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IV. A New Table of Standard Wave-lengths.

By Prof. HENRY A. ROWLAND*.

DURING the last ten years I have made many observations of wave-lengths, and have published a preliminary and a final table of the wave-lengths of several hundred lines in the solar spectrum.

For the purpose of a new table I have worked over all my old observations, besides many thousand new ones, principally made on photographs, and have added measurements of metallic lines so as to make the number of standards nearly one thousand.

Nearly all the new measurements have been made on a new measuring-machine whose screw was specially made by my process† to correspond with the plates and to measure wave-lengths direct with only a small correction.

The new measures were made by Mr. L. E. Jewell, who has now become so expert as to have the probable error of one setting about $\frac{1}{1000}$ division of Ångström, or 1 part in 5,000,000 of the wave-length. Many of these observations, however, being made with different measuring-instruments, and before such experience had been obtained, have a greater probable error. This is especially true of those measurements made with eye-observations on the spectrum direct. The reductions of the readings were made by myself.

Many gratings of 6 in. diameter and $21\frac{1}{2}$ ft. radius were used; and the observations were extended over about ten years.

The *standard* wave-length was obtained as follows:—Dr. Bell's value of D_1 was first slightly corrected and became 5896.20. C. S. Peirce's value of the same line was corrected as the result of some measurements made on his grating and became 5896.20. The values of the wave-length then become:—

Weight.	Observer.	D.
1.	Ångström, corrected by Thalén.....	5895.81
2.	Müller & Kempf.....	5896.25
2.	Kurlbaum	5895.90
5.	Peirce	5896.20
10.	Bell	5896.20
Mean.....		5896.156

* Reprinted from a separate copy from the 'Astronom. and Astero-Physics' communicated by the Author.

† See *Encyc. Brit.*, art. Screw.

As the relative values are more important for spectroscopic work than the absolute, I take this value without further remark. It was utilized as follows:—

1st. By the method of coincidences with the concave grating, the wave-lengths of 14 more lines throughout the visible spectrum were determined from this with great accuracy for primary standards.

2nd. The solar standards were measured from one end of the spectrum to the other many times; and a curve of error drawn to correct to these primary standards.

3rd. Flat gratings were also used.

4th. Measurements of photographic plates from 10 to 19 inches long were made. These plates had upon them two portions of the solar spectrum of different orders. Thus the blue, violet, and ultra-violet spectra were compared with the visible spectrum, giving many checks on the first series of standards.

5th. Measurements were made of photographic plates having the solar spectrum in coincidence with metallic spectra, often of three orders, thus giving the relative wave-lengths of three points in the spectrum.

Often the same line in the ultra-violet had its wave-length determined by two different routes back to two different lines of the visible spectrum. The agreement of these to $\frac{1}{100}$ division of Ångström in nearly every case showed the accuracy of the work.

6th. Finally, the important lines had from 10 to 20 measurements on them, connecting them with their neighbours and many points in the spectrum, both visible and invisible; and the mean values bound the whole system together so intimately that no changes could be made in any part without changing the whole.

This unique way of working has resulted in a table of wave-lengths from 2100 to 7700 whose accuracy might be estimated as follows:—

Distribute less than $\frac{1}{100}$ division of Ångström properly throughout the table as a correction, and it will become perfect within the limits 2400 and 7000.

The above is only a sketch of the methods used. The complete details of the work are ready for publication, but I have not yet found any journal or society willing to undertake it.

Description of the Table.

The first column gives the name of the element whose wave-length has been measured. If a letter stands at the left, it is the “name” of the line in the solar spectrum. A(o)

and A(wv) denote lines due to absorption by the oxygen and the water-vapour, respectively, in the earth's atmosphere. An ? mark after an element means that it is doubtful if the line is really due to the element named. If two elements are given *on the same line* (e. g. Mn-Di w.l. 3295·957), it is to be understood that they have apparently coinciding lines at that particular wave-length. If two or more elements are bracketed

$$e. g., \left. \begin{array}{c} \text{Mn} \\ \text{Ti} \\ \text{Fe} \end{array} \right\} \text{w.l. } 5260\cdot384,$$

it means that the first one has a line coinciding with one side of the corresponding line in the solar spectrum, the second one has a line coinciding with the middle, &c., and the appearance of the solar line itself is given in a later column. An ? standing alone denotes that the element which corresponds to the given wave-length is unknown.

The second column gives the intensity of the line in the arc spectrum; the third its appearance, and the fourth and fifth do the same for the line in the solar spectrum. R stands for "reversed;" N, nebulous; d, double; t, triple; ?, doubtful or difficult. The size of the number indicates to some extent the intensity of the line. For instance the intensity 10 means that the line is apparently 10 times as intense as the intensity 1. Measurements of intensity by eye-observations, direct or on photographic plates, are of course most uncertain. And so the figures given are estimates which do not apply to comparisons of different portions of the spectrum, but are intended to give some idea of the relative effects. The intensity of some lines in the arc spectrum of a given substance, e. g. Ca, is often so much greater than that of the others, that the absence of some lines in the solar spectrum is easily understood. The sixth column gives the character of the standard. M means that the line is a standard in the arc spectrum; ☉ means that the line is an ordinary solar standard; ☉', a better solar standard; ☉'', a remarkably good solar standard; and ☉₁ a rather poor solar standard.

The next two columns give the "weights" to be attached to the values of the wave-lengths as standards in the arc and solar spectra, respectively.

The last two columns give the final values of the wave-lengths measured in Ångström units, i. e., in ten millionths of a millimetre in ordinary air at about 20° C. and 760 millim. pressure.

Notes marked J. are by Mr. Jewell.

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Sr	2	...	...	...	M	1	...	2152-912	
Sr	3	...	...	...	M	1	...	2165-990	
Si	2	...	...	...	M	2	...	2208-060	
Si	3	...	...	...	M	2	...	2210-939	
Si	2	...	...	...	M	2	...	2211-759	
Si	4	...	...	...	M	2	...	2216-760	
Si	2	...	...	...	M	2	...	2218-146	
Al	3	...	...	...	M	2	...	2263-507	
Al	4	...	...	...	M	2	...	2269-161	
Sr	10	R	...	...	M	1	...	2275-376	
Ca	20	R	...	...	M	3	...	2275-602	
Fe ?	...	...	...	...	M	2	...	2298-246	
Ba	20	R	...	...	M	1	...	2304-364	
Ba	20	R	...	...	M	1	...	2335-267	
Fe	...	...	...	...	M	2	...	2343-571	
Fe	...	...	...	...	M	2	...	2348-385	
Fe	...	...	...	...	M	2	...	2364-897	
Al	6	...	...	...	M	3	...	2367-144	
Al	7	...	...	...	M	3	...	2373-213	
Fe	...	...	...	...	M	2	...	2378-771	
Fe ?	...	...	...	...	M	3	...	2382-122	
Fe	...	...	...	...	M	2	...	2388-710	
Fe ?	...	...	...	...	M	3	...	2395-715	
Ca	25	R	...	...	M	5	...	2398-667	
Fe	...	...	...	...	M	2	...	2399-328	
Fe	...	...	...	...	M	2	...	2404-971	
Fe	...	...	...	...	M	2	...	2406-743	
Fe	...	...	...	...	M	2	...	2410-604	
Si	8	...	...	...	M	15	...	2435-247	
Si	3	...	...	...	M	10	...	2438-864	
Si	3	...	...	...	M	10	...	2443-460	
Fe ?	...	...	...	...	M	3	...	2447-785	
Si	3	...	...	...	M	10	...	2452-219	
Fe ?	...	...	...	...	M	3	...	2457-680	
Fe	...	...	...	...	M	3	...	2462-743	
Fe	...	...	...	...	M	3	...	2472-974	
C*	10	...	...	...	M	15	...	2478-661	
Fe	...	...	...	...	M	3	...	2479-871	
Fe	...	...	...	...	M	3	...	2483-359	
Fe	...	...	...	...	M	3	...	2484-283	
Fe	...	...	...	...	M	3	...	2488-238	
Fe	...	...	...	...	M	3	...	2489-838	
Fe	...	...	...	...	M	3	...	2490-723	
Fe	...	...	...	...	M	3	...	2491-244	
Bo	15	...	...	...	M	20	...	2496-867	
Bo	20	...	...	...	M	20	...	2497-821	
Fe	...	...	...	...	M	3	...	2501-223	
Si	10	...	...	...	M	15	...	2506-994	
Fe	...	...	...	...	M	3	...	2510-934	
Si	7	...	...	...	M	10	...	2514-417	
Si	15	...	...	...	M	7	...	2516-210	
Fe	...	...	...	...	M	3	...	2518-188	

* This line seems to be the only single line of carbon, not belonging to a band in the arc spectrum. It was determined to belong to carbon by the spark spectrum. (R.)

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Si	8	...	...	...	M	10	...	2519-297	
Fe	...	...	...	...	M	3	...	2522-948	
Si	9	...	...	...	M	10	...	2524-206	
Fe	...	...	...	...	M	3	...	2527-530	
Si	10	...	...	...	M	5	...	2528-599	
Fe	...	...	...	...	M	3	...	2535-699	
Hg*	50	R	...	...	M	2	...	2536-648	
Fe	...	...	...	...	M	3	...	2541-058	
Fe	...	...	...	...	M	3	...	2546-068	
Fe	...	...	...	...	M	2	...	2549-704	
Al	10	...	...	...	M	5	...	2568-085	
Al	10	...	...	...	M	5	...	2575-198	
Mn	...	...	...	...	M	2	...	2576-195	
Fe?	...	...	...	...	M	2	...	2584-629	
Fe	...	...	...	...	M	2	...	2585-963	
Mn	...	...	...	...	M	2	...	2593-810	
Fe	...	...	...	...	M	2	...	2598-460	
Fe	...	R	...	...	M	3	...	2599-494	
Fe	...	...	...	...	M	2	...	2611-965	
Fe	...	...	...	...	M	3	...	2631-125	
i	5	...	...	...	M	7	...	2631-392	
Fe	...	...	...	...	M	3	...	2679-148	
Fe	...	...	...	...	M	2	...	2706-684	
Fe	...	...	...	...	M	3	...	2719-119	
Fe	...	...	...	...	M	3	...	2720-989	
Ca	5	...	...	...	M	1	...	2721-762	
Fe	...	...	...	...	M	3	...	2723-668	
Fe?	...	...	...	...	M	3	...	2733-673	
Fe?	...	...	...	...	M	3	...	2737-405	
Fe	...	...	...	...	M	3	...	2742-485	
Fe	...	...	...	...	M	3	...	2750-237	
Fe	...	...	...	...	M	2	...	2755-837	
Fe	...	...	...	...	M	3	...	2756-427	
Fe	...	...	...	...	M	2	...	2761-876	
Fe	...	...	...	...	M	2	...	2762-110	
Fe	...	...	...	...	M	2	...	2767-630	
Fe	...	...	...	...	M	2	...	2772-206	
Mgt	5	R	...	...	M	5	...	2776-798	
Fe	...	...	...	...	M	2	...	2778-340	
Mgt	5	R	...	...	M	3	...	2778-381	
Mgt	8	R	...	...	M	5	...	2779-935	
Mgt	5	R	...	...	M	5	...	2781-521	
Fe	...	...	...	...	M	1	...	2781-945	
Mgt	5	R	...	...	M	5	...	2783-077	
Fe	...	...	...	...	M	3	...	2788-201	
Mn	...	...	...	...	M	3	...	2794-911	
Mg	20	R	...	...	M	12	...	2795-632	
Mn	...	...	...	...	M	3	...	2798-369	
Mn	...	...	...	...	M	3	...	2801-183	
Mg	20	R	...	...	M	10	...	2802-805	
Fe	5	...	...	...	M	3	...	2813-388	
Fe	3	...	...	...	M	1	...	2823-389	

* This line appears as a sharp reversal, with no shading, in the spectra of all substances tried that contained any trace of continuous spectrum in this region. (J.)

