14. COMMISSION DES ÉTALONS DE LONGUEUR D'ONDE ET DES TABLES DE SPECTRES SOLAIRES

PRÉSIDENT: M. W. F. MEGGERS, *National Bureau of Standards, Washington, D.C.*

MEMBRES: MM. Babcock, Buisson, Burns, Ch. Fabry, A. Fowler, Harrison, Kayser, Nagaoka, Pérard.

I. THE PRIMARY STANDARD

The red radiation, 6438·4696 A., emitted by a cadmium lamp of Michelson type was first chosen in 1907 by the International Union for Co-operation in Solar Research (*Trans. I.U.S.R.* **2**, 109, 1907) as a definition of the unit of wave-length. This primary standard was subsequently adopted by the International Astronomical Union (*Trans. I.A.U.* **1**, 35, 1922) and by the International Committee on Weights and Measures (*Procès-Verbaux Comité Int. Poids et Mesures* (2), **12**, 67, 1927). Specifications for the production of this primary standard were adopted provisionally by the I.A.U. in 1925 (*Trans. I.A.U.* **2**, 47, 232, 1925), and by the I.C.W.M. in 1927 (*Procès-Verbaux Comité Int. Poids et Mesures* (2), **12**, 67, 1927). Three reports of this Commission (*Trans. I.A.U.* **3**, 77, 236, 1928; *ibid.* **4**, 58, 233, 1932; *ibid.* **5**, 81, 299, 1935) have discussed the divergences in these specifications and pointed out the unsatisfactory features of each. This discussion culminated in a revised specification (*Trans. I.A.U.* **5**, 303, 1935) which was adopted unanimously by the I.C.W.M. in 1935 (*Procès-Verbaux Comité Int.* (2), **17**, 91, 1935). Since Commission 14 in its last meeting decided to defer further action on this matter until the I.C.W.M. had made its recommendation, it now seems appropriate to recommend that the I.A.U. adopt the identical specification, which is as follows:

"Spécifications pour la lampe à cadmium du type Michelson. Pour émettre dans des conditions favorables le raie primaire des longueurs d'onde lumineuses $\lambda = 6438{\cdot}4696$ UA, la lampe à cadmium du type Michelson, comportant des électrodes intérieures et excitée par courant électrique, continu, ou alternatif de fréquence industrielle, doit être maintenue à une température voisine de 300° C. (en tout cas ne dépassant pas 320°) et contenir de l'air sous une pression comprise entre 0·7 mm. et 1 mm. de mercure à cette température. Si elle présente un tube capillaire ou plus généralement un étranglement destiné à augmenter sa brillance, aucune dimension latérale de cet étranglement ne devra être inférieure à 2 mm. L'intensité du courant d'excitation ne dépassera pas une valeur telle que sa densité risque d'atteindre 7 mA par millimètre carré de la section la plus étroite de la région observée."

II. SECONDARY STANDARDS. IRON LINES

Except for three iron lines adopted in 1932 (*Trans. I.A.U.* **4**, 234, 1932) no additions or extensions have been made to the list of 235 secondary standards adopted in 1928 (*Trans. I.A.U.* **3**, 86, 1928). These extend from 3370·787 to 6677·993 A., thus covering less than one octave of spectrum. Repeated recommendations that this system be extended both to longer and to shorter waves have been responsible for interferometer measurements of iron lines in the infra-red and ultra-violet. Unfortunately, no efforts to confirm the infra-red values quoted in the last report (*Trans. I.A.U.* **5**, 84, 1935) have been announced and it is, therefore, impossible to extend the present system of secondary iron standards in this direction.

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However, a considerable extension of secondary standards in the ultra-violet is now obtained by averaging the measurements made by Burns and Walters (*Publ. Allegheny Obs.* **6**, 159, 1929; *ibid.* **8**, 39, 1931), by C. V. Jackson (*Proc. Roy. Soc.* (*London*), A, **130**, 395, 1931; *ibid.* A, **133**, 553, 1931), and by Meggers and Humphreys (*J. Research, Nat. Bur. Stand.* **18**, 543, 1937). These are displayed in Tables 1 and 2. The data published by Burns and Walters consist of vacuum arc values, those reported in 1929 being based on neon standards, or calculated from terms thus established, while those appearing in 1931 were interpolated between values previously determined for iron and copper lines. Jackson compared iron lines from the Pfund arc directly with the primary standard or with standard neon lines, and similar measurements were made by Meggers and Humphreys relative to cadmium, neon, and krypton standards.

TABLE 1

Wave-Lengths of Iron Arc Secondary Standards in Air at 15° C. and 760 mm. Pressure, 3497 to 3370 A.

Recommended λ	I.A.U. 1928 Standard	 Interpolated	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
3497·843	·844	·844	·842	·843	·842	$a\,^5D_1 - a\,^5P_2^\circ$
3490·575	—	—	·574	·575	·575	$a\,^5D_3 - a\,^5P_3^\circ$
3485·342	—	·342	·341	·342	·342	$a\,^5P_2 - a\,^5P_1^\circ$
3476·704	·705	·706	·703	·703	·704	$a\,^5D_0 - a\,^5P_1^\circ$
3465·863	·863	·863	·862	·863	·862	$a\,^5D_1 - a\,^5P_1^\circ$
3445·151	—	·152	·151	·150	·151	$a\,^5P_2 - 19R_3^\circ$
3443·878	—	—	·878	·878	·877	$a\,^5D_2 - a\,^5P_1^\circ$
3427·121	—	·121	·120	·121	·121	$a\,^5P_3 - 18R_4^\circ$
3413·135	—	·135	·135	—	·134	$a\,^5P_2 - d\,^3D_3^\circ$
3407·461	—	·462	·461	—	·461	$a\,^5P_3 - c\,^3F_4^\circ$
3401·521	·522	·522	·520	·522	·520	$a\,^5F_4 - b\,^5P_3^\circ$
3399·336	—	·336	·335	·337	·334	$a\,^5P_2 - d\,^3D_2^\circ$
3396·978	—	·980	·978	—	·977	$a\,^5F_3 - b\,^5P_2^\circ$
3383	—	—	·980	—	·981	$a\,^5P_3 - c\,^3F_3^\circ$
3380	—	—	(·110)	—	·111	—
3370·786	·787	·787	(·783)	·786	·784	—

It was shown in the 1932 report (*Trans. I.A.U.* **4**, 64, 1932) that the spectral-term depressions measured by Babcock for a pressure of one atmosphere permitted the calculation of wave-lengths for the iron arc in air from those observed in the vacuum arc. The Burns and Walters values quoted in Tables 1 and 2 have been calculated in this manner by applying the appropriate corrections to their vacuum-arc terms, recalculating wave-numbers from these corrected terms and finally reading the wave-lengths in standard air from Kayser's Schwingungszahlen (H. Kayser, *Tabelle der Schwingungszahlen*, S. Hirzel, Leipzig, 1925; *Phys. Rev.* **48**, 98, 1935). Values in parentheses are quoted from vacuum-arc observations since data for their conversion to atmospheric-arc values are lacking either because the Fe I lines are unclassified or because they are Fe II lines for which no term depressions have been measured. When the proper corrections for these lines are determined it will be possible to derive several dozen additional ultra-violet standards from the means of three independent determinations.

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TABLE 2

Wave-Lengths of Iron Arc Secondary Standards in Air at 15° C. and 760 mm. Pressure, 3355 to 2100 A.

