The Colors of Our Common Lights.

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Although many forms of Photometers have been devised within the last hundred years, little has been done towards measuring the brilliancy of our brighter lights, and nothing so far as I am aware towards determining their colors. With these two objects and especially the latter one in view, I have written this article.

That the measurement must finally be made with a Spectroscope was clear; but the first difficulty was to obtain a steady light, of which the ratio of the component colors should be constant, for use as a standard. I first thought of using a brass crucible with a flat platinum side, in front of which was to be placed a diaphragm. The crucible was to be filled with some salt which should be kept just at the melting point.

A constant heat would thus be obtained, and hence a constant light. I soon found that in order to obtain a sufficiently high temperature, a crucible composed wholly of platinum must be adopted. Theoretically the same amount of light would be given out in any direction by a curved surface, as by a flat one; but I soon found that at the very edges, the curved surface was noticeably more brilliant than in the middle. That this effect was not due to contrast, was shown by placing a brilliant background behind the crucible, when if the contrast produced any effect at all, it should have been the other way. But no change in the result was noticeable. Now the opacity of the atmosphere surrounding the sun has been calculated on the supposition that the theoretical rule was correct; hence if incorrect, it is clear that the value so obtained must be somewhat increased. By using a small diaphragm in front of my crucible, a practically uniform light was obtained. The temperature was increased by surrounding the crucible with a clay muffle and using a blast-lamp.

The next thing was to find a suitable salt, which would not be decomposed at the high temperature, and which would have a suitable melting point. To this end I tried successively $NaCl$, $CaCl_2$, Na_2SO_4, $CaSO_4$, $CaFl_2$, $BaCl_2$, three different slags, and finally some metallic silver in a porcelain crucible. Below I give the salts in the order of their melting points beginning at the lowest, estimating from the ease with which fusion took place. $BaCl_2$, $NaCl$, $CaCl_2$, Na_2SO_4, $CaFl_2$, $CaSO_4$. I could not fuse the $CaSO_4$ at all. The $CaFl_2$ fused somewhat, and slightly attacked the crucible. The salt which best answered my purpose was Na_2SO_4, and I accordingly experimented with it at length. There was no difficulty in keeping it just at the melting point, and on one occasion I did so without any readjustment for a full half hour. The method adopted was to keep a solid cake of it floating in the melted salt. But after three or four successive fusions and coolings, I noticed my crucible began to leak, and on examination found that a vertical rent had been torn in the platinum, owing to the crystalization of the salt during cooling. At the same time a quantity of it was reduced, (though I had only used the oxidizing flame) to Na_2S. In previous fusions no perceptible reduction had been noticed. I had the crucible soldered with gold, but found that its melting point was about the same, or slightly lower than that of the Na_2SO_4. The fusing point of gold is usually stated at about 1250°C. I thus obtained an approximation to the fusing point of the salt. I next constructed a small crucible out of platinum foil. I could heat this very rapidly and strongly, but the difficulty I had feared was realized, in as much as I found it nearly impossible to keep its temperature constant. I now turned my attention to melting silver in a porcelain crucible. It melts at 1000°C approximately and I should judge at about the same temperature as NaCl. The specific heat is so small however, that I found it next to impossible to keep it at a constant temperature, and had to abandon it. Having spent two months out of the three on this single branch, I therefore deferred further experiment until some future time, and devoted my remaining month to measurements of the component colors of the various artificial lights, and other matters pertaining thereto.

It remained for me now to select my standard from the various artificial lights at my disposal. The first one to suggest itself was naturally the standard candle, but a very few experiments sufficed to show that it would not do; and I have since found that of all the lights examined by me, including the Sun, Lime, Magnesium and Electric, none was so uncertain in its color as the standard candle. I tried using a diaphragm in front of it, but the flame was too small. I next tried a lard oil lamp, with a flat half inch wick, but even this flame was not large enough. I think however that if a large enough wick could be used, say an inch across, that such a lamp burning either lard oil, or a mixture of turpentine and alcohol as suggested by Dr. Crookes, and having a diaphragm placed in front of the flame, might give an exceedingly constant light, particularly if a platinum wick were employed.

The Standard I finally adopted was the Gas flame from an Argand burner, using about 5 cu. ft. per hour. A diaphragm ·568 cm. in diameter, and having an area of ·253 cm^2, was placed over the most brilliant portion of the flame. A standard was thus obtained, which would be almost absolutely constant in both light, and color, during any one set of experiments, (one set usually occupied about an hour), and which I judge from subsequent experiments would vary very little even in the course of a month. The candle power of the whole flame when burning 5 ft^3 per hour is about 16.0 that of my Standard ·67.

