Lamp, uncored carbons	159
Rousseau's Diag., uncored carbons	160
Plot for G. E. Lamp 336090 cored carbons	166
Rousseau's Diag., cored carbons	167

Draughts. Plats. & Diagrams (cont) PAGE

Plot for J.E. Lamp 5/2677 cored carbons 174
Rousseau's diag. cored carbons 175
Plot for J.E. Lamp 5/2677 uncored Carbons 184
Rousseau's diag. uncored carbons 185
Plot for Midget Lamp, cored carbons 190
Rousseau's diag., cored carbons 191
Plot for Midget Lamp, uncored carbons 198
Rousseau's diag., uncored carbons 199

- INDEX -

PART I

	PAGE
Object of Thesis	1
Preliminary	2
Statement of Preliminary Investigation	3
Incandescent Light Room	3-9
Method of Testing	10-12
Method of Setting Photometer	12-14
Method of Working up Data	15-16
Construction of Flicker Photometer	19-21
Setting of Flicker Photometer	21-22
General Remarks on Flicker Phot.	22
DATA on Flicker Phot., Red Light	23-24
DATA on Flicker Phot., Blue Light	25-26
DATA on Flicker Phot., White Light	27-29
DATA on Critical Speed, Flicker Phot.	30-31
Lummer Brodhun Phot.	34
DATA Lummer Brodhun, Red Light	35-37
DATA Lummer Brodhun Blue Light	38-40
DATA Lummer Brodhun White Light	41-43

INDEX

	PAGE
Bunsen Photometer	45
DATA Bunsen Phot., Red Light	46-48
DATA Bunsen Phot., Blue Light	49-52
DATA Bunsen Phot., White Light	53-59
Explanation of a Table	60
Table of Results, Red Light	61-62
Table of Results, Blue Light	63-64
Table of Results, White Light	65-66
Synopsis of Conclusions to Part I	67-68
Conclusions to Part I	68-73

PART II

Object	76
Description of Arc Light Room	76-81
Method of Calibrating Lamps	82-84
Conditions Under Which Lamps Were Tested	84-85
Method of Conducting Test	86-90
Explanation of Rousseau's Diag.	90-92

- INDEX -

PAGE

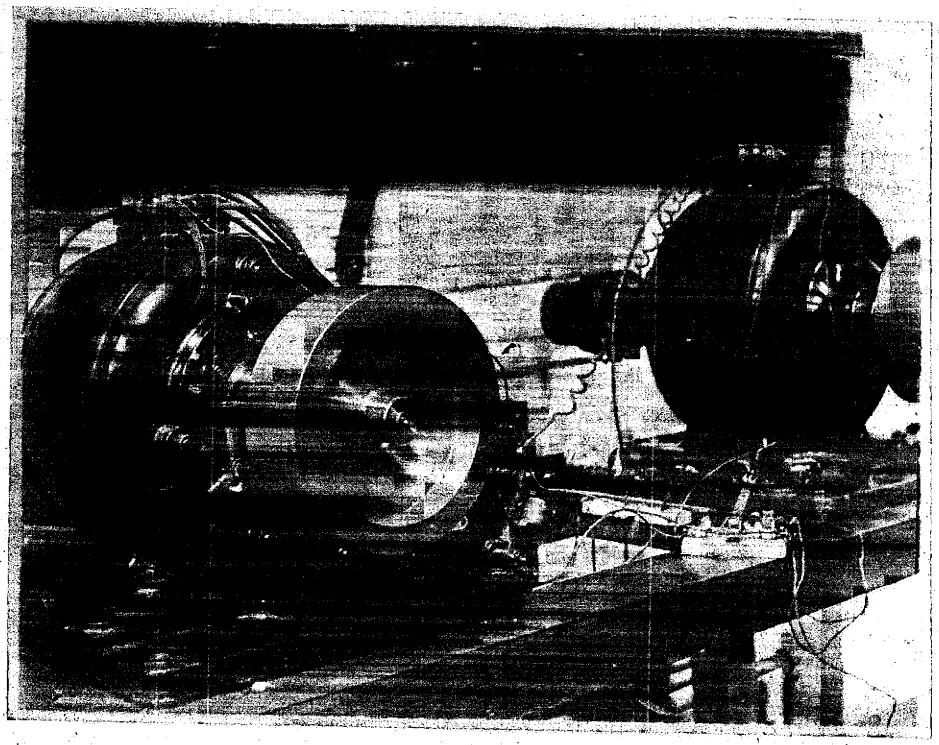
Explanation & Arrangment of Data 92-93
DATA on Calibration of Lamps 96-98
DATA on Watt Test - "Jacques" cored 99
DATA on C.P. Test, "Jacques" cored 100-106
DATA on Watt Test, "Jacques" uncored 110
DATA on C.P. Test "Jacques" uncored 111-117
DATA on Watt Test "Gaudusel" cored 121
DATA on C.P Test "Gaudusel", cored 122-128
DATA on Watt Test "Gaudusel" uncored 132
DATA on C.P. Test, "Gaudusel" uncored 133-138
DATA on Watt Test, "Helios" cored 142
DATA on C.P. Test, "Helios" cored 143-148
DATA on Watt Test, "Helios" uncored 152
DATA on C.P. Test, "Helios" uncored 153-158
DATA on Watt Test, G.E. 336090, uncored 162
DATA on C.P. Test, G.E. 336090, uncored 163-165
DATA on Watt Test, G.E. 512677 cored 167
DATA on C.P. Test, G.E. 512677, cored 168-173

- INDEX -

	PAGE
DATA on Watt Test "G.E." 512677, uncored.	177
DATA on C.F. Test "G.E." 512677, uncored.	178-183
DATA on Watt Test, "Midget", cored.	185
DATA on C.F. Test, "Midget", cored.	186-189
DATA on Watt Test, "Midget" uncored	193
DATA on C.F Test, "Midget," uncored	194-197
Conclusions	200-202

— PART I —

FRONTPIECE



A Photometrical Study of the Arc Light

Can the arc light be reliably rated upon a purely photometrical basis? All literature on photometry being conspicuous for its conflicting and discrepant data, and inasmuch, too, as previous experience has shown that the arc light compels the photometrician to face all the special difficulties and uncertainties that photometry can include, has led us to investigate as to the real source of these unreliabilities and to what extent they may be removed.

In presenting the data of an investigation covering so short a time, and any conclusions

which we ourselves may have drawn, we can not be so criminal as to request that this paper may be accepted as of scientific value. We present merely a collection of facts derived from what has been to us a most interesting study. Unbiased and unprejudiced as to every piece of apparatus used and all numerical data taken, we present our results as they stand - even though they may seem a source of contradiction and disagreement.

The first and perhaps greatest difficulty incident to our investigation was a purely physiological one, - the fact that as yet no function has been obtained that will connect the illuminating powers

of differently colored lights. Even with the incandescent lamps standard, and from the standpoint of its quality of light and its general commercial advantages, the difficulties of comparison by means of either a transmission or reflecting screen are bewilderingly great. We therefore set about to make a preliminary and essential investigation - a study of photometers. Which of the three ordinary commercial forms of photometer - Rumford, Flicker, and Lummer-Brodhun - is best adapted for comparison of differently colored lights.[2]

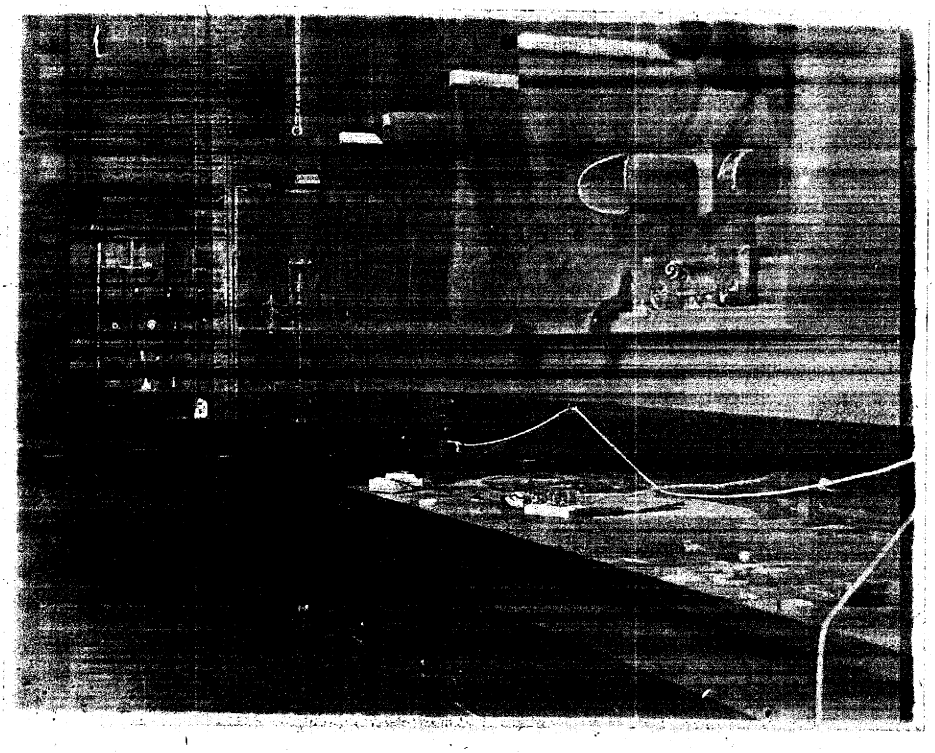
This preliminary investigation was performed in a new photometer room of the Massachusetts Institute of Technology. The room

is specially designed for incandescent light photometry, and is strictly modern in equipment and construction. The scientific simplicity in which it is planned, and the elaborate manner in which it is equipped, furnished us with ideal advantages for this part of our research.

The design of this room is such as to reduce all (sources of) extraneous sources of error to a minimum. It is high studded, permanently darkened, the main floor and entire equipment blackened. By these precautions there is no irregular reflection, and all light is radiated directly from the light sources.

The photometer bar is exactly 200" long between light sources, a

PLATE 1.

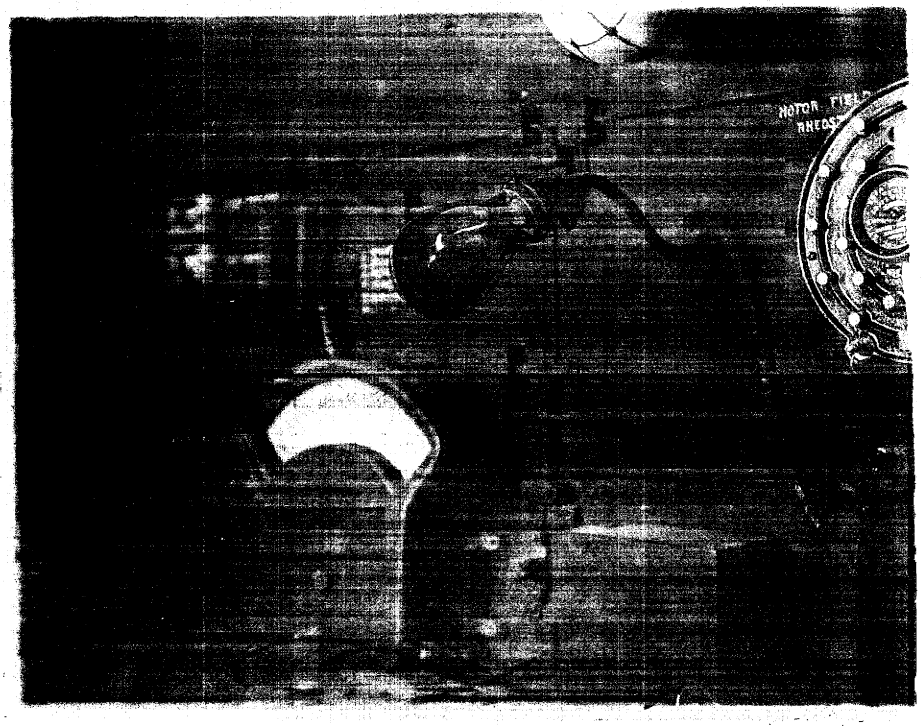


pointer on the carriage indicating what would be the projection of the screen upon the bar. The bar is directly graduated in ratios, these ratios representing the factor by which the standard light must be multiplied to give the candle power of the comparison light.

The two light sources are connected in parallel, with a water and a carbon rheostat in series with each lamp circuit. The manner in which the comparison light is arranged in a rotating socket can be seen from Photograph No. Plate I.

Means are provided for measuring the potential difference at the mains, standard light

PLATE 2.



and comparison light, also that between the standard and comparison lights. This is done by means leads carried from these several points to a common plug box and thence to a voltmeter, a switch being provided for reversals should the voltmeter read negatively. Photograph No Plate 2 shows this arrangement.

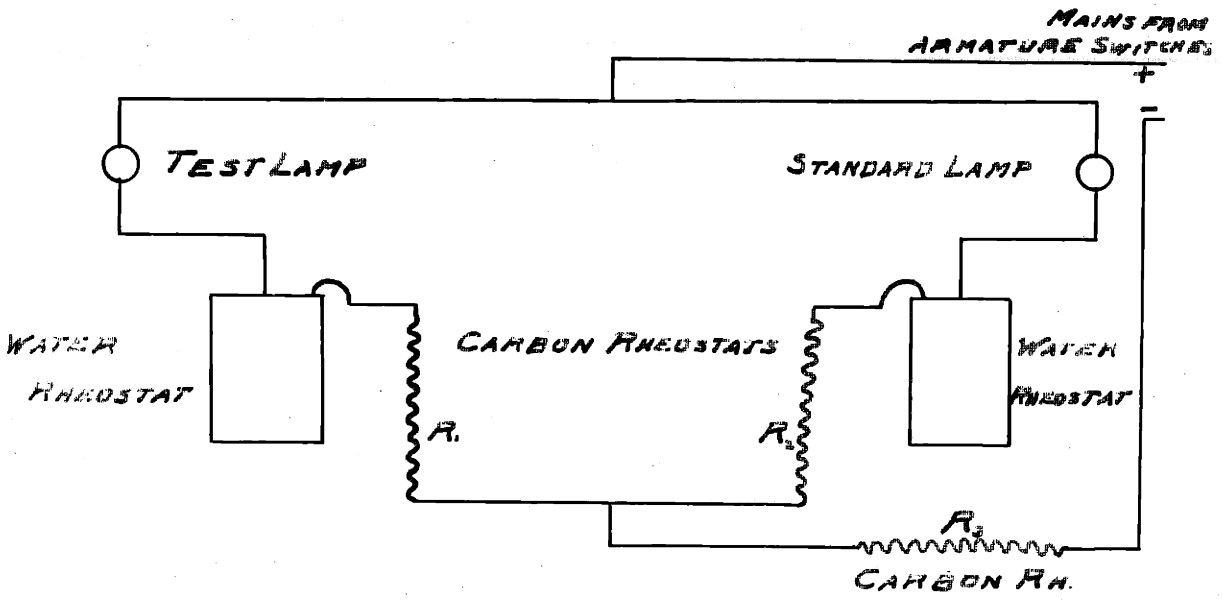
The source of illuminating power is a Waltger-Cabot, 240 v, 8ª motor driven generator connected on the three wire principle. The motor field is controlled by a rheostat placed directly over the photometer bench. The room itself is illuminated from the Edison Mains.

PLATE 3.

WIRING DIAGRAM

OF

INCANDESCENT LAMP PHOTOMETER ROOM



In carrying out these tests it was unessential to consider candle powers, but merely the ratios of candle powers. Precautions were taken, however, to fix the position of each lamp in its socket, and see that all data was taken with the lamps in this position.

The following method was used. In order to have extremes of color, comparison lamps of the same commercial rating were used - 110 v. 16 c. p. - data being taken by comparing with the standard a counterpart, also one with a deep blue, and one with a carmine red bulb. With the exception of two cases, to which special attention will be called,

the same set of four lamps was used. Therefore, inasmuch as by the system of regulation previously mentioned the lamps were kept throughout every test at 110, there is no diversity in the data due to (causes) the cause of variation in the conditions of the tests.

A glance over the data shows a greater or less diversity in the data of each test carried out. To what, then, are these due? They are due to the incomplete removal of the following sources of error,- (1) That due to the personal equation of the observer. (2) That due to the fatigue of the eye. (3) Uncertainty as to equal illumination of both sides of the screens.

In order to get an idea as

to the magnitude of this personal equation, the data of each observer has been separately worked up. To avoid, insofar as possible, any error due to fatigue, the greater part of the readings on this investigation were taken by the observers in alternation. Those readings however that were taken by one observer in a series of any length, clearly manifest the deviations due to fatigue. The errors due to the uncertainties as to equal illumination were extremely hard to reduce, more especially when differently colored lights were compared. A preliminary investigation, however, showed the following systematic procedure to

give the most reliable results. The photometer was first set so as to give fairly approximately equal illumination. The photometer was then moved until the first indication of transparency (was) on one side of the screen was observed, then by moving it in the opposite direction until first indications of transparency on the other side were noticed, and bisecting the distance through which the photometer had been moved the reading was taken. This procedure gave us every reason to conclude the error was thereby reduced to a minimum. It allowed the readings of different observers to check to a fair degree of accuracy. In

order to satisfy ourselves as to the reliability of this conclusion, we had several uninterested persons make settings after this method, and their readings checked remarkably well with our own. It might be here added that we found continued practice to be an essential for good work, and for this reason a considerable amount of our early data was thrown out.

A description of each photometer used, and the data taken thereon, will now be given, followed by our conclusions as to the information which this data affords. As a preliminary guide, however, to be used in studying the data, a few words should

be said as to the method after which it has been worked up

For ready comparison, the data of each observer, where two persons took data on the same test, is specially designated on the same page with that test. The mean of the observers readings is taken as being the best representative value. The average of the deviations of the separate readings from the mean is tabulated. This furnishes a measure of the variable parts of the errors, and is designated by (a.d.),— deviation measure of the single observations. Following this is found the average deviation of the mean, designated by $A.D. = \frac{a.d.}{\sqrt{n}}$; where (n) is the number of observations." It measures the effect upon

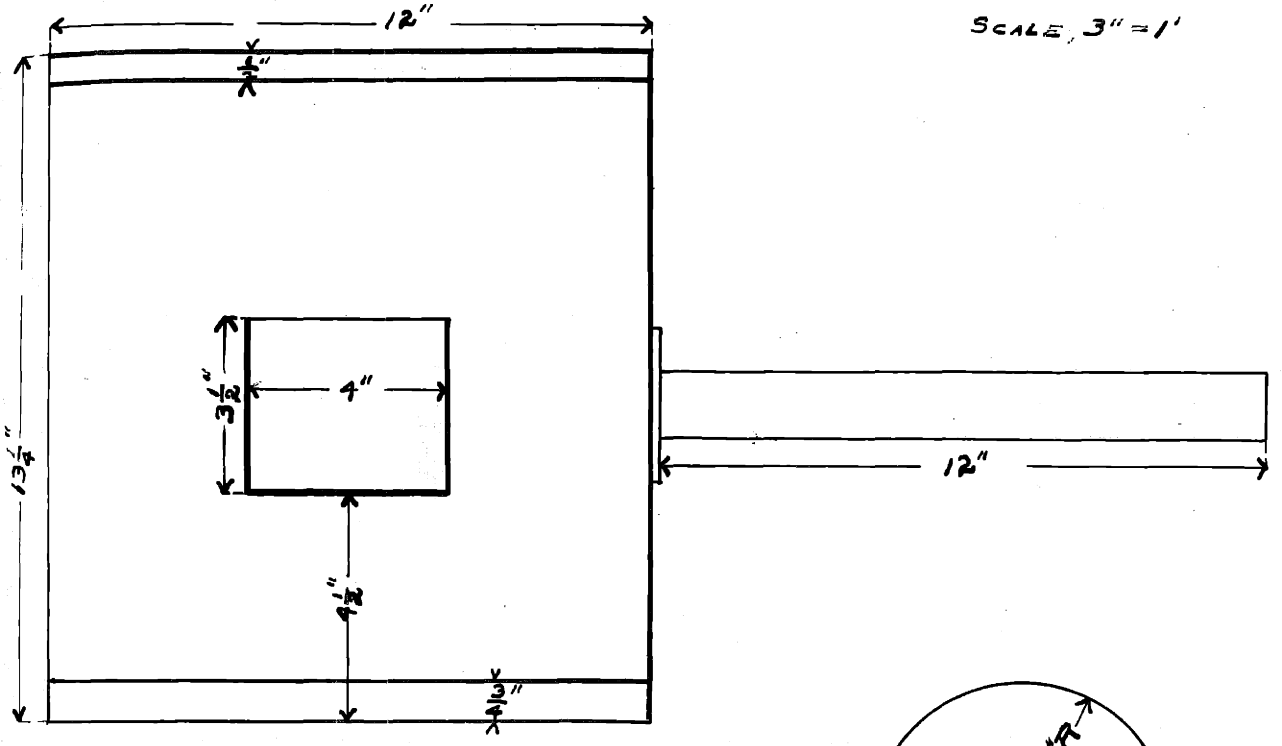
the mean result of the average of the variable parts of the errors entering into the single observations, and bears the same relation to the mean result (a.δ.) does to a single observation" Halman.

It is intersting to compare those values as obtained by the separate observers, the comparison being of particular interest as it gives prominence to the existance of a personal equation.

There will lastly be found a tabulation of the average of the mean of the readings of separate observers, this average giving the best representative value for that particular test. This value is of important consideration, and forms the basis of our final conclusions.

PLATE 4a

SCALE, 3" = 1'



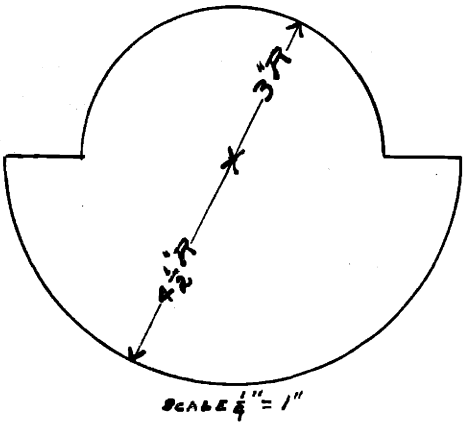


FIG. 2.

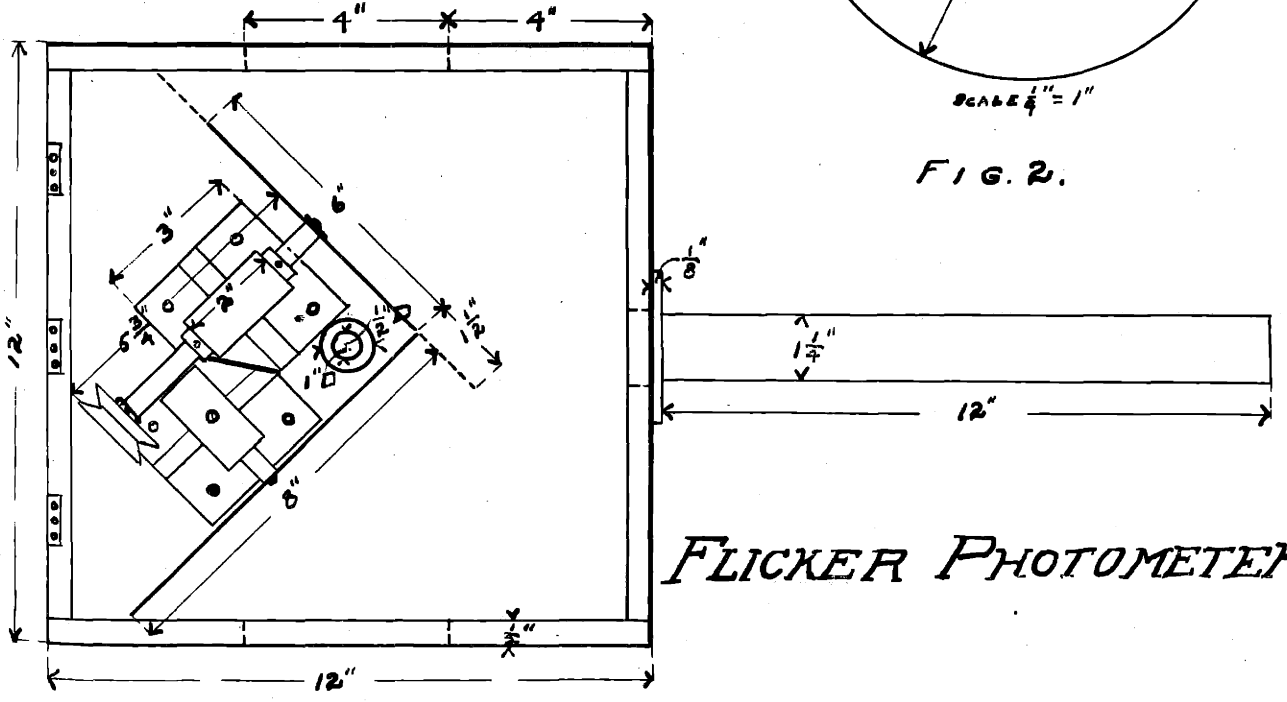
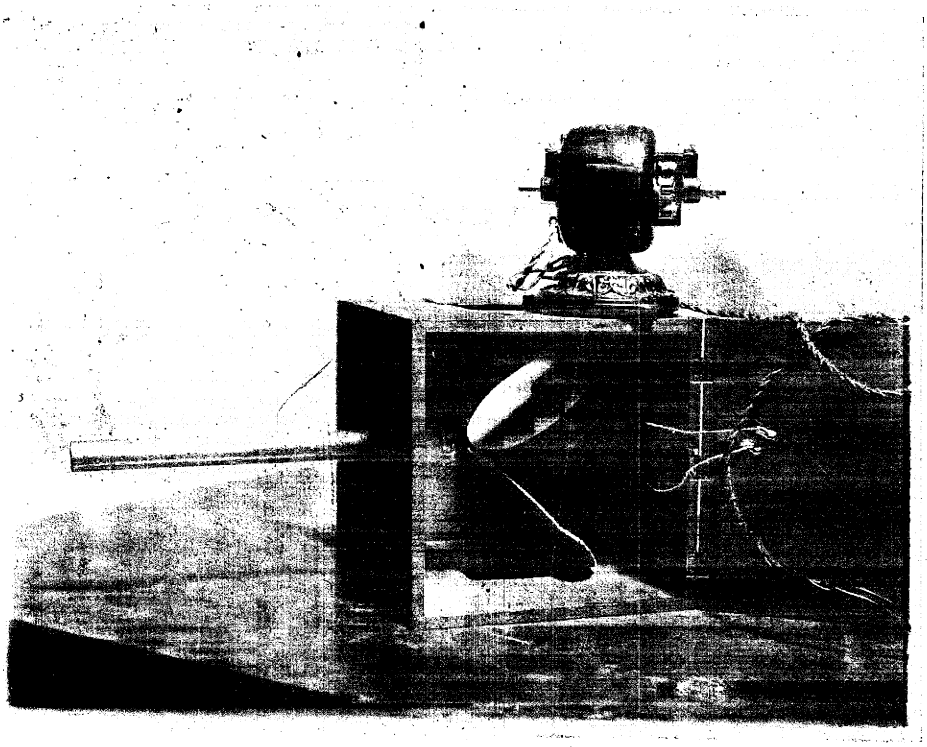


FIG. 1.

