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REPORT ON MARS, No. 10.

WILLIAM H. PICKERING.

In the previous Reports on Mars frequent mention has been made of the Martian Date, and in future reports, as we come to study more and more the seasonal changes on the planet, the term will very frequently be employed. Since its usage in astronomical literature is necessarily not very extended, a few words may be said with regard to it. It was first proposed and used by Professor Douglass in the Annals of the Lowell Observatory, Vol. 2. It is derived directly from the martian longitude of the sun ⊙, given in the Ephemeris, which in turn differs from the heliocentric longitude of the planet by the constant 87°.7. As previously used by the writer it is defined in Report No. 2 under the name Equivalent Terrestrial Date, as he was not at that time aware that the quantity had been previously suggested, employed, and named by Professor Douglass. As there defined the Martian Date of March 20 begins when the solar longitude ⊙ reaches 0°.0. The martian orbit is divided into 365 equal angular divisions, and the date increases directly in proportion to ⊙, regardless of the eccentricity of the orbit of the planet.

While the martian date has proved very useful in the past, as far as it went, in giving us an idea of what portion of the planet's year any event took place, as for instance the flooding of the Syrtis Major on the martian date of April 12, observed by us January 17 and 18, 1914, yet there is the distinctly inconvenient feature of the quantity that it necessarily bears no relation to the number of martian days elapsed. Thus to travel in its orbit between the martian dates of May 1 and May 31 the planet requires 68 terrestrial days, or about 66 martian ones. Again to traverse the equal interval between November 1 and December 1, on the other side of its orbit, the planet requires only 47 martian days. Clearly the quantity as thus defined, could only be considered as a provisional one, and justified merely by the fact that there was nothing better to be had. To remedy this defect the writer has computed a table based on the length of the martian day, and corrected for the eccentricity of the planet's orbit. This table he herewith presents in the form of a calendar for the planet.

In the construction of the terrestrial calendar two conditions are of vital consequence: (*a*) That the length of the calendar day and of the mean solar or civil day should be identical, in order that for business purposes the calendar day should always begin at the same hour, namely midnight. (*b*) The number of days in the year should be so adjusted that the vernal equinox should always come on about the same date, and the seasons should therefore remain the same. Since the year does not contain an integral number of days, this latter result is maintained by means of the additional day occasionally added in February, with its various complications.

In constructing a calendar for another planet it is most desirable that all complications should be reduced to a minimum. Since the martian year contains 668.6 martian solar days, it is evident that the leap years would give considerable trouble. Since we do not live on Mars, however, condition (*a*) may be neglected, and we may consequently divide the martian year into exactly 669 calendar days. This will not only entirely avoid the trouble of leap year, but will make our calendar quite independent of any future changes that observation may suggest in the length of the martian sidereal day. Unlike the case of the Earth, the calendar day will then begin all over the planet at the same instant of time. The lengths of the three martian days are therefore:—

Sidereal day [Marth]	24^h	37^m	$22^s.65$
Calendar day	24	38	42.04
Mean solar day (civil)	24	39	35.19

The first is the true period of rotation of the planet, from which its ephemeris is computed, the second the period by which we date our observations, while the last is the most important of all to the inhabitants of Mars, and is the one by which they control their daily life, but is of no consequence whatever to us. The calendar day, it will be seen, is only $53^s.15$ shorter than their mean solar day, and at no time in the year introduces a greater deviation in the revised martian date than 0.2 of a day. The martian calendar day equals 1.0269 terrestrial mean solar days, and the terrestrial mean solar day is 0.9738 martian calendar days.

With these fundamental questions settled, we may at once consider the more or less arbitrary questions involved in the construction of a calendar. The general principle borne clearly in mind in its construction has been that it should resemble our own as closely as possible without becoming too complex. The year has therefore been divided into twelve months, the first nine months each containing 56 martian days, and the last three 55. The week now becomes a convenient unit, when we do not wish to be too precise in our specifications, and we have the rule that 7 days make a week, 8 weeks make a month, and 12 months make a year, one day being dropped from the last week of the last three months.

In approximating the martian calendar to our own, it is a convenient circumstance that the northern winter solstice and the perihelion are similarly situated in so far as their being near together is concerned, for both planets. For the earth the latter follows the former by 11°.5, for Mars it precedes it by 23°.3. In order that the three short months should cluster about perihelion they have been placed at the end of the year.

On account of the great eccentricity of the martian orbit, the martian date will sometimes get several days ahead of our own, and sometimes fall several days behind it. This might have been remedied by making the martian months of different lengths, but there would still have remained the difficulty of the greater number of days in each month. It was therefore thought best to avoid all complications and adopt the present plan. To make this excess and deficit of the martian date as nearly equal as possible, it was necessary to decide what day of the month we should assign to the martian equinox. It appears that equality can be nearly secured by adopting the convenient date of March 1.

TABLE I

MARTIAN CALENDAR.

