The Spectrum of Fluorine, F II, F III, F IV

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The spectrum of fluorine extending from 125A to 620A has been obtained by using a two-meter grazing-incidence spectrograph. A large number of these lines, including nearly all of the stronger ones, have been classified as transitions in the F II, F III and F IV ions. This has made possible the classification of additional lines measured by Dingle in the longer wave-length regions. These analyses yield the following ionization potentials: F II 34.81 volts, F III 62.35 volts, F IV 87.34 volts.

IN the present investigation new plates of the fluorine spectrum were obtained extending over the range from 125A to 620A. The source was a vacuum spark between hollow aluminum electrodes into which LiF had been fused. The spectrograph was of the grazing-incidence type using a two-meter radius glass grating which was ruled with 960 lines per mm on an engine built and operated by Mr. Julius Pearson of the California Institute shop. The various stages of ionization were partially differentiated by the introduction of self-induction into the spark circuit. Oxygen and aluminum wave-lengths determined by Edlén were used as standards.

The observed lines that it has been possible to classify in the present investigation as transitions between terms of F IV, F III and F II are listed in Tables I, III and V, respectively. Tables II, IV and VI give the term values obtained from the analyses of the spectra of these ions. For the sake of completeness terms located by earlier authors have been included with, however, some minor changes in the absolute values as discussed below. These analyses account for nearly all of the strong extreme ultraviolet lines.

In Table II the values of the triplet terms of F IV were fixed by extrapolating the values of the terms of the s^2p3d configuration from the corresponding terms in C I, N II and O III. The value thus obtained should be correct to a very few thousand frequency units. The singlet terms were somewhat less accurately obtained by an extrapolation of the relative positions of the singlet and triplet terms of the s^2p^2 configuration of these same ions.

TABLE I. *Classified lines of F IV.*

Int.	λ(Vac.)	ν	Classification	Int.	λ(Vac.)	ν	Classification
1	199.763	500593	$s^2p^2\ ^3P_{1,\,0}-s^2p3d\ ^3P_{0,\,1}$	4	251.026	398365	$s^2p^2\ ^1D-s^2p3s\ ^1P$
1	199.836	500410	$s^2p^2\ ^3P_1-s^2p3d\ ^3P_1$	3	270.222	370066	$s^2p^2\ ^1S-s^2p3s\ ^1P$
1	199.923	500193	$s^2p^2\ ^3P_1-s^2p3d\ ^3P_2$	6	419.662	238287	$s^2p^2\ ^3P_0-sp^3\ ^3S$
1	199.996	500010	$s^2p^2\ ^3P_2-s^2p3d\ ^3P_1$	7	420.061*	238061	$s^2p^2\ ^3P_1-sp^3\ ^3S$
3	200.086	499785	$s^2p^2\ ^3P_2-s^2p3d\ ^3P_2$	8	420.743*	237675	$s^2p^2\ ^3P_2-sp^3\ ^3S$
2	201.008	497493	$s^2p^2\ ^3P_0-s^2p3d\ ^3D_1$	7	430.742	232158	$s^2p^2\ ^1D-sp^3\ ^1P$
3	201.066	497349	$s^2p^2\ ^3P_1-s^2p3d\ ^3D_2$	4	490.607	203829	$s^2p^2\ ^1S-sp^3\ ^1P$
4	201.160	497117	$s^2p^2\ ^3P_2-s^2p3d\ ^3D_3$	8	491.048	203646	$s^2p^2\ ^1D-sp^3\ ^1D$
1	201.232	496939	$s^2p^2\ ^3P_2-s^2p3d\ ^3D_2$	5	570.643*	175241	$s^2p^2\ ^3P_0-sp^3\ ^3P$
3	239.864	416903	$s^2p^2\ ^3P_1-s^2p3s\ ^3P_2$	7	571.357*	175022	$s^2p^2\ ^3P_1-sp^3\ ^3P$
3	240.016	416639	$s^2p^2\ ^3P_0-s^2p3s\ ^3P_1$	7	572.640*	174630	$s^2p^2\ ^3P_2-sp^3\ ^3P$
5	240.094	416504	$s^2p^2\ ^3P_2-s^2p3s\ ^3P_2$	4	676.06*	147916	$s^2p^2\ ^3P_0-sp^3\ ^3D_1$
2	240.163	416384	$s^2p^2\ ^3P_1-s^2p3s\ ^3P_1$	5	677.17*	147643	$s^2p^2\ ^3P_1-sp^3\ ^3D_2$
3	240.280	416181	$s^2p^2\ ^3P_1-s^2p3s\ ^3P_0$	5	679.19*	147234	$s^2p^2\ ^3P_2-sp^3\ ^3D_3$
3	240.384	416001	$s^2p^2\ ^3P_2-s^2p3s\ ^3P_1$				

* Previously classified by Bowen (reference 2).

