

Popular Astronomy.

Vol. XXXIV, No. 5

MAY, 1926

Whole No. 335

REPORT ON MARS, NO. 35.

By **WILLIAM H. PICKERING.**

THE APPARITION OF 1924, CONTINUED.

Our last Report contained the drawings of four of the eight observers whose work was accepted this year for publication. The present Report contains the drawings of the remaining four, one American, and three from Asiatic stations. These are arranged as heretofore in the order of their longitudes. The designations, localities, and equipment of these astronomers are as follows:

D Professor A. E. Douglass, Tucson, Arizona. 36-inch reflector by Brashear, but the aperture reduced at different times by eccentric diaphragms to 14, 10, and 6 inches. Magnification 220. Seeing not recorded.

N K. Nakamura, Esq., Kyoto, Japan. Reflectors of 10 and 6.5 inches aperture by Brashear, and Ellison, and apochromatic refractor of 7 inches by Zeiss. Magnifications 270, 240, and 200. Seeing on Standard Scale 6 to 9.

S R. Schofield, Esq., Kobe, Japan. 8.5-inch Calver reflector. Magnifications 235, 245, and 310. Seeing on Standard Scale 7 to 9.

E Dr. F. O'B. Ellison, Colombo, Ceylon. 12-inch reflector. Mirror by Rev. W. F. A. Ellison, mounting by himself. Magnifications 200, 275, and 500. Seeing approximately on Standard Scale 5 to 8.

It will be noticed that Professor Douglass has changed from an 8-inch Clark refractor, used at all the previous apparitions, to a 36-inch Brashear reflector. The 8-inch evidently gave excellent definition, as we find that with it he generally held the record for the largest number of confirmed canals seen by any of our observers. It was returned to Harvard in 1923, at their request, as they wanted to loan it for observations of variable stars. Fortunately Douglass secured the reflector in time for use at the apparition of 1924. Unfortunately, however, for Martian observations, the refractor appears to have been the better instrument, as will appear by Tables III and IV, according to which four of the observers saw many more confirmed canals than he. More complete figures for the whole planet will be given in a future Report. Nakamura also obtained two new reflectors, which he was able to use to advantage for three of his drawings. We are very glad to welcome a new observer this year, Dr. Ellison in the island of Ceylon, who by using one of his brother's mirrors was able to see many canals.

PLATE IX.



Fig. 25
Douglass 354° A



Fig. 26
Nakamura 355° A

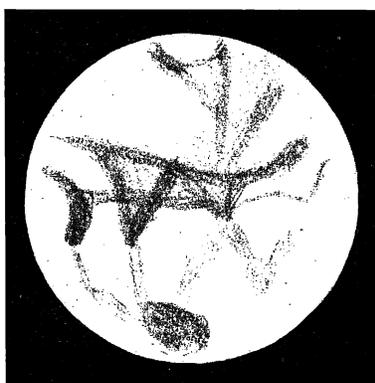


Fig. 29
Douglass 43° B

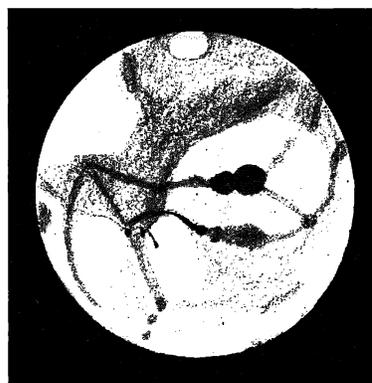


Fig. 30
Nakamura 87° B

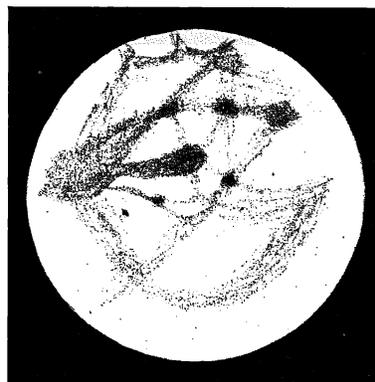


Fig. 33
Douglass 81° C



Fig. 34
Nakamura 108° C

DRAWINGS OF MARS IN 1924.

POPULAR ASTRONOMY, No. 335.

PLATE X.

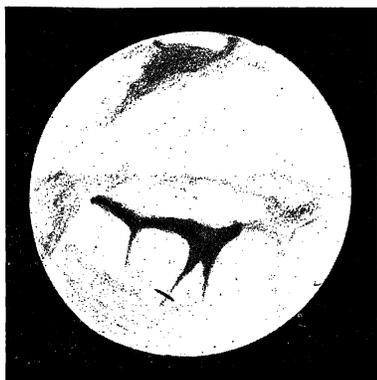


Fig. 27
Schofield 350° A

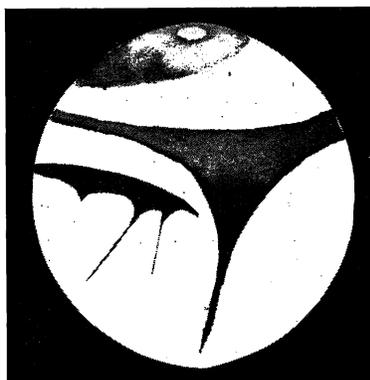


Fig. 28
Ellison 20° A



Fig. 31
Schofield 67° B

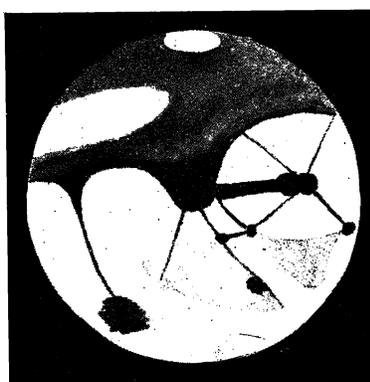


Fig. 32
Ellison 60° B



Fig. 35
Schofield 120° C

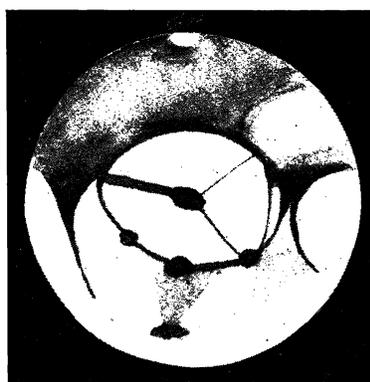


Fig. 36
Ellison 105° C

DRAWINGS OF MARS IN 1924.

As in our former reports, the drawings of the observers are so arranged that all in the same horizontal row shall represent approximately the same longitude on the planet. In the vertical columns the longitudes are intended to differ by just 60° , beginning with 0° . Thus six views of the planet are contributed by each observer, covering the whole visible surface. The six regions are indicated by the letters **A, B, C, D, E,** and **F.** 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 the observer, the aperture of the instrument, the magnification employed, the seeing on the Standard Scale, which is described in Report No. 9, 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, as described in the Ephemeris, and the corresponding Martian Date, taken from Report No. 10.

TABLE I.