† A remarkable symmetrical group of five lines in the spectrum of magnesium.

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	5	...	...	...	M	1	...	2825.667	
Fe	4	...	...	...	M	7	...	2832.545	
Fe	3	...	...	...	M	1	...	2838.226	
Fe	3	...	...	...	M	1	...	2843.744	
Fe	5	...	...	...	M	7	...	2844.085	
Fe	6	...	...	...	M	5	...	2851.904	
Mg	100	R	...	...	M	15	...	2852.239	
Si	15	...	...	...	M	12	...	2881.695	
Fe	7	R	...	...	M	3	...	2912.275	
Fe	8	R	...	...	M	3	...	2929.127	
Fe	10	R	...	...	M	4	...	2937.020	
Fe	8	R	...	...	M	4	...	2947.993	
Fe	7	R	...	...	M	4	...	2954.058	
Fe	5	...	...	...	M	3	...	2957.485	
Fe	5	...	...	...	M	3	...	2965.381	
Fe	...	...	...	...	M	1	...	2966.985	
Fe	8	R	...	...	M	12	...	2967.016	
Fe	4	R	...	...	M	7	...	2970.223	
Fe	6	R	...	...	M	7	...	2973.254	
Fe	12	R	...	...	M	15	...	2973.358	
Fe	2	...	...	...	M	6	...	2981.570	
Fe	10	R	...	...	M	15	...	2983.689	
Fe	...	...	...	...	M	1	...	2987.410	
Si	4	...	...	...	M	5	...	2987.766	
Fe	8	R	...	...	M	18	...	2994.547	
Ca	7	R	...	...	M	3	...	2995.074	
Ca	10	R	...	...	M	3	...	2997.430	
Fe	4	R	...	...	M	5	...	2999.632	
Ca	6	R	...	...	M	3	...	2999.767	
Ca	8	R	...	...	M	3	...	3000.976	
Fe	8	R	...	...	M	15	...	3001.070	
?	...	...	3	...	⊙	1	...	.....	3005.160
?	...	...	4	...	⊙	1	...	.....	3005.404
Ca	15	R	...	...	M	3	...	3006.978	
Fe	2	...	...	...	M	1	...	3007.260	
Fe	1	...	...	...	M	3	...	3007.408	
Fe	6	R	...	...	M	15	...	3008.255	
Ca	7	R	...	...	M	3	...	3009.327	
Fe	4	R	...	...	M	3	...	3009.696	
?	...	...	4	...	⊙	5	...	.....	3012.557
?	...	...	6	d?	⊙	4	...	.....	3014.274
Fe	...	...	3	...	M	1	...	3016.296	
Fe	5	...	...	...	M	1	...	3017.747	
Fe	5	...	...	...	M	1	...	3019.109	
Fe	...	...	...	...	M	1	...	3019.752	
Fe	10	R	...	...	M	15	...	3020.611	
Fe	25	R	...	...	M	18	...	3020.759	
Fe	15	R	...	...	M	18	...	3021.191	
Fe	7	R	7	...	M	7	...	3024.154	
?	...	...	5	...	⊙	7	...	.....	3024.475
?	...	...	4	...	⊙	7	...	.....	3025.394
Fe	10	R	10	...	M	7	...	3025.958	
Fe	...	...	...	...	M	1	...	3027.245	
?	...	...	5	...	⊙	7	...	.....	3035.850
Fe	15	R	15	...	M	10	2	3037.505	3037.492

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Ca	15	R	4	...	M $\odot_1$	3	2	3044-114	3044-119
Mn.....	10	R	3	...	$\odot_1$	5	...	.....	3044-683
?	...	...	...	...	$\odot_1$	1	...	.....	3046-778
Fe	20	R	20	...	M	13	...	3047-720	
?	...	...	3	d	$\odot''$	...	5	.....	3050-212
Fe	...	...	3		$\odot'$	...	5	.....	3053-173
?	...	...	3	d	$\odot'$	...	1	.....	3053-527
?	...	...	3		$\odot''$	...	5	.....	3055-821
Fe	10	R	10	...	M	8	...	3057-557	
Fe	10	R	10	...	M	15	...	3059-200	
?	...	...	3	...	$\odot'$	...	1	.....	3061-098
Co	8	R	3	...	M $\odot''$	1	5	3061-932	3061-930
Fe	10	R	10	...	M	10	...	3067-363	
Ti	6	...	8	...	M	3	...	3075-339	
Fe	10	R	10	...	M	4	...	3075-849	
Fe	...	...	2	...	M	1	...	3077-216	
?	...	...	4	...	$\odot$	...	6	.....	3077-303
Fe?	...	...	4	...	$\odot''$	...	6	.....	3078-148
Ti	4	...	6	...	M	3	...	3078-759	
Mn.....	7	...	2	...	$\odot''$	...	1	.....	3079-724
?	...	...	5	...	$\odot''$	...	1	.....	3080-863
Al	20	R	7	...	M	17	...	3082-272	
Fe	6	R	7	...	M	5	...	3083-849	
?	...	...	4	...	$\odot''$	...	1	.....	3086-891
Ti	8	R	8	...	M	1	...	3088-137	
Al	20	R	10	...	M	15	...	3092-824	
Al	4	...	2	...	M	8	...	3092-962	
?	...	...	2	...	$\odot'$	...	9	.....	3094-739
Fe	1	...	3	...	$\odot'$	...	9	.....	3095-003
Fe	4	...	7	...	M	3	...	3100-064	
Fe(Mn)	4-?	...	4	...	M	3	...	3100-415	
Fe	6	...	6	...	M	3	...	3100-779	
Ni	20	R	8	...	M	3	...	3101-673	
Ni	10	R	6	...	M	3	...	3101-994	
?	...	...	2	...	$\odot$	...	1	.....	3106-677
Cr?	...	...	3	...	$\odot'$	...	1	.....	3109-434
Fe	...	...	2	...	$\odot''$	...	3	.....	3115-160
Va*	7	...	5	...	$\odot''$	...	9	.....	3121-275
Zr	3	...	1	...	$\odot'$	...	5	.....	3129-882
Ni	10	R	8	...	M	1	...	3134-223	
Co	4	...	2	...	$\odot'$	...	3	.....	3137-441
Fe	...	...	3	...	$\odot'$	...	5	.....	3140-869
Fe	...	...	2	...	$\odot'$	...	3	.....	3153-870
Ca	...	...	8	...	M	1	1	3158-994	3158-988
Mn.....	...	...	1	...	$\odot'$	...	5	.....	3167-290
Fe?	...	...	5	...	$\odot''$	...	1	.....	3172-175
La?	1	...	1	...	$\odot'$	...	5	.....	3176-104
Or?	4	N	4	...	$\odot'$	...	5	.....	3188-164
Ni†	3	...	3	...	M	1	1	3195-729	3195-702
Ti	10	R	4	...	M $\odot$	1	5	3200-040	3200-032

* There is a very faint line on the violet side in the solar spectrum.

† There is a line towards the red, also.

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	5	...	5	...	M	1	...	3214.152	
Ti	4	...	3	...	⊙''	...	6	.....	3218.390
Fe	...	...	6	...	⊙'	...	1	.....	3219.697
Fe	...	...	6	...	⊙'	...	1	.....	3219.909
Fe? }	6	...	5	d	M ⊙	3	1	3222.197	3222.203
? }	?	...	7						
Ti	6	...	4	...	⊙''	...	3	.....	3224.368
Fe	8	...	8	...	M	3	1	3225.907	3225.923
Ti }	5	...	5	...	⊙''	...	1	.....	3231.421
? }	?								
Ti	6	...	4	...	⊙	...	12	.....	3232.404
Ti	10	R	8	...	M	1	1	3236.696	3236.697
? }	...	...	6	...	⊙''	...	12	.....	3246.124
Fe }	...	...	6	...	⊙''	...	12	.....	3246.124
Cu	40	R	9	...	M ⊙ ₁	15	5	3247.671	3247.680
Mn }	4	...	4	...	⊙'	...	10	.....	3260.384
Ti }	3								
Fe }	1	...	...	...	⊙''	...	10	.....	3267.839
Va	10	...	4	...	⊙''	...	10	.....	3267.839
Cu	30	R	6	...	M ⊙''	15	5	3274.090	3274.092
Ti	6	...	5	...	⊙''	...	9	.....	3287.791
Fe }	5	...	5	d?	⊙''	...	10	.....	3292.174
Co-T }	4 7								
Mn-Di }	3 2	...	4	...	⊙''	...	9	.....	3295.957
Na	15	R	6	...	M ⊙''	1	6	3302.504	3302.501
Na*	10	R	5	...	M ⊙ ₁	1	6	3303.119	3303.107
? }	...	...	3	d	⊙'	...	10	.....	3303.648
Fe }	...	...	3						
Fe†	10	...	7	...	M ⊙ ₁	1	5	3306.119	3306.117
Fe†	10	...	7	...	M ⊙ ₁	1	5	3306.481	3306.471
Mn... }	2	...	1	d	⊙''	...	10	.....	3308.928
Co-Ti }	3 6								
Ti	5	...	5	...	⊙''	...	10	.....	3318.163
Fe	2	...	2	...	⊙'	...	8	.....	3331.741
Cr }	3	...	3	d	⊙'	...	9	.....	3348.011
Fe }	3	...	3						
Fe	2	...	2	...	⊙'	...	9	.....	3351.877
Zr	4	...	1	...	⊙''	...	8	.....	3356.222
Ti } §	5	...	3	d	⊙''	...	9	.....	3377.667
Ti }	5	...	3						
Fe	2	...	2	...	⊙''	1	12	3389.913	3389.887
Co }	10	R	3	d	⊙'	1	12	3405.255	3405.272
Ti }	1	...	3						
Fe	2	...	1	...	⊙'	1	18	3406.602	3406.581
Fe	5	...	4	...	⊙'	1	18	3406.965	3406.955
?	...	...	2	...	⊙''	...	15	.....	3425.721
Fe	6	...	5	...	M	2	1	3427.279	3427.282
Fe	15	R	15	...	M ⊙ ₁	7	4	3440.756	3440.759

* Red component of a double which has a Zn line between. There is another Zn line at about 3302.7 in the solar spectrum.

† Second line from red side of a group of five lines.

‡ Second line from violet side of a group of four lines.

§ A very wide nebulous line of Ba comes here.

|| Red component of a double (the other line being also Fe) having another fainter line at the red edge.