FLICKER PHOTOMETER.

PLATE 5



which would be later remarked.

In accordance with the fact that the Flicker photometer has been generally considered as best adapted to the comparison of differently colored lights, we have put it through a series of rigid tests. The working of the apparatus is based on the presenting to the eye sectors illuminated by each light source in rapidly alternating succession. Of apparatus of this type being in possession of the Institute, one was designed after the idea of Mr. J. C. Hutchinson. A drawing of the instrument as we constructed it is shown in plate 4, and a photograph on Plate 5 No. —.

A sector of white bristal board was cut as dimensioned in Fig 2.

This was mounted, by means of a screw and washer, to the end of a shaft, which by means of a motor driven pulley, is made to revolve in bearings furnished by an upright casting shown in the draught. This disc revolves before a similarly mounted, but stationary, circular disc, in such a manner that the sector of greater radius eclipses the circular disc when observed through the sight tube. The castings were made of cast iron, the shafts of steel, and the shafts of brass. The photometer box was made of white wood, and equiped with a brass sight tube, all parts being thoroughly blackened. Light was admitted by square holes, so cut that their centers were in

direct line with the axis through the two lamps. The motor used to drive the slotted disc was a the Holtzer Cabot 0.1 H type. This was placed upon the top of the photometer box, and the belt was passed through holes drilled in the box cover. The motor was supplied with a rheostat in its base, and by shunting an incandescent lamps across the brushes a wide range of speed could be obtained, somewhere within which the critical speed could be obtained. That is the speed at which the illumination is consecutive. The data on pages 30-31, shows the determination of the critical speeds. The speed being thus adjusted, the photometer (being thus adjusted) is moved

along the bar until the intensity of illumination on the fixed and rotating sides of the screen is the same - that is mounted until the "flicker" vanishes.

Knowing the Purkinje effect to be a source of error in this we had to guard ourselves, inasmuch as the illumination was quite bright, against setting in favor of the red in comparison of red and white light, and in favor of the white light in comparing the white and blue. Furthermore, as is the case with all sight-test instruments, the eye soon became fatigued, and its sensitiveness favorable to one side of the screen.

Flicker Photometer
Standard White Comparison Red

3/28-'03

Jones Ratio	Dev	Pearson Ratio	Dev.
.416	.10	.535	.012
.515	.00	.505	.018
.530	.01	.528	.005
.560	.04		
.512	.01		
.538	02		
.570	05		
3.641	.23	1.568	.035
A = .523	aδ = .033	A = .523	aδ = .012
$A.D. = \frac{.033}{\sqrt{7}} = .013$		$A.D. = \frac{.012}{\sqrt{3}} = .0069$	

Mean reading of test = .522

Flicker Photometer

Standard - White Comparison - Red

3/31/1903

Jones		Pearson	
Ratio	Dev	Ratio	Dev
.65	.02	.627	.01
.67	.04	.745	.11
.62	.01	.598	.04
.62	.01	.660	.02
.59	.04	.582	.06
3.15	.12	3.272	.24
A = .63	ad. = .024	A = .642	ad. = .048
A.D. = $\frac{.024}{15}$ = .011		A.D. = $\frac{.048}{15}$ = .0215	

Mean Reading of test = .64

Flicker Photometer.

Standard - White Comparison - Blue

3/28-1903

Jones Ratio	dev.	Jones Ratio	dev.
.142	.007	.135	.000
.124	.011	.132	.003
.138	.003	.132	.003
.125	.010	.140	.005
.144	.009	.138	.003
		1.350	.054
		A = .135	a.d. = .005
		$AD = \frac{.005}{110} = .0016$	

Mean Reading of test = .135

Flicker Photometer

Standard - White Comparison - Blue

3/30-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.147	.009	.143	.008
.124	.014	.155	.004
.140	.002	.152	.001
.144	.006	.162	.011
.136	.002	.144	.007
.691	033	.756	.031
A = .138	a δ = .007	A = .151	a δ = .006
A.D = $\frac{.007}{5}$ = .0031		A.D = $\frac{.006}{5}$ = .0027	

Mean reading of test = .145

Duboscq Colorimeter

Standard - White Comparison - White

3/24-1903.

James		Pearson	
Ratio	Dev.	Ratio	Dev.
1.28	.05	1.28	.02
1.35	.02	1.26	.00
1.37	.04	1.28	.02
		1.23	.03
4.00	11	5.05	.07
A = 1.33	a.d. = .037	A = 1.26	a.d. = .018
A.D. = $\frac{.037}{13}$ = .0017		A.D. = $\frac{.018}{14}$ = .009	

Mean reading of test = 1.30

Flicker Photometer

Standard. White Comparison. White.

3/30-1903.

Jones		Pearson	
Ratio	dev.	Ratio	dev.
1.12	.03	1.01	.10
1.22	.07	1.22	.11
1.13	.02	1.09	.02
1.15	.00	1.09	.02
1.12	.03	1.13	.02
5.74	.15	5.54	.27
A = 1.15	a.d. = .03	A = 1.11	a.d. = .054
A.D. = $\frac{.03}{5}$ = .013		A.D. = $\frac{.054}{5}$ = .024	

Mean reading of test = 1.13

Flicker Photometer

Standard - White. Companion - White.

3/31-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.68	.02	.76	.03
.84	.14	.80	.01
.69	.01	.85	.06
.72	.02	.73	.06
.73	.03	.79	.01
.78	.04		
4.20	.26	3.93	.17
A = .70	ad = .043	A = .79	ad = .034
A.D. = $\frac{.043}{6}$ = .018		A.D. = $\frac{.034}{5}$ = .015	

Mean reading of test = .75

Critical Speeds

Circumference of motor pulley = 1.25

Circumference of photometer pulley = 1.575

Revolutions per minute, at critical speed of motor shaft for:-

Blue light = 1958

Red light = 2710

White light = 2820

- Blue Light -

$$\frac{1958}{S_B} = \frac{3.857}{1.25}$$

$$S_B = \frac{1.25 \times 1958}{3.857} = 631.6 \text{ r.p.m.}$$

$$= 10.53 \text{ r.p.s}$$

- Red Light -

$$\frac{2710}{S_R} = \frac{3.857}{1.25}$$

$$S_R = \frac{1.25 \times 2710}{3.857} = 874.2 \text{ r.p.m}$$

$$= 14.57 \text{ r.p.s}$$

Critical Speeds

- White Light -

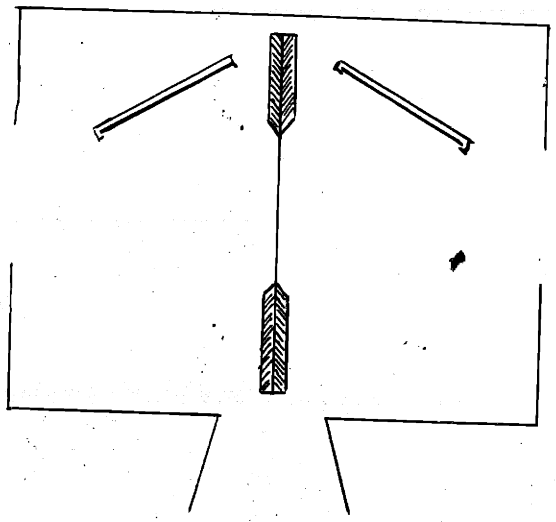
$$\frac{2820}{S_W} = \frac{3.857}{1.25}$$

$$S_W = \frac{2820 \times 1.25}{3.857} = 909.7 \text{ r. p. m.}$$

$$= 15.16 \text{ r-p. s.}$$

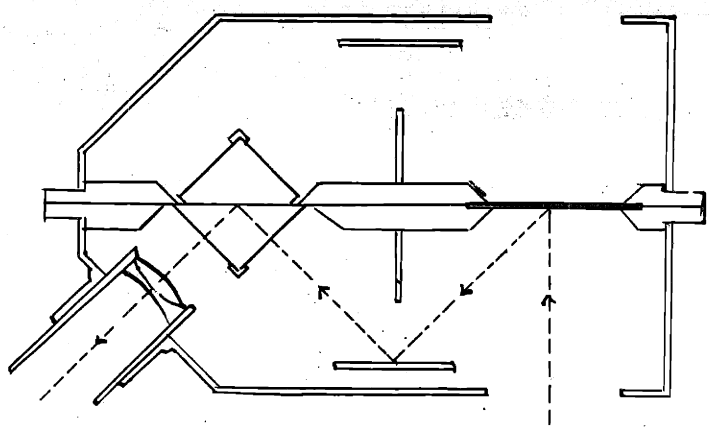
Color	R.P.M.	R.P.S.
Blue	631.6	10.53
Red	874.2	14.57
White	909.7	15.16

PLATE 6



BUNSEN PHOTOMETER

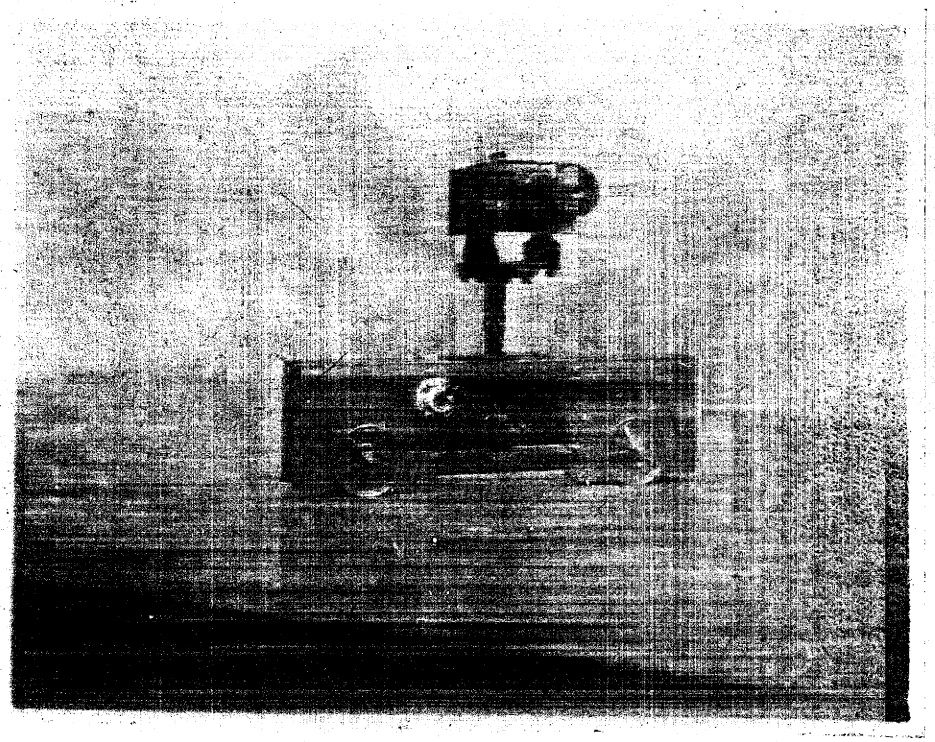
FIG. 1. (STENE)



LUMMER-BRODHUN PHOTOMETER.

FIG. 2. (STINE)

PLATE 7



The data obtained from a series of tests on the Lummer Brodhun or Reichsanstalt photometer will next be given. This is a diffusion screen photometer, a full description of the principle of which can be found in Elem. Photometrical Measurements, from which the diagram Fig 2 plate 6 was taken. The photometer is mounted upon the carriage in the usual manner, and two illuminated fields side by side are viewed through the sight tube. The reading of this photometer caused the eye to become very soon fatigued, effecting the advantage due to the compared fields. A discussion of the results obtained from this photometer will be given in the general conclusion.

Lummer-Brodhun Photometer
Standard-White Comparison-Red.
3/26-1903.

Pearson Ratio	Pearson Dev.	Pearson Ratio	Pearson Dev.
.384	.013	.383	.012
.360	.011	.369	.002
.365	.006	.362	.009
.330	.041	.394	.023
.387	.016	.355	.016
[illegible]		3.709	.149
[illegible]		A = .371	a.d. = .015
		A.D. = .0047	

Mean reading of test = .371

Lummer-Brodhun Photometer
Standard White Comparison Red

4/3-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.59	.00	.63	.01
.61	.02	.66	.02
.56	.03	.62	.02
.56	.03	.63	.01
.54	.05	.64	.00
.62	.03	.66	.02
.57	.02	.66	.02
.61	.02	.64	.00
.61	.02	.65	.01
.55	.04	.65	.01

Continued next page

Lummer - Brodhun Photometer -
Standard - White Comparison Red.
4/3 - 1903

Jones Ratio	Dev.	Pearson Ratio	Dev.
.57	.02	.65	.01
.59	.00	.64	.00
.65	.07	.66	.02
.63	.04	.63	.01
.61	.02	.64	.00
8.87	.41	9.66	.16
A = .591	a.d. = .028	A = .64	a.d. = .01
$A.D. = \frac{.028}{\sqrt{15}} = .0092$		$A.D. = \frac{.01}{\sqrt{15}} = .0026$	

Mean reading of test = .62

Lummer - Brodhun Photometer
Standard - White Comparison - Blue
3/26 - 1903 -

Pearson Ratio	Dev.	Pearson Ratio	Dev.
.256	.009	.250	.015
.246	.019	.300	.035
.251	.014	.285	.020
.256	.009	.278	.013
.270	.005	.260	.005
		2.652	.144
		A = .265	a.d. = .014
		A.D. = $\frac{.014}{\sqrt{10}}$ = .014	

Mean reading of test = .265

Summer - Rhodium Photometer.
Standard White Comparison - Blue

4/3-1903

James		Pearson	
Ratio	Dev.	Ratio	Dev.
.146	.004	.155	.013
.166	.024	.144	.024
.126	.016	.164	.004
.148	.006	.167	.001
.145	.003	.168	.000
.144	.002	.167	.001
.149	.007	.167	.001
.133	.009	.166	.002
.148	.006	.162	.006
.151	.009	.189	.021

Continued next page

Summer. Sodium Photometer
Standard-White Comparison-Blue
8/3-1903.

Jones		Pearson	
Ratio	dev	Ratio	dev
.139	.003	.165	.003
.148	.006	.193	.025
.122	.020	.164	.004
.131	.011	.170	.002
.138	.004	.172	.004
2.634	.130	2.513	.171
A= 142	$\Sigma\delta$=.0087	A=.168	$\Sigma\delta$=.0074
A.D. = $\frac{.0087}{115}$ = .0023		A.D. = $\frac{.0074}{115}$ = .0019	

Mean reading of test = .155

Lummer-Brodhun Photometer.
Standard White Comparison White
3/26-1903

James Ratio	dev	Jones Ratio	dev
.823	.006	.818	.011
.816	.013	.806	.023
.808	.021	.805	.024
.828	.001	.872	.043
.832	.003	.882	.053
		8.290	.198
		A = .829	ad = .0198
		A.D. = $\frac{.0198}{110}$ = .0065	

Mean Reading of test = .829

Summer Brodhun Photometer
Standard White Comparison White

4/3-1903

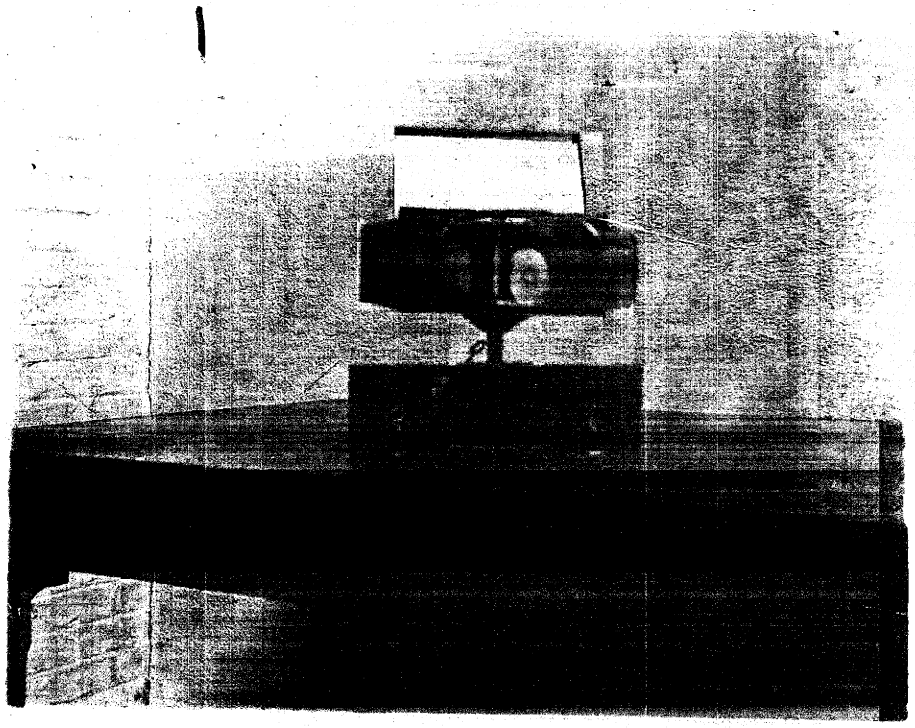
Jones		Pearson	
Ratio	Dev.	Ratio	Dev.
1.42	.01	1.43	.02
1.39	.02	1.41	.00
1.42	.01	1.42	.01
1.39	.02	1.39	.02
1.46	.05	1.39	.02
1.50	.07	1.41	.00
1.33	.08	1.41	.00
1.45	.04	1.41	.00
1.51	.10	1.42	.01
1.46	.05	1.42	.01

Continued next page

Sumner Gridhum Photometer.
Standard White Comparison White
4/3 - 1903

Jones		Pearson	
Ratio	Div.	Ratio	Div.
1.42	.01	1.41	.00
1.37	.04	1.42	.01
1.30	.11	1.39	.02
1.32	.09	1.39	.02
1.35	.06	1.43	.02
21.09	.78	21.15	.16
A = 1.406	a.d. = .052	A = 1.41	a.d. = .01
$A.D. = \frac{.052}{\sqrt{15}} = .0134$		$A.D. = \frac{.01}{\sqrt{15}} = .0026$	

Mean reading of test = 1.41



Finally we will present the data taken upon the simplest, the most widely used photometer – the Bunsen. It is of the grease spot type, and the principle of its action being so generally known, we will deal only with the results which our data and experience in working, also a photograph of the instrument actually used is shown on Plate 8 Fig No. — and a cross section is to be found on Plate 7. Notwithstanding the fact that the Bunsen photometer is particularly efficient for comparison of similarly colored lights, the data which we have taken upon differently colored lights show results that are at least interesting, when compared with other so called more efficient types.

Bunsen Photometer

Standard White Comparison, Ed.

3/23-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.58	.22	.82	.10
.95	.13	.93	.01
.85	.03	1.04	.12
.87	.05	.93	.01
.85	.02	.87	.05
4.10	.46	4.59	.29
A = .82	$\Sigma\delta = .092$	A = .92	$\Sigma\delta = .058$
$A.D. = \frac{.09}{5} = .040$		$A.D. = \frac{.058}{5} = .0259$	

Mean reading of test = .87

Bunsen Photometer

Standard - White Comparison - Test

3/30-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.80	.02	.812	.05
.77	.01	.823	.06
.75	.03	.770	.01
.79	.01	.727	.04
		.731	.03
		.720	.04
3.81	.07	4.583	.23
A = .78	aδ = 018	A = .764	aδ = 038
A.D = $\frac{018}{14}$ = 009		A.D = $\frac{038}{16}$ = 0155	

Mean reading of test = .77

Bunsen Photometer

Standard. White Comparison. Red.

3/31-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.41	.05	.52	.01
.51	.04	.54	.01
.42	.05	.55	.02
.52	.04	.52	.00
.51	.04	.51	.02
2.37	.23	2.65	.06
A = .47	$a\delta$ = .047	A = .53	$a\delta$ = .012
A.D = $\frac{.047}{15}$ = .021		A.D = $\frac{.012}{15}$ = .0043	

Mean reading of test = .50

Bunsen Photometer

Standard - White Comparison - Blue

3/23 - 1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.126	.008	.114	.021
.128	.006	.126	.009
.141	.007	.137	.002
.117	.017	.148	.013
.156	.022	.150	.015
.668	.060	.675	.060
A = .134	$\Sigma\delta$ = .012	A = .135	A = .012
A.D. = $\frac{.012}{15}$ = .0054		A.D. = $\frac{.012}{15}$ = .0054	

Mean reading of test = .135

Bunsen Photometer

Standard: White Comparison - Blue

9/28-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.124	.005	.140	.004
.130	.001	.131	.005
.133	004	.136	.000
.134	005	.138	.002
.128	.001	.136	000
.649	.016	.681	.011
A = .129	a.d. = 003	A = .136	a.d. = 002
$A.D. = \frac{003}{\sqrt{5}} = .0013$		$A.D. = \frac{002}{\sqrt{5}} = .00089$	

Mean reading J test = .133

Bunsen Photometer

Standard. White Comparison. Blue

3/31-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.220	.008	.186	.018
.215	.003	.199	.005
.213	.001	.202	.012
.208	.004	.216	.012
.203	.009	.216	.012
1.059	.025	1.019	.059
A = .212	a.d. = .005	A = .204	a.d. = .012
$A.D. = \frac{.005}{5} = .0022$		$A.D. = \frac{.012}{5} = .0054$	

Mean reading of test = .208

Bunsen Photometer

Standard White Comparison, Line

3/31-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.215	.009	.199	.008
.211	.005	.216	.009
.218	.012	.212	.005
.205	.001	.216	.009
.202	.004	.205	.002
.201	.005	.202	.005
.202	.004	.208	.001
.200	.006	.201	.006
.199	.007	.205	.002
.205	.001	.207	.000
2.060	.054	2.071	.047
A = .206	σ = .0054	A = .207	σ = .0047
A.D. = $\frac{.0054}{10}$ = .0017		A.D. = $\frac{.0047}{10}$ = .0015	

Mean reading of bar = .207

Bunsen Photometer

Standard- White Comparison- White

9/28-1903

Jones		Pearson	
Ratio	Dev.	Ratio	Dev.
1.30	.02	1.33	.01
1.23	.05	1.28	.04
1.26	.02	1.34	.02
1.30	.02	1.34	.02
1.31	.03	1.34	.02
6.40	.14	6.60	.11
A = 1.28	a.δ = .028	A = 1.32	a.δ = .022
A.D. = $\frac{.028}{5}$ = .0125		A.D. = $\frac{.022}{5}$ = .0098	

Mean reading of test = 1.30

Bunsen Photometer

Standard-White Comparison-White

Fatigue Test

3/23-1903

Jones Ratio	Dev.	Jones Ratio	Dev.
1.358	.00	1.378	.02
1.370	.01	1.413	.05
1.362	.00	1.330	.03
1.347	.01	1.342	.02
1.350	.01	1.378	.02
1.357	.00	1.358	.00
1.340	.02	1.352	.01
1.346	.01	1.358	.00
1.308	.05	1.438	08
1.382	.02	27.23	.37
1.368	.01	A = 1.36	a.δ. = 018
		A.D. = $\frac{018}{20}$ = .0041	

Mean reading J test = 1.36

Standard - White

Pearson Ratio	dev.
1.395	.00
1.302	.10
1.412	.01
1.410	.01
1.430	.03
1.372	.03
1.437	.04
1.347	.05
1.352	.05
1.400	.00
1.430	-03
1.320	.08
1.444	.04
1.387	.01
1.417	.02
1.410	.01
1.446	.05

Comparison - White

Pearson Ratio	dev.
1.340	.00
1.430	.10
1.480	.08
1.402	.00
1.344	.06
1.348	.05
1.379	.02
1.368	.03
1.378	.02
1.329	.07
1.439	.06
1.357	.04
1.476	.08
1458	.06
43.239	1.23
A = 1.395	a.d. = .040
A.D. = $\frac{040}{131}$ = .0072	

Mean reading of test = 1.395

Standard - White Comparison - White

3/26-03

Pearson Ratio	Pearson Dev.	Pearson Ratio	Pearson Dev.
.910	.049	1.003	.044
1.030	.071	.900	.059
.965	.034	.938	.021
.994	.006	1.005	.046
.955	.035	.980	.021
.928	.004	.964	.005
.952	.031	.926	.033
.938	.007	.941	.018
.960	.021	.978	.019
.979	.001	.983	.024
.971	.020	.949	.010
.941	.018	.935	.024
.941	.018	.987	.028
.994	.035	.950	.009
.978	.019	.982	.023
.910	.049	30.673	.803
.960	.001	A = .959	a.d. = .025
		$A.D = \frac{.025}{\sqrt{32}} = .0044$	

Mean reading of test = .959

Dunsen Photometer

Standard White Comparison White

3/28-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
1.30	.14	1.25	.08
1.09	.07	1.22	.05
1.13	.03	1.14	.03
1.15	.01	1.12	.05
1.12	.04	1.12	.05
5.79	.29	5.85	.26
A = 1.16	$\Sigma\delta$ = .058	A = 1.17	$\Sigma\delta$ = .052
A.D. = $\frac{.058}{.05}$ = .026		A.D. = $\frac{.052}{.15}$ = .023	

Mean reading of test = 1.165

Bunsen Photometer Stand White Comp. White

3/31-1903

Jones		Pearson	
Ratio	Dev.	Ratio	Dev.
.710	.01	.70	.10
.680	.02	.70	.00
.697	.00	.70	.00
.710	.01	.69	.01
.700	.00	.70	.00
.695	.00	.70	.00
.690	.01	.70	.00
.690	.01	.69	.01
.706	.01	.70	.00
.704	.00	.69	.01
690	.01	.69	.01
702	.00	.70	.00
698	.00	.71	.00
701	.00	.70	.01

Continued on next page

Bunsen Photometer.

Standard-White. Comparison-White.