TABLE II. *Term values in F IV.*

		$s^2p^2\,^3P_0$	708000	$sp^3\,^3D_3$	560154
		$s^2p^2\,^3P_1$	707774	$sp^3\,^3D_2$	560101
		$s^2p^2\,^3P_2$	707388	$sp^3\,^3D_1$	560084
		$s^2p^2\,^1D$	683200	$sp^3\,^3P$	532756
		$s^2p^2\,^1S$	654881	$sp^3\,^1D$	479554
				$sp^3\,^3S$	469713
				$sp^3\,^1P$	451042
$s^2p3s\,^3P_0$	291593			$s^2p3d\,^3D_1$	210507
$s^2p3s\,^3P_1$	291379			$s^2p3d\,^3D_2$	210433
$s^2p3s\,^3P_2$	290878			$s^2p3d\,^3D_3$	210271
$s^2p3s\,^1P$	284835			$s^2p3d\,^3P_2$	207592
				$s^2p3d\,^3P_1$	207371
				$s^2p3d\,^3P_0$	207181

In F III, Dingle[1] had classified a large number of lines as transitions between terms arising from the addition of a $3s$, a $3p$ or a $3d$ electron to the ^3P state of the core and Bowen[2] had identified a group of strong lines involving the s^2p^3 and sp^4 configurations. In the present analyses a large number of extreme ultraviolet lines have been identified as transitions to these low levels of the s^2p^3 configuration from the high levels found by Dingle and also from a large group of additional high levels that had not previously been located. Among others, all of the terms caused by the addition of a $3s$, $3p$ or $3d$ electron to the ^1D state of the core were found. The location of these terms made it possible to classify many of the strong unclassified lines in Dingle's list as

