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

PRÉSIDENT: M. A. FOWLER, *Yarrow Research Professor of the Royal Society, Imperial College, London, England.*

MEMBRES: MM. Babcock, Buisson, Burns, Carroll, Evershed, C. Fabry, Hamy, Meggers, Monk, Nagaoka, St John, Saunders.

I. THE PRIMARY STANDARD

(*a*) SOURCE OF PRIMARY STANDARD

In the 1928 report of this Commission, reference was made to differences in the specifications for the production of the red cadmium line adopted by the International Conference of Weights and Measures in 1927 and by the International Astronomical Union in 1925. The difference appears to have arisen mainly from the inadvertent adherence of the International Conference to the text of the provisional recommendation of the Commission on Wave-lengths (*Tr. I.A.U.* **2**, 47) instead of to that finally adopted (p. 232). In view of the possibility that the question may be reconsidered, with a view to securing uniformity, at the next International Conference in 1933, it may be useful to repeat here the details of the two specifications; namely:

I.A.U. 1925: "L'étalon primaire de longueur d'ondes, λ 6438·4696 du cadmium, sera produit par un courant électrique à haute tension dans un tube à vide portant des électrodes intérieures. La lampe sera maintenue à une température ne dépassant 320° C., et devra donner des différences de marche d'au moins 200,000 longueurs d'ondes. La valeur efficace du courant d'excitation ne depassera pas 0·05 ampère. À la température de la salle, le tube ne sera pas lumineux quand il sera connecté au circuit habituel à haute tension."

Int. Conf. of Weights and Measures, 1927: "La lumière doit être produite par un courant électrique de haute tension, continu ou alternatif, de fréquence industrielle (à l'exclusion de la haute fréquence), dans un tube à vide ayant des électrodes intérieures. La lampe doit avoir un volume ne dépassant pas 25 cm.^{3} et un tube capillaire dont le diamètre ne soit pas inférieur à 2 mm.; elle doit être maintenue à une température voisine de 320°, et la valeur du courant qui la traverse ne doit pas excéder 0·02 ampère. À la température ambiante, le tube ne doit pas être lumineux lorsque le circuit à haute tension y est établi." (*La Septième Conférence Générale des Poids et Mesures*, Paris, 1927, p. 52; Gauthier-Villars, 1930.)

The chief point of difference, it will be noted, is the adoption by the I.A.U. of the condition that the cadmium lamp used as source should be capable of giving well-defined interference fringes with retardations of at least 200,000 wave-lengths, in place of the specification of tube dimensions adopted by the International Conference. As stated in the 1928 report of this Commission (p. 237), Babcock considers that the imposition of this condition also makes it unnecessary to prescribe limits for the temperature and current strength. This possible simplification of the specification of the source of the primary standard would appear to be worthy of further experimental investigation.

A further interferometric investigation of the cadmium vacuum arc as a possible substitute for the Michelson lamp has been reported by C. V. Jackson (*Proc. Roy. Soc.* A, **133**, 563, 1931). Using pure cadmium, it was found that the wave-length of the red line from this source was identical with that given by the Michelson tube within one part in ten million; i.e. within 0·0006 A. It may be recalled (Report,

1928) that, in agreement with some previous observers, Brown had already concluded that the difference in wave-length of the red line from the two sources was less than 0·001 A. Various types of quartz-mercury-cadmium vapour lamp were also tested by Jackson, but none proved useful as a source of the standard line, as the wave-length of the red line was always greater than that given by the standard source. Burns (quoted by Jackson) has also found that amalgam lamps give too high a wave-length for the red cadmium line.

A new form of cadmium lamp has been described by Nagaoka and Sugiura (*Sc. Pap. Inst. Ph. Ch. Res.* No. 191, Tokyo, 1929). The lamp is designed to run on direct current at 100 volts and has a life of about 3 hours. In testing the lamp with an adjustable Fabry-Perot interferometer, the fringes of the red cadmium line were clearly visible up to the limit of the instrument at 20 cm. As the distance between the plates was increased, it was observed that there was a periodic variation in the clearness of the fringes, suggesting that the red line may be complex.

(*b*) COMPARISONS OF THE METRE WITH THE STANDARD CADMIUM LINE

A new investigation of the length of the metre in terms of the wave-length of the red cadmium line has been made by N. Watanabe and M. Imaizumi (*Proc. Imp. Acad. Japan*, **4**, 350, 1928). The agreement with the earlier values is very close, no change in the length of the prototype metre being detected after the lapse of twenty-one years. At the same time it was confirmed that the red cadmium line given by Michelson's lamp is quite reliable as a standard of length.

It is interesting to note also that a new wave-length comparator has been constructed at the National Physical Laboratory, Teddington, England, and has already been used for preliminary measurements of the length of the metre in terms of the red cadmium line, both in air and *in vacuo*. The results found for λ_R, which are to be regarded as provisional only, are as follows:

Source	Condition	No. of waves in 1 metre	Wave-length (1×10^{-6} metre)
Michelson lamp	Standard air*	1,553,163·69	0·6438 4714
	Vacuum	1,552,734·44	0·6440 2513

The above result for standard air may be compared with the present internationally accepted value of 0·6438 4696 10^{-6} metre, which it has been shown†, in the light of more recent knowledge of the line standards used in the determination of Benoît, Fabry and Perot, should be increased to 0·6438 4703 10^{-6} metre.

From the ratio of the results for vacuum and for standard air, the value of the refractive index of air for λ_R is found to be:

$$1{\cdot}00027645,$$

which may be compared with

1·000276413 (Pérard)

and 1·000275814 (Meggers and Peters).

Definitive determinations are now being undertaken, which are to be followed by an investigation of other sources of monochromatic radiations as possible alternatives to the Michelson type of cadmium lamp.

---

[*] Dry air at 15° C. and at a pressure of 760 mm. mercury, containing a normal proportion of 0·03 % CO_2.

[†] C. E. Guillaume, *La Création du Bureau International des Poids et Mesures et Son Oeuvre*, p. 224, Gauthier-Villars, Paris, 1927.

II. STANDARDS OF 1928

(*a*) Iron Arc Lines

It is probable that the wave-lengths of iron arc lines recommended as standards by the Commission in 1928 (*Tr. I.A.U.* **3**, 86) will not require further revision for a considerable period. Many spectra, however, have been measured in terms of the standards recommended in 1922, and it seems desirable to indicate more completely how such measurements may be revised to the scale of 1928.

By comparing the "interpolated" wave-lengths of 1922 with the "revised interpolated" wave-lengths of 1928, it is found that the corrections applied in making the revision were as follows:

Region	Subtract from 1922 λ
3370–4000	0·001A
4000–5506	0·002
6027–6065	0·005
6128–6265	0·006
6297–6462	0·007
6475–6609	0·008
6663–6750	0·009

These ranges of wave-length are restricted to tabulated lines, but they may be extended by plotting the mean wave-lengths against the respective corrections. The results are then as follows:

Region	Subtract from 1922 λ
<4000 A	0·001 A
4000–5600	0·002
(5600–5780)	(0·003)
(5780–5960)	(0·004)
5960–6125	0·005
6125–6290	0·006
6290–6455	0·007
6455–6630	0·008
6630–6790	0·009

There are at present no data for evaluating the precise corrections between λ5506 and λ6027, and the figures in brackets are merely interpolated values.

The corrections thus derived are in general accord with those stated in less detail in the 1928 report, with the exception that the correction in the region more refrangible than λ4000 appears as 0·001 in place of 0·002.

For the purposes of the present report, however, Mr Babcock has made a special investigation of the differences between the two scales in the ultra-violet by comparing the interpolated values of 1922 with "the means of measured values" of 1928. In this way he has found the following corrections:

Region	No. of lines	Subtract from 1922 λ
3370–3705	31	0·0006
3719–3849	34	0·0015
3850–3969	29	0·0015

Thus, although the general mean in the ultra-violet is little more than 0·001 A, it may be desirable to use these more precise corrections when it is desired to convert *wave-numbers* from one scale to the other.

In further explanation of Table I of the 1928 report, mention of the following additional particulars has seemed desirable.

(1) The wave-lengths under "M.K.B." were quoted without modification from

the paper by Meggers, Kiess and Burns (*Sc. Papers, Bur. of St.* **19**, 263, 1924). The observations were made with a standard arc in direct comparison with the cadmium standard.

(2) The values under "Monk" were obtained from a standard iron arc by interferometric comparisons with neon lines.

(3) The wave-lengths under "Babcock" were taken from *Ap. J.* **66**, 256, Tables I and V, Nov. 1927. They were obtained from a standard iron arc, and most of them were determined by the interferometer with reference to the primary cadmium standard. A few were determined with reference to adjacent iron lines. The line 3485·341 is misquoted as 3485·343. In a communication to the President of the Commission, Mr Babcock has explained that the values given by him at a later date (*Ap. J.* **67**, 240, April 1928) are from combinations of his 1927 wave-lengths with some earlier observations and with some calculated values; these are not of equal weight with the data in the 1928 report, and should not be used in the adoption of standards.

Three additional iron lines in the violet have since been measured with the interferometer by C. V. Jackson (*Proc. Roy. Soc.* A, **130**, 403, 1931). These have also been measured by Babcock (*Ap. J.* **67**, 247, 1928), and, in the vacuum arc, by Burns and Walters. The latter may be corrected to the arc in air by using Babcock's pressure displacements in the way described later. The three values are compared with the computed values in the following table:

Recommended λ	Babcock	B. W. corrected	Jackson	Computed
4063·597	·597	·597	·597	·597
4071·740	·741	·740	·740	·740$_6$
4260·479	·480	·478	·479	·478$_4$

These lines may well be included in the list of recommended secondary standards.

(*b*) SOLAR STANDARDS

It should be carefully noted that the standards for solar lines given in Table IV of the 1928 report have been adjusted to the secondary iron standards of 1928. They accordingly differ from the wave-lengths of the "Rowland Revision" (published in 1928 by the Carnegie Institution), which are on the iron arc scale of 1922. The wave-lengths of the Rowland Revision, however, may be reduced to the iron scale of 1928 by applying the subtractive corrections tabulated in the previous section.

In explanation of the fact that wave-lengths thus obtained from the revised Rowland tables are not in all cases identical with the values under "St J." in Table IV of the 1928 report, Mr Babcock has stated that St John's contributions to the latter were not identical with his earlier published work, but included also some later measures.

