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REPORT ON MARS. NO. 25.

By WILLIAM H. PICKERING.

The Observing Staff.

In the preparation of this General Report on the observations made by the Associated Observers of Mars, during the apparition of 1920, we note with regret the absence from our contributors of Mr. L. J. Wilson, who has made such excellent drawings in the past. This fortunately is only temporary and in his place we have substituted from among our other contributors Dr. M. Maggini.

Opposition occurred on April 20, ⊙ 122°.9, Martian Date July 41, diameter of the disk 15″.9. According to the plan formulated in our Report No. 8, the observers are divided into two groups, the drawings of each group being arranged according to the longitude of their stations, so that in general the views on the left were drawn a few days before those on the right (see Table I), but all the views in the same horizontal line represent approximately the same Martian longitude. The longitudes shown in successive lines are intended to differ from one another by 60°, beginning with 0°. Since each observer furnishes six drawings, his work for the planet is complete, and is represented on two pages. Besides the four principal observers, the work of five others is also shown. Only one of these sent a complete set of drawings, but the best examples of the work of the other four have been selected, and combined to form a sixth complete set. We are very glad to welcome Mr. Attkins of England, and Mr. Brindley of Australia as new observing members of the Associated Observers. The designations, location, and equipment of the nine observers are as follows:

Mg. Dr. M. Maggini, Florence, Italy. 9½-inch refractor by Amici. Magnification 318 and 500. Seeing on Standard Scale ranging from 8 to 11.

Pl. Rev. T. E. R. Phillips, Epsom, England. 8-inch refractor by Cooke and 12¼-inch reflector by Calver. Magnification 350 and 400. Seeing on Standard Scale ranging from 4 to 7.

Pk. Professor W. H. Pickering, Mandeville, Jamaica. 11-inch refractor by Clark. Magnification 330 and 430. Seeing on Standard Scale ranging from 6 to 12.

D. Professor A. E. Douglass, Tucson, Arizona. 8-inch refractor

PLATE XI

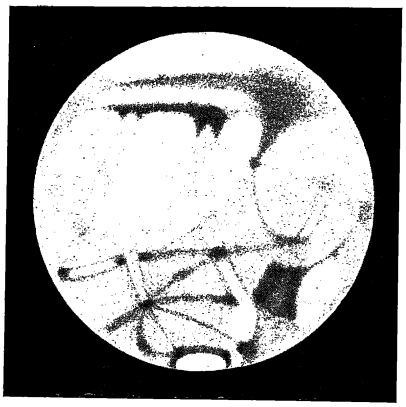

Fig. 1
Maggini 355° A

Fig. 2
Phillips 0° A

Fig. 5
Maggini 56° B

Fig. 6
Phillips 44° B

Fig. 9
Maggini 122° C

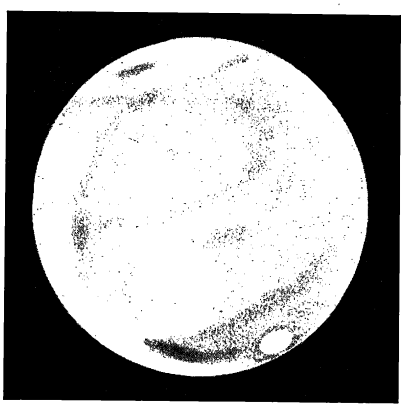

Fig. 10
Phillips 115° C

DRAWINGS OF MARS 1922.

POPULAR ASTRONOMY, No. 304.

PLATE XII

Fig. 3
Pickering 3° **A**

Fig. 4
Douglass 358° **A**

Fig. 7
Pickering 63° **B**

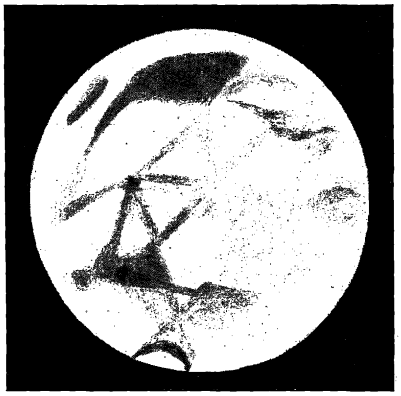

Fig. 8
Douglass 60° **B**

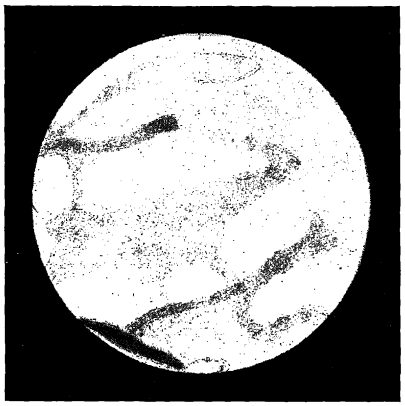

Fig. 11
Pickering 120° **C**

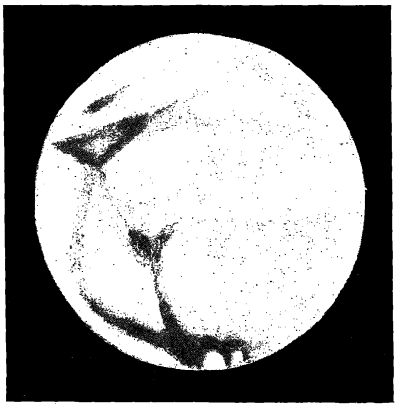

Fig. 12
Douglass 120° **C**

DRAWINGS OF MARS 1922.

by Clark. Magnification 220 and 350. Seeing on Standard Scale ranging from 6 to 10.

A. E. A. L. Attkins, Esq., N. Romford, England. 8½-inch reflector. Magnification 225, 350, and 525. Seeing on Standard Scale ranging from 5 to 9.

E. Rev. W. F. A. Ellison, Armagh, Ireland. 10-inch refractor by Grubb. Magnification 170 and 320. Seeing never really first rate.

Bk. R. N. Buckstaff, Esq., Oshkosh, Wisconsin. 8½-inch reflector by Mellish. Magnification 320. Seeing good.

Br. T. Brindley, Esq., Sydney, Australia. 8½-inch reflector by Calver. Magnification 200 and 360. Seeing fairly good.

T. H. Thomson, Esq., Epsom, England. 8-inch refractor by Cooke and 12¼-inch reflector by Calver. Magnification 325 and 300. Seeing poor.

The Two Ways of Representing the Surface of the Planet.

As is well known to those interested in planetary research, the modern observers of Mars are divided into two schools. One of these is represented in general by the leading members of the Associated Observers, the other we have designated in the past as the Lowellian School, after its founder. It has I believe heretofore been a mystery to nearly everyone how the same planet, Mars, seen under similar conditions by the two schools of observers, could appear so utterly unlike to them.