Day	⊙	Martian	Terrestrial	Day	⊙	Martian	Terrestrial
1	0°.0	Mar. 1	Mar. 20	25	11°.9	Mar. 25	Apr. 1
2	0.5	2	"	26	12.4	26	"
3	1.0	3	21	27	12.9	27	2
4	1.5	4	"	28	13.3	28	"
5	2.0	5	22	29	13.8	29	3
6	2.5	6	"	30	14.3	30	"
7	3.0	7	23	31	14.8	31	4
8	3.5	8	"	32	15.3	32	"
9	4.0	9	24	33	15.8	33	5
10	4.5	10	"	34	16.3	34	"
11	5.0	11	25	35	16.8	35	6
12	5.5	12	"	36	17.3	36	"
13	6.0	13	26	37	17.7	37	7
14	6.5	14	"	38	18.3	38	"
15	7.0	15	27	39	18.7	39	8
16	7.5	16	"	40	19.2	40	"
17	8.0	17	28	41	19.7	41	9
18	8.5	18	"	42	20.2	42	"
19	9.0	19	29	43	20.6	43	10
20	9.5	20	"	44	21.1	44	"
21	10.0	21	30	45	21.6	45	11
22	10.5	22	"	46	22.0	46	"
23	11.0	23	31	47	22.5	47	12
24	11.4	24	"	48	23.0	48	"

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial
49	23°.5	Mar. 49	Apr. 13
50	24.0	50	"
51	24.5	51	14
52	24.9	52	"
53	25.4	53	15
54	25.9	54	"
55	26.3	55	"
56	26.8	56	16
57	27.3	Apr. 1	"
58	27.8	2	17
59	28.3	3	"
60	28.7	4	18
61	29.1	5	"
62	29.6	6	19
63	30.1	7	"
64	30.5	8	20
65	31.0	9	"
66	31.5	10	21
67	31.9	11	"
68	32.4	12	22
69	32.9	13	"
70	33.3	14	23
71	33.8	15	"
72	34.3	16	24
73	34.7	17	"
74	35.2	18	25
75	35.7	19	"
76	36.1	20	"
77	36.6	21	26
78	37.1	22	"
79	37.5	23	27
80	38.0	24	"
81	38.4	25	28
82	38.8	26	"
83	39.3	27	29
84	39.8	28	"
85	40.2	29	30
86	40.7	30	"
87	41.2	31	May 1
88	41.6	32	"
89	42.1	33	2
90	42.5	34	"
91	42.9	35	"
92	43.4	36	3
93	43.9	37	"
94	44.3	38	4
95	44.8	39	"
96	45.3	40	5
97	45.7	41	"
98	46.2	42	6
99	46.6	43	"
100	47.0	44	7
101	47.5	45	"
102	48.0	46	8
103	48.4	47	"
104	48.9	48	9
105	49.4	49	"
106	49.8	50	10
107	50.3	51	"

Day	⊙	Martian	Terrestrial
108	50°.7	Apr. 52	May 11
109	51.1	53	"
110	51.6	54	"
111	52.1	55	12
112	52.5	56	"
113	53.0	May 1	13
114	53.5	2	"
115	53.9	3	14
116	54.4	4	"
117	54.8	5	15
118	55.2	6	"
119	55.7	7	16
120	56.2	8	"
121	56.6	9	17
122	57.1	10	"
123	57.5	11	18
124	57.9	12	"
125	58.4	13	19
126	58.8	14	"
127	59.2	15	"
128	59.7	16	20
129	60.2	17	"
130	60.6	18	21
131	61.1	19	"
132	61.6	20	22
133	62.0	21	"
134	62.5	22	23
135	62.9	23	"
136	63.3	24	24
137	63.8	25	"
138	64.3	26	25
139	64.7	27	"
140	65.2	28	26
141	65.6	29	"
142	66.0	30	"
143	66.5	31	27
144	66.9	32	"
145	67.3	33	28
146	67.8	34	"
147	68.3	35	29
148	68.7	36	"
149	69.2	37	30
159	69.7	38	"
151	70.1	39	31
152	70.6	40	"
153	71.0	41	June 1
154	71.4	42	"
155	71.9	43	2
156	72.4	44	"
157	72.8	45	3
158	73.3	46	"
159	73.7	47	4
160	74.1	48	"
161	74.6	49	"
162	75.0	50	5
163	75.4	51	"
164	75.8	52	6
165	76.2	53	"
166	76.7	54	7