Fig.	Ob.	Apr.	Mag.	S.	1924	R. Long.	Δ Long.	Lat.	Diam.	\odot	M. D.
						°	°	°	"	°	
25	D	6	220	—	Sept. 1	A 354	— 6	—16	24.6	248.3	Nov. 33
26	N	10	270	9	Aug. 14	A 355	— 5	—17	24.8	236.8	Nov. 16
27	S	8.5	235,310	7	Sept. 16	A 350	—10	—17	22.5	257.8	Nov. 48
28	E	12	200,275	—	Oct. 25	A 20	+20	—21	15.3	282.1	Dec. 31
29	D	6,10	220	—	Aug. 27	B 43	—17	—16	25.0	245.1	Nov. 29
30	N	7	240	9	Sept. 7	B 87	+27	—16	24.0	252.0	Nov. 39
31	S	8.5	235,310	8,9	Oct. 13	B 67	+ 7	—19	17.3	274.7	Dec. 19
32	E	12	200,500	—	Sept. 14	B 60	0	—16	22.8	256.5	Nov. 46
33	D	6,14	220	—	Aug. 24	C 81	—39	—16	25.1	243.2	Nov. 26
34	N	7	240	7,6	Sept. 6	C 108	—12	—16	24.1	251.4	Nov. 38
35	S	8.5	235,310	8,7	Aug. 1	C 120	0	—17	23.3	228.6	Nov. 3
36	E	12	200	(5)	Sept. 9	C 105	—15	—16	23.7	253.3	Nov. 41
37	D	6	220	—	Aug. 16	D 161	—19	—16	24.9	238.1	Nov. 18
38	N	7	240	8	Aug. 30	D 177	— 3	—16	24.8	247.0	Nov. 31
39	S	8.5	235	7,8	Sept. 29	D 210	+30	—18	20.0	266.0	Dec. 5
40	E	12	275	(7)	Aug. 30	D 200	+20	—16	24.8	247.0	Nov. 31
41	D	14	220	—	Aug. 7	E 244	+ 4	—17	24.1	232.4	Nov. 9
42	N	6.5	200	8,9	Aug. 22	E 247	+ 7	—16	25.1	241.9	Nov. 24
43	S	8.5	235,310	7,8	Sept. 25	E 270	+30	—17	20.8	263.4	Dec. 1
44	E	12	200,275	(8)	Aug. 24	E 255	+15	—16	25.1	243.2	Nov. 26
45	D	6	220	—	Sept. 13	F 292	— 8	—16	23.0	255.8	Nov. 45
46	N	6.5	200	9	Aug. 23	F 302	+ 2	—16	25.1	242.6	Nov. 25
47	S	8.5	235	8	Aug. 18	F 300	0	—16	25.0	239.4	Nov. 20
48	E	12	275	(7)	Aug. 20	F 310	+10	—16	25.1	240.6	Nov. 21

The average date of the drawings was September 3, or 11 days after the opposition. The average hitherto has been 8 days, with a tendency to be earlier in our winter months. Low magnifications were the rule, only one observer on only one occasion venturing to use anything higher than 310. This was perhaps natural, since with the exception of Nakamura's 7-inch, all the instruments were reflectors. Reflectors of the usual size being of short focus, high magnifications are impossible to obtain, without the use of high power eye-pieces, which are objectionable. This difficulty can of course be overcome by means of a Barlow lens, but this device does not seem to be in very general use.

REMARKS OF THE OBSERVERS.

Professor Douglass makes no comment on his drawings, but Messrs. Nakamura and Schofield were both struck by a conspicuous rift in the polar cap nearly parallel to its northern edge, which appeared to them independently on July 9, and which both were certain was covered by a yellow cloud on the previous night. This rift on account of its orientation was a very curious phenomenon of this apparition, and was first detected here on May 10. It was not continuously visible however until later in the season. We were unable to secure any observations here on July 7, 8, or 9, or we might have recorded how it appeared as seen from the opposite direction on the planet to the Japanese observers. The peculiarity of the rift was that it was always seen nearly parallel to the edge of the snow, no matter what the central meridian of the planet. This of course implied a ring structure, and it was in fact so seen by Hamilton for three weeks in June. Channels radiating from it towards the edge of the snow were detected on June 19, 20, and 21. On only June 20 did I get a drawing of it, and the structure then appeared to me to be very irregular, but not as a ring. Two channels were seen that were nearly radial, but neither of them quite reached the rim. This may have been due to invisible cloud, because water does undoubtedly surround the cap in the form of marshes, when the snow is melting rapidly.

On August 14 Nakamura doubled Gehon, and perhaps Euphrates, Figure 26. This is not confirmed elsewhere, and he suggests that it may in this case have been due to the doubling of the images that is often seen in reflectors when first opened for the night's work, due to air currents in the tube. Nectar, Cerberus, Ganges, and Nepenthes were also seen at times to be double, but as is usually the case, no matter what the size of the telescope, they were doubled only by glimpses. He finds the duplication is confined to rather broad sharply defined canals, and he believes it is not genuine, but is perhaps a contrast effect. He also notes that, when a lightly shaded region crosses a desert, he has a tendency to see a canal at the boundary, but he believes that also to be due to contrast. On September 7 he saw clearly four of the dark region canals, Figure 30. He found Juventae a rather difficult object, but Sirenius and a lake at its end, perhaps Biblis, were easily seen, Figure 38. Central clouds were seen over the deserts near Ganges. He detected the marked change that occurred in the shape of Nepenthes. It disappeared in July, but was conspicuous again in August. He as well as Schofield noted a very marked darkening in Libya early in November, which fully explains the complete change in shape of the Syrtis noted here between October 19 and November 18. We must defer a detailed description of it however until our next report.

Nakamura makes an interesting comparison of his 6.5-inch reflector and his 7-inch refractor. Both he says have their individual advantages. The latter is better when the seeing is poor, as is always found to be the case with refractors, but when good, the former gives stronger con-

trasts, and sharper definition, so that the canals are more easily seen with it. He states that the canals always appeared to him broad, and never like spider lines. This of course was due to his small aperture, with which the finer canals would never be visible. He also says that he draws only those canals of which he is sure, never those which he merely suspects, or sees by glimpses. This plan cannot be impressed too strongly on the young, would-be, Martian observer. Dr. Ellison also gives us some very interesting information regarding his last observations of Mars in 1925, but this we must defer to our next report.

THAUMASIA.

This bright area, which immediately surrounds the conspicuous dark marking known as Solis Lacus, is one of the most interesting regions upon Mars, as well as the most striking one in appearance when the southern hemisphere of the planet is turned towards the Earth. The area that we shall consider lies mainly between the equator and latitude 50° south, and between longitudes 60° and 120° . It measures linearly 1900 by 2400 miles, and covers therefore 4,500,000 square miles of territory, or about once and a half the area of the United States or of Europe.

In order to map it, and to discuss the changes occurring within it due to the progress of the seasons, we need at least a few accurate fundamental positions. Eight of these have already been published and mapped in Report No. 33, dealing with the apparitions of 1914 to 1922, when the northern hemisphere was turned towards the sun, and this region was experiencing its winter. The winter solstice of the planet, which was midsummer for Thaumasia, occurred in 1924 during the latter part of our September, when Mars was still quite near the earth, and over $20''$ in diameter. This region was therefore well seen at that time.