We think ourselves fortunate in having secured as a collaborator and colleague Dr. Maggini, who although he distinctly states that he does not accept the Lowellian theories of Mars, certainly represents by his drawings the work of the late astronomer in a manner surpassed by none. But not merely is he a keen sighted observer, but what is even more important, I have found him both willing and able to explain how he works, and why he represents what he sees as he does. He says for instance that he could make drawings of Mars closely resembling those of the other observers if he chose to do so. That is to say their drawings resemble the planet as he sees it. He prefers however to add to the general outlines and canals that he readily sees, certain other features which are extremely faint and difficult, so difficult in fact that in order to show them at all on paper their intensity must be greatly exaggerated,—exaggerated out of all proportion to the other detail. This of course destroys the resemblance of the drawings to the planet. This statement at once explains a good deal, and I believe really solves the question.

The writer in the past has insisted on several points which have a direct bearing on the matter here under discussion. He has stated for instance that there was no use in covering the whole surface of the planet with a confused network of canals, unless we were sure that they were really there. Also that even if they were there, the general

shape and intensity of the main features of the surface, which were subject to constant changes, seasonal and otherwise, was a matter of far greater consequence than the addition of a hundred or more insignificant canals. In other words we are likely to learn much more about the conditions on Mars by a study of these changes, and the changes in the forty or fifty major canals, discovered by Schiaparelli and his predecessors, than we are by a study of the scarcely visible innumerable minor canals depicted since his time. These minor canals, those of them that are really there, may perhaps teach us something, but they should not be permitted to overlie and conceal the clearly marked changing surface features of which we are certain.

Still another point on which the writer has especially insisted was that since near the limit of vision detail is very uncertain, and since it is better to leave out some general detail than it is to put in some that is not there, we should draw only those objects that we can hold in steady vision, and should omit all those that we can only glimpse. With the exception of Dr. Maggini this plan I believe has been followed by all the principal observers, those whose instrumental equipment is excellent and whose seeing is especially good. I have considered it important, since their work is harder to check than that of those working under less favorable conditions.

In emphasis of this point I may say that I have generally omitted Aryn from my drawings, although nearly all the other observers put it in. I represented it once in a very much shortened form in Report **17** Figure 2, much as it was seen at the same time by Wilson, Figure 3. In 1914 and 1918 I refused to represent it at all. In 1892 it was conspicuous in Arequipa, and has been clearly seen the past year, now that Mars is again approaching the same position in its orbit. There is no doubt but that during the apparitions of 1914, 16, 18, and 20 it was an extremely difficult object, because its surface was then darkened, and it was accordingly lacking in contrast with the two bays on either side of it. It is also pretty certain that nobody would have drawn it or discovered it during those years if he had not known that it was sometimes visible there. Nevertheless one observer not associated with us has represented it as perhaps the most conspicuous object upon the disk! This does not strike us as good drawing, and we might say more.

While for those belonging to our school it is felt that the rule should be recognized, and followed, to draw only those features of the planet that can be held by the eye continuously, on the other hand we are very glad to publish along with our drawings those of a member of the other school, who has now become one of our prominent Associates, and who feels that he should draw everything that he sees, even if seen only by glimpses, so long as he believes that it is really there, and that he is representing it to the best of his ability. I think we can now more clearly understand why there are two ways of drawing

the markings on Mars, and in what precedes I have endeavored to explain why, and to represent the views of both sides as fairly as possible.

Characteristics of the Different Observers.

At the four oppositions of Mars from 1914 to 1920 the diameter of the planet ranged from 15″.0 to 15″.9. The magnification which appears best adapted to bringing out the finer surface detail with modern instruments of the most approved apertures, that is from 12 to 16 inches, seems to be about 400 diameters. With this magnification therefore the disk appears to be 100′ in diameter, or three times the size of the moon as seen with the naked eye. Owing sometimes in part to inferior seeing, and at others mainly to the properties of light itself, rather than to any imperfect construction of our telescopes, we are only occasionally, and at only the three nearer oppositions of the planet, able to see it any better than we can the moon with the naked eye. That is to say all the detail that we see may be considered as confined to a disk measuring one-quarter of an inch in diameter, such as the end of a lead pencil, held at a distance of two feet from the eye.

Now when it comes to dealing with such small details, the eyes of different observers differ greatly among themselves in their capacity for seeing different features. Some for instance can see finer markings than others, some on the other hand can distinguish fainter contrasts, while still others have a better sense of proportion. Thus Dr. Maggini has been able to draw more canals, and far more lakes than any other observer. Professor Douglass has been able to draw more canals that could be confirmed by others, and has no equal in the number of canals that he detects in the dark regions, while Mr. Phillips and Mr. Thomson draw the planet, showing the shape and appearance of its general features exactly as they appear to me, and because of this three-fold agreement I personally believe that their sense of proportion is the best. That is to say their's are the characteristics that would enable an artist to draw a portrait which should resemble the original. The four remaining observers work under less favorable conditions than the five above mentioned, and I think their drawings give the best idea of the planet as it would appear to the average amateur. Their work moreover has also a special importance which will appear later.

We thus see why it is important in giving a general discussion of the appearance of the planet at each succeeding apparition, to secure drawings from many different observers. This is the reason why we are glad to secure a representative of the Lowellian School, especially one who can talk, and explain what he sees, and why we are very glad that all our observers do not see and represent the planet exactly alike.

The changes which have been already recorded by our observers in the lakes, canals, and coarser surface details during these four apparitions have been in some respects very marked, much more so than,

outside of clouds and color effects, would have been seen by an equally distant observer in the case of our earth. Some of these changes we hope to describe in a future paper. Nevertheless the changes occurring in the next four apparitions, which will bring us back to the same Martian season as that with which we started, in 1914, will it is already known be greater still.

Description of the Drawings.

In Table I is given a statement of the main facts relating to the various drawings. The table is arranged as in previous Reports, the successive columns giving the number of the figure, the designation of

TABLE I.

Fundamental Data of the Figures.