Elements	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	ApPear-ance.		In Arc.	In Sun.		
Fe	10	...	10	...	M $\odot_1$	6	4	3441·135	3441·135
Fe	8	R	8	...	M $\odot_1$	6	4	3444·024	3444·032
Co	6	R	4	...	$\odot''$	...	10	.....	3455·384
Sr?.....	8	...	3	...	$\odot''$	...	8	.....	3464·609
Co } *	10	R	4	d	M	7	3	3466·010	3465·991
Fe }	10	R	6						
Fe†	10	R	10	...	M	7	3	3475·602	3475·594
Fe†	7	R	8	...	M	5	2	3476·848	3476·831
Co }	2	}	4	...	$\odot''$	...	10	.....	3478·001
Fe }	3								
Ni }	2								
Ni	4	R	5	...	$\odot'$	...	9	.....	3486·036
Fe§	10	R	10	...	M	7	3	3490·724	3490·721
Co }	4	R	4	...	$\odot''$	...	8	.....	3491·464
? }	?	...							
Fe	5	...	5	...	M	1	1	3497·266	3497·264
Fe } ¶	6	R	7	d	M	5	4	3497·991	3497·991
? }	?	...							
Fe	2	...	3	...	$\odot''$	...	4	.....	3500·721
Ni	7	R	7	...	$\odot''$	...	4	.....	3500·993
Ti**	5	...	4	...	$\odot'$	...	8	.....	3510·987
Fe††	7	R	6	...	M	2	3	3513·981	3513·947
Co	6	R	5	...	$\odot''$	...	10	.....	3518·487
Th	40	R	...	...	M	1	...	3519·342	...
Fe	5	R	7	...	M	6	5	3521·409	3521·404
Th	20	R	...	...	M	1	...	3529·547	...
Fe	3	...	5	...	$\odot''$	...	10	.....	3540·266
?	...	...	4	...	$\odot''$	...	6	.....	3545·333
Yt	6	...	2	...	M $\odot''$	1	1	3549·147	3549·145
Fe	2	...	3	...	$\odot''$	...	7	.....	3550·006
Fe	9	R	8	...	M $\odot$	3	4	3558·674	3558·670
Ti }	2	}	4	d?	$\odot''$	...	12	.....	3564·680
Fe }	1								
Fe	10	R	12	...	M	6	4	3565·530	3565·528
Fe††	20	R	20	...	M	8	4	3570·253	3570·225
Fe	10	...	10	...	M	1	1	3570·412	3570·402
Fe	30	R	40	...	M $\odot_1$	9	6	3581·344	3581·344
Fe?	2	...	4	...	$\odot''$	...	12	.....	3583·483
Yt	6	...	2	...	M	1	1	3584·662	3584·662
C §§	2	...	1	...	M	8	...	3585·992	...
C	...	...	2	...	M	2	...	3586·041	...
C	...	...	3	...	M	7	...	3590·523	...
Fe	5	...	4	...	$\odot''$	...	12	.....	3597·192

* The metal measured was Fe.

† Strongest line of group of six lines.

† Also the strongest line in a group of six lines.

§ There is a Co line near this towards the red.

|| Red component of a double.

¶ Violet component of a double. Other component was not measured.

** A strong compound bismuth line also comes here.

†† Violet component of a double.

†† Red component of a double. There is also another Fe line towards the red.

§§ First line in the second head of the carbon band.

||| First line in the first head of carbon band.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Yt (Fe) ...	10-?	...	4	...	M $\odot$ "	1	1	3600-884	3600-880
Yt ...	6	...	2	...	M $\odot$	1	1	3602-065	3602-061
Cr* ...	10	R	4	...	M $\odot_1$	1	2	3605-497	3605-483
Fe* ...	5	...	7	d	M $\odot_1$	2	2	3605-621	3605-635
Fe† ...	4	...	6	...	M	2	2	3606-836	3606-831
Fe ...	15	R	15	...	M $\odot$	11	10	3609-015	3609-015
Yt ...	7	...	3	...	M $\odot$	1	1	3611-196	3611-193
Fe ...	4	...	4	...	$\odot'$	1	15	3612-237	3612-217
Ca } † ...	...	...	2	d	M $\odot_1$	1	1	3617-939	3617-920
Fe } ...	4	...	3						
Fe ...	20	R	20	...	M $\odot_1$	11	10	3618-922	3618-924
Yt ...	3	...	1	...	M	1	1	3621-096	3621-122
Fe ...	4	...	4	...	M $\odot$	2	2	3621-616	3621-606
Fe ...	4	...	4	...	M $\odot$	2	3	3622-161	3622-147
Fe ...	4	...	4	...	M $\odot_h$	1	14	3623-338	3623-332
Fe§ ...	2	...	3	...	$\odot''$	...	10	...	3623-603
Yt ...	3	...	2	...	M $\odot$	1	1	3628-853	3628-853
Fe ...	20	R	20	...	M $\odot_1$	11	10	3631-616	3631-619
Yt ...	5	...	3	d	M	1	1	3633-277	3633-259
Ti ...	10	R	3	...	M $\odot'$	3	1	3635-615	3635-616
Fe ...	5	...	5	...	M $\odot_1$	1	1	3638-454	3638-435
Pb¶ ...	50	R	1	...	M	4	...	3639-728	...
Cr } † ...	2	...	5	...	M $\odot''$	1	14	3640-545	3640-536
Fe } ...	5								
Fe ...	10	R	10	...	M $\odot$	10	11	3647-995	3647-995
Co ...	5	R	3	...	$\odot''$	...	5	...	3652-692
Ti ...	10	R	4	...	M $\odot'$	2	7	3653-639	3653-639
Mn } ...	2	...	2	...	$\odot'$	...	7	...	3658-688
Fe } ...	2								
Fe ...	5	...	3	...	$\odot''$	...	13	...	3667-397
Fe ...	8	R	8	...	M $\odot$	8	7	3680-064	3680-064
Co } ...	9	...	6	...	$\odot''$	1	13	3683-209	3683-202
Fe } ** ...	3								
Va } ...	4								
Pb ...	60	R	1	...	M	5	...	3683-622	...
Fe ...	5	...	6	...	$\odot''$	1	14	3684-268	3684-259
Fe ...	10	R	8	...	M $\odot$	8	6	3687-609	3687-607
Yt ...	...	...	3	...	M $\odot$	1	1	3694-351	3694-349
Fe ...	5	...	5	...	$\odot''$	1	11	3695-208	3695-194
Fe†† ...	7	R	8	...	M $\odot$	7	5	3705-715	3705-711
Fe ...	5	...	5	...	$\odot''$	1	11	3707-201	3707-186
Fe ...	10	R	10	...	M $\odot_1$	6	4	3709-395	3709-397
Yt ...	10	...	3	...	M $\odot$	1	1	3710-442	3710-438

* In the solar spectrum these belong to a group of several lines. Of the three most prominent, the middle line is Cr, with possibly a weak line on its red edge; and the red one is a close double, the violet component of the double being Fe. (J.)

† The solar line is a group of four lines. The third from the violet side is the brightest and is Fe.

‡ Metal measured was Fe.

§ There is a faint line on the red side.

|| Red component of double.

¶ In the solar spectrum this is the red component of a double, the other being cobalt.

** The metallic line measured was Fe.

†† Violet component of a double.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	4	...	7	...	○"	1	12	3716.601	3716.585
Fe	40	R	50	...	M⊙	11	10	3720.082	3720.086
Ni	4	}	10	d	M⊙	7	5	3722.712	3722.691
Fe-Ti } *	8 5								
Fe	6	R	7	...	M	5	3	3727.768	3727.763
Fe	5	...	5	...	○"	1	15	3732.549	3732.542
Fe	6	R	7	...	M⊙	5	3	3733.467	3733.467
Fe	40	R	50	...	M⊙	8	7	3735.012	3735.014
Ni }	6	}	3	d	○ ₁	...	2	.....	3736.969
Mn }	2								
Ca	4	R	...	...	M⊙ ₁	2	3	3737.081	3737.075
Fe	25	R	30	...	M⊙	7	8	3737.280	3737.282
Ti }	3	}	2	t	M⊙	4	2	3743.506	3743.502
Fe } *	5								
Cr }	3	}	2	...	M	8	6	3745.708	3745.701
Fe†	10								
Fe	7	R	7	...	M	6	5	3746.048	3746.054
Fe } *	3	}	7	d	○'	1	9	3747.082	3747.095
? }	?								
Fe	10	R	10	...	M⊙	7	8	3748.410	3748.409
Fe	20	R	20	...	M⊙	7	8	3749.633	3749.633
? }	...	}	2	d	○	...	12	.....	3754.664
? }	...								
Fe	2	...	2	...	○'	...	12	.....	3756.211
Fe	15	R	15	...	M⊙	8	7	3758.380	3758.379
Fe	9	R	10	...	M	9	8	3763.939	3763.942
Fe	7	R	8	...	M⊙	9	8	3767.342	3767.344
Fe	3	...	4	d?	○	...	12	.....	3770.130
Yt?	6	...	3	...	M⊙	1	1	3774.478	3774.480
Th	40	R	...	...	M	1	...	3775.869	...
?	...	...	4	...	○'	...	15	.....	3780.846
Fe	2	...	3	...	○'	...	15	.....	3781.330
Ni	10	R	6	...	○	...	15	.....	3783.674
Fe	7	R	8	...	M⊙	3	3	3788.029	3788.032
Fe-Cr	1 1	...	3	...	○	...	15	.....	3794.014
Fe†	8	...	8	...	M	3	4	3795.148	3795.150
Fe	7	...	7	...	○	...	2	.....	3798.662
Fe	8	...	8	...	○	...	2	.....	3799.698
Fe	2	...	3	...	○"	...	15	.....	3804.153
Fe-Di	4 ?	...	6	...	○"	...	15	.....	3805.487
Fe	20	R	20	...	M⊙	4	3	3815.984	3815.985
Fe	30	R	30	...	M⊙	4	4	3820.566	3820.567
Fe	5	...	6	...	○	...	10	.....	3821.318
Mn(Cr) ...	5 1	R	5	...	○'	...	10	.....	3823.651
Fe	20	R	20	...	M⊙	4	4	3826.024	3826.024
Fe	8	R	8	...	M	1	1	3827.973	3827.973
Mg	20	R	8	...	M	...	2	.....	3829.505
Mg	30	R	10	...	M	...	2	.....	3832.446
?-C	...	...	4	...	○	...	8	.....	3836.226
C§	...	...	5	d	M⊙ ₁	1	1	3836.638	3836.652
Mg	40	R	20	...	M	...	2	.....	3838.430

* The metallic line measured was Fe.

† Violet portion of broad solar double is composed of three lines, the red line is Fe and the middle one Co. (J.) ‡ There is a Va line towards the violet.