3/31-1903

Jones		Pearson	
Ratio	dev.	Ratio	dev.
.702	.00	.71	.00
.705	.01	.71	.00
.700	.00	.70	.01
.703	.00		
.702	.00		
.710	.01		
.705	.01		
14.700	.11	11.89	.06
A = .700	$a\delta$ = .0052	A = .70	$a\delta$ = .0035
A.D. = $\frac{.0052}{\sqrt{21}}$ = .0011		A.D. = $\frac{.0035}{\sqrt{17}}$ = .00085	

Mean reading of test = .70

In order that we may now have data in a form from which our final conclusions may be more readily drawn, the following arrangement will be made. Under the head of "Red Light" will be tabulated the mean of the results obtained from each particular test, by comparing the red with the standard white, and by use of the Bureau Sticker, and Lummer Brodhun photometers respectively. The a.d's (small) and A.D.'s (large) will also be tabulated. A similar arrangement for blue light and for white light will then be made.

Red Light -

Duncan

Date	Ratio	Dev
March 23	.87	.16
March 28	.77	.06
March 31	.50	.21
	2.14	.43
	A = .71	ad = .14
A.D. = $\frac{.14}{13}$ = .0808		

Flicker

Date	Ratio	Dev.
March 28	.52	.06
March 31	.64	.06
	1.16	.12
	A = .58	ad = .06
A.D. = $\frac{.06}{12}$ = .0883		

- Red Light -

Summer. Bodhum

Date	Ratio	Dev
March 26	.371	.12
April 3	62	13
	.991	.25
	A = .49	a.d. = 125
A.D. = $\frac{125}{12}$ = .0883		

Blue Light

Burner

Date	Ratio	Dev
March 23	.135	.001
March 28	.133	.001
	.268	.002
	A = .134	$\Sigma\delta$ = .001
A. D. = $\frac{.001}{12}$ = .0007		

Flicker

Date	Ratio	Dev.
March 28	.135	.005
March 31	.145	.005
	.280	.010
	A = .140	$\Sigma\delta$ = .005
A. D. = $\frac{.005}{12}$ = .0035		

Blue Light

Summer - Buchanan

Date	Ratio	Dev.
March 26	.265	.045
April 3	.155	.045
	.420	.090
	A = .210	a.d. = .045
A.D. = $\frac{.045}{12}$ = .0035		

Special Test with new Stand.

Duncan

Date	Ratio	Dev.
March 31	.208	.000
March 31	.207	.001
	.415	.001
	A = .208	a.d. = .001
A.D. = $\frac{.001}{12}$ = .0007		

- White Light -

Bunsen

Date	Ratio	Dev.
March 23	1.30	.10
March 23	1.38	.18
March 26	1.17	.03
March 31	.96	.24
	4.81	.55
	A = 1.20	ad. = .138
A.D. = $\frac{.138}{14}$ = .069		

Flicker

Date	Ratio	Dev.
March 24	1.30	.24
March 28.	1.13	.07
March 31	.75	.31
	3.18	.62
	A = 1.06	ad. = .21
A.D. = $\frac{.21}{13}$ = .038		

White Light

Summer Brodhun

Date	A	a.δ.
March 26	.829 A.D=.0065	.020

Special Test- Two Stars

Summer Brodhun

Date	A	a.δ.
April 3	1.41 A.D. = 0.0	0.0

Throughout this whole con-
cluding discussion, whenever we
speak of a red, blue or white light
it must be borne in mind that
the incandescent light with the
white bulb, and maintained
at its regulation voltage - 110 -
in these tests - is the standard.
In the summary four things will
be discussed, namely:-
(I) To what kind of work is
each type of photometer especially
adapted?
(II) Taking in succession a com-
parison light in which the red, blue,
and white are respectively pre-
dominant, what type of photom-
eter shall we use?
(III) What type of photometer is best
for general use.

(II) What type of photometer is especially adapted to arc light work.

(I) Taking the A.D.s as the basis for comparison, a study of the (comspa) data shows the Flicker photometer best adapted for work on blue light. Further, in contradiction of the of the general belief, it is almost as well adapted for comparison of lights of a similar color. For work on red light, it should, according to the results of these tests, be thrown out altogether.

A study of the tests on the Summer-Brodhun show it to be best adapted to comparison of lights of a similar color, and

most best adapted for work on the blue. For red light work it should not be considered, being even worse than the Flicker

The Bunsen photometer is by far best adapted for work where the blue is predominant, and most best adapted for similarly colored lights. In work on the blue, the tests show it to be almost as efficient as (the) for that on the red.

(II) A comparison of the A.D's readily shows the Flicker photometer to be particularly fitted for work where red is predominant in the comparison light, the A.D. being only

about one half that for the Bunsen and Lummer Brodhun. For work on lights of a similar color there is not the least question but what the Lummer-Brodhun is the best. Noting during our work how efficient this photometer was for white light work, getting an A.D. of only .0065, we made a test using a new standard light and obtained an A.D. of .0!

For blue light the Bunsen gave an A.D. of .0007, both observers getting the same value. A check test was made using a new standard and A.D's of values .0015 and .0017 were ob-

tained. A comparison of these results with those on the Flicker and Lummer Brodhun, shows those latter types out entirely, though of the two, one is almost as efficient as the other.

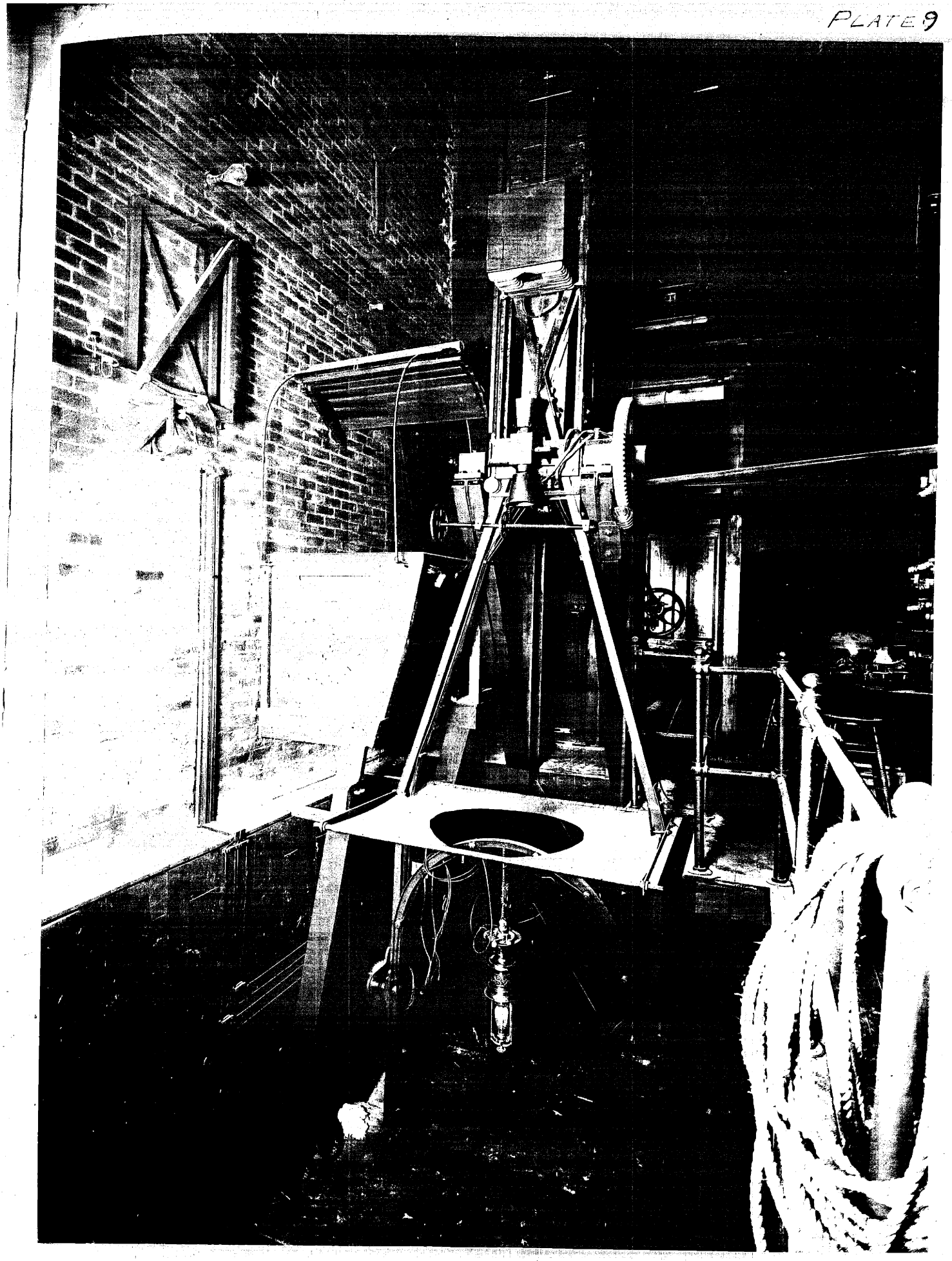
(III) Which photometer is best adapted to general use? For each photometer, a tabulation of the (two) A.D.'s is shown below, and taking the smallest average as representing the preferable photometer, the Flicker is the best.

Bunsen	L. B.	Flicker
.069	.0083	.042
.0808	.037	.0035
.0007	.0065	.038
.1505	.1318	.0835
A=.0502	A=.0439	A=.0028

(II) Which photometer is best adapted for work on the arc light? To settle this question has been the primary object for which this whole preliminary portion of the inves has been carried out, and we can conscientiously state that the Bunsen is the best. Knowing at the start the main characteristic of the arc light to be its predominant blue, the tests on that color were specially extended. A review of the data on blue light and the conclusions we have drawn there from under heads (I) and (II), a consideration of its simplicity and ease of manipulation, the readiness and small

amount of fatigue with which
it can be read, - all these
would demand the most
biased and prejudiced person
to decide in its favor.

— PART II —



The object of this part of the investigation has been to conduct a series of photometric tests upon direct current enclosed arc lamps, using coated and uncoated carbons, and to make a comparison study of the information derived therefrom.

These tests were conducted in the new arc light photometric room of the Massachusetts Institute of Technology. A view of the room and apparatus is shown on Plate 9. This photograph was taken by Mr. R. R. Lawrence, and kindly loaned to me by him. This form of apparatus is unique in its design, and furnishes ideal advantages, not only from a illu-

tific but commercial stand-
point, and we therefore take
both pride and pleasure in
presenting this the first inves-
tigation that has been carried
out with it.

In reference to the cut shows
the following mechanical arrange-
ments. The frame work is a
steel girder pivoted at its center
of gravity. The arc lamp is
suspended from an arch pivot-
ed between the arms of the
girder. This arch is so coun-
ter-weighted by means of a
changable system of weights, that
it is always maintained by
gravity in a perpendicular
position. The distance from
the photometer screen to the

plane of the arch is a constant of 10', the photometer readings being taken by changing the position of the standard. To accomplish this, the metal box containing the standard is mounted in guides and can be moved backwards or forwards by means of a chain and sprockets driven by a hand wheel. A steel tape is directly attached at one end to the carriage, the other end being wound around a drum pivoted through its cylindrical axis. A spiral spring always tends to wind the tape around the drum. This tape is so calibrated that the reading coincident with a white line in the plane of the

screen, gives the ratio of the candle powers directly. By means of a worm and gear, the girder can be turned through 180°. A pointer attached to the frame, and figures marked on the gear, indicate the degrees the girder has been turned from its original position of -90°. By these arrangments we are enabled to determine the illuminating power of the arc at any angle from -90° to +90°. The type of photometer used is that which we have already determined as most efficient for arc light work - the Bunsen. The apparatus and equipment is so designed as to prevent too brillant illumination of the photometer screen,

for with a weak light the eye is more sensitive to changes in illumination. The same precautions against errors due to absorption and external reflection etc., were taken as in the incandescent light room previously described. The readings were taken from a bridge overlooking the pit, the eyes of the observer being screened from the illuminating source by means of a canopy.

As a standard the 110 v direct current incandescent lamp is used. In the containing box is a revolving disc carrying three lamp sockets, any one of which can be brought directly opposite the circular opening

from which the light is emitted. The feed wires are carried to a plug-jack immediately over the recording table. This jack is numbered corresponding to the sockets and allows any light to be readily thrown into circuit. The illuminating source is the same motor generator described in Part I.

Means are provided for calibrating the (standard) lights to be used as standards against a light that has previously been standardized in terms of the amyl acetate flame. The incandescent lamp is placed upon a bracket which can be swung away from the wall and placed across the girder. By proper dis-

BLANK PG.

tances, indicated by marks on the girder and bracket the bulb can be brought directly opposite the screen. The standard and unit light to be standardized are maintained at the same voltage by means of carbon rheostats; the feed wires being so connected to the switch-board that a voltmeter can be readily thrown into each lamp circuit. Having obtained the mean of a series of photometer readings we can find the candle power by the equation $S_x = \frac{S \times 100}{R \times D^2}$ where

S = C. P. of the standard

R = photometer reading

D = distance in ft. of S from screen

In this manner we calibrated a set of six 110° lamps,

of commercial ratings 5-10-16-32-50 and 50 candle power the data and computations thereof being given on pages 96-98 In conducting these tests, great attention was paid to keeping each lamp always in the position in which it was calibrated and at the constant potential of 110°. It was noted that a variation of 1° was readily detectable by the photometer. In maintaining this voltage the armature windings of the generator were thrown in parallel, and final adjustment made by the carbon rheostat.

With the exception of in one case 110° arc lamps were used. Each lamp was adjusted

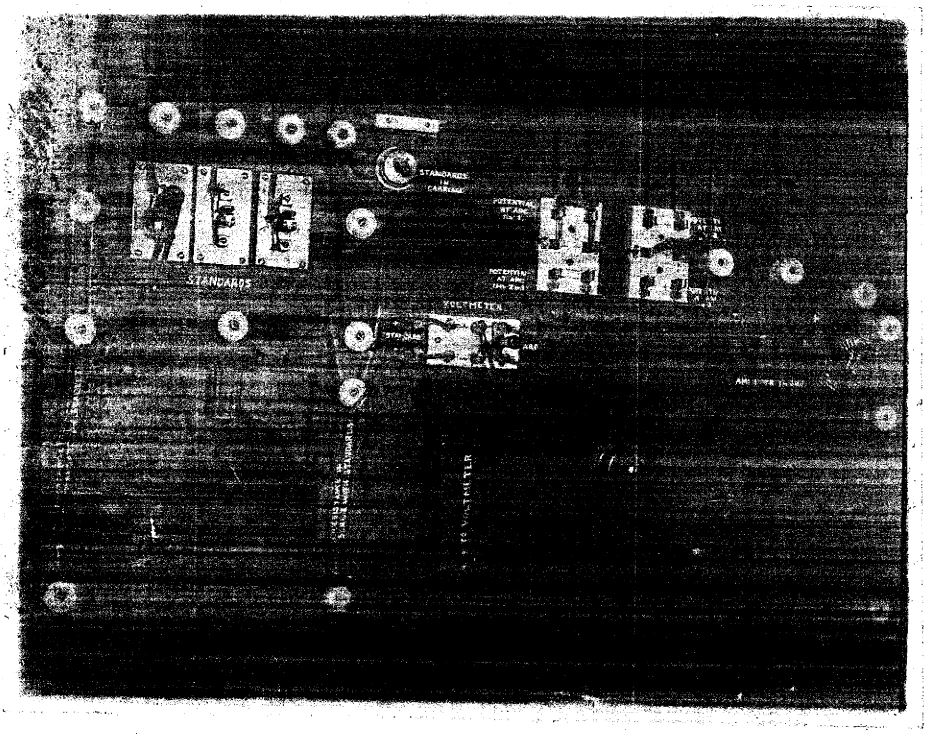
as to form of inclosing globe, size and position of carbons as according to standard regulations for that lamp.

In placing inclosed arc lamps upon a basis for comparison, it has seemed to us that the lamp should be stripped of all auxiliary reflecting devices - outer globes, shades etc. - and only a transparent inclosing globe be used. In this way we do away with supplementary reflection dispersion absorption, etc, and put each lamp on one fair, common basis. Inasmuch, therefore, as the Jaques lamp was used with an outer globe, the data thereon should

not be used in any comparison estimates. We might indeed note in passing that this form of lamp is almost entirely gone out of use, and it was used more especially to obtain practice.

Aside from a photometric point of view but as a matter of interest and importance in any arc light test, a series of twenty (20) readings at ten second intervals were taken of the current and potential on the mains, and the watts calculated. As a means of afterwards determining the efficiency of the lamp a similar series of readings on the potentials at the arc was taken,

PLATE 10



and the watts consumed at the arc are calculated. Plate 10 shows the manner in which the switch-board is wired and designed to give means of obtaining the various voltmeter and ammeter readings. By plotting the volts at the arc, the volts on the mains, the current and watts consumed at the arc, there is presented through the eye an idea as to variations, not only in the regulation of the lamp itself but in the entire electrical circuit.

Two tests were made on each lamp under the same conditions, with the exception that for cored carbons were substituted (for the) uncored carbons. Various notes were taken as to

the behaviour of the arc under these conditions, the appearance of the enclosing shade after the run etc. but we will retain from any discussions, comparisons, or conclusions, until we have presented the data upon the various lamps.

With the exception of three cases, where the object was to obtain only the mean lower hemispherical candle power, a series of ten readings was taken at 10° intervals for 180°; the mean of the ten readings being taken as the best representative value of the reading of the photometer at that angle. Multiplying the candle power of the standard used by this ratio, gives

the corresponding candle power
& the arc Readings for 90° were
taken by the observers in alter-
nation, in order that the eyes
& the observer might be kept
in the best condition for
reading the screen.

Accompanying each test
will be found the Rousseau
diagram, from which the mean
spherical and mean lower hemi-
spherical candle power has been
determined. A glance at the
diagrams will show how these
determinations are made. On the
radius corresponding to the an-
gles (that have been laid off) at which
the candle powers have been
determined, that candle power
is laid off to the scale of

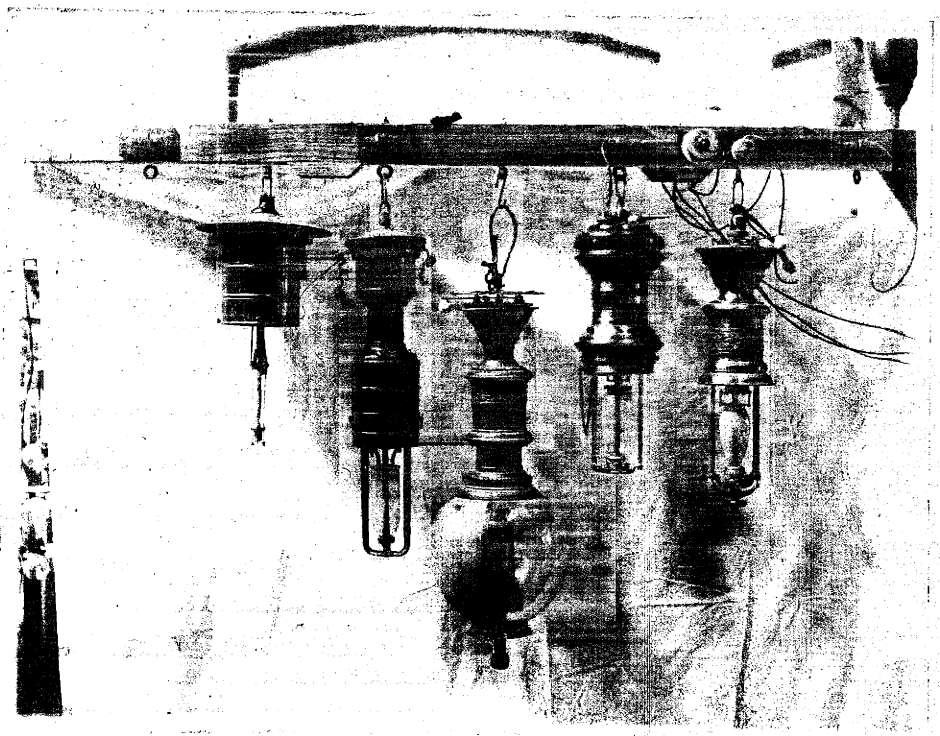
200 c.p. = 1". Elevate the length of radius corresponding to the maximum candle power by R. With R as a radius, draw a circle from the center corresponding to the center of the arc. Extend the radii to intersect this circle and draw a tangent parallel to the axis of reference. Upon this project the intersections of the radii with the circumference, and draw ordinates. Upon these ordinates lay off the corresponding intensities of illumination and draw a smooth curve through the points. The enclosed area divided by 2R gives the mean spherical intensity. In cases where we were unable to get readings

for the whole 180°, are divided by the length at which we could get readings. — Of course less than 2 R. As an Example of this see Plate . The same process, (though) only dividing by R, gives the mean lower Semi-spherical candle power. The efficiency in watts per candle power is determined by dividing the watts consumed observed at the arc by the the mean spherical or mean lower hemispherical candle power.

Previous now to any discussion, we will present the data in the order in which it was taken. The name of the lamp, its standard requirements for its regulation, etc., will precede each set of data. The data will be

arranged in two sets of tables, the first set giving the watt tests and the second the standard used, the angles, the ratios and their mean, and the candle power as determined. Following this will be found a plats of the current (I), E (arc), E (mains, and W (arc), and lastly will be found the Rousseau diagram. Upon this diagram will be given the compilation and tabulation of the mean spherical and mean lower hemispherical candle power, and also the mean spherical, or mean lower hemispherical efficiency, or both.

The photograph on Plate II shows all but one of the lamps



1 2 3 4 5

tested, the lamp not shown in the picture being a Jewel Electric Co. similar to number 4, but an older type.

No 1 .... Upton "Budget" 110"

No 2 .... "Helios," 220"

No 3 .... Jacques, 110"

No 4 .... Jewel Electric Co 110"

No 5 ... Jandus 110"

110 Volts

C. p. Stand. on Bracket = 17.3

Rated C.p. = 5	Rated C.p. = 10
Distance of Stand. on Bracket = 6′	Distance of Stand on Bracket = 6′
18.2	5.00
18.1	5.00
17.9	5.02
18.2	4.96
17.5	5.01
18.4	5.07
17.8	4.97
18.6	5.08
19.1	5.07
18.9	5.07
182.7	50.25
A = 18.27	A = 5.03

True c.p. $= \frac{17.3 \times 100}{18.27 \times 36} = 2.6$

True c.p. $= \frac{17.3 \times 100}{5.03 \times 36} = 9.55$

110 Volts

C.p. Standard on Bracket = 17.3

Rated c.p. = 16	Rated c.p. = 50 NEW
Distance of Stand. on Bracket = 6'	Distance of Stand on Bracket = 3'
3.04	2.98
3.05	3.06
3.08	3.04
3.00	3.09
3.00	3.10
3.10	3.13
3.30	3.10
3.01	3.03
3.23	2.94
3.13	3.05
30.94	30.52
A = 3.09	A = 3.05

True c.p. $= \frac{17.3 \times 100}{3.09 \times 36} = 15.55$ True c.p. $= \frac{17.3 \times 100}{3.05 \times 9} = 63.0$ NEW.