TABLE III. *Classified lines in F III.*

Int.	λ(Vac.)	ν	Classification	
2	214.788	465575	$s^2p^3\,^4S$	$-s^2p^2(^3P)5d\,^4P_{\frac{1}{2},1\frac{1}{2}}$
2	214.857	465426	$s^2p^3\,^4S$	$-s^2p^2(^3P)5d\,^4P_{2\frac{1}{2}}$
3	226.083	442315	$s^2p^3\,^4S$	$-s^2p^2(^3P)4d\,^4P_{\frac{1}{2},1\frac{1}{2}}$
3	226.169	442147	$s^2p^3\,^4S$	$-s^2p^2(^3P)4d\,^4P_{2\frac{1}{2}}$
0	243.397	410851	$s^2p^3\,^2D$	$-s^2p^2(^3P)4d\,^2D$
3	244.786	408520	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^2F_{3\frac{1}{2}}$
3	245.020	408130	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^2F_{2\frac{1}{2}}$.
0	245.876	406709	$s^2p^3\,^2D$	$-s^2p^2(^1D)4s\,^2D$
4	254.178	393425	$s^2p^3\,^2P$	$-s^2p^2(^3P)4d\,^2D$
4	255.718	391056	$s^2p^3\,^4S$	$-s^2p^2(^3P)3d\,^4P_{\frac{1}{2}}$
5	255.775	390969	$s^2p^3\,^4S$	$-s^2p^2(^3P)3d\,^4P_{1\frac{1}{2}}$
6	255.866	390830	$s^2p^3\,^4S$	$-s^2p^2(^3P)3d\,^4P_{2\frac{1}{2}}$
5	256.358	390079	$s^2p^3\,^4S$	$-s^2p^2(^3P)3d\,^4D_{\frac{1}{2},1\frac{1}{2},2\frac{1}{2}}$
1	256.892	389269	$s^2p^3\,^2P$	$-s^2p^2(^1D)4s\,^2D$
3	260.312	384154	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$
3	260.387	384044	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$
2	260.500	383877	$s^2p^3\,^2D$	$-s^2p^2(^3P)4s\,^2P$
6	261.729	382075	$s^2p^3\,^2D$	$-s^2p^2(^1D)3d\,^2D$
6	263.809	379062	$s^2p^3\,^2D$	$-s^2p^2(^1D)3d\,^2F$
3	270.670	369454	$s^2p^3\,^2P$	$-s^2p^2(^1D)3d\,^2S$
2	272.701	366702	$s^2p^3\,^2P$	$-s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$
1	272.755	366629	$s^2p^3\,^2P$	$-s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$
2	272.910	366421	$s^2p^3\,^2P$	$-s^2p^2(^3P)4s\,^2P$
4	274.254	364625	$s^2p^3\,^2P$	$-s^2p^2(^1D)3d\,^2D$
4	276.776	361303	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2D_{2\frac{1}{2}}$
3	276.887	361158	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2D_{1\frac{1}{2}}$
7	279.685	357545	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2F_{3\frac{1}{2}}$
7	280.002	357140	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2F_{2\frac{1}{2}}$
1	280.804	356120	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^4D_{3\frac{1}{2}}$
1	280.897	356002	$s^2p^3\,^2D$	$-s^2p^2(^3P)3d\,^4D_{\frac{1}{2},1\frac{1}{2},2\frac{1}{2}}$
2	281.199	355620	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
3	281.343	355438	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
4	290.838	343834	$s^2p^3\,^2P$	$-s^2p^2(^3P)3d\,^2D_{2\frac{1}{2}}$
3	290.941	343712	$s^2p^3\,^2P$	$-s^2p^2(^3P)3d\,^2D_{1\frac{1}{2}}$
1	295.366	338563	$s^2p^3\,^2P$	$-s^2p^2(^3P)3d\,^4D_{\frac{1}{2},1\frac{1}{2},2\frac{1}{2}}$
3	295.708	338171	$s^2p^3\,^2P$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
3	295.880	337975	$s^2p^3\,^2P$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
8	315.227	317232	$s^2p^3\,^4S$	$-s^2p^2(^3P)3s\,^4P_{2\frac{1}{2}}$
7	315.545	316912	$s^2p^3\,^4S$	$-s^2p^2(^3P)3s\,^4P_{1\frac{1}{2}}$
6	315.759	316697	$s^2p^3\,^4S$	$-s^2p^2(^3P)3s\,^4P_{\frac{1}{2}}$
7*D*	322.657	309927	$s^2p^3\,^2D$	$-s^2p^2(^1D)3s\,^2D$
4	341.926	292461	$s^2p^3\,^2P$	$-s^2p^2(^1D)3s\,^2D$
5	343.895	290786	$s^2p^3\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^3P)3s\,^2P_{1\frac{1}{2}}$
4	344.387	290371	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^3P)3s\,^2P_{\frac{1}{2}}$
5	365.864	273326	$s^2p^3\,^2P$	$-s^2p^2(^3P)3s\,^2P_{1\frac{1}{2}}$
4	366.384	272938	$s^2p^3\,^2P$	$-s^2p^2(^3P)3s\,^2P_{\frac{1}{2}}$
9	429.496*	232831	$s^2p^3\,^2D_{1\frac{1}{2}}$	$-sp^4\,^2P_{\frac{1}{2}}$
10*D*	430.173*	232465	$s^2p^3\,^2D_{1\frac{1}{2},2\frac{1}{2}}$	$-sp^4\,^2P_{1\frac{1}{2}}$
6	464.302*	215377	$s^2p^3\,^2P$	$-sp^4\,^2P_{\frac{1}{2}}$
8	465.132*	214993	$s^2p^3\,^2P$	$-sp^4\,^2P_{1\frac{1}{2}}$
10*D*	567.712*	176146	$s^2p^3\,^2D$	$-sp^4\,^2D$
4	630.17*	158687	$s^2p^3\,^2P$	$-sp^4\,^2D$
7	656.10*	152416	$s^2p^3\,^4S$	$-sp^4\,^4P_{\frac{1}{2}}$
8	656.86*	152239	$s^2p^3\,^4S$	$-sp^4\,^4P_{1\frac{1}{2}}$
8	658.34*	151897	$s^2p^3\,^4S$	$-sp^4\,^4P_{2\frac{1}{2}}$
0	1071.66	93313	$s^2p^2(^3P)3p\,^4D_{2\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^4P_{1\frac{1}{2}}$
0	1099.10	90984	$s^2p^2(^3P)3p\,^4P_{1\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^4P_{1\frac{1}{2}}$
0	1101.55	90781	$s^2p^2(^3P)3p\,^4P_{1\frac{1}{2},2\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^4P_{2\frac{1}{2},1\frac{1}{2}}$