§ Central line of symmetrical group in carbon band.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	7	R	7	...	M	2	2	3840.589	3840.584
Fe	4	...	5	...	⊙	...	8	.....	3843.406
Fe	6	...	7	...	M	1	2	.....	3856.517
Fe	10	R	10	...	M⊙ ₁	2	3	3860.050	3860.048
O*	...	...	3	...	⊙'	...	8	.....	3864.441
C†	...	...	4	...	M	4	4	3871.527	3871.528
?	...	...	3	...	⊙	...	15	.....	3875.224
Va }	...	...	7	...	M⊙ ₁	5	3	3883.479	3883.472
C†	...	...	...	...	M⊙ ₁	...	8	3883.523	3883.548
O§	...	...	1	...	⊙	...	12	.....	3883.773
Cr	...	...	9	...	M⊙ ₁	7	6	3886.421	3886.427
Fe	15	R	4	...	⊙'	...	12	.....	3897.599
Fe	3	...	10	...	M	4	4	3905.670	3905.666
Si	10	R	3	...	⊙'	1	12	3916.886	3916.875
Fe	3	...	4	...	⊙'	...	15	.....	3924.669
Ti	6	...	4	...	⊙'	...	15	.....	3925.345
Fe } ... 1 }	...	...	4	...	⊙'	...	13	.....	3925.792
Va } ... 2 }	...	...	4	...	⊙	...	12	.....	3926.123
Fe } ... 3 }	...	...	8	...	M	1	3	3928.000	3928.071
? } ... 4 }	...	...	300	...	M	6	5	3933.809	3933.809
Fe	75	R	4	...	⊙'	...	8	.....	3937.474
R-Co	4	4	5	...	⊙	1	15	3941.034	3941.021
? } **	...	...	2	...	⊙	...	15	.....	3942.559
Fe } ... 5 }	...	...	10	...	M⊙ ₁	7	7	3944.165	3944.159
Al	20	R	2	...	M	1	2	3949.070	3949.034
Ca††	4	...	4	...	⊙''	...	15	.....	3950.101
Fe	4	...	2	...	⊙	...	13	.....	3950.497
Yt	10	...	2	...	⊙'	...	13	.....	3954.001
Fe	2	...	6	...	⊙''	1	2	3957.228	3957.180
Fe-Ca	5	6	3	...	M⊙ ₁	...	11	.....	3960.429
Fe	3	...	15	...	⊙'	7	8	3961.680	3961.676
Al	30	R	...	...	M	7	5	3968.617	3968.620
H Ca¶	70	R	...	...	⊙'	...	11	.....	3970.05
H††	...	...	4	...	M	...	1	2	3973.881
Fe§§	5	...	3	d	⊙''	...	15	.....	3977.891
Ca	5	...	4	...	...	...	...	...	...
Fe	5	...	...	...	...	...	...	...	...

* One of the lines in the carbon band.

† Second head of carbon band.

‡ First line of first head of carbon band.

§ Edge of first head of carbon band.

|| .087 apart.

¶ The solar line is doubly reversed and spread out into broad shading for 6.000 or 7.000 on either side. In each case the second reversal is slightly eccentric with respect to the other, being displaced towards the red. (J.)

** Components .085 apart.

†† Red component of a triple.

‡‡ Value determined by Dr. Ames.

§§ Red component of a double.

||| Red component of double, the violet component being Fe. There is also a Ni line close to violet side.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe-Ti ...	6?	...	4	...	⊙	...	14	.....	3981·914
Cr } * ...	5 }	...	6	d	⊙	...	9	.....	3984·078
Fe } ...	3 }	...	7	d	⊙	...	9	.....	3986·903
? } † ...	? }	...	1	...	⊙	...	9	.....	3987·216
Mn } ...	4 }	...	6	t	⊙	...	4	.....	4003·916
? } ‡ ...	? }	...	3	...	⊙	...	9	.....	4005·305
Mn... } ...	4 }	...	3	...	⊙	...	3	.....	4016·578
Co ... } ...	2 }	...	4	...	⊙	...	10	.....	4029·796
Ce-Fe-Ti... 4 1 2	...	...	3	...	⊙	...	9	.....	4030·914
Fe-?§ ...	10	...	10	...	⊙	...	3	.....	4033·225
Fe ...	...	...	3	...	⊙	...	7	.....	4034·642
Fe } ...	2 }	...	4	...	⊙	...	10	.....	4035·88
Zr ...	2	...	7	...	M	3	4	4035·88	4035·88
Mn ...	30	R	6	...	M	3	4	4044·301	4044·293
Mn ...	25	R	5	...	M	2	2	4045·975	4045·975
Mn¶ ...	20	R	3	...	M	7	7	4047·373	4048·893
Mn¶¶ ...	7	...	1	...	M	2	2	4055·701	4062·602
K ...	50	R	20	...	M ⊙ ₁	7	7	4063·755	4063·756
Fe ...	20	R	1?	...	M	5	6	4071·903	4071·904
K ...	40	R	6	d	⊙	...	13	.....	4073·920
Zr } ...	1 }	...	5	...	⊙	...	13	.....	4077·876
Mn } ** ...	8 }	...	5	...	⊙	...	8	.....	4083·767
Cr } ...	2 }	...	5	...	⊙	...	8	.....	4083·928
Mn ...	8	...	15	...	⊙	...	8	.....	4088·716
Fe ...	5	...	10	...	⊙	...	10	.....	4103·101
Fe ...	15	R	4	...	⊙	...	12	.....	4107·646
Fe ...	10	...	4	...	⊙	...	14	.....	4114·600
Fe ...	4	...	2	...	⊙	...	14	.....	4121·476
Sr ...	50	R	2	...	⊙	...	7	.....	4121·481
Fe } ...	2 }	...	2	...	⊙	...	7	.....	4121·968
Mn } ...	5 }	...	4	...	⊙	...	17	.....	4157·948
Fe ...	2	...	6	...	⊙	...	10	.....	4158·2
Fe ...	2	...	5	d?	⊙	...	20	.....	4185·063
Fe ...	3	...	4	...	⊙	...	6	.....	4197·256
Si } ...	3 }	...	1	...	⊙	1	12	4121·476	4121·481
Mn } ...	1 }	...	3	...	⊙	...	13	.....	4121·968
Fe ...	5	...	3	...	⊙	...	17	.....	4157·948
Fe ...	3	...	3	...	⊙	...	20	.....	4185·063
Cr } †† ...	1 }	...	1	...	⊙	5	6	4197·256	4197·251
Co ...	10	R	3	...	⊙	...	13	.....	4121·968
Fe-Cr ...	3 1	...	3	...	⊙	...	17	.....	4157·948
Fe ...	4	...	3	...	⊙	...	20	.....	4185·063
C ...	...	...	3	...	⊙	...	6	.....	4197·256
Fe ...	4	...	1	...	⊙	...	6	.....	4197·251
C†† ...	...	...	1	...	⊙	...	6	.....	4197·251

* Components about ·060 apart.

† Hazy line shaded to red. Shading is due to a Mn line on red side.

‡ Triple line. Central line is brightest.

§ Seven or eight lines. The brightest and most of the others are due to Fe.

|| Violet component of double, being itself double or reversed in Sun. The other component is weak.

¶ Red component of double, being itself double or reversed in Sun. The other component is weak.

** An unequal double, violet component being much the weaker.

†† Cobalt line was measured.

‡‡ First line of second head of carbon band.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Zr } ...	2 }	...	5	...	⊙''	2	22	4199-257	4199-263
Fe } ...	5 }	...	5	...	⊙'	2	4	4202-187	4202-188
Fe } ...	8 }	...	...	...	⊙	...	2	...	4215-616
Fe } ...	2 }	2	...	d	⊙	...	18	...	4215-667
Sr } ...	40	R	4	...	M⊙	6	3	4215-688	4215-687
O* } ...	...	...	1	...	M⊙	4	2	4216-133	4216-137
Fe } ...	2	...	4	...	⊙''	1	22	4222-396	4222-381
g Ca } ...	50	R	10	...	M⊙	9	10	4226-898	4226-892
Fe } ...	4	...	5	...	⊙'	1	1	4250-300	4250-290
Fe } ...	5	...	7	...	⊙	4	3	4250-949	4250-956
Cr } ...	20	R	7	...	M⊙''	2	15	4254-494	4254-502
Fe } ...	6	R	7	...	⊙	4	3	4260-647	4260-638
? } ...	?	...	1	d	⊙	...	12	...	4267-958
Fe } ...	1	...	2	...	M⊙	8	9	4271-920	4271-924
Fe } ...	10	R	8	...	M⊙	1	2	4274-954	4274-958
Cr } ...	15	R	5	...	M⊙	2	4	4283-175	4283-170
Ca } ...	5	R	3	...	M⊙	3	5	4289-527	4289-523
Ca } ...	4	R	3	...	M⊙	2	2	4289-884	4289-881
Cr } ...	10	R	4	d	⊙'	...	14	...	4293-249
? } ...	...	...	4	...	M⊙	3	5	4299-153	4299-152
Ca } ...	3	R	2	...	M	5	7	4302-690	4302-689
Ca } ...	6	R	4	...	M	1	...	4305-636	...
Sr } ...	8	...	2	...	M⊙	4	4	4306-071	4306-071
Ti } ...	10	R	4	...	⊙	3	3	4307-906	4307-904
Ca } ...	4	R	2	d	⊙	...	3	...	4308-034
G } ...	7	R	5	...	⊙	8	10	4308-072	4308-071
Fe } ...	4	R	3	...	M⊙''	3	16	4318-816	4318-818
f Fe } ...	10	R	8	...	M⊙'	8	15	4325-932	4325-940
Cr } ...	2	...	1	d?	⊙	...	11	...	4343-387
Fe } ...	2	...	2	...	⊙''	1	17	4352-908	4352-903
Fe } ...	4	...	3	...	⊙	...	10	...	4359-778
Ni } ...	3	...	1	t	⊙	...	10	...	...
Cr } ...	4	...	3	...	⊙''	1	14	4369-948	4369-943
Zr } ...	5	...	1	...	⊙''	1	17	4376-108	4376-103
Fe } ...	4	...	5	...	M⊙'	10	11	4383-721	4383-721
d Fe } ...	15	R	10	...	⊙	...	14	...	4391-149
Fe } † ...	2	...	3	...	M⊙	10	11	4404-928	4404-927
Ti } ...	1	...	1	...	⊙	...	19	...	4407-850
Fe } ...	10	R	8	...	M	3	...	4413-181	...
Va } ...	9	R	2	d	M⊙	9	7	4415-298	4415-299
Fe } ...	3	...	3	...	M⊙''	5	7	4425-616	4425-609
Od } ...	6	...	6	...	M⊙	5	5	4435-133	4435-132
Fe } ...	4	R	4	...	M⊙''	5	6	4435-856	4435-852
Ca } ...	5	R	4	...	⊙''	2	18	4447-912	4447-899
Ca } ...	4	R	3	...	M⊙ ₁	6	6	4454-949	4454-956
Fe† } ...	8	...	5	...	...	...	...	...	...
Ca§ } ...	6	R	6	...	...	...	...	...	...

* First line in first head of carbon band.

† Unequal double, components being about .050 apart.

‡ There is a faint side line towards the red.

§ There is a faint line close to violet side.

New Table of Standard Wave-lengths.