It should have been noted that Babcock's wave-lengths to the violet side of λ6868 had not previously been published; these are all interferometer determinations of high weight. Mr Babcock has also stated that λ4053·824 in Table IV should be omitted; the true wave-length is nearer 4053·830, but it is still unsatisfactorily determined.

The reference to the source of A.O.-B.S. values in Table IV should have been *Pub. Alleg. Obs.* **6**, nos. 7, 8, 9 (1927). It should also have been remarked that these values were determined by interferometer comparisons with neon lines.

With reference to the remarks following recommendation no. 6 on p. 82 of the 1928 report, Dr Burns desires to draw attention to the fact that the observations of St John appear to have shown that in the neighbourhood of λ4600, the wave-lengths of lines of intensities 3, 4, 5 are 0·002 A greater in integrated sunlight than in light from the centre of the disc, and that a similar result has been obtained by observers at the Einstein Turm. He has suggested that the paragraph in question should be amended as follows: "It is found by calculation from the known changes of wave-length and intensity in passing from centre to limb, that the difference in wave-length in the neighbourhood of 4600 A would be about one part in two million for lines of moderate intensity, integrated sunlight giving slightly greater wave-lengths than those obtained when observation is confined to the centre of a large solar disc."

III. THE VACUUM IRON ARC

One of the recommendations made by the Commission in 1928 was "that vacuum-arc and furnace spectra be investigated carefully to determine if their use will improve the system of secondary standards."

Dr Meggers has stated (1928 report, p. 237) that low-pressure sources have the following advantages: "(1) sharper lines and less self-reversal; (2) no appreciable pressure displacements or pole-effects; (3) simpler specification; (4) probably greater luminosity with larger permissible current strength; (5) closer correspondence with solar spectrum conditions; (6) consistency with standards in the extreme ultra-violet, which are necessarily derived from vacuum sources." Similar views have been expressed by Burns (*Pub. Alleg. Obs.* **8**, no. 1, 1929).

While most of these advantages will probably be generally conceded, different opinions have been expressed as to the relative luminosities of the vacuum arc and the arc in air. Dr Burns has reported to the effect that for a given sharpness there is no great difference in intensity whether the source be in vacuum or in air, and that a higher current may be used in vacuum without influencing the wave-lengths unduly. On the other hand, Mr Babcock considers that besides being far more troublesome to use, the vacuum arc is markedly less bright than the arc in air, especially in the region of greater wave-lengths.

The most important question seems to be whether the vacuum arc as a source of standard wave-lengths will lead to any substantial gain in accuracy over the standard Pfund arc in air. There is actually at present no conclusive evidence on this point, but Babcock maintains that the vacuum arc has no advantage in this respect sufficient to justify the substitution of the vacuum arc for the standard arc in air as the recognized source of standard wave-lengths.

For the present, then, it would seem that while it is probable that the standard Pfund arc in air will usually be found to be the most convenient source of comparison for accurate interpolations of wave-lengths, either this or the vacuum arc may be used at the discretion of the observer.

Although standard vacuum iron arc wave-lengths have not yet been adopted by the Union, important contributions towards this end have been made by Burns and Walters (*Pub. Alleg. Obs.* **6**, no. 11, April 1929; and **8**, no. 4, June 1931). The first of these papers includes about 600 lines which were measured by direct comparisons with neon, extending from λ2800 to λ8800; and about 1200 wave-lengths which were computed for the vacuum arc on the neon scale between λ2100 and λ9000. The second includes the wave-lengths of several hundred lines in the ultra-violet spectrum of the iron arc, which were interpolated by means of the interferometer between wave-lengths in the vacuum arcs of iron and copper. From λ2150 to λ2800, computed wave-lengths were used as standards, and these were supplemented by copper standards which had previously been measured (*Pub. Alleg. Obs.* **8**, 27–35, 1930). In addition, the tables include a considerable number of computed lines in this region. A valuable feature of both sets of tables is the indication of the term classifications of the lines, so far as they were known. Tables of term values for the vacuum arc are also given. Further reference to these will be made later.

Vacuum arc wave-lengths of iron lines, extending over the region λ3020–λ5371, have also been measured with the interferometer, in comparison with neon standards, by Kiess (*B. Stand. J. Res.*; *R. P.* no. 4, 1928). The probable errors (see Table I) are: A, 1 part in 6 million; B, 1 in 4½ million; C, 1 in 3 million; D, greater than 1 in 3 million.

Other values of vacuum arc wave-lengths are provided by Babcock's interferometer work on the displacements of lines due to a pressure of one atmosphere (see p. 64). Measurements were made over the range λ3895–λ6318, and the vacuum arc wave-lengths may readily be derived from the tabulated values in air by applying the corrections for displacement.

An additional comparison is afforded by values computed from the terms of the iron arc spectrum, which are considered later (Table III)*.

As bearing on the question of the relative merits of the vacuum arc and the arc in air as a source of standards, it is interesting to compare the different sets of observations which have been mentioned. Such a comparison is made in Table I, over the range common to the three sets of observations.

TABLE I

Vacuum Arc Wave-Lengths of Iron Lines, λ3899–λ5371

Kiess							
λ	Prob. error	B. W.	B.	Computed	Intensity	Class	Combination
3899·712	D	·707	·707	·705	30R	a	$a\,^5D_2-a\,^5D_2^0$
3920·261	D	·258	·258	·258	20R	a	$a\,^5D_0-a\,^5D_1^0$
3922·914	C	·912	·912	·912	25r	a	$a\,^5D_3-a\,^5D_4^0$
3927·919	A	·919	·920	·920	30R	a	$a\,^5D_1-a\,^5D_2^0$
3930·294	C	·297	·297	·296	25R	a	$a\,^5D_2-a\,^5D_3^0$
4005·244	C	·242	·242	·242	25	b	$a\,^3F_3-b\,^3F_2^0$
4045·813	A	·811	·811	·812	60r	b	$a\,^3F_4-b\,^3F_4^0$
4071·740	A	·737	·738	·738	40	b	$a\,^3F_2-b\,^3F_2^0$
4132·060	B	·057	·058†	·059	25	b	$a\,^3F_2-b\,^3F_3^0$
4143·869	B	·867	·868†	·867	15	b	$a\,^3F_3-b\,^3F_4^0$
4202·030	A	·029	·029	·029	30	b	$a\,^3F_4-a\,^3G_4^0$
4235·937	D	·936	·938	·939	25	d	$a\,^7D_4^0-a\,^7D_4$
4250·789	A	·786	·788	·787	25	b	$a\,^3F_3-a\,^3G_3^0$
4260·476	B	·474	·476	·474	35	d	$a\,^7D_5^0-a\,^7D_5$
4271·762	A	·760	·761	·760	35	b	$a\,^3F_4-a\,^3G_5^0$
4383·545	A	·544	·545†	·544	45	b	$a\,^3F_4-a\,^5G_5^0$
4415·123	A	·122	·122†	·122	20	b	$a\,^3F_2-a\,^5G_3^0$
5269·539	A	·537	·539	·538	60	a	$a\,^5F_5-a\,^5D_4^0$
5328·044	A	·038	—	·039	50	a	$a\,^5F_4-a\,^5D_3^0$
5371·488	D	·490	·491	·490	50	a	$a\,^5F_3-a\,^5D_2^0$

---

* The term values tabulated are for the arc in air, but in applying them for the present purpose they have been corrected to the vacuum arc by adding the amounts shown in brackets under "B. W."

† Wave-lengths for arc in air are given under "Babcock" in Table I of 1928 report.

It will be noted that for the A and B lines of Kiess the agreement between the three observers is very close, and that, with the exception of λ5328, the mean of the three values in no case differs from the computed value by more than 0·001 A. The comparison, however, does not suggest that vacuum arc wave-lengths determined by different observers are more consistent than similar determinations with the open arc as source.

It may be useful to note that the vacuum iron arc wave-lengths used by St John in his discussion of the gravitational displacements of solar lines (*Ap. J.* **67**, 195, 1928) were not independent determinations, but were a combination of preliminary data obtained by Babcock with some from other sources. For the purposes of his investigation St John changed the scale of Babcock's measurements from that of 1928 to that of 1922.

IV. DISPLACEMENTS OF IRON ARC LINES DUE TO A PRESSURE OF ONE ATMOSPHERE

A valuable connecting link between wave-lengths of the iron arc in air and *in vacuo* has been provided by Babcock's interferometric measurements of the displacements due to a change of pressure of one atmosphere (*Ap. J.* **67**, 240, 1928). The measurements include 130 lines occupying the region λ3895–λ6678. The displacements are interpreted as the result of depressions of the terms with increase of pressure, the terms being referred to the deepest term of the iron arc spectrum (a^5D_4) as zero. High-level terms were found to be much more affected than those of low level, and those of quintet and septet multiplicity more than the triplet terms. The results of the observations are indicated in Table II.

TABLE II

Term Depressions, Fe Arc

		Triplets					Quintets and septets		
Term		Mean level	Depression	Wt	Term		Mean level	Depression	Wt
		cm.$^{-1}$	cm.$^{-1}$				cm.$^{-1}$	cm.$^{-1}$	
C	a^{3}F	12,500	·001	—	A	a^{5}D	0	·000	—
D′	a^{3}P	18,700	·002	1	B	a^{5}F	7,500	·000	3
v	a^{3}H	19,600	·003	3	D	a^{5}P	17,700	·003	—
c	b^{3}F	20,800	·003	3	E	a^{7}D^0	19,600	·003	3
V′	a^{3}G	22,000	·007	3	V	a^{7}F^0	23,000	·006	1
Z	a^{3}D^0	31,600	·006	3	W	a^{7}P^0	24,100	·005	3
I	a^{3}F^0	31,700	·008	1	F	a^{5}D^0	26,200	·008	3
K′	a^{3}P^0	34,200	·013	2	G	a^{5}F^0	27,300	·009	3
M	a^{3}G^0	35,700	·014	3	H	a^{5}P^0	29,400	·012	3
N	b^{3}F^0	37,100	·015	3	J	b^{5}D^0	33,600	·015	3
P	b^{3}D^0	38,600	·015	1	K	b^{5}F^0	34,200	·013	1
q	x^{3}D	51,600	·035	3	L	a^{5}G^0	35,400	·011	1
p	x^{3}G	54,000	·040	1	O	b^{5}P^0	37,100	·007	1
					Q	c^{5}D^0	40,000	·020	2
					Y	a^{5}S^0	40,900	·010	1
					*X	a^{7}D	43,300	·027	3
					†T	b^{5}D	45,200	·029	3
					‡U	b^{5}F	47,600	·033	1
					§T′	c^{5}D	51,800	·029	1
							53,800	·038	1
					L′	y^{5}F	53,900	·028	1

* x^{7}D. † x^{5}D. ‡ x^{5}F. § y^{5}D (Babcock).