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial	Day	⊙	Martian	Terrestrial
167	77°.1	May 55	June 7	228	105°.1	July 4	July 6
168	77.5	56	"	229	105.6	5	7
169	78.0	June 1	8	230	106.0	6	"
170	78.4	2	"	231	106.5	7	8
171	78.9	3	9	232	107.0	8	"
172	79.4	4	"	233	107.4	9	9
173	79.8	5	10	234	107.9	10	"
174	80.2	6	"	235	108.4	11	10
175	80.7	7	11	236	108.8	12	"
176	81.2	8	"	237	109.3	13	11
177	81.6	9	12	238	109.8	14	"
178	82.1	10	"	239	110.3	15	12
179	82.5	11	13	240	110.8	16	"
180	83.0	12	"	241	111.3	17	13
181	83.5	13	14	242	111.7	18	"
182	83.9	14	"	243	112.2	19	14
183	84.3	15	15	244	112.7	20	"
184	84.8	16	"	245	113.1	21	15
185	85.2	17	16	246	113.6	22	"
186	85.7	18	"	247	114.1	23	16
187	86.2	19	17	248	114.5	24	"
188	86.6	20	"	249	115.0	25	17
189	87.1	21	18	250	115.5	26	"
190	87.6	22	"	251	116.0	27	18
191	88.0	23	"	252	116.5	28	"
192	88.4	24	19	253	117.0	29	19
193	88.9	25	"	254	117.4	30	"
194	89.3	26	20	255	117.9	31	20
195	89.8	27	"	256	118.4	32	"
196	90.3	28	21	257	118.9	33	21
197	90.7	29	"	258	119.4	34	"
198	91.2	30	22	259	119.9	35	22
199	91.7	31	"	260	120.4	36	"
200	92.1	32	23	261	120.9	37	23
201	92.5	33	"	262	121.4	38	"
202	93.0	34	24	263	121.8	39	24
203	93.4	35	"	264	122.3	40	"
204	93.9	36	25	265	122.8	41	25
205	94.4	37	"	266	123.2	42	"
206	94.8	37	26	267	123.7	43	26
207	95.3	39	"	268	124.2	44	"
208	95.8	40	27	269	124.7	45	27
209	96.2	41	"	270	125.2	46	"
210	96.7	42	28	271	125.7	47	28
211	97.2	43	"	272	126.1	48	"
212	97.6	44	29	273	126.6	49	29
213	98.1	45	"	274	127.1	50	"
214	98.6	46	30	275	127.6	51	30
215	99.0	47	"	276	128.1	52	"
216	99.5	48	July 1	277	128.7	53	31
217	100.0	49	"	278	129.2	54	Aug. 1
218	100.4	50	"	279	129.7	55	"
219	100.5	51	2	280	130.2	56	2
220	101.4	52	"	281	130.7	Aug. 1	"
221	101.8	53	3	282	131.2	2	3
222	102.3	54	"	283	131.7	3	"
223	102.8	55	4	284	132.2	4	4
224	103.2	56	"	285	132.7	5	"
225	103.7	July 1	5	286	133.2	6	5
226	104.2	2	"	287	133.7	7	"
227	104.6	3	6	288	134.2	8	6

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial
289	134°.7	Aug. 9	Aug. 6
290	135.2	10	7
291	135.7	11	"
292	136.2	12	8
293	136.7	13	"
294	137.2	14	9
295	137.8	15	10
296	138.3	16	"
297	138.8	17	11
298	139.3	18	"
299	139.8	19	12
300	140.3	20	"
301	140.8	21	13
302	141.3	22	"
303	141.8	23	14
304	142.4	24	"
305	142.9	25	15
306	143.4	26	"
307	144.0	27	16
308	144.5	28	17
309	145.0	29	"
310	145.5	30	18
311	146.0	31	"
312	146.5	32	19
313	147.1	33	"
314	147.6	34	20
315	148.1	35	"
316	148.7	36	21
317	149.3	37	22
318	149.8	38	"
319	150.4	39	23
320	150.9	40	"
321	151.4	41	24
322	152.0	42	"
323	152.5	43	25
324	153.0	44	"
325	153.6	45	26
326	154.1	46	27
327	154.6	47	"
328	155.2	48	28
329	155.7	49	"
330	156.2	50	29
331	156.8	51	"
332	157.3	52	30
333	157.9	53	"
334	158.5	54	31
335	159.0	55	Sept. 1
336	159.5	56	"
337	160.1	Sept. 1	2
338	160.6	2	"
339	161.1	3	3
340	161.7	4	"
341	162.2	5	4
342	162.8	6	5
343	163.4	7	"
344	163.9	8	6
345	164.4	9	"
346	165.0	10	7
347	165.5	11	"
348	166.2	12	8
349	166.8	13	9
350	167°.3	Sept. 14	Sept. 9
351	167.9	15	10
352	168.5	16	"
353	159.0	17	11
354	169.5	18	"
355	170.1	19	12
356	170.6	20	13
357	171.3	21	"
358	171.9	22	14
359	172.4	23	"
360	173.0	24	15
361	173.6	25	16
362	174.1	26	"
363	174.7	27	17
364	175.3	28	"
365	175.8	29	18
366	176.4	30	19
367	177.0	31	"
368	177.6	32	20
369	178.2	33	"
370	178.8	34	21
371	179.3	35	"
372	179.9	36	22
373	180.5	37	23
374	181.1	38	"
375	181.7	39	24
376	182.3	40	25
377	182.9	41	"
378	183.5	42	26
379	184.1	43	"
380	184.7	44	27
381	185.3	45	28
382	185.9	46	"
383	186.5	47	29
384	187.1	48	"
385	187.7	49	30
386	188.3	50	Oct. 1
387	188.9	51	"
388	189.5	52	2
389	190.1	53	"
390	190.7	54	3
391	191.3	55	4
392	191.9	56	"
393	192.5	Oct. 1	5
394	193.1	2	6
395	193.7	3	"
396	194.3	4	7
397	195.0	5	"
398	195.6	6	8
399	196.2	7	9
400	196.8	8	"
401	197.4	9	10
402	198.0	10	11
403	198.7	11	"
404	199.3	12	12
405	199.9	13	"
406	200.6	14	13
407	201.2	15	14
408	201.8	16	"
409	202.4	17	15
410	203.0	18	16