Recommended λ	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
3355	(·228)	·229	·228	—
3347·927	·928	·928	·926	$a\ {}^{3}P_{2}-4R_{2}^{\circ}$
3340·566	·567	·566	·566	$a\ {}^{3}P_{2}-2R_{2}^{\circ}$
3337	(·666)	·667	·666	—
3328	(·866)	·866	·867	—
3323	(·735)	·737	·737	—
3314	(·742)	·741	·742	—
3298·133	·134	·131	·133	$a\ {}^{5}P_{1}-4R_{2}^{\circ}$
3286·755	·757	·754	·754	$a\ {}^{5}P_{3}-e\ {}^{5}P_{3}^{\circ}$
3284·588	·589	·587	·589	$a\ {}^{5}P_{2}-e\ {}^{5}P_{2}^{\circ}$
3280	(·259)	·261	·261	—
3271·002	·003	·001	·001	$a\ {}^{5}P_{2}-e\ {}^{5}P_{1}^{\circ}$
3257·594	·596	·592	·594	$a\ {}^{5}P_{3}-4R_{2}^{\circ}$
3254	(·362)	·362	·363	—
3244·190	·190	·190	·189	$a\ {}^{7}D_{4}^{\circ}-34W_{5}$
3239·436	·436	·437	·436	$a\ {}^{7}D_{4}^{\circ}-33W_{4}$
3236·223	·223	·222	·223	$a\ {}^{5}D_{3}-a\ {}^{3}F_{4}^{\circ}$
3225·789	·789	·790	·788	$a\ {}^{7}D_{5}-53W_{6}$
3222·069	·070	·069	·068	$a\ {}^{7}D_{5}^{\circ}-34W_{5}$
3217·380	·380	·381	·380	$a\ {}^{7}D_{5}^{\circ}-33W_{4}$
3215·940	·941	·940	·940	$a\ {}^{7}D_{2}^{\circ}-20W_{2}$
3205·400	·402	·400	·399	$a\ {}^{7}D_{1}^{\circ}-43W_{1}$
3200·475	·476	·474	·474	$a\ {}^{7}D_{2}^{\circ}-17W$
3196·930	·930	·930	·929	$a\ {}^{7}D_{4}^{\circ}-25W_{5}$
3191·659	·660	·660	·658	$a\ {}^{5}D_{4}-a\ {}^{3}D_{3}^{\circ}$
3184·896	·896	·896	·895	$a\ {}^{5}D_{3}-a\ {}^{3}F_{3}^{\circ}$
3178·015	·014	·016	·014	$a\ {}^{7}D_{5}^{\circ}-27W_{4}$
3175·447	·447	·447	·446	$a\ {}^{7}D_{5}^{\circ}-25W_{5}$
3160·658	·660	·657	·658	$a\ {}^{7}D_{4}^{\circ}-16W_{4}$
3157·040	·040	·042	·039	$a\ {}^{7}D_{4}^{\circ}-13W_{4}$
3143	—	—	·990	—
3134·111	·111	·111	·111	$a\ {}^{5}F_{3}-c\ {}^{5}D_{4}^{\circ}$
3116·633	·633	·633	·633	$a\ {}^{5}F_{1}-c\ {}^{5}D_{2}^{\circ}$
3091·578	·577	·579	·578	$a\ {}^{5}F_{1}-c\ {}^{5}D_{0}^{\circ}$
3083·742	·742	·743	·742	$a\ {}^{5}F_{2}-c\ {}^{5}D_{1}^{\circ}$
3075·721	·721	·722	·720	$a\ {}^{5}F_{3}-c\ {}^{5}D_{2}^{\circ}$
3067·244	·246	·245	·243	$a\ {}^{5}F_{4}-c\ {}^{5}D_{3}^{\circ}$
3059·086	·086	·085	·087	$a\ {}^{5}D_{3}-b\ {}^{5}D_{4}^{\circ}$
3057·446	·446	·447	·445	$a\ {}^{5}F_{5}-c\ {}^{5}D_{4}^{\circ}$
3055	·263	—	·263	$a\ {}^{3}F_{3}-c\ {}^{3}D_{2}^{\circ}$
3047·605	·604	·605	·606	$a\ {}^{5}D_{2}-b\ {}^{5}D_{3}^{\circ}$
3040	·427	—	·428	$a\ {}^{5}F_{4}-c\ {}^{5}F_{5}^{\circ}$
3037·388	·389	·387	·389	$a\ {}^{5}D_{1}-b\ {}^{5}D_{2}^{\circ}$
3030	(·148)	—	·149	—
3024	·033	—	·033	$a\ {}^{5}D_{1}-a\ {}^{3}P_{2}^{\circ}$

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TABLE 2 (*continued*)

Recommended λ	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
3015	—	—	·913	—
3009	·572	—	·570	$a\,{}^5F_4 - c\,{}^5F_4^\circ$
3003	·034	—	·031	$a\,{}^5F_3 - c\,{}^5F_2^\circ$
2999·512	·512	·513	·512	$a\,{}^5F_5 - c\,{}^5F_5^\circ$
2990	(·391)	—	·392	—
2987·292	·293	·291	·292	$a\,{}^5F_4 - c\,{}^5F_3^\circ$
2981·446	·446	·446	·445	$a\,{}^5D_3 - a\,{}^3P_2^\circ$
2965·255	·255	·255	·255	$a\,{}^5D_0 - b\,{}^5F_1^\circ$
2959	(·991)	—	·992	—
2957·365	·365	·365	·365	$a\,{}^5D_1 - b\,{}^5F_1^\circ$
2953·940	·940	·940	·940	$a\,{}^5D_2 - b\,{}^5F_2^\circ$
2941·343	·343	·343	·343	$a\,{}^5D_2 - b\,{}^5F_1^\circ$
2929·008	·008	·008	·008	$a\,{}^5D_3 - b\,{}^5F_2^\circ$
2920	·691	—	·691	$a\,{}^3F_2 - c\,{}^3F_2^\circ$
2912·158	·158	·158	·158	$a\,{}^5D_4 - b\,{}^5F_3^\circ$
2899	(·414)	—	·416	—
2895	·035	—	·035	$a\,{}^3F_3 - c\,{}^3F_3^\circ$
2894	(·504)	—	·505	—
2877	·301	—	·300	$a\,{}^3F_4 - 18R_4^\circ$
2874	·173	—	·172	$a\,{}^5D_4 - a\,{}^5G_5^\circ$
2869·308	·308	·307	·308	$a\,{}^5D_3 - a\,{}^5G_4^\circ$
2863	·864	—	·864	$a\,{}^5D_2 - a\,{}^5G_3^\circ$
2851·798	·799	·797	·797	$a\,{}^3F_1 - b\,{}^5G_2^\circ$
2845	·595	—	·594	$a\,{}^5F_3 - c\,{}^5P_2^\circ$
2838·120	·122	·120	·119	$a\,{}^5F_2 - b\,{}^5G_2^\circ$
2832·436	·438	·436	·435	$a\,{}^5F_3 - b\,{}^5G_4^\circ$
2823·276	·278	·276	·275	$a\,{}^5F_3 - b\,{}^5G_3^\circ$
2813·288	·290	·288	·286	$a\,{}^5F_4 - b\,{}^5G_5^\circ$
2806	(·985)	·985	·984	—
2804·521	·523	·521	·520	$a\,{}^5F_4 - b\,{}^5G_4^\circ$
2797	(·775)	—	·775	—
2781	·837	—	·835	$a\,{}^5F_2 - d\,{}^5D_3^\circ$
2778·221	·224	·220	·220	$a\,{}^5F_5 - b\,{}^5G_5^\circ$
2767·523	·524	·525	·521	$a\,{}^5F_4 - d\,{}^5D_4^\circ$
2763	·111	—	·108	$a\,{}^5F_2 - 52R_3^\circ$
2755	(·738)	—	·737	$a\,{}^4D_4 - a\,{}^4F_3^\circ$
2749	(·322)	—	·325	$a\,{}^4D_3 - a\,{}^4F_4^\circ$
2746	(·983)	—	·982	$a\,{}^4D_3 - a\,{}^4D_3^\circ$
2746	(·482)	—	·483	$a\,{}^4D_2 - a\,{}^4F_3^\circ$
2739	(·546)	—	·547	$a\,{}^4D_4 - a\,{}^4D_4^\circ$
2735·475	·477	·476	·473	$a\,{}^5F_4 - d\,{}^5D_3^\circ$
2727	(·538)	—	·540	$a\,{}^4D_3 - a\,{}^4D_2^\circ$
2723·577	·577	·577	·577	$a\,{}^5D_2 - b\,{}^5P_1^\circ$
2718	·436	—	·435	$a\,{}^5F_2 - 47R_1^\circ$
2714	(·411)	—	·413	$a\,{}^4D_4 - a\,{}^4D_3^\circ$
2711	·656	—	·655	$a\,{}^5F_4 - 50R_5^\circ$
2706	·584	—	·581	$a\,{}^5F_3 - 51R_2^\circ$
2699·107	·106	·108	·106	$a\,{}^5F_4 - 49R_4^\circ$
2689·212	·213	·212	·212	$a\,{}^5F_4 - 48R_3^\circ$
2679·062	·062	·063	·061	$a\,{}^5F_5 - 50R_5^\circ$