The term designations of Burns and Walters have here been substituted for those of Moore and Russell which were used by Babcock; "odd" terms are distinguished by the sign^0. The first column under "Term" indicates the arbitrary symbols which were previously in use.

For triplet terms the observed depressions in wave-number units due to a change of pressure from 0 to 1 atmosphere are closely represented by the formula

$$d = 1{\cdot}15\ V^2 - 1{\cdot}93\ V$$

where d is the depression in units of 0·001 cm.$^{-1}$ and V is the term value expressed in volts ($V = T/8100$). For example, if a triplet term has the value 32,400 cm.$^{-1}$ (the lowest level a^5D being taken as zero), $V = 4$ and $d = 0{\cdot}011$ cm.$^{-1}$. The displacement of a line is, of course, the difference between the values of d for the two terms involved in its production.

Similarly, for quintet and septet terms, the depressions for one atmosphere may be calculated from the formula

$$d = 0{\cdot}94\ V^2 - 0{\cdot}61\ V.$$

It is noted, however, that the measured depressions of five quintets of lowest weight fall systematically below those of the terms of high weight, and if these be omitted the formula becomes

$$d = 1{\cdot}15\ V^2 - 1{\cdot}27\ V.$$

Babcock appears to prefer values derived from this formula to the observed values shown in Table II.

It will be clear that for lines which have been classified, these formulae permit the calculation of wave-lengths for the arc in air from those observed in the vacuum arc, or *vice versa*. Term values determined for the vacuum arc may similarly be reduced to their values for the arc in air.

Considerable use of the term depressions has been made in the sections which follow.

V. TERM VALUES FOR THE IRON ARC SPECTRUM

All recent work has tended to prove that the combination principle may be applied with confidence in the computation of wave-lengths from spectroscopic terms. The accuracy of such wave-lengths is necessarily limited by possible defects of the measured wave-lengths on which the term values are based and by arithmetical considerations. As pointed out by Burns and Walters, however, while the combination principle can show the relative accuracy of wave-lengths or wave-numbers, it cannot reveal a systematic error expressible by the formula $\nu = a + b\nu_{\text{obs}}$. Moreover, the refraction table of Meggers and Peters, which is in general use, applies to dry air, and observations have mostly been made in air of unknown water-vapour content. As the dispersion of water-vapour has not been allowed for, it is possible that slight differences between computed and measured wave-lengths may arise in this way.

Three sets of term values, derived under definitely stated conditions, are available:

(1) Term values deduced by Babcock, which are included in a paper by Moore and Russell (*Ap. J.* **68**, 151, 1928) but have not otherwise been published. Table II of this paper comprises all the then known terms of *Fe* I, counted upwards from the zero level a^5D_4, the values by Babcock being distinguished by the sign §. These are of a high order of accuracy and definitely refer to the arc in air on the scale of 1928.

(2) Term values applicable to the vacuum arc spectrum given by Burns and Walters (*loc. cit.*). These may be reduced to values for the arc in air by the use of Babcock's formulae for term depressions.

(3) Term values deduced by Meggers (*Ap. J.* **60**, 60, 1924), which, however, are definitely on the scale of 1922. For the red and infra-red, wave-lengths approximating to those on the 1928 scale had been determined by Meggers and Kiess (*Bur. St. Sci. Paper*, No. 479, 1923), but these were increased by ($\lambda/6438$) 0·005 × A to make them consistent with the 1922 scale. These term values appear to be of sufficient accuracy to justify an attempt to express them on the scale of 1928. It will be convenient to use the arbitrary term symbols (see Table II) in explaining how this has been done.

In converting the term values of Meggers to the scale of 1928, they were first referred to the a^5D_4 level as zero, and the A and B terms were then reduced by 0·009 in order to bring them into as close agreement as possible with the means of the values given by Babcock and by Burns and Walters. If 0·009 were subtracted from all the terms, the combinations would obviously give the same values as those given by the original terms; but the wave-numbers of lines on the 1928 scale are larger than those on the scale of 1922, and for many of the term combinations the difference is sufficiently compensated by the lower values assigned to the A and B terms. Thus, the correction for scale ranges from 0·007 at λ5506 to 0·012 at λ4000; for shorter wave-lengths the corrections are less certain, but using those given by Babcock (p. 60) the wave-numbers of lines have to be increased by amounts ranging from 0·005 at λ3370 to 0·010 from λ3719 to λ3969. In view of the uncertain significance of the third decimals in the wave-numbers, all these corrections are probably sufficiently near to 0·009 to justify the retention of the original values of Meggers for terms which have been directly determined from combinations with A and B. Utilising only those combinations with A and B which yield lines in the region covered by the standard wave-lengths, it results that when A and B have been reduced by 0·009, the original values of Meggers for E, F, G, H, I, J, K, L, M, N and O represent quite closely the term values on the scale of 1928.

Without going into further details, it may be stated that with the modified values of the A and B terms, the original values of the terms P, Q, S, U, Z and Y assigned by Meggers may also be retained, while corrections of − 0·010 are required for C and D, and + 0·007 for T, and + 0·008 for X and T′, and + 0·009 for V.

The term values for which two or three determinations are available are collected in Table III. The recommended values in the first column are the means of those shown in the succeeding columns. The corrected values of Meggers are given under "M." and the corrections which have been applied are indicated by the figures in brackets. Under "B." are the values of Babcock, quoted without any modification. Burns and Walters' values, as corrected for term depressions, are shown under "B.W.," the amount of correction (always subtractive) being shown in brackets. Subsequent columns show the various notations which have been used for the terms, and the corresponding electron configurations as given by Burns and Walters.

A supplementary list of term values is given in Table IV. These are from Burns and Walters, with corrections for term depressions as before. The table includes only such terms of known types as are made use of in later sections of this report; numerous additional terms have been given by Moore and Russell and by Burns and Walters.

TABLE III

Principal Terms of *Fe* I (Values for Arc in Air, scale of 1928)

Relative term values				Notation			Configuration
Recommended	M.	B.	B. W.	B. W.	M. R.; B.	M.	B. W.
	(– ·009)		(·000)				
– 0·003	– ·009	·000	·000	$a\,{}^5D_4$	$a\,{}^5D$	A	$d^6\,s^2$
415·930	·927	·930	·934	D_3			
704·000	3·999	·999	4·001	D_2			
888·129	·131	·129	·126	D_1			
978·071	·077	·067	·068	D_0			
	(– ·009)		(·000)				
6928·277	·276	·284	·272	$a\,{}^5F_5$	$a\,{}^5F'$	B	$d^7\,s$
7376·772	·771	·772	·772	F_4			
7728·068	·069	·066	·068	F_3			
7985·792	·793	·792	·791	F_2			
8154·722	·727	·723	·717	F_1			
	(– ·010)		(·000)				
11976·257	·260	·259	·251	$a\,{}^3F_4$	$a\,{}^3F'$	C	$d^7\,s$
12560·950	·956	·947	·948	F_3			
12968·570	·578	·562	·571	F_2			
	(– ·010)		(– ·003)				
17550·207	·212	·204	·204	$a\,{}^5P_3$	$a\,{}^5P'$	D	$d^7\,s$
17727·014	·016	·018	·008	P_2			
17927·408	·409	·410	·405	P_1			
	(·000)		(– ·004)				
19350·891	·882	·895	·895	$a\,{}^7D_5^0$	$a\,{}^7D'$	E	$d^6\,sp$
19562·454	·448	·460	·453	D_4			
19757·037	·033	·044	·033	D_3			
19912·508	·512	·506	·506	D_2			
20019·645	·639	·646	·651	D_1			
	(·000)		(– ·006)				
22650·424	·409	·422	·441	$a\,{}^7F_6^0$	$a\,{}^7F$	V	$d^6\,sp$
22845·877	·869	·878	·883	F_5			
22996·683	·675	·684	·690	F_4			
23110·945	·943	·945	·946	F_3			
23192·505	·503	·501	·510	F_2			
23244·844	·837	·845	·849	F_1			
23270·389	·379	·389	·399	F_0			
	(·000)		(– ·007)				
23711·464	·457	·467	·468	$a\,{}^7P_4^0$	$a\,{}^7P$	W	$d^6\,sp$
24180·873	·864	·877	·877	P_3			
24506·925	·917	·925	·932	P_2			
	(·000)		(– ·008)				
25899·999	·000	·001	·995	$a\,{}^5D_4^0$	$a\,{}^5D'$	F	$d^6\,sp$
26140·190	·193	·188	·190	D_3			
26339·705	·709	·706	·701	D_2			
26479·390	·392	·391	·386	D_1			
26550·492	·500	·492	·484	D_0			
	(·000)		(– ·009)				
26874·559	·556	·560	·561	$a\,{}^5F_5^0$	$a\,{}^5F$	G	$d^6\,sp$
27166·834	·833	·836	·832	F_4			
27394·700	·702	·697	·709	F_3			
27559·595	·600	·591	·594	F_2			
27666·359	·364	·358	·354	F_1			
	(·000)		(– ·010)				
29056·338	·334	·339	·342	$a\,{}^5P_3^0$	$a\,{}^5P$	H	$d^6\,sp$
29469·030	·030	·027	·034	P_2			
29732·746	·746	·745	·748	P_1			

TABLE III (*continued*)