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial
411	203°.6	Oct. 19	Oct. 16
412	204.3	20	17
413	204.9	21	"
414	205.5	22	18
415	206.2	23	19
416	206.8	24	"
417	207.4	25	20
418	208.0	26	21
419	208.6	27	"
420	209.2	28	22
421	209.9	29	"
422	210.5	30	23
423	211.1	31	24
424	211.8	32	"
425	212.4	33	25
426	213.0	34	26
427	213.7	35	"
428	214.3	36	27
429	214.9	37	28
430	215.6	38	"
431	216.2	39	29
432	216.8	40	"
433	217.5	41	30
434	218.1	42	31
435	218.7	43	"
436	219.4	44	Nov. 1
437	220.0	45	2
438	220.6	46	"
439	221.3	47	3
440	221.9	48	4
441	222.6	49	"
442	223.3	50	5
443	223.9	51	"
444	224.5	52	6
445	225.2	53	7
446	225.8	54	"
447	226.4	55	8
448	227.1	Nov. 1	9
449	227.7	2	"
450	228.4	3	10
451	229.1	4	11
452	229.7	5	"
453	230.3	6	12
454	231.0	7	13
455	231.6	8	"
456	232.2	9	14
457	232.9	10	"
458	233.5	11	15
459	234.2	12	16
460	234.9	13	"
461	235.5	14	17
462	236.1	15	18
463	236.8	16	"
464	237.4	17	19
465	238.0	18	20
466	238.7	19	"
467	239.3	20	21
468	240.0	21	"
469	240.7	22	22
470	241.3	23	23
471	241.9	24	"
472	242°.6	Nov. 25	Nov. 24
473	243.2	26	25
474	243.8	27	"
475	244.5	28	26
476	245.1	29	27
477	245.8	30	"
478	246.5	31	28
479	247.1	32	"
480	247.7	33	29
481	248.4	34	30
482	249.0	35	"
483	249.7	36	Dec. 1
484	250.4	37	2
485	251.0	38	"
486	251.7	39	3
487	252.4	40	4
488	243.0	41	"
489	253.6	42	5
490	254.3	43	6
491	254.9	44	"
492	255.5	45	7
493	256.2	46	"
494	256.9	47	8
495	257.6	48	9
496	258.2	49	"
497	258.9	50	10
498	259.5	51	11
499	260.1	52	"
500	260.8	53	12
501	261.5	54	13
502	262.1	55	"
503	262.8	Dec. 1	14
504	263.5	2	15
505	264.1	3	"
506	264.8	4	16
507	265.5	5	17
508	266.1	6	"
509	266.8	7	18
510	267.4	8	19
511	268.0	9	"
512	268.7	10	20
513	269.3	11	"
514	269.9	12	21
515	270.6	13	22
516	271.2	14	"
517	271.8	15	23
518	272.5	16	"
519	273.1	17	24
520	273.7	18	25
521	274.4	19	"
522	275.0	20	26
523	275.6	21	27
524	276.3	22	"
525	276.9	23	28
526	277.5	24	"
527	278.2	25	29
528	278.8	26	30
529	279.4	27	"
530	280.1	28	31
531	280.7	29	"
532	281.3	30	Jan. 1

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial
533	282°.0	Dec. 31	Jan. 2
534	282.6	32	"
535	283.2	33	3
536	283.9	34	4
537	284.5	35	"
538	285.1	36	5
539	285.8	37	"
540	286.4	38	6
541	287.0	39	7
542	287.7	40	"
543	288.3	41	8
544	288.9	42	9
545	289.6	43	"
546	290.2	44	10
547	290.8	45	"
548	291.4	46	11
549	292.0	47	12
550	292.6	48	"
551	293.3	49	13
552	293.9	50	"
553	294.5	51	14
554	295.1	52	15
555	295.7	53	"
556	296.3	54	16
557	296.9	55	"
558	297.5	Jan. 1	17
559	298.1	2	18
560	298.8	3	"
561	299.4	4	19
562	300.0	5	"
563	300.6	6	20
564	301.2	7	21
565	301.8	8	"
566	302.4	9	22
567	303.0	10	"
568	303.6	11	23
569	304.2	12	24
570	304.8	13	"
571	305.4	14	25
572	306.0	15	"
573	306.6	16	26
574	307.2	17	27
575	307.8	18	"
576	308.4	19	28
577	309.0	20	"
578	309.6	21	29
579	310.2	22	"
580	310.8	23	30
581	311.4	24	31
582	312.0	25	"
583	312.6	26	Feb. 1
584	313.2	27	"
585	313.8	28	2
586	314.3	29	"
587	314.9	30	3
588	315.5	31	4
589	316.1	32	"
590	316.7	33	5
591	317.3	34	"
592	317.8	35	6
593	318.4	36	7
594	319°.0	Jan. 37	Feb. 7
595	319.5	38	8
596	320.1	39	"
597	320.7	40	9
598	321.2	41	"
599	321.8	42	10
600	322.4	43	"
601	322.9	44	11
602	323.5	45	12
603	324.1	46	"
604	324.6	47	13
605	325.2	48	"
606	325.8	49	14
607	326.3	50	"
608	326.9	51	15
609	327.5	52	16
610	328.0	53	"
611	328.6	54	17
612	329.2	55	"
613	329.7	56	18
614	330.3	Feb. 1	"
615	330.9	2	19
616	331.4	3	"
617	332.0	4	20
618	332.6	5	21
619	333.1	6	"
620	333.7	7	22
621	334.2	8	"
622	334.7	9	23
623	335.3	10	"
624	335.9	11	24
625	336.4	12	"
626	337.0	13	25
627	337.5	14	"
628	338.0	15	26
629	338.6	16	27
630	339.1	17	"
631	339.6	18	28
632	340.2	19	"
633	340.7	20	Mar. 1
634	341.2	21	"
635	341.8	22	2
636	342.3	23	"
637	342.8	24	3
638	343.4	25	"
639	343.9	26	4
640	344.4	27	"
641	345.0	28	5
642	345.5	29	"
643	346.0	30	6
644	346.6	31	7
645	347.1	32	"
646	347.6	33	8
647	348.1	34	"
648	348.6	35	9
649	349.1	36	"
650	349.7	37	10
651	350.2	38	"
652	350.7	39	11
653	351.3	40	"
654	351.8	41	12

MARTIAN CALENDAR—CONTINUED.