Having obtained a satisfactory light, the next step was to get an instrument by means of which the various lights to be measured could conveniently be compared. For this purpose I use an ordinary double-slit-spectroscope, furnished with a grating, having the lines (6480 to the inch) photographed on glass. In front of the slits were placed two right-angled prisms, arranged to reflect the light in from opposite directions. On looking through the instrument the two spectra will be seen one right above the other, and by means of two sliding metal plates, placed at the focus of the telescope, the spectra may be cut down so that only a narrow vertical strip of each shall be visible.

The Standard light is fastened upon a little car, rolling upon a track over a fixed scale, by means of which its distance from the slit is measured. The light to be compared is placed at a known distance on the other side of the slit; the telescope is pointed on some particular color, and the Standard moved backwards or forwards till the two spectra are of the same brilliancy. The distance is then read off on the scale. In measuring the red and violet ends, I usually find it necessary to place the light to be measured nearer to the slit than for the other colors. The "Standard" slit was kept at a constant breadth of ·056 mm. through all the experiments, and the light could be moved from it through a distance of from 10 to 60 cms. It was found however that it was generally better not to place the Standard nearer than 15 cms. It will be noticed that the slits are generally kept quite narrow, as it was found that greater accuracy could be attained when the colors were rather faint. Four points in the spectrum were selected for observation, and from these the intervening portions were to be interpolated. These points were equidistant, and were situated one in the red, one in the yellow, one in the green, and one in the violet; or to speak more accurately, in the neighborhood of the lines C, D, and E, and at a point between F and G. They will be designated hereafter by the letters R, Y, G, and V.

I give below my observations on the Lime light in full, as a fair example of the accuracy of the instrument, and of the method I employ. It will be seen that the first two figures only, are of value, the third being used merely for obtaining the mean results. In all my experiments, I divide my observations into two sets, which are made at different times, and the light extinguished between whiles. Each set is divided into four series, one for each color, and each series consists of at least three, and frequently more observations; thus making at least twenty-four observations on each light. The means of the series are then taken, and compared two and two, and their means obtained. From these last the relative brilliancies as compared with the Standard are calculated, and plotted as a curve. (See Plate I.)

The Lime Light.

Bredth of Slit .011 mm.

Dist: to Slit 1.5 m.		Dist: to Slit 3.0 m.	
R	Y	G	V
21.2	38.8	39.2	21.3
26.9	39.4	36.4	25.7
25.9	35.0	34.2	23.4
3 | 74.0	3 | 23.2	3 | 19.8	3 | 10.4
3 | 24.7	3 | 37.7	3 | 36.6	3 | 23.5
8.2	12.6	12.2	7.8
2			
16.4			

2nd Set.

Dist. to Slit 1.5 m. Dist. to Slit 3.0 m.

R	Y	G	V
28.1	42.1	36.5	21.2
21.3	33.2	38.2	25.9
30.2	41.1	36.2	17.6
22.9	45.9		26.9
29.6	4 2.3	3 20.9	4 11.6
25.3	3 40.6	3 37.0	3 22.9
6 37.4	13.5	12.3	7.6
3 26.2			
8.7			
2			
17.4			

Mean Scale Readings of both Sets.

R	Y	G	V
16.4	12.6	12.2	7.8
17.4	13.5	12.3	7.6
16.9	13.0	12.2	7.7

Relative Brilliancies.

R $16.9^2 = 28561$ recip $= 3501$ $\propto$ 59
Y $13.0^2 = 16900$ " $= 5917$ 100
G $12.2^2 = 14884$ " $= 6718$ 113
V $7.7^2 = 5929$ " $= 16866$ 285

After measuring the brightness, I observe the limits of the spectrum under two different brilliancies, and the very curious effect was noticed, that while the red end ~~of~~ under the increased illumination advanced considerably, — in the present instance 27', the violet did not move at all. The same effect is noticeable in all the lights to a greater or less extent, the violet usually moving from 1' to 3'. This is probably accounted for by the fact, that the fluids of the eye absorb nearly all the rays of short wave length, thus cutting off all the spectra at nearly the same place. The position of the red end on the other hand depends merely on the intensity of the light.

Limit of the Spectrum.

Dist: 1.5 m. Slit .2 mm.		Dist 1.0 m. Slit .4 mm	
R	V	R	V
41° 55'	37° 23'	42° 24'	37° 24'
56	23	24	24
54	24	18	21
41° 55'	37° 23'	42° 22'	37° 23'

These figures do not represent the deviation of the ray, but merely the numbering on my divided circle. Reducing them to wave lengths we obtain:–

R	V	Slit:	Dist.
709	414	.2 mm	1.5 m.
740	414	.4 mm	1.0 m.
31	0	Advanced.	