Relative term values				Notation			Configuration
Recommended	M.	B.	B. W.	B. W.	M. R.; B.	M.	B. W.
	(·000)		(− ·010)				
31307·269	·275	·264	·267	$a\,^3F_4^0$	$a\,^3F$	I	$d^6\,sp$
31805·094	·101	·090	·090	F_3			
32134·011	·018	·006	·010	F_2			
	(·000)		(− ·015)				
31322·636	·642	·640	·627	$a\,^3D_3^0$	$a\,^3D'$	Z	$d^6\,sp$
31686·374	·384	·369	·370	D_2			
31937·347	·362	·337	·343	D_1			
	(·000)		(− ·015)				
33095·959	·954	·961	·961	$b\,^5D_4^0$	$b\,^5D'$	J	$d^7\,p$
33507·141	·138	·138	·146	D_3			
33801·592	·592	·592	·593	D_2			
34017·124	·128	·124	·121	D_1			
34121·620	·619	·624	·618 ±	D_0			
	(·000)		(− ·015)				
33695·415	·413	·418	·414	$b\,^5F_5^0$	$b\,^5F$	K	$d^7\,p$
34039·537	·541	·537	·533	F_4			
34328·772	·771	·774	·772	F_3			
34547·232	·238	·231	·228	F_2			
34692·169	·174	·172	·162	F_1			
	(·000)		(− ·016)				
34843·977	·988	·976	·968	$a\,^5G_6^0$	$a\,^5G'$	L	$d^7\,p$
34782·445	·451	·446	·438	G_5			
35257·342	·348	·342	·335	G_4			
35611·646	·651	·646	·640	G_3			
35856·421	·425	·422	·415	G_2			
	(·000)		(− ·014)				
35379·234	·234	·235	·232	$a\,^3G_5^0$	$a\,^3G'$	M	$d^7\,p$
35767·588	·590	·584	·589	G_4			
36079·392	·395	·385	·397	G_3			
	(·000)		(− ·015)				
36686·201	·198	·202	·202	$b\,^3F_4^0$	$b\,^3F$	N	$d^7\,p$
37162·767	·765	·765	·772	F_3			
37521·183	·184	·180	·186	F_2			
	(·000)		(− ·018)				
36766·995	7·002	—	6·989	$b\,^5P_3^0$	$b\,^5P$	O	$d^6\,sp$
37157·591	·596	—	·586	P_2			
37409·572	·580	—	·565	P_1			
	(·000)		(− ·017)				
38175·379	·383	·379	·374	$b\,^3D_3^0$	$b\,^3D'$	P	$d^7\,p$
38678·064	·075	·061	·058	D_2			
38995·761	·770	·760	·754 ±	D_1			
	(·000)		(− ·022)				
39625·826	·828	·826	·825	$c\,^5D_4^0$	$c\,^5D'$	Q	$d^6\,sp$
39969·877	·878	·880	·874	D_3			
40231·362	·357	·372	·356	D_2			
40404·541	·540	·544	·539	D_1			
40491·309	·309	·310	·307	D_0			
	(·000)		(− ·023)				
40257·	·290	—	·344	$c\,^5F_5^0$	$c\,^5F$	R	$d^6\,sp$
40594·	·383	—	·430 ±	F_4			
40842·	·145	—	·162 ±	F_3			
41018·	·028	—	*·033 ±	F_2			
41130·	·648	—	†·640 ±	F_1			
	(·000)		(− ·023)				
40895·019	·019	·024	·013	$a\,^5S_2^0$	$a\,^5S'$	Y	$d^7\,p$

* ·05 in second paper.

† ·60 in second paper.

TABLE III (*continued*)

Relative term values				Notation			Configuration
Recommended	M.	B.	B. W.	B. W.	M. R.; B.	M.	B. W.
	(+ ·008)		(− ·026)				
42815·852	·842	·849	·864	$a\,^7D_5$	$x\,^7D$	X	d^6 s5s
43163·324	·314	·324	·334	D_4			
43434·630	·622	·632	·636	D_3			
43633·532	·523	·532	·540	D_2			
43763·979	·970	·976	·991	D_1			
	(·000)		(− ·027)				
43499·	·545	·546	·513	$d\,^5D_4^0$	$d\,^5D'$	S	d^7 p
43922·	·717	·716	·673	D_3			
44183·	·670	·674	·647	D_2			
44411·	—	—	·173	D_1			
44458·	—	—	·967	D_0			
	(+ ·007)		(− ·029)				
44677·007	·007	·008	·006	$b\,^5D_4$	$x\,^5D$	T	d^6 s5s
45061·331	·323	·329	·331	D_3			
45333·877	·880	·874	·876	D_2			
45509·152	·150	·152	·153	D_1			
45595·081	·083	·077	·083 ±	D_0			
	(+ ·009)		(− ·032)				
47005·507	·507	—	·506	$b\,^5F_5$	$x\,^5F'$	U	d^7 5s
47377·964	·977	·955	·959	F_4			
47755·533	·533	·526	·539	F_3			
48036·664	·663	·658	·670	F_2			
48221·320	·324	·317	·320	F_1			
	(+ ·008)		(− ·029)				
51350·502	·506	·491	·510	$c\,^5D_4$	$y\,^5D$	T′	
51770·574	·576	·572	·574	D_3			
52049·841 ±	·816	·860	·848	D_2			
52214·354 ±	·373	·322	·367	D_1			
52257·37 ±	·382	—	·360 ±	D_0			

TABLE IV

Supplementary Terms of *Fe* I (Arc in Air)

Relative term values	Notation		Relative term values	Notation	
B. W.	B. W.	M. R.	B. W.	B. W.	M. R.
(− ·012)			(− ·028)		
33946·951	$a^3P_2^0$	a^3P	47017·211	$d^3D_3^0$	c^3D'
34362·878	P_1		47136·114	D_2	
34555·609 ±	P_0		47272·067	D_1	
(− ·027)			(− ·029)		
42784·360	$b^5G_6^0$	b^5G'	47960·944	c^3F_4	x^3F'
42911·891	G_5		48531·867	F_3	
43022·971	G_4		48928·394	F_2	
43137·484	G_3		(− ·032)		
43210·017	G_2		47966·600 ±	$6R_0 = e^5P_3^0$	e^5P
(− ·030)			48163·477 ±	$5R_0 = P_2$	
45608·32	$c^5G_6^0$	c^5G'	48289·887 ±	$3R_0 = P_1$	
45726·14	G_5				
45833·23	G_4				
45913·49	G_3				
45964·94	G_2				

TABLE IV (*continued*)

Relative term values B. W.	Notation B. W.	Type
(– ·027)		
44243·693	$50R_5^0$	^5F
44415·103	$49R_4^0$	^5F
44551·353	$48R_3^0$	^5F
(– ·034)		
50342·146	$53W_6$	^7F
50377·916	$34W_5$	^7D
50808·019	$27W_4$	^7D
50833·451	$25W_5$	^7D
50998·652	$20W_2$	^7P
51192·286	$16W_4$	^7P
51208·005 ±	$43W_1$	^7P
51219·025	$13W_3$	^7D

It should be noted further that a list of all the known terms of the iron arc spectrum is included in a paper by M. A. Catalán (*An. Real. Soc. Esp. Fis. y Quim.* **28**, 1239, Dec. 1930). Many of the principal term values, including those of Babcock and Meggers, are from the paper by Moore and Russell. A large number of additional terms was determined by Catalán himself, but the precision of the wave-lengths on which these term values were based is somewhat uncertain.

Catalán's paper is a most useful collection of data relating to the arc spectrum of iron. In addition to the term values, there is a table of Zeeman effects, and a list of classified lines with indications of pressure classes and term combinations, extending from λ2084 to λ11975. The number of classified lines is 2350, involving 304 levels.

VI. WAVE-LENGTHS OF IRON LINES IN THE ULTRA-VIOLET

(*a*) IRON LINES, λ2327–λ3356

The iron arc standards adopted in 1928 terminated towards the ultra-violet with λ3370·787, but attention was directed to certain computed wave-lengths in the region λ2858–λ3236 (Table II, 1928 report, p. 92). The Commission recommended that further measurements be made on these provisional standards and that further search be made for suitable lines to serve as standards in the ultra-violet below λ2800.

In this connection, interferometer measurements by direct comparisons with the primary cadmium line, or with standard neon lines, have been made on the Pfund arc in air by C. V. Jackson in Professor Fowler's laboratory (*Proc. Roy. Soc.* A, **130**, 395, 1931; A, **133**, 553, 1931). These extend from λ2327 to λ3498; though all the lines occur in the arc, the majority of those between λ2327 and λ2628 are due to *Fe* II. As so few interferometer measurements in this region are available, Jackson's wave-lengths are given in full in the third column of Table V.

Other wave-lengths which are available for comparison with the measurements of Jackson are those measured or calculated with the vacuum arc as source by Burns and Walters (*loc. cit.*). These are shown in the second column of Table V; first, in brackets, as given for the vacuum arc; and, secondly, as corrected to a pressure of one atmosphere by the formulae of Babcock.

Another comparison for many of Jackson's lines is afforded by wave-lengths calculated from term values included in Tables III and IV. These are for atmospheric pressure and are shown in the fourth column of Table V. Computed wave-lengths are given only for those lines derived from terms of known type for which corrections to atmospheric pressure can be made. Computed wave-lengths for which one or both terms depend entirely on Burns and Walters are marked with an asterisk.

For many lines the agreement of the three values of the wave-length is very close and the mean may be recommended for adoption. For others the agreement is not so good as might be desired, and for these the decimal part of the wave-length has not been included in the first column.

TABLE V

Wave-Lengths of Iron Lines, λ2327–λ3091

Provisional λ	Burns and Walters		Jackson Air arc 1931	Computed (Tables III and IV)	Classification B. W.
	Vacuum arc 1931	Air arc			
2327	(·394)		·392		(*Fe* II)
2331	(·305)		·305		(*Fe* II)
2332	(·796)		·795		(*Fe* II)
2338	(·005)		·002		(*Fe* II)
2359	(·104)		·102		(*Fe* II)
2364	(·826)		·825		(*Fe* II)
2379	(·275)		·273		(*Fe* II)
2380	(·759)		·757		(*Fe* II)
2388	(·627)		·625		(*Fe* II)
2399	(·239)		·238		(*Fe* II)
2406	(·659)		·657		(*Fe* II)
2410	(·518)		·517		(*Fe* II)
2411	(·064)		·066		(*Fe* II)
2413	(·308)		·309		(*Fe* II)
2447·708	(·707)	·708	·708	·709 ±	$a^5D_4-c^5F_3^0$
2457	(·595)		·595		—
2465	(·148)		·148		a^5F_4-142B
2468	(·878)		·879		—
2474	(·813)		·814		—
2496	(·534)		·533		—
2507·899	(·898)		·900		—
2516			·114		—
2529·834	(·833)	·834	·833	·834	$a^5D_1-c^5D_1^0$
2530·692	(·691)		·692		—
2542·102	(·101)		·102		—
2562·534	(·533)		·534		(*Fe* II)
2584	(·538)	·540	·535	*·536	$a^5F_5-c^5G_6^0$
2585·877	(·877)		·876		(*Fe* II)
2598·369	(·368)		·369		(*Fe* II)
2611·873	(·873)		·872		(*Fe* II)
2613·823	(·823)		·822		(*Fe* II)
2625·668	(·666)		·668		(*Fe* II)
2628·29	(·292)		·292		(*Fe* II)
2635	(·808)	·810	·807	*·811	$a^5F_2-c^5G_3^0$
2644	(3·999)	·001	·005	*·001	$a^5F_1-c^5G_2^0$
2679·063	(·061)	·063	·063	*·063	$a^5F_5-50R_5^0$
2689·213	(·212)	·214	·212	*·213	$a^5F_4-48R_3^0$
2699·107	(·104)	·106	·108	*·106	$a^5F_4-49R_4^0$
2723·577	(·576)	·577	·577	·577	$a^5D_2-b^5P_1^0$
2735·476	(·475)	·477	·476	·475 ±	$a^5F_4-d^5D_3^0$

* From B. W. terms only.