63

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Ca*	3	R	2	...	M	5	3	4456.055	4456.047
Ca	1	...	1	...	M $\odot$ ₁	2	2	4456.791	4456.793
Fe	...	...	5	...	$\odot$ "	1	18	4494.756	4494.735
Cr }	5	...	4	}	$\odot$ ₁	...	14	.....	4497.041
Zr }	2	...	1		$\odot$ "	...	8	.....	4499.070
Mn }	...	...	2		$\odot$ '	...	7	.....	4499.315
? }	...	...	1	d	$\odot$ '	...	18	.....	4501.444
Ti.....	6	...	5	...	$\odot$ '	...	...	4502.6	.....
O	...	...	...	...	...	...	...	4502.6	.....
Ti?	...	...	4	...	$\odot$ "	...	17	.....	4508.456
In.....	...	...	...	...	M	4	...	4511.474	.....
In.....	...	...	...	...	M	3	...	4513.883	.....
Ba	70	R	7	...	M $\odot$ "	6	8	4554.212	4554.213
Ti.....	4	...	6	...	$\odot$ "	...	13	.....	4563.939
Mg	3	...	5	...	$\odot$ "	1	14	4571.281	4571.277
Ti.....	5	...	6	...	$\odot$ "	...	14	.....	4572.157
Ca-Ti	3 1	N	4	...	$\odot$ "	1	14	4578.807	4578.781
Cr?	...	...	4	...	$\odot$ "	...	14	.....	4588.384
Ti?	...	...	4	...	$\odot$ "	...	15	.....	4590.129
Fe	2	...	4	...	$\odot$ "	...	20	.....	4602.183
Li†	50	R	...	...	M	1	...	4602.25	.....
C†	...	...	...	...	...	...	...	4606.6	.....
Sr.....	50	R	2	...	M $\odot$ '	5	4	4607.506	4607.509
? } §	?	...	2	}	$\odot$ ₁	...	11	.....	4611.453
Fe }	4	...	6		$\odot$ '	...	13	.....	4629.515
Ti }	4	...	...		$\odot$ '	...	14	.....	4637.683
Co }	5	...	5	...	$\odot$ '	...	14	.....	4638.194
Fe	3	...	4	...	$\odot$ "	...	17	.....	4643.645
Fe	3	...	4	...	$\odot$ "	...	17	.....	4648.833
Ni	6	R	3	...	M $\odot$	1	1	4648.833	4648.835
? }	?	...	2	}	$\odot$ '	...	11	.....	4668.303
Fe }	3	...	5		$\odot$ '	...	11	.....	4668.303
Cd	...	...	4?		M	3	3	4678.339	4678.353
Fe	3	...	6	...	$\odot$ '	...	12	.....	4679.028
Zn	...	...	2	...	M	1	...	4680.319	.....
Fe	2	...	3	...	$\odot$ "	...	13	.....	4683.743
Ni	4	...	4	...	$\odot$ "	...	12	.....	4686.395
? }	...	...	4	...	$\odot$ '	...	14	.....	4690.324
Ti }	3	...	2	}	$\odot$ ₁	...	11	.....	4691.581
Fe }	3	.....	4		$\odot$ '	...	11	.....	4691.581
Mg¶	5	...	9		$\odot$ "	1	11	4703.249	4703.180
Ni	3	...	3	...	$\odot$ "	...	13	.....	4703.986
Ni**	9	R	6	d?	M $\odot$	1	1	4714.598	4714.599
Zn	4	...	4	...	M $\odot$ "	2	2	4722.339	4722.349
Fe }	2	...	4	}	$\odot$	...	11	.....	4727.628
Mn }	7	...	3		$\odot$	...	11	.....	4727.628

* Red component of a double. Other line is Mn.

† First line in first head of blue carbon band.

‡ Strong line with fine line very close to violet side and another farther to violet.

§ Besides the double line measured there is another fine line near the red side.

|| The Mg line is of the nature of a band, shaded toward the red. It coincides with the solar line when there is very little material in the arc. (R.)

¶ Solar line is shaded towards the violet, probably owing to a close side line.

** Much the same in character as the red lithium line. (J.)

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Mn	15	R	6	...	☉''	...	11	.....	4754.226
Mn	10	R	6	...	M☉''	1	1	4783.607	4783.601
Cd	...	...	?	...	M	3	...	4800.097	
? }	?	...	1	d	☉ ₁	...	3	.....	4805.253
Ti }	1	...	4		☉ ₁	...	3	.....	4805.253
Zn	...	...	3	...	M☉''	1	1	4810.725	4810.723
Mn	10	...	6	...	M☉''	1	12	4823.715	4823.697
Fe?	...	...	4	...	☉''	...	11	.....	4824.325
Fe	4	...	5	...	☉''	...	14	.....	4859.934
F H	...	...	15	...	☉'	...	5	.....	4861.496
Fe	7	...	7	...	☉''	...	11	.....	4890.945
Ti*	4	...	2	d	☉'	...	11	.....	4900.098
Yt*	...	...	2		☉'	...	11	.....	4900.306
Cr }	2	}	6	d?	☉''	...	14	.....	4903.488
Fe }	5		...	...	M	1	...	4905.634	
Pb	...	...	...	...	☉''	...	4	.....	4919.183
Fe†	9	...	9	...	M☉''	1	7	4920.676	4920.682
Fe	2	...	4	...	☉''	...	13	.....	4924.109
Fe	3	...	2	...	☉''	...	12	.....	4924.955
Ba†	60	...	7	d?	M☉	1	10	4934.237	4934.247
Fe	...	...	6	...	M☉ ₁	...	3	.....	4957.482
Fe	...	...	8	...	M☉ ₁	...	3	.....	4957.786
Neb**	...	...	...	...	...	...	...	4959.02	
Ti }	1	}	3	...	☉''	...	10	.....	4973.274
Fe }	3		...	...	☉''	...	10	.....	4973.274
? \$	...	...	1	d?	☉''	...	8	.....	4978.782
Fe \$	3	...	3		☉''	...	8	.....	4978.782
Ni \$	5	...	3	d	☉	...	5	.....	4980.362
? \$	?	...	1		☉	...	5	.....	4980.362
Ti	10	...	4	...	☉	1	10	4981.893	4981.915
Fe	3	...	4	...	☉''	...	7	.....	4994.316
Ti-La	10 10	R N	4	...	M☉	...	8	4999.668	4999.693
Pb	...	...	...	...	M	5	...	5005.634	
Fe	3	...	4	...	☉'	...	10	.....	5005.904
Fe¶	...	...	6	...	☉''	...	8	.....	5006.303
Ti	10	R	4	d	☉''	...	10	.....	5007.431
Fe }	3	...	3		☉''	...	10	.....	5007.431
Neb**	...	...	...	...	...	...	...	5007.05	
Mg b'd††	...	...	...	...	M	3	10	5007.473	
(Ni) Ti }	?	...	3	d	M☉'	...	10	5014.412	5014.422
Ti }	5	...	4		M☉'	...	10	5014.412	5014.422
Ti	7	...	3	...	☉'	...	8	.....	5020.210
Ti }	6	...	3	d	☉'	...	8	.....	5036.113
Ni }	3	...	2		☉'	...	8	.....	5036.113
Ca	3	N	2	...	M	2	1	5041.867	5041.795

* A Ba line comes between these and does not coincide with either.

† Shaded, and has a faint line towards the red.

‡ A very difficult double with a fine line towards the violet. (J.)

\$ There is a faint line towards the red.

¶ Ti line was measured.

|| There is a faint side line towards the violet.

** Values determined by J. E. Keeler from his measurements at the Lick Observatory using the values of the Pb, Fe, and Mg lines given in this table.

†† Commencement of the head of Mg band.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WRIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	5	...	5	...	⊙''	...	12	.....	5050-008
Fe	2	...	2	...	⊙'	...	15	.....	5060-252
Ti	10	...	3	...	⊙'	...	12	.....	5064-833
Fe	4	...	4	...	⊙''	...	14	.....	5068-946
Fe	4	...	3	...	⊙''	...	9	.....	5083-525
Cd	...	...	?	...	M	1	...	5086-001	
Fe	3	...	2	...	⊙''	...	9	.....	5090-959
Fe*	3	...	2	...	⊙'	...	7	.....	5097-176
Fe(Cu)... 3?	3?	...	3	...	⊙ _h	...	12	.....	5105-719
Fe	3	...	2	...	⊙''	...	11	.....	5109-825
?	?	...	2	...	⊙'	...	11	.....	5110-570
Fe }	4	...	3	d					
Ni	5	...	2	...	⊙''	...	9	.....	5115-558
Ni }	2	...	1	...	⊙ ₁	...	9	.....	5121-797
Co	3	...	3	d					
Fe	3	...	2	...	⊙''	...	9	.....	5126-369
Fe }	4	...	4	...	⊙''	...	9	.....	5127-530
?	?	...	6	d	⊙''	...	12	.....	5133-871
Fe }	4	...	6	d					
Fe }	5	...	6	d	⊙	...	4	.....	5139-437
Fe }	2	...	3	...	⊙	...	4	.....	5139-539
Ni }	5	...	2	...	⊙''	...	5	.....	5139-645
Fe }	3	...	4	d	⊙ ₁	...	1	.....	5141-916
Ni }	5	...	3	...	⊙ ₁	...	5	.....	5142-967
?	?	...	3	...	⊙ ₁	...	2	.....	5143-042
Fe }	4	...	3	...	⊙''	...	10	.....	5143-106
Mn }	2	...	1	d	⊙	...	9	.....	5151-026
Ti? Co?	6	...	2	...					
Ni	6	...	2	...	⊙''	...	10	.....	5154-237
F ?	4	...	2	...	⊙''	...	10	.....	5155-937
Fe	4	...	4	...	⊙''	...	11	.....	5159-240
C§	...	...	1	...	⊙''	...	13	.....	5162-448
Fe	2	...	2	...	M	2	1	5165-241	5165-190
Mg }	20	R	8	...	⊙	...	10	.....	5165-588
b ₄ Fe }	6	...	6	d	M⊙ ₁	2	3	5167-488	5167-501
Fe }	3	...	4	...	⊙	...	7	.....	5167-572
b ₃ Fe }	3	...	4	d	M⊙ ₁	2	3	5167-664	5167-686
Fe }	3	...	4	...	⊙''	...	3	.....	5169-066
Fe }	5	...	5	...	⊙''	...	5	.....	5169-161
b ₂ Mg }	35	R	10	...	⊙''	...	3	.....	5169-218
					⊙''	...	11	.....	5171-783
					M⊙''	2	9	5172-866	5172-871

* The fine line near to violet side belongs to Ni?

† There is a Cr line near to red side.

‡ The Mn line is a faint side line towards the red from the Fe line.

§ Measurements in the arc spectrum were on the first line of the first head of the green carbon band; measurements in the solar spectrum were probably on the brightest of a group of faint lines near the head of carbon band (J.). Much of the band can be seen on my map of the solar spectrum extending to the left (R.).

¶ Components about 0.180 apart on photographic plates. (J.)

¶ Components about 0.138 apart as measured by Rowland in solar spectrum and 0.150 apart as measured on photographic plates. (J.)