A comparison of our drawings made in that year with those made at previous apparitions showed at once that certain changes in detail had taken place, most noticeably in the shape of Solis itself, and the canal Nectar joining it to Aurorae, the mare lying to the east of it. It was seen that the distance from Maeisia to Aurorae had also very obviously increased, and that Phoenicis appeared to have moved farther south. Formerly, during its colder season, the water had reached this region from the melting of the northern polar cap, but now the water was pouring down from the southern one, due to the evaporation and melting of the snow, and it was clear that very different conditions prevailed. It was therefore decided to locate these same eight points over again, based solely on the drawings of 1924. On comparing the results of the two surveys it was found that the longitudes on the average had shifted some two degrees eastward, but that the mean latitude had moved southerly only $0^{\circ}.2$, or about seven miles, owing clearly chiefly to the large southerly individual motion of Phoenicis. Had we been obliged to use the data given in the Ephemeris, it would have appeared

that the mean motion of the eight points in latitude was $-1^{\circ}.4$, or comparing them with their latitudes in 1922, $-1^{\circ}.3$, or about fifty miles southerly. Incidentally this is the direction in which we predicted that the Ephemeris data would apparently cause the whole surface of the planet to move (see last paragraph of Report No. 28). The apparent shift southerly will be continued and increased at this year's and at the next apparition, unless the Ephemeris for 1928 can be corrected before that time.

In Table II, following the name of the station, the second column gives the number of nights on which it was measured during the apparitions of 1914 to 1922 inclusive, and the third and fourth its deduced latitude and longitude, each followed by the probable error of the mean. The next three columns give similar results for the apparition of 1924, and the last two the mean of the two latitudes and the two longitudes. These last are used as the foundation of the accompanying map, Figure 50. In 1924, Nectar for a part of the time did not reach Aurorae except as a threadlike canal, but the eastern end of the canal is the point measured in each of these surveys. The fourth and sixth points are arcs lying in an east and west direction. Their longitudes are therefore indefinite. The map is published on orthographic projection, with the center of the disk in latitude -15° . Consequently when that latitude is central on the disk, with longitude 90° also central, the map will show the planet exactly as it appears in the sky, with no distortion whatever.

TABLE II.
LATITUDES AND LONGITUDES IN AND AROUND THAUMASIA.

Station	—1914 to 1922—			—1924—			Mean	
	No.	Lat.	Long.	No.	Lat.	Long.	Lat.	Long.
Juventae S.	3	-5.0 ± 0.4	62.7 ± 2.0	4	-3.0 ± 0.9	60.4 ± 0.5	-4.0	61.6
Nectar p.	10	-25.5 ± 1.1	63.5 ± 1.2	5	-23.1 ± 0.4	57.8 ± 0.5	-24.3	60.6
Maeisia	5	-11.5 ± 0.5	72.4 ± 1.3	3	-12.3 ± 0.7	72.3 ± 0.7	-11.9	72.4
Solis N.	5	-21.9 ± 0.5	84.7 ± 2.2	5	-24.6 ± 0.3	81.1 ± 1.6	-23.2	82.9
Solis f.	5	-28.0 ± 1.1	94.1 ± 2.1	5	-29.6 ± 0.5	91.0 ± 1.3	-28.8	92.6
Thaumasia S.	4	-46.6 ± 1.0	95.0 ± 1.6	4	-44.2 ± 0.4	87.5 ± 1.3	-45.4	91.2
Phoenicis	7	-12.0 ± 0.8	106.5 ± 0.8	5	-16.8 ± 0.7	105.1 ± 0.6	-14.4	105.8
Thaumasia f. M.	2	-32.8 ± 1.0	124.6 ± 4.4	5	-31.3 ± 1.1	123.8 ± 0.6	-32.0	124.2

A map of Thaumasia on Bonne's conical projection (Figure 49) based on observations made with the great telescope at Meudon has also been published by M. Antoniadi in *L'Astronomie*, 1924, 38, 426. Its limiting latitudes agree well with ours, but its limiting longitude on the west is 5° , and on the east 9° higher than our own. If his longitudes of the other Martian markings differ from ours in the same direction, and to the same extent, that will fully account for his statement, p. 429, and that of M. Baldet of the same observatory, 1925, 39, 35, that the longitudes given in the *American Ephemeris*, on which all European as well as all American observers depend, are about 4° too high. We trust that no change will be made in the longitudes. They appear to us to be correct, as compared with those of the last thirty

years. We have been inconvenienced enough by the former change of $-4^{\circ}.8$ introduced into the Ephemeris in 1896. The two French observers also criticise the latitudes, and what they say there is more or less true, and similar criticisms have reached me from other directions. The mistake made, however, is in supposing that the error exists only in the inclination of the planet's axis. That error is less than 1° . The large error that is causing most of the trouble is, as we have already shown, the erroneous azimuth, which affects the node.

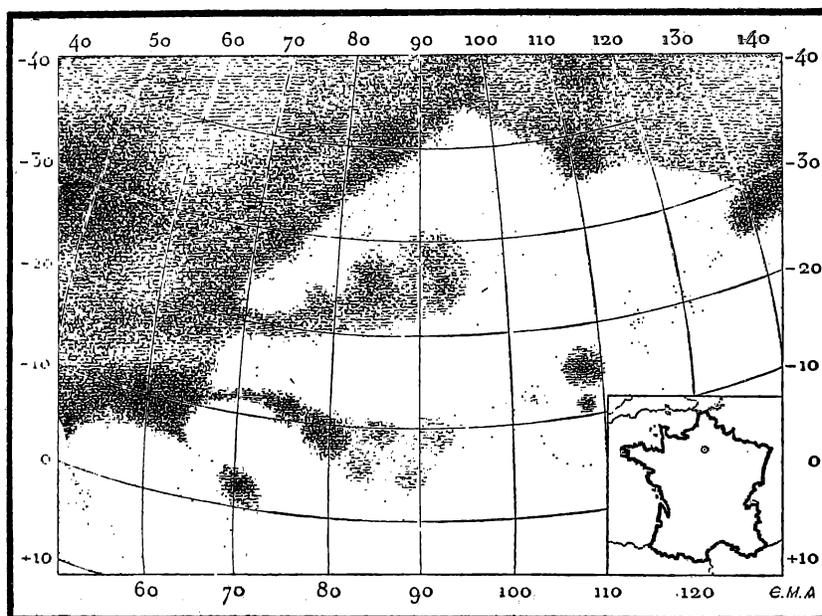


Fig. 49. Map of Thaumasia on Bonne's conical projection, drawn by M. Antoniadi from observations made with the great telescope at Meudon in 1924. From *L'Astronomie*, 1924, **38**, 426.

The details of the map, Figure 50, are taken from my drawings, published and unpublished, modified in those places where it seemed desirable to do so by those of Mr. Hamilton, Dr. Trumpler, and the other observers. Regarding the shape of the principal formations the drawings of these three observers, as may be seen in Report No. 34, are practically identical, the chief modifications necessary relating to the insertion of certain lakes and canals. It should be stated here that no canal or lake has been inserted on the map unless it was seen by at least two observers at this apparition, or unless it was confirmed by some drawing at a previous apparition by some other observer. It will indeed appear later by Tables III and IV that there was but one of the inserted canals, number 16, and only one of the lakes, number 9, which were not seen by at least three different observers.