0	1103.64	90609	$s^2p^2(^3P)3p\,^4P_{2\frac{1}{2}}$	$-s^2p^2(^3P)4d\,^4P_{2\frac{1}{2}}$
	λ(Air)			
$\frac{1}{2}$	2455.81	40707.4	$s^2p^2(^3P)3p\,^4D_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
7	2470.279	40469.02	$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$
2	2470.48	40465.8	$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$
6	2478.709	40331.40	$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2P_{\frac{1}{2}}$
0	2492.58	40107.0	$s^2p^2(^3P)3p\,^4P_{2\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2F_{3\frac{1}{2}}$
1	2543.4	39305.7	$s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2D_{2\frac{1}{2}}$
1	2596.5	38501.9	$s^2p^2(^3P)3p\,^4P_{\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
0	2602.9	38407.2	$s^2p^2(^3P)3p\,^4P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
$\frac{1}{2}$	2610.8	38291.0	$s^2p^2(^3P)3p\,^4P_{\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
1	2617.3	38195.9	$s^2p^2(^3P)3p\,^4P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
7	2625.000	38083.89	$s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2G_{3\frac{1}{2}}$
8	2629.686	38016.03	$s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2G_{4\frac{1}{2}}$
1	2630.93	37998.1	$s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^2D)3d\,^2P_{1\frac{1}{2}}$
$\frac{1}{2}$	2634.8	37942.2	$s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$
4	2639.05	37881.1	$s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$
0	2645.5	37788.8	$s^2p^2(^3P)3p\,^4S$	$-s^2p^2(^3P)3d\,^2D_{1\frac{1}{2}}$
2	2727.93	36646.9	$s^2p^2(^1D)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2S$
4	2737.954	36512.84	$s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2S$
5	2747.870	36381.08	$s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{2\frac{1}{2}}$
1	2751.8	36329.1	$s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{3\frac{1}{2}}$
1	2752.8	36315.9	$s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{2\frac{1}{2}}$
4	2755.307	36282.89	$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$
7	2755.556	36279.61	$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$
5	2756.664	36265.02	$s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{3\frac{1}{2}}$
10	2759.589	36226.60	$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$
3	2759.81	36223.7	$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2D_{2\frac{1}{2}}$
4	2781.956	35935.35	$s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2D_{2\frac{1}{2}}$
$1\frac{1}{2}$	2949.91	33889.5	$s^2p^2(^1D)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$
2	2955.13	33829.6	$s^2p^2(^1D)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$
2	2959.666	33777.76	$s^2p^2(^3P)3p\,^4S$	$-s^2p^2(^3P)3d\,^2F_{2\frac{1}{2}}$
5	2961.596	33755.74	$s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$
1	2966.89	33695.5	$s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$
$1\frac{1}{2}$	3034.54	32944.3	$s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{2\frac{1}{2}}$
7	3039.254	32893.26	$s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{3\frac{1}{2}}$
6	3039.746	32887.94	$s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2F_{2\frac{1}{2}}$
10	3042.808	32854.85	$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$
2	3048.80	32790.3	$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$
8	3049.139	32786.64	$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	$-s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$
4	3154.387	31692.74	$s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^1D)3d\,^2D_{2\frac{1}{2}}$
1	3357.82	29772.7	$s^2p^2(^3P)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^4D_{\frac{1}{2}}$
1	3367.65	29685.8	$s^2p^2(^3P)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^4D_{\frac{1}{2}}$
1	3372.24	29645.3	$s^2p^2(^3P)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^4D_{1\frac{1}{2}}$
2	3401.62	29389.4	$s^2p^2(^3P)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
3	3411.66	29302.8	$s^2p^2(^3P)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$
2	3426.34	29177.3	$s^2p^2(^3P)3p\,^2P_{\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$
4	3436.57	29090.5	$s^2p^2(^3P)3p\,^2P_{1\frac{1}{2}}$	$-s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$