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TABLE 2 (*continued*)

Recommended λ	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
2673	·211	—	·213	$a\ ^{5}F_{1} - c\ ^{3}D_{1}^{\circ}$
2662	·056	—	·056	$a\ ^{5}F_{3} - c\ ^{3}D_{2}^{\circ}$
2651	·706	—	·706	$a\ ^{5}F_{3} - b\ ^{3}G_{4}^{\circ}$
2647	·557	—	·558	$a\ ^{5}D_{3} - b\ ^{3}D_{3}^{\circ}$
2644	·001	·005	3·997	$a\ ^{5}F_{1} - c\ ^{5}G_{2}^{\circ}$
2635·808	·810	·807	·808	$a\ ^{3}F_{2} - c\ ^{5}G_{3}^{\circ}$
2628	(·292)	—	·292	$a\ ^{6}D_{1} - a\ ^{6}D_{2}^{\circ}$
2625	(·666)	·668	·666	$a\ ^{6}D_{4} - a\ ^{6}D_{5}^{\circ}$
2621	(·667)	—	·669	$a\ ^{6}D_{1} - a\ ^{6}D_{1}^{\circ}$
2617	(·615)	—	·616	$a\ ^{6}D_{3} - a\ ^{6}D_{3}^{\circ}$
2613	(·823)	—	·824	$a\ ^{6}D_{2} - a\ ^{6}D_{1}^{\circ}$
2611	(·873)	·872	·872	$a\ ^{6}D_{4} - a\ ^{6}D_{4}^{\circ}$
2598	(·368)	·369	·369	$a\ ^{6}D_{4} - a\ ^{6}D_{3}^{\circ}$
2585	(·877)	·876	·875	$a\ ^{6}D_{5} - a\ ^{6}D_{4}^{\circ}$
2584·536	·539	·535	·535	$a\ ^{5}F_{5} - c\ ^{5}G_{6}^{\circ}$
2576	—	—	·103	—
2575	(·744)	—	·744	—
2562	(·533)	·534	·535	$a\ ^{4}D_{4} - a\ ^{4}P_{3}^{\circ}$
2551	(·090)	—	·094	—
2542	(·101)	·102	·101	—
2530	(·691)	·692	·694	—
2519	(·627)	—	·628	—
2507	(·898)	·900	·899	—
2496	(·534)	·533	·532	—
2487	(·064)	—	·064	—
2474	(·813)	·814	·813	—
2468	(·878)	·879	·878	—
2465	(·148)	·148	·148	—
2457	(·595)	·595	·596	—
2453	(·472)	—	·475	—
2447·708	·708	·708	·709	$a\ ^{5}D_{4} - c\ ^{5}F_{3}^{\circ}$
2443	·869	—	·871	$a\ ^{5}F_{5} - 25R_{4}^{\circ}$
2442	—	—	·567	—
2438	(·179)	—	·181	—
2431	(·023)	—	·025	—
2413	(·308)	·309	·309	$a\ ^{6}D_{1} - a\ ^{6}F_{2}^{\circ}$
2411	(·064)	·066	·066	$a\ ^{6}D_{1} - a\ ^{6}F_{1}^{\circ}$
2410	(·518)	·517	·517	$a\ ^{6}D_{2} - a\ ^{6}F_{3}^{\circ}$
2406	(·659)	·657	·659	$a\ ^{6}D_{2} - a\ ^{6}F_{2}^{\circ}$
2404	(·429)	—	·430	$a\ ^{6}D_{2} - a\ ^{6}F_{1}^{\circ}$
2399	(·239)	·238	·240	$a\ ^{6}D_{3} - a\ ^{6}F_{3}^{\circ}$
2389	·970	—	·971	$a\ ^{5}D_{2} - c\ ^{5}P_{3}^{\circ}$
2388	(·627)	·625	·627	$a\ ^{6}D_{4} - a\ ^{6}F_{4}^{\circ}$
2384	(·385)	—	·386	$a\ ^{4}F_{2} - a\ ^{4}D_{2}^{\circ}$
2380	(·759)	·757	·759	$a\ ^{6}D_{3} - a\ ^{6}P_{4}^{\circ}$
2379	(·275)	·273	·276	$a\ ^{4}F_{4} - a\ ^{4}D_{4}^{\circ}$
2375	(·191)	—	·193	$a\ ^{4}F_{2} - a\ ^{4}D_{1}^{\circ}$
2374	·517	—	·517	$a\ ^{5}D_{0} - c\ ^{5}P_{1}^{\circ}$
2371	·428	—	·428	$a\ ^{5}D_{2} - c\ ^{5}P_{2}^{\circ}$
2370	(·495)	—	·497	$a\ ^{4}F_{2} - a\ ^{4}F_{2}^{\circ}$

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TABLE 2 (*continued*)

Recommended λ	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
2368	(·594)	—	·595	$a\,^4F_3 - a\,^4D_2^\circ$
2366	(·590)	—	·592	$a\,^4F_3 - a\,^4F_3^\circ$
2364	(·826)	·825	·827	$a\,^6D_4 - a\,^6P_4^\circ$
2362	(·019)	—	·019	$a\,^4F_4 - a\,^4F_4^\circ$
2360	(·292)	—	·294	$a\,^4F_4 - a\,^4D_3^\circ$
2359	(·997)	—	·997	$a\,^4F_5 - a\,^4F_5^\circ$
2359	(·104)	·102	·104	$a\,^6D_2 - a\,^6P_3^\circ$
2354	(·888)	—	·889	$a\,^4F_3 - a\,^4F_2^\circ$
2344	(·279)	—	·280	$a\,^6D_1 - a\,^6P_2^\circ$
2338	(·005)	·002	·005	$a\,^6D_1 - a\,^6P_2^\circ$
2332	(·796)	·795	·797	$a\,^6D_4 - a\,^6P_3^\circ$
2331	(·305)	·305	·307	$a\,^4F_5 - a\,^4F_4^\circ$
2327	(·394)	·392	·394	$a\,^6D_3 - a\,^6P_2^\circ$
2320	·356	—	·356	$a\,^5D_3 - d\,^5D_4^\circ$
2313	·102	—	·102	$a\,^5D_2 - d\,^5D_3^\circ$
2308	·996	—	·997	$a\,^5D_1 - d\,^5D_2^\circ$
2303	·578	—	·579	$a\,^5D_1 - 45R_2^\circ$
2303	(·422)	—	·422	—
2301	·681	—	·682	$a\,^5D_0 - d\,^5D_1^\circ$
2300	·140	—	·140	$a\,^5D_2 - 52R_3^\circ$
2299	·217	—	·218	$a\,^5D_2 - d\,^5D_2^\circ$
2297	·785	—	·785	$a\,^5D_3 - d\,^5D_3^\circ$
2296	·924	—	·925	$a\,^5D_1 - d\,^5D_1^\circ$
2294	·405	—	·406	$a\,^5D_1 - d\,^5D_0^\circ$
2293	(·847)	—	·845	—
2292	·522	—	·523	$a\,^5D_3 - 53R_4^\circ$
2291	(·117)	—	·122	—
2287	(·628)	—	·632	—
2287	·247	—	·248	$a\,^5D_2 - d\,^5D_1^\circ$
2284	·083	—	·087	$a\,^5D_3 - d\,^5D_2^\circ$
2283	·653	—	·653	$a\,^5D_1 - 51R_2^\circ$
2277	(·094)	—	·098	—
2276	·024	—	·025	$a\,^5D_4 - d\,^5D_3^\circ$
2274	·087	—	·088	$a\,^5D_2 - 51R_2^\circ$
2272	·066	—	·067	$a\,^5D_3 - 49R_4^\circ$
2271	(·778)	—	·781	—
2270	·860	—	·860	$a\,^5D_4 - 53R_4^\circ$
2265	·051	—	·053	$a\,^5D_3 - 48R_3^\circ$
2264	(·390)	—	·389	—
2260	(·078)	—	·079	$a\,^6D_5 - a\,^4F_5^\circ$
2259	(·511)	—	·511	—
2255	(·859)	—	·861	—
2253	(·122)	—	·125	$a\,^6D_4 - a\,^4F_4^\circ$
2249	(·173)	—	·177	$a\,^6D_5 - a\,^4D_4^\circ$
2248	(·855)	—	·858	—
2245	·649	—	·651	$a\,^5D_2 - c\,^3D_3^\circ$
2240	—	—	·627	—
2231	·210	—	·211	$a\,^5D_3 - c\,^3D_3^\circ$
2228	·168	—	·170	$a\,^5D_2 - c\,^3D_2^\circ$
2211	·234	—	·234	$a\,^5D_2 - c\,^5G_3^\circ$