Fig.	Obs.	Aper.	Magn.	Seeing	1920		Reg.	Long.	ΔLong.	Lat.	Diam.	☉	M. D.
								°	°	°	″	°	
1	Mg	9.5	318,500	10	May	3	A	355	— 5	+20.6	16.0	129.2	Jul. 54
2	Pl	8	350	—	May	9	"	0	0	21.3	15.7	132.1	Aug. 3
3	Pk	11	430	11	May	12	"	3	+ 3	21.6	15.5	133.6	Aug. 6
4	D	8	350	7,9	May	16	"	358	— 2	22.0	15.2	135.6	Aug. 10
5	Mg	9.5	318,500	8	Apr.	27	B	56	— 4	19.9	16.0	126.3	Jul. 48
6	Pl	8	350	5	May	4	"	44	—16	20.8	15.9	129.7	Jul. 55
7	Pk	11	430	6,9	May	6	"	63	+ 3	21.0	15.9	130.6	Jul. 56
8	D	8	350	8,10	May	11	"	60	0	21.5	15.6	133.1	Aug. 5
9	Mg	9.5	500	9	Apr.	24	C	122	+ 2	19.5	16.0	124.8	Jul. 45
10	Pl	8	350	6	Jun.	2	"	115	— 5	23.0	13.7	144.1	Aug. 27
11	Pk	11	430,330	12	May	1	"	120	0	20.4	16.0	128.3	Jul. 52
12	D	8	350	6,8	May	5	"	120	0	20.9	15.9	130.1	Jul. 55
13	Mg	9.5	500	10	Apr.	16	D	181	+ 1	18.4	15.7	121.0	Jul. 37
14	Pl	8	350	7	Apr.	19	"	182	+ 2	18.8	15.9	122.4	Jul. 40
15	Pk	11	430,330	10	Jun.	1	"	178	— 2	22.9	13.8	143.6	Aug. 26
16	D	8	220,350	7.8	Apr.	25	"	185	+ 5	19.6	16.0	125.3	Jul. 46
17	Mg	9.5	500	11	Apr.	8	E	246	+ 6	17.4	15.1	117.2	Jul. 29
18	Pl	8	350	4	May	19	"	238	— 2	22.2	15.0	137.0	Aug. 13
19	Pk	11	430	7	Apr.	20	"	238	— 2	18.9	15.9	122.9	Jul. 41
20	D	8	220,350	7,9	Apr.	22	"	241	+ 1	19.2	16.0	123.9	Jul. 43
21	Mg	9.5	318,500	9	May	6	F	305	+ 5	21.0	15.9	130.6	Jul. 56
22	Pl	8,12.2	350,400	6	May	14	"	290	—10	21.8	15.4	134.6	Aug. 8
23	Pk	11	430	10	May	19	"	305	+ 5	22.2	15.0	137.1	Aug. 13
24	D	8	350	8	Apr.	14	"	307	+ 7	18.1	15.6	120.1	Jul. 35
25	A	8.5	350	5.6	Jun.	13	A	4	+ 4	23.1	12.6	149.7	Aug. 37
26	E	10	170,232	—	May	7	"	356	— 4	21.1	15.8	131.1	Aug. 1
27	A	8.5	350,525	—	Jun.	6	B	71	+11	23.0	13.3	146.1	Aug. 31
28	E	10	170,232	—	Apr.	29	"	63	+ 3	20.1	16.0	127.2	Jul. 50
29	A	8.5	225,525	9	Jun.	1	C	117	— 3	22.9	13.8	143.6	Aug. 26
30	Bk	8	320	—	Jun.	12	"	111	— 9	23.1	12.7	149.2	Aug. 36
31	A	8.5	525	6,8	May	26	D	169	—11	22.7	14.3	140.5	Aug. 20
32	Br	8 5	200,360	—	May	9	"	200	+20	21.3	15.7	132.1	Aug. 3
33	A	8.5	225,525	7,8	May	19	E	248	+ 8	22.2	15.0	137.0	Aug. 13
34	T	8	325	—	May	22	"	232	— 8	22.4	14.7	138.5	Aug. 16
35	A	8.5	225,525	5,7	May	13	F	288	—12	21.7	15.4	134.1	Aug. 7
36	T	12.2	300	—	May	12	"	305	+ 5	21.6	15.5	133.6	Aug. 6

the observer, the aperture of his instrument, the magnifications employed, the seeing on the Standard Scale, the date of the drawing, the region depicted, the longitude of the central meridian, its deviation from the desired standard, the latitude of the center of the disk, the

angular diameter of the planet, the longitude of the sun as seen from Mars, and the corresponding Martian date, taken from Report No. **10**. The average date of the drawings was May 9, or 19 days after the opposition.

Observers' Remarks.

Dr. Maggini refers first to a bright projection or cloud that he observed over Edom Promontory on the night of March 24, and then to the white veil seen by all the observers over a portion of the Syrtis in April and May. He next gives a list of the 28 canals that he observed as double. They are as follows: Anian, Arnon, Casius, Cerberus, Chrysorrhoas, Deuteronilus, Erebus, Euphrates, Ganges, Gehon, Gigas, Granicus, Gyndes, Heliconius, Hiddekel, Iris, Jamuna, Marsyas, Nilokeras, Nilus, Orcus, Phison, Phlegethon, Protonilus, Pyriphlegethon, Tartarus, Thoth, and Xenius. Their duplicity lasted in some cases for a few days only, and in others for the whole duration of visibility of the canal. He states that the duplication is not due to the doubling of a single line, but rather to the addition of a new line to the original one. The space between the two canals is sometimes bright, sometimes dark gray.

In addition to the work of our regular observers, I have had the pleasure of examining some photographs of drawings made by Mr. G. H. Hamilton at the Lowell Observatory. On six drawings, coinciding nearly in longitude with our six regions, he identified for me the 15 following canals as being double: *Arnon,* Asopus, Astaboras, Callirrhoe, *Deuteronilus, Euphrates, Gehon, Gigas,* Nepenthes, Nilosyrtis, *Phison,* Pierias, Pyramus, Sitacus, and *Thoth.* Two of these, Asopus and Sitacus, are not recorded by Maggini. Of the remaining 13, seven were seen double by both observers. That is to say one-quarter of Maggini's and one-half of Hamilton's were confirmed. These names are printed in italics. It is noticeable that 5 of these 7 lay in region **A**. Maggini's remarks concerning the method of formation, and duration of the duplication, were independently described to me by Mr. Hamilton.

Mr. Phillips says he thinks it is of little use to observe the planet in England when it is south of the equator. He refers, as in a former article, to the fact that unless the seeing is very good indeed he prefers the 8-inch aperture to the 12-inch. It will be seen by Table I that he used the larger aperture on only one of his drawings this year. The most remarkable things that he noted were (*a*) the extension of the Syrtis in a westerly direction near Astusapes, (*b*) the appearance of a canal near Amenthes, [this was perhaps Triton], (*c*) the cloud lying near the polar cap May 21, which had moved off the next evening, but was still close to the limb. This may have been the forerunner of those snowstorms described and illustrated in our Report No. **23**. He refers also to the small size and faintness of the northern polar cap throughout the apparition.

What most impressed the writer was (*a*) the bright area visible over the Syrtis in March and April, (*b*) the broad, distinct, lightly shaded bands crossing the deserts in longitudes 0°, 60°, and 120° in early May, (*c*) the marked gulfs which had formed on either side of the northern point of the Syrtis, (*d*) the changes in the shape of Elysium, and (*e*) the snowstorms in June and early July that accompanied the disappearance of the northern polar cap and the formation of the large new one in the Martian August. These snowstorms have been already described in Report No. **23**. They are believed to have been snow, because they were bluish white rather than yellowish white like the clouds.