M. Antoniadi shows perhaps 12 canals in all upon his map, of which

one, Hyscus, although evidently conspicuous, was apparently visible for a few days only, and is therefore interesting. It was not seen by any of our eight observers. It was certainly not visible here in August, when we studied this region very carefully, and it was not seen by any of our Asiatic observers as late as September 14. It was first recognized by one of our European members, Mr. Phillips, on September 17, M. N. 1924, **85**, 184, Plate 8, Figure 1, and was last recorded by M. Baldet on the 19th, Figure 54. The writer obtained two drawings on

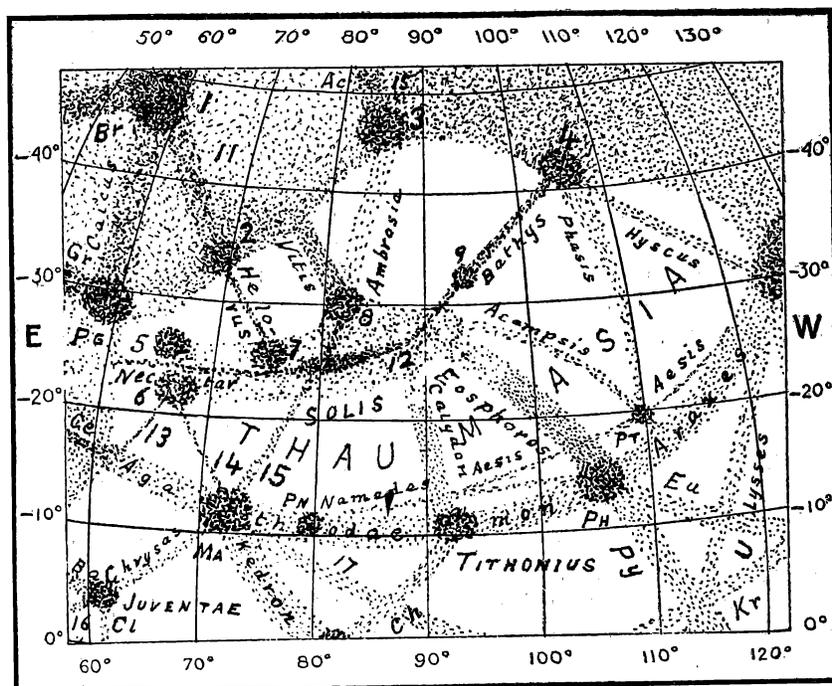


Fig. 50. Map of Thaumasia drawn by Professor W. H. Pickering from observations in 1924.

that same date, made perhaps 6 hours later, seeing 8, and others on September 20, 22, and 28. On none of these drawings was the canal visible. On the last date Hamilton also observed the region, and again on October 1, when he detected 8 of the confirmed canals, but did not see this one. Since neither of us saw the canal, in spite of its obviously conspicuous character to European observers, it is presumable, as far as it is possible for negative evidence to go, that it was not visible after September 19, and perhaps not before the 15th.

Antoniadi's 11 other canals were all seen by our observers, in general by six or more of them. We confirmed in all 23 canals not shown on his map. He shows 23 lakes, of which we were able to confirm 12, the remaining 11 being seen by none of our observers. We wish he had

given us more information regarding these numerous lakes. For instance if they were all seen with one instrument, and by one observer only, or if they were confirmed by others. We also would like to know which ones were seen on more than one night. We attach little value to unconfirmed lakes, and in some cases consider them worse than useless, because misleading, and perhaps non-existent.

It is certainly creditable to his judgment that he should not have recorded any canals of which he was not certain, and that we should have been able to confirm so fully all that he did show. Of the 23 on the other hand which he could not see, four, namely Caicus, Chryso-rhoas, Kedron, and Vitis, were seen respectively by 4, 5, 6, and 7 of our observers. The remainder were all either faint, or more generally were very fine lines. He however, unfortunately, then goes on to state very explicitly that no such lines exist. (Translation) "We affirm in the most categorical fashion that no inextricable system of fine lines exists on Mars." p. 429. We think that he might at least have said that he had seen no such system. That would have been logically more sound than a "universal negation," and would have had the further incidental advantage of being true. M. Baldet of the same observatory, and in the same magazine, for 1925, **39**, 35, makes a similar, but more cautious statement.

We regret to notice in M. Antoniadi's article the unnecessary virulence of his attack on the late Dr. Lowell. Of course Lowell made mistakes, as every one else does, and it is unfortunate that Marth and Crommelin should have put as much of his work as they did into the *Ephemeris*, which affects us all alike. It is also perfectly true that Lowell could not draw. The canals do not look in the least as he depicted them. But at the same time he did a good deal of work which was very good, particularly in regard to the finer canals and more minute lakes, which could not at that time be seen elsewhere. This, his best work, and to which he devoted the most of his time, is that part for which sidereal astronomers now chiefly and wrongly criticize him. That is to say, they say little about the unsatisfactory part of his work, but criticize him for that which is good. I have no doubt but that with the exception of the duplications, which are doubtful, nearly all of the minute canals and lakes that he drew were really there—at the time that he drew them. Many of these canals, however, seem to have been merely temporary affairs, which perhaps were never to appear again in the same locality. Others might reappear for a short time at intervals, and these last we are now endeavoring to identify and segregate—particularly those which, like many of Schiaparelli's, appear regularly at successive apparitions. In the region under discussion Lowell in 1909 drew 21 lakes. Antoniadi in 1924 shows us, as we have just seen, 23.

Some confusion regarding the nomenclature of this region has arisen, since different authorities have given different names to its principal canal, stretching from *Aurorae Sinus* on the left of the map,

PLATE XI.



Fig. 37
Douglass 161° D

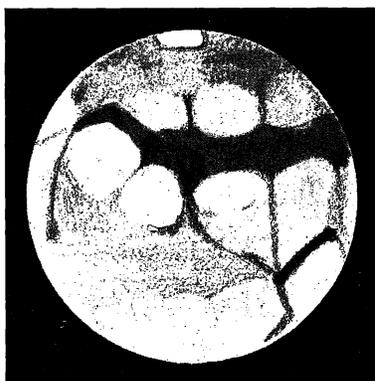


Fig. 38
Nakamura 177° D

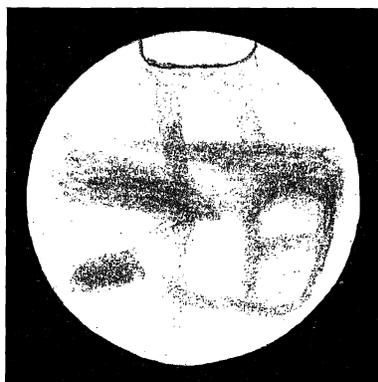


Fig. 41
Douglass 244° E

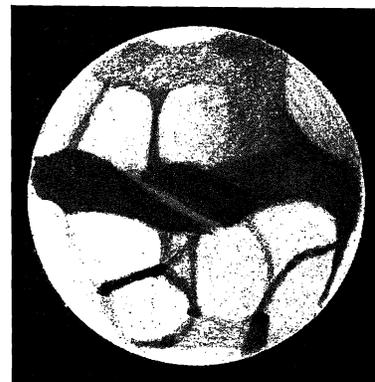


Fig. 42
Nakamura 247° E

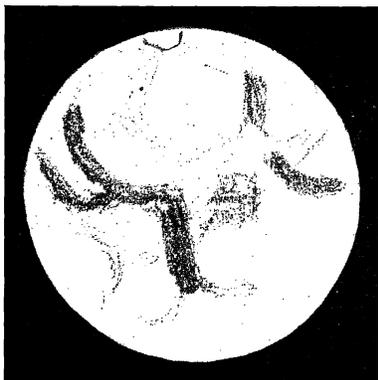


Fig. 45
Douglass 292° F

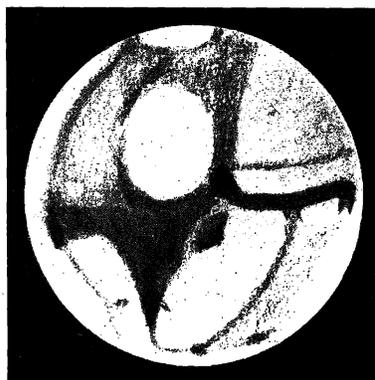


Fig. 46
Nakamura 302° F

DRAWINGS OF MARS IN 1924.