* Previously classified by Bowen (reference 2). Wave-lengths above 2000A are taken from Dingle's list of unclassified lines (references 1 and 3).

[1] H. Dingle, Proc. Roy. Soc. **A122**, 144 (1929).

[2] I. S. Bowen, Phys. Rev. **29**, 245 (1927).

TABLE IV. *Term values in F III.*

		$s^2p^3\,^4S$	505404	$sp^4\,^4P_{2\frac{1}{2}}$	353507
		$s^2p^3\,^2D_{2\frac{1}{2}}$	471329	$sp^4\,^4P_{1\frac{1}{2}}$	353165
		$s^2p^3\,^2D_{1\frac{1}{2}}$	471298	$sp^4\,^4P_{\frac{1}{2}}$	352988
		$s^2p^3\,^2P$	453857	$sp^4\,^2D$	295169
				$sp^4\,^2P_{1\frac{1}{2}}$	238864
				$sp^4\,^2P_{\frac{1}{2}}$	238474
$s^2p^2(^3P)3s\,^4P_{\frac{1}{2}}$	188702.7	$s^2p^2(^3P)3p\,^2S$	160971.6	$s^2p^2(^3P)3d\,^4F_{1\frac{1}{2}}$	118152.7
$s^2p^2(^3P)3s\,^4P_{1\frac{1}{2}}$	188491.4	$s^2p^2(^3P)3p\,^4D_{\frac{1}{2}}$	156709.5	$s^2p^2(^3P)3d\,^4F_{2\frac{1}{2}}$	118043.8
$s^2p^2(^3P)3s\,^4P_{2\frac{1}{2}}$	188172.5	$s^2p^2(^3P)3p\,^4D_{1\frac{1}{2}}$	156594.6	$s^2p^2(^3P)3d\,^4F_{3\frac{1}{2}}$	117888.2
$s^2p^2(^3P)3s\,^2P_{\frac{1}{2}}$	180920.1	$s^2p^2(^3P)3p\,^4D_{2\frac{1}{2}}$	156404.9	$s^2p^2(^3P)3d\,^4F_{4\frac{1}{2}}$	117684.5
$s^2p^2(^3P)3s\,^2P_{1\frac{1}{2}}$	180535.6	$s^2p^2(^3P)3p\,^4D_{3\frac{1}{2}}$	156146.0	$s^2p^2(^3P)3d\,^2P_{1\frac{1}{2}}$	115886.5
$s^2p^2(^1D)3s\,^2D_{2\frac{1}{2}}$	161393.8	$s^2p^2(^3P)3p\,^4P_{\frac{1}{2}}$	154175.9	$s^2p^2(^3P)3d\,^2P_{\frac{1}{2}}$	115674.3
$s^2p^2(^1D)3s\,^2D_{1\frac{1}{2}}$	161390.5	$s^2p^2(^3P)3p\,^4P_{1\frac{1}{2}}$	154081.6	$s^2p^2(^3P)3d\,^4D_{2\frac{1}{2}}$	115334.3
		$s^2p^2(^3P)3p\,^4P_{2\frac{1}{2}}$	153892.9	$s^2p^2(^3P)3d\,^4D_{1\frac{1}{2}}$	115331.7
		$s^2p^2(^3P)3p\,^2D_{1\frac{1}{2}}$	149430.4	$s^2p^2(^3P)3d\,^4D_{\frac{1}{2}}$	115291.6
		$s^2p^2(^3P)3p\,^2D_{2\frac{1}{2}}$	149040.0	$s^2p^2(^3P)3d\,^4D_{3\frac{1}{2}}$	115201.6
		$s^2p^2(^3P)3p\,^4S$	147933.0	$s^2p^2(^3P)3d\,^4P_{2\frac{1}{2}}$	114577.7
		$s^2p^2(^3P)3p\,^2P_{\frac{1}{2}}$	145063.8	$s^2p^2(^3P)3d\,^4P_{1\frac{1}{2}}$	114436.0
		$s^2p^2(^3P)3p\,^2P_{1\frac{1}{2}}$	144976.9	$s^2p^2(^3P)3d\,^4P_{\frac{1}{2}}$	114364.8
		$s^2p^2(^1D)3p\,^2F_{2\frac{1}{2}}$	128603.8	$s^2p^2(^3P)3d\,^2F_{2\frac{1}{2}}$	114154.4
		$s^2p^2(^1D)3p\,^2F_{3\frac{1}{2}}$	128539.0	$s^2p^2(^3P)3d\,^2F_{3\frac{1}{2}}$	113784.5
		$s^2p^2(^1D)3p\,^2D_{2\frac{1}{2}}$	125167.1	$s^2p^2(^3P)3d\,^2D_{1\frac{1}{2}}$	110143.9
		$s^2p^2(^1D)3p\,^2D_{1\frac{1}{2}}$	125110.9	$s^2p^2(^3P)3d\,^2D_{2\frac{1}{2}}$	110025.9
		$s^2p^2(^1D)3p\,^2P_{\frac{1}{2}}$	121059.1	$s^2p^2(^1D)3d\,^2F_{3\frac{1}{2}}$	92273.9
		$s^2p^2(^1D)3p\,^2P_{1\frac{1}{2}}$	120924.8	$s^2p^2(^1D)3d\,^2F_{2\frac{1}{2}}$	92222.9
				$s^2p^2(^1D)3d\,^2G_{4\frac{1}{2}}$	90523.0
				$s^2p^2(^1D)3d\,^2G_{3\frac{1}{2}}$	90519.9
				$s^2p^2(^1D)3d\,^2D_{2\frac{1}{2}}$	89231.9
				$s^2p^2(^1D)3d\,^2P_{\frac{1}{2}}$	87229.4
				$s^2p^2(^1D)3d\,^2P_{1\frac{1}{2}}$	87169.1
				$s^2p^2(^1D)3d\,^2S$	84412.1
$s^2p^2(^3P)4s\,^2P$	87436			$s^2p^2(^3P)4d\,^4P_{2\frac{1}{2}}$	63284
$s^2p^2(^1D)4s\,^2D$	64596			$s^2p^2(^3P)4d\,^2F_{2\frac{1}{2}}$	63168
				$s^2p^2(^3P)4d\,^4P_{1\frac{1}{2}}$	63095
				$s^2p^2(^3P)4d\,^2F_{3\frac{1}{2}}$	62809
				$s^2p^2(^3P)4d\,^2D$	60447
				$s^2p^2(^3P)5d\,^4P_{2\frac{1}{2}}$	39978
				$s^2p^2(^3P)5d\,^4P_{1\frac{1}{2},\frac{1}{2}}$	39829