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TABLE 2 (*continued*)

Recommended λ	Burns-Walters calc.	Jackson	Meggers-Humphreys	Term combination
2210	·685	—	·686	$a\,^5D_4 - c\,^3D_3^\circ$
2207	·065	—	·068	$a\,^5D_4 - b\,^3G_5^\circ$
2201	·115	—	·117	$a\,^5D_3 - c\,^5G_4^\circ$
2200	·722	—	·723	$a\,^5D_1 - d\,^5P_2^\circ$
2196	·037	—	·040	$a\,^5D_1 - d\,^5P_1^\circ$
2191	·200	—	·202	$a\,^5D_0 - 20R_1^\circ$
2187	·190	—	·192	$a\,^5D_2 - d\,^5P_1^\circ$
2186	·888	—	·890	$a\,^5D_1 - 20R_1^\circ$
2183	—	—	·979	—
2180	·864	—	·866	$a\,^5D_1 - b\,^3P_2^\circ$
2176	·836	—	·837	$a\,^5D_0 - b\,^3P_1^\circ$
2173	·209	—	·212	$a\,^5D_1 - 16R_2^\circ$
2172	·580	—	·581	$a\,^5D_1 - b\,^3P_1^\circ$
2165	(·859)	—	·861	—
2164	·545	—	·547	$a\,^5D_2 - 16R_2^\circ$
2163	·858	—	·860	$a\,^5D_0 - 10R_1^\circ$
2163	(·363)	—	·368	—
2161	·575	—	·577	$a\,^5D_1 - d\,^3D_2^\circ$
2157	·790	—	·792	$a\,^5D_3 - 19R_3^\circ$
2153	·002	—	·004	$a\,^5D_2 - d\,^3D_2^\circ$
2151	·096	—	·099	$a\,^5D_3 - c\,^3F_4^\circ$
2150	·180	—	·182	$a\,^5D_2 - c\,^3F_2^\circ$
2145	·186	—	·188	$a\,^5D_3 - d\,^3D_3^\circ$
2141	·714	—	·715	$a\,^5D_3 - c\,^3F_3^\circ$
2139	·694	—	·695	$a\,^5D_4 - 18R_4^\circ$
2138	·588	—	·589	$a\,^5D_4 - 19R_3^\circ$
2135	—	—	·957	—
2132	·013	—	·015	$a\,^5D_4 - c\,^3F_4^\circ$
2130	—	—	·962	—
2115	·166	—	·168	$a\,^5D_2 - e\,^5P_1^\circ$
2112	·965	—	·966	$a\,^5D_0 - e\,^5P_1^\circ$
2110	—	—	·233	—
2108	·955	—	·955	$a\,^5D_1 - e\,^5P_1^\circ$
2102	·350	—	·349	$a\,^5D_3 - e\,^5P_3^\circ$
2100	·794	—	·795	$a\,^5D_2 - e\,^5P_1^\circ$

In Table 1, the new measurements are compared with those adopted in 1928 (*Trans. I.A.U.* **3**, 86, 1928) for the overlapping range, 3497 to 3370 A. A similar comparison, made in the 1932 report (*Trans. I.A.U.* **4**, 73, 1932), suggested slight amendments to a few of the 1928 values but no action was taken. The present comparison, which includes another set of observations, indicates definitely that some of the adopted values should be reduced by 0·001 A. In Table 2 the thrice determined values between 3370 and 2447 A. are in remarkably good agreement (except for 2644 A.), but for waves shorter than 2330 A., the Burns and Walters values are systematically 0·0014 A. lower than those by Meggers and Humphreys. This difference is only 1/15 of the phase-dispersion correction which was experimentally determined by Meggers and Humphreys as necessary at 2100 A. for 2 mm. etalons and aluminized interferometer plates. This correction for the spectral change of phase at reflection, which is inherent in the Fabry-Perot interferometer

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method of comparing wave-lengths, may impose a limit on the accuracy with which lines far removed from the primary standard can be measured relative to the latter. For this reason it may be preferable to make such comparisons by a reflection-echelon method (proposed by W. E. Williams, *Proc. Phys. Soc.* **45**, 699, 1933) in which no account need be taken of the variation with wave-length of the phase change at reflection. Regardless of method, a third set of determinations of iron lines in the ultra-violet is required to give the present system of secondary standards a possible extension to 2100 A.

III. WAVE-LENGTH STANDARDS IN THE EXTREME ULTRA-VIOLET

No interferometer measurements of wave-lengths shorter than 2100 A. have been reported. For these, and for the entire range of vacuum spectroscopy, it appears advisable to recommend the use of the reflection echelon whose theoretical advantages over the Fabry-Perot interferometer include a constant and possibly higher resolving power, avoidance of differential phase-change corrections, and perfect transparency throughout the extreme ultra-violet.

Other methods of fixing standards in the extreme ultra-violet involve computations based on series formulas or on the combination principle of spectroscopy. Paschen's (*Preuss. Akad.* 1929, 662) calculations of the H and He wave-lengths are an illustration of the former, while Shenstone's (*Phil. Trans.* **235**, 195, 1936) paper on Cu II is a fine example of the latter. From terms whose relative values are fixed by interferometer (and grating) measurements from the infra-red to the ultra-violet at 2100 A., Shenstone was able to calculate the wave-lengths of more than 100 Cu II lines lying between 2000·339 and 685·139 A. These values are thought to have an accuracy varying from 0·003 A. at 1700 A. to 0·0006 A. at 800 A.

In view of the superior quality of secondary standards obtained from the first spectra of the noble gases we might expect to calculate satisfactory standards throughout the extreme ultra-violet if the relative values of the terms for their second and third spectra can be accurately fixed by interferometer observations of the longer waves. An attempt, at the National Bureau of Standards, to carry this through for A and Kr failed because none of the conventional light sources emit sufficiently homogeneous spark lines of the noble gases to allow high precision measurement of their wave-lengths.