Elysium has of late years been so nearly circular in form that it is particularly well adapted to showing the shifting about of the canals over the surface, which is one of the most interesting and suggestive features of the planet's topography. There is no question but that in the earlier years of this century its shape was that of a very regular pentagon. This is proved by the drawings of numerous observers, as well as by photographs (see Report No. **22**). During the apparitions of 1914, 1916, and 1918 it was practically circular. On February 14 of 1920, ⊙ 92°.8, when central, it was drawn with considerable care to show its conspicuous ellipticity. The major axis lay in a meridional direction, and the relative length of the axes was in the ratio of 8 to 10. The major axis measured just one-quarter the diameter of the planet. In Report No. **22**, 3, the ratio for my drawing of Elysium when circular is given as 0.228 and for the photograph taken in 1907 as 0.222. On March 15, when central, only the preceding side of the ellipse was visible, but this was unusually strongly marked. On April 20 two drawings were secured showing marked irregularity in shape. One of these is represented in Figure 19. The form is now no longer elliptical but lemon shaped, with the major axis strongly inclined to the meridian. The form apparently changed appreciably during the two hours interval which separated the two drawings. This irregularity of shape is confirmed by the two drawings of Professor Douglass made on April 22 and 25 (see Figures 20 and 16). By this time a dark veil seems to have been drawn over the north preceding end of the figure. Elysium itself was not notably bright, and all three drawings show that the canals themselves had changed in shape and position, so that what was seen cannot be explained as merely due to a shifting cloud.

On May 19 and 22 (Figures 18 and 34), Messrs. Phillips and Thomson show the shape to be again nearly circular. Any marked irregularity of form is not likely to have been missed by these two skillful draftsmen. On May 28 the writer describes its shape as "far from circular," and draws it of a somewhat pear shaped form, with the stem on the south following side, much as it is shown by Douglass. A very fine canal crossing it is also noted. On May 29 it is again drawn

lemon shaped, with some fine canals and a minute lake situated near its center. This of itself proves not only that our seeing was excellent, but also that the effect shown is not due simply to a covering of cloud, which would have hidden the detail. By June 1 it appears to have been circular, but on July 2 markedly elliptical, with the major axis more nearly meridional than in Figure 19. July 5 it was according to the drawing nearly circular, but on July 8, $\odot = 163°.0$, again strongly elliptical, the major axis now lying more nearly east and west than in any of the other drawings. During the whole of the three previous apparitions it had appeared to me to be uniformly circular.

We conclude from these various representations and records that the canals are subject occasionally to irregular shifts of position, the change in the course of a few days, or less, sometimes amounting to nearly 200 miles. The observed changes occurred between the Martian dates June 33 and September 6. While these observations all corroborate the "shower track" explanation of the larger canals, and that these showers, owing to the low atmospheric pressure, occur practically every night, there is still much to be learned before we can consider this explanation as definitely proved. What we can say is that such rapid and extensive shifts are opposed to the hypothesis of vegetation, as applied to the more important canals, and favor an atmospheric explanation.

Regarding the canals, Professor Douglass writes, "I believe I only put down the canals I can hold, or see again and again. I have felt about the same confidence in the dark region canals as in the light, barring only the fact that other people do not seem to see them. I only get them when I look for them deliberately, just as I do for the light region canals."

Mr. Attkins refers to the white area over the Syrtis shown in Figure 33, and through which the Syrtis itself was faintly visible. This formation he shows on the meridian in Figure 35. The white triangular area in the northern hemisphere of Figure 29 was brilliant. It may have been cloud, since it seems rather too far to the south for an early snowstorm, although its shape suggests the latter. Mr. Phillips does not record it the following night in Figure 10, though he shows a bright area in that vicinity.

Mr. Ellison says that the most remarkable feature of the apparition was the unusual prevalence of great white areas, generally but not always on the planet's limb. He draws several of these, in two cases showing how one of them completely concealed the wider portion of the Syrtis, leaving only the northern tip visible. This is shown also in Mr. Thomson's sketch, Figure 34. The complete concealment of the Syrtis, which was then near the limb, is shown in Figure 26. He speaks of the sharpness of Charontis, which appears to him forked, the prongs facing away from Cerberus. Solis Lacus he represents as a

small black point in Figure 28. In general also he sees the canals as extremely narrow sharp lines. In this respect his drawings resemble those of Lowell and Maggini. He uses a lower power than most of the observers (see Table I), and it is possible that this explains in part the difference in the results obtained.

Mr. Buckstaff remarks that the greens, which were predicted for this apparition of the planet, were visible in the maria. This statement is corroborated by the writer and others. He describes some of them as gray green. Acidalium, Casius, and Caloe Palus were a dark gray green. Some of the wider canals he thinks were brownish. Later the maria again turned gray. On May 28 and 29 a white area covered the southern part of the Syrtis and Libya. This was also noted here. He states that is was not visible three days earlier. He refers to the snowstorm that he observed on June 18 and 19. This has been already described, and his drawing given in Report No. **23**.

Mr. Thomson remarks on the several cloud areas shown in his two drawings, Figures 34 and 36, on the gulf shown on the Syrtis at Astusapes, and on the hazy dark line following the limb cloud over Libya. I have often noticed such a line bounding a cloud myself. It presents the appearance of deposited moisture, that is to say of moistened ground, as if due to rain. He makes Hammonis Cornu more pronounced than most of the observers, but I saw it the same way myself at about the same time.

Identification of the Canals.

In the early days of canal discovery, some forty years ago, when even the existence of these objects was doubted by many astronomers, the suggestion was made that they were not really dark streaks drawn on the surface of the planet, but simply the boundary lines between lighter and darker areas. Those who had seen the canals smiled at this idea, as they did at some of the other earlier suggestions offered to explain them, such as that they were water courses, or the grooves ploughed by colliding asteroids.

It now appears however that while the vast majority of the canals are undoubtedly dark and comparatively narrow streaks, yet to some eyes the boundary line between a light region and one only slightly darker does present the appearance of a canal. Thus there can be but little doubt but that what appears to Maggini as a double canal perpendicular to the limb in Figure 5, appears to Douglass in Figure 8 merely as the two sides of a dark band lying between a light and a somewhat darker region. Again this same canal is shown by Maggini in Figure 9, while to the writer and to Douglass it appears again in Figures 11 and 12 as simply the boundaries of a wide dark region. It is of course possible that Maggini's interpretation is the correct one.