110 Volts
C. P. Stand. on Bracket = 17.3

Rated C.P = 32	Rated C.P = 50
Distance of Standard on Bracket = 4'	Distance of Standard on Bracket = 3'
4.20	3.85
4.14	3.78
4.25	3.79
4.14	3.75
4.19	3.70
4.13	3.70
4.21	3.75
4.22	3.75
4.31	3.76
4.07	3.78
41.86	37.61
A = 4.19	A = 3.76

True c.p = $\frac{17.3 \times 100}{4.19 \times 16} = 25.8$

True c.p = $\frac{17.3 \times 100}{3.76 \times 9} = 51.13$

E (arc)	E (mains)	I (mains)	W (mains)	W (arc)
69.0	110.5	5.90	652	407
73.5	110.5	5.80	641	426
72.0	110.5	5.10	575	367
71.0	110.5	5.30	576	376
70.0	110.5	5.90	652	413
71.0	110.5	5.20	575	369
73.0	110.5	5.95	658	434
72.0	110.5	5.25	580	377
69.0	110.5	5.70	631	394
70.0	110.5	5.45	603	381
71.0	110.5	5.20	575	362
70.0	110.5	5.30	576	371
72.0	110.5	5.20	575	374
71.0	110.5	5.90	652	419
69.0	110.5	5.70	631	393
72.0	110.5	5.20	575	374
70.0	110.5	5.20	575	364
71.0	110.5	5.25	580	372
71.0	110.5	5.90	652	419
70.0	110.5	5.20	575	364

Angle = −90°	Angle = −80°	Angle = −70°
Stand = 2.6	Stand = 2.6	Stand = 2.6
3.14	3.19	5.15
3.09	3.12	5.13
3.06	3.26	5.32
3.06	3.24	4.88
3.02	3.27	4.91
2.95	3.25	5.10
2.93	3.19	5.02
2.94	3.18	4.93
2.92	3.30	5.21
292	3.16	5.02
30.03	32.10	50.11
A = 3.00	A = 3.21	A = 5.01
c.p. = 3 × 2.6 = 7.8	c.p. = 3.2 × 2.6 = 8.35	c.p. = 5.01 × 2.6 = 13.0

Angle = -60	Angle = -50	Angle = -40
Stand. = 2.6	Stand = 2.6	Stand. = 9.6
7.50	10.10	6.87
7.40	8.74	6.55
7.95	8.72	6.70
7.50	9.00	6.60
6.60	8.70	6.60
7.00	9.20	6.40
7.20	9.10	6.40
6.60	9.70	6.90
7.60	9.75	6.12
7.60	9.87	6.41
73.04	92.88	65.55
A = 7.30	A = 9.28	A = 6.56
c/p. = 7.3 x 2.6 = 19.0	c/p. = 9.28 x 2.6 = 24.1	c/p. = 6.56 x 9.6 = 63.0

Angle = -30	Angle = -20	Angle = -10
Stand = 9.6	Stand = 9.6	Stand = 9.6
7.64	6.22	10.60
6.90	5.97	9.35
7.42	6.41	9.60
7.84	7.32	10.05
8.13	6.90	10.40
7.90	7.48	9.28
7.23	6.93	8.52
7.83	7.40	8.87
8.31	7.60	8.50
7.18	7.77	8.81
76.28	70.01	92.70
N = 7.63	A = 7.00	A = 9.27
c.p. = 7.63 × 9.6 = 73.2	c.p. = 7 × 9.6 = 67.1	c.p. = 9.27 × 9.6 = 89.0

Angle = 0	Angle = +10	Angle = +20
Stand. = 9.6	Stand = 9.6	Stand. = 15.6
9.34	19.0	10.2
9.57	18.3	10.6
10.30	18.1	10.9
9.81	19.3	12.4
8.57	18.1	11.6
10.56	17.3	11.7
9.74	18.0	10.2
9.72	17.3	10.7
9.00	18.3	10.2
9.65	18.0	10.7
97.27	181.7	109.2
A = 9.73	A = 18.2	A = 10.9
c.p. = 9.73 × 9.6 = 93.4	c.p. = 18.2 × 9.6 = 1749	c.p. = 10.9 × 15.6 = 170

Angle = +30	Angle = +40	Angle = +50
Stand. = 15.6	Stand. = 51.1	Stand = 51.1
11.40	9.8	15.0
11.70	10.1	16.0
10.60	10.5	14.5
13.00	10.5	13.7
14.10	9.8	12.9
12.10	9.8	12.9
11.80	11.2	12.2
12.60	11.9	13.6
12.70	12.2	13.2
12.70	9.7	11.0
120.00	106.6	135.0
A = 12.0	A = 10.7	A = 13.5
c.p. = 12.0 x 15.6 = 187	c.p. = 10.7 x 51.1 = 547	c.p. = 13.5 x 51.1 = 691

Angle = +60	Angle = +70	Angle = +80
Stand. = 15.6	Stand. = 2.6	Stand = 2.6
15.1	16.8	15.3
15.4	15.8	15.0
13.1	15.0	15.2
12.5	15.3	14.6
14.7	15.6	14.1
13.8	16.3	14.35
15.9	16.8	14.0
13.9	16.3	14.4
14.6	14.9	14.6
15.1	16.0	14.1
144.1	158.0	145.6
A = 14.4	A = 15.9	A = 14.6
c.p. = 14.4 x 15.6 = 224	c.p = 15.9 x 2.6 = 41.4	c.p. = 14.6 x 2.6 = 37.9

Angle = +90
Stand = 2.6
15.0
17.3
16.8
17.2
16.5
17.3
17.3
17.7
17.4
16.6
169.1
A = 16.9
c.f. = 16.9 x 2.6 = 43.9

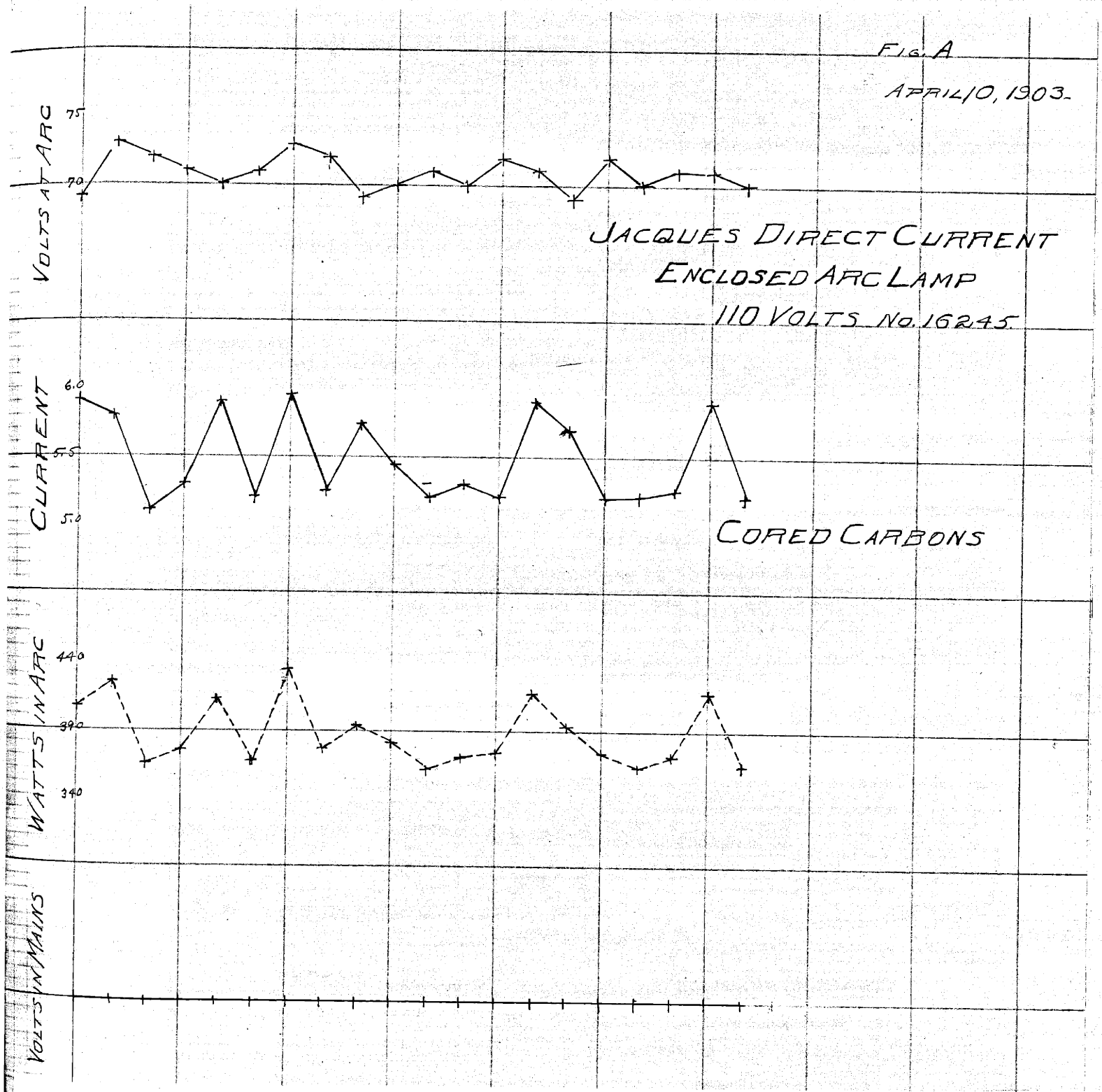


FIG. A
APRIL 10, 1903.
VOLTS AT ARC
75
70
JACQUES DIRECT CURRENT
ENCLOSED ARC LAMP
110 VOLTS No. 16245
CURRENT
6.0
5.5
5.0
CORED CARBONS
WATTS IN ARC
440
390
340
VOLTS IN MAINS

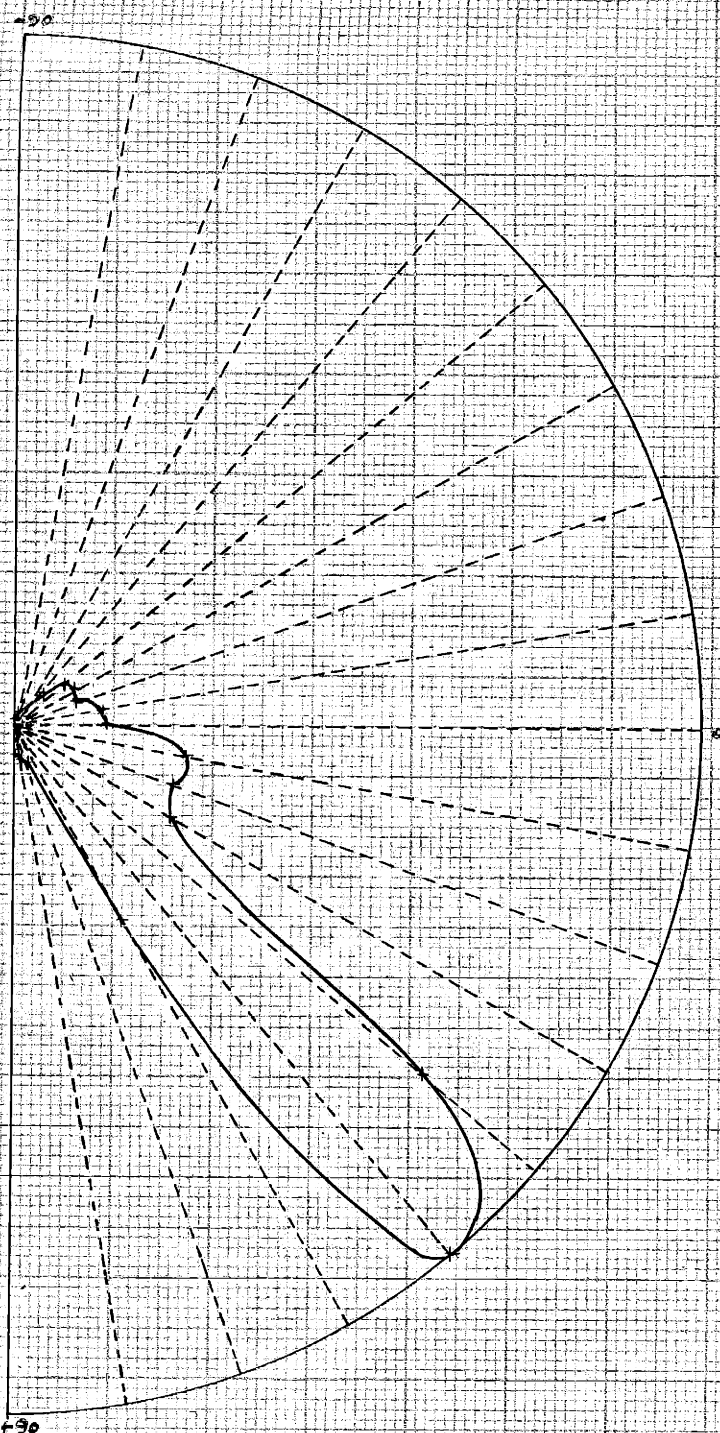
FIG. 8

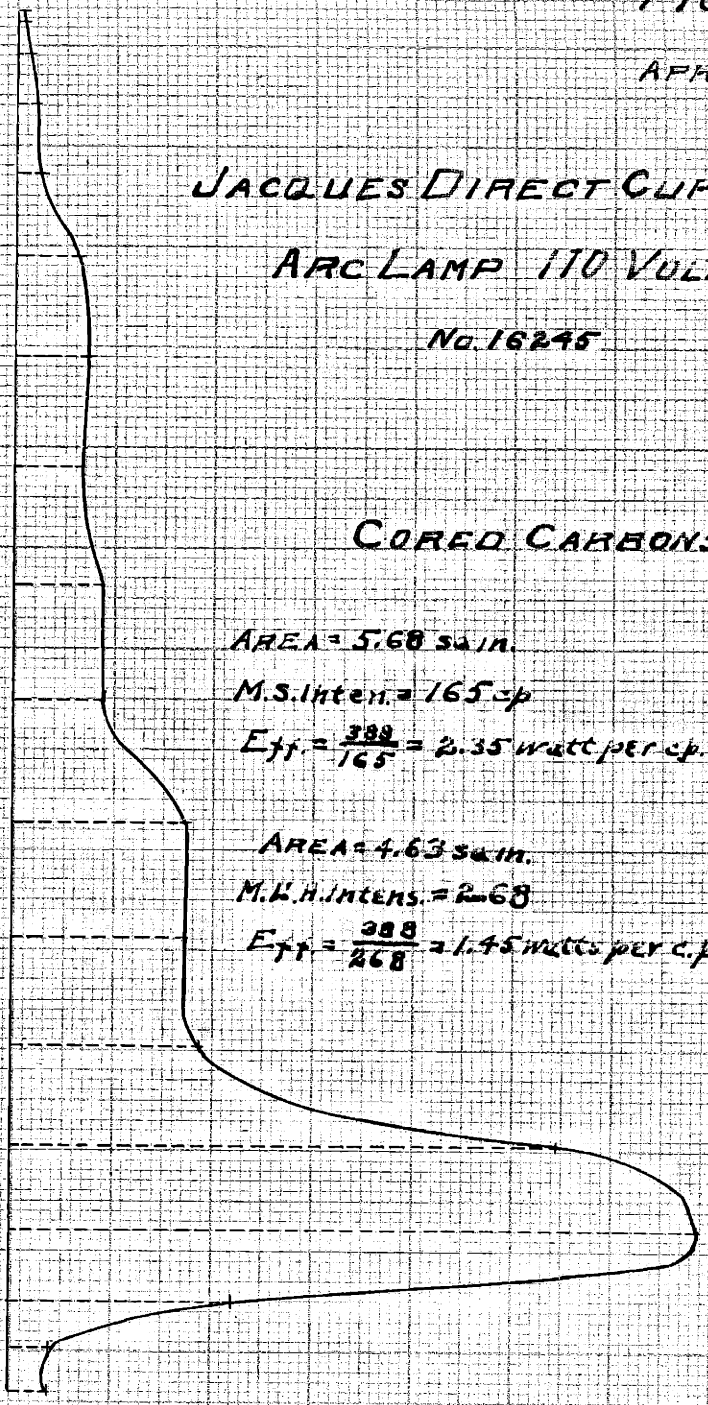
APRIL , 1903

JACQUES DIRECT CURRENT ARC LAMP 110 VOLTS

No. 16245

COREO CARBONS





AREA = 5.68 sq in.

M.S. Inten. = 165 c.p.

$E_{ff} = \frac{388}{165} = 2.35$ watt per c.p.

AREA = 4.63 sq in.

M.H.S. Intens. = 268

$E_{ff} = \frac{388}{268} = 1.45$ watts per c.p.

PUBLISHED BY A. D. MACLACHLAN, BOSTON.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

Test on

Jacques Arc Lamp no K245.

110° D.C

Conditions same as previous test except uncored carbons were used.

E (arc)	E (mains)	I	W (mains)	W (arc)
70	110.5	5.5	608	385
72	110.3	6.1	674	439
71	110.3	6.0	663	426
70	110.2	6.5	718	455
70	110.4	6.2	680	434
73	110.1	5.8	639	423
70	110.1	6.7	739	469
69	110.0	6.1	671	421
70	110.2	6.4	696	448
71	110.5	5.7	630	405
70	110.0	5.9	649	413
72	110.2	5.6	619	403
69	110.4	6.2	680	435
70	110.3	5.6	619	392
70	110.2	6.1	674	427
71	110.0	5.2	572	369
70	110.5	5.7	630	399
71	110 8	5.9	652	419
70	110 2	6.4	706	448
70	110.5	6.1	674	428

Angle = -90	Angle = +80	Angle = -70
Stand = 2.6	Stand = 2.6	Stand = 2.6
2.97	3.42	4.02
2.81	3.61	4.40
2.75	3.72	3.68
2.78	3.46	3.68
2.72	3.93	4.10
3.02	3.48	4.56
3.37	4.01	3.92
3.43	2.95	4.28
3.25	2.97	4.35
3.00	3.75	4.75
30.10	35.30	41.82
A = 3.0	A = 3.5	A = 4.18
c.p. = 3.0 x 2.6 = 6.8	c.p. = 3.5 x 2.6 = 9.18	c.p. = 4.18 x 2.6 = 10.9

Angle = - 6.0	Angle = - 5.0	Angle = - 4.0
Stand. = 2.6	Stand. = 2.6	Stand. = 2.6
5.37	5.37	8.90
5.43	5.43	10.80
5.22	5.22	8.25
5.70	5.70	8.85
4.52	4.52	8.20
4.90	4.90	8.25
5.60	5.60	8.85
5.02	5.02	9.05
5.67	5.67	8.35
4.80	4.80	8.30
52.23	52.23	87.80
A = 5.22	N = 5.22	A = 8.78
c/p. = 5.2 x 2.6 = 13.6	c/p. = 5.2 x 2.6 = 13.6	c/p. = 8.78 x 2.6 = 22.8

Angle = -30	Angle = -20	Angle = -10
Stand. = 15.6	Stand. = 15.6	Stand. = 15.6
8.7	5.95	6.00
9.8	4.18	5.85
9.05	4.30	6.05
7.9	5.00	6.50
7.8	5.28	6.95
8.75	5.13	7.53
7.10	5.29	7.35
6.95	5.12	9.00
	5.38	7.30
	5.55	7.85
66.05	51.18	70.40
A = 8.26	A = 5.12	A = 7.04
c.p. = 8.26 x 15.6 = 129	c.p. = 5.12 x 15.6 = 79.9	c.p. = 7.04 x 15.6 = 109.5

Angle = 0	Angle = +10°	Angle = +20
Stand. = 15.6	Stand = 15.6	Stand. = 15.6
9.1	9.47	17.50
10.1	9.40	16.70
8.2	8.93	16.50
7.0	9.76	14.90
7.5	9.78	14.60
8.85	9.81	15.12
8.40	14.00	13.35
8.35	16.30	15.20
8.70	15.00	14.15
8.35	15.30	16.20
84.55	118.35	169.55
A = 8.46	A = 11.8	A = 16.96
c.f. = 8.46 x 15.6 = 132	c.f. = 11.8 x 15.6 = 184	c.f. = 16.96 x 15.6 = 265

Angle = +30	Angle = +40	Angle = +50
Stand = 15.6	Stand. = 25.8	Stand = 25.8
16.30	14.10	11.72
17.40	14.45	11.70
17.50	15.60	11.38
18.90	13.90	15.55
18.40	15.90	16.70
15.82	14.55	12.23
16.00	12.85	11.50
15.80	15.45	16.90
16.90	15.55	17.50
16.40	15.63	17.20
168.4	147.98	142.38
A = 16.84	A = 14.8	A = 14.2
C.p. = 16.84 x 15.6 = 262	C.p. = 14.8 x 25.8 = 382	C.p. = 14.2 x 25.8 = 366

Angle = +60	Angle = +70	Angle = +80
Stand = 25.8	Stand = 15.6	Stand = 15.6
14.90	3.91	3.48
14.54	5.50	3.20
12.62	6.70	3.04
16.50	4.70	3.17
13.90	2.71	3.35
12.65	3.68	2.93
13.12	4.65	3.87
4.39	7.42	3.99
12.65	4.04	4.28
16.40	4.37	3.97
98.23	47.63	35.18
A = 14.03	A = 4.76	A = 3.52
c.p. = 14 x 25.8 = 362	c.p. = 4.76 x 15.6 = 746	c.p. = 3.52 x 15.6 = 549

Angle = +90
Stand. = 15.6
7.20
5.01
5.13
5.32
5.18
4.90
4.18
4.41
5.12
6.10
52.55
A = 526
c/b. = 526 x 15.6 = 8221

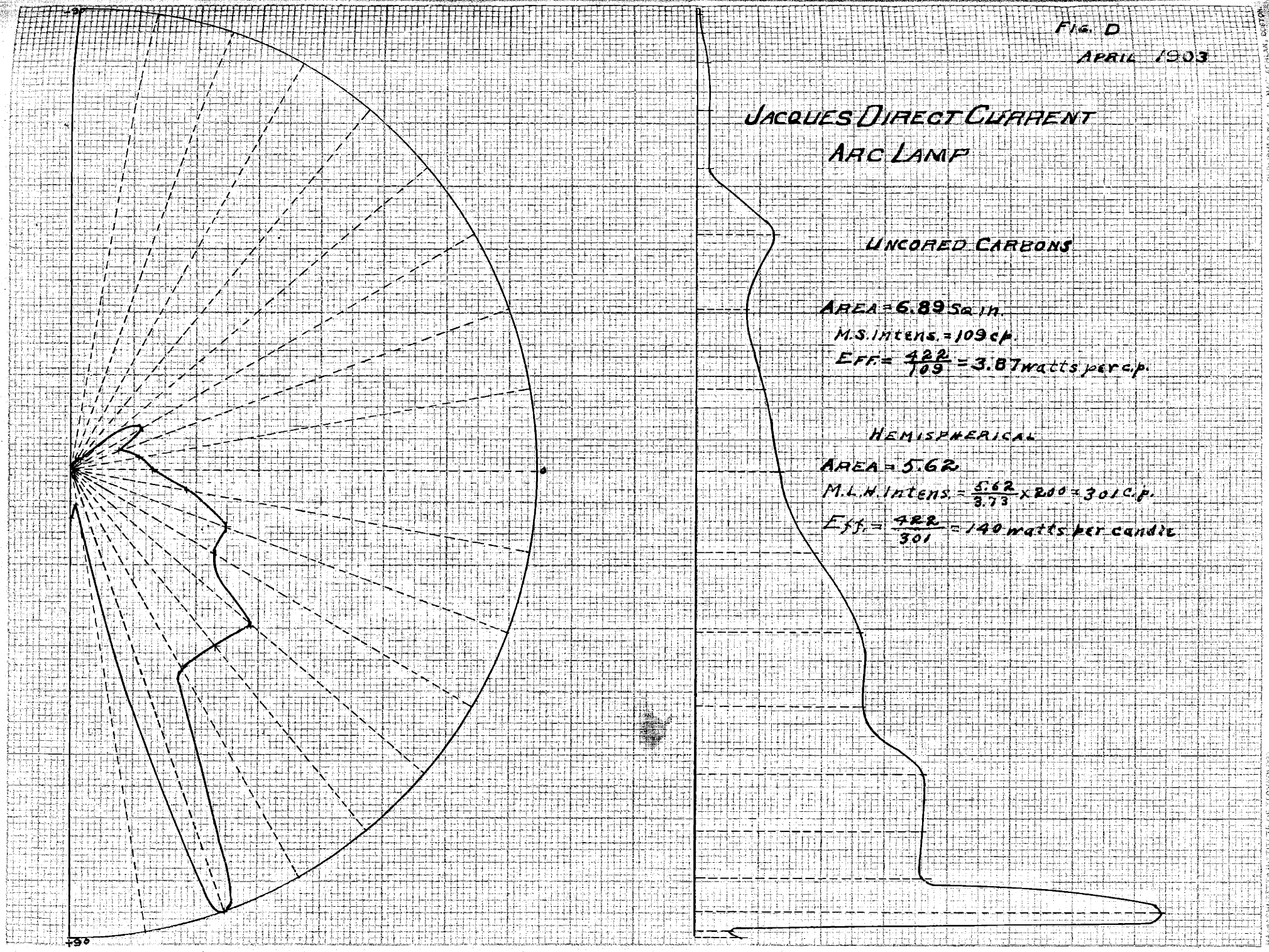


FIG. D
APRIL 1903
JACQUES DIRECT CURRENT
ARC LAMP
UNCORED CARBONS
AREA = 6.89 SQ IN.
M.S. Intens. = 109 c.p.
EFF. = 422/109 = 3.87 watts per c.p.
HEMISPHERICAL
AREA = 5.62
M.L.H. Intens. = 5.62/3.73 x 200 = 301 c.p.
Eff. = 422/301 = 140 watts per candle
+90
0
+90

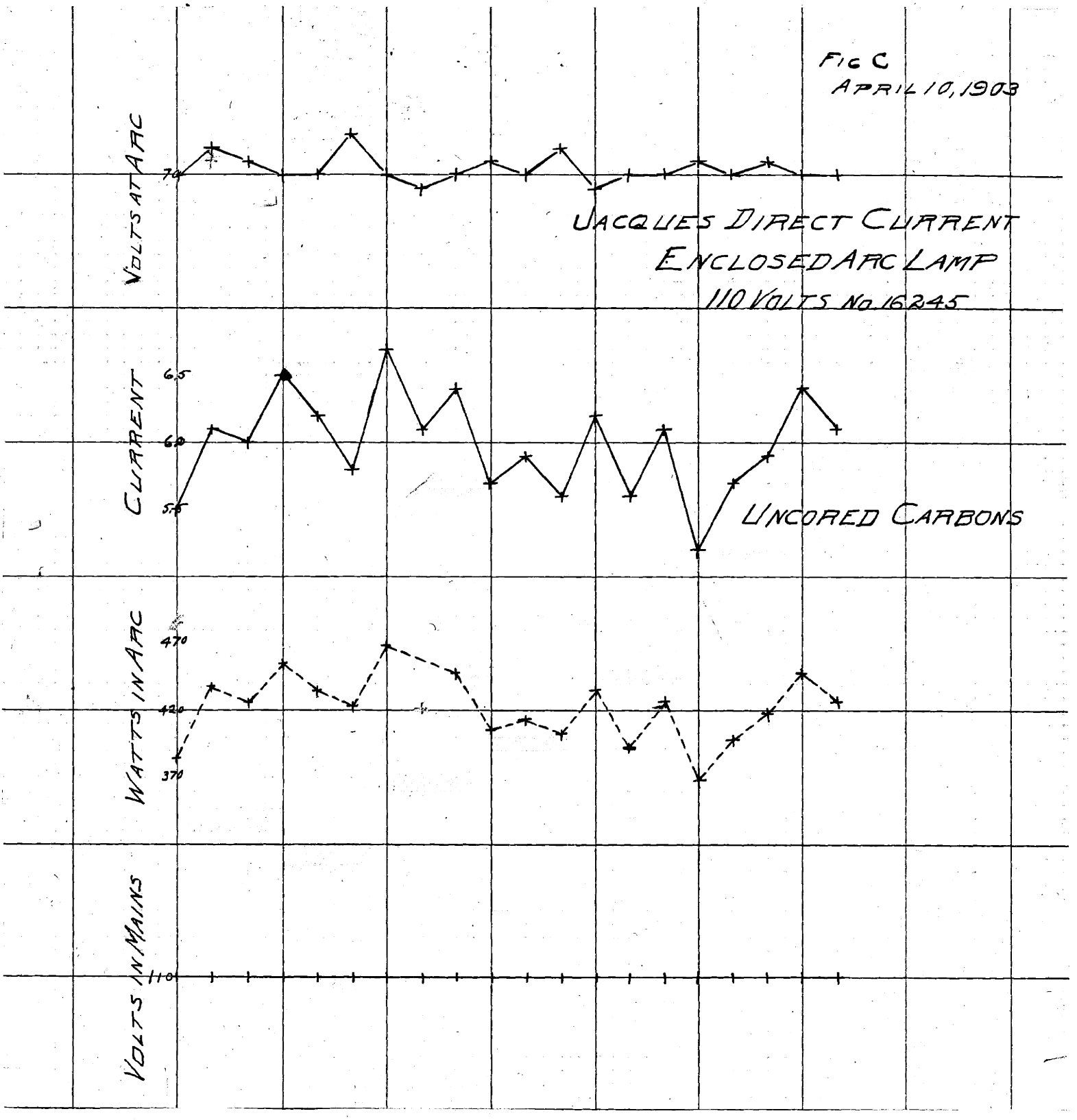


Fig C
April 10, 1903
Jacques Direct Current
Enclosed Arc Lamp
110 Volts No. 16245
Volts at Arc
70
Current
6.5
6.0
5.5
Uncored Carbons
Watts in Arc
470
420
370
Volts in Mains
110

Test on
Gandusee Arc Lamp.
110° D.C.
– Cored Carbons.