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Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Ti.....	10	R	3	...	☉''	...	11	.....	5173·912
b ₁ Mg.....	40	R	20	...	M☉''	2	11	5183·791	5183·792
Ti.....	2	...	4	...	☉''	...	3	.....	5188·863
Ca } *	...	...	4	...	☉''	...	7	.....	5188·948
	6	...	4	...	M☉''	1	3	5189·019	5189·020
Ti.....	8	...	3	...	M☉''	2	8	5193·134	5193·139
Fe.....	3	...	4	...	☉''	...	10	.....	5198·885
?.....	?	...	2	...	☉''	...	11	.....	5202·483
Fe }	4	...	3	d	☉''	...	11	.....	5202·483
Cr }	8	R	4	...	☉''	...	10	.....	5204·708
Fe }	3	...	3	d	☉''	...	10	.....	5204·708
Ti.....	10	R	3	...	M☉''	2	12	5210·549	5210·556
Fe.....	3	...	4	...	☉''	...	10	.....	5215·352
Fe.....	3	...	4	...	☉''	...	10	.....	5217·559
Fe.....	2	...	2	...	☉''	...	10	.....	5225·690
Fe.....	4	...	4	...	☉''	...	8	.....	5230·014
Fe.....	7	...	8	...	☉''	...	9	.....	5233·124
Fe.....	3	...	3	...	☉''	...	10	.....	5242·662
Fe.....	2	...	2	...	☉''	...	11	.....	5250·391
Fe.....	3	...	3	...	☉''	...	11	.....	5250·825
Fe.....	2	...	3	...	☉''	...	12	.....	5253·649
Ca.....	2	...	1	...	M☉ ₁	1	5	5260·556	5260·557
Ca.....	6	...	3	...	☉	1	12	.....	5261·880
Cr }	2	...	3	...	☉	1	12	.....	5261·880
?.....	...	...	1	...	M☉ ₁	...	1	.....	5262·341
Ca.....	6	...	2	d	☉	2	5	5262·408	5262·391
Cr.....	4	R	3	...	☉	...	3	.....	5264·327
Ca } †	...	...	6	...	☉''	...	2	.....	5264·371
	6	...	3	...	M☉	2	3	5264·408	5264·395
Ca.....	8	...	3	...	☉	1	2	5265·725	5265·727
(Ni?)	...	...	5	...	☉	...	2	.....	5265·789
	4	R	2	...	☉	...	1	.....	5265·884
Cr.....	4	R	2	...	☉	...	1	.....	5265·884
Fe.....	6	...	6	...	☉''	1	8	5266·733	5266·729
E ₂ Fe.....	8	...	8	d?	☉''	1	16	5269·714	5269·722
Ca.....	10	...	4	...	M☉	2	3	5270·445	5270·448
E ₁ Fe } §	...	...	4	d	☉''	...	12	.....	5270·495
	6	...	4	...	M☉	...	3	.....	5270·533
Fe.....	3	...	3	...	☉''	...	6	.....	5273·344
Fe }	...	...	3	d	☉'	...	5	.....	5273·443
	3	...	3	...	☉''	...	8	.....	5273·554
?.....	?	...	2	...	☉''	...	8	.....	5273·554
Cr.....	5	...	2	t	☉''	...	11	.....	5276·205
Co.....	3	...	1	...	☉''	...	11	.....	5281·968
Fe.....	4	...	5	...	☉''	...	11	.....	5281·968

* Components about 0·155 apart on photographic plates. (J.)

† Another set of measurements on photographic plates gives the components as 0·083 apart.

‡ Components about 0·088 apart on photographic plate. It is an exceedingly difficult double and it is possible that this doubleness of E₂ is really a case of the reversal of line in the Sun. (J.)

§ Components 0·077 apart as determined by another short series (R.); 0·130 on photographic plates (J.).

|| Components of double about 0·075 apart on photographic plates. The fine side line to red is about 0·110 from the red component of double. (J.)

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	5	...	6	...	⊙''	...	11	.....	5283.803
Fe	2	...	2	...	⊙''	...	12	.....	5288.708
Cr	6	R	4	...	⊙''	...	12	.....	5296.873
Cr	2	...	3	...	⊙''	...	9	.....	5300.918
Fe	3	...	4	...	⊙''	...	10	.....	5307.546
Fe? }	...	...	4	...	⊙	...	1	.....	5316.790
1474 } *	...	d	6	d	⊙	...	7	.....	5316.870
Co? }	2	...	3	...	⊙	...	1	.....	5316.950
Fe	9	...	8	...	⊙''	...	8	.....	5324.373
Fe?	3	...	4	...	⊙'	...	9	.....	5333.092
Ca	7	...	5	...	M ⊙	1	4	5349.599	5349.623
Th†	75	t?	...	...	M	2	...	5350.670	
Fe-Ni†	3.3	...	4	...	⊙ ₁	...	8	.....	5353.592
?	...	...	2	...	⊙	...	7	.....	5361.813
Fe(Co) } §	1.3	...	1	...	⊙	...	5	.....	5363.011
? }	?	...	3	d	⊙	...	1	.....	5363.056
Fe	4	...	6	...	⊙''	...	8	.....	5367.670
Fe	4	...	6	...	⊙''	...	8	.....	5370.165
Ni	2	...	2	...	⊙ ₁	...	8	.....	5371.686
Fe-Cr }	9.2	...	7	d	⊙ ₁	...	8	.....	5371.686
Fe	2	...	3	...	⊙''	...	9	.....	5379.776
Fe	6	...	6	...	⊙''	...	11	.....	5383.576
Fe	3	...	4	...	⊙''	...	11	.....	5389.683
Fe	4	...	5	...	⊙''	...	11	.....	5393.378
Fe	7	...	7	...	⊙''	1	12	5397.319	5397.346
Fe	7	...	7	...	⊙''	1	14	5405.979	5405.987
Cr	10	R	5	...	⊙''	...	7	.....	5410.000
Fe }	4	...	6	...	⊙''	...	12	.....	5415.421
Va }	4	...	6	...	⊙''	...	12	.....	5415.421
Va }	3	...	7	...	⊙''	...	10	.....	5424.284
Fe }	5	...	7	...	⊙''	...	10	.....	5424.284

* The distance apart of the components of this 1474 line measured accurately is 0.146 by Crew, and 0.141 by Rowland. The coincidences with Fe and Co are very doubtful. The Co line comes more nearly between the two rather than coinciding with either. (R.)

A trial of substances in the arc gave the following results:—iron, manganese, chromium, titanium, and two different specimens of meteoric stones showed two faint lines having the same relative intensities with respect to each other as the components of 1474 in the solar spectrum, and either coincided with the components of 1474 or nearly so. When cobalt and nickel were tried, the lines were the same distance apart but the relative intensities were reversed, the red component being much the stronger.

With the best definition 1474 is a triple, or rather a double the red component of which has a weak side line to violet. The components as measured on a photographic plate are respectively 0.120 and 0.050 apart. The main components as determined by a series of measurements on photographic plates are 0.170 apart.

Probably the violet component of the double is iron and the weak side line of the red component is cobalt, but the red component is unknown. (J.)

† With but little material in the arc this is a difficult triplet. The violet component is very strong, the red component about half as strong, and between them, but nearer the red component, is a very narrow line much weaker than either of the others. (J.)

‡ There are some fine lines near to red side.

§ Components about 0.110 apart on photographic plates. (J.)

|| Red component itself is an exceedingly difficult double. (J.)

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	5	...	6	...	⊙''	1	9	5434·725	5434·742
Fe *	7	...	7	...	⊙''	1	9	5447·116	5447·130
Fe? }	...	...	3	...	⊙	...	1	.....	5455·666
Fe }	6	...	6	...	⊙'	...	8	.....	5455·759
Ni	3	...	1	...	⊙	...	1	.....	5455·826
Fe	3	...	4	...	⊙'	...	7	.....	5462·732
Fe	3	...	4	...	⊙''	...	9	.....	5463·174
Fe	3	...	4	...	⊙''	...	10	.....	5463·493
Fe	3	...	3	...	⊙''	...	10	.....	5466·608
Ni	15	R	4	...	⊙''	...	10	.....	5477·128
Fe	2	...	3	...	⊙'	...	5	.....	5487·968
Fe	3	...	4	...	⊙''	...	8	.....	5497·731
Fe	5	...	4	...	⊙''	...	8	.....	5501·685
Fe	5	...	4	...	⊙''	...	8	.....	5507·000
Ca	5	N	3	...	⊙	1	8	5513·127	5513·207
Mg†	10	...	7	...	⊙''	4	8	5528·672	5528·636
Fe	3	...	2	...	⊙''	...	8	.....	5535·073
Fe	3	...	2	...	⊙''	...	8	.....	5543·418
Fe	3	...	2	...	⊙''	...	9	.....	5544·158
Fe†	4	...	3	...	⊙'	...	8	.....	5555·113
Fe	6	...	5	...	⊙''	...	8	.....	5569·848
Fe	5	...	4	...	⊙''	...	7	.....	5576·319
Ca	6	...	4	...	M⊙''	2	9	5582·204	5582·195
Ca	10	R	6	...	M⊙''	2	9	5588·977	5588·980
Ca	5	...	4	...	M⊙''	2	5	5590·352	5590·342
Ca	7	R	5	...	M⊙	2	5	5594·689	5594·695
Fe	3	...	2	...	⊙	1	2	5598·563	5598·555
Ca	7	...	4	...	⊙'	2	4	5598·712	5598·715
Ca	5	...	4	...	M⊙''	2	4	5601·502	5601·501
Fe } §	2	...	2	...	⊙'	...	10	.....	5603·097
Ca }	6	...	3	...					
Fe }	5	...	5	...					
Fe	2	...	2	...	⊙'	...	10	.....	5615·526
Fe	2	...	6	...	⊙'	...	10	.....	5615·879
Fe	2	...	2	...	⊙''	...	12	.....	5624·253
Fe-Va	5 2	...	4	...	⊙''	...	14	.....	5624·768
Fe	2	...	3	...	⊙''	...	5	.....	5634·167
Fe	2	...	3	...	⊙''	...	10	.....	5641·661
Si	...	...	2	...	⊙	...	9	.....	5645·835
Fe	2	...	4	...	⊙'	...	9	.....	5655·707
Yt?	1	...	4	...	⊙''	...	9	.....	5658·096
Fe	3	...	5	...	⊙''	...	9	.....	5662·745
Ti	3	...	2	...	⊙	...	8	.....	5675·648
Fe	2	...	3	...	⊙''	...	8	.....	5679·249
Na	3	...	4	...	⊙''	...	9	.....	5682·861

* A difficult double. (J.)

† This Mg line is shaded to one side when there is much Mg in the arc and is therefore a poor metallic standard. The solar line corresponds to the extreme edge of this band-like line. (R.)

‡ There is a side line towards the violet.

§ This triplet is made up of close double and a line close to red stronger than either component of double; wave-length of components about 5602·995; 5603·080 and 5603·180 as measured on a photographic plate. (J.)

|| Lines used by Percey in his determinations of absolute wave-lengths.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Na	...	...	6	...	○''	...	7	.....	5688.434
Fe	4	...	5	...	○''	...	8	.....	5701.769
Si	...	...	5	...	○''	...	4	.....	5708.620
Fe	...	...	6	d	○	...	6	.....	5709.616
Ni	5	...	5		○	...	8	.....	5709.760
Mg *	...	...	6		⊙	4	...	5711.374	5711.318
Ni	5	...	5	...	○''	...	10	.....	5715.309
Fe-Ti }	3 }	...	5	...	○''	...	10	.....	5731.973
Fe	...	...	5	...	○''	...	10	.....	5742.066
Fe	...	...	3	...	○	...	10	.....	5752.257
Fe	...	...	4	...	○''	...	10	.....	5753.342
Fe	...	...	5	...	○''	...	10	.....	5754.884
Ni }	...	...	5	...	○''	...	9	.....	5763.215
?	...	...	5	...	○	...	8	.....	5772.360
Fe†	...	...	7	...	○''	...	6	.....	5775.304
Si	...	...	5	...	○''	...	9	.....	5782.346
Fe	...	...	7	d?	○''	...	9	.....	5784.081
Cu?Co?	...	...	4	...	○''	...	13	.....	5788.136
Cr	6	...	5	...	○''	...	16	.....	5791.207
Cr	7	...	7	d?	○''	...	10	.....	5793.087
Cr }	10	...	4	...	○''	...	9	.....	5798.400
Fe }	...	...	5	...	○''	...	8	.....	5805.448
?	...	...	5	...	○''	...	7	.....	5806.954
Fe	...	...	5	...	○''	...	14	.....	5809.437
Fe†	...	...	6	...	○	...	14	.....	5816.594
Ni	3	...	3	...	○	...	6	.....	5831.832
Ba	10	...	5	...	○''	...	14	.....	5853.903
Ca§	10	...	7	...	○'	...	14	.....	5857.672
Fe	...	...	6	...	○''	...	15	.....	5859.810
Fe	...	...	6	...	○''	...	16	.....	5862.580
D ₃ He	...	...	...	...	...	...	...	.....	5875.982
Fe }	...	...	6	d	⊙ ₁	...	11	.....	5884.048
Δ(wv) }	...	...	4		⊙ ₁	...	8	.....	5889.854
Δ(wv)	...	...	3		⊙ ₁	...	20	.....	5890.182
D ₂ Na	...	...	15	...	⊙	...	14	.....	5893.098
Ni**	3	d?	4	...	⊙	...	...	.....	...