TABLE V (*continued*)

Provisional λ	Burns and Walters Vacuum arc 1931	Burns and Walters Air arc	Jackson Air arc 1931	Computed (Tables III and IV)	Classification B. W.
2767·524	(·522)	·524	·525	·522 ±	$a^5F_4-d^5D_4^0$
2772	(·113 ±)	·114 ±	·109	·109	$a^5D_2-b^5P_3^0$
2778·221	(·221)	·223	·220	*·224	$a^5F_5-b^5G_5^0$
2804·522	(·521)	·523	·521	*·524	$a^5F_4-b^5G_4^0$
2806	(·985)		·985		a^5F_4-80B
2813·289	(·287)	·289	·288	*·290	$a^5F_4-b^5G_5^0$
2823·276	(·274)	·276	·276	*·278	$a^5F_3-b^5G_3^0$
2832·438	(·437)	·439	·436	*·439	$a^5F_3-b^5G_4^0$
2838·121	(·119)	·121	·120	*·123	$a^5F_2-b^5G_2^0$
2851·799	(·797)	·799	·797	*·800	$a^5F_1-b^5G_2^0$
2869·308	(·308)	·309	·307	·308	$a^5D_3-a^5G_4^0$
2912·158	(·159)	·160	·158	·157	$a^5D_4-b^5F_3^0$
2929·008	(·008)	·009	·008	·007	$a^5D_3-b^5F_2^0$
2941·343	(·344)	·345	·343	·342	$a^5D_2-b^5F_1^0$
2953·940	(·939)	·940	·940	·940	$a^5D_2-b^5F_2^0$
2957·366	(·366)	·367	·365	·365	$a^5D_1-b^5F_1^0$
2965·255	(·255)	·256	·255	·255	$a^5D_0-b^5F_1^0$
2981·446	(·445)	·446	·446	*·445 ±	$a^5D_3-a^3P_2^0$
2987·292	(·292)	·294	·291	·294 ±	$a^5F_4-c^5F_3^0$
2999·514	(·514)	·516	·513	·514 ±	$a^5F_5-c^5F_5^0$
3037·389	†(·389)	·391	·387	·389	$a^5D_1-b^5D_2^0$
3047·606	(·607)	·609	·605	·605	$a^5D_2-b^5D_3^0$
3057·447	(·447)	·449	·447	·447	$a^5F_5-c^5D_4^0$
3059·086	‡(·085)	·087	·085	·086	$a^5D_3-b^5D_4^0$
3067·245	(·244)	·246	·245	·245	$a^5F_4-c^5D_3^0$
3075·722	(·721)	·723	·722	·721	$a^5F_3-c^5D_2^0$
3083·743	(·741)	·743	·743	·742	$a^5F_2-c^5D_1^0$
3091·579	(·577)	·579	·579	·578	$a^5F_1-c^5D_0^0$
3116·633	(·632)	·634	·633	·633	$a^5F_1-c^5D_2^0$
§3125	(·652)		·658		—
3134·111	(·108)	·110	·111	·111	$a^5F_3-c^5D_4^0$
3157·041	(·038)	·041	·042	*·040	$a^7D_4-13W_3$
3160	(·659)	·662	·657	*·660	$a^7D_4-16W_4$
3175·447	(·445)	·448	·447	*·446	$a^7D_5^0-25W_5$
3178·015	(·013)	·016	·016	*·014	$a^7D_5^0-27W_4$
3184·895	(·894)	·895	·896	·895	$a^5D_3-a^3F_3^0$
3191·660	(·659)	·661	·660	·659	$a^5D_4-a^3D_3^0$
3196·930	(·927)	·930	·930	*·930	$a^7D_4^0-25W_5$
3200	(·471)		·474		$a^7D_2^0-17W$
3205·401	(·399)	·402	·400	*·401	$a^7D_1^0-43W_1$
3215·941	(·939)	·942	·940	*·941	$a^7D_2^0-20W_2$
3217	(·377)		·381		$a^7D_5^0-33W_4$
3222·069	(·067)	·070	·069	*·069	$a^7D_5^0-34W_5$
3225·790	(·788)	·791	·790	*·788	$a^7D_5^0-53W_6$
3236·223	(·223)	·224	·222	·222	$a^5D_3-a^3F_4^0$
3239	(·434)		·437		$a^7D_4^0-33W$
3244·190	(·187)	·190	·190	*·191	$a^7D_4^0-34W_5$

* From B. W. terms only.
† 3037·394 in second paper.
‡ 3059·090 in second paper.
§ Unsuitable for standard; has 3 components.

TABLE V (*continued*)

Provisional λ	Burns and Walters: Vacuum arc 1931	Burns and Walters: Air arc	Jackson Air arc 1931	Computed (Tables III and IV)	Classification B. W.
3254	(·363)		·362		—
3257	(·593)		·592		$a^5P_3–4R_2^0$
3271·002	(·999)	·002	·001	*·004 ±	$a^5P_2–e^5P_1^0$
3280	(·260)		·261		—
3284·589	(·588)	·591	·587	*·590 ±	$a^5P_2–e^5P_2^0$
3286·755	(·753)	·756	·754	*·757 ±	$a^5P_3–e^5P_3^0$
3298	(·132)		·131		$a^5P_1–4R_2^0$
3314	(·741)		·741		—
3233	(·735)		·737		—
3328	(·867)		·866		—
3337	(·666)		·667		—
3340	(·565)		·566		$a^3P_2–2R_2^0$
3347	(·926)		·928		$a^3P_2–4R_2^0$
3355	(·228)		·229		—
3356	(·400)	·403	·407	*·403 ±	$a^3P_2–e^5P_2^0$

* From B. W. terms only.

(*b*) IRON LINES, λ3370–λ3498

Jackson's measurements between λ3370 and λ3498 fall in the region included in the range of standards given in the 1928 report. They are shown in the third column of Table VI, and, as in the previous table, are compared with Burns and Walters, and with computed values. For completeness, all the previous standards and "revised interpolated" wave-lengths in this region are included in the table. Slight amendments to a few of the 1928 values are suggested.

TABLE VI

Wave-Lengths of Iron Lines, λ3370–λ3497

Recommended λ	I.A.U. 1928: St.	I.A.U. 1928: R. I.	Jackson 1931	Burns and Walters: Vacuum arc	Burns and Walters: Air arc	Computed (Tables III and IV)	Classification B. W.
3370·787	·787	·787	·786	(·784)			—
3379·021		·022		(·017)	·019	*·021	$a^5P_3–d^3D_2^0$
3396		·980		(·974)	·976	·976	$a^5F_3–b^5P_2^0$
3399·336		·336	·337	(·333)	·336	*·336	$a^5P_2–d^3D_2^0$
3401·522	·522	·522	·522	(·518)	·520	·519 ±	$a^5F_4–b^5P_3^0$
3407·462		·462	·463	(·460)	·463	*·461	$a^5P_3–c^3F_4^0$
3413·134		·135		(·131)	·134	*·136	$a^5P_2–d^3D_3^0$
3427·121		·121	·121	(·119)			$a^5P_3–18R_4^0$
3443·878			·878	(·878)	·879	·878	$a^5D_2–a^5P_1^0$
3445·151		·152	·150	(·148)			$a^5P_2–19R_3^0$
3458		·305					—
3465·862	·863	·863	·863	(·860)	·861	·862	$a^5D_1–a^5P_1^0$
3476·704	·705	·706	·703	(·702)	·703	·704	$a^5D_0–a^5P_1^0$
3485·342		·342	·342	(·339)			—
3490·575			·575	(·574)	·575	·575	$a^5D_3–a^5P_3^0$
3495		·290		(·285)			$b^3F_4–35R_3^0$
3497·843	·844	·844	·843	(·841)	·842	·843	$a^5D_1–a^5P_2^0$

Note. The R terms appearing in this table are of unknown types so that corrections to atmospheric pressure cannot yet be applied.

* From B. W. terms only.

(*c*) IRON LINES, λ2015–λ2320

In view of the lack of standard lines in the region beyond λ2320, the vacuum arc wave-lengths of Burns and Walters (*loc. cit.*) will probably be found of great value, and it has accordingly been considered desirable to include a selected list in the present report. The source was an arc (in vacuum) 4 or 5 mm. in length, operated at 6 to 8 amp. The short arc was adopted in order to photograph weak lines in a reasonable time of exposure, and to bring out lines of *Fe* II; it is considered unlikely that the change from the long arc has introduced any great relative displacements.

The selection of lines in Table VII includes most of the stronger lines, fainter lines in otherwise blank regions, and, in some cases, lines which may facilitate identification. Intensities are indicated by the figures in brackets which follow the wave-lengths; it will be noted that the scale of intensities adopted in 1931 was more open than that of 1929.

The wave-lengths tabulated are applicable to the vacuum arc source. The corrections to the arc in air, as calculated from Babcock's term depressions, do not differ materially from + 0·001 A over this region, so far as they can be determined.