A similar effect may be observed by comparing the four central doubles in Figure 1 with the shadings of Figure 3. We have in this

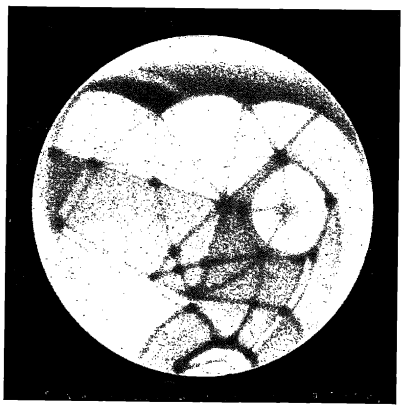

Fig. 13
Maggini 181° D

Fig. 14
Phillips 182° D

Fig. 17
Maggini 246° E

Fig. 18
Phillips 238° E

Fig. 21
Maggini 305° F

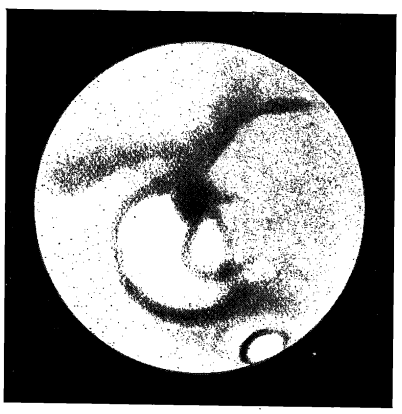

Fig. 22
Phillips 290° F

DRAWINGS OF MARS 1922.

POPULAR ASTRONOMY, No. 304.

PLATE XIV

Fig. 15
Pickering 178° **D**

Fig. 16
Douglass 185° **D**

Fig. 19
Pickering 238° **E**

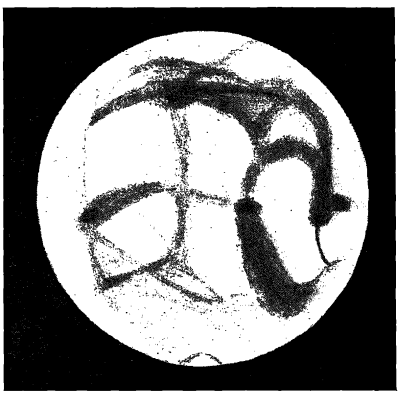

Fig. 20
Douglass 241° **E**

Fig. 23
Pickering 305° **F**

Fig. 24
Douglass 307° **F**

DRAWINGS OF MARS 1922.

case a very distinct example of the two schools of representation. Figure 3 was drawn with great care with regard to having the shapes, widths, and proportions of the central shaded regions exactly correct. These markings were perfectly sharp and distinct to my eye, and there was not a trace of a narrow canal-like marking visible. The sides were not at all parallel, and our seeing was 11, or practically at its best. Figure 3 was drawn but 9 days later than Figure 1, which latter was also drawn under very favorable conditions, seeing 10. The other four drawings of this region do not give any particular help as to which of these two is the more likely on the face of it to be correct. Figure 4, drawn but four days later than Figure 3, makes the canals of intermediate width, single, and not differing in any respect from numerous other canals which the three observers all agree were narrow and single. The seeing was fair, 7 to 9, and since the three observers all used the same Standard Scale, their recorded seeings are comparable with one another. The separation of the central canals in Figure 1 ranges from 0″.6 to 0″.9, and it is now clear that one of two things is true, either that double canals of this separation affect the writer's eye as faint, uniform, somewhat irregular shaped surfaces, or else that slightly darkened surfaces of this description affect the eyes of the Lowellian school of observers as parallel canals.

The canal Arnon the writer did not see, but each of the other six seen by both Maggini and Hamilton as a double canal appears to the writer simply as a broad rather faintly marked band, the edges being no darker than the middle. Is it then true that the duplication seen by some observers is due simply to contrast between a bright surface and the two edges of a slightly darker moderately wide band? Report No. **5**, 2. Exactly the same effect is seen clearly by the writer on the moon, where a dark canal or run crosses the snow in a bright craterlet. The contrast in this case is very marked, and the edges of the lunar canal certainly appear darker than the middle, giving the effect of a very clear double. These questionable lunar doubles must not however be confounded with the real clearly marked doubles found in the craters of Aristillus, Eratosthenes, and in a few other places.

Again there is sometimes noted a tendency among the observers to see canals, whose existence is doubtful, in places where one might naturally expect to find them. Thus in Figures 17 and 18 Amenthes is shown going straight south to the Syrtis Minor, whereas in Figures 19 and 20 there is no doubt but that the canal follows the course of Triton, and curves to the left to Cimmerium. The writer made a particular study of this point and could not see Amenthes. It seems very strange that Maggini who could see so many canals, could not see Triton, which was fairly obvious. Again in Figure 21 the region north of the Syrtis does not agree in shape at all with Figures 22, 23, 24, 35, and 36, although it does resemble our standard map (Report No. **15**) more closely than any of the other drawings.

In Table II the canals seen by the different observers are arranged in alphabetical order, the headings of the five following columns give the abbreviations of the observers' names, and the columns themselves give the letters which indicate on which drawings the canals are to be found. These letters are also given in Table I ,and under the drawings themselves. The last column gives the number of observers who saw each of the canals. In some cases no canal is found on our standard map which can be identified with the ones observed. Fortunately Lowell covered the whole surface of the planet with canals so completely, that we can almost always find one that will fit sufficiently well, and we thus do not have to trouble ourselves with finding new names. For this purpose the best maps are contained in his Annals, Vol. III. An index of canals given on page 268 will be found of much assistance. These canals are indicated by the letter L. The canal Marne marked with a P has now been visible at four successive apparitions. A description of it will be found in Report **21**, 7. There are a few cases however, given at the end of our list, where Maggini has succeeded in discovering canals seen neither by Lowell, Jarry-Desloges, nor anybody else. Unless they should in future turn out to be important, it is not considered desirable to increase the enormous number of names, nearly five hundred, with which the planet is already overburdened. Several other canals lie in the dark regions, and are all of them taken from Lowell's maps. Most of them were found by Douglass while he was at the Lowell Observatory, and he is now responsible for putting them on our lists. These canals are indicated by a (*d*), standing for dark region. The eight anonymous canals may be described as follows:

(*a*) Found in Figures 1 and 5, extending from Oxia to Lunae, and probably identical with one detected by the writer, and recorded in Report **21**, as anonymous (*a*).

(*b*) Found in Figure 5, extending from Oxia to Jamuna, south of the previous one, and probably identical with one found by Maggini, also recorded in Report **21**, and there wrongly identified also as anonymous (*a*).

(*c*) Found in Figure 5, extending from Nilokeras I to Issedon, and shown merely as a boundary in Figure 7.

(*d*) Found in Figure 5, but not in Figure 1, north of and nearly parallel to Deuteronilus.

(*e*) Found in Figure 9 just north of Tanais.

(*f*) Found in Figure 13 just north of Boreas.

(*g*) Found by Douglass in Figure 20 north of Libya and to the west of Triton, and curving in the opposite direction.

(*h*) Found in Figure 21 lying parallel to Dosaron and to the west of it.