This lamp was directly tested as it had been used in practice, but stripped of its reflector. Enclosing globe $1\frac{1}{8}'' \times 1\frac{7}{8}'' \times 6\frac{1}{2}''$ lamp manufactured by Gandusee Electric Co., Cleaveland, Ohio

I	E(mains)	E(arc)	W(mains)	W(arc)
5.3	110.5	72.5	586	384
5.28	111.0	72.0	586	380
5.28	111.0	72.0	586	380
5.27	111.0	72.0	585	380
5.26	111.0	71.0	584	374
5.27	111.5	73.0	588	385
5.28	111.0	72.0	586	380
5.31	111.0	72.0	590	382
5.30	111.5	71.0	591	376
5.28	111.0	69.0	586	364
5.29	111.5	70.0	590	370
5.24	111.5	70.0	585	367
5.26	111.5	70.0	587	368
5.30	111.5	70.0	591	371
5.34	111.5	70.0	595	374
5.31	111.5	69.5	592	369
5.32	111.5	70.0	594	372
5.32	111.5	70.0	594	372
5.29	111.5	70.0	590	370
5.32	111.5	70.0	594	372

Angle = -90	Angle = -80	Angle = -70
Stand. = 2.6	Stand. = 2.6	Stand. = 2.6
2.33	2.31	2.52
2.32	2.34	2.52
2.32	2.34	2.40
2.37	2.37	2.36
2.31	2.41	2.47
2.29	2.32	2.56
2.32	2.41	2.55
2.20	2.37	2.48
2.24	2.30	2.52
2.26	2.32	2.53
22.96	23.79	24.91
A = 2.30	A = 2.35	A = 2.49
c/b. = 2.30 x 2.6 = 5.98	c/b. = 2.35 x 2.6 = 6.11	c/b. = 2.49 x 2.6 = 6.48

Angle = -60	Angle = -50	Angle = -40
Stand. = 2.6	Stand. = 2.6	Stand. = 2.6
3.57	10.02	11.12
3.57	10.43	13.42
3.16	9.43	12.67
3.06	9.19	12.00
3.74	10.43	11.57
4.66	9.70	11.26
7.43	10.02	10.80
7.34	10.15	11.70
3.61	10.02	10.70
4.69	10.12	10.82
44.84	99.51	11.794
A = 4.48	A = 9.95	A = 11.79
c.f. = 4.48 x 2.6 = 11.7	c.f. = 9.95 x 2.6 = 25.7	c.f. = 11.79 x 2.6 = 33.3

Angle = -30	Angle = -20	Angle = -10
Stand. = 15.6	Stand. = 15.6	Stand. = 15.6
9.33	5.63	4.77
11.40	5.30	5.10
10.54	5.47	4.72
8.87	4.83	4.10
8.40	4.72	4.18
6.69	5.58	4.17
7.68	5.67	3.57
7.22	4.84	4.97
6.78	5.15	5.32
6.34	4.46	4.87
86.25	51.65	45.77
A = 8.63	A = 5.17	A = 4.58
c/b. = 8.63 x 15.6 = 135	c/b. = 5.17 x 15.6 = 80.7	c/b. = 4.58 x 15.6 = 71.5

Angle = 0	Angle = +10	Angle = +20
Stand = 15.6	Stand = 25.8	Stand. = 25.8
7.02	7.97	15.1
9.01	10.50	13.9
7.44	11.00	13.25
8.18	11.26	13.43
7.85	12.10	14.00
10.18	10.22	12.70
11.30	10.70	12.60
10.97	11.65	12.60
10.09	12.00	12.50
8.00	12.10	12.75
90.04	109.50	133.33
A = 9.00	A = 10.95	A = 13.33
c.p. = 9 x 15.6 = 140.4	c.p. = 10.95 x 25.8 = 284	c.b. = 13.33 x 25.8 = 343

Angle = +30	Angle = +40	Angle = +50
Stand = 51.1	Stand. = 51.1	Stand. = 51.1
8.50	9.32	8.75
8.10	9.45	9.07
8.47	9.18	8.50
9.10	9.62	6.90
9.67	9.90	6.05
9.92	8.80	5.85
10.55	8.65	5.57
10.90	8.00	7.50
10.75	7.08	8.20
10.90	6.40	8.12
96.86	76.40	74.51
A = 9.69	A = 7.64	A = 7.45
e.p. = 9.69 x 51.1 = 390	e.p. = 7.64 x 51.1 = 390	e.p. = 7.45 x 51.1 = 380

Angle = +60	Angle = +70	Angle = +50
Stand. = 25.8	Stand. = 15.6	Stand = 2.6
9.60	5.25	7.56
9.55	4.95	7.30
11.70	3.77	8.55
13.55	8.65	9.90
10.30	2.96	8.45
11.10	3.50	9.30
12.60	3.62	9.50
15.30	3.48	8.05
7.50	3.70	7.20
16.50	3.75	8.25
117.70	46.96	84.59
A = 11.77	A = 4.70	A = 8.46
c.f. = 11.8 X 25.8 = 304	c.f. = 47 X 5.6 = 73.4	c.f. = 8.46 X 2.6 = 22.0

Angle = +90
Diam. = 2.6
4.75
3.70
5.75
4.40
3.63
5.85
5.19
5.78
3.99
2.85
45.39
A = 4.54
Cp. = 4.54 x 26 = 11.8

FIG. E

APRIL 14, 1903.

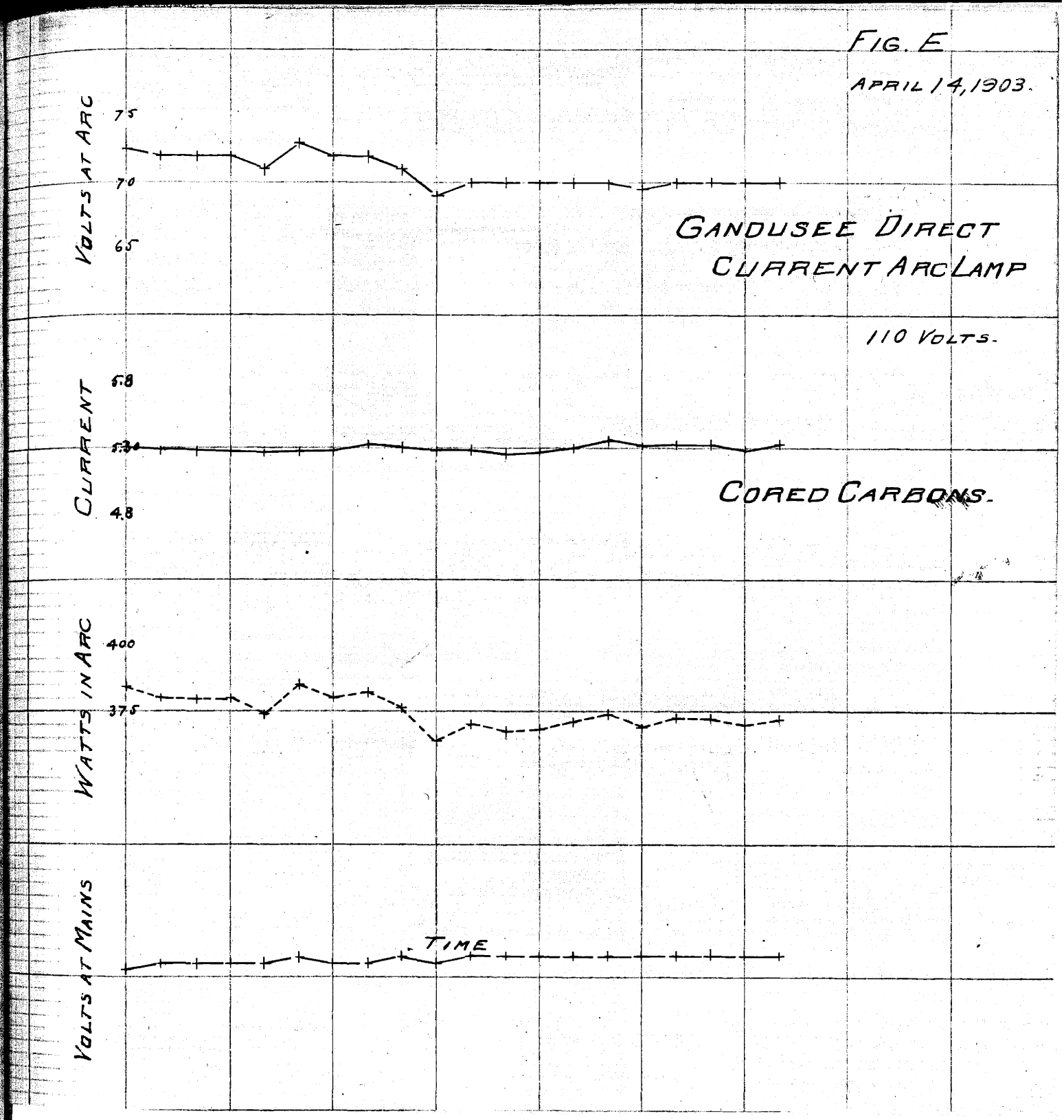
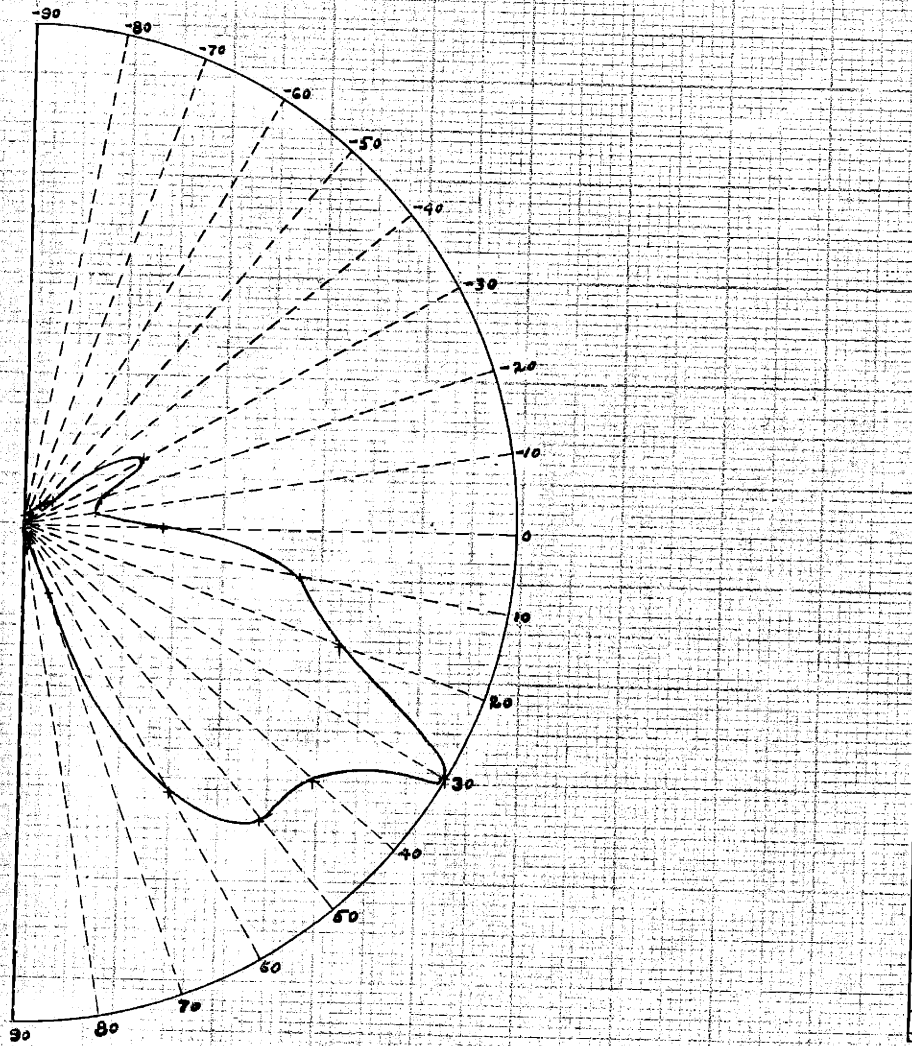
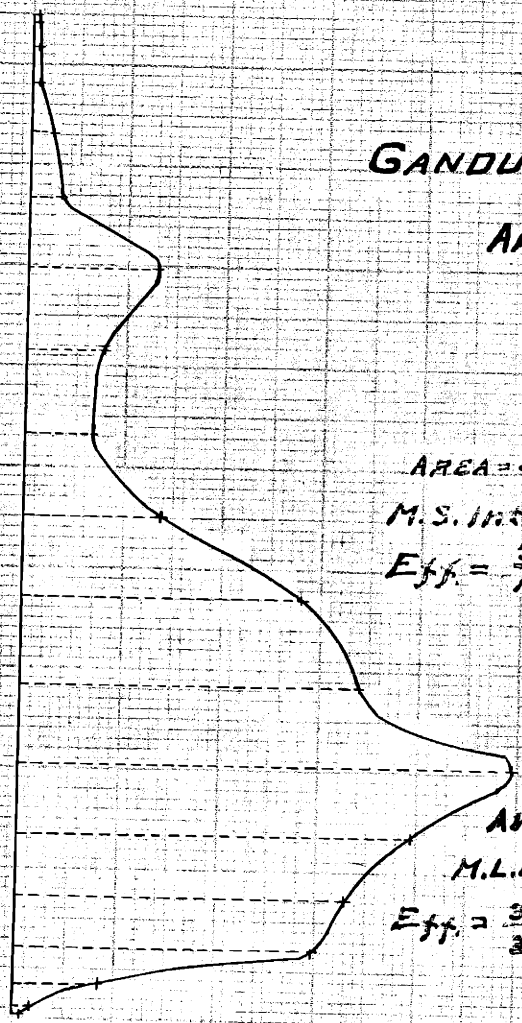


FIG. F

APRIL 14, 1903





GANDUSEE DIRECT CURRENT

ARC LAMP 110 VOLTS.

CORED CARBONS

AREA = 4.76 sq. in.

M.S. Intens. = 190 c.p.

Eff. = $\frac{375}{190}$ = 1.97 watts per candle

Hemispherical

AREA = 3.91 sq. in.

M.L.H. Intens. = 311 c.p.

Eff. = $\frac{375}{311}$ = 1.21 watts per candle.

Test on
Gondusee Arc Lamp -
110° D.C.
Uncoud Carbons -
See Page

E(arc)	E(mains)	I	W(mains)	W(arc)
68	111.0	5.47	607	372
69	111.0	5.47	607	377
70	111.0	5.45	605	381
68	111.0	5.50	611	374
69	111.0	5.45	605	376
70	111.0	5.48	609	384
70	111.0	5.43	603	380
69	111.0	5.48	609	378
70	111.0	5.48	609	384
68	111.0	5.49	610	373
68	111.0	5.49	609	373
69	111.0	5.48	609	378
70	111.0	5.48	609	384
68	111.0	5.48	609	372
69	111.0	5.48	609	378
70	111.0	5.45	605	382
69	111.0	5.48	609	378
70	111.0	5.50	611	385
69	111.0	5.48	609	378
70	111.0	5.50	611	385

Angle = -90	Angle = -80	Angle = -70
Stand. = 2.6	Stand. = 2.6	Stand. = 2.6
2.30	2.45	2.59
2.20	2.68	2.62
2.52	2.62	2.88
2.40	2.63	2.80
2.45	2.55	2.63
2.37	2.58	2.57
2.48	2.57	2.61
2.48	2.50	2.59
2.36	2.48	2.62
2.23	2.42	2.66
23.8	25.48	26.57
A = 2.38	A = 2.55	A = 2.66
c/s = 2.38 x 2.6 = 6.19	c/s. = 2.55 x 2.6 = 6.64	c/s. = 2.66 x 2.6 = 6.92

Angle = -60	Angle = -50	Angle = -40
Stand. = 2.6	Stand = 2.6	Stand = 15.6
3.19	18.5	3.28
3.22	18.2	4.00
3.12	21.8	4.18
2.94	23.0	3.89
2.87	23.0	4.07
3.02	21.6	4.37
2.96	21.6	4.19
2.85	21.7	6.69
2.99	21.7	5.73
2.56	21.7	3.17
29.92	211.8	43.57
A = 2.99	A = 21.18	A = 4.36
c/p. = 2.99 x 2.6 = 7.78	c/p. = 21.18 x 2.6 = 55.1	c/p. = 4.36 x 15.6 = 68.0

Angle = -30	Angle = -20	Angle = -10
Stand = 15.6	Stand = 15.6	Stand = 15.6
4.30	5.97	4.27
4.81	4.91	4.37
4.80	3.87	4.30
3.74	3.85	4.78
5.03	3.84	3.91
5.60	4.02	3.97
5.35	3.67	3.73
5.80	3.47	3.83
5.05	3.48	3.60
4.75	3.78	3.64
49.30	40.86	40.46
A = 4.93	A = 4.09	A = 4.05
c.p. = 4.93 x 15.6 = 77.0	c.p. = 4.09 x 15.6 = 40.86	c.p. = 4.05 x 15.6 = 63.2

Angle = 0	Angle = +10	Angle = +20
Stand. = 15.6	Stand. = 51.1	Stand. = 51.1
2.99	5.08	6.50
2.91	4.95	6.60
2.92	3.73	7.00
2.76	8.72	6.90
2.87	7.00	6.90
2.85	5.65	6.97
2.93	4.87	6.65
2.74	4.32	6.60
2.93	4.12	6.37
2.82	4.41	6.10
28.72	56.85	65.59
A = 2.87	A = 5.69	A = 6.56
c.p. = 2.87 x 15.6 = 44.8	c.p. = 5.69 x 51.1 = 296	c.p. = 6.56 x 51.1 = 335

Angle = +30	Angle = +40	Angle = +50
Stand. = 51.1	Stand. = 51.1	Stand. = 51.1
7.98	8.10	8.20
7.50	7.40	11.80
7.00	8.20	11.20
6.60	8.20	12.70
6.48	8.32	11.25
5.97	8.12	10.55
7.40	8.16	10.00
6.90	7.42	10.20
6.75	8.50	10.05
6.72	8.20	9.55
69.30	83.42	105.5
A = 6.93	A = 8.34	A = 10.55
c.f. = 6.93 x 51.1 = 354	c.f. = 8.34 x 51.1 = 426	c.f. = 10.6 x 51.1 = 542

Angle = +60	Angle = +70	Angle = 80 – 90
Stand. = 25.8	Stand = 2.6	
16.1	6.49	Below limits
13.4	6.47	of smallest
11.1	5.35	standard.
14.4	6.30	
13.6	4.90	
13.3	4.00	
13.2	2.68	
15.0	2.47	
14.0	2.65	
13.7	2.67	
137.8	43.98	
A = 13.78	A = 4.40	
c.p. = 1378 x 25.8 = 354	c.p. = 440 x 2.6 = 11.5	

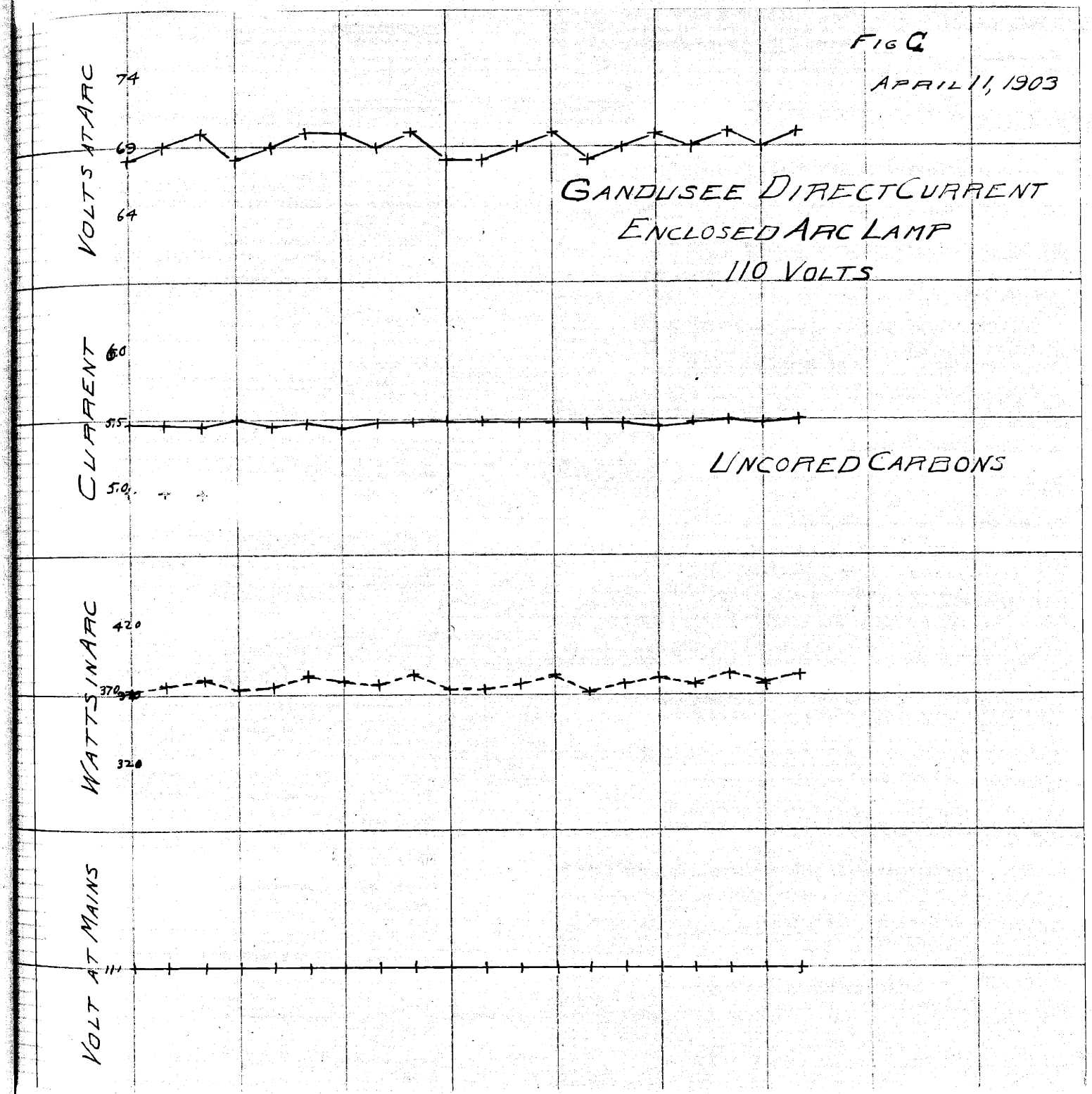
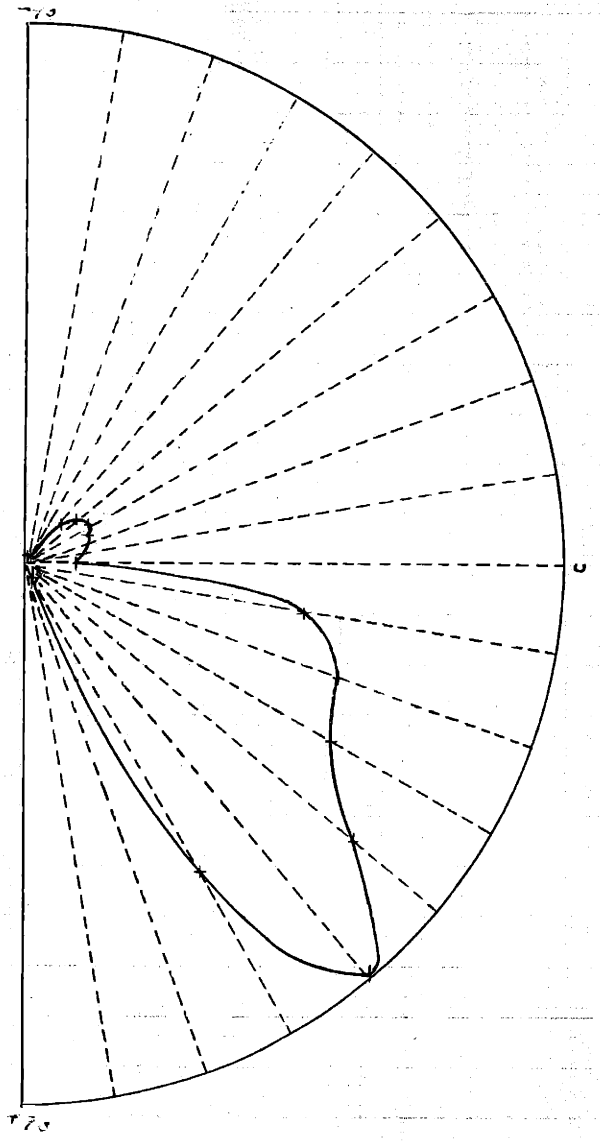
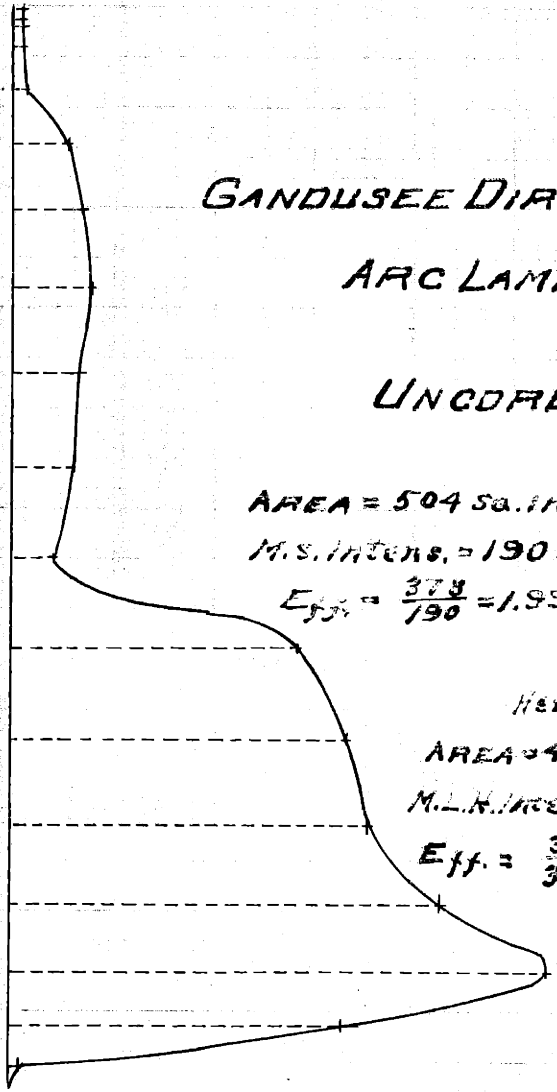


FIG C
APRIL 11, 1903
GANDUSEE DIRECT CURRENT
ENCLOSED ARC LAMP
110 VOLTS
UNCORED CARBONS
VOLTS AT ARC
74
69
64
CURRENT
60
5.5
5.0
WATTS IN ARC
420
370
328
VOLT AT MAINS
111

FIG. H

APRIL , 1903.





GANDUSEE DIRECT CURRENT ARC LAMPS 110 VOLTS

UNCORED CARBONS

AREA = 504 Sq. In.

M.S. Intens. = 190 c.p.

$E_{ff.} = \frac{378}{190} = 1.99$ Watts per candle

Hemispherical.