TABLE VII

Wave-Lengths of Iron Lines, λ2015–λ2320

(Vacuum Arc, Burns and Walters)

λ	Observed 1931	Computed 1931	Computed 1929	*Fe*	λ	Observed 1931	Computed 1931	Computed 1929	*Fe*
2015			·293 (1)	I	2222	·75 (7)			
2032			·337 (1)	I	2228	·164 (10)	·167	·167 (7)	I
2070			·304 (1)	I	2231	·211 (15)	·208	·208 (15)	I
2084			·116 (5r)	I	2242			·568 (15)	I
2093			·679 (4r)	I	2245	·646 (15)	·648	·648 (10)	I
2102			·349 (4)	I	2248	·855 (25)			
2106			·389 (3)	I	2249	·173 (20)	·176		II
2108			·954 (2)	I	2253	·122 (30)	·124		II
2115			·164 (3)	I	2255	·859 (45)			
2132			·011 (4)	I	2259	·511 (15)			
2139			·929 (2)	I	2264	·390 (45)			
2146			·715 (4)	I	2266	·903 (10)			
2148		·397 (3)		I	2267	·465 (15)			II
2153			·001 (5)	I	2269	·093 (18)	·094		I
2157	·793 (5)	·789	·789 (5)	I	2270	·858 (18)	·859	·857 (10)	I
2158			·529 (6)	I	2271	·778 (40)			
2165	·859 (20)				2272	·065 (15)	·065		I
2166	·769 (100)	·768	·771 (50r)	I	2276	·023 (12)	·022	·021 (10)	I
2171	·292 (40)	·291	·291 (10)	I	2284	·083 (40)	·081	·081 (10)	I
2186	·483 (40)	·482	·484 (9r)	I	2287	·248 (30)	·246	·244 (5)	I
2187	·188 (40)	·188	·188 (12r)	I	2287	·628 (15)			
2191	·836 (60)	·835	·834 (25r)	I	2289	·032 (10)			
2196	·037 (50)	·036	·036 (20r)	I	2291	·117 (15)			
2200	·721 (15)	·720	·719 (15)	I	2292	·523 (30)	·521	·519 (8)	I
2210			·684 (9)	I	*2293	·847 (25)			

* *Cu* coincident.

TABLE VII (*continued*)

λ	Observed 1931	Com-puted 1931	Computed 1929	*Fe*
2294	·406 (25)	·404	·405 (6)	I
*2296	·926 (15)	·923	·921 (5)	I
*2297	·787 (35)	·784	·783 (8)	I
2298			·166 (12r)	I
2299	·218 (25)	·216	·216 (6)	I
2300	·139 (30)	·138	·136 (4)	I
2301	·681 (20)	·680	·678 (6)	I
2303	·422 (15)			
2303	·577 (20)	·577		I
2308	·996 (30)	·995	·995 (6)	I
2313	·102 (40)	·101	·100 (7)	I
2320	·355 (40)	·354	·355 (8)	I

* Probably double.

(*d*) IRON LINES, λ1550–λ1732

Lines of *Fe* II in the Schumann region which have been computed by Burns and Walters from terms applicable to the vacuum arc are included in Table VIII.

TABLE VIII

Fe II Lines in the Schumann Region (computed)

λ	ν	Classification
1550·270	64504·91	$a\,^4F_5–b\,^4F_4^0$
1563·785	63947·41	$a\,^4F_4–b\,^4F_4^0$
1566·821	63823·50	$a\,^4F_5–b\,^4F_5^0$
1573·823	63539·55	$a\,^4F_3–b\,^4F_4^0$
1580·628	63266·00	$a\,^4F_4–b\,^4F_5^0$
1724·568	57985·52	$a\,^4D_3–b\,^4F_4^0$
1731·878	57740·80	$a\,^4D_4–b\,^4F_5^0$

VII. ELEMENTS OTHER THAN IRON

(*a*) KRYPTON

The spectrum of Krypton (I), in addition to the yellow and yellow-green lines, contains a group of ten very strong lines in the violet. These lines are easily photographed and possess a high degree of homogeneity, and would appear to be eminently suitable for use as standards of wave-length. For this reason, C. V. Jackson has made a careful investigation on their constancy of wave-length, and on the values of their wave-lengths in terms of the red cadmium line λ6438·4696 (not yet published). The wave-lengths were determined with both the "adjustable" and "fixed" types of Fabry-Perot étalons, and separations of 1, 2 and 3 cm. were used. It was found that the wave-lengths obtained with these different separations showed no variation greater than the probable error of the observations. The lines were observed also with a 6 cm. separation and were found to give good fringes, but no measurements were made from these plates. No difference in wave-length was found whether the tube was observed end-on or transversely.

The results are in good agreement with those of Humphreys (*B.S. Journ. Res.* **3**; *R.P.* No. 245, p. 1041, 1930), who used the neon scale, and also with those of Meggers (*B.S. Sc. Papers*, No. 414, 1921), who compared directly with the primary standard. Meggers, however, only made six or seven observations, whereas most of Jackson's lines were observed between twenty and thirty times. Jackson's wave-lengths are for air at 15° C. and 760 mm., humidity 50 per cent.; the measurements of Humphreys and Meggers were also reduced to N.T.P., but the humidity of the air was not stated. The interference paths were similar in the three sets of observations.

The wave-lengths are compared in Table IX. The figures in the second column indicate the number of observations made by Jackson and the attached letter the probable error, A representing 0·0001 A and B 0·0002 A. The last column gives values which are recommended for consideration with a view to their adoption as standards of equal weight with the neon standards.

TABLE IX

Wave-Lengths of Krypton Lines, λ4273–λ4502

Jackson					
λ	*N*	Prob. error	Humphreys	Meggers	Recommended λ
4273·9702	26	A	·9705	·9696	4273·9702
4282·9689	14	A	·9686	*·967*	4282·9688
4318·5522	7	A	·5523	·552	4318·5522
4319·5801	21	B	·5798	·580	4319·5800
4362·6425	24	A	·6429	·6422	4362·6425
4376·1221	28	A	·1217	·122	4376·1220
4399·9673	16	A	·9675	*·969*	4399·9674
4453·9179	28	A	·9183	·9174	4453·9179
4463·6906	29	A	·6897	·690	4463·6903
4502·3548	27	B	·3546	·354	4502·3546

It is interesting to note that there is no systematic difference amounting to more than 0·0001 A between the measurements on the neon scale by Humphreys and those measured against the primary standard by Jackson. This may be taken as an indication that the neon scale is identical with the primary standard to within about one part in 50 million. Jackson also came to this conclusion as a result of other tests carried out concerning the accuracy of the neon scale. The measurements of Jackson are believed by him to be correct within one or two units in the last figure and the good agreement with the values obtained by Humphreys favours this conclusion.

At the meeting of the International Conference of Weights and Measures in 1927, Kosters, of the Reichsanstalt, proposed the yellow-green line of krypton (λ5649) as a substitute for the red cadmium line as the fundamental standard of wave-length. Objection has been made to this line, however, on the ground that its luminosity is inadequate for the purpose. More recently, Pérard (*Comptes Rendus*, **194**, 1633, 1932) has suggested that the yellow line at λ5562 may be suitable for adoption as primary standard. He points out that the more intense lines λ5570 and λ5870, besides having other lines near them, are accompanied by satellites which affect the accuracy of observation; while λ5562 is notably monochromatic and is still of satisfactory intensity. The value he has obtained for this line is λ5562·22576 ± 0·00002$_5$, which would require an additional zero in the decimal part for the red cadmium line; namely, 6438·46960.

Other observations of the yellow and yellow-green lines have been made by Fabry and Buisson, Humphreys, Meggers and Jackson. The various values are collected in Table X.

TABLE X

Wave-Lengths of Krypton Lines in the Yellow and Yellow-green

Pérard 1932	Pérard 1923*	Jackson	Humphreys	Meggers	Fabry and Buisson
5562·22576	·2257	·2266	·2251	·224	
5570·2894	·2892	·2900	·2890	·2872	·2908
5649·5628	·5627				
5870·9161	·9154	·9167	·9153	·9137	·9172

* *Comptes Rendus*, **176**, 1060, 1923.

The values obtained by the different observers are much more discordant than the probable errors would lead one to expect, and none of these lines appears to be promising as a standard of the highest possible accuracy.

(*b*) TITANIUM

The vacuum arc spectrum of titanium has been investigated by means of the interferometer by three independent observers.

(1) Brown (*Ap. J.* **56**, 53, 1922) has published wave-lengths of more than 100 lines between λ4250 and λ6261 which he determined with reference to the primary standard.

(2) Kiess (*B.S. Jour. Res. R.P.* No. 4, 1928) has measured the positions of more than 300 lines, extending from λ2941 to λ6743, with reference to the neon standards. It was considered that for many of the lines the accuracy is greater than 1 part in 6 million and for the majority 1 part in 4½ million. Term classifications are indicated for most of the lines, and a list of terms of the triplet system is included.

(3) Burns (*Pub. Alleg. Obs.* **8**, No. 1, 1930) has published wave-lengths of both the vacuum arc and the arc in air in the regions λ4055–λ4482 and λ5739–λ6556. The relative values of air and vacuum arc wave-lengths are believed to be more correct than the scale of either list. The pressure shifts agree closely with those of Gale and Adams in the violet but are decidedly smaller in the red.

In the region λ4263–λ4489 there is a close agreement between the three sets of observations for most of the lines, and Kiess and Brown agree well for numerous lines from λ4489 to λ5675. In the region λ5866–λ6258, common to the three observers, Kiess and Burns are in good agreement, but Brown's wave-lengths are systematically lower.

In view of the improbability that the vacuum arc of titanium will often be required as a source of standard wave-lengths, it has been considered unnecessary to include an extended list of titanium lines in the present report. It may, however, be useful to give the measured values for lines in the region λ5506–λ6258, where good lines in the iron spectrum are not numerous. All the lines measured by Kiess in this region, with their intensities and probable errors, are given in Table XI, with corresponding wave-lengths for some of them found by Brown and by Burns.

TABLE XI

Wave-Lengths in Titanium Vacuum Arc, λ5503–λ6258

Kiess				
λ	Int.	Wt.*	Brown	Burns
5503·897	8	B		
5512·529	25	A	·526	
5565·476	9	A	·477	
5644·137	18	A	·136	
5648·570	5	D		
5662·154	12	A	·155	
5675·413	9	B	·413	
5689·465	10	B		
5715·123	9	D		
5739·464	9	B		·472
5766·330	4*n*	D		
5774·037	5*n*	C		
5785·979	5*n*	B		
5804·265	5*n*	C	·264	
5866·453	35	A	·451	·454
5899·295	25	A	·292	·294
5903·317	5	D		
5918·548	10	D		·538
5922·112	18	C	·109	·112
5937·806	6	D		·809
5941·755	12	B		·754
5953·162	30	A	·160	·162
5965·828	30	A	·825	·829
5978·543	25	A	·541	·543
5999·668	8	D		·663
6064·631	9	B		
6085·228	20	A	·224	·228
6091·175	20	B	·172	·174
6126·217	20	A	·213	·221
6258·103	40	A	·099	·104

* Probable errors: A = 1 part in 6 million; B = 1 in 4½ million; C = 1 in 3 million; D = probable errors greater than 1 in 3 million.

Babcock has derived values for term depressions in the arc spectrum of titanium, as in the case of iron already considered (*Ap. J.* **67**, 256, 1928).