TABLE V. *Classified lines in F II.*

Int.	λ(Vac.)	ν	Classification	Int.	λ(Vac.)	ν	Classification
0	353.452	282924	$s^2p^4\,^3P_2 - s^2p^3(^2P)3d\,^3P_2$	3	436.288	229206	$s^2p^4\,^3P_1 - s^2p^3(^2P)3s\,^3P$
2	375.300	266454	$s^2p^4\,^3P_2 - s^2p^3(^2D)3d\,^3P_2$	1	436.578	229054	$s^2p^4\,^3P_0 - s^2p^3(^2P)3s\,^3P$
1	375.434	266358	$s^2p^4\,^3P_2 - s^2p^3(^2D)3d\,^3S$	6	457.183	218731	$s^2p^4\,^1D - sp^5\,^1P$
1	375.718	266157	$s^2p^4\,^3P_1 - s^2p^3(^2D)3d\,^3P_{0,1}$	6	471.990	211869	$s^2p^4\,^3P_2 - s^2p^3(^2D)3s\,^3D_3$
1	375.793	266104	$s^2p^4\,^3P_1 - s^2p^3(^2D)3d\,^3P_2$	5	472.710	211546	$s^2p^4\,^3P_1 - s^2p^3(^2D)3s\,^3D_2$
1D	375.928	266008	$s^2p^4\,^3P_{1,0} - s^2p^3(^2D)3d\,^3S, P_1$	3	473.021	211407	$s^2p^4\,^3P_0 - s^2p^3(^2D)3s\,^3D_1$
1	376.686	265473	$s^2p^4\,^3P_2 - s^2p^3(^2D)3d\,^3D_3$	8	484.650	206334	$s^2p^4\,^1D - s^2p^3(^2P)3s\,^1P$
0	377.140	265154	$s^2p^4\,^3P_1 - s^2p^3(^2D)3d\,^3D_2$	4	513.637	194690	$s^2p^4\,^1S - sp^5\,^1P$
2	380.902	262535	$s^2p^4\,^1D - s^2p^3(^2P)3d\,^1D$	6	514.942	194197	$s^2p^4\,^1D - s^2p^3(^2D)3s\,^1D$
1	393.664	254024	$s^2p^4\,^3P_2 - s^2p^3(^4S)4d\,^3D$	6	546.846*	182867	$s^2p^4\,^3P_2 - s^2p^3(^4S)3s\,^3S$
0	394.194	253682	$s^2p^4\,^3P_1 - s^2p^3(^4S)4d\,^3D$	4	547.873*	182524	$s^2p^4\,^3P_1 - s^2p^3(^4S)3s\,^3S$
1	400.579	249639	$s^2p^4\,^1D - s^2p^3(^2D)4s\,^1D$	3	548.324*	182374	$s^2p^4\,^3P_0 - s^2p^3(^4S)3s\,^3S$
4	405.644	246522	$s^2p^4\,^1D - s^2p^3(^2D)3d\,^1F$	3	548.511	182312	$s^2p^4\,^1S - s^2p^3(^2P)3s\,^1P$
5	407.053	245668	$s^2p^4\,^1D - s^2p^3(^2D)3d\,^1P$	8	605.67*	165106	$s^2p^4\,^3P_2 - sp^5\,^3P_1$
4	407.511	245392	$s^2p^4\,^1D - s^2p^3(^2D)3d\,^1D$	7	606.27*	164943	$s^2p^4\,^3P_1 - sp^5\,^3P_0$
1	417.891	239297	$s^2p^4\,^1S - s^2p^3(^2P)3d\,^1P$	9	606.81*	164796	$s^2p^4\,^3P_2 - sp^5\,^3P_2$
1	422.012	236960	$s^2p^4\,^3P_2 - s^2p^3(^4S)4s\,^3S$	4	606.95*	164758	$s^2p^4\,^3P_1 - sp^5\,^3P_1$
0	422.650	236602	$s^2p^4\,^3P_1 - s^2p^3(^4S)4s\,^3S$	7	607.48*	164614	$s^2p^4\,^3P_0 - sp^5\,^3P_1$
5	430.905	232070	$s^2p^4\,^3P_2 - s^2p^3(^4S)3d\,^3D_3$	8	608.06*	164457	$s^2p^4\,^3P_1 - sp^5\,^3P_2$
5	431.541	231728	$s^2p^4\,^3P_1 - s^2p^3(^4S)3d\,^3D_2$		λ(Air)		
3	431.812	231582	$s^2p^4\,^3P_0 - s^2p^3(^4S)3d\,^3D_1$	4	3739.60	26733.2	$sp^5\,^1P - s^2p^3(^2P)3p\,^1D$
4	435.640	229547	$s^2p^4\,^3P_2 - s^2p^3(^2P)3s\,^3P$	6	4083.919	24479.39	$s^2p^3(^2P)3p\,^1P - s^2p^3(^2P)3d\,^1D$
				2	5173.16	19325.2	$sp^5\,^1P - s^2p^3(^2P)3p\,^1P$

* Previously classified by Bowen (reference 2). Wave-lengths above 2000A are taken from Dingle's list of unclassified lines (reference 3).