Day	⊙	Martian	Terrestrial	Day	⊙	Martian	Terrestrial
	°				°		
655	352.3	Feb. 42	Mar. 12	663	356.5	Feb. 50	Mar. 16
656	352.8	43	13	664	357.0	51	17
657	353.3	44	"	665	357.5	52	"
658	353.8	45	14	666	358.0	53	18
659	354.4	46	"	667	358.5	54	"
660	354.9	47	15	668	359.0	55	19
661	355.4	48	"	669	359.5	56	"
662	356.0	49	16				

In Table I the four successive columns give the day of the year, the solar longitude ⊙, and the equivalent martian and terrestrial dates. The martian dates are exact year after year, but owing to the leap year the terrestrial ones change through a range of about one degree. Every date begins with the longitude given in the table, and lasts until the following longitude, thus March 1 begins at solar longitude 0°.0, and lasts until 0°.5. In order to compare the martian and terrestrial dates when they are not in the same month, convert the terrestrial date into the previous month by adding 28, 30, or 31 days as may be necessary. Table II gives the deviation on different martian dates.

TABLE II

M.D.	M-T	M.D.	M-T	M.D.	M-T	M.D.	M-T
Mar. 56	+9	Apr. 1	−15	Sept. 56	+22	Oct. 1	−4
Apr. 56	+14	May 1	−12	Oct. 55	+16	Nov. 1	−8
May 56	+18	June 1	−7	Nov. 55	+12	Dec. 1	−13
June 56	+22	July 1	−4	Dec. 55	+8	Jan. 1	−16
July 56	+23	Aug. 1	−1	Jan. 56	+7	Feb. 1	−17
Aug. 56	+24	Sept. 1	−1	Feb. 56	+9	Mar. 1	−19

It will be noticed by the first two columns that at the end of every month throughout the year the martian date is in excess, but the effect of their long months is such that on the next day, the beginning of the new month, as shown by the two remaining columns, it is always behind the corresponding terrestrial date. The maximum deviations are +24 and −19 days. On the following dates the calendars coincide: April 30, May 23, 24, June 14, 15, July 8, 9, August 3, 4, September 2, 3, October 11, 12, November 21, 22. There is of course no necessity that the two calendars should be identical throughout, but it is desirable that they should not differ very widely. The important thing is that the Martian Date should always mean the same thing. This calendar will be used in all of our future reports.

The following important dates are the same every martian year:—

Vernal Equinox	⊙ = 0°.0	March	1.0
Summer solstice	90 .0	June	27.4
Autumnal equinox	180 .0	September	36.2
Winter solstice	270 .0	December	12.1
Perihelion	246 .7	November	31.3
Aphelion	66 .7	May	31.5

In Report No. 7 attention was called to the fact that all the ephemerides of Mars for the coming opposition were using the erroneous value for the diameter found by Peirce of 10″.11. It is understood that the Washington authorities are now considering a revision of this figure. In order to make this point a little clearer the writer has investigated the matter further since his former publication. In Flammarion's Mars **1**, 504 is given a table giving all the published diameters of the planet prior to 1893. Peirce's value is based on meridian observations,—an obviously inaccurate method. Since 1850 five such results have been published by different authorities of which the mean is 10″.29 ± 0″.50. Since 1860 thirteen different results have been published based on micrometer measurements. The mean is 9″.37 ± 0″.08, thus reducing the average deviation fully six times. The large systematic error of the meridian observations is doubtless due chiefly to irradiation. The value found at the Lowell Observatory 9″.35 (Annals Lowell Observatory **1**, 75), is based on the measures of three observers taken in 1894, when the planet was unusually near us. It appeared too late to be given in Flammarion's list. The value used at Greenwich for many years past, and only abandoned the present year was 9″.36.

The only quantities in the Ephemeris affected are the diameter d, and the maximum defect of illumination q. Neither are very important, and both can be readily corrected by subtracting 1/14, or more accurately 1/13.6. Using the diameter 9″.36 and the solar parallax 8″.80, the diameter of the planet becomes 4216 miles or 6784 kilometers. The value of 1° of latitude is 36.79 miles, or 59.20 kilometers.

Since the coming opposition of Mars, as well as the one that is just past, should, according to Schiaparelli, be favorable to seeing the duplication of the canals, a few words may be said in this place on the subject. According to his Memoir **3**, 367 seventeen canals were first seen double in 1882 between the dates of January 19 and February 19, or between 40 and 71 terrestrial days after the vernal equinox of Mars, which fell on December 10, 1881. This would correspond to between 39 and 69 martian calendar days, which by Table I we see correspond to solar longitudes 18°.7 and 32°.9, and to the martian dates March 39 and April 13. Mean longitude 25°.8. Mean date March 53.