(*c*) COPPER VACUUM ARC

Extensive interferometer measurements of the copper arc in vacuum have been made by Burns and Walters (*Pub. Alleg. Obs.* **8**, No. 3, 1930 and *Supplement* 1931). All lines of greater wave-length than λ3820 were compared directly with neon. For the shorter wave-lengths, a few lines were compared with neon, but most of them were referred to iron lines, or to copper lines previously determined by Kiess (*B.S. Jour. Res.* **1**, 75, 1928) or by Meggers and Burns (unpublished). The observed wave-lengths range from λ2104 to λ8092, and the term classification is given for every line in the list. Relative term values are tabulated both for *Cu* I and *Cu* II. It should be noted that important corrections of some of the lines and terms are stated in the supplement to the first paper. The accuracy attained for individual lines is about one part in a million for the region shorter than λ2300 and the precision increases with the wave-length.

An important part of this contribution refers to calculated wave-lengths in the region more refrangible than λ2100, based upon term values derived from lines of greater wave-length. The intensities of such lines were estimated from a plate by Shenstone. In view of the need for reliable values of wave-length in this region, the computed wave-lengths are reproduced in Table XII.

TABLE XII

Computed Wave-Lengths of Copper Lines (Burns and Walters)

Cu II			*Cu* I
λ air	Int.	λ vac.	λ vac.
1943·944	2	1944·586	1703·843
1969·843	—	1970·489	1713·364
1979·300	25	1979·947	1725·664
1989·200	20	1989·849	1741·574
1999·688	25	2000·339	1774·820
2015·576	20		1817·265
2016·885	5		1825·348
2025·475	20		
2035·845	35		
2037·119	35		
2043·791	60		
2054·969	30		
2085·295	25		

The lines of *Cu* I in the above table have been observed by Selwyn (*Proc. Phys. Soc. London*, **41**, 392, 1929) and by L. and E. Bloch (*Journ. Phys. Rad.* **6**, 154, 1925). The reasons for assigning them to *Cu* I have been given by Shenstone (*Phys. Rev.* **34**, 1623, 1929).

Vacuum arc wave-lengths of 26 copper lines between λ2824 and λ5782 have also been given by Kiess (*B.S. Journ. Res. R.P.* No. 4, 1928). These are in close agreement with the values obtained by Burns and Walters.

(*d*) CALCIUM

Wave-lengths of 25 lines in the vacuum arc spectrum of calcium between λ5265 and λ8662 have been given by Burns (*Pub. Alleg. Obs.* **8**, No. 1, 1929), and of 15 lines between λ3933 and λ6499 by Kiess (*B.S. Journ. Res. R.P.* No. 4, 1928), both from measurements with the interferometer. The two sets of values are compared in Table XIII, from which it will be seen that most of the lines common to the two are in good agreement.

TABLE XIII

Calcium Vacuum Arc

λ Burns	λ Kiess	Int.	λ Burns	λ Kiess	Int.
	3933·669	400 R	6122·215	·217	100
	3968·469	350 R	6162·168	·173	150
	4226·728	500 R		6169·048	25
5265·553		40		6169·554	40
5270·267		60	6439·070	·073	150
5349·463		25	6449·810	·809	50
5581·754		80	6462·565	·565	125
5594·460		60	6471·658	·661	40
5598·480		50	6493·780	·780	80
5601·273		30	6499·646	·651	30
5602·841		25	7148·145		10
5857·450	·451	100	7326·148		2
6102·720	·720	80	8498·019		
			8542·089		
			8662·137		

Evershed (*M.N.R.A.S.* **90**, 189, 1929) has measured the H and K lines with high-dispersion liquid prisms and with a grating, and for the arc in air has obtained λ3968·470 and λ3933·663 respectively (scale of 1928). These would be reduced by about 0·002 A if corrected for pressure, so that while there is satisfactory agreement with Kiess for H, there is a large discordance for K. Evershed's $\Delta\lambda = 34{\cdot}807$ is in closer accordance with $\Delta\lambda = 34{\cdot}809$ derived by St John than with Kiess's $\Delta\lambda = 34{\cdot}800$. Again, Evershed's $\Delta\nu = 222{\cdot}902$ is in better agreement with $\Delta\nu = 222{\cdot}891$ deduced from λλ8498, 8662 in Table XIII, than with Kiess's $\Delta\nu = 222{\cdot}856$.

(*e*) MISCELLANEOUS ELEMENTS

In addition to the elements already mentioned, Kiess (*loc. cit.*) has made interferometer measures of a few lines in the vacuum arc spectra of sodium (5895·927, 5889·954), aluminium (3961·527, 3944·009), vanadium (4379·234), chromium (4254·337, 3593·488, 3578·687), manganese (6021·789, 6016·639, 6013·490), nickel (7 lines in the red), and barium (14 lines in the orange and red). The estimated accuracy is 1 in 6 million for most of the lines, and 1 in 4½ million for the remainder. Some of these elements occurred as impurities in the electrodes employed for other purposes.

Burns (*Pub. Alleg. Obs.* **8**, No. 1, 1929) has similarly measured 16 lines in the vacuum arc spectrum of manganese. For the three lines measured by Kiess he gives the wave-lengths 6021·794, 6010·638 and 6013·490; and for the well-known triplet in the violet he gives 4034·481, 4033·064 and 4030·751. Six lines in the vacuum arc spectrum of chromium λ4942–λ4254, have also been measured by Burns.

Burns has also given an interesting discussion of the question as to whether the accepted values of the iron standards are applicable when only a trace of iron is present in the source. It seems possible that iron lines observed as impurities may have slightly smaller wave-lengths than they have in the iron arc, but the difference does not appear to exceed 0·001 A.

A very valuable table of wave-lengths of the extreme ultra-violet lines from gas discharges, including lines of carbon, sodium, silicon and mercury which frequently occur as impurities, has been compiled by J. M. MacInnes and J. C. Boyce (Palmer Physical Laboratory, Princeton, New Jersey). The table is produced in mimeographed form and extends from λ2500 to λ115·8, and includes a full bibliography to about the end of 1930. It is understood that copies have been sent to all who are known to be working in vacuum spectroscopy. Provisional standards in this part of the spectrum have mostly been determined by the method of overlapping orders, the iron arc being used as a comparison spectrum. The following comparisons of some of the results obtained by different observers will give an indication of the precision which has been attained in this difficult region. (Table XIV.)

It should be noted that Ericson and Edlén's values were not obtained from overlapping orders, but by an application of the theory of the concave grating to measurements from the directly reflected image of the slit.

Table XIV

C I			*C* II	
Zumstein and Marston*	Bowen and Ingram†	Bowen‡	Bowen§	Ericson and Edlén‖
1560·30	·257	·267	341·14	·200
1560·69	·660	·660	360·59	·623
1561·39	·378	·381	371·73	·727
			389·05	388·96
				389·06
1656·27		·27	399·71	·69
1656·97		57·01	459·532	·472
1657·37		·37	459·643	·600
1657·90		·92	499·493	·515
1658·12		·13	538·108	·148
			538·318	·306

* *Phys. Rev.* **38**, 305, 1931.
† *Phys. Rev.* **28**, 444, 1926.
‡ *Phys. Rev.* **29**, 231, 1927.
§ *Phys. Rev.* **38**, 128, 1931.
‖ *Zeit. f. Phys.* **59**, 656, 1930; **64**, 64, 1930.

VIII. WORK REPORTED IN PROGRESS

Meggers and Burns have made interferometer measures of the vacuum lanthanum arc between λ3600 and λ6500, and Burns reports similar observations of the vacuum arc spectrum of cobalt over the range λ2200–λ6500. Publication of these results, however, is being delayed until observations have been extended to longer wave-lengths by the use of the new infra-red sensitive plates introduced by the Eastman Kodak Company. With these plates it now appears to be no more difficult to photograph 10,000 A than 5000 A, while with longer exposures one can record strong lines beyond 12,000 A. The need for better standards in the near infra-red is thus likely to become urgent.

Meggers reports that preliminary measurements of iron lines in the region λ9500–λ11,000 have already been made with the aid of the new plates. Iron, however, does not appear to emit any strong lines in a considerable interval above λ10,532 A, and better standards will probably be provided by the rare gases neon, argon, krypton and xenon, which have a satisfactory distribution of strong lines between λ8000 and λ12,000. Neon appears to be especially promising as a source of infra-red standards. Measurements of these spectra are in progress.

Babcock reports that much work has already been done at Mount Wilson on the infra-red solar spectrum. A reasonably complete list of wave-lengths from λ7330 to λ9800 has been prepared on the basis of interferometer measurements*, and from λ9800 to λ11,634, 357 lines have been determined with reference to the standards of 1928 by the use of overlapping second and third order grating spectra. With the aid of the new plates, however, it is hoped to extend the use of the interferometer to much greater wave-lengths than 9800λ.

It is planned to publish, as soon as possible, a new table of infra-red solar wave-lengths, beginning at λ7330 and including the positions and intensities of all lines believed to be real, together with all available information as to the identifications of the lines and their energy levels.

Babcock further reports that large differences are found between his new wave-lengths in the region λ9112–λ9801 and those of Brackett which were used exclusively in compiling the Rowland Revision. Through an unfortunate systematic

---

* See Table XV below.

error, Brackett's wave-lengths over this range are much too great, the mean correction found by Babcock being – 0·072 A.

Other work in progress at Mount Wilson is directed to the completion of the investigation of Fraunhofer lines due to terrestrial oxygen. The list of such lines in course of preparation includes nearly 400 lines ranging in intensity from 1 to 10^5, and there is evidence from combinations that the relative wave-lengths in any one band are reliable to one part in 5 million. These observations are of special importance in connection with the structure of the oxygen molecule and the masses of the isotopes O^{18}, O^{17}, but the accurate location of the oxygen lines on the wave-length scale gives them additional interest for astrophysicists.

Some interesting researches on sources of monochromatic radiation have been made by F. Esclangon (*Comptes Rendus*, **194**, 266, 1932), making use of electrodeless tubes illuminated by induction. Under suitable conditions it was found possible to obtain lines of great intensity without loss of sharpness. The first observations were made on the vapours of sodium and cadmium, but Prof. Fabry reports that in experiments on helium, neon, krypton and xenon, very narrow lines of great intensity could also be obtained.