TABLE II.

CANALS IDENTIFIED IN THE DRAWINGS.

No.	Canals	Mg	Pl	Pk	D	A	Misc.	Obs.
1	Abalos	C						1
2	Aces		C	C	C	C		4
3	Acheron			D	CD	D		3
4	Adonis	D						1
5	Aeolus (*d*) *L*				F			1
6	Aesacus	DE		E	E		E	4
7	Aethiops	D			E			2
8	Agathodaemon	BC	C	BC	BC	BC		5
9	Alander L	BC		B	B			3
10	Alcyonius	E			E			2
11	Amenthes	EF	E			E	E	4
12	Anelon L	B						1
13	Anian	DE			E			2
14	Antaeus	D						1
15	Araxes	C			C			2
16	Arnon	AF			AF			2
17	Asopus				A		F	2
18	Astaboras	AEF	F		AF	F		4
19	Astapus	EF			F			2
20	Astusapes	EF	F	F	E		F	5
21	Aurum (*d*) L				A			1
22	Ausonium (*d*) L				EF			1
23	Baphyras (*d*) L				B			1
24	Boreas	D	E	D	DE			4
25	Boreosyrtis		F	E	E	E		4
26	Borysthenes (*d*) L				B			1
27	Brontes		D	D	D			3
28	Cadmus	F			A			2
29	Caleso (*d*) L				F			1
30	Callirrhoe	AF	A	A	AF		B	5
31	Casius	EF	EF	EF	EF	EF	EF	6
32	Casuentus (*d*) L				F			1
33	Cedron	AF						1
34	Cephissus						D	1
35	Ceraunius	BC	C	C	BC		C	5
36	Cerberus	DE	DE	DE	DE	DE	DE	6
37	Chaos	DE	DE	DE	DE		E	5
38	Chrysorrhoas	BC	C	BC	BC	B		5
39	Clarius	C	C	BC	C		C	5
40	Coprates			B	BC			2
41	Cyaneus (*d*)				D			1
42	Cyclops	E		E	D			3
43	Cydnus	D						1
44	Daemon	BC	C	C	BC			4
45	Dardanus			B	A			2
46	Deuteronilus	ABF	A	AF	ABF	A	B	6
47	Djihoun L	A						1
48	Dosaron (*d*) L	F			F			2
49	Dyras (*d*) L				E			1
50	Erebus	D		D	D	D	E	5
51	Erigone		D	D	D			3
52	Erymanthus (*d*) L				E			1
53	Eumenides	CD		C	CD			3
54	Eunostos	DE	DE	DE	DE		E	5
55	Euphrates	AF		A	AF			3
56	Eurotas	CD	C	C	CD			4
57	Fevos	D			D			2
58	Fortuna	BC			BC			2
59	Galaesus (*d*) L	E			D			2

TABLE II.—CONTINUED.

No.	Canals	Mg	Pl	Pk	D	A	Misc.	Obs.
60	Galaxias	DE			E			2
61	Ganges	BC			B	B	C	4
62	Gehon	AF		A	A	A		4
63	Gigas	D	C	CD	BC			4
64	Gorgon					C		1
65	Gyndes	D	E	E	D	D	DE	6
66	Hades	D	D	D	DE	D	D	6
67	Hebe			B	B			2
68	Hebrus	C						1
69	Heliconius	DE	E	E	E	E	E	6
70	Hephaestus	E			E		E	3
71	Hiddekel	AF						1
72	Hippalus	C		C				2
73	Hippus (*d*) L	F						1
74	Hyblaeus	DE	DE	DE	DE		E	5
75	Hylias (*d*) L				F			1
76	Hypanis (*d*) L				B			1
77	Hyperboreas	BDF	ABF	BEF	BC	E	DE	6
78	Ilissus			C	C			2
79	Indus	AB				A		2
80	Iris	C						1
81	Isiacum L	EF						1
82	Issedon	B						1
83	Jamuna	AB			AB	B		3
84	Japhyx L				D			1
85	Kison	AF			A			2
86	Laestrigon	DE			DE			2
87	Laus (*d*) L				E			1
88	Limyrus L	DE						1
89	Lophis L	E						1
90	Lycus	C						1
91	Marne P	D		D				2
92	Mascas L	E						1
93	Nar L	E						1
94	Nasamon	EF						1
95	Nectar	BC		BC	B			3
96	Nepenthes	EF	EF	EF	EF	EF	EF	6
97	Nilokeras	B	B	B	B	B	AB	6
98	Nilokeras I L	ABC	C	B	BC	B		5
99	Nilosyrtis	EF	F	AEF	AEF	EF	F	6
100	Nilus					BC	C	2
101	Orcus	D	D	D	D			4
102	Orontes	F			A			2
103	Orosines (*d*) L	F			F			2
104	Oxus			A	AB		A	3
105	Pactolus	E				E		2
106	Phison	AF		A	F			3
107	Phlegethon			B	C		C	3
108	Pierius	AF		AF	AF		F	4
109	Protonilus	AF	AF	AF	AF	F	F	6
110	Pyramus	F			A			2
111	Pyriphlegethon	CD		D		D		3
112	Python	AF		F				2
113	Rhymmus (*d*) L				B			1
114	Rhyndacus	D			D			2
115	Sirenius	D		C		C	C	4
116	Siris	A			A			2
117	Sitacus		A	A	F	A	A	5
118	Steropes L	B						1
119	Styx	DE	DE	DE	DE	DE	E	6

TABLE II.—CONTINUED.

No.	Canals	Mg	Pl	Pk	D	A	Misc.	Obs.
120	Subus L	EF						1
121	Tanais	BC		C	ABC		C	4
122	Tantalus			D				1
123	Tartarus	D						1
124	Thestor (*d*) L				B			1
125	Thoth	EF	EF	EF	EF	EF	EF	6
126	Titan	CD						1
127	Triton			E	EF			2
128	Typhonius	F						1
129	Ulysses	C						1
130	Uranius	BC	C	CD	B			4
131	Xenius	AF						1
132	Anonymous (*a*)	AB						1
133	" (*b*)	B						1
134	" (*c*)	B						1
135	" (*d*)	B						1
136	" (*e*)	C						1
137	" (*f*)	D						1
138	" (*g*)				E			1
139	" (*h*)	F						1

STATISTICS OF THE CANALS.

Information regarding the number of canals recorded by each observer is contained in Table III. When a canal was seen by all six observers we may describe its visibility as 6. When seen by only five observers its visibility is 5, and so on. The first column of the table records the visibility, and the next six give the number of canals of each of these visibilities seen by each observer. The last column gives the total number of canals of each degree of visibility. The next to last horizontal row of figures gives the total number of canals seen by each observer, and the last row the number of his canals that were confirmed by at least one other person. Thus Professor Douglass saw 6 more confirmed canals than any other observer, and what is remarkable is that of his 17 unconfirmed canals 15 were in the dark regions of the planet, so that he had only 2 unconfirmed canals in the bright regions. Some 19 in all of these dark region canals were observed, 18 by Douglass and 4 by Maggini. Only 3 therefore were seen in common. Douglass is very certain that they exist, but few other observers can see them.