Again according to his Memoir **6**, 106 the middles of the two duplication periods occur three terrestrial months before, and five terrestrial months after the martian summer solstice. This would correspond to 91 terrestrial or 88 martian calendar days before the solstice. The solstice occurs June 27, or day 195 according to the calendar. The duplication day would therefore be 107, the solar longitude 50°.3, and the martian date April 51. In the Lowell Bulletin **15**, and in Report **5** the solar longitude is given as 50°. The second day of duplication is 343, the corresponding solar longitude 163°.4 and the martian date September 7. The value previously given was 165°.

We thus find two values of the solar longitude ⊙ for the first duplication, 25°.8 and 50°.3. The first of these gives the average time when the canals were first seen to duplicate, the second the supposed middle of the duplication. Schiaparelli assumes that three terrestrial months after the martian vernal equinox are the same thing as three terrestrial months before the summer solstice. On account of the eccentricity of the martian orbit the deviation is considerable, and as shown by the Table would bring the mean date of duplication back to calendar day 88, corresponding to solar longitude 41°.6 and to the martian date April 32 instead of April 51. In 1914 the terrestrial dates corresponding to solar longitudes 25°.8 and 41°.6 were January 24 and February 28. At the coming opposition they are December 12, 1915 and January 16, 1916.

In 1914 the first date came but 19 days after opposition. According to Schiaparelli, the separation ranged from 4° to 12°, or from 150 to 440 miles, distances which would have been conspicuous to Messrs Phillips, Douglass, and the writer, yet none of us more than vaguely suspected a duplication, as recorded in Reports Nos. 5 and 8. Duplications, as is well known, are constantly seen by Messrs. Lowell and Slipher. Using the second duplication date as the more favorable, the doubling should be well seen this year if it exists. The middle date occurs twenty-four days before opposition, and the duplication should continue for about one month after it.

While these facts do not appear very favorable to the detection of the duplication by the first three observers at the coming opposition, yet there are certain facts to be considered on the other side of the question. The 17 canals which were seen double between the specified dates in 1882 were Acheron, Antaeus, Avernus, Cyclops, Erebus, Eumenides, Eunostos, Euphrates, Ganges, Gehon, Gigas, Hephaestus, Jamuna, Orcus, Phison, Thoth, and Typhon. Only three of these canals, Eunostos, Hephaestus and Thoth, were clearly seen in Jamaica the past year, nine others were faintly seen at different times, while the remaining five were not seen at all.

As pointed out in Report No. 8, several of the canals which the Lowell Observatory reported as double (there were twelve of them), were seen of the same breadth by the other observers, the only difference being that the latter did not see any bright streak running down the middle of the canal. On looking for such a streak the writer on two evenings vaguely suspected it, but concluded in both cases that what he saw was probably merely a contrast effect, caused by the dark band of the canal crossing a bright background, and thus making its edges appear darker than its middle. It appears to the writer that when the canals begin to fade out, it is possible that the middles may in some cases fade first. There would be nothing particularly surprising if this were so. It seems the more likely since this is just what happens in the case of the double canal in Aristillus, and also in a more conpicuous way to a canal or dark band lying along the eastern rim of the crater Eratosthenes. This band first appears at about colongitude 120°, begins to divide the next night, and is clearly divided into two dark lines, parallel for part of their length, at colongitude 148°. With a low power the canal of this double are as straight, uniform, and artificial looking as anything seen upon Mars.

Another reason why the writer has not given up all hope of seeing the duplication is a statement which the late Major Molesworth made after the opposition of 1901. In that opposition Mars was in the same portion of its orbit that it will be in this coming winter. Major Molesworth was one of the most skilful observers since Schiaparelli, and he worked under very favorable conditions in Ceylon, with a 12-inch reflector. He writes: "The gemination of Martian canals appears to be real, and not illusive, and, I think, is due, in almost every case, to the existence and variable visibility of two almost parallel, distinct canals; sometimes one canal, sometimes both being visible... When both canals are seen, the space between them is generally slightly shaded, and this shaded streak often gives the impression of a single, broad, diffuse canal, when the darker edgings are not seen." (Memoirs Brit. Astron. Assoc. **11**, 89.)

In our last Report we described the precautions which should be taken in recording the colors exhibited by the planet. We shall now describe our own results and also those which some other observers obtained at the past opposition. In most of our work we employed an incandescent carbon filament as the source of illumination, but in a number of cases a 2 c.p. tungsten lamp was used, and a few paintings were made by daylight. As pointed out in Report No. 9, in future observations we should use a very blue source of light to illumine our paper. A 25 c.p. tungsten light shining through light blue glass was recommended. The writer has since learned from Dr. Mees of the Eastman Kodak Co., that he has prepared a gelatin film of the proper color to give the effect of sunlight. The Artificial Daylight Co., of New York, prefer blue glass of a standard color to give the same result, so that observers at the coming opposition can readily furnish themselves with a suitably colored medium to meet their requirements.