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PLATE XII.



Fig. 39
Schofield 210° D



Fig. 40
Ellison 200° D



Fig. 43
Schofield 255° E

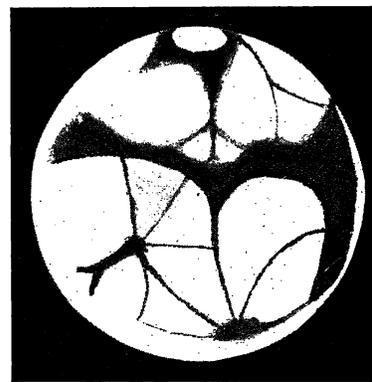


Fig. 44
Ellison 255° E



Fig. 47
Schofield 300° F

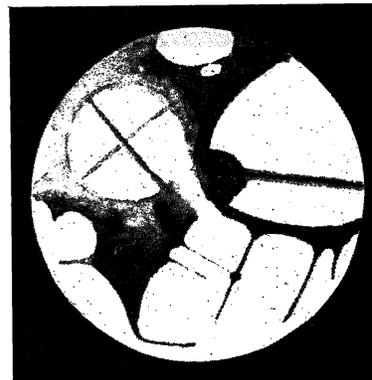


Fig. 48
Ellison 310° F

DRAWINGS OF MARS IN 1924.

to Lacus Phoenicis shown on the right. This canal may for convenience of description be divided into three nearly equal lengths, (a) that portion stretching from Aurorae to Maeisia, (b) that from Maeisia to Tithonius, and (c) that from Tithonius to Phoenicis. In Schiaparelli's original maps of 1877 and 1879 he called the whole of it Agathodaemon. That portion of it near Aurorae he represented in 1877 as two distinct canals uniting before they reached what is now called Maeisia. To the southern of these two branches he applied the name Agathodaemon, and left the northern shorter one unnamed. This southern branch was last seen by him faintly in 1890, and by 1892 at Arequipa it had disappeared. Had he applied the name to the northern branch instead of to the southern one, it is probable that none of the subsequent confusion would have arisen.

Lying to the north of section (b) is a sharply curved canal uniting Maeisia to Messeis and sometimes extending south-westerly to Tithonius. Lowell in 1894 united this curved canal with section (a), under the name of Agathodaemon. Section (b) he called Coprates, and section (c) Daemon. Jarry-Desloges, in his map dated 1913, revives very faintly Schiaparelli's southern branch, which he calls Agathodaemon. Section (a) including its northern branch, and half of the above mentioned curved canal he calls Coprates, and sections (b) and (c) Araxes II. The application of Roman numerals to Martian markings excepting as a temporary convenience, not for publication, is, I think, objectionable. For the northern curved canal the writer formerly suggested the name Kedron, and, since during the five past apparitions it has remained as a fairly conspicuous marking, it is proposed to retain that name for it. Excepting when section (c) is occasionally obscured by temporary cloud, the three sections of the main canal are always visible together. There thus seems to be no occasion for the added names Coprates, Daemon, and Araxes II.

It is accordingly proposed to return to Schiaparelli's original nomenclature, and call the three sections all taken together Agathodaemon. Should the short southern branch near Aurorae ever again appear, a new name will have to be found for it. It was never recorded by Lowell, nor ever seen by myself. The short canal stretching from Solis to Tithonius Lacus, Lowell also named Tithonius. It appears to me objectionable that two different objects in close proximity should have the same name, and especially so if we are going to omit the generic term. We have therefore adopted for this canal the name Calydon, suggested for it and published by M. Jarry-Desloges. The name Nectar we have applied in our survey to the extremely narrow canal joining Solis to the Mare preceding it. It seems to be the nucleus of the wider Nectar, which we have known in former apparitions as well as for part of the time in the present one. Its continuation through the thickened region to the following end of Solis we have numbered 12. Hamilton thought he saw two narrow canals parallel to it on either side, thus making a triple, but this has not been confirmed by others. Vitis

is a name given by Jarry-Desloges, and at this apparition it has been very prominent. Seven previously unnamed canals are shown and numbered. Owing to the objection to giving lakes the same names as the canals leading from them, two of Lowell's names for lakes have been discarded in favor of numbers, and seven new lakes in addition have been discovered and numbered, making 9 numbered lakes in all. Nakamura shows two small lakes on Bathys (Figure 30). One of them, No. 9, was seen by Lowell in 1909, the other was confirmed by

TABLE III.

Name	CANALS VISIBLE IN 1924.										Tot.	P'	H'	L	J
	Ab.	P	H	W	D	T	N	S	E						
Acampusis		+									1	+	+	+	
Acis	Ac.		+				+				2		+	+	
Aesis							+				1			+	+
Agathodaemon		+	+	+	+	+	+	+	+		8	+	+		
Ambrosia			+	+		+					3	+	+		
Araxes		+	+	+	+	+	+	+	+		8	+	+		
Baetis	Ba.	+	+				+	+			5	+	+		
Bathys		+	+	+	+	+	+	+			8	+	+		
Bradanus	Br.	+	+	+			+				4	+	+		+
Caicus		+	+	+			+				4	+	+		+
Calydon		+	+	+	+	+	+	+			7	+	+		
Cestrus	Ce.	+									1		+	+	
Chrysas				+		+			+		3		+	+	
Chrysorrhoeas	Ch.		+	+	+	+			+		5		+		
Clitumnus	Cl.		+			+					2				+
Eosphoros		+	+	+	+	+	+	+			8	+	+		
Eumenides	Eu.	+			+	+	+				3	+	+		
Garrhuenus	Ga.		+	+	+	+	+				5	+	+		
Helorus		+	+								2	+	+		+
Hyscus											0				+
Kedron		+	+	+	+	+	+				6	+	+		
Krith	Kr.										0	+	+		+
Namades						+					1	+	+		+
Nectar		+	+	+	+	+	+	+	+		8	+	+		
Phasis			+	+	+				+		4	+	+		
Pyriphlegethon	Py.		+	+		+		+			4	+	+		
Ulysses						+	+				1	+	+		+
Vitis		+	+		+	+	+	+			7	+	+		
11						+					1	+	+		
12		+	+			+					3	+	+		
13		+		+							2		+		
14		+	+								2		+		+
15			+						+		2		+		+
16		+									1				+
17		+	+				+				3		+		
		20	23	16	12	23	12	9	10	35					

no one else, and therefore by our rules was omitted. He also shows one just to the north of Pnyx, which is not confirmed in that position, and is not far enough north to be identical with one shown on Antoniadi's map. Ten degrees of latitude is equivalent to 368 miles, or 592 kilometers, which will furnish a scale for the map.