AREA = 4.275 Sq. In.

M.H.S. Intens. = 335 c.p.

$E_{ff.} = \frac{378}{335} = 1.13$ Watts per candle

Test on
Helios Arc. Lamp Type 652.
220° D.C.
Cored Carbons used.

Length upper carbon 12" x 1/2"
Length lower carbon 4 1/8" x 1/2"
Enclosing globe 1" x 2 5/8" x 7"
Lamp manufactured by Helios
Electric Co.

I	E(mains)	E(arc)	W(mains)	W(arc)
3.2	221	140	717	448
2.90	224	141	650	409
2.90	224	142	650	412
3.10	224	143	695	444
2.98	224	145	661	428
3.00	223	142	667	416
2.85	224	138	639	394
3.05	224	139	684	424
3.90	220	140	859	546
3.70	220	140	837	532
3.70	221	141	819	522
3.60	221	142	795	511
3.60	222	144	800	519
3.75	222	142	833	532
2.90	222	145	644	420
2.70	223	138	603	373
3.70	220	140	815	518
3.80	222	140	844	532
3.80	221	142	840	540
3.80	221	143	840	544

Angles 90 - 70	Angle = +00	Angle = -50
	Stand. = 25.8	Stand. = 25.8
Readings can not be taken on account of shadow thrown by tab of blank.	3.45	3.62
	2.96	3.44
	3.00	4.97
	3.62	4.87
	2.98	4.47
	3.01	4.18
	3.29	4.14
	3.32	3.96
	3.44	4.17
	3.65	3.90
	32.72	47.72
	A = 3.27	A = 4.77
	c/s. = 3.27 x 25.5 = 845	c/s. = 4.77 x 25.5 = 123

Angle = -40	Angle = -30	Angle = -20
Stand. = 25.8	Stand. = 25.8	Stand. = 25.8
4.60	4.50	2.92
4.11	5.03	2.82
4.27	5.21	2.92
4.23	5.21	2.89
4.31	4.91	2.73
4.23	4.43	3.43
4.30	3.94	3.35
3.47	4.69	3.17
4.38	4.88	2.97
4.19	4.92	2.87
41.99	48.02	30.01
A = 4.20	A = 4.80	A = 3.00
c.f. = 4.2x25.8 = 108.	c.f. = 4.8x25.8 = 124	c.f. = 3. x25.8 = 774

Angle = -10	Angle = 0	Angle = +10
Standard = 51.1	Standard = 51.1	Standard = 51.1
2.61	4.45	4.27
2.67	4.08	4.13
2.70	3.97	3.95
2.64	3.10	4.35
2.63	3.24	4.03
2.62	3.13	3.95
2.63	3.28	4.07
2.67	3.08	4.05
2.72	3.15	6.80
2.60	3.30	4.52
26.49	34.78	44.14
A = 2.65	A = 3.48	A = 4.41
c.f. = 2.65 x 51.1 = 135	c.f. = 3.48 x 51.1 = 178	c.f. = 4.41 x 51.1 = 225

Angle = +20	Angle = +30	Angle = +40
Stand. = 51.1	Stand. = 51.1	Stand. = 51.1
5.30	6.97	7.53
5.27	9.25	7.65
4.77	8.25	7.38
5.58	9.10	7.40
4.88	7.82	7.40
4.75	7.15	6.80
4.79	6.99	7.67
4.68	7.70	9.20
4.32	8.00	8.38
4.52	8.05	8.65
48.86	79.28	78.06
A = 4.89	A = 7.93	A = 7.81
c.f. = 4.89 x 51.1 = 250	c.f. = 7.93 x 51.1 = 405	c.f. = 7.81 x 51.1 = 399

Angle = +50	Angle = +60	Angle = +70
Stand. = 51.1	Stand = 51.1	Stand. = 25.8
11.32	4.19	6.42
10.32	4.80	10.58
12.05	3.28	10.38
10.80	4.64	8.65
11.20	4.56	7.72
9.00	4.80	6.40
10.03	4.71	7.29
10.70	3.88	7.33
10.98	5.48	6.23
10.20	3.91	7.01
106.60	44.25	78.01
A = 10.66	A = 4.43	A = 7.80
c/p. = 10.66 x 51.1 = 547	c/p. = 4.43 x 51.1 = 226	c/p. = 7.8 x 25.8 = 201

Angle = +80	Angle = +90
Stand. = 25.8	Stand. = 2.6
7.28	10.52
6.57	10.08
5.11	10.25
5.53	9.16
4.53	9.06
6.20	10.35
6.06	9.05
6.58	8.10
6.40	8.71
5.32	9.70
59.58	93.98
A = 5.96	A = 9.40
c/b. = 5.96 × 25.8 = 154	c/b. = 9.4 × 2.6 = 24.4

FIG. I

APRIL 14, 1903.

HELIOS DIRECT CURRENT ARC LAMP

TYPE 652.

220 VOLTS.

CORED CARBONS.

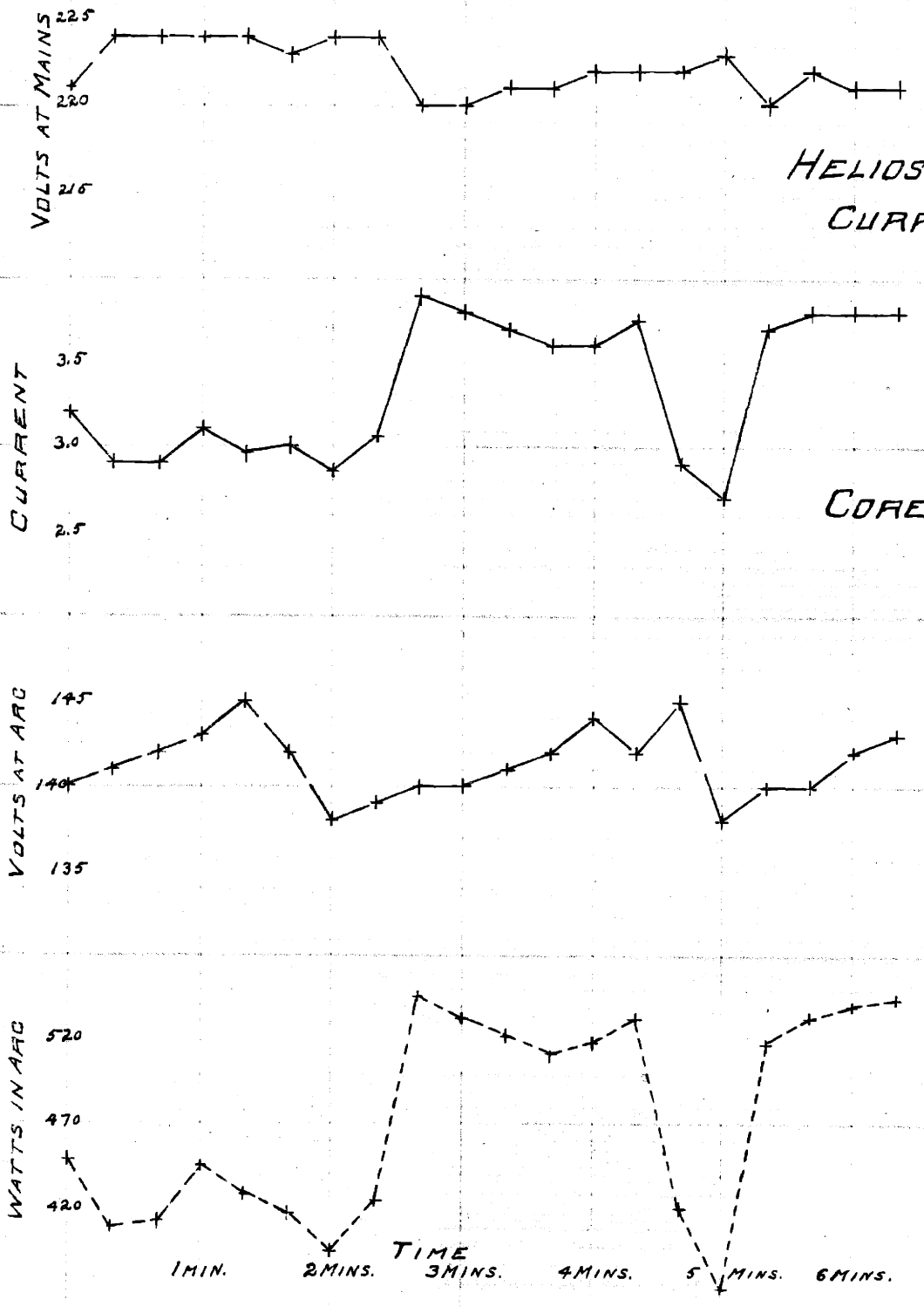
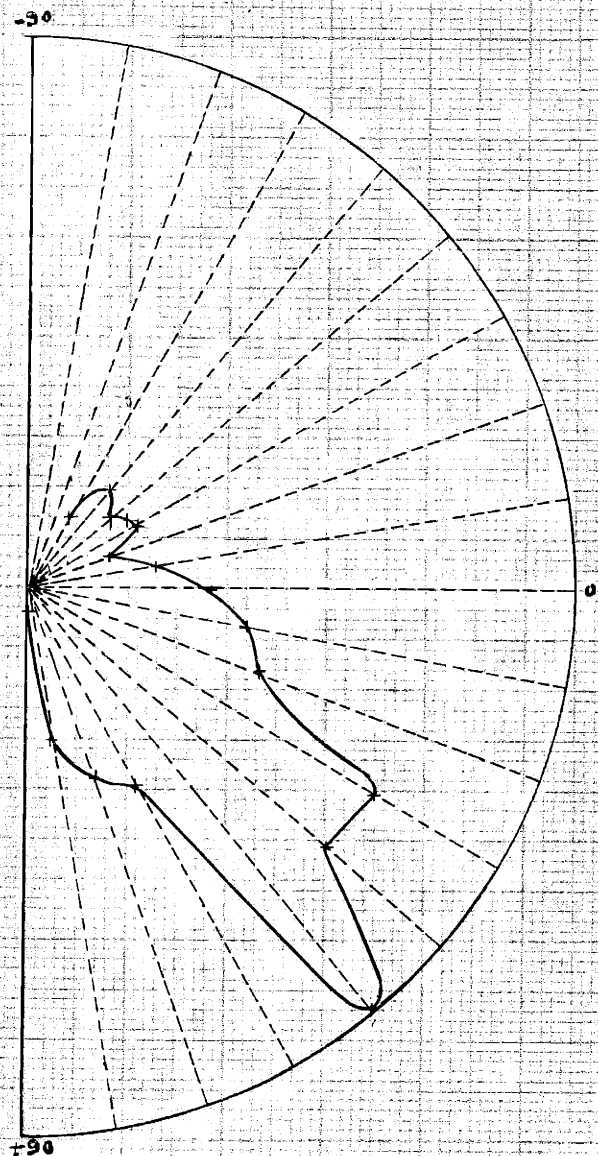
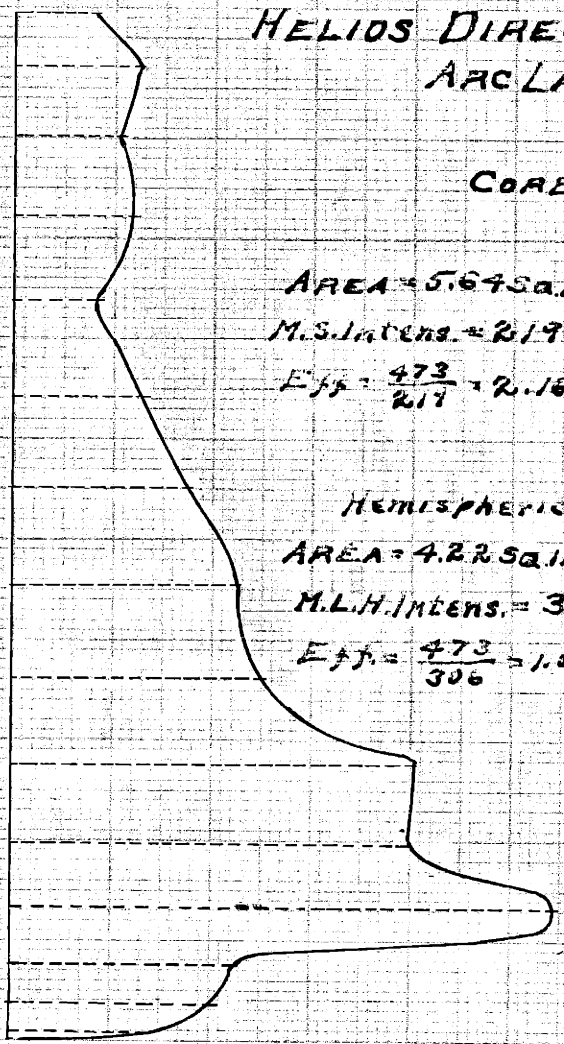


Fig 8

April 1903





Helios Direct Current Arc Lamp

Cored Carbons

Area = 5.64 Sq. in.

M.S. Intens. = 219 c.p.

Eff. = $\frac{473}{219}$ = 2.16 watts per candle

Hemispherical

Area = 4.22 Sq. in.

M.L.H. Intens. = 306 c.p.

Eff. = $\frac{473}{306}$ = 1.55 watts per candle

Test on

Helios Arc Lamps Type 652.

220 v D.C.

Uncored Carbons used

See Page

E(arc)	E(mains)	I	W(mains)	W(arc)
140	220	2.90	639	406
139	223	2.90	647	403
138	220	2.90	639	400
141	221	3.00	663	423
140	224	2.80	628	392
140	225	2.90	653	406
140	223	3.00	669	420
139	224	3.00	672	417
138	224	2.90	650	400
140	225	3.00	675	420
141	222	2.95	655	416
142	223	2.70	602	384
140	225	2.65	597	371
140	223	2.95	648	403
140	223	2.75	614	385
140	224	2.90	650	406
140	221	2.90	620	406
140	224	2.65	594	371
140	223	2.90	647	406
140	223	3.05	680	427

Angle = ~~-90 to -70~~	Angle = -60	Angle = -50
Stand. = 2.6	Stand. = 15.6	Stand. = 15.6
Impossible	3.69	5.43
to read since	4.62	4.67
the top of the	4.62	5.55
lamp casts a	3.44	4.93
shadow.	4.01	4.04
	4.07	5.14
	3.85	4.88
	3.47	5.16
	3.90	4.56
	4.34	4.67
	40.01	49.32
	A = 4.00	A = 4.93
	c.p. = 4 × 15.6 = 62.4	c.p. = 4.93 × 15.6 = 77

Angle = -40	Angle = -30	Angle = -20
Stand. = 15.6	Stand. = 15.6	Stand. = 25.8
4.88	5.39	2.50
4.90	4.77	2.95
4.03	4.36	3.08
4.88	4.40	3.33
4.29	4.10	3.35
4.07	4.02	3.33
4.27	3.77	3.32
4.63	6.03	3.26
4.74	5.20	3.29
3.97	4.43	3.23
44.63	47.27	31.34
A = 4.46	A = 4.73	A = 3.13
c/p. = 4.46 x 15.6 = 69.6	c/p. = 4.73 x 15.6 = 73.9	c/p. = 3.13 x 25.8 = 80.8

Angle = -10	Angle = 0	Angle = +10
Stand. = 25.8	Stand. = 25.8	Stand. = 25.8
4.14	6.07	5.55
4.70	5.78	5.60
4.76	6.35	5.65
4.65	4.05	5.05
4.67	5.30	4.98
4.60	5.33	6.45
4.43	5.18	6.40
4.30	7.22	6.32
4.15	6.65	5.27
4.52	6.43	4.18
44.92	58.36	55.45
A = 4.49	A = 5.84	A = 5.55
c.p. = 449x25.8=116	c.p. = 5.84x25.8=152	c.p. = 5.6x25.8 = 310

Angle = +20	Angle = +30	Angle = +40
Stand. = 25.8	Stand. = 25.8	Stand. = 25.8
7.75	5.30	6.55
7.75	5.55	7.72
7.55	5.57	7.30
7.65	5.58	7.70
7.81	5.30	7.87
7.92	5.32	8.40
7.20	5.45	8.70
7.08	5.20	7.20
7.21	6.60	7.32
7.27	6.68	7.15
75.19	53.85	77.91
A = 7.52	A = 5.39	A = 7.79
c/p. = 7.52 x 25.8 = 194	c/p. = 5.39 x 25.8 = 139	c/p. = 7.8 x 25.8 = 175

Angle = +50	Angle = +60	Angle = +70
Stand. = 25.8	Stand. = 51.1	Stand. = 51.1
8.81	8.51	6.34
8.80	7.66	6.44
7.90	8.42	5.98
8.10	6.75	6.31
8.08	7.89	5.52
8.40	7.30	6.35
7.40	7.29	5.90
6.40	6.82	6.21
6.65	6.92	6.11
8.70	7.32	6.31
79.24	74.98	61.47
A = 7.92	A = 7.50	A = 6.15
c/p. = 7.9 x 25.8 = 204	c/p. = 7.5 x 51.1 = 384.	c/p. = 6.15 x 51.1 = 314

Angle = +80	Angle = +90
Stand. = 2.6	Stand. = 2.6
7.56	5.16
7.36	7.05
6.91	7.20
6.46	7.92
6.47	10.10
6.54	11.08
6.03	9.50
6.38	9.25
6.22	8.01
6.85	8.40
66.78	82.67
A = 6.68	A = 8.27
cp. = 6.68 x 2.6 = 17.7	cp. = 8.27 x 2.6 = 21.5

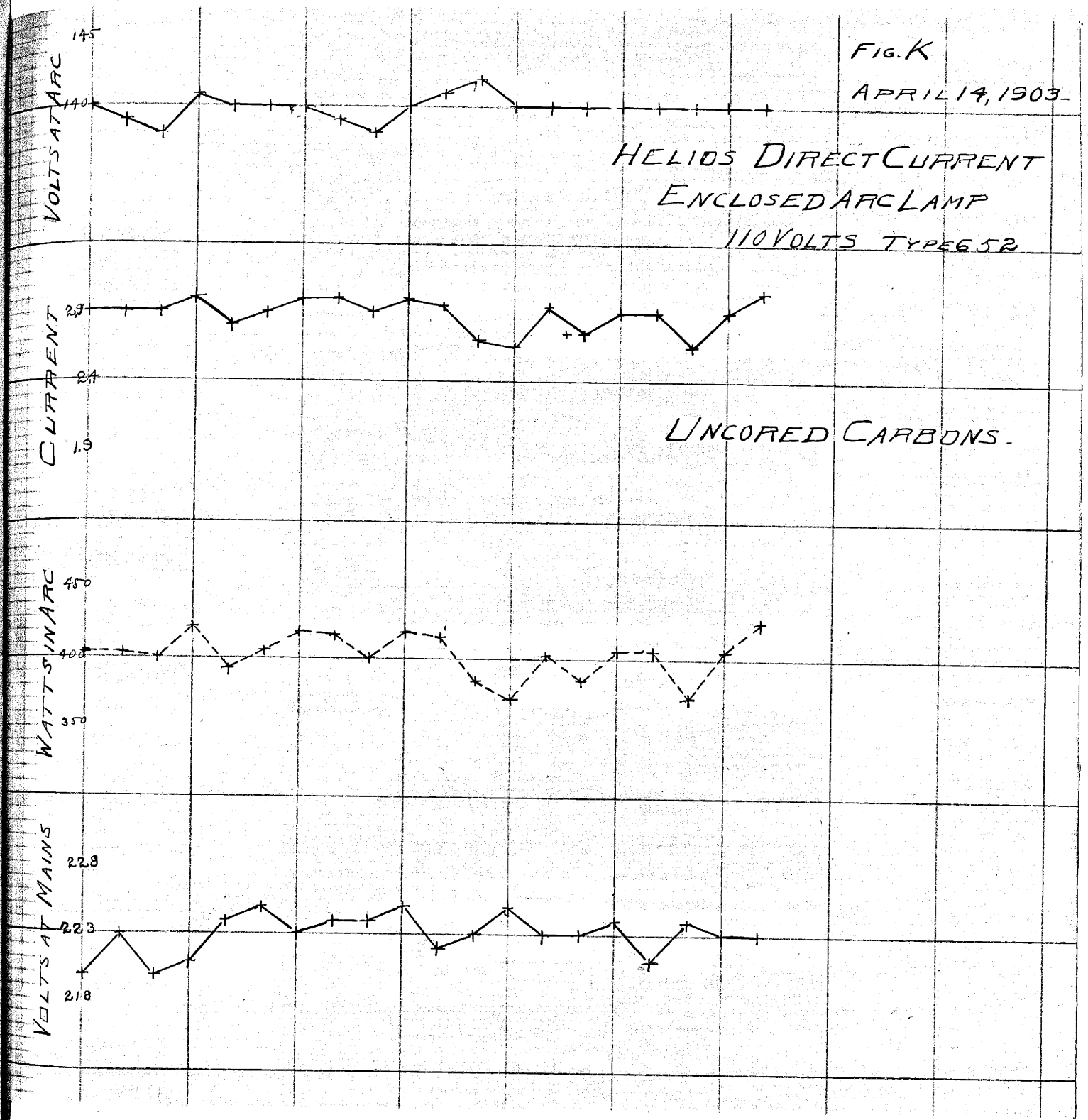
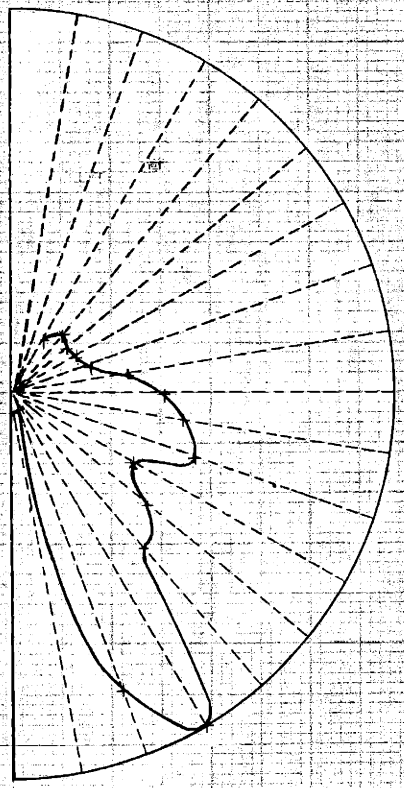


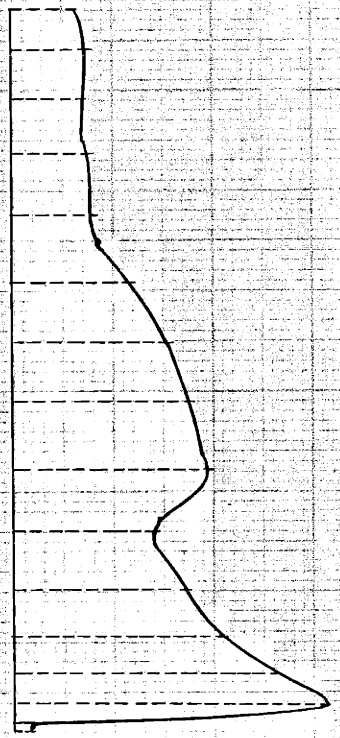
FIG. K
APRIL 14, 1903.
HELIOS DIRECT CURRENT
ENCLOSED ARC LAMP
110 VOLTS TYPE 652
UNCORED CARBONS.
VOLTS AT ARC
145
140
CURRENT
2.3
2.1
1.9
WATTS IN ARC
450
400
350
VOLTS AT MAINS
228
223
218

Fig 6

APRIL 1903

HELIOS DIRECT CURRENT ARC LAMP





UNCORED CARBONS

AREA = 2.59 sq. in.

M.S. INTENS. = 143 c.p.

Eff = $\frac{403}{143}$ = 2.82 watts per candle

HEMISPHERICAL

AREA = 1.86 sq. in.

M.L.H. INTENS. = $\frac{1.86}{1.94}$ = 192

Eff. = $\frac{403}{192}$ = 2.10 watts per candle.