The desert regions furnish the largest areas of one color upon the planet, and their color is the one most affected by the source of illumination. If the paper is illumined by a carbon filament, and examined through a round hole of the proper size in a black mask placed in contact with the paper, the color of these portions of the planet will be found to range between pure white and yellow ochre. If viewed by either a redder or bluer light, their color will become redder. It is very certain that it is subject to change, in part owing to the presence of more or less invisible martian cloud, and in part to a real change of surface. A change of color was also suggested by Schiaparelli. (Flammarion **1**, 356). It is not clear why a redder illumination should cause us to paint the disk redder, but such seems to have been the fact for at least two observers. If painted by daylight the disk appears very much redder, owing to the blue illumination of our paper by the sky, but it is still probably not red enough, as is shown in Report No. 9, owing to the blue light coming to us from that portion of our atmosphere lying between us and the planet.

The greens on Mars, which are occasionally even more prominent than the yellows, are of about the color of our own vegetation when seen at a distance of a mile or so on a clear day. Under tungsten illumination they are paler, as might be expected, than when the paper is illuminated by the carbon filament. Occasionally some very vivid greens are seen in the polar cap or along the limb, which are not easy to explain. They are subject to sudden variations from night to night, were most frequently seen at dawn or twilight early in the martian season, before the snow had replaced the clouds, and are probably due to some subjective effect. Sometimes the limb would be described as green, yet when the rotation brought the region nearer the center of the disk the color would have entirely vanished. Something similar, though less vivid, has been seen upon the moon, when the snow was forming on Pico (Popular Astronomy, March, 131). Something analogous indeed has been seen also in the case of our own clouds. If we examine some that are fairly dense, using a magnification of about 400, and protecting our eyes from the glare by neutral tinted glasses, we shall find that to represent the color on paper we shall sometimes have to use a distinctly greenish colored crayon. Often on the other hand they appear of nearly the same color that they do to the naked eye or with a low power, drab or neutral tint. Without the shade glasses the light is so bright that little color can be detected.

These subjective greens are certainly puzzling, but they are not to be confounded with the real greens seen upon Mars which last for months at a time, are clearly seasonal, and are most conspicuous at some distance from the limb. They first appeared at this past opposition on November 17, 1913, when the southern dark areas Cimmerium and Sirenum are described as distinctly greener than those to the north.

The corresponding longitude of the Sun was 353°.3, and the martian date February 44. On the martian date of February 34, it is recorded that no green was visible in Cimmerium. The date of the appearance of the first real green this year is therefore pretty closely fixed, but it will be noted that it was found in the southern hemisphere, in latitude −30°, and therefore appeared in their autumn, at the close of their hot dry summer, as soon as the moisture from the opposite polar cap reached it.

From this date on, with one exception, clearly marked greens were constantly recorded in the southern hemisphere, but though dark areas were visible in the north for much of the time, and it was the spring of their year, they always appeared of a colorless grey, in strong contrast to the southern regions. During the opposition of 1890 these same southern regions were painted green at the time of their spring. At the opposition of 1892 they were several times noted as greenish or greenish grey, but although it was their spring time, it is clear that the green was by no means as pronounced nor as continuous as at the past opposition, corresponding to their autumn.

The northern region Acidalium Mare, between the martian dates of September 20 and 22, that is just before the autumnal equinox, also appeared green in 1890. Also in 1892 the northern portion of the Syrtis Major was several times noted as greenish gray, at about this same season. The north pole itself was also frequently greenish in 1892. There appears therefore to be evidence of some green in these portions of the northern hemisphere during their autumn. It appears then in general that it is in autumn rather than in the spring time that vegetation bursts forth, and is at its greenest upon Mars.

Beginning with Cimmerium during the past opposition the greens were recorded all the way around the planet in that same latitude, with the exception of a break in the region south of Sabaeus. Although represented as greenish December 2, it was recorded as grey when other neighboring regions were green, upon the nights of November 30 and December 3, 8, and 10. Grey was therefore probably its real color at this time. When next seen, January 6, Deucalionis was pale, but Pandorae was a clear vivid green. The grey color previously seen may have been due to martian haze, or the vegetation there may have been a little different from that in the other longitudes and have required a little longer time to develop.

In the other regions described as greenish the color rapidly increased in intensity, so that by December 3 it is recorded as "more pronounced than heretofore," and the next night it was painted as a bright vivid green. This bright color was maintained throughout the period of observation, except when concealed by martian haze, and as late as

May 8, corresponding to the martian date of May 43, it is recorded that the maria were as green as in the painting of December 4, corresponding to March 4. The diameter of the planet at this time was reduced to only 5″.9.

The blue color appeared in Acidalium very suddenly on November 30, when it was described as "a blue grey, the blue clearly marked, and different from anything else on the disk." The corresponding martian date was February 56. Two days previously the same region was the same shade as the other greys, although darker. This was the chief blue area upon the planet, and except when interrupted by terrestrial or martian clouds retained its color for nearly five months, for as late as April 21 it was still described as bluish, although the diameter of the planet was then reduced to 6″.5. Other blue polar areas were Boreosyrtis and the twin bays that appeared near Propontis.

The appearance of the temporary blue marsh at the northern extremity of the Syrtis Major on January 17 has been already described in our Report No. 4. The equivalent martian date was March 47. All these blues faded sooner or later into greys, not into browns, as had been observed on a former occasion in 1894.