These dark region canals form a class by themselves, and are really another kind of phenomenon. Therefore leaving them out of consideration, Professor Douglass's result of recording 77 confirmed canals, with only 2 that were unconfirmed, establishes a record as far as our experience goes. Of course it could not have been done without Dr. Maggini's very efficient aid as a "runner up." Especial stress is laid on the small number of canals unconfirmed, which is the only thing which makes the record remarkable. The number of confirmed canals on each of his drawings was on A 19, B 19, C 18, D 20, E 22, F 17, average 19. They seem to have been very uniformly distributed in

longitude. These numbers are interesting as showing how many canals we should expect to find on any one drawing made under really favorable conditions. It will be noted that the observations were all secured with an 8-inch Clark refractor. All the other observers used, or had access to, instruments of larger aperture. See list of Observers.

TABLE III.

THE NUMBER OF CANALS RECORDED.

Obs.	Mg	Pl	Pk	D	A	Misc.	Total
6	13	13	13	13	13	13	13
5	11	11	12	12	5	9	12
4	14	10	13	14	8	7	16
3	9	2	12	13	3	3	14
2	24	0	8	25	2	1	31
1	33	0	1	17	1	1	53
Total	104	36	59	94	32	34	139
Confirmed	71	36	58	77	31	33	86

It will be noticed that Phillips, Attkins, and the miscellaneous observers all saw about the same number of canals, and that their observations were generally confirmed by others. The fact that they saw far fewer canals than the other three was undoubtedly due to the circumstance that the planet was to the south of the equator, which while it helped the Australian, interfered with all the other observers. The three observers who saw the largest number of canals saw 40 in common, or more than half the number of confirmed canals seen by any of them.

It should be pointed out here that the work of the miscellaneous observers is considered to be of very considerable importance. Not only do their drawings, if they are skillful draftsmen, confirm or distinguish between the shapes of the various details as shown by the other observers, who are more fortunately situated, but the mere fact that they cannot see so many canals enables us to classify these objects with regard to their visibility. To record one hundred canals is not of much consequence by itself, but if we can group them so as to say at this season of the planet's year these twenty canals were most conspicuous, those twenty next, and so on, then we have accomplished something worth doing. From this point of view the miscellaneous observers may consider themselves quite as important as any of the others, because they are helping us to do something that could not well be done without their aid.

Of the 30 canals taken from Lowell's maps, 5 were seen by two or more observers. These were Alander, Dosaron, Galaesus, Nilokeras I, and Orosines. Nilokeras I was very prominent this year. It was seen by 5 observers, but was not recorded at all during the three previous apparitions. Alander was seen by three observers. In 1914 the total number of confirmed canals numbered 45, in 1916 54, in 1918 83, and the present apparition 86, showing as was expected that we had now about reached the maximum number.

TABLE IV.

PROPORTION OF THE CANALS VISIBLE TO THE DIFFERENT OBSERVERS.

Visible	Mg	Pl	Pk	D	A	Misc.	Total
6	1.00	1.00	1.00	1.00	1.00	1.00	13
5	.92	.92	1.00	1.00	.42	.75	12
4	.88	.62	.81	.88	.50	.44	16
3	.64	.14	.86	.93	.21	.21	14
2	.77	.00	.26	.81	.07	.03	31
1	.62	.00	.02	.32	.02	.02	53
Confirmed	.83	.42	.68	.90	.36	.38	1.00

In Table IV the arrangement is similar to that in Table III, except that instead of giving the total number of canals seen by each observer, it gives the proportion of the total number recorded. These total numbers are given in the last column of Table IV, and are taken directly from Table III. As we descend the columns to fainter and fainter canals, the proportion of the total number seen by each observer should gradually decrease, falling off sharply when he approaches his limit, and this we find in general to be the case. Thus Pickering and Douglass both saw all of the 25 most conspicuous canals. The number holds well for the former until we get down to visibility 2, when he saw only one-quarter of the canals of this grade. This therefore establishes his limit. Douglass goes one step further. The last horizontal line of the table shows the proportion of confirmed canals that each observer contributed to the final result. It is deduced from the last horizontal row of Table III.

TABLE V.

LAKES IDENTIFIED IN THE DRAWINGS.

No.	Lakes	Mg	Pl	Pk	D	A	Misc.	Obs.
1	Acidalius L				B			1
2	Ammonium	D						1
3	Arethusa	AF		AF				2
4	Arsenius	D	D	D		D	D	5
5	Ascraeus	BC			C			2
6	Aspledon L	C						1
7	Caesia L	D						1
8	Caloe	AEF	F	AF	F	E	F	6
9	Cassotis L	DE						1
10	Castorius	C	D	D	D			4
11	Copais	F						1
12	Cranium L	A						1
13	Cyane L		C			C	C	3
14	Gomer L				E			1
15	Gordii	CD						1
16	Hecatis	DE						1
17	Hipponis L	EF						1
18	Hipponitis L II	AF						1
19	Hyperboreas	ABC	AB	B	B			4
20	Isidis L II	F						1
21	Ismenius	AF		AF	AF	A	F	5
22	Jovis L	C						1
23	Juventae			B				1
24	Laestrygonis L				D			1