I next measure the total brilliancy of the light in Candle powers. In the present case I made two determinations, one at the end of each set. These measurements were made with a Bunsen Photometer, As the arrangement of the scale in this instance was somewhat complicated and the form of the observations is well known, I will merely state the results in the two instances as 90 and 84 candle power. I have since measured the light, and obtained a maximum brilliancy of 231 c.p. And from this by varying the supply of gas, and the distance of the Lime from the burner, the light could be diminished gradually to any extent.

The Intrinsic brilliancy is then obtained, by placing a diaphragm of known size over the light and remeasuring. As no good standard of intrinsic brilliancy exists, I adopt for the present purpose the light given off by my "Standard", at a distance of 1 meter. This is about .67 of a candle power at the same distance. When at a maximum, I found the intrinsic brilliancy of the Lime 121 St. When the total light was 90 c.p. the intrinsic was 54 St.

Probable Error. Using a perfectly invariable light, I find the Mean Probable Error of six observations for the different colors to be;- Red 6.7% Yellow 3.4% Green 2.4% Violet 6.1%. These figures may seem pretty large, but when we consider that in most of the lights, the chief discrepancies were caused not by instrumental errors, but by differences of color, and brilliancy in the lights themselves, we see that it would not be much advantage, to have the instrument more accurate than it is; and that if we are to measure the lights at all, we must be willing to allow some pretty large variations. Moreover the different lights vary from each other frequently by more than 100%, which leaves room for pretty large differences. In fact we find this to be a subject where the magnitudes are of great range; and accuracy such as we are in the habit of obtaining in other branches, is out of the question. The Mean Probable Error of six observations with the Bunsen Photometer on a constant source, varies from .5% under the most favorable circumstances, up to 2 or 3% when less favorable.

Description of Plate I.

On this Plate, each broken line represents some particular light. The abscissae denote wave lengths expressed in .00001 of a mm. The ordinates represent the brilliancies of each color, the unit being the brightness of the "Standard", for that particular wave length. The Standard light is therefore represented by the straight horizontal line St. As observations were taken only at four particular points, we have no means of knowing the shape of the curves outside of these,— they are therefore prolonged as horizontal dotted lines; to the furthest limit at which their spectra could be clearly traced. Each curve is designated by a letter, viz:- St Standard, G Gas, C Candle, L Lime, Mo Moon, E Electric, Mg Magnesium, Su Sun. The line representing Sunlight is not drawn in full for lack of space, but should be carried up to ordinate 29.7 or about five inches and a half above the line where it terminates at present. Its limit is represented by the dotted line at the top of the sheet. The positions of the chief solar lines are also marked for convenience of reference. It will be noticed as a curious fact, that the lines a, C, D, E, a point between F and G and the line H, are almost exactly equidistant; the greatest difference being in the case of C — .9 mm on the present scale. B is just midway between a and C, G midway between the missing line and H. They appear in short something like overtones, but increasing in arithmetical instead of geometrical ratio. Can they thus differ from the fainter lines?

The following lights were measured in the same manner as the Lime, I shall therefore give only a synopsis of my observations on them.

Gas Light.

This is probably the easiest of all the lights to measure, on account of the steadiness and uniformity of its flame. An argand burner was employed, burning about 5 ft.^{3} per hour. It will be seen that it is considerably bluer than the Standard, having 25% more violet in it. This probably comes from the blue part of the flame, which is generally supposed not to give off much light. It has been the custom in constructing gas burners to suppress this portion as much as possible, but it may be that what a flame thus gains in brilliancy it loses in whiteness.

The following Mean Readings were obtained.

R	Y	G	V
14.5	13.1	12.4	9.4
14.0	11.3	11.6	12.4
14.2	12.2	12.0	10.9

Brilliancies.

74	100	103	125

Limits

R	V	Slit	Dist.
690	424	.05 mm	1.4 m
726	426	.40 mm	1.0 m
36	−2	Advanced	

Total brilliancy 16 c.p. Intrinsic 1 st.

"Intrinsic" refers in all cases to the brightest part of the flame.

Standard Candle.

I found this one of the hardest lights to manage. It was necessary to be continually snuffing the wick, otherwise the flame would become too brilliant, and besides which too much red would be introduced. After a little practise however, better results were obtained, and when calculated the curve followed very closely that of the Gas flame. See Plate I.

