REPORT ON MARS, No. 8.

WILLIAM H. PICKERING.

Early in 1913 it occurred to the writer that it would be desirable to obtain if possible an authoritative representation of the appearance of Mars at the following opposition by a small association of recognized experts. The surface of Mars changes so clearly from one opposition to the next, quite independently of its seasons, that it is certain that the most reliable record possible at each opposition should be left by us to posterity, and the sooner this fact is generally recognized the better.

After consultation with a number of prominent American astronomers, and also with the Council of the British Astronomical Association, it was decided that the writer should invite a certain number of American experts to contribute drawings, and that the Association should similarly invite certain European astronomers to do the same, and that the results should be published in the Memoirs of the Association. A circular was issued by the writer which was sent to all the contributing astronomers, of which the following is an extract:—

"It is proposed that an effort be made to secure drawings of six different aspects of the planet Mars at this next opposition, the drawings being made at several different observatories. The central meridians will be at 0°, 60°, 120°, 180°, 240°, and 300° Martian longitude. It is allowable for the observers if they choose to study the planet upon previous evenings and to make preliminary sketches. They may even sketch in the main features of the disk on the final drawing on a previous night, if they wish, but nothing must be drawn which is not certainly visible within the hour selected. Notes of suspected features, and also a list of those canals which can be held steadily for three seconds, should any such be found, may be added. A statement should also be made regarding the seeing, aperture, and magnification employed. Remarks on the visibility of the finer divisions in Saturn's rings just previous to beginning the drawings would also be useful. Photographs of Mars, taken as soon as possible either before or after the drawings are made, or at corresponding hours upon other nights, would be desirable.

The object of the investigation is three-fold: (A) To determine, as a result of investigation by the most practised living observers of Mars, what should be generally accepted as *definitely known* surface markings. (B) This investigation should also enable us to determine if many of the so-called canals can be seen in the same places on the

Fig. 1
Phillips A

Fig. 2
Pickering A

Fig. 5
Phillips B

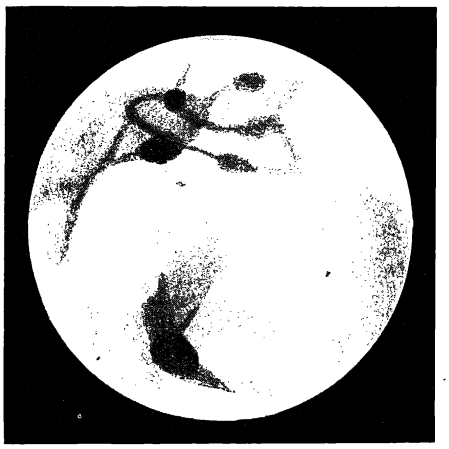

Fig. 6
Pickering B

Fig. 9
Phillips (Sup.)

Fig. 10
Pickering C

Fig. 3
Douglass A

Fig. 4
Slipher (Sup.)