The two most striking brown areas, Cerberus and Sabaeus, were like the blue areas of small size. The first time the color of the former was clearly seen, December 16, it was pronounced brown, and at the last observation March 5 it was still of the same color. The first time the color of Sabaeus was recorded, November 30, it was described as grey. By January 6 it had turned to a clear chocolate brown, and was still of that color February 12, but a few days later was described as grey, and on March 21 as brown or grey. The planet was then only 8″.3 in diameter. At intermediate dates both areas were frequently described as brown. On February 5 Lunae Lacus was first seen as a large brown area. It was also seen of the same color on February 6 and 7, but returned to its grey hazy condition on February 8, 10, and 12. The spot was again detected on March 15 and April 21, but its color was not noted.

In 1892, May 9, Sabaeus was described as grey. The equivalent martian date was September 23. By June 6, equivalent to September 50, it was bluish grey. By July 11, equivalent to October 27, it was a clear light blue. By August 15, equivalent to November 8, it is described as brownish grey without a trace of blue. It appears therefore that soon after the southern polar cap begins to melt Sabaeus shares with the Syrtis Major the fate of being temporarily converted into a marsh. When the northern cap melts only the Syrtis, as far as we have seen, becomes marshy, but there is some evidence that Sabaeus may do so later. It should be carefully watched this next year.

The region of the south pole was subject to marked changes of color and brightness. When first observed in July it was described as red, indicating a lack of vegetation. Later it turned yellow, indicating cloud. On one or two occasions it was thought to be white, indicating snow. On February 1 it was described as dark greenish grey, darker than the rest of the terminator, and on February 10 as bright greenish grey, not at all yellow, and brighter than any other region save the north polar cap.

After the melting of the southern polar cap there seems to be much more cloud in the atmosphere of Mars than there is after the northern cap melts. This cloud takes three forms: (*a*) That of a widely diffused general haze, which may either lie along the limb as a crescent, or may cover the whole surface of the planet. (*b*) Large brilliant cloud masses, several hundred or even thousand miles in length, lying along the terminator. (*c*) Minute individual cloudlets. In 1892 the latter were very numerous and easily seen. The conditions seemed much more nearly terrestrial than after the melting of the northern cap this past year, when some haze and large cloud masses, but comparatively few individual clouds, were visible.

While the clouds on Mars are usually yellow or yellowish, yet this is not always the case. On December 31 it is recorded that there was a whitish cloud at the south pole and along the terminator, while the limb itself was yellow and apparently clear. Clouds bounded all the dark details on the northern sides. February 7 the south pole was colorless and unusually bright, although much less so than the northern one. On February 13, central meridian 10°, Acidalium was blue and followed by a conspicuous white cloud reaching to the terminator. On February 15 and 16 the south polar and limb clouds were whitish. On March 15 the limb was white. Our own clouds are often by no means white even to the naked eye as compared with white paper, and might frequently be described as yellowish, yellowish grey or even brownish.

Venus when seen by daylight is of a strong lemon yellow color, very different indeed from that of the terrestrial clouds. This is not due to contrast with the blue sky, for if watched on a partly cloudy day, the yellow will still remain when the whole background owing to cloud has turned whitish, the color being entirely different from that of the background, and will persist until the planet becomes too faint to enable us to recognize any color at all. The magnifications employed in this study were 330 and 430. Jupiter also appears yellow, not white, but its light is comparatively faint. That the martian clouds sometimes appear of a much more distinct yellow color than anything of the sort that we have on the earth is undoubted, but that does not prove that they would appear so if seen under similar circumstances to our own. To explain any of them as due to dust carried up into the air by martian winds, strikes the writer as improbable, first because they occasionally rise to a height of over 20 miles, and second because they then move very slowly, rarely if ever at a speed exceeding 20 miles per hour, and we cannot conceive of the thin martian atmosphere supporting coarse yellow dust under circumstances when it would be impossible even for our much denser terrestrial atmosphere to do so. The writer believes that these and all other martian clouds are like our own, due simply to condensed water vapor, and that their yellow appearance is due to our point of view, as explained in more detail in Monthly Report No. 4.

The limb of Mars is usually brighter than the center of the disk, but near opposition the effect is occasionally reversed. Thus on December 25 the limb as well as the terminator were darker than the centre. January 4 the limb was the same brightness and color as the center.

The next night was opposition, and on the following night the terminator was distinctly brighter than the limb. This was doubtless due to clouds on the terminator. It is surprising, however, considering how frequently clouds appear along the limb, that they so seldom appeared upon the terminator, this past year, even when the planet was near opposition. Consequently observations of this sort were very exceptional.

Among the contributions that the writer has received from his various correspondents interested in Mars, mention should be made in this place of some beautifully executed color studies by Father Algué of the Observatory of Manila, of the surface of the planet. They were made at the end of January and early in February, and in all of them the blues and greens are strongly shown, while even the yellows have a greenish tint. The central portions are often shown as reddish. Some very artistic color sketches have also been received from Mr. McEwen of Glasgow. They were painted by the light of an oil lamp, and the prominent colors are orange, red, violet, and drab. The red is often strongly marked. The lack of blues and greens is probably due to the source of illumination, drab and violet taking their place.

This is a somewhat neglected branch of astronomical research, perhaps because it requires a special training of the eye, and a capacity to see color that many people do not seem to possess. In connection with Mars, however, it should be by no means neglected, and it is hoped that others may be induced to take it up at subsequent oppositions.