Mean Readings.

R	Y	G	V
20.5	17.9	16.5	19.2
22.5	19.0	19.6	12.6
21.5	18.4	18.0	15.9

Brilliancies.

73	100	104	134

Limits.

R	V	Slit	Dist.
677	432	.2 mm	1.0 m
691	429	.4 mm	.7 m
14	3	Advanced	

Total Brilliancy 1 c.p. Intrinsic 1 st.

Lime Light

This was the next flame measured and has already been refered to. It is very steady and uniform and comparatively easy to measure.

Magnesium Light.

This was obtained by burning two coils of wire simultaneously, in a lantern adapted for that purpose. The coils weighed together 56 gms, and burned at the rate of ·37 gms per. minute, and would therefore last without renewal for about two hours and a half. Three bright lines were visible in the spectrum, namely D, b, and a line which would come about half way between b and F. These lines fortunately did not come into the field of view in either of my measurements, but would be represented on the curves in Plate I by long vertical lines drawn at these points. The light itself had a very curious appearance when viewed through colored glass. It was the shape of a broad inverted candle flame, wavering from side to side, and sometimes splitting in two for nearly its whole length. There seemed to be no real flame, but a brilliant striated structure, from which poured up clouds of smoke. The flickering did not annoy me as much as I had expected in my measurements, but was most noticeable in the red. The limits however varied considerably, so I took their maximum position.

Mean Scale Readings.

R	Y	G	V
473	310	229	100
295	362	222	100
384	336	225	100

The second Red was clearly wrong, it was therefore discarded and the first only used.

Brilliancies.

R	Y	G	V
50	100	223	1129

The well known blueness of the flame is clearly accounted for by the great quantity of violet rays present.

Limits.

R	V	Slit	Dist.
695	411	.03 mm	1.0 m
715	408	.04 mm	1.0 m
20	3	Advanced.	

Total brilliancy 215 c.p Intrinsic 20.8 st.

Electric Light.

The light was obtained from a Duboscq Lantern, using 40 Grove Cells. Six observations were made in each series, instead of three as in the case of the other lights. The intrinsic brilliancy of both the arc and the carbons was measured. I found the arc to be much fainter, and to vary considerably, while the carbons remained quite constant. I imagine the latter to give the boiling point of carbon at the pressure of the air. If the pressure were increased, it is possible the light might thus be rendered more intense. If a more powerful current had been used, I think the intrinsic brilliancy of the arc might have increased a little, but the chief difference would have been in its area and that of the ingnited carbons.

Mean Scale Readings.

R	Y	G	V
192	178	151	68
238	144	155	57
215	161	153	62

The second yellow was here discarded as obviously incorrect.

Brilliancies.

R	Y	G	V
61	100	121	735

Limits.

R	V	Slit	Dist.
697	411	.100 mm	1.5 m.
735	411	.197 mm	1.0 m.
38	0	Advanced	

Total brilliancy. 362 c.p. Intrinsic. Carbons 3741,
Arc 645.

Moonlight.

On account of interruption by clouds, the observations are not quite so satisfactory as some of the preceeding ones. Only one series was made on the violet. The Moon was just 10 days old, and the observations lasted from 9 to 10 P.M. Altitude 44°.

Mean Scale Readings.

R	Y	G	V
440	461	326	242
550	588	415	
	565		
495	538	370	242

It would seem as if the last two yellows were too faint. They were discarded.

Brilliancies.

R	Y	G	V
87	100	155	363

It will be noticed that of all the violet-rays sent out by the sun, very few are reflected from the moon, (See Plate I); and that the proportion of red rays is quite large; indicating that the surface might partake somewhat of that color, — perhaps like brown lava. And in this case its reddish appearance during total eclipse, may not be wholly, as heretofore supposed, due to the absorption of the blue from the solar rays by our atmosphere. As is well known, the Moon is not white, but nearly black; this is clearly shown by the small proportion of light reflected — $\frac{\overset{10}{\cancel{1}\cancel{1}}}{1,\cancel{4}\cancel{4}00}$ %.

On account of clouds the limits

of the spectrum were not determined.

The total brilliancy was observed several days later, – the day before full moon. Time 9 P.M. Altitude 20°. Observations were made with both the Bunsen and Rumford Photometers, and are given in full below. Unit-1 of an inch.

Bunsen.		Rumford.
C. side.	M. side.	
883	887	1097
850	892	1133
882	913	1110
956	937	1115
983	906	1125
911	907	1116

Limits.