* This Mg line is shaded on one side, especially when there is much Mg in the arc and therefore should not be used for a metallic standard. (R.)

† There is a fine line near to violet side.

‡ There is a line close to violet side.

§ There is a Ni line near to red.

|| This value of the wave-length of D₃ is the result of three series of measurements made with a grating having 20,000 lines to the inch, and is accurate to perhaps 0.02.

Observations were made in the first spectrum on both sides of the Sun. The line does not occur as a dark line in the solar spectrum; but is sometimes, if not always, present as a very weak bright line. This is shown by a study of the best photographs of this region of the solar spectrum. (J.)

¶ A water-vapour line is toward the red about 0.080 from the Fe line and ordinarily forms a double with it.

** An exceedingly close equal double when there is very good definition. There is also a solar line near to the violet side, and a water-vapour line near to the red. (J.)

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
D, Na	...	...	10	...	⊙''	...	20	.....	5896.154
A(wv)	...	...	3	d?	⊙ ₁	...	10	.....	5898.395
Fe?	...	...	1			...	...	.....	...
A(wv)	...	...	5			...	...	.....	...
Fe?	...	...	1	d	⊙ ₁	...	13	.....	5901.681
Fe	...	...	5	...	⊙''	...	15	.....	5905.895
Fe ... *	...	...	4	d	⊙''	...	17	.....	5914.384
?-(wv)	...	...	5			...	...	.....	...
Fe	...	...	5			...	16	.....	5916.475
A(wv)	...	...	6	...	⊙''	...	12	.....	5919.855
Fe	...	...	6	...	⊙''	...	14	.....	5930.410
Fe	...	...	6	...	⊙''	...	13	.....	5934.883
Si	...	...	6	...	⊙''	...	14	.....	5948.761
Fe	...	...	5	...	⊙''	...	12	.....	5956.925
Fe	...	...	4	...	⊙''	...	12	.....	5975.576
Fe	...	...	5	...	⊙	...	13	.....	5977.005
A(wv)	...	...	2	...	⊙ _h	...	1	.....	5977.254
Fe	...	...	6	...	⊙''	...	6	.....	5985.044
Fe	...	...	6	...	⊙''	...	7	.....	5987.286
Fe	...	...	6	...	⊙''	...	7	.....	6003.245
Fe	...	...	4	...	⊙''	...	3	.....	6008.196
Fe	...	...	6	...	⊙''	...	6	.....	6008.782
Mn	10	...	6	...	⊙''	...	5	.....	6013.717
Mn	10	...	6	...	⊙''	...	8	.....	6016.856
? } †	...	...	3	d	⊙ ₁	...	6	.....	6020.347
Fe }	...	...	5			...	...	.....	...
Ma }	10	...	5			...	6	.....	6022.017
Fe	...	...	6	...	⊙''	...	8	.....	6024.280
Fe	...	...	4	...	⊙''	...	7	.....	6027.265
Fe	...	...	4	...	⊙''	...	8	.....	6042.316
Fe	...	...	5	...	⊙''	...	9	.....	6056.232
Fe	...	...	7	...	⊙''	...	13	.....	6065.708
Fe	...	...	5	...	⊙''	...	13	.....	6078.709
Fe	...	...	3	...	⊙''	...	12	.....	6079.223
Fe	...	...	4	...	⊙'	...	4	.....	6102.408
Ca } ‡	10	R	6	...	⊙''	...	9	.....	6102.941
Fe }	...	...	4	d	⊙ ₁	...	8	.....	6103.449
? }	...	...	1			...	...	.....	...
Li	20	...	...	...	M	4	...	6103.812	...
Ni	5	...	6	...	⊙''	...	8	.....	6108.338
Ni	4	...	3	...	⊙'	...	8	.....	6111.287
Fe	5	...	6	...	⊙''	...	8	.....	6116.415
Ca	15	R	9	...	⊙''	...	11	.....	6122.428
Fe	...	...	8	...	⊙'	...	9	.....	6136.834
Fe-Ba ...	?-15	...	7	...	⊙''	...	9	.....	6141.934
Na	...	...	3	...	⊙''	...	5	.....	6154.431
Na	...	...	5	...	⊙''	...	4	.....	6160.970
Ca	15	R	10	...	⊙''	...	9	.....	6162.383
Ca	6	...	6	...	⊙''	...	4	.....	6169.260
Ca	7	...	7	...	⊙''	...	8	.....	6169.775

* Components about 0.100 apart. Red component is partly solar and partly water-vapour. (J.)

† Components about 0.200 apart.

‡ Components 0.100 apart.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length. in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Fe	...	...	6	...	⊙''	...	8	.....	6173.554
Ni	5	...	6	...	⊙''	...	8	.....	6177.028
Fe	...	...	6	...	⊙''	...	8	.....	6180.419
Ni	4	...	6	...	⊙''	...	9	.....	6191.397
Fe	...	...	8	...	⊙''	...	10	.....	6191.770
Fe	...	...	6	...	⊙''	...	10	.....	6200.533
Fe	...	...	6	...	⊙''	...	9	.....	6213.646
Fe	...	...	6	...	⊙''	...	10	.....	6219.493
Fe-Va	?-6	...	7	...	⊙''	...	12	.....	6230.946
?	...	...	4	...	⊙''	...	8	.....	6237.529
Fe	...	...	7	...	⊙''	...	9	.....	6246.530
Fe	...	...	7	...	⊙''	...	9	.....	6252.776
Fe*	...	...	7	...	⊙''	...	9	.....	6254.454
Ni }	7 }	...	6	...	⊙''	...	8	.....	6256.574
Fe }	5 }	...	2	...	⊙''	...	9	.....	6261.316
Ti	...	...	5	...	⊙''	...	11	.....	6265.347
Fe	...	...	3	...	⊙''	...	10	.....	6270.439
Fe	...	...	4	d	⊙''	...	9	.....	6278.289
αA(O)†	...	...	2	...	⊙'	...	7	.....	6281.374
A(O)†	...	...	2	...	⊙'	...	5	.....	6289.608
A(O)‡	...	...	3	...	⊙	...	6	.....	6293.152
A(O)§	...	...	3	...	⊙''	...	7	.....	6296.144
Fe	...	...	7	...	⊙''	...	7	.....	6301.719
Ni	6	...	4	...	⊙''	...	7	.....	6314.874
Fe	...	...	3	...	⊙ _h	...	5	.....	6315.541
Fe-(Ca)	...	...	6	...	⊙ _h	...	14	.....	6318.242
Fe	...	...	5	...	⊙''	...	13	.....	6322.912
Fe	...	...	6	...	⊙''	...	12	.....	6335.550
Fe	...	...	6	...	⊙''	...	12	.....	6337.042
Fe	...	...	5	...	⊙''	...	6	.....	6344.370
Fe¶	...	...	5	...	⊙''	...	8	.....	6355.259
Fe	...	...	6	...	⊙''	...	8	.....	6358.902
Ni	5	...	2	...	⊙ _h	...	2	.....	6378.461
Fe	...	...	4	...	⊙ _h	...	6	.....	6380.951
Fe	...	...	7	...	⊙''	...	9	.....	6393.818
Fe	...	...	8	...	⊙ ₁	...	5	.....	6400.200
Fe	...	...	3	...	⊙ ₁	...	6	.....	6400.509
Fe	...	...	6	...	⊙ _h	...	8	.....	6408.231
Fe	...	...	7	...	⊙''	...	10	.....	6411.864
Fe	...	...	5	...	⊙''	...	8	.....	6420.171
Fe**	...	...	6	...	⊙	...	10	.....	6421.569
Fe	...	...	6	...	⊙''	...	10	.....	6431.063
Cd	...	...	...	...	M	1	...	6438-680	
Ca	10	R	7	...	⊙''	...	11	.....	6439.298
Ca	5	...	6	...	⊙	...	6	.....	6450.029

* This is a difficult double or there is a side line close to violet.

† Chief line in the α group. It is a very close atmospheric double with some weak atmospheric lines towards the red and a faint water-vapour line near to violet side. (J.)

‡ First line of the first pair of lines in the tail of the α group.

§ Second line in the second pair of the tail of α. Faint line to violet.

|| There is a side line towards the red.

¶ There is a faint line near to red side.

** There is a Ni line towards red side.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sith.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
Ca } ...	10	R	9 }	d	⊙"	...	9	.....	6462.835
Fe } ...	?	...	3 }		⊙"	...	7	.....	6471.881
Ca 5	...	...	5	...	⊙"	...	6	.....	6480.264
A(wv) ...	...	...	1	...	⊙"	...	8	.....	6482.099
?	...	...	4	...	⊙"	...	10	.....	6494.001
Ca 8	...	...	6	...	⊙"	...	9	.....	6495.209
Fe	...	...	7	...	⊙"	...	10	.....	6499.871
Ca 5	...	...	5	...	⊙"	...	7	.....	6516.315
?	6	...	4	...	⊙'	...	10	.....	6518.594
Fe	...	...	4	...	⊙'	...	7	.....	6532.546
A(wv) ...	...	...	1	...	⊙"	...	12	.....	6534.173
?	...	...	3	...	⊙"	...	11	.....	6546.486
Ti } ...	3 }	...	6	...	⊙"	...	6	.....	6552.840
Fe } ...	?	...	2	...	⊙"	...	13	.....	6563.054
A(wv) ...	...	...	30	...	⊙"	...	13	.....	6569.461
Fe 6	...	...	1	...	⊙"	...	5	.....	6572.312
A(wv) ...	...	...	2	...	⊙"	...	7	.....	6574.477
?	...	...	4	...	⊙ ^h	...	11	.....	6575.179
Fe*	...	...	5	...	⊙"	...	12	.....	6593.161
Fe 4	...	...	4	...	⊙"	...	9	.....	6594.115
Fe 4	...	...	4	...	⊙"	...	7	.....	6609.354
Fe†	...	...	3	...	⊙"	...	10	.....	6633.992
Ni 5	...	...	5	...	⊙"	...	4	.....	6643.882
?	...	...	1 }	d	⊙"	...	6	.....	6663.525
Fe 4	...	...	5	...	⊙"	...	10	.....	6663.696
Fe 5	...	...	2	...	⊙"	...	10	.....	6678.232
?	...	...	3	...	⊙"	...	12	.....	6703.813
?	...	...	5	...	⊙"	...	10	.....	6705.353
Li† 75	t?	...	...	...	M	3	6708.070	.....	6717.934
Ca§ 10	...	...	3	...	⊙"	...	7	.....	6722.095
?	...	...	3	...	⊙"	...	12	.....	6726.923
Fe 3	...	...	4	...	⊙"	...	7	.....	6750.412
Fe 2	...	...	4	...	⊙'	...	9	.....	6752.962
Fe 5	...	...	3	...	⊙'	...	10	.....	6768.044
Ni 2	...	...	1	...	⊙'	...	5	.....	6772.565
Fe 2	...	...	2	...	⊙'	...	6	.....	6787.137
Fe 3	...	...	3	...	⊙'	...	8	.....	6807.100
Fe 2	...	...	2	...	⊙'	...	5	.....	6810.519
Fe 2	...	...	3	...	⊙'	...	7	.....	6820.614
Fe 3	...	...	3	...	⊙'	...	6	.....	6828.850
Fe 3	...	...	3	...	⊙'	...	5	.....	6841.591
Fe 3	...	...	3	...	⊙'	...	10	.....	6843.908
Fe 3	...	...	3	...	⊙'	...	11	.....	6855.425
A[O] ...	...	...	3	...	⊙'	...	...	.....	6867.461

* There is a water-vapour line near to violet side.