In Tables III and IV following the name of the canal or lake, the second column gives the abbreviation by which it is designated upon the map, in case there is not room to print its name in full. The eight

following columns headed by the initials of the observers are arranged as in our previous Reports in the order of the longitudes of their stations. Each column indicates which canals were shown by the observer on his two drawings published in Report No. 34, or in this Report. For Professor Douglass's drawing of region C which we have used here, a maximum aperture of 14 inches was employed. His other drawing, region B, could not be used, since its central meridian was too far from the required longitude, 60° , to be of any use for this purpose. The eleventh column gives the total number of observers who saw each canal, and it may thus be considered as showing the canal's relative visibility. The twelfth and thirteenth columns show all the canals in this region that were seen here in Mandeville, by the two observers,

TABLE IV.

Name	LAKES VISIBLE IN 1924.										Tot.	P'	H'	L	J
	Ab.	P	H	W	D	T	N	S	E	S					
Juventae S.		+	+		+	+	+		+	6	+	+			
Maesia	MA.	+	+	+	+	+	+		+	7	+	+			
Pegasus	PG.		+	+		+				3	+	+			
Petelinus	PT.		+							1			+	+	
Phoenicis	PH.	+	+	+	+	+	+		+	7	+	+			
Pnyx	PN.	+	+	+		+	+		+	4			+	+	
Tithonius		+	+			+	+		+	5	+	+			
1		+	+	+		+				4	+	+			
2		+	+			+				3	+	+			
3		+	+		+	+				4	+	+			
4		+	+		+	+				4	+	+			
5		+	+			+				3	+	+			
6		+	+							2	+	+		+	
7		+	+			+				3	+	+			
8		+	+			+				3	+	+		+	
9							+			1				+	
		13	14	5	5	13	6	0	4	16					

during the months of July, August, and September. Krith was seen a number of times, but does not appear on any of the published drawings. Since three observers saw it however, it is entered on the map. Mr. Hamilton made a special study of this region, and in all his drawings taken together shows 32 confirmed canals out of a possible 35, as against 23 shown in his two published drawings. The two remaining columns refer to observations by Dr. Lowell and M. Jarry-Desloges. They do not indicate however by any means all the canals that these drawings and maps contain, but serve merely to confirm those canals and lakes which otherwise were seen by comparatively few observers. The totals at the bottoms of the columns of both Tables III and IV, curiously enough, serve to divide the observers into two groups, the three who used the larger refractors and the five who used reflectors.

DRAWINGS BY OTHER OBSERVERS.

Fifteen drawings of this formation by eight different observers have now been published in this report and its predecessor. Owing to the general interest in Mars which was aroused at this close apparition, it

was believed that others would be willing to contribute, and in response to requests in several cases, six other drawings of this particular formation have been secured, four of them representing the work of some of the largest telescopes in the world. Especial stress is laid on the size of the telescope, since some sidereal astronomers, particularly on the continent of Europe, still believe that these large instruments are the only ones capable of giving really reliable representations of the planetary surfaces.

Looking now at the canals only, and excluding the coarser Nectar, which of course everybody saw, we find 15 of them lying within the region of Thaumasia south of Agathodaemon and Araxes. Of these 15 Pickering shows 9, Hamilton 10, Wilson 4, and Trumpler 7 on their drawings in Report No. 34. In the present report Douglass shows 5, Nakamura and Schofield each 4, and Ellison 5. Four of these canals were distinctly more visible than any of the others, as is shown by Table III, column 11, and were seen by nearly all of the observers. They are Bathys visibility 8, Calydon 7, Eosphoros 8, and Vitis 7. This group of comparatively conspicuous canals we will select as a test of the remaining drawings, not of their quality, for that depends on the skill of the artist, but as a test simply of the visibility of the finer details which their observers were capable of detecting at this close apparition. The observer who holds the record of observing all four canals with the smallest aperture is Nakamura with his 7-inch Zeiss refractor (Figure 30).

Our first additional drawing is by our fellow member the Rev. T. E. R. Phillips. He feels that little of value can be done on Mars in his latitude, 51° , when the planet is south of the equator, but we hope to hear from him later, now that the planet is again moving northerly. As it is he succeeded in showing three of the four canals with an 8-inch lens (M. N. 1924, 85, 179). Our next drawing is one by M. M. du Martheray of Geneva, Switzerland, with a 5.5-inch French refractor. (*Bulletin Soc. Astron. Flammarion Genève*, 1925, 1, 3). He shows the same three canals. His drawings may be compared also with Figures 32 and 36 by Ellison, with a 12-inch reflector. Both of them saw and represented Bathys and Eosphoros satisfactorily, but one saw Calydon and the other Vitis, these being, as we have seen, the two more difficult ones of the four.

As representative of the first of the larger instruments, a number of drawings were sent me by Professor Menzel made with the 20-inch refractor of the Chamberlin Observatory at Denver. They have now been returned to him at his request, but rather to my surprise but little was shown upon them, considering the excellent locality of the observatory. There may have been one or two out of the four canals visible. Our next figure is by Dr. Steavenson, the present Director of the Mars Section of the British Astronomical Association. The drawing was made with the 28-inch refractor of the Greenwich Observatory, the largest instrument of its kind in the British Empire (*Greenwich Obs.*, 1924,

C 4). Dr. Steavenson is known by his previous drawings to have acute eyesight, and the instrument used should be a good one. He states that the aperture was usually cut down by diaphragms to from 20 to 15 inches, in order to secure steadier definition, and reduce the illumination, although the full aperture was also used. He saw none of the four canals, but he did see *Juventae S*, which as shown by Table IV is equally difficult,—at least for small apertures. Had he reduced his aperture to 8 or 10 inches, it is possible that some of the canals would have been seen, since Mr. Phillips, located but a few miles south of London, saw as we have just seen, three of them with an 8-inch refractor. Dr. Steavenson's drawing was made rather late in the year, on September 24, which puts him at a disadvantage, but Mr. Phillips made one on September 17, not shown here, which shows clearly at least two of the canals. Here in Jamaica we saw five canals in this region on November 1, and two on December 11, when the diameter of the planet was reduced to 9".7.

Our next drawing is by M. F. Baldet of the observatory of Meudon, using the great 32-inch refractor of that institution, the largest telescope of its kind in Europe, and also therefore the largest in the Eastern Hemisphere (*L'Astronomie* 1925, **39**, 33). He saw 15 lakes, of which our observers confirmed 12, but when it came to the selected canals he saw only 3 of them—the same ones that were seen by Mr. Ellison. His drawing implies that large apertures, when well situated, are suited to seeing the Martian lakes. On the other hand it appears that as far as canal observation is concerned, the larger instrument, located where it was, was inferior to the two smaller ones used in Japan.