IX. WAVE-LENGTHS OF 319 SOLAR AND ATMOSPHERIC LINES SUITABLE FOR USE AS STANDARDS, λ 7330–λ 11,204, DETERMINED AT MOUNT WILSON OBSERVATORY, MAY 1932*

The wave-lengths in Table XV are based on (*a*) interferometer measurements of solar and atmospheric lines, λ 7000–λ 9000, by Babcock (*Ap. J.* **53**, 140, 1927), (*b*) the standard iron arc and solar wave-lengths adopted by the Union in 1928. Throughout the region covered by the interferometer observations these have been used as standards for the reduction of numerous new spectrograms made with three gratings, both plane and concave. The smoothing process which has thus been applied to the results previously published has no doubt increased the accuracy of their relative values. The wave-lengths in this part of Table XV are thus more reliable than those in the Rowland Revision or in Table V of the 1928 report because of the additional data included, but in general the differences are satisfactorily small.

For that part of Table XV where no interferometer data are available the new wave-lengths have been measured in terms of overlapping higher order spectra, of the iron arc out to λ 9900 and of the sun beyond that point. Large differences are found between these new wave-lengths and those previously published because of an unfortunate systematic error in the observations of Brackett (*Ap. J.* **53**, 121, 1921) whose wave-lengths were used exclusively between λ 9112 and λ 9801 in the Revision. From twelve independent determinations the correction to Brackett's results is found to be – 0·072 A. In addition to this, the increased scale and resolving power of the new spectrograms have made possible so many improvements in the relative wave-lengths of these lines that Brackett's results are omitted altogether from Table XV.

The wave-lengths stated in the table are measured in air at 15° C. and 760 mm. pressure. For the solar lines the usual corrections to the sun have been applied. Beyond λ 9800 it is probable that the lines tabulated are all of solar origin but this is not certain. No origin is stated for these lines therefore except in the case of five to which footnotes make reference.

---

* This section was added to the draft report at the meeting of the Commission. It was prepared by H. D. Babcock and W. D. Hoge, Mount Wilson Observatory.

In the second column of Table XV all telluric lines are marked A merely to save printing, although most of these are known to be due to water-vapour. Between λ7594 and λ7703 these A lines are due to atmospheric oxygen, being chosen from a large amount of unpublished work done at Mount Wilson on the band spectrum of both ordinary and isotopic molecules of this gas. It will be noted that the intensities corresponding to these oxygen lines are marked either S or W instead of having a numerical value. This is merely to indicate that some are members of the strong "A" band of O^{16}–O^{16}, or of one of the weak bands of O^{16}–O^{18}. Intensities of all telluric lines are troublesome to describe briefly because of the wide range which they exhibit and it is probable that some of the stronger water-vapour lines which are listed will be found too strong for accurate measurement when observed with long air path at high humidity. No intensities are assigned beyond λ9831 but the lines given in the table are those best suited to measurement on our spectrograms.

TABLE XV

Temporary Standards of Wave-Length in the Infra-red Solar Spectrum (Scale of 1928)

λ I. A.	El.	Int.
*7333·684	A	1
*7335·335	A	1
7344·769	A	0
7355·891	*Cr*	1
7360·347	A	1
7369·206	A	1
7383·721	A	1
*7389·391	*Fe*	2
*7393·609	*Ni*	2
7400·188	*Cr*	1
*7405·790	*Si*	1
7414·514	*Ni*	1
7415·958	*Si*	1
7418·672	*Fe*	0
*7422·286	*Ni*	1
*7423·509	*Si*	1
7440·919	*Fe*?	1
7445·758	*Fe*	2
*7462·341	*Cr* Fe^{+} ?	2
*7491·652	*Fe*	1
7495·077	*Fe*	2
7507·273	*Fe*	1
*7511·031	*Fe*	2
7525·118	*Ni*	1
*7531·152	*Fe*	2
7555·607	*Ni*	2
*7568·905	*Fe*	1
*7574·046	*Ni*	1
*7583·796	*Fe*	1
*7586·025	*Fe*	2
7594·509	A	S
7615·061	A	S
7616·146	A	S
7619·698	A	W
7638·308	A	W
7647·204	A	W
7660·454	A	S
7682·756	A	S
7695·836	A	S
7696·868	A	W
7702·736	A	W
7703·754	A	W
7714·309	*Ni*	3
7727·616	*Ni*	3
7742·722	*Fe*	2
7780·567	*Fe*	3
7797·587	*Ni*	2
7807·915	*Fe*	1
7832·207	*Fe*	2
7849·984	—	1
7887·117	A	1
7901·780	A	3
7918·383	*Si*	1
7937·149	*Fe*	3
7945·857	*Fe*	2
7960·733	A	1
7968·121	A	0
*7971·522	A	0
7984·340	A	1
*7994·488	*Fe Ni*	1
8000·301	A	2
*8012·940	A	1
8034·294	A	1
8036·461	A	1
8039·598	A	1
8045·531	*Fe*	1
*8046·055	*Fe*	2
8047·624	*Fe*	1
8075·155	*Fe*	0
8092·640	*Cu* ?	1

* High weight.

TABLE XV (*continued*)

λ I. A.	El.	Int.
8094·271	A	– 1
8103·165	A	0
8107·838	A	1
8110·567	A	0
8118·908	A	1
8120·661	A	1
*8125·444	A	1
8133·209	A	0
*8135·047	A	5
8136·207	A	1
8139·720	A	2
8141·938	A	4
8144·193	A	0
*8146·214	A	2
8147·188	A	2
8149·269	A	1
8152·497	A	4
8158·021	A	6
8161·433	A	8
8165·338	A	1
8168·820	A	4
8169·384	A	2
8174·678	A	1
8177·932	A	4
8178·491	A	2
8181·846	A	6
*8186·371	A	5
8194·837	*Na*	2
8199·989	A	2
8200·696	A	3
*8207·748	*Fe*	1
8210·322	A	2
8212·132	A	4
8218·112	A	5
8221·553	A	4
8225·685	A	2
8229·761	A	3
8233·907	A	5
8234·629	A	1
8237·343	A	3
8239·132	*Fe*	0
*8239·925	A	3
8248·136	*Fe*	0
8248·800	—	0
8252·727	A	2
8259·693	A	4
8263·445	A	3
*8272·041	A	4
*8279·600	A	5
8282·024	A	8
8289·535	A	4
8300·408	A	3
8304·300	A	1
8313·872	A	0
8318·139	A	2
*8327·060	*Fe*	2
8329·683	A	3
8333·584	A	2
8342·284	A	1
8357·041	A	1
8357·441	A	0
*8365·641	*Fe*	1
8367·331	A	2
8373·710	A	1
*8387·782	*Fe*	3
8394·018	A	0
*8412·356	*Ti*	0
8426·514	*Ti*	0
8434·966	*Ti*	1
*8435·655	*Ti*	1
8460·245	A	0
*8468·418	*Fe Ti*	2
8471·744	*Fe*	– 1
8496·994	*Fe*	0
*8514·082	*Fe*	1
8515·121	*Fe*	0
8526·675	*Fe*	0
8536·163	—	0
8556·794	*Si ?*	1
8571·809	—	– 1
*8582·272	*Fe*	1
8592·969	*Fe*	– 1
8595·970	—	– 1
8598·835	*Fe*	– 1
*8611·812	*Fe*	1
8613·945	—	– 1
8616·284	*Fe*–	0
8621·616	*Fe*	1
8648·471	—	2
8674·758	*Fe*	1
8686·368	—	– 1
*8688·641	*Fe*	2
8699·462	*Fe*	1
8710·398	*Fe*	0
8713·210	*Fe*	– 1
8717·834	—	0
8728·024	—	0
8742·466	–, *Si ?*	1
*8752·025	*Si ?*	1
8757·199	*Fe*	1

* High weight.

TABLE XV (*continued*)

λ I. A.	El.	Int.	λ I. A.	El.	Int.
8763·978	*Fe*	1	9587·132	A	3
8772·884	—	0	9590·217	A	4
8773·908	—	0	9601·177	A	0
8790·454	*Fe*	1	9614·050	A	1
8793·350	*Fe*	1	9624·499	A	1
8804·637	*Fe*	0	9643·109	A	1
*8824·236	*Fe*	2	9664·637	A	3
8838·447	*Fe*	1	9681·732	A	0
*8862·562	*Ni*	0	9698·290	A	2
8866·943	*Fe*	1	9723·191	A	3
8868·443	—	0	9724·575	A	3
8879·322	A	1	9730·648	A	2
8912·098	—	0	9753·830	A	3
*8917·523	A	0	9776·815	A	2
*8927·388	—	− 1	9779·398	A	2
8930·275	A	0	9791·017	A	3
*8934·095	A	1	9799·473	A	2
8942·352	A	0	9803·238		2
8954·314	A	1	9813·473		2
8958·404	A	1	9825·539		3
8972·906	A	0	9831·981		3
8976·430	A	1	9861·770		
8986·608	A	2	9870·286		
9031·369	A	2	9873·706		
9040·066	A	0	9889·086		
9052·961	A	2	9898·999		
9074·291	A	3	9908·29		
9105·406	A	3	9920·24		
9115·628	A	0	9926·54		
9118·006	A	1	9967·38		
9132·465	A	1	9977·12		
9160·907	A	1	9993·09		
9175·265	A	2	9997·64		
9192·571	A	2	10016·82		
9232·774	A	1	10036·84		
9251·118	A	2	10041·64		
9273·082	A	2	10053·27		
9301·900	A	2	†10065·05		
9320·751	A	5	10077·64		
9363·315	A	1	10087·08		
9400·114	A	2	10099·98		
9450·289	A	3	10118·97		
9476·761	A	1	10123·89		
9486·013	A	2	†10145·52		
9489·793	A	1	10153·14		
9514·480	A	1	10191·02		
9525·086	A	4	†10216·32		
9538·438	A	4	10226·66		
9550·946	A	1	10235·95		
9568·892	A	4	10237·27		

* High weight.

† Probably due to *Fe*.

TABLE XV (*continued*)

λ I. A.	El.	Int.	λ I. A.	El.	Int.
10273·00			10810·97		
10288·91			10827·15		
10327·32			10832·14		
10340·93			10857·36		
10343·85			10859·96		
10371·25			10888·80		
10378·58			10901·04		
10420·52			10922·99		
10455·45			10930·86		
10469·68			10946·37		
10496·16			10972·99		
10532·27			10993·89		
10585·15			10996·43		
10603·45			11027·60		
10627·71			11038·90		
10661·01			11063·94		
*10683·14			11074·44		
10689·73			11088·27		
10694·21			11119·12		
*10707·35			11145·00		
10727·39			11155·38		
10743·54			11157·25		
10749·40			11177·46		
10786·88			11204·87		
10799·64					

* Probably due to *C*.

A. FOWLER
President of the Commission

August 1932