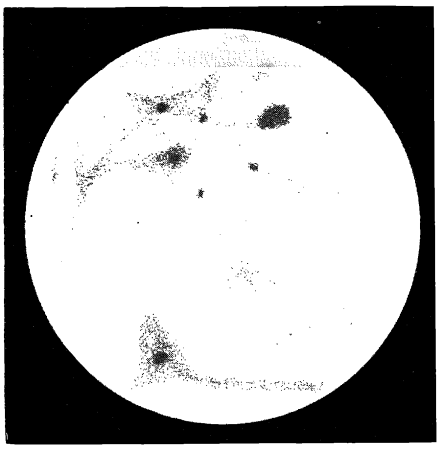

Fig. 7
Douglass B

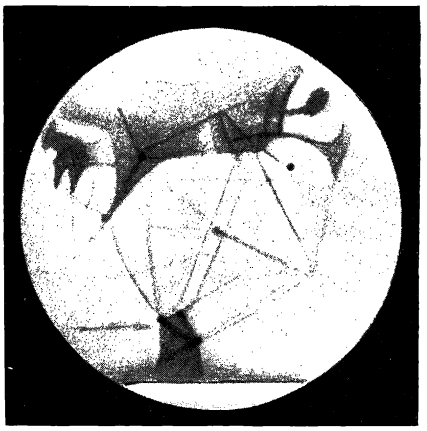

Fig. 8
Slipher B

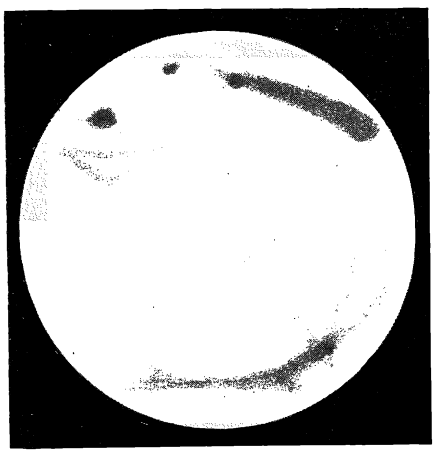

Fig. 11
Douglass C

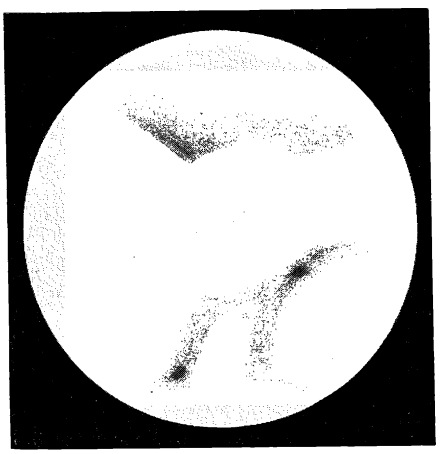

Fig. 12
Douglass (Sup.)

planet, and presenting the same appearance, to different widely located observers, at about the same time. Also, if they can be held in steady vision for an appreciable interval. Our views on their objective reality should be influenced by the result, and the question perhaps definitely settled. (C) It is known that certain astronomers believe, that, where it is not a question of the amount of light, climate is everything, and aperture, within rather wide limits, of comparatively little consequence. If this view is correct, it is certainly desirable to find it out. If it is not correct it is important that that also should be determined."

All the American astronomers invited, except Professor Barnard were able to contribute. He reported almost continuously cloudy weather at the Yerkes Observatory, and when clear the seeing was unfavorable. On the other hand although several European observers had agreed to furnish drawings, only one was able to do so. For various reasons considerable delay in the publication of the results occurred, and the writer finally proposed to the Association, in order to expedite matters, to take the whole question of publication off their hands, and have the results appear in one of his Reports on Mars. To this the Council of the Association very kindly agreed, although some work had been already done by their committee, and indeed their contribution is much larger than appears on the face of it.

The observers who took part, with their equipment are as follows:—

Rev. P. E. R. Phillips, Ashtead, Surrey, England. 12¼-inch reflector by Calver, and 8-inch refractor by Cooke. Magnification employed 230 to 400. Scale of seeing 1 excellent, 5 very bad.

Dr. Percival Lowell and Mr. E. C. Slipher, Flagstaff, Arizona. 40-inch reflector and 24-inch refractor, both by Clark, apertures ranging from full size down to 14 inches. Magnification 365 and 392.

Professor A. E. Douglass, Tucson, Arizona. 8-inch refractor by Clark. Full aperture. Magnification 220 and 340, usually the latter. Seeing on the standard scale, ranging from 5 to 9.

Professor W. H. Pickering, Mandeville, Jamaica. 11-inch refractor by Clark. Full aperture. Magnification 330 and 660. Seeing on standard scale ranging from 10 to 12.

In the four plates illustrating this article the figures are arranged in four columns of six rows each. Each row, as far as may be, consists of views of one of the six selected areas of the planet. The first row shows region **A**, second row region **B**, and so on. When an observer was unable to furnish a complete set of views, the space is filled with a supplementary drawing, as for instance Figure 9 of Plate XV. Each column, as far as possible, consists of the work of one observer, the columns being arranged in the order of the longitudes of their stations.

In general therefore the views on the left were drawn a few days before those on the right. The last column on Plates XVI and XVIII contains three regular and three supplementary drawings, the latter being by Messrs. Slipher, Douglass and Lowell.

In Table I are given the data regarding these views. The first four columns require no explanation. In the fifth the seeing is not given by the Lowell Observatory. Mr. Phillips numbers it in the inverse order to the other observers, 1 indicating his best. The others both use the standard Scale H. A. **61**, 29, so called because each division of the scale can be accurately described and recorded. Perfect seeing with a 5-inch aperture is marked 10 on this scale. Doubling the aperture adds two units to it, which for an 11-inch aperture therefore makes perfect seeing 12. This requires that the outer rings of a bright star shall either be stationary, or else exhibit only a very slow motion, when seen with a ¼-inch eye-piece. Such an eye-piece gives a magnification of about 60 to each inch of aperture. The sixth column gives the date

TABLE I.

DATA RELATING TO THE FIGURES.