We now come to a drawing by Dr. Van Biesbroeck made with the 40-inch telescope of the Yerkes Observatory—the largest refractor in the world, but diaphragmed down in this case to 30-inches—and furnished by the kindness of the Director. He too saw a considerable number of lakes, 7 of which we have confirmed, but only two of the four canals that we can certainly identify, namely *Bathys* and *Eosphoros*. These are the two easier ones, which all eight of our observers saw. They appeared to him so wide that we should hardly recognize them as canals. Indeed he himself says in *Ciel et Terre*, 1924, Nov., Dec., p. 276, (translation) "Neither now nor at any other time in the course of the present opposition, have I been able to convince myself of the presence on Mars of anything resembling the famous canals, that geometrical network with which certain observers have so generously decorated the soil of our neighboring planet." Of course he shows *Nectar*, *Agathodaemon*, and *Araxes*, which have always heretofore been called canals, and since the days of Schiaparelli have been so designated upon all maps of this region. He saw no trace of *Baetis* which was very easy this year, and was seen by 5 of our observers. Without doubt his eyesight is excellent, and he saw about what we should have expected, but had he diaphragmed his lens down to ten inches instead of thirty it is probable that he would have seen more.

Our last drawing was made by Mr. Pease with the great 100-inch reflector of the Mount Wilson Observatory, the largest telescope in the world; and was kindly furnished me by the Director. The low latitude of his station, $+34^\circ$, gave Mr. Pease a great advantage over all the European observers, whose most southern station at Geneva, is in latitude $+46^\circ$. His drawing and his description of what he saw is therefore of particular interest. He says "On the nights of July 27 and 28, and again on August 25, the region of Solis Lacus was in a position suitable for observation." August 25 was only two days after the opposition, when the planet was nearer to us than it had been for over a hundred years. It is also the season of the very best seeing for northern observers, so that every condition seems to have been favorable to a fine view in this southern latitude of the most delicate detail. Mr. Pease succeeded nevertheless in seeing only two out of the four selected conspicuous canals, Vitis and Eosphoros. Oddly enough however, perhaps by accident, he also recorded number 13, one of the moderately difficult ones, which was seen nowhere else at this apparition outside of Jamaica, although drawn here on several nights by both Hamilton and myself, and seen by Lowell in 1909. A comparison of Pease's drawing with those of Nakamura (Figure 30), Schofield (Figure 31), and Du Martheray (Figure 52) also makes it clear that he saw distinctly less than either of these observers who were limited to telescopes of 7, 8.5 and 5.5 inches aperture. He saw oddly enough very few lakes as compared with M. Baldet—only 5 that we could identify.

He remarks, "The moments of better seeing showed it (Solis Lacus) resolved into three balloon shaped markings or sinuses. * * * These markings and their connections showed a most exquisite mottling in light and shade, the pattern or blocking itself being irregular in shape and size." These singular balloon shaped sinuses which he was able to see for only a portion of the time, when viewed under the favorable conditions existing in Jamaica, resolved themselves into four very commonplace little lakes, two of which Mr. Pease saw as one. These lakes, numbers 5, 6, 7, and 8 of Table IV, were all of them seen by at least three different observers, and are similarly represented in their drawings (see Report No. 34). What he means precisely by the "exquisite mottling in light and shade" I do not know. The darker areas simply presented their usual uniform shading, except where a lake occurred or a canal crossed them.

That the Mount Wilson telescope is admirably adapted to delicate photographic work, we know from the very beautiful pictures of the moon taken by Ritchey. Dr. Hale, and Mr. Pease himself more recently, have also secured photographs of Mars of the highest excellence. This is probably on account of the short exposures possible, because of the great light gathering power of the instrument. These photographs are indeed so good as to be nearly if not quite equal in definition to Mr. Pease's drawing. This is not the case with smaller telescopes, for instance at the Lowell Observatory, where the photographs are possibly

as good as those taken at Mount Wilson, while the drawings are infinitely better. This at once raises the question whether the quality of Mr. Pease's drawing is entirely explained by the great aperture of the instrument.

Evidence bearing on this question is furnished in the same article by Mr. Pease himself, which is illustrated by his drawing (*Pub. Astr. Soc. Pac.* 1924, **36**, 346). He there states that he is wholly unable to see a very obvious lunar test object, and thought he saw something entirely different in its place. He seems even to have thought that the object I mentioned did not exist. Now it so happens that a few years ago I received a letter from Dr. Hale, in which in referring to a much more difficult test, the dividing of the double canal inside of the lunar crater Aristillus, he wrote that with the 100-inch he could see it very clearly. This proves conclusively that the telescope can do good visual work. This same canal has been divided by Nakamura at Kyoto with his 7-inch refractor.

While the 100-inch telescope is clearly too large to show the finest planetary detail, or to add anything whatever to our visual knowledge of Mars, yet on account of its southern latitude, and the undoubted excellence of the seeing on Mount Wilson, we hope that some other observer, possibly a local artist, as well as Mr. Pease, will make some drawings with it at the coming apparition, and that these drawings will be published. There seems to be no reason why the 100-inch on Mount Wilson, if properly used, should not give as good results as Douglass's Brashear reflector, in the same latitude in Tucson. The telescope has established such a fine reputation for itself in lunar and planetary, as well as in stellar photography, that it seems only fair to Ritchey, its maker, as well as a pity on general principles, not to give it visually another chance. Mr. Pease of course did as well as the other observers with large telescopes. It is merely on account of his low southern latitude and good seeing, together with the excellent photographs that he and others have secured with the 100-inch, that we should have expected him to secure better results.

The results of this last investigation are summarized in Table V, where the third column indicates whether the instrument employed was furnished with a lens or a mirror, the fourth gives the date of the drawing, the fifth the aperture of the telescope, and the sixth the size of the diaphragm employed. The next four columns indicate which of the four canals were detected, and the last the number of them shown. It will be recalled that Eosphoros and Bathys were seen by 8 of our observers, Vitis and Calydon by 7. None of the large telescopes showed this last, and only two showed Bathys. In this test of giant telescopes it will be seen by this column that Meudon came off the best, and detected the most fine detail. It also incidentally scored in the total number of confirmed lakes that were seen with it. In this matter in fact it nearly equalled the 36-inch Lick telescope which showed 13, but it was hardly in the same class with the Lick in the matter of fine detail,

as indicated by the number of canals recorded (see also Table III). The mistake made by the two observers who diaphragmed their lenses was that they used much too large diaphragms. We should hardly expect that diaphragms of that size would produce any noticeable effect whatever.

In case some of my readers may think that I have been unduly severe in my criticism of the work of these observers, I may say that there are still many sidereal astronomers, some of these observers among them, who evidently believe that better work can be done on the planets by sidereal astronomers working with large apertures, than by the planetary astronomers themselves, who work with smaller ones. Also some of these observers, with no experience of their own whatever, have expressed very definite doubt as to the reliability of the careful, conservative, and painstaking observations, of planetary observers who like Lowell have devoted anywhere from twenty to forty years of their

TABLE V.
IDENTIFICATION OF CERTAIN CANALS.