TABLE VI. *Term values in F II.*

		$s^2p^4\ ^3P_2$	282193	$sp^5\ ^3P_2$	117395
		$s^2p^4\ ^3P_1$	281850	$sp^5\ ^3P_1$	117089
		$s^2p^4\ ^3P_0$	281701	$sp^5\ ^3P_0$	116907
		$s^2p^4\ ^1D$	260393	$sp^5\ ^1P$	41668.4
		$s^2p^4\ ^1S$	236355		
$s^2p^3(^4S)3s\ ^5S$	105536.00	$s^2p^3(^4S)3p\ ^5P_1$	79580.55	$s^2p^3(^4S)3d\ ^5D_4$	51032.12
$s^2p^3(^4S)3s\ ^3S$	99325.0	$s^2p^3(^4S)3p\ ^5P_2$	79569.22	$s^2p^3(^4S)3d\ ^5D_3$	51031.21
$s^2p^3(^2D)3s\ ^3D_3$	70323.58	$s^2p^3(^4S)3p\ ^5P_3$	79549.67	$s^2p^3(^4S)3d\ ^5D_2$	51030.01
$s^2p^3(^2D)3s\ ^3D_2$	70302.51	$s^2p^3(^4S)3p\ ^3P_1$	74490.29	$s^2p^3(^4S)3d\ ^5D_1$	51029.33
$s^2p^3(^2D)3s\ ^3D_1$	70289.48	$s^2p^3(^4S)3p\ ^3P_0$	74487.29	$s^2p^3(^4S)3d\ ^5D_0$	51028.81
$s^2p^3(^2D)3s\ ^1D$	66200.4	$s^2p^3(^4S)3p\ ^3P_2$	74485.59	$s^2p^3(^4S)3d\ ^3D_1$	50126.02
$s^2p^3(^2P)3s\ ^1P$	54045.2	$s^2p^3(^2D)3p\ ^3D_1$	46019.85	$s^2p^3(^4S)3d\ ^3D_2$	50125.22
$s^2p^3(^2P)3s\ ^3P_2$	52648.37	$s^2p^3(^2D)3p\ ^3D_2$	46017.13	$s^2p^3(^4S)3d\ ^3D_3$	50123.14
$s^2p^3(^2P)3s\ ^3P_1$	52646.76	$s^2p^3(^2D)3p\ ^3D_3$	45994.63	$s^2p^3(^2D)3d\ ^3G$	17695.5
$s^2p^3(^2P)3s\ ^3P_0$	52644.10	$s^2p^3(^2D)3p\ ^1F$	45627.1	$s^2p^3(^2D)3d\ ^3F_2$	17237.08
		$s^2p^3(^2D)3p\ ^3F_4$	44682.29	$s^2p^3(^2D)3d\ ^3F_3$	17231.57
		$s^2p^3(^2D)3p\ ^3F_3$	44681.48	$s^2p^3(^2D)3d\ ^3F_4$	17224.29
		$s^2p^3(^2D)3p\ ^3F_2$	44680.83	$s^2p^3(^2D)3d\ ^3D_3$	16717.50
		$s^2p^3(^2D)3p\ ^1P$	42946.6	$s^2p^3(^2D)3d\ ^3D_2$	16691.46
		$s^2p^3(^2D)3p\ ^3P_2$	42097.10	$s^2p^3(^2D)3d\ ^3D_1$	16673.06
		$s^2p^3(^2D)3p\ ^3P_1$	42036.86	$s^2p^3(^2D)3d\ ^3S$	15829.51
		$s^2p^3(^2D)3p\ ^3P_0$	42010.29	$s^2p^3(^2D)3d\ ^3P_2$	15735.93
		$s^2p^3(^2D)3p\ ^1D$	34986.3	$s^2p^3(^2D)3d\ ^3P_1$	15691.08
		$s^2p^3(^2P)3p\ ^3S$	28886.0	$s^2p^3(^2D)3d\ ^3P_0$	15673.85
		$s^2p^3(^2P)3p\ ^3D_3$	27496.90	$s^2p^3(^2D)3d\ ^1D$	15000.0
		$s^2p^3(^2P)3p\ ^3D_2$	27481.84	$s^2p^3(^2D)3d\ ^1P$	14721.5
		$s^2p^3(^2P)3p\ ^3D_1$	27475.24	$s^2p^3(^2D)3d\ ^1F$	13869.9
		$s^2p^3(^2P)3p\ ^1S$	25667.4	$s^2p^3(^2P)3d\ ^3F$	4111.4
		$s^2p^3(^2P)3p\ ^3P_0$	24945.3	$s^2p^3(^2P)3d\ ^3P_0$	−697.8
		$s^2p^3(^2P)3p\ ^3P_1$	24930.4	$s^2p^3(^2P)3d\ ^3P_1$	−714.2
		$s^2p^3(^2P)3p\ ^3P_2$	24906.5	$s^2p^3(^2P)3d\ ^3P_2$	−748.7
		$s^2p^3(^2P)3p\ ^1P$	22343.4	$s^2p^3(^2P)3d\ ^1D$	−2136.0
		$s^2p^3(^2P)3p\ ^1D$	14935.0	$s^2p^3(^2P)3d\ ^1P$	−2951.4
				$s^2p^3(^2P)3d\ ^3D_3$	−4502.7
				$s^2p^3(^2P)3d\ ^3D_2$	−4507.4
				$s^2p^3(^2P)3d\ ^3D_1$	−4508.1
$s^2p^3(^4S)4s\ ^5S$	46879.05			$s^2p^3(^4S)3d\ ^3D$	28169.
$s^2p^3(^4S)4s\ ^3S$	45228.57			$s^2p^3(^4S)4f\ ^3F$	27642.9
$s^2p^3(^2D)4s\ ^1D$	10761.8			$s^2p^3(^4S)4f\ ^5F$	27487.1