Test on

General Electric Co Arc Lamp - Form 5

No 336090

110° D C. 5ª

Uncored Carbons

Upper carbon 12" x 1/2"

Lower carbon 6" x 1/2"

Maximum diam 1/2" carbons .520"

Minimum diam 1/2" carbons .500"

Maximum diam 7/16" carbons .445"

Minimum diam 7/16" carbons .425"

Maximum diam 3/8" carbons .400"

Minimum diam 3/8" carbons .390"

Globe (Enclosing) 11/8" x 17/8" x 6 1/2"

I	E(mains)	E(arc)	W(mains)	W(arc)
5.00	110.	75	550	375
5.70	110.	78	627	445
5.10	110.	80	568	408
5.10	110.	78	561	398
5.45	110.	79	600	430
5.10	110.	79	561	403
5.20	110.	78	572	405
4.90	109.5	80	537	392
5.10	109.5	77	565	397
5.40	109.	78	589	421
5.50	110.	78	605	429
5.41	110	77	596	416
5.40	110.	78	594	421
5.10	110.	79	561	408
5.20	110.	79	572	411
5.20	110.	79	572	411
5.60	110.	78	616	437
5.20	110.	79	572	411
5.30	110.	80	584	424
5.40	110.	78	594	421

Angle = 0°	Angle = +10	Angle = +20
Stand = 51.1	Stand. = 51.1	Stand. = 51.1
5.53	7.45	7.15
5.26	9.90	6.40
4.60	8.65	11.65
7.40	7.95	8.40
6.70	8.60	8.17
5.92	14.80	13.20
5.48	8.90	10.90
4.90	8.92	12.70
7.00	6.35	13.95
6.30	8.97	10.88
59.09	89.49	103.41
A = 5.91	A = 8.949	A = 10.34
c/p. = 5.91 x 51.1 = 302	c/p. = 8.95 x 51.1 = 457	c/p. = 10.34 x 51.1 = 528

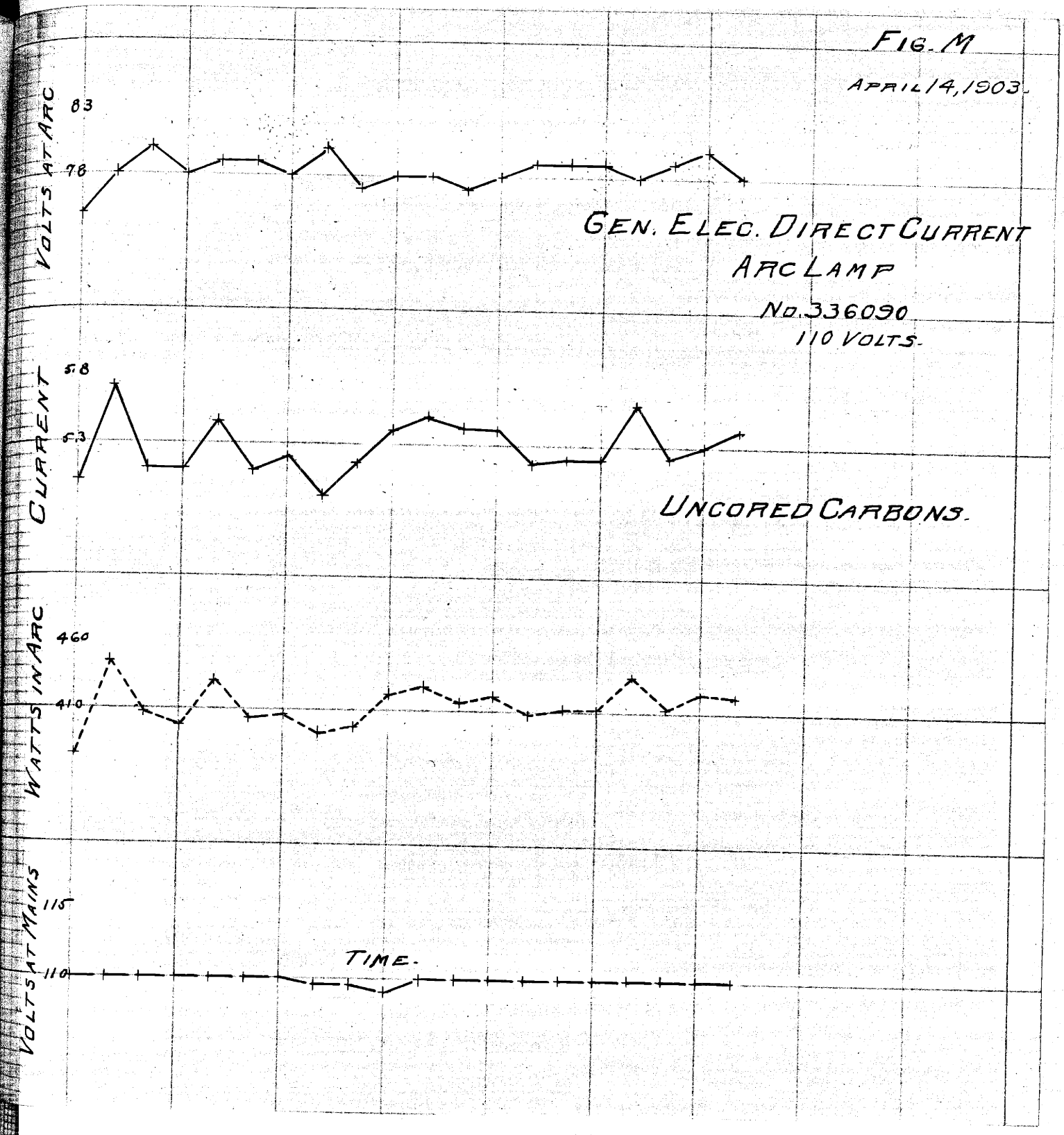
Angle = +30	Angle = +40	Angle = +50
Stand. = 51.1	Stand. = 51.1	Stand. = 51.1
13.70	15.40	18.20
10.60	15.40	15.90
13.55	15.45	16.10
14.90	14.00	15.70
11.30	13.20	17.40
11.70	14.47	16.70
8.90	12.90	12.80
9.90	12.29	16.90
10.20	12.16	14.30
13.85	13.30	14.50
118.60	140.02	158.00
A = 11.86	A = 14.00	A = 15.85
c.p. = 11.86 x 51.1 = 598	c.p. = 14 x 51.1 = 715	c.p. = 15.85 x 51.1 = 813

Angle = +60	Angle = +70	Angle = +80
Stand. = 25.81	Stand. = 25.81	Stand = 2.6
19.50	7.09	4.33
18.80	9.25	4.67
18.90	9.41	3.15
19.30	11.30	3.31
17.50	13.80	2.20
15.65	12.26	3.04
18.70	14.15	2.87
17.50	14.10	2.63
16.90	12.80	2.46
17.60	7.76	2.48
180.85	111.92	31.14
A = 18.1	A = 11.19	A = 3.11
c/p. = 18.1 x 25.81 = 466	c/p. = 11.19 x 25.81 = 289	c/p. = 3.11 x 2.6 = 8.1

Impossible to get readings on +90°

FIG. M

APRIL 14, 1903.



GEN. ELEC. DIRECT CURRENT
ARC LAMP
No. 336090
110 VOLTS.

UNCORED CARBONS.

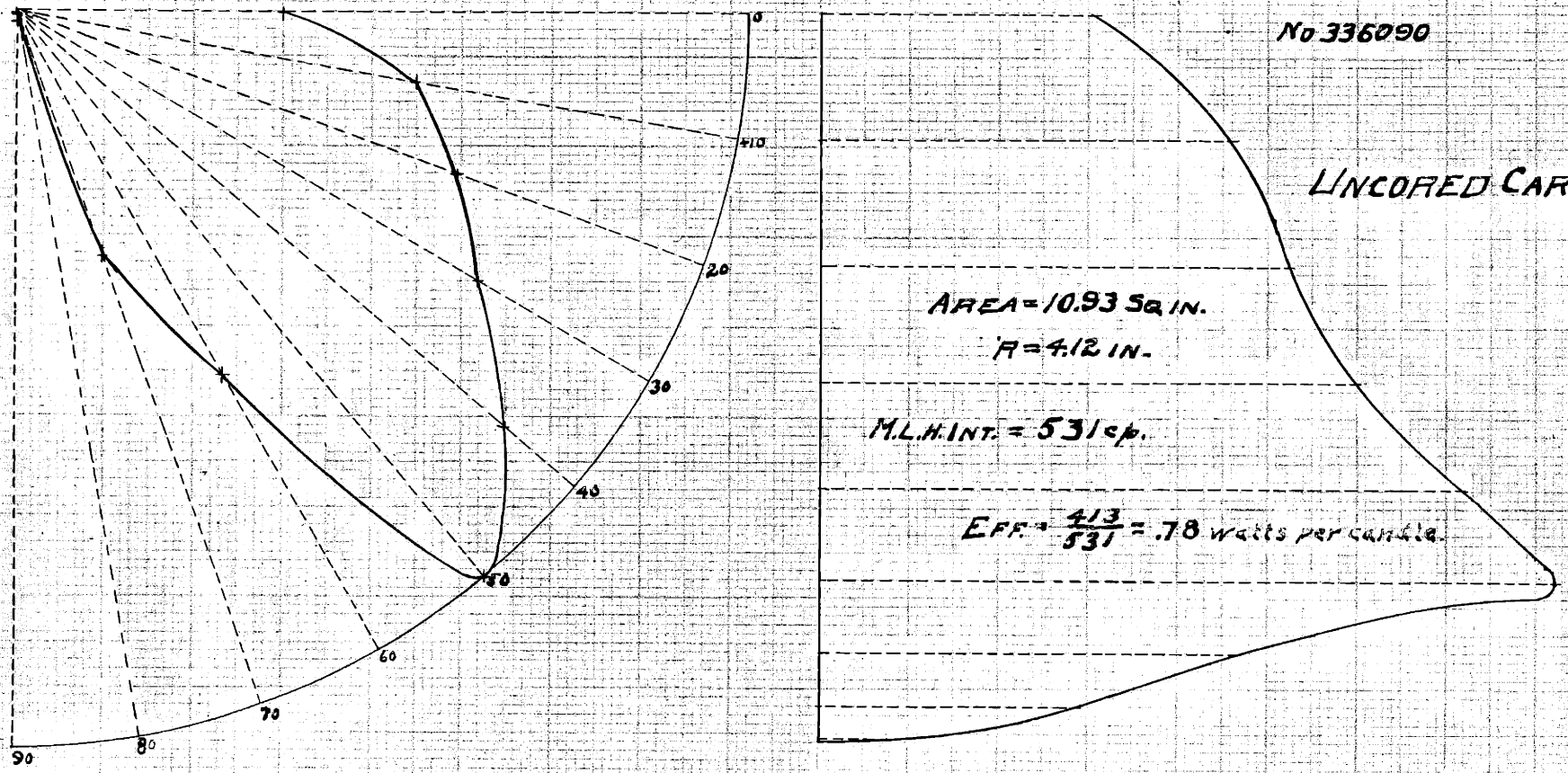
FIG N

APRIL 1903

GEN. ELEC. DIRECT CURRENT

ARC LAMP

No 336090



UNCORED CARBONS

AREA = 10.93 SQ IN.

R = 4.12 IN.

M.L.H. INT. = 531 cp.

EFF. = $\frac{413}{531}$ = .78 watts per candle.

Test on
General Electric Co Arc Lamp Form 5.
No 512677
110° DC 5ª 80° at arc
Catalogue No 3474
No Casing 3567

Cored Carbons -
Enclosing globe No 3. 3" x 6½"
Upper carbon 12" x ½"
Lower carbon 5¾" x ½"
Maximum diam. of ½" carbons .520"
Minimum diam of ½" carbons .505"
Maximum diam of 7/16" carbons .445"
Minimum diam of 7/16" carbons .430"
Maximum diam of 3/8" carbons .400"
Minimum diam of 3/8" carbons .390"
This was a new lamp purchased purposely for this investigation.

I	E(mains)	E(arc)	W(mains)	W(arc)
5.00	110	80	550	400
4.90	110	81	539	397
4.85	110	80	534	388
5.00	110	79	550	395
5.10	110	80	561	408
5.00	110	79	550	395
5.00	110	80	550	400
5.00	110	79	550	395
4.80	110	80	528	384
5.00	110	79	550	395
5.10	110	80	561	408
4.90	110	79	539	387
4.95	110	80	545	396
5.00	110	81	550	405
5.00	110	80	550	400
5.10	110	81	561	413
4.95	110	80	545	396
5.00	110	79	550	395
5.00	110	80	550	400
4.95	110	80	545	396

Angle = -90°-0-10°	Angle = -60°	Angle = -50°
	Stand = 2.6	Stand = 2.6
Impossible	3.29	14.58
to obtain	3.72	15.00
readings	3.12	15.75
	3.32	16.75
	3.14	15.16
	3.00	15.90
	3.06	15.58
	3.06	15.70
	3.10	16.00
	3.00	16.93
	31.81	157.32
	A = 3.18	A = 15.73
	c/p. = 3.18 x 2.6 = 8.27	c/p. = 15.73 x 2.6 = 40.8

Angle = -40	Angle = -30	Angle = -20
Stand = 2.6	Stand = 15.6	Stand. = 15.6
14.58	6.0.8	5.69
15.00	5.67	6.53
15.75	5.91	5.23
16.75	5.93	5.53
15.16	5.69	5.17
15.93	5.33	4.78
15.58	5.23	5.00
15.70	5.37	5.39
16.00	5.41	5.56
1690	5.68	5.67
157.32	56.30	54.55
A = 15.73	A = 5.63	A = 5.46
c/o. = 15.73 x 2.6 = 40.8	c/o. = 5.63 x 15.6 = 87.8	c/o. = 5.46 x 15.6 = 85.2

Angle = -10	Angle = 0	Angle = +10
Stand. = 15.6	Stand. = 15.6	Stand. = 15.6
5.04	4.84	5.33
5.50	5.04	5.21
6.40	5.01	4.98
5.71	5.29	4.69
6.35	5.36	4.79
6.35	5.84	4.67
5.96	5.23	5.04
5.87	5.42	5.12
6.15	5.67	4.91
5.17	5.25	5.00
58.57	52.95	49.64
A = 5.85	A = 5.30	A = 4.96
c.p. = 5.85 x 15.6 = 91.3	c.p. = 5.3 x 15.6 = 82.7	c.p. = 4.96 x 15.6 = 77.5

Angle = +20	Angle = +30	Angle = +40
Stand. = 15.6	Stand. = 63	Stand. = 63
12.50	9.31	7.28
12.62	10.44	8.60
12.47	8.80	8.20
12.28	9.60	7.80
12.86	9.42	9.80
12.00	8.72	8.90
14.10	8.50	8.85
13.90	7.60	8.72
14.60	6.75	8.95
12.10	6.50	9.47
128.73	83.64	86.57
A = 12.87	A = 8.36	A = 8.66
c.p. = 12.87 x 15.6 = 204	c.p. = 8.36 x 63 = 526	c.p. = 8.66 x 63 = 545

Angle = +50	Angle = +60	Angle = +70
Stand. = 63	Stand. = 63	Stand. = 2.6
9.01	9.38	12.34
8.70	8.57	13.60
8.85	8.10	15.25
9.07	7.90	14.45
9.81	7.59	14.00
8.68	7.06	11.23
8.69	7.55	11.20
8.90	7.72	14.18
8.50	8.47	16.60
8.45	9.31	14.72
88.66	83.85	137.57
A = 8.87	A = 8.39	A = 13.76
c.p. = 8.87 x 63 = 559	c.p. = 8.39 x 63 = 528	c.p. = 13.8 x 2.6 = 35.9

Angle = +80	Angle = +90
Standard = 2.6	Stand. = 2.6
8.50	3.08
8.98	3.38
8.45	3.31
7.57	3.13
7.84	3.11
7.50	3.18
7.17	3.22
7.69	3.37
7.12	3.22
6.81	3.31
77.93	32.33
A = 7.79	A = 3.23
c/s = 7.79 × 26 = 202	c/s = 3.23 × 2.6 = 8.0

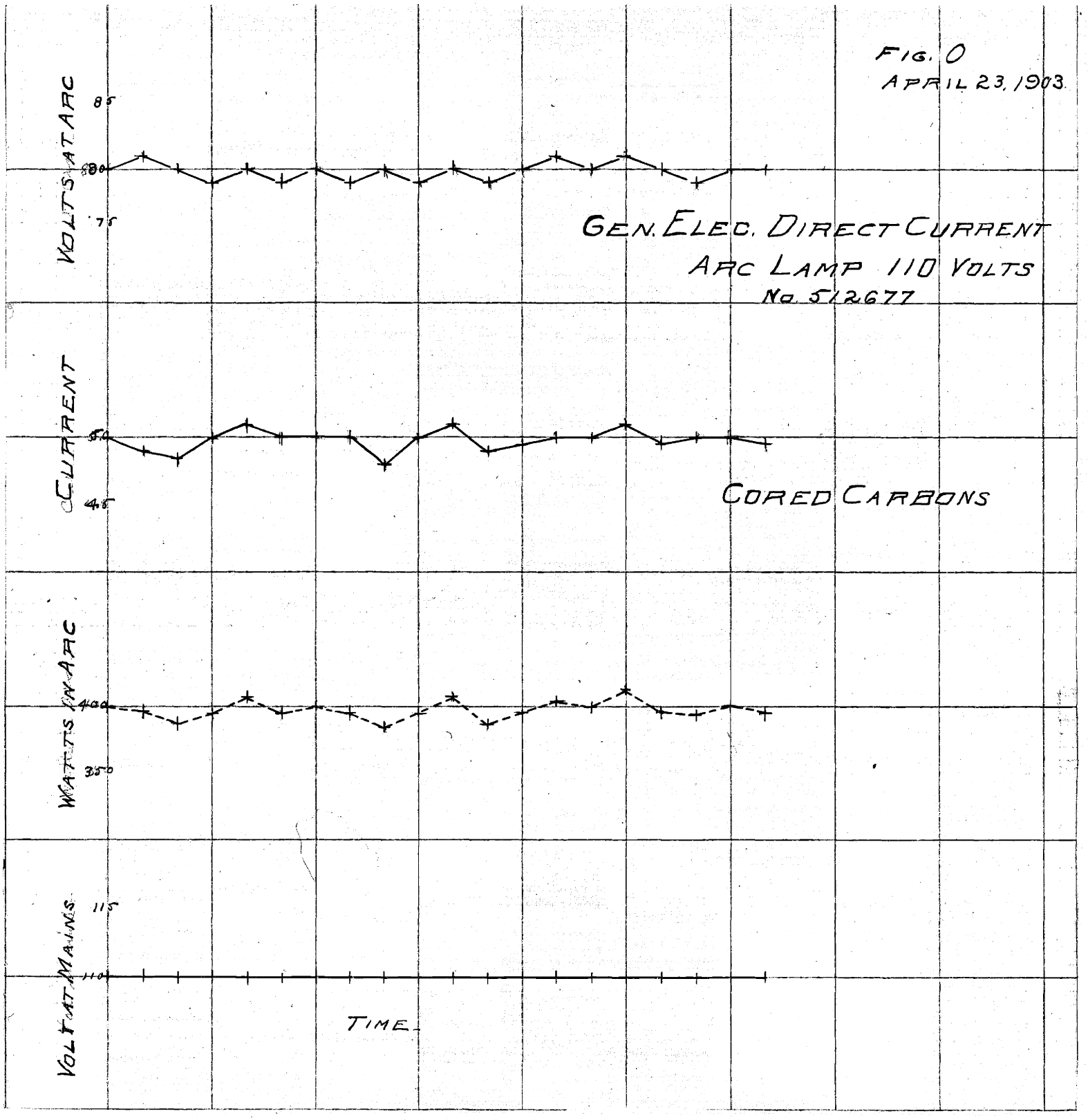
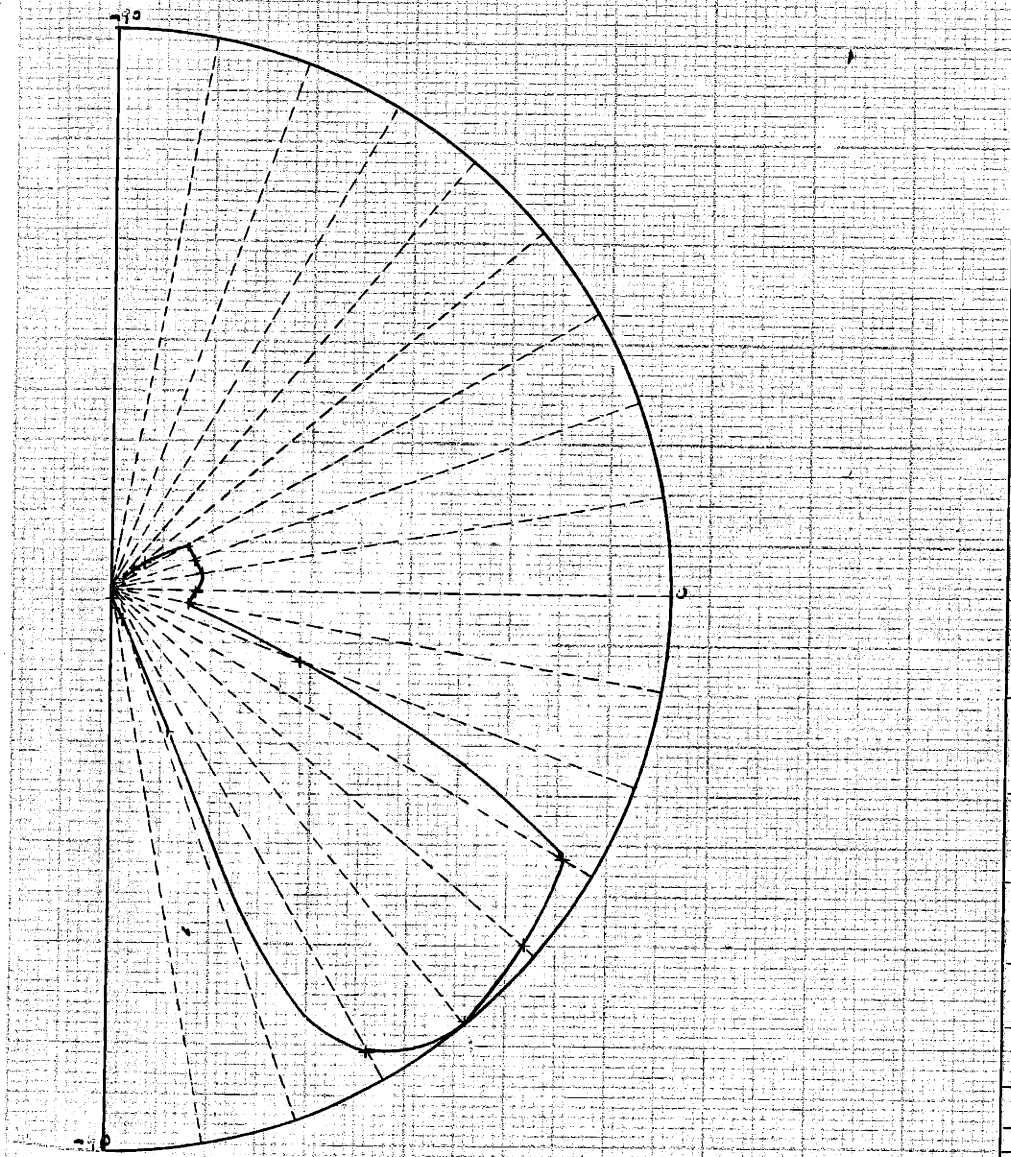
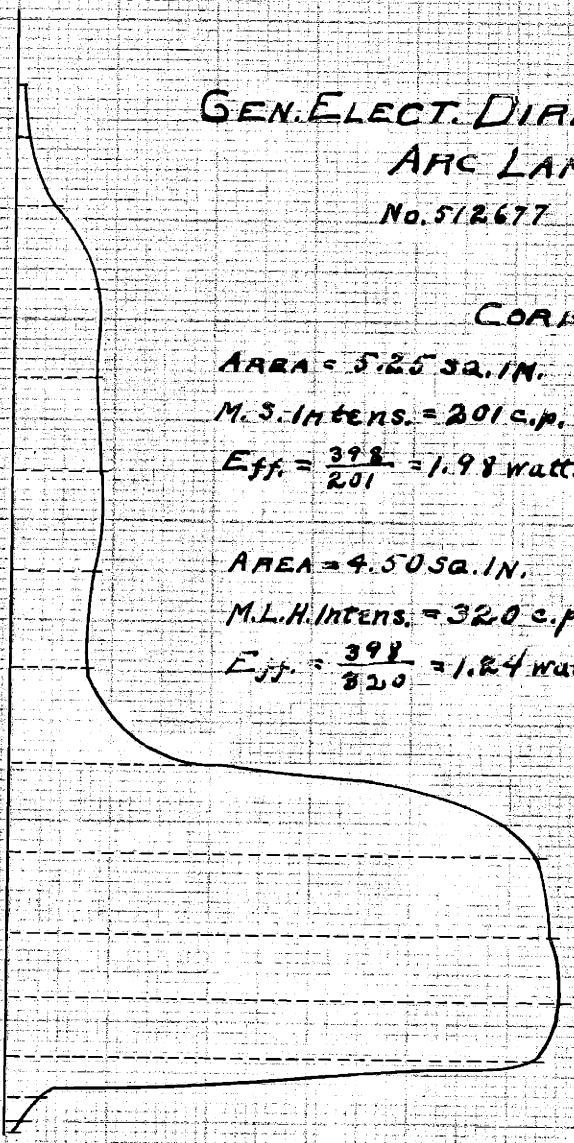


FIG. O
APRIL 23, 1903.
VOLTS AT ARC
85
80
75
GEN. ELEC. DIRECT CURRENT
ARC LAMP 110 VOLTS
No. 512677
CURRENT
5.0
4.5
CORED CARBONS
WATTS IN ARC
400
350
VOLT AT MAINS
115
110
TIME.

Fig 20

APRIL 1903.





GEN. ELECT. DIRECT CURRENT ARC LAMP

No. 512677

CORED CARBONS

AREA = 5.25 SQ. IN.

M.S. Intens. = 201 c.p.

$Eff. = \frac{398}{201} = 1.98$ watts per candle.

AREA = 4.50 SQ. IN.

M.L.H. Intens. = 320 c.p.

$Eff. = \frac{398}{320} = 1.24$ watts per candle.

Test on
General Electric Co. Arc Lamp Form 5
No 512677
Uncoated Carbons
See page

I	E(mains)	E(arc)	W(mains)	W(arc)
4.78	110	78.5	526	375
4.69	110	77.5	516	364
4.60	110	78.4	506	361
4.65	110	77.5	512	360
4.81	110	77.5	530	373
4.71	110	78.1	518	368
4.65	110	78.5	512	368
4.75	110	77.5	523	375
4.84	110	77.5	332	364
4.65	110	78.4	512	368
4.65	110	79.0	512	369
4.72	110	78.2	520	363
4.65	110	78.0	512	376
4.79	110	78.5	526	362
4.60	110	78.6	506	374
4.76	110	78.7	524	364
4.61	110	79.0	507	372
4.71	110	79.0	518	376
4.71	110	78.8	518	375
.469	110	78.9	376	376

BLANK PG.