Observer	Observatory	Tel.	1924	Aper.	Dia.	Eos.	Bath	Vit.	Cal.	Tot.
Phillips	Private	L	Aug. 12	8	8	+	+		+	3
Du Martheray	Private	M	Aug. 15	8	8	+	+		+	3
Steavenson	Greenwich	L	Sept. 24	28	20, 15					0
Baldet	Meudon	L	Sept. 19	32	32	+	+	+		3
Van Biesbroeck	Yerkes	L	Aug. 24	40	30	+	+			2
Pease	Mt. Wilson	M	July 27, 28	100	100	+		+		2

lives to these especial investigations. This past apparition of Mars appeared to me to be an unusually favorable occasion to settle the question whether the criticisms of the sidereal astronomers were justified. They spoke very plainly and forcibly in some cases about the work of their colleagues, and I trust that in my reply to them I have not exceeded the usages of good taste. I have endeavored to credit the drawings of all the observers, whether with large or small apertures, with all the canals and lakes that they show. In any case it has seemed to me that the facts should be generally known, not merely to the sidereal astronomers themselves, but to the intelligent public as well, many of whom would otherwise continue to believe that the larger the telescope, the better it will serve for every purpose.

And now a few words in closing with regard to why these great telescopes have not shown us more than they have. Our atmosphere puts a rigid limit on the defining power of any telescope for planetary detail. This limit is far more rigid than it is in the case of double stars. Thus a 20-inch objective with fair seeing will separate a distinctly closer double than a 10-inch one, but for planetary detail there is usually but little difference between them. With poor seeing a 5-inch telescope will show all the planetary detail that can be seen with one of the very largest size. With better seeing we can use a larger aperture to advantage, but even with the best seeing that we have in Jamaica it is doubtful if there would be any advantage gained by using a larger

PLATE XIII.



Fig. 51
Phillips 8-inch



Fig. 52
Du Martheray 8-inch



Fig. 53
Steavenson 28-inch

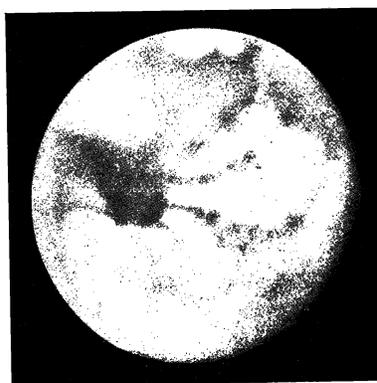


Fig. 54
Baldet 32-inch

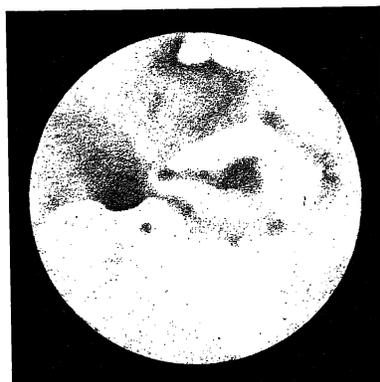


Fig. 55
Van Biesbroeck 40-inch



Fig. 56
Pease 100-inch

DRAWINGS OF MARS IN 1924.

POPULAR ASTRONOMY, No. 335.

aperture than 20 inches. Beyond the limit, the larger the aperture, the less can be seen with it. This is because poor seeing affects large apertures more than it does small ones, the explanation being that the large cylinder of rays joining the objective of the larger instrument to the planet will contain more than one crest and trough of the larger atmospheric waves which cause the poorest seeing, while the smaller cylinder of the smaller telescope will contain only a portion of one wave.

It may be well to give in this place a brief list of the observed dimensions of certain small objects which we are able to see or could detect under favorable conditions with a 10-inch aperture.

The diameter of the first diffraction ring, computed,	1".568
The diameter of a star disk according to Dawes,	0.456
The diameter of a bright star disk, H. A. 61, 43	0.60
The diameter of a faint star disk, H. A. 61, 43	0.35
An equal double which may be detected, Ellipticity 1.06, H. A. 82, 40	0.23
A faint separating band visible, unpublished	0.50
Black parallel lines on white paper separated, H. A. 32, 149	0.63
Bright points in a network of squares visible, unpublished	0.54
A black dot on a white background visible, P. A. 23, 577	0.20
A black line on a white background visible, P. A. 23, 577	0.03

The last two results are given in my Report No. 11. It is because the finest lines are so much narrower than the smallest dots, that the good seeing secured with small apertures gives them an advantage over the larger ones in seeing the canals, while the lakes, regarding which the seeing is not so important, are better seen with the larger apertures. A measured human hair has been clearly seen with the 11-inch Harvard refractor at a distance a little short of a quarter of a mile. At this distance its diameter was only 0".029. A double star as close as that would be far beyond the range of our largest telescopes, even if the seeing were perfect. Owing therefore to the properties of light itself, a *fine canal under favorable atmospheric conditions is a far more delicate test for seeing with a given aperture, than the closest resolvable double star.*

We may quote here the interesting numerical results obtained by M. Jarry-Desloges, one of the leading European planetary observers. He has a 20-inch refractor, and has made a very extensive and elaborate study of diaphragms with it. He writes that he finds that at his observatory one should not usually use an aperture exceeding 14 inches, and that it should be capable of being stopped down to 8.5. Such a telescope he says would possess an advantage over others for planetary research in 95 to 98 cases out of 100. In the remaining 2 to 5 cases it would be inferior to an aperture of 20 inches but in at least 75 cases would be definitely superior to the larger instrument. His observatory is located in Algeria, and his drawings, and evidently his seeing also, are of the very highest grade (*Observations des Surfaces Planétaires*, VI, 340).

At the Lick Observatory the seeing is so excellent in the summer and early autumn, that somewhat I confess to my surprise, Dr. Trumpler

with the full aperture of the 36-inch lens saw about all that Mr. Hamilton and I could see here in Jamaica with our 11-inch. Indeed in some portions of the planet, notably in the desert regions north of Sabaeus he saw more, but in the snow cap less. Of course our aperture was altogether too small to do the best work on Mars. It is probable that if we could have increased it to 20 inches, and if he could have reduced his to the same figure, we should both of us have seen more than we actually did. There are as we have just seen still a few sidereal astronomers left who do not yet understand these simple astronomical principles, but excepting at the Lick Observatory, where we now know that it is distinctly worth while, it is obviously a sheer waste of money to use the time of a large and valuable telescope in attempting to do a kind of visual work for which it is wholly unsuited, and which can be done *much better* elsewhere with a cheaper instrument. This apparently is now well understood at the Yerkes Observatory, and also at Mount Wilson, where with the 100-inch reflector only one drawing of Martian detail was attempted, or at all events published.

The purpose for which very large telescopes are constructed at the present day is not well understood by the public. It is distinctly *not* to obtain better definition for the study of the moon and planets. For that purpose we now know that they are useless. The Yerkes telescope, those at Mount Wilson, and the great reflector at Victoria, B. C., were built expressly in order to gather at one point as much light as possible for the study of spectra, and of faint stars and nebulae. The last of these instruments I believe has never been used for any other purpose, and the others only rarely.

Although not applying so directly to Mount Wilson, another obvious handicap of the remaining three large telescopes just discussed, the Greenwich, Meudon, and especially the Yerkes, is that they lie in the great anticyclone belt of our planet. Within that belt the seeing never is, and never can be, at all comparable to what is usually found in certain more southern localities. In these latter the best planetary observations always have been, and always will be made, and it is of no use for other stations, no matter what their equipment, to try to compete with them. It is not at all a question of the observer, providing, of course, that he has the proper initiative, and if his eyesight is simply fairly good. Anyone with a reasonable amount of skill with the pencil, when suitably located, can make satisfactory drawings of the canals and lakes of Mars.

Private Observatory, Mandeville, Jamaica, B. W. I.

March 15, 1926.