Since the best-observed constant wave-number differences and cyclical combinations indicate that the combination principle is probably an exact law of atomic spectra, it would seem that the calculation of wave-lengths in this manner would be the ideal method of producing standards in spectral regions unobserved and difficult to observe. However, aside from the experimental difficulty of establishing the relative values of spectral terms with sufficient accuracy, this method may have a limited precision at present on account of its dependence on the dispersion of air, since cyclical combinations leading to extreme ultra-violet standards are based on standard-air wave-lengths which are converted to vacuum values by means of refractive indices. The 1932 report (*Trans. I.A.U.* **4**, 59, 1932) quoted some new determinations of the index of refraction of air for the primary standard which indicated that the correct value was 1·0002764 as compared with 1·0002758 derived from the formula published by Meggers and Peters (*B.S. Sci. Pap.* **14**, 697, 1918). Although this difference is important for the correct conversion

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of the primary standard from air to vacuum, relative values of wave-lengths will not be affected unless the dispersion data now in common use are shown to be in error.

IV. THE DISPERSION OF AIR

In Table 3 the calculated refractivity data of Meggers and Peters (*loc. cit.*) for standard air are compared with values recently indicated by Paschen (*Ann. der Phys.* (5), **31**, 75, 1938), and with values computed from formulas communicated by Sears (*vide infra*), or by Kösters and Lampe (*Phys. Zeit.* **35**, 223, 1934), or by Pérard (*Trav. Bur. int. Poids Mes.* **19**, 78, 1934).

TABLE 3

Refractivity of Dry Air at 15° C. and 760 mm.

$(n-1)\,10^7$

λA	Meggers and Peters	Paschen	Sears	Kösters and Lampe	Pérard
2000	3255·8	3240	3190·6	3216·7	3264·7
3000	2906·9	2910	2912·6	2916·4	2920·5
4000	2817·1	2822	2826·8	2828·0	2827·2
5000	2781·3	2788	2789·2	2790·0	2788·8
6000	2763·3	2772	2769·2	2770·1	2769·3
7000	2753·0	2760	2757·4	2758·4	2758·0
8000	2746·5	2751	2749·8	2750·9	2750·7
9000	2742·1	2748	2744·6	2745·8	2745·8
10000	2739·1	2744	2740·9	2742·2	2742·4

By comparison the first mentioned are too large at 2000 A. and too small for waves longer than 2500 A., the latter difference being greatest near 4000 A. No doubt remains that the dispersion of air should be redetermined, preferably by two or more observers working independently.

Preparations are being made at the National Bureau of Standards to measure refractivities of standard air from 2000 to 12,000 A., taking advantage of twenty years of improvements in light sources, interferometry, and photography. Preliminary observations give a value of 1·0002764 for the primary standard, and confirm the larger positive correction required by blue and green light.

The following report on "Recent Measurements of the Refractive Index of Air at the National Physical Laboratory" was kindly supplied by Mr Sears at the request of Professor Fowler:

"Since 1935, work at the National Physical Laboratory has been directed to a determination of definitive values of the refraction and dispersion of dry CO_2-free air for the visible spectrum, an exact knowledge of which is essential before a wave-length definition of the units of length can be adopted for practical purposes in metrology. The measurements were made over an optical path equivalent to more than 2×10^6 wave-lengths of red light, at temperatures extending from 12° C. to 30° C. and at pressures extending from 100 mm. to 800 mm.

"Preliminary calculations have shown that the observed results can be closely represented by the following formulae:

Dry, CO_2*-free air at* 20° C. *and* 760 *mm., visible spectrum*:

$$(n_{20,760}-1)\,10^6=267{\cdot}872_5+\frac{1{\cdot}5189}{\lambda^2_{\text{vac.}}}+\frac{0{\cdot}01246}{\lambda^4_{\text{vac.}}}.$$

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At temperature t° C. *and pressure* p *mm.*:

$$(n_{t,p}-1)=(n_{20,760}-1)\,\frac{p\,(1+\beta p)}{760\,(1+760\beta)}\cdot\frac{1+20\alpha}{1+\alpha t},$$

where $\beta=0{\cdot}73\times10^{-6}$, $\alpha=0{\cdot}003674$ and $\lambda_{\text{vac.}}$ is expressed in microns (1×10^{-6} m.).

"The definitive values given by these equations are in good accordance with those previously obtained by Pérard (*Trav. Bur. int. Poids Mes.* **19**, 66, 1932) at the Bureau International des Poids et Mesures, and by Kösters and Lampe (*Phys. Zeit.* **35**, 223, 1934) at the Physikalisch-Technische Reichsanstalt, both of which are very close to the general mean of all determinations since 1857, and are appreciably higher than those of Meggers and Peters (*Bull. Bur. Stand.* **14**, 697, 1918), which have been generally regarded during the past twenty years as standard values, particularly for spectroscopic purposes.

"Further examination of the complete series of measurements made at the National Physical Laboratory between 1935 and 1937 has led to some interesting conclusions, particularly concerning the relation between refractive index and density of air, and some confirmation has been found for D. Berthelot's (*Trav. Bur. int. Poids Mes.* **13**, 1907) representations of the characteristic behaviour of gases at low pressures, based on modifications of the equations of state of van der Waals and Clausius. Another interesting feature is that no evidence has been found in support of the relationship suggested by Tilton (*J. Research, Nat. Bur. Stand.* **13**, 111, 1934) between the refractivity of dry air and sunspot activity, although the experimental work occupied a period when sunspot activity was probably increasing at its maximum rate for the present cycle.

"It may be added that from internal evidence the experimental accuracy of the work is shown to be equivalent to about ± 1 part in 10^8 of the value of the refractive index.

"Finally some experiments have been made to determine the effect of moisture upon the refraction and dispersion of dry CO_2-free air, as the information at present available upon this subject is rather meagre. From the results obtained, the refraction and dispersion of water vapour at low pressures were calculated, the values found being in reasonably good agreement with those given by C. and M. Cuthbertson (*Phil. Trans. Roy. Soc.* A, **213**, 1, 1914) as the result of an investigation upon steam.

"It is intended to make similar measurements of the refraction and dispersion of dry, CO_2-free air for the infra-red and ultra-violet regions; such extensions should provide a more accurate knowledge of the form of the dispersion curve than is at present available for the whole region extending from 2000 A. up to 10,000 A."

V. NOBLE GAS STANDARDS

The 8-figure neon and krypton standards adopted in 1935 (*Trans. I.A.U.* **5**, 86, 87, 1935) continue to serve excellently for spectroscopical and metrological observations of the highest precision, demonstrating that they are reproducible and convenient. C. V. Jackson's final publication of krypton measurements (*Phil. Trans.* **236**, 1, 1936) does not affect the adopted standards, but makes available some additional provisional values in the blue and ultra-violet.

The possibility of extending noble gas standards in the ultra-violet has been

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thoroughly investigated by Humphreys (*J. Research, Nat. Bur. Stand.* **20**, 17, 1938), who has published 8-figure values for 27 neon lines (3754·2160 to 3369·8086 A.), 40 argon lines (4702·3164 to 3319·3446 A.), and 37 krypton lines (4812·6367 to 3424·9433 A.). Relative values as tested by the combination principle appear to be correct within 1 part in 20,000,000. No other measurements of comparable precision have been made for ultra-violet lines from noble gas spectra, except those of Kr by C. V. Jackson. These are quoted in Table 4 and compared with Humphreys's values.