transitions between them. As in several cases these high terms included two or three members of a series, it was possible to fix the absolute values of the terms with a much greater accuracy than had hitherto been possible. Furthermore, the identification of fourteen intercombination lines made it possible to fix the relative positions of the doublets and quartets. These results called for a shift of +6300 frequency units in Dingle's quartet term values and of +5534.5 units in his doublets. The relative positions of the terms based on the ^1D and on the ^3P term of the core may be in error by as much as ten frequency units as the only connections between them involve lines of about 300A wave-length.

For the sake of completeness the term values found by Dingle, corrected as mentioned above, are included in Table IV. The positions of the $s^2p^2(^3P)3d^2P$ terms, tentatively fixed by Dingle on rather meager evidence, were not confirmed by lines connecting them with the ^2P and ^2D states of the s^2p^3 configuration. The extreme ultraviolet lines, listed in Table III, point to another position, namely that indicated in Table IV. Unfortunately the lines that should connect the terms in this new position with $s^2p^2(^3P)3p\ ^2P$ fall outside the range of the Table of F III lines given by Dingle. In his Table of F II lines,[3] however, there are a group of four lines, listed at the end of Table III of this article, at exactly the right position and having the correct relative intensity. The separation of the $s^2p^2(^3P)3d\ ^2P$ terms found in this way is the same as that adopted by Dingle, thus indicating that his identifications of $s^2p^2(^3P)3p\ ^2S-s^2p^2(^3P)3d\ ^2P$ were correct but those of

[3] H. Dingle, Proc. Roy. Soc. **A128**, 600 (1930).

$s^2p^2(^3P)3s\ ^2P - s^2p^2(^3P)3p\ ^2S$ were not. If this rearrangement is valid the latter lines should fall in the green where they may have failed to appear because of lack of plate sensitivity. The new arrangement is supported by the fact that it makes the relative position of the terms of both the $s^2p^2(^3P)3p$ and $s^2p^2(^3P)3d$ configurations very similar to that of the corresponding terms in O II.

Dingle[3] has also classified a large number of visible and near ultraviolet lines in F II. By utilizing the present data it has been possible to identify many of the extreme ultraviolet lines as transitions between high level terms, including those found by Dingle and the terms of the s^2p^4 configuration. These new lines connect all of Dingle's triplet levels together and also all of his singlet levels, although no intercombinations between the two systems have been found. These connections and other relationships in the newly identified lines indicate that Dingle's levels should be shifted as follows: triplets of families A and B should be increased by $+2000\ \text{cm}^{-1}$, of family C by $+2530\ \text{cm}^{-1}$; singlets of family B by $+1000\ \text{cm}^{-1}$, and of family C by $+3610\ \text{cm}^{-1}$. The quintets remain unchanged. One or two minor changes in Dingle's identification of lines were made on the basis of additional evidence now available. Table VI includes all levels that have been fixed, those taken from Dingle's list being shifted as indicated above.

These analyses indicate that the ionization potential of F II is 34.81 volts, of F III, 62.35 volts and of F IV, 87.34 volts.