1002	1043	1190
790	822	996
896	927	1093

Difference.

212	221	204

Candle Power at 1 meter's distance.
Bunsen ·187 Rumford ·124

The observations with the Bunsen were made from both sides of the disc. In those marked C side, I had my head on the side of the candle, in the others it was on the side of the Moon. The two means agree very closely; but it was noticed that when the yellow light of the candle, passed through the oiled paper, the spot almost completely disappeared; on the other hand when it was reflected directly from the surface, the setting was much more difficult to make. This difference was very marked, and an examination of the results, will show that those made on the side of the moon, agree much better than those made on the other side. We shall refer to this point again when we come to the measurements of the Sun. When we came to use the Rumford, we were struck with the fact that the measurements did not at all agree with those made by the Bunsen. They agreed with each other however more nearly than those made by that instrument, and the difference between their limits was less. I then set the screen at the mean of the Bunsen readings, but could not convince myself that the shadows were equally dark. The effect is probably subjective, owing to the great difference of color, and the Bunsen readings are the ones to be relied upon. This would show that the Rumford must never be used to measure lights of different colors, unless the constant error is allowed for. In this case it amounts to 50% of the whole reading.

Sunlight.

My observations on this source were somewhat interfered with by clouds, as though it was generally clear in the mornings, it nearly always clouded up in the afternoons, which latter were the only times the observations could be made. The first R, Y, and G, were obtained at 1 P.M. Altitude of Sun 57°. And the rest between 3.00 and 4.30 P.M. Altitude of sun 30°.

Mean Scale Readings.

R	Y	G	V
592	352	276	54
454	325	186	50
	369	201	88
523	349	221	64

Brilliancies.

R	Y	G	V
45	100	250	2971

The enormous value of the violet as compared with that of the preceding lights is very striking, (See Plate I).

Limits.

The spectroscope was exposed to the full rays of the Sun. The second V. could not be determined on account of the large amount of diffused light admitted.

R	V	Slit
728	395	.030 mm.
742	—	.076 mm.
14	—	Advanced

The total brilliancy of the sun when at an altitude of 25°, I found to be 64700 c.p. at 1 meters distance. Another time when at 40°, I found it 82000. That is it would be equal to about 350000 full moons. To understand this comparison better, we may add that if the whole visible heaven were turned into one extensive full moon, it would give rather less ~~bright~~ than one quarter of the light of the sun. The brilliancy has been stated at 600 000 full moons, but I do not know the authority, nor the accuracy of the method employed.

Intrinsic brilliancy 36 100 st.

These measurements were made with the Bunsen Photometer, and were all observed from the same side of the disc as the sun. Judging from my measurement of the Moon, I had supposed that it would be easier to make my observations from this side, but I was not prepared for the great difference exhibited. From the side of the sun, the spot disappeared nearly as perfectly as when measuring a gas flame, particularly if the line of sight was nearly perpendicular to the disc, and the eye was thrown out of focus for it. From the side of the Gas, the appearance was that of a bright yellow spot on a bright blue background; and the comparison was almost impossible. The varying brilliancy of different parts of the disc was very marked. I took as usual the brightest portion namely the center.

In order to determine the amount of light lost by the Porte Lumière, a reflecting photometer was planned and constructed. A somewhat lengthy series of observations, showed that the light lost with the best plate glass mirrors, 3 mms in thickness, varied from about 17% to 21%; depending on the angle made by the incident and reflected rays. For lack of time I must cut short a description of this instrument and method. The results at present are not wholly satisfactory, excepting as to the general amount of light cut off;

but by a recent improvement, I hope soon to greatly increase the accuracy of the measurements. I believe no passable results have hitherto been attained, and the measurement has only been attempted once or twice. My results are represented in the upper curve Plate II. The abscissae represent the angle of the incident and reflected rays. The left hand ordinates give the percent of light reflected, the right-hand ones the per cent lost.

On the Measurement of High Temperatures by the Spectroscope.

It is a fact of common experience, that as we heat a body to higher and higher temperatures, it becomes brighter, and at the same time whiter, — in other words more violet light is given off. Here then we have a means of determining qualitatively the temperature of any source. Now if we only knew by what law, either the intrinsic brilliancy, or the violet rays increased with the temperature, and knowing at the same time the melting points of some of the metals, we should be able to form some idea of the temperatures not only of the Lime, Electric, and Magnesium lights, but also of the Sun and Fixed Stars.