† There is a faint line near to each side.

‡ With but little material in the arc this is a difficult triplet. The violet component is very strong, the red component about half as strong, and between them but nearer the red component is a very narrow line much weaker than either of the others. (J.)

§ There is a side line towards the violet.

|| This line and the following one are at the beginning of the head of B. There is a fine line midway between them.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
A[O]* ...	...	...	3	...	⊙'	...	11	.....	6867.800
A[O] ...	...	...	1	...	⊙ ₁	...	2	.....	6868.124
A[O] ...	...	...	6	d	⊙	...	2	.....	6868.393
A(O) ...	...	...	1	d	⊙ ₁	...	3	.....	6868.779
A(O) ...	...	...	3						
A(O) ...	...	...	4	d	⊙'	...	5	.....	6869.141
A(O) ...	...	...	4						
BA(O)† ...	...	...	4	d	⊙''	...	12	.....	6870.186
BA(O) ...	...	...	4						
A(O) ...	...	...	5	...	⊙'	...	6	.....	6871.179
A(O) ...	...	...	5	...	⊙'	...	6	.....	6871.527
A(O) ...	...	...	5	...	⊙''	...	5	.....	6872.493
A(O) ...	...	...	5	...	⊙''	...	4	.....	6873.076
A(O) ...	...	...	5	...	⊙''	...	5	.....	6874.039
A(O) ...	...	...	5	...	⊙''	...	5	.....	6874.884
A(O) ...	...	...	5	...	⊙''	...	9	.....	6875.826
A(O) ...	...	...	5	...	⊙''	...	7	.....	6876.957
A(O) ...	...	...	5	...	⊙''	...	7	.....	6877.878
A(O) ...	...	...	5	...	⊙''	...	11	.....	6879.294
A(O) ...	...	...	3	...	⊙''	...	11	.....	6880.176
Cr ...	1	...	1	...	⊙	...	5	.....	6881.970
Cr ...	2	...	1	...	⊙	...	5	.....	6882.772
Cr ...	3	...	1	...	⊙	...	5	.....	6883.318
A(O)† ...	...	...	4	...	⊙''	...	13	.....	6884.083
1 { A(O) ...	...	...	5	...	⊙''	...	12	.....	6886.008
1 { A(O) ...	...	...	5	...	⊙''	...	12	.....	6886.987
2 { A(O) ...	...	...	5	...	⊙''	...	5	.....	6889.194
2 { A(O) ...	...	...	5	...	⊙''	...	5	.....	6890.149
3 { A(O) ...	...	...	6	...	⊙''	...	5	.....	6892.614
3 { A(O) ...	...	...	6	...	⊙''	...	5	.....	6893.559
4 { A(O) ...	...	...	6	...	⊙''	...	7	.....	6896.292
4 { A(O) ...	...	...	6	...	⊙''	...	8	.....	6897.195
5 { A(O) ...	...	...	6	...	⊙''	...	6	.....	6900.199
5 { A(O) ...	...	...	6	...	⊙''	...	8	.....	6901.113
6 { A(O) ...	...	...	6	...	⊙''	...	5	.....	6904.358
6 { A(O) ...	...	...	6	...	⊙''	...	5	.....	6905.263
7 { A(O) ...	...	...	6	...	⊙''	...	5	.....	6908.785
7 { A(O) ...	...	...	6	...	⊙''	...	9	.....	6909.675
8 { A(O) ...	...	...	5	...	⊙''	...	5	.....	6913.454
8 { A(O) ...	...	...	5	...	⊙''	...	4	.....	6914.328
Ni ...	5	...	3	...	⊙'	...	4	.....	6914.819
? ...	...	...	2	...	⊙'	...	5	.....	6916.957
9 { A(O) ...	...	...	4	...	⊙''	...	5	.....	6918.363
9 { A(O) ...	...	...	4	...	⊙''	...	9	.....	6919.245
10 { A(O) ...	...	...	3	...	⊙''	...	8	.....	6923.557
10 { A(O) ...	...	...	3	...	⊙''	...	11	.....	6924.420
11 { A(O) ...	...	...	2	...	⊙'	...	5	.....	6928.992
11 { A(O) ...	...	...	2	...	⊙'	...	8	.....	6929.838
12 { A(O) ...	...	...	1	...	⊙	...	4	.....	6934.646
12 { A(O) ...	...	...	1	...	⊙	...	5	.....	6935.530

* This line and the preceding one are at the beginning of the head of B. There is a fine line midway between them.

† The principal line in the head of B. It is a difficult double.

‡ Single line at the beginning of the tail of B.

Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
A(wv?)...	...	...	8	...	⊙"	...	10	.....	6947·781
A(wv?)...	...	...	2	d	⊙ ₁	...	4	.....	6953·838
A?	...	...	1			...	4	.....	6956·700
A(wv)...	...	...	8	...	⊙"	...	12	.....	6959·708
A(wv?)...	...	...	3	...	⊙	...	10	.....	6961·518
A(wv?)...	...	...	6	...	⊙	...	12	.....	6978·655
?	...	...	2	...	⊙	...	5	.....	6986·832
A(wv)...	...	...	5	...	⊙	...	10	.....	6989·240
A(wv?)*	...	...	5	...	⊙	...	7	.....	6999·174
A(wv?)†	...	...	5	d?	⊙ ₁	...	6	.....	7000·143
?	...	...	4	...	⊙	...	3	.....	7006·160
?	...	...	5	...	⊙ ₁	...	5	.....	7011·585
?	...	...	3	...	⊙	...	6	.....	7016·279
A(wv?)...	...	...	3	...	⊙ ₁	...	5	.....	7016·690
A(wv?)...	...	...	6	...	⊙ ₁	...	9	.....	7023·225
?	...	...	4	...	⊙ ₁	...	1	.....	7023·747
?	...	...	3	...	⊙ ₁	...	7	.....	7024·988
?	...	...	3	d?	⊙ ₁	...	2	.....	7027·199
?	...	...	1	...	⊙	...	1	.....	7027·726
?	...	...	3	...	⊙	...	7	.....	7035·159
?	...	...	6	...	⊙'	...	8	.....	7038·470
?	...	...	2	...	⊙	...	6	.....	7040·058
?	...	...	4	...	⊙	...	10	.....	7090·645
?	...	...	4	...	⊙'	...	5	.....	7122·491
?	...	...	6	...	⊙	...	5	.....	7147·942
?	...	...	1	...	⊙	...	4	.....	7148·427
?	...	...	7	...	⊙'	...	4	.....	7168·191
?	...	...	3	...	⊙	...	5	.....	7176·347
A(wv?)...	...	...	3	...	⊙	...	6	.....	7184·781
A(wv?)...	...	...	4	...	⊙	...	7	.....	7186·552
A(wv?)...	...	...	5	d	⊙	...	6	.....	7193·921
A(wv)...	...	...	7	...	⊙	...	3	.....	7200·753
A(wv)...	...	...	10	...	⊙	...	5	.....	7201·468
A(wv)...	...	...	10	...	⊙	...	5	.....	7216·812
A(wv?)...	...	...	6	...	⊙	...	4	.....	7223·930
?	...	...	8	...	⊙	...	5	.....	7227·765
?	...	...	6	...	⊙	...	4	.....	7232·509
?	...	...	3	...	⊙	...	3	.....	7233·171
?	...	...	8	...	⊙	...	4	.....	7240·972
A(wv)...	...	...	4	...	⊙	...	5	.....	7243·904
A(wv)...	...	...	15	...	⊙	...	4	.....	7247·461
A(wv?)...	...	...	4	...	⊙	...	2	.....	7264·851
A(wv?)...	...	...	8	...	⊙	...	3	.....	7265·833
A(wv?)...	...	...	8	...	⊙	...	3	.....	7270·205
?	...	...	3	d	⊙	...	2	.....	7273·256
A(wv?)...	...	...	8	...	⊙	...	4	.....	7287·689
A(wv?)...	...	...	6	...	⊙	...	3	.....	7290·714
A(wv)...	...	...	10	d?	⊙	...	3	.....	7300·056
A(wv)...	...	...	4	...	⊙	...	3	.....	7304·475
A(wv?)...	...	...	7	...	⊙	...	4	.....	7318·818
A(wv?)...	...	...	5	d?	⊙	...	4	.....	7321·056
?	...	...	2	...	⊙	...	3	.....	

* There is a line towards the violet.

† There is a line close to violet side.

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Elements.	IN ARC.		IN SUN.		Kind of Stand-ard.	WEIGHT.		Wave-length in Arc.	Wave-length in Sun.
	Inten-sity.	Appear-ance.	Inten-sity.	Appear-ance.		In Arc.	In Sun.		
?	...	...	2	...	...	...	3	.....	7331-206
?	...	...	7	...	...	...	2	.....	7389-696
?	...	...	6	...	...	...	2	.....	7409-554
?	...	...	6	...	...	...	3	.....	7446-038
?	...	...	6	...	...	...	2	.....	7462-609
?	...	...	6	...	...	...	3	.....	7495-351
?	...	...	6	...	...	...	3	.....	7511-286
?	...	...	3	...	...	...	1	.....	7545-921
A(O)*	...	...	...	...	...	...	4	.....	7594-059
A(O)†	...	...	10	...	⊙'	...	5	.....	7621-277
1 {	A(O)	...	12	...	⊙	...	4	.....	7623-526
	A(O)	...	12	...	⊙	...	4	.....	7624-853
2 {	A(O)	...	14	...	⊙	...	3	.....	7627-232
	A(O)	...	14	...	⊙	...	3	.....	7628-585
7 {	A(O)	...	14	...	⊙	...	3	.....	7659-658
	A(O)	...	14	...	⊙	...	3	.....	7660-778
10 {	A(O)	...	8	...	...	...	3	.....	7665-265
	A(O)	...	8	...	...	...	3	.....	7666-239
11 {	A(O)	...	7	...	...	...	3	.....	7670-993
	A(O)	...	7	...	...	...	3	.....	7671-994
?	...	...	7	...	...	...	1	.....	7699-274
?	...	...	4	...	...	...	1	.....	7714-686

* Beginning of the head of A. Outside edge.

† Single line at the beginning of the tail of A.

V. On the Drawing of Curves by their Curvature.

By C. V. BOYS, A.R.S.M., F.R.S.*

[Plate I.]

WHILE giving a course of lectures to working men on Capillarity at the R. School of Mines in 1891, I wished to explain the principles upon which the form of a water-drop depends, and to show that an accurate scale-drawing could actually be produced by following Lord Kelvin's rule (Proc. R. Inst. Jan. 29, 1886); but found that the procedure was so cumbersome as to be in no way adapted to popular exposition. In my attempt to simplify the operation I devised a method of carrying it out which has the double advantage that any of these capillary surfaces of revolution can be drawn with a facility which cannot be approached by following Lord Kelvin's instructions explicitly, while the accuracy of any curve thus determined is so great

* Communicated by the Physical Society: read May 12, 1893.