PLATE XV

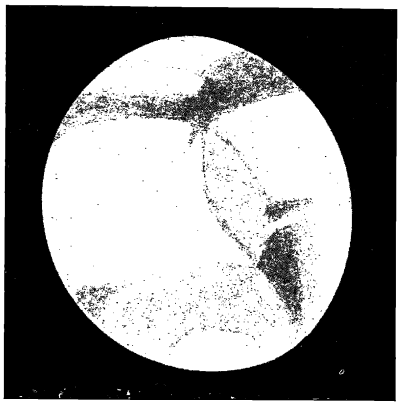

Fig. 25
Attkins 4° A

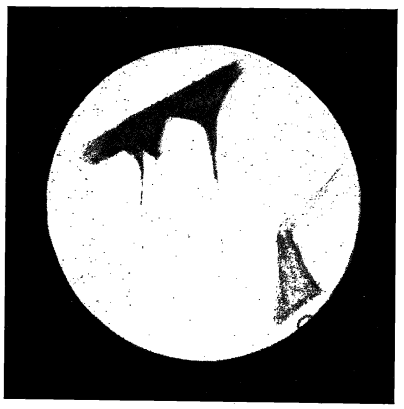

Fig. 26
Ellison 356° A

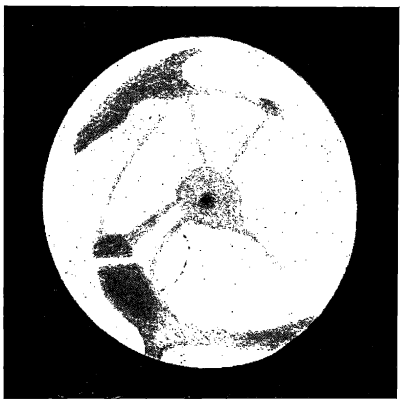

Fig. 27
Attkins 71° B

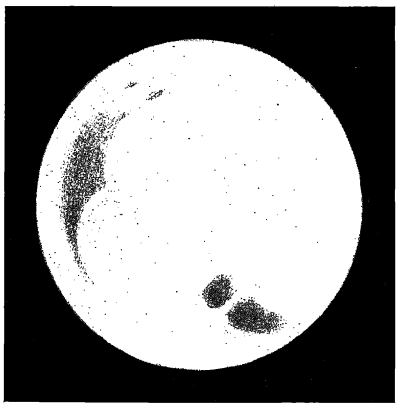

Fig. 28
Ellison 63° B

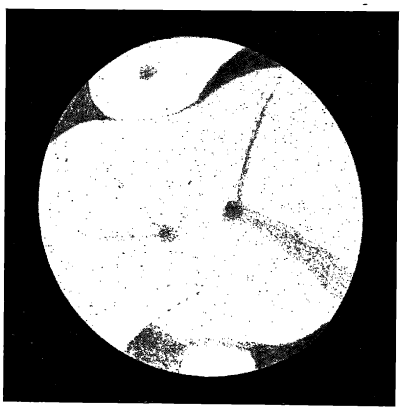

Fig. 29
Attkins 117° C

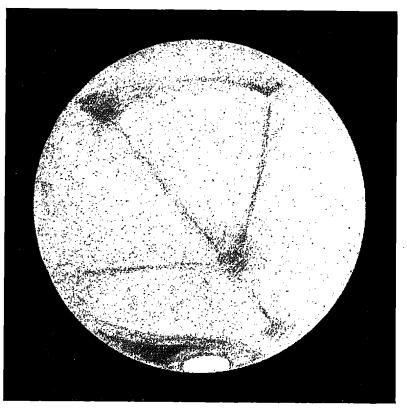

Fig. 30
Buckstaff 111° C

DRAWINGS OF MARS 1922.

POPULAR ASTRONOMY, No. 304.

PLATE XVI

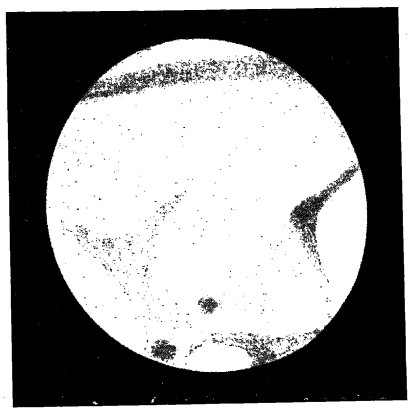

Fig. 31
Attkins 169° D

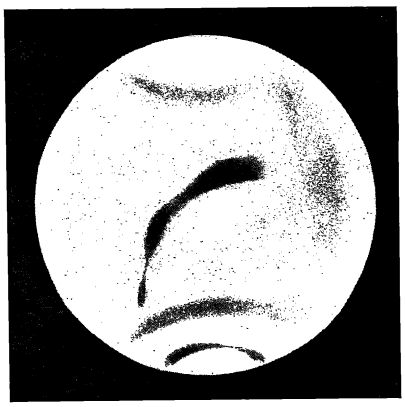

Fig. 32
Brindley 200° D

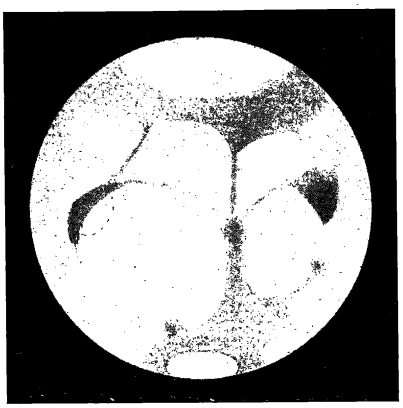

Fig. 33
Atkins 248° E

Fig. 34
Thomson 232° E

Fig. 35
Attkins 288° F

Fig. 36
Thomson 305° F

DRAWINGS OF MARS 1922.

TABLE V—Continued.

No.	Lakes	Mg	Pl	Pk	D	A	Misc.	Obs.
25	Lucrinus L	DE						1
26	Lunae	ABC	C	B	B	B		5
27	Maeisia L	B			B			2
28	Maeotis	C						1
29	Maricae L	C						1
30	Messeis L	BC	B	B	BC	B	B	6
31	Moeris	E						1
32	Molorchi L	E						1
33	Moreh L	D						1
34	Morpheos L	DE					E	2
35	Nectaris	C						1
36	Niliacus	B	AB	AB	AB	AB	B	6
37	Nilus L	E						1
38	Novem Viae L	A			A			2
39	Nuba	EF	E			EF	E	4
40	Olympia L				A			1
41	Ortygia L	D						1
42	Oxia	AB		A				2
43	Panopis L					C		1
44	Phoenicis	CD		C				2
45	Propontis I	D	D	D	D	D	D	6
46	Propontis II	D						1
47	Pseboas L	E						1
48	Scotitas L	DE						1
49	Secundus L	DE		D	DE	D	E	5
50	Semnon L	D						1
51	Siloe	ABF						1
52	Sirbonis	F						1
53	Sithonius	DE				E		2
54	Solis	BC	C	B	BC	C	B	6
55	Stymphalius	DE						1
56	Tertius L	DE						1
57	Thymbra L	D						1
58	Tithonius	BC			BC			2
59	Triton	EF			E			2
60	Anonymous (*a*)	AB						1
61	" (*b*)	B						1
62	" (*c*)	B						1
63	" (*d*)	B						1
64	" (*e*)	B						1
65	" (*f*)						E	1

TABLE VI.

THE NUMBER OF LAKES RECORDED.

Obs.	Mg	Pl	Pk	D	A	Misc.	Total
6	5	5	5	5	5	5	5
5	4	2	4	3	4	3	4
4	3	3	2	2	1	1	3
3	0	1	0	0	1	1	1
2	10	0	3	5	1	1	10
1	35	0	1	4	1	1	42
Total	57	11	15	19	13	12	65
Confirmed	22	11	14	15	12	11	23

IDENTIFICATION AND STATISTICS OF THE LAKES.

In Table V is given a list of the various lakes identified in 1920 upon the planet. Maggini saw about 50 anonymous lakes, either single ones that had not been seen before, or duplications of lakes that had already