Three attempts have been made to determine the temperature of the Sun; one by Secchi, supposing the temperature proportional to the radiation of heat, the second founded on Newtons law of cooling, the third dependant on a numerical exponent, determined from the experiments of Dulong and Petit. The first two give a temperature of several million degrees, the third about two thousand. I give below the opinion of four of the most distinguished modern astronomers, three of them having made the Sun their specialty.

Père Secchi says, "As to the absolute value of this temperature, we cannot fix it with certainty: *** Nevertheless, this temperature must be several million degrees of our thermometer, and capable of maintaining all known substances in a state of vapor."

Prof. Newcomb's views. "For the temperature of the photosphere it seems likely that the lower estimates are more nearly right, but the temperature of the interior must be immensely higher".

Prof. Young's views. "As to the temperature of the sun's surface, I have no settled opinion, except that I think it must be much higher than that of the carbon points of the electric light. *** The estimates dependant on Newton's law seem to me manifestly wrong and exaggerated; on the other hand the low estimates of the French physicists seem to me hardly more trustworthy."

Prof. Langley says "The temperature of the sun is, in my view, necessarily much greater than that assigned by the numerous physicists, who maintain it to be comparable with that obtainable in the laboratory furnace; but we cannot assign any upper limit to it, until physics has advanced beyond its present merely empirical rules connecting emission and temperature."

Now we know from the experiments of Prof. Draper and others, that as the temperature rises, the light increases much more rapidly than the heat; and let is suppose that this law holds good up to the temperature of the Sun. Since we do not know any terrestrial high temperature with certainty, great accuracy is manifestly out of the question. Silver melts at about 1000° C. Many determinations of the melting point of Platinum have been made, which give it in the neighborhood of 2000° C. The temperature of the Electric arc has been estimated between 3000° and 4000° C let us say 3500°. The intrinsic brilliancy of the carbons of the electric light we found to be 3141, that of the Sun 36100. This was determined at an altitude of 25°, let us suppose our atmosphere removed and double it, obtaining 72000. It was shown by my brother Prof. Pickering, that only about one fourth the light from the center of the sun's disc reached the earth. We will therefore multiply its brilliancy by 4, obtaining 288000. Divide by the intrinsic brilliance of the electric light (3141), and we find the sun to be 90 times as brilliant. Then the heat can certainly not be more than 90 times as great, and is probably much less. 90(3500-600)+500 = 270,500 ~~90 × 3500° = 315000°~~ C. We would thus bring down our upper limit from several millions to about 300000°.

Now as to the lower limit. The temperature of the hottest blast furnaces is about 2000°C or about that of the Lime light. That the sun is far hotter than this or even than the Electric or Magnesium light is manifest by an examination of the curves in Plate I. On observing the spectrum of my melted silver, I found that it just about reached to the violet rays. Here then was one point. If an exceedingly fine platinum wire, be placed in the blowpipe flame of the Lime light, using oxygen and

× Error.

coal gas it will not melt; but a slight additional temperature, produced by heating the gases and using a muffle will melt it.× Here then was a second point, and the before mentioned temperature of the Electric arc was the third. Now let us plot these three points, for three are enough to give an idea of a curve. On Plate II, lower figure, the unit of abscissae is 1000° C, the ordinates are the same as in Plate I, but reduced to half size. And we find the three points all in a straight line! If the temperatures we adopted were correct, this would give us a very simple empirical law, viz:— *The temperature is always proportional to some function of the ratio of the wave lengths. For artificial sources, for the wave lengths* 5-85 *and* 45-5 *it varies directly as this ratio*. Supposing this law to be uniformly true, the temperature of the Sun would be ~~16800~~ 11 000°C. But from a comparison of the experiments of Dr. Vogel, and Prof. Pickering, it would seem that the sun's atmosphere absorbs a much larger proportion of the violet rays, than it does of the yellow. We know this to be the case with our atmosphere, therefore let us double the temperature, and I think this would be a very fair allowance.

Therefore the temperature of the Sun is approximately ~~35~~ 22 000°C.

This amount is we notice considerably within the limits we had previously set.

The temperature of the Magnesium light, perhaps the highest terrestrial temperature we have yet attained, would be 4,900°C, as shown by Plate II.

Its small intrinsic brilliancy is readily accounted for, when we recollect that this depends on the area of the ignited solid matter, and that this in the case of the Magnesium light consists almost wholly of the impalpable oxide which forms the smoke. It is perhaps unnecessary to add, that the above mentioned law of the increase of the violet rays, is inapplicable to flames like the blue part of the gas flame, where no solid matter is introduced. It probably applys in a modified form to line flames, as witness the disappearance of the blue line in the strontium spectrum, at low temperatures.