Angle = -90 to -50	Angle = -40	Angle = -30
Stand =	Stand. = 15.6	Stand. = 15.6
Impossible to obtain readings	11.23	8.55
	12.40	11.65
	10.89	7.85
	8.28	11.75
	10.40	8.67
	12.25	11.22
	12.90	10.72
	11.95	9.90
	9.37	9.10
	10.50	8.97
	110.17	98.38
	A = 11.02	A = 9.84
	c.p. = 11.02 x 15.6 = 172	c.p. = 9.84 x 15.6 = 153

Angle = -20	Angle = -10	Angle = 0
Stand. = 15.6	Stand. = 15.6	Stand. = 25.8
5.63	9.32	4.73
6.30	9.91	6.10
5.73	10.21	3.83
5.93	10.15	4.40
6.30	10.95	4.85
4.78	11.10	5.75
4.55	11.50	5.64
4.22	10.35	6.38
6.90	10.50	6.90
7.25	11.55	7.72
57.59	105.54	55.27
A = 5.76	A = 10.55	A = 5.53
c.p. = 5.76 x 15.6 = 90.0	c.p. = 10.55 x 15.6 = 165	c.p. = 5.53 x 25.8 = 143

Angle = +10	Angle = +20	Angle = +30
Stand. = 25.8	Stand. = 25.8	Stand. = 63
9.8	19.40	7.60
9.5	19.20	7.35
9.1	18.60	7.83
8.95	19.55	7.78
7.16	18.90	8.60
13.20	19.60	8.18
10.08	19.35	8.60
9.00	19.70	9.25
7.88	19.70	8.90
8.85	19.10	9.60
94.52	193.10	836.9
A = 9.45	A = 19.31	A = 83.7
c.p. = 9.45 × 25.8 = 244	c.p. = 19.31 × 25.8 = 498	c.p. = 83.7 × 63 = 527

Angle = +40	Angle = +50	Angle = +60
Stand = 63	Stand = 63	Stand = 63
6.15	11.10	8.10
6.10	10.88	9.80
6.50	10.80	9.23
9.30	10.47	10.10
8.75	11.20	7.50
7.95	10.90	9.25
7.20	11.80	9.55
9.75	11.80	9.90
8.10	12.10	9.80
7.85	11.85	9.65
77.65	112.90	92.58
A = 7.77	A = 11.29	A = 9.26
c.p. = 7.77 x 63 = 490	c.p. = 11.3 x 63 = 712	c.p. = 9.26 x 63 = 583

Angle = +70	Angle = +80	Angle = +90
Stand = 2.6	Stand = 2.6	Stand =
6.61	8.80	Impossible
7.08	7.60	to obtain
9.45	6.90	readings
8.90	7.15	
8.75	7.25	
9.00	7.43	
7.90	7.43	
8.25	6.83	
8.05	5.48	
7.93	5.60	
81.92	70.47	
A = 8.19	A = 7.05	
c/p. = 8.19 × 2.6 = 21.3	c/p. = 7.05 × 2.6 = 18.3	

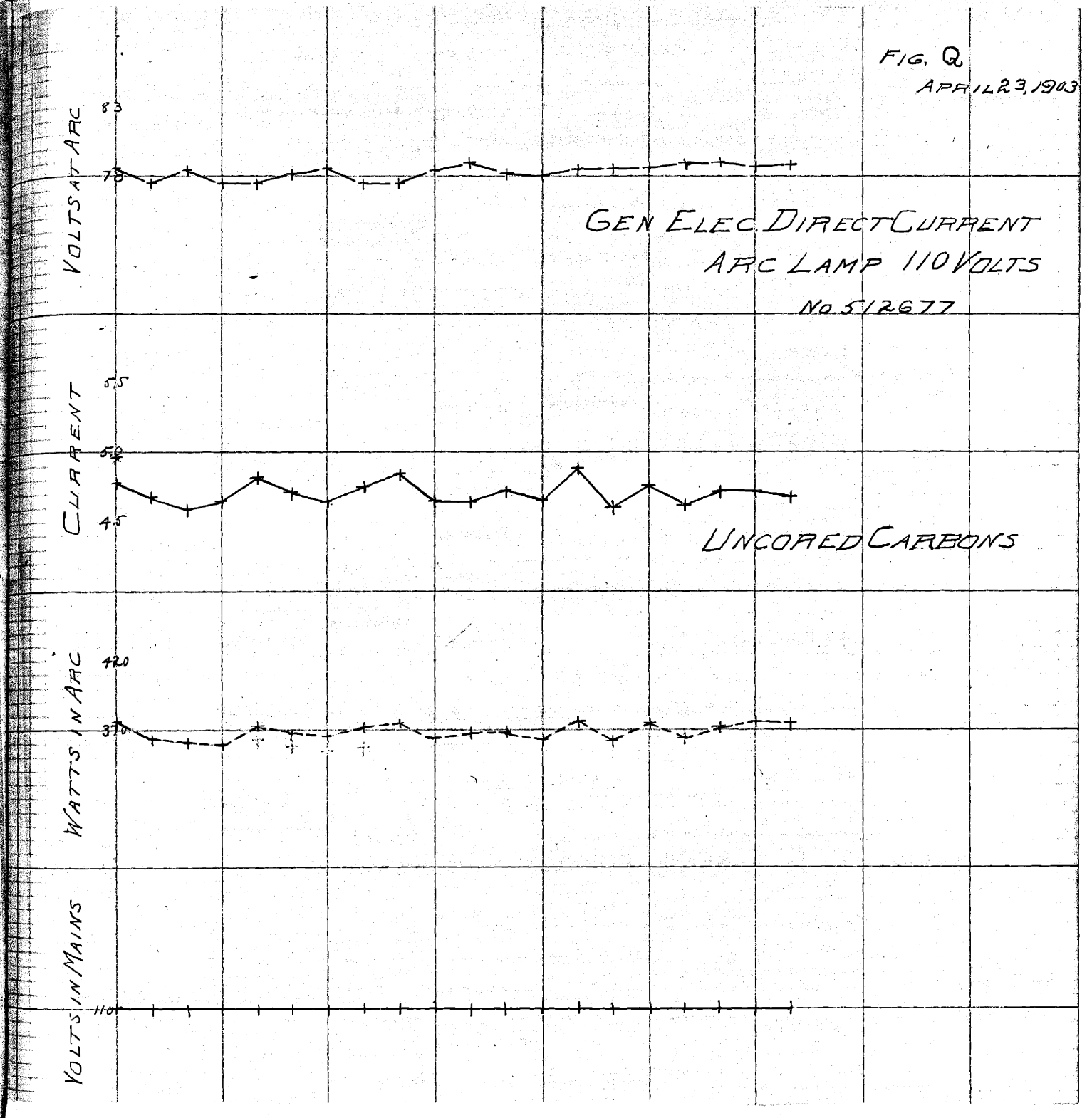


FIG. Q
APRIL 23, 1903
GEN ELEC. DIRECT CURRENT
ARC LAMP 110 VOLTS
No. 5/2677
UNCORED CARBONS
VOLTS AT ARC
83
78
CURRENT
5.5
5.0
4.5
WATTS IN ARC
420
370
VOLTS IN MAINS
110

F. L. R.

APRIL, 1903.

GEN. ELECT DIRECT CURRENT ARC LAMP

NO. 512677

UNCORED CARBONS.

AREA = 9.05 SQ. IN.

M. S. Intens. = 308 c.p.

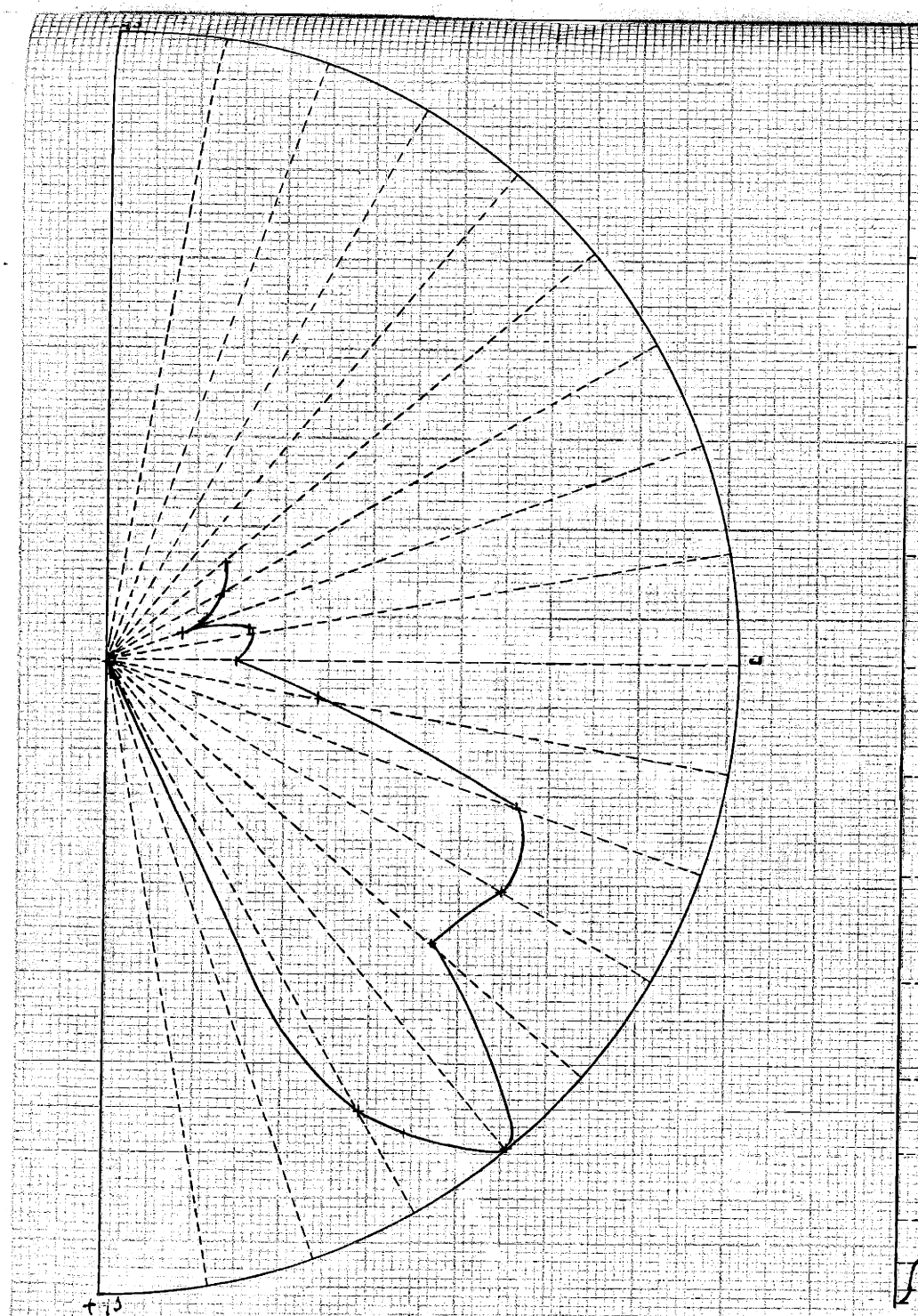
$Eff = \frac{360}{308} = 1.17$ watts per candle

Hemispherical

AREA = 7.34 sq. in.

M. H. Intens. = 413 c.p.

$Eff = \frac{368}{413} = .89$ watts per candle



Test on
Midget Arc Lamp —
110 D.C
Manufactured by Upton Electric
Co.

Cored Carbons
Upper carbon 12" x 1/2"
Lower carbon 5" x 1/2"
Enclosing globe 1 1/2 x 1 5/8" x 6"

I	E(mains)	E(arc)	W(mains)	W(arc)
8.20	105	55	861	450
8.15	105	55	856	448
8.20	105	55	861	450
8.50	105	55	893	468
8.30	105	55	872	456
8.25	105	55	866	453
8.60	105	55	903	473
8.60	105	55	903	473
8.70	105	55	914	478
8.20	105	55	861	450
9.00	105	55	945	495
8.50	105	55	883	468
8.50	105	55	883	468
8.35	105	55	876	459
8.10	105	55	857	449
8.30	105	55	872	456
8.25	105	55	867	454
8.20	105	55	861	450
8.30	105	55	872	456
8.30	105	55	872	456

Angle = 0	Angle = +10	Angle = +20
Stand = 25.8	Stand = 25.8	Stand = 25.8
4.34	5.22	7.38
4.36	5.22	8.54
4.39	7.10	8.36
3.88	5.02	6.17
5.40	5.57	7.32
4.70	5.33	7.24
4.87	4.73	6.62
4.57	4.78	8.57
4.05	5.48	8.59
	5.27	9.15
40.56	53.72	78.94
A = 4.06	A = 5.37	A = 7.89
c.p. = 4.06 × 25.8 = 105	c.p. = 5.37 × 25.8 = 139	c.p. = 7.89 × 25.1 = 204

Angle = +30	Angle = +40	Angle = +50
Stand. = 25.8	Stand. = 25.8	Stand. = 25.8
17.70	16.50	10.75
10.74	17.20	10.74
10.98	16.30	10.75
14.20	17.00	10.75
10.62	16.10	10.75
15.62	17.00	10.74
11.74	16.30	10.75
10.52	16.70	10.75
10.50	16.90	10.75
14.10	16.70	10.75
126.72	166.70	107.88
A = 12.67	A = 16.67	A = 10.79
c.p. = 12.67 × 25.8 = 328	c.p. = 16.7 × 25.8 = 431	c.p. = 10.79 × 25.7 = 278

Angle = +60	Angle = +70	Angle
Stand. = 25.8	Stand. = 25.8	Stand = 2.6
4.84	13.70	12.24
5.84	10.20	11.20
3.15	10.30	11.80
2.98	3.07	17.70
3.98	8.55	14.78
2.95	7.38	6.71
16.00	6.54	18.00
17.70	12.62	12.70
10.18	12.45	11.60
17.60	12.49	11.92
45.22	97.27	128.65
A = 4.52	A = 9.73	A = 12.87
c.f. = 4.52 × 25.8 = 117	c.f. = 9.73 × 25.8 = 251	c.f. = 12.87 × 2.6 = 33.6

Angle = +90
Slant = 2.6
10.20
10.20
10.20
10.20
10.20
10.20
10.20
10.20
10.20
10.20
102.00
A = 10.20
c/s. = 10.2 x 2.6 = 26.5

FIG. 8

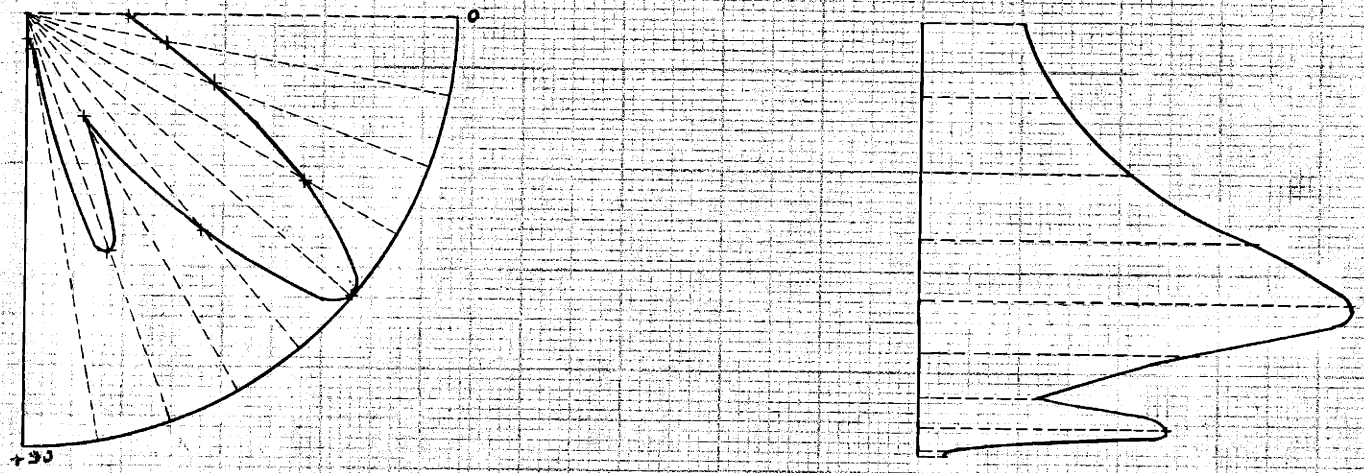
APRIL 24, 1903

Fig. 7

APRIL 1903

MIDGET DIRECT CURRENT ARC LAMP

CORED CARBONS



Hemispherical

Area = 2.51 sq in.

M.L.H. Intens. = 231 C.P.

$Eff. = \frac{461}{231} = 3.11$ watts per candle

Test on
Midget Arc Lamp.
110° D.C.

See page

I	E(main)	E(arc)	W(main)	W(arc)
8.59	106.5	40.5	915	431
8.62	106.4	45.5	917	484
8.60	106.4	40.5	915	431
8.59	106.6	41.0	915	437
8.72	106.5	39.5	928	421
8.72	106.4	42.5	928	452
8.72	106.6	41.2	929	439
8.80	106.5	38.5	937	410
8.72	106.4	42.2	928	450
8.72	106.5	47.8	929	510
8.72	106.3	48.0	927	511
9.02	106.4	48.0	960	511
8.90	106.4	48.8	947	519
8.95	106.4	48.7	953	519
8.92	106.5	49.2	950	508
8.87	106.5	48.0	945	524
8.75	106.2	48.1	930	512
8.70	106.2	48.0	925	511
8.90	106.0	47.8	944	507
9.02	106.2	47.9	959	510

Ang. = 0	Angle = +10	Angle = +20
Stand. = 15.6	Stand. = 15.6	Stand. = 15.6
4.53	6.42	12.70
4.48	6.30	9.70
4.50	6.48	14.50
4.65	6.52	14.50
5.95	6.57	14.72
5.45	6.51	9.75
5.45	6.57	9.85
5.25	6.61	8.80
5.25	6.58	15.00
5.25	6.60	9.25
50.76	65.16	118.17
A = 5.08	A = 6.52	A = 11.82
c.p. = 5.08 × 15.6 = 79.4	c.p. = 6.52 × 15.6 = 102	c.p. = 11.82 × 15.6 = 184

Angle = +30	Angle = +40	Angle = +50
Plant. = 25.8	Plant. = 25.8	Plant = 5.1.1
15.00	20.50	12.65
14.40	18.70	13.20
14.35	20.30	15.30
14.95	19.70	10.60
14.50	20.00	12.50
15.70	19.50	14.10
12.35	20.25	14.70
13.25	20.10	14.50
14.10	21.90	12.35
14.80	17.50	12.65
143.40	199.05	132.55
A = 14.34	A = 19.91	A = 13.26
c.p. = 14.3 x 25.8 = 370	c.p. = 19.91 x 25.8 = 514	c.p. = 13.3 x 51.1 = 680

Angle = +60	Angle = +70	Angle = +80
Stand. = 51.1	Stand = 25.8	Stand = 2.6
12.60	3.85	6.25
10.45	3.43	5.10
8.75	17.80	4.65
9.30	2.82	5.68
9.75	19.35	3.62
11.35	2.58	3.45
11.95	3.78	5.90
8.30	7.48	7.32
9.30	15.50	4.20
11.00	11.90	15.58
102.75	92.49	49.17
A = 10.28	A = 9.25	A = 4.92
c.f. = 10.28 x 51.1 = 527	c.f. = 9.25 x 25.8 = 239	c.f. = 4.92 x 2.6 = 12.8

Angle = +90
Stand = 2.6
5.50
7.60
2.35
2.82
7.85
8.10
2.35
2.93
4.21
4.90
48.62
A = 4.96
c.f. = 4.96 x 2.6 = 12.6

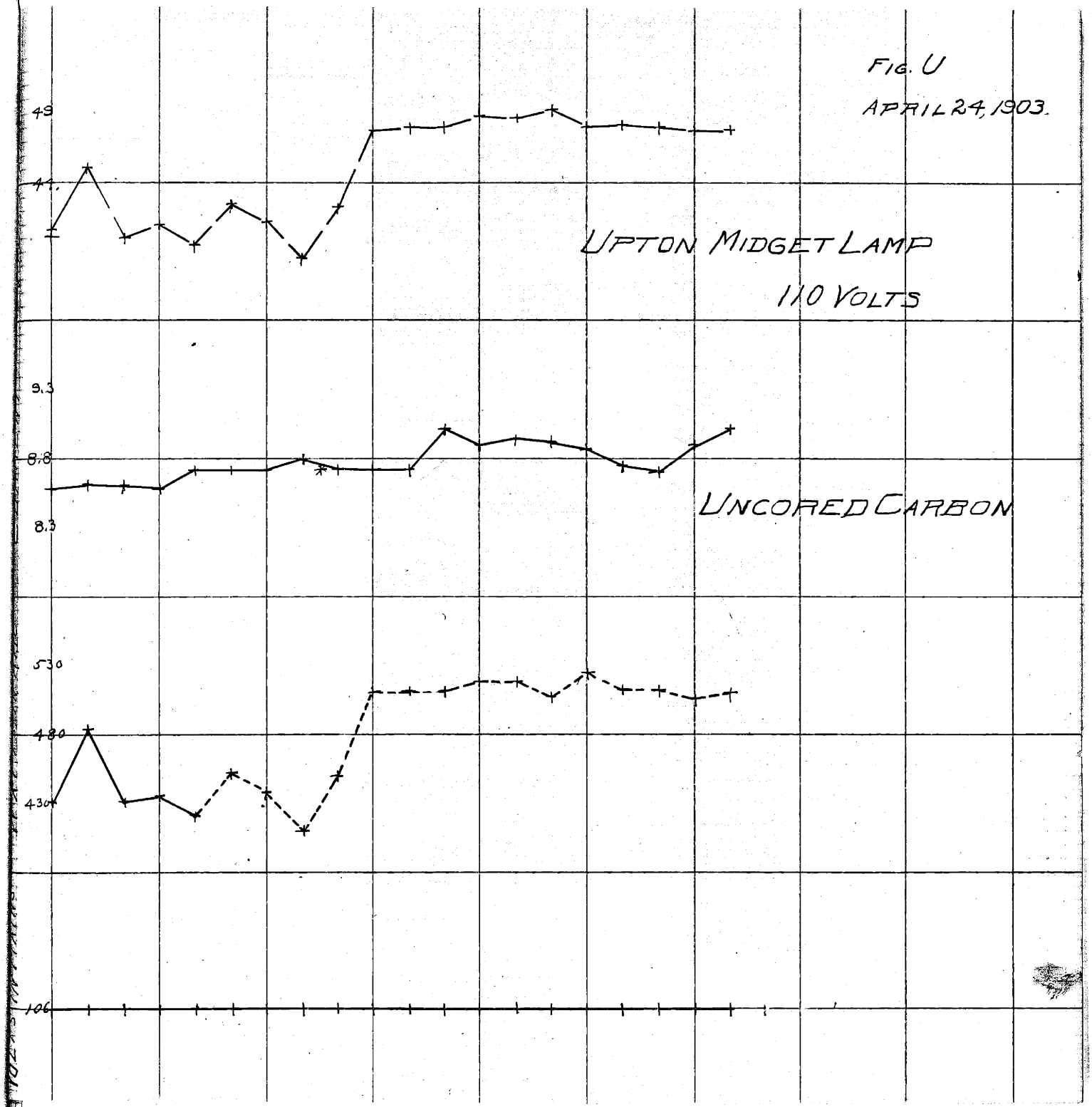


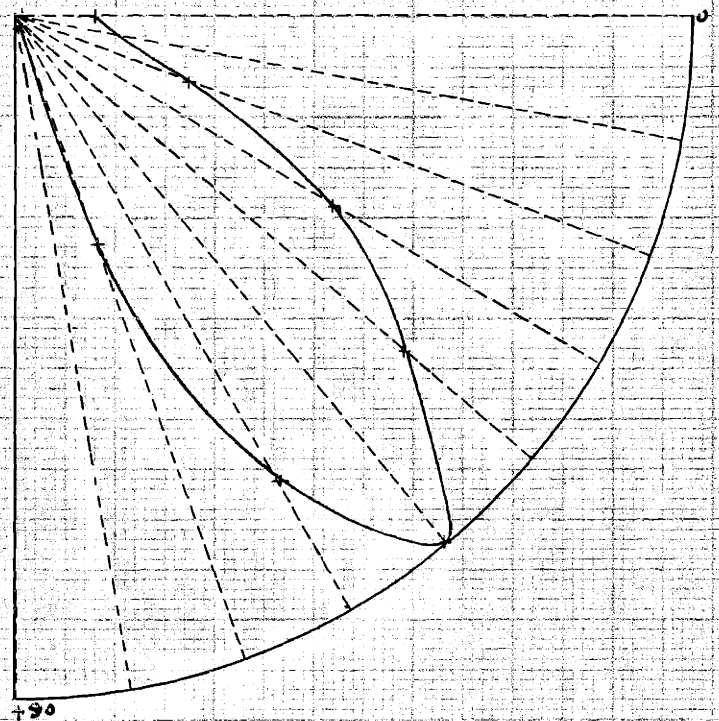
FIG. U
APRIL 24, 1903.
49
44.
UPTON MIDGET LAMP
110 VOLTS
9.3
8.8
8.3
UNCORED CARBON
530
480
430
106

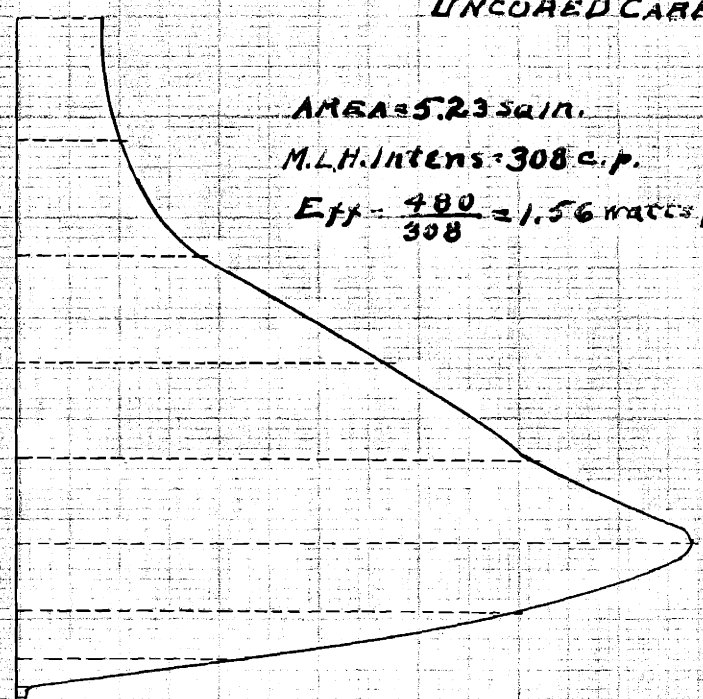
Fig. V

APRIL, 1903

MIDGET DIRECT CURRENT ARC LAMP

UNCORED CARBONS





AREA = 5.23 sq in.

M.L.H. Intens = 308 c.p.

$$Eff = \frac{480}{308} = 1.56 \text{ watts per candle}$$

Having now finished this series of tests, what conclusions can be drawn as to preference in the use of coated and uncoated carbons? The aim in the use of the coated carbon, is to steady the light by holding the arc in one position. None of our observations throughout this investigation go to show that it fulfills this aim, — indeed the observations go to show that it does not fulfil it, and that the arc "travels" even worse than it does with the use of the uncoated carbon. Careful investigation seems to show that the cause of this is, that the soft core is soon

burned away, and the arc finding a shorter path in some other place, begins to "travel." The deposit of gray dust, due to the volatization of the carbon, was noted to be far in excess of that deposited by the uncored carbon, the previously, transparent enclosing globe having, at the end of some hrs, an almost opal appearance. The uncored carbon gives a much greater mean spherical and lower mean hemispherical candlepower, and a greater mean lower hemispherical efficiency. The only place the cored carbon showed any thing but a disadvantage over the uncored, was in the mean spherical efficiency, and the

advantage there is more than off-set by the fact that the cored carbons burn out much more rapidly, and require more attention.

As regards, now, the question as to whether or not the enclosed arc lamp can be reliably rated upon a photometrical basis, we would say that it can be as reliably rated by this means as by any other, provided, (1) that the lamp be "stripped" as in these tests; (2) that a sufficiently extended and carefully taken set of photometer readings be observed; and (3) that the rating include all the detailed observations of the test. A mere reading of the tests just presented, shows the

importance of including all these provisions. It is true that the method is open to serious criticism and dissatisfaction, but so are they all, and it seems to us that such a rating presents a fair, reasonable, and general idea of what a bank can do.

— The end. —