TABLE 4

Wave-Lengths of Ultra-violet Krypton Lines

λ Whole number A	λ Fraction A	
	Humphreys Kr standard	Jackson Cd standard
3845	·9778	—
3837	·8162	·8162
3837	·7028	—
3812	·2155	·2159
3800	·5437	·5440
3796	·8839	·8840
3773	·4241	·4247
3698	·0452	·047
3679	·6111	—
3679	·5609	—
3668	·7363	·7374
3665	·3259	·3263
3632	·4896	—
3628	·1570	·1571
3615	·4755	·4749
3540	·9538	—
3539	·5416	—
3522	·6747	·675
3511	·8963	—
3503	·8981	—
3502	·5537	—
3495	·9900	·9897
3434	·1423	—
3431	·7217	—
3424	·9433	—

Unfortunately the first spectra of the noble gases have, below 3300 A., no strong lines which can be observed conveniently with interferometers. But since the tested ultra-violet lines appear to be of the same high quality as the visible ones it is urged that they be determined as accurately as possible so that they may be substituted for the primary standard when measuring ultra-violet wave-lengths, thus reducing in future measurements the corrections necessary on account of dispersion of phase change, or standard air.

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VI. STANDARD SOLAR WAVE-LENGTHS

Seven-figure values of wave-lengths (3597·027 to 7122·206 A.) measured in the solar spectrum were adopted as standards in 1928 (*Trans. I.A.U.* **3**, 93, 1928). Babcock submitted further measurements of red and infra-red lines in 1932 (*Trans. I.A.U.* **4**, 83, 1932), and in 1935 (*Trans. I.A.U.* **5**, 91, 1935). Similar observations have since been made by the Allegheny Observatory and National Bureau of Standards, and a portion of these results are reported in Table 5, together with the Mount Wilson results for the same spectral range. The latter consist of the latest published values (*Ap. J.* **83**, 103, 1936) and of additional values supplied by Babcock in time for insertion in the printer's proof of this report. The Mt. Wilson results are based on standards of reference chosen from the "A" band of terrestrial oxygen as previously determined from neon standards. The unpublished interferometer measurements of Allegheny Observatory and Bureau of Standards embrace many hundreds of lines between 7000 and 10,960 A., but only those between 7569 and 9899 A. are ready for inclusion in this report. All measurements of solar lines by Allegheny Observatory and Bureau of Standards are referred directly to neon standards and standard air. Both sets of data, MW and AO-BS, are for integrated sunlight, and all lines of solar origin are corrected for Doppler-Fizeau displacements. Data for the interval 7569 to 9899 A. are collected in Table 5. Estimates of the probable error are either not available, or omitted to save space, but it may be stated that the AO-BS values represent the means of 5 to 35 determinations. Calculated probable errors are perhaps less informative than a comparison of these independent results. Such a comparison for 229 MW and AO-BS values in Table 5 reveals an average difference of one part in 4,600,000 and an insignificant systematic difference, AO-BS minus MW, of plus one in 29,000,000! In column 2 of Table 5, seven-figure values are entered for all lines whose independent determinations deviate less than 1 part in 4,000,000 from the mean. These 229 lines are recommended for adoption as secondary standards.

TABLE 5

Standard Wave-Lengths in the Infra-red Solar Spectrum (7569–9899 A.)

Origin	Recommended λ	MW	AO-BS
Fe	7568·906	·905	·907
Ni	7574·048	·046	·050
Fe	7583	·796	·802
Fe	7586·027	·025	·029
A	7593	—	·697
A	7593	—	·996
A	7594	—	·512
A	7595·770	·768	·772
A	7599·462	·463	·462
A	7601	—	·123
A	7602·995	·996	·994
A	7607	—	·365
A	7611·194	·194	·194
Ni	7616·980	·980	·981
Ni	7619·214	·212	·215

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	7619	—	·696
A	7621·802	·801	·803
A	7625·354	·353	·354
A	7626	—	·520
A	7629	—	·092
A	7630	—	·241
A	7633	—	·034
A	7638·306	·308	·305
A	7642	—	·650
A	7647·202	·204	·200
A	7649·553	·552	·554
A	7651·963	·963	·963
Mg	7657·606	·605	·608
Fe	7664	—	·297
A	7665·944	·944	·945
A	7670	·600	·605
A	7671·669	·670	·668
A	7676·565	·563	·567
A	7677·619	·618	·620
Si	7680	·267	·272
A	7682·758	·756	·759
A	7683·802	·800	·803
A	7689	·177	·183
A	7690·218	·217	·220
A	7695·838	·836	·840
A	7696·869	·868	·870
A	7702	·736	·741
A	7703	·754	·761
Fe	7710	—	·371
Ni	7714·310	·309	·312
Fe	7723	—	·215
Ni	7727·616	·616	·616
Fe	7742	·722	·727
Fe	7748·284	·284	·283
Fe	7751·116	·116	·115
O	7775	—	·400
Fe	7780·568	·567	·568
Ni	7788·933	·933	·933
Ni	7797·588	·587	·589
Fe	7807·916	·915	·917
Fe	7832·208	·207	·210
Al	7836·130	·132	·129
⊙	7849	·984	·974
Fe	7855	—	·398
A	7864·437	·437	·437
A	7866	—	·068
A	7872	—	·795
A	7880	—	·694
A	7885·014	·014	·014
A	7887·117	·117	·117

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Table 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	7893·512	·511	·513
A	7896	—	·037
A	7901	—	·776
A	7908	—	·752
Fe	7912·870	·869	·871
A	7915·634	·632	·635
Si	7918	—	·384
A	7920·666	·664	·667
A	7924	—	·354
A	7928·618	·617	·620
Fe	7937·150	·149	·151
Fe	7941·096	·096	·096
Fe	7945·858	·857	·859
A	7953	—	·820
A	7958·492	·491	·492
A	7960	—	·739
A	7961	—	·621
A	7964	—	·353
A	7971·522	·520	·524
A	7975	—	·003
A	7980	—	·465
A	7984·342	·343	·341
Fe	7994·488	·488	·489
A	8000·300	·302	·299
A	8007	—	·480
A	8012·940	·940	·940
A	8020	—	·715
Fe	8028	—	·324
A	8028	—	·542
A	8034	—	·298
A	8036·460	·460	·460
A	8039·600	·598	·601
A	8043	—	·169
A	8045·530	·531	·530
Fe	8046·058	·056	·059
Fe	8047·625	·625	·625
A?	8059	—	·544
A?	8063·286	·286	·286
A	8070	—	·018
Fe	8075·158	·158	·157
Fe	8085	—	·170
A?	8094	—	·274
A	8096·580	·580	·581
A?	8103·165	·165	·165
A	8107·842	·841	·843
A	8110	—	·574
A	8113	—	·950
A	8118·910	·908	·912
A	8125·445	·444	·446
A	8130	—	·015

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	8130	—	·463
A	8133·209	·209	·209
A	8135	—	·050
A	8136	—	·209
A	8139·718	·718	·717
A	8141	—	·936
A	8144	—	·194
A	8146·213	·214	·212
A	8147·188	·188	·187
A	8149	—	·271
A	8149	—	·692
A	8152	—	·499
A	8158	—	·024
A	8161	—	·434
A	8165·337	·338	·336
A	8168	—	·822
A	8169·386	·384	·387
A	8174	—	·683
A	8177·932	·932	·932
A	8178·491	·491	·491
A	8181·848	·847	·850
A	8186	·371	·376
Na	8194·836	·836	·837
A	8199	—	·994
A	8200·694	·695	·693
Fe	8207·749	·747	·751
A	8212·132	·132	·131
A	8218·114	·112	·115
A	8221·553	·553	·553
A	8225·688	·688	·688
A	8229·762	·762	·762
A	8233·906	·907	·905
A	8234·628	·628	·629
A	8237·341	·342	·340
Fe	8239·132	·132	·133
A	8239·924	·925	·922
A	8243	—	·128
Fe	8248·137	·139	·135
⊙	8248·802	·800	·804
A	8252·727	·727	·727
A	8257	—	·865
A	8259·692	·692	·691
A	8263·445	·446	·444
A	8269	—	·184
A	8272·042	·041	·043
A	8273	—	·082
A	8279·600	·600	·600
A	8282	—	·024
A	8287	—	·944
A	8294	—	·162