That there is still considerable doubt in regard to the temperature of the Sun, arises from three unsettled points. 1st: The astronomical question of the absorption of the sun's and earth's atmospheres for the different colored rays. 2nd. The physical question of the determination of some fixed high terrestrial temperatures. 3d. The confirmation of the above mentioned law. The 1st and 3d questions I hope to partially solve, by observations on melting wires of platinum, gold, silver, and copper, & by means of a new form of instrument I have recently devised, and which will be much more convenient to use. When these three questions are finally settled, it would seem as if there would be no especial difficulty in measuring the solar, and high terrestrial temperatures, with a considerable degree of accuracy.

Note. From a recently discovered method, dependant on the intrinsic brilliancies, it would seem likely that the Sun's temperature lies between 6000° and 40000° C. This would be an additional confirmation.

Respectfully Submitted, by

W. H. Pickering.

Books of Reference.

Popular Astronomy. S. Newcomb.

Proceedings of the Amer. Acad. of Arts an Sciences, "On the light absorbed by the atmosphere of the Sun." E. C. Pickering and D. P. Strange.

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Scientific Memoirs. J. W. Draper.

Index.

Those points which to the best of my knowledge are new, are followed by a number in parenthesis.

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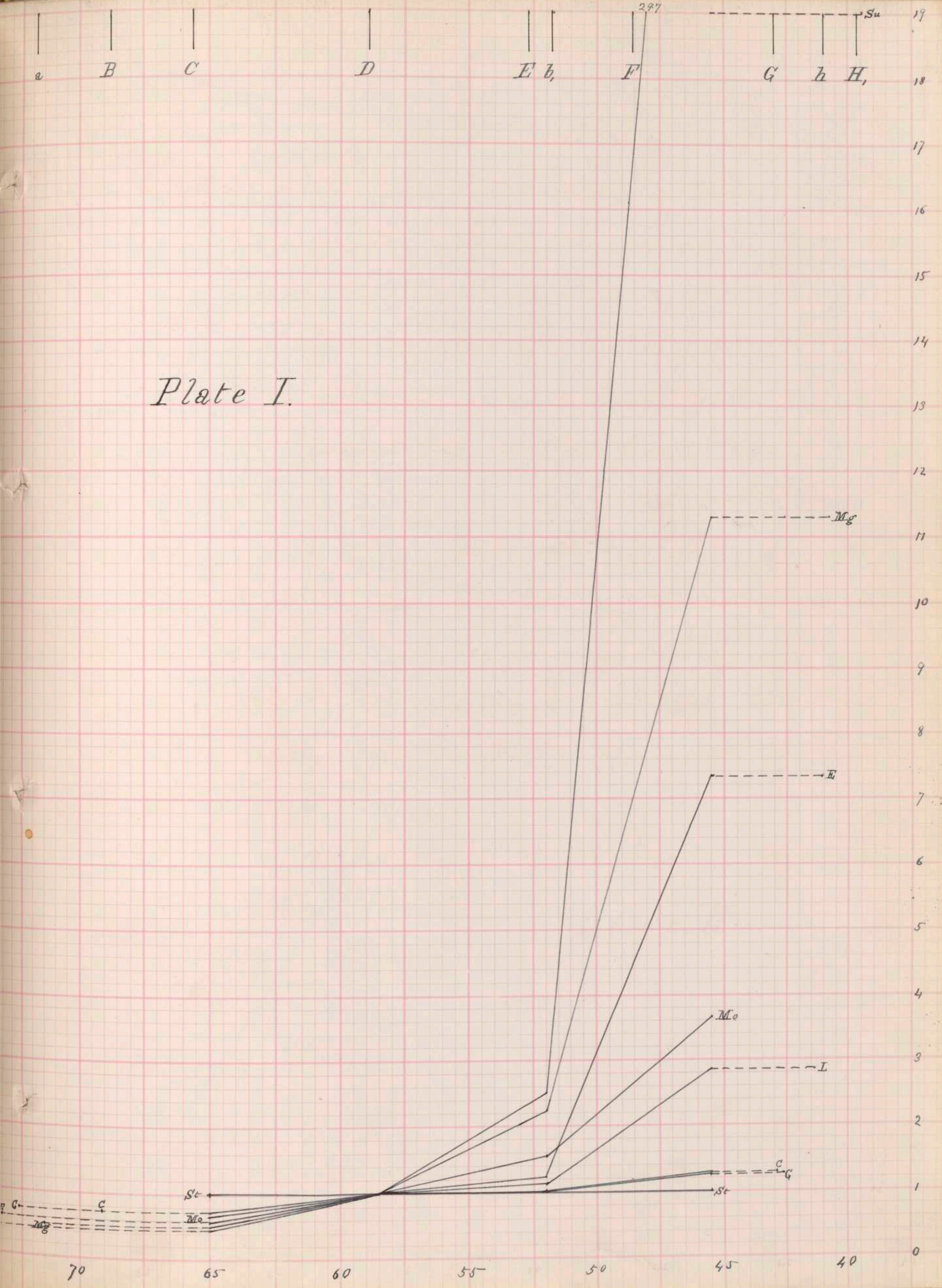
Plate I.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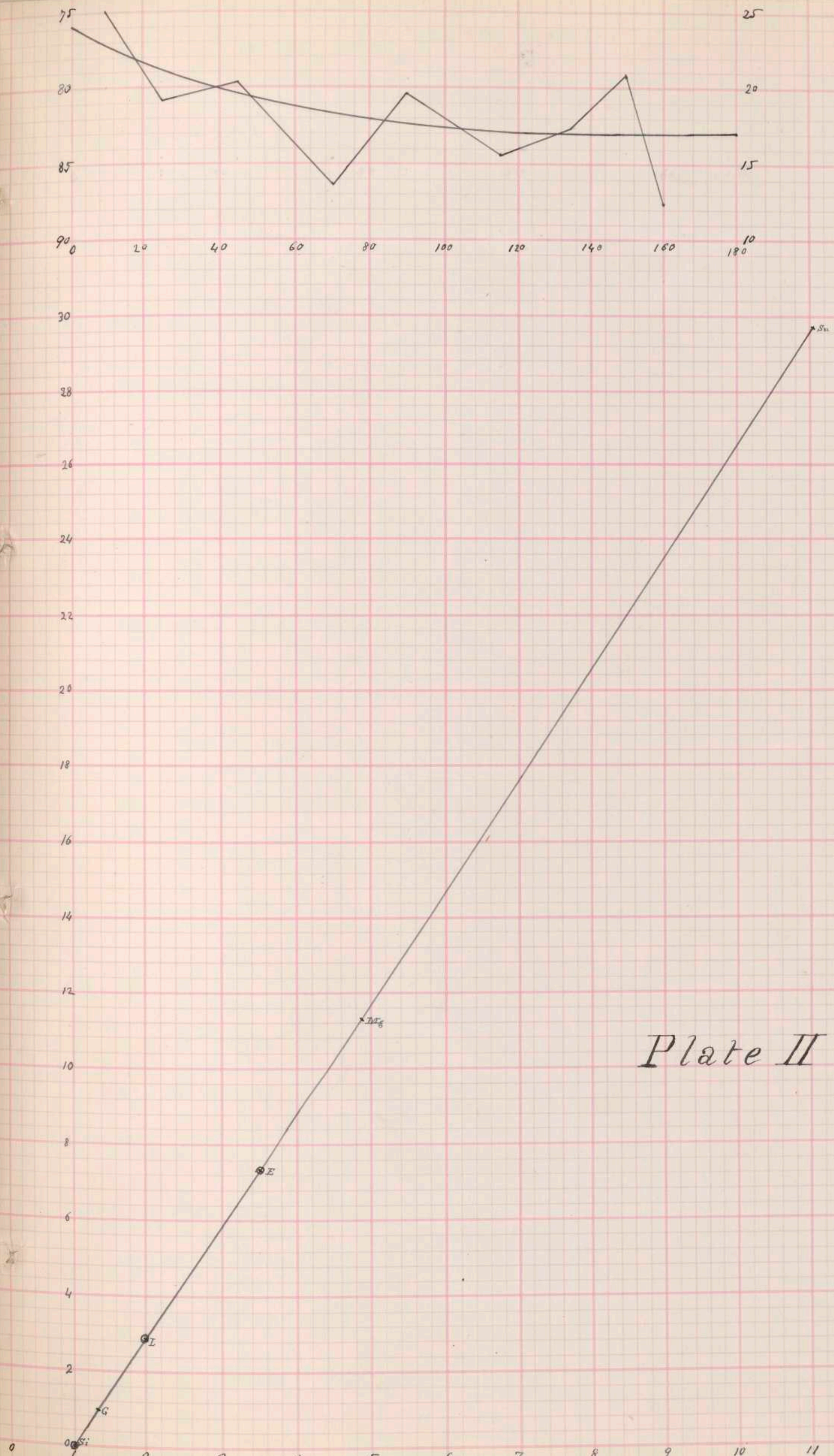
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Plate II