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	8295	—	·305
A	8300·408	·407	·410
A	8304·300	·301	·298
A	8311·956	·955	·958
A	8313	—	·873
A	8316·224	·225	·222
A	8318	—	·139
A	8321	—	·244
Fe	8327·061	·060	·062
A	8329·682	·682	·682
A	8333·584	·584	·584
Fe	8339	—	·420
A (V)	8342·290	·289	·292
A	8349·162	·160	·164
A	8353	—	·653
A	8357·040	·041	·039
A	8357	—	·444
A	8362·302	·302	·302
Fe	8365	—	·645
A	8367·331	·332	·330
A	8373	·711	—
A	8376·381	·382	·380
Fe	8387	·782	·788
A	8394·020	·018	·022
A	8397·152	·152	·153
A	8408	—	·760
Ti	8412	·356	·367
A	8415	—	·451
Fe	8424	—	·145
Ti	8426·514	·514	·514
Ti	8434·968	·968	·967
Ti	8435	·655	—
Fe	8439·581	·580	·582
—Si	8443	—	·981
O	8446	—	·374
Fe	8468·418	·418	·419
Fe	8471·744	·744	·744
Ca+	8498	—	·062
Si	8502	—	·233
Fe	8514·082	·081	·082
Fe	8515·122	·121	·122
A	8519	—	·645
Fe	8526·676	·674	·677
Si	8536	—	·174
A	8540	—	·812
Ca+	8542	—	·135
Si	8556·797	·795	·799
⊙	8571·807	·809	·805
Fe	8582·271	·271	·271
Fe	8592	—	·969

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
Si	8595·968	·970	·967
Fe (Ni)	8598·836	·835	·836
Fe	8611·812	·813	·812
Fe	8613·946	·945	·946
Fe	8616·284	·284	·283
Fe	8621	—	·610
Si	8648·472	·472	·471
Ca$^+$	8662	—	·184
Fe (Mn)	8674·756	·756	·755
A?	8679	—	·641
A?	8686	—	·365
Fe	8688	·642	·634
– S	8694	—	·647
Fe	8699·461	·460	·462
Fe	8710	—	·394
⊙	8712	—	·695
Fe	8713·208	·210	·206
⊙	8717·833	·833	·833
– Si	8728	·024	·016
Mg	8736	·040	·032
Si	8742	—	·459
Fe	8747·438	·437	·440
Si	8752	·025	·017
Fe	8757	—	·193
Fe	8763	—	·973
Al	8773·906	·907	·905
Fe	8784·444	·443	·445
Fe, Si	8790·454	·454	·453
Fe	8793·350	·350	·351
Fe	8796	—	·496
Fe	8804	·637	·631
Mg	8806	—	·775
Ni	8809	—	·414
Fe	8824·234	·236	·232
Fe	8838	—	·436
Fe	8846	—	·745
A	8858	—	·810
Ni	8862	—	·558
Fe	8866·943	·943	·943
Fe$^-$	8868·444	·446	·442
Fe	8876·030	·031	·029
A	8879·316	·318	·315
Si	8892	—	·732
A	8900	—	·621
⊙	8912	·101	·096
A	8917·506	·506	·507
Fe	8920	—	·028
⊙	8927·392	·392	·392
A	8930·270	·269	·271
A	8934	—	·092

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	8940	—	·203
A	8942	—	·343
A	8946·878	·878	·877
A	8950·744	·746	·743
A	8954	—	·305
A	8958·402	·401	·402
A	8963·492	·492	·492
A	8966	—	·413
A	8969·030	·029	·032
A	8972	—	·897
A	8976·424	·422	·426
A	8981	—	·417
A	8986	·600	·595
A	8993·043	·042	·044
A	9009	—	·052
A	9018	·090	·097
A	9029	—	·396
A	9031	·395	·406
A	9040	—	·093
A	9047·412	·411	·414
A	9051	—	·093
A	9052·974	·972	·976
A	9060·434	·435	·434
A	9073·134	·132	·136
A	9074·306	·308	·305
A	9085	·451	·457
A	9092·482	·481	·484
A	9101	—	·512
A	9105·399	·401	·397
A	9115	·644	·652
A	9118·009	·010	·008
A	9127	—	·820
A	9132·443	·442	·444
A	9140·457	·456	·458
A	9150·800	·798	·801
A	9160	·904	—
A	9168	—	·773
A	9175·249	·249	·249
A	9178·534	·535	·533
A	9181·203	·202	·204
A	9190·208	·208	·209
A	9192·568	·568	·569
A	9199	—	·094
A	9205·584	·586	·583
A	9212	—	·826
A	9222	—	·013
A	9225·006	·007	·004
A	9232·750	·751	·749
A	9234	—	·783
A	9238	—	·090

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	9240	—	·383
A	9251·100	·100	·099
A	9254·347	·347	·347
A	9266	—	·208
A	9275·072	·072	·071
A	9289·856	·855	·858
A	9296	—	·425
A	9301·910	·910	·911
A	9311·734	·735	·733
A	9314·006	·007	·005
A	9320·768	·767	·768
A	9321·650	·650	·651
Fe	9328	—	·708
A	9330	·456	—
A	9348·382	·382	·381
A	9360	—	·595
A	9361·227	·226	·228
A	9363·334	·332	·335
A	9374·280	·278	·281
A	9400·094	·094	·095
A	9402	—	·614
A	9406·904	·903	·904
A	9412	—	·674
A	9420	—	·055
A	9420	—	·737
A	9444·412	·410	·414
A	9450	—	·314
A	9463·992	·993	·990
A	9467	—	·060
A	9472·418	·420	·416
A	9472	—	·975
A	9476·754	·753	·756
A	9478·884	·884	·884
A	9483·970	·969	·972
A	9486·042	·044	·040
A	9491	·526	·534
A	9503	—	·260
A	9504·434	·435	·432
A	9507·742	·742	·742
A	9512·630	·630	·629
A	9514	—	·484
A	9526	—	·872
A	9533·411	·411	·411
A	9547	—	·096
A	9549·958	·957	·958
A	9550·962	·961	·963
A	9558·836	·835	·836
A	9570	—	·325
A	9575·680	·680	·680
A	9583	—	·592

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	9587·126	·125	·128
A	9596	—	·417
A	9598·870	·871	·868
A	9601·170	·168	·172
A	9610	—	·642
A	9612	—	·538
A	9614	·048	·043
A	9624·496	·496	·495
A	9629·997	·996	·998
A	9633	—	·494
A	9643·105	·105	·105
A	9651·932	·932	·933
A	9659	·729	·724
A	9664·646	·646	·645
A	9667	—	·309
Ti	9675	—	·551
A	9681	—	·746
A	9686·386	·386	·385
A	9694·588	·588	·587
A	9698	—	·292
A	9700·139	·140	·138
A	9708·922	·922	·921
A	9719	—	·722
A	9724	·576	—
A	9726	—	·704
A	9730·638	·636	·639
A	9737	—	·866
A	9747	—	·804
A	9749	·322	—
A	9753	—	·832
A	9755·979	·980	·978
Fe	9764	—	·378
A	9765·495	·497	·493
A	9768·637	·638	·636
A	9776·818	·818	·817
A	9779·406	·408	·404
A	9787·146	·147	·144
A	9791·006	·006	·006
A	9795·288	·289	·288
A	9799·476	·475	·477
A	9803·241	·242	·240
A	9808	—	·553
A	9813	·461	·456
A	9821·754	·754	·755
A	9831·960	·961	·958
A	9835·758	·760	·757
A	9840·092	·090	·094
A	9843·978	·980	·976
A	9850·524	·526	·522
Fe (A?)	9861	·746	·736

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TABLE 5 (*continued*)

Origin	Recommended λ	MW	AO-BS
A	9865	—	·517
A	9870	—	·271
A	9873·638	·640	·636
A, Fe	9878·200	·200	·201
Fe	9889·050	·052	·048
Ni (A?)	9898	·972	·965

Preliminary values of selected lines in the solar spectrum (10,628 to 12,425 A.) resulting from grating measurements at the Mount Wilson Observatory were presented in the last report (*Trans. I.A.U.* **5**, 92, 1935), and a similar but not identical list (10,628 to 12,103 A.) was subsequently published (*Ap. J.* **83**, 117, 1936). Mr Babcock now submits a supplementary list of 30 lines (12,015 to 13,376 A.), printed here as Table 6. These preliminary values, at present among the best determined solar wave-lengths exceeding 10,600 A., are given with the hope that they will be measured by other observers co-operating to establish the scale of the infra-red solar spectrum to its present photographic limit.

TABLE 6

Supplementary List of Wave-Lengths and Intensities in the Solar Spectrum (12,015 to 13,376 A.)

λ	Intensity	λ	Intensity
12015·21	8	13000·79	3
12047·42	6	13062·90	10
12078·06	3	13077·73	10
12088·36	3	13119·06	5
12096·51	3	13166·54	40
12165·26	2	13184·84	3
12223·08	2	13210·79	10
12267·20	3	13228·50	5
12270·65	3	13237·05	5
12604·66	3	13288·77	5
12621·77	3	13297·88	10
12656·93	4	13321·20	5
12723·70	1	13345·91	10
12737·75	3	13356·56	25
12818·10	50*	13376·33	4
12970·05	3		

VII. SPECTROSCOPIC NOTATION

At its last meeting, this Commission recommended that consideration be given to the standardization of notation for the character and for the quantum description of spectral lines. The suggestion originated with Prof. Kayser who, in compiling spectroscopic data for more than a quarter of a century, encountered a confusion

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* Second member of the Paschen series of hydrogen.

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of symbols representing special characteristics or properties of spectral lines in addition to wave-lengths and intensities. A list of such symbols or abbreviations is presented in Table 7 for discussion or adoption.

TABLE 7

Proposed Notation for the Description of Spectral Lines

A = Angstrom unit*
B = band head
c = complex (narrow fine structure, isotopic or nuclear-spin hyperfine structure)
d = unresolved double (approximate coincidence of two lines)
e = enhanced at electrode
E = enhanced in spark as compared with arc
f = narrow fine structure, e.g. He 5875 A.
g = ghost
h = hazy, diffuse, nebulous
H = very hazy, diffuse, nebulous
i = isotopic fine structure, e.g. Ne lines
hfs = nuclear-spin hyperfine structure
l = shaded or displaced to longer waves
s = shaded or displaced to shorter waves
p = part of band structure
r = narrow self-reversal
R = wide self-reversal
u = unsymmetrical
w = wide
W = very wide
? = doubtful
( ) = masked by line inclosed in parentheses
0·1 = 0·5 > probable error > 0·05
0·01 = 0·05 > probable error > 0·005
0·001 = 0·005 > probable error > 0·0005
0·0001 = 0·0005 > probable error > 0·00005

It seems probable that all useful qualitative information about individual spectral lines can be expressed by one or more of these symbols. Thus *Bl* = band head, shaded to longer waves, *ci* = complex, isotopic fine structure, *g?* = ghost, doubtful, *us* = unsymmetrical, shaded to shorter waves, etc. The symbol *hfs* is already in common use for hyperfine structure, and will not be confused with the combination *h*, *f*, *s* because hazy lines cannot reveal narrow fine structure. When the cause of complexity of a spectral line can be recognized, it is informative to distinguish between *f* = narrow fine structure, *hfs* = hyperfine structure due to nuclear spin, and *i* = isotopic fine structure, although more than one cause may be present, e.g. *i*, *hfs*.

With regard to a satisfactory notation for the representation of spectral terms and for the designation of quantum-interpreted spectral lines, the present state of affairs is most pleasing. Discussion of this subject by a large number of contributors led to the formulation of a system of notation for atomic spectra which was published in 1929 (*Phys. Rev.* **33**, 900, 1929). This system completely supplanted earlier notations, employing gothic or greek letters with arbitrary appurtenances, and is now universally used (with minor variations) for the analytical description of spectra. Together with its logical extension to hyperfine structure phenomena (H. E. White, *Introduction to Atomic Spectra*, 352, McGraw Hill, 1934), it has proved to be entirely satisfactory for the complete quantum classification of the data of

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* See also page 378.

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atomic spectra, and should receive the distinction of formal adoption by the International Astronomical Union. The principal variation has been the use of either italic capitals or Roman capitals for spectral term symbols. On account of the advantages of vertical symmetry in placement of super- and sub-scripts and to conform with the rule that italicized symbols do not have quantitative values, the Roman capitals are preferred as symbols for atomic energy levels.

VIII. SUMMARY OF RECOMMENDATIONS

1. It is recommended that the specification for producing the primary standard of wave-length, adopted by the International Committee on Weights and Measures, be formally adopted by the International Astronomical Union.
2. It is recommended that the seven-figure values for ultra-violet iron lines in column 1 of Tables 1 and 2 be adopted as secondary standards of wave-length.
3. It is recommended that the seven-figure values for infra-red solar lines presented in column 2 of Table 5 be adopted as solar-spectrum standards of wave-lengths.
4. It is recommended that the notation in Table 7 for qualitative description of spectral lines, and the spectral term notation outlined in *Phys. Rev.* **33**, 900, 1929, be adopted.

IX. WORK REPORTED IN PROGRESS

Massachusetts Institute of Technology. The following statement is an abstract of a report submitted by Prof. Harrison:

Grating measurements on about 10,000 iron arc and spark lines between 10,000 and 2000 A. have been made with maximum dispersion of 0·4 A./mm., employing the international Pfund arc and Hilger's purest iron. After impurity and ghost lines have been eliminated, many new lines are observed. Testing by means of the combination principle finds the wave-lengths internally consistent to about 0·002 A. on the average.

With the aid of automatic comparators (*J.O.S.A.* **25**, 169, 1935; *R.S.I.* **9**, 15, 1938) in the past two years more than 8,000,000 wave-length measurements have been made relative to secondary iron standards and interferometer observations of ultra-violet iron lines by Jackson and by Meggers and Humphreys. The precision appears to be limited by the high intensity and breadth of some of the iron standards when exposed sufficiently to record all of them. This makes it appear desirable to provide at least one set of tertiary standards where the lines are more uniform in intensity and more evenly spaced than those of iron. Consideration of cerium or a similar complex spectrum is suggested.

Allegheny Observatory. Dr Burns reports that interferometer measurements of strontium lines (2282–10,915 A.) emitted by the vacuum arc at Allegheny Observatory have been completed. Further observations on the solar spectrum are contemplated to supply values in the range 7000–7570 A. and 9900–11,000 A. In the later interval lines of solar origin must be recognized as such in order that the measured wave-lengths may be corrected for relative motion.

National Bureau of Standards. Final preparations are being made for a redetermination of the refractive indices of air for homogeneous wave-lengths distributed throughout the spectrum from 2000 to 12,000 A. Term depressions for the Fe II spectrum are being measured, and the possibility of measuring wave-

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lengths of noble-gas spark lines with precision comparable with that attained for arc lines will be further investigated. Infra-red arc spectra are being photographed, measured and analysed to a limit approaching 13,000 A. Some of these, notably silicon and iron, lead to further identifications of solar lines.

Mount Wilson Observatory. Mr Babcock states that the extensive study of the infra-red solar spectrum has not yet reached a stage warranting its publication, although a large amount of it is practically complete. New impetus has lately been given to this programme through the availability of better instrumental equipment and much more rapid progress is anticipated in the near future.

W. F. MEGGERS
President of the Commission

WASHINGTON, D.C.
March 15, 1938

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