No.	Obs.	Aper.	Magn.	Seeing	1913,4	Reg.	Long.	Δ Long.	Lat.	Diam.	M. D.
							°	°	°	″	
1	Pl	12	—	2	Dec. 29	A	5	+5	+6	15.0	Apr. 2
2	Pk	11	330,660	10	Jan. 4	A	5	+5	5	15.0	" 5
3	D	8	220,340	7	" 8	A	352	—8	4	14.9	" 7
4	S	14,17	392	—	" 13	—	315	—	3	14.6	" 10
5	Pl	12	—	2	Dec. 21	B	97	+37	7	14.8	Mar. 30
6	Pk	11	330,660	10	" 31	B	64	+4	5	15.0	Apr. 3
7	D	8	340	8,9	Jan. 3	B	58	—2	5	15.0	" 5
8	S	24,14	392	—	" 6	B	42	—18	4	15.0	" 6
9	Pl	12,8	—	2	Dec. 27	—	28	—	6	15.0	" 1
10	Pk	11	330,660	12	" 25	C	125	+5	6	14.9	" 1
11	D	8	340	8,9	" 29	C	116	—4	6	15.0	" 2
12	D	8	220,340	7	" 22	—	166	—	7	14.8	Mar. 30
13	Pl	12,8	—	1·5,2	Jan. 17	D	174	—6	3	14.3	Apr. 11
14	Pk	11	330,660	10	Dec. 17	D	185	+5	8	14.5	Mar. 28
15	D	8	340	8,9	Jan. 25	D	191	+11	2	13.6	Apr. 15
16	L	40	365	—	" 21	—	229	—	2	14.0	" 14
17	Pl	12	—	1·5,5	" 11	E	231	—9	4	14.7	" 9
18	Pk	11	330,660	10	" 18	E	240	0	2	14.3	" 12
19	D	8	340	7,9	" 24	E	248	+8	2	13.7	" 15
20	S	40	365	—	" 21	E	245	+5	2	14.0	" 14
21	Pl	12,8	—	1·5	" 3	F	319	+19	5	15.0	" 5
22	Pk	11	330,660	11	" 17	F	284	—16	3	14.3	" 12
23	D	8	220,340	5,8	" 13	F	294	—6	3	14.6	" 10
24	S	14	392	—	Dec. 12	F	284	—16	9	14.2	Mar. 25

of observation, the seventh the region of Mars observed, and the eighth and ninth the recorded martian longitude, and difference of longitude from that required by the circular. The tenth column gives the latitude of the center of the disk. The last two columns give the diameter and the martian date.

It is the writer's belief that there are still a few astronomers left who either deny that canals exist on Mars, or else assert that their existence has not yet been proved. For this reason it may be worth while to devote a few lines to considering the resemblances between the accompanying drawings, before entering on the more interesting subject of their differences.

If the reader will examine region **E** and **F** shown in the two lower rows of Plates XVII and XVIII, it is believed that he cannot fail to be impressed the fact that the four observers all saw the same markings and that these markings were real. Figures 16 and 20 were drawn independently by two observers on the same night with the same instrument. The elongated narrow dark areas shown in these nine drawings are the so-called canals. The fact that in some cases, as in Figures 6 and 7, one observer shows a number of canals not shown by the other does not affect the question. When the canals first appear they are often exceedingly faint, broad, and ill-defined. Probably something of this sort was seen in the lower part of the disk, which Professor Douglass interpreted as canals, and which the writer interpreted otherwise. The fact that they clearly saw the same canals in the upper part of the disk shows that these latter canals, like those shown in regions **E** and **F**, actually exist on the planet. It must be remembered that the planet is rapidly revolving on its axis, and therefore that the canals are constantly shifting their places from west to east. The central meridian in these two cases was in longitudes 64° and 58°. In Figure 8 it was only 42°, while in Figure 5 it was 97°.

In saying that the canals actually exist, we mean to say that they are straight or curved elongated markings, and that they are not due to irregularly distributed separated dots and fine detail, not recognizable as such, but integrated by the eye into lines. This latter question has been already dealt with at length in Report No. 6, and need not be further considered here. As to the explanation of the canals, that is still a different question, dealt with in Reports Nos. 6 and 7, and has nothing whatever to do with the present point that the canals so-called really exist as dark elongated markings.

In this Report No. 7 the writer says "The most important question of the observer's personality, however, relates to the proportions and position of the main markings and canals. Here, however, the writer believes that personality has but little effect, and that the general shape is in all these cases pretty accurately represented." It is thought the present series of drawings corroborates this view, and that the drawings presented in the former Report may therefore be relied upon to represent accurately the general form and position of the chief canals and other details, and also the very striking change in character of the detail itself, shown at the various oppositions there represented.

When we come to discuss the differences between the drawings, it should be remembered that the disk of Mars, with the usual magnification of 400, appears nearly twice the diameter of the moon as seen through an ordinary opera glass, although of course not quite so sharply defined. Bearing this fact in mind, it is perhaps rather surprising that the drawings should differ among themselves as much as they do. In some cases, as in Figure 22, the formation of the large dark blue central spot is due to an actual change, of brief duration, already described in Report No. 4. This change, as far as the writer's observations indicate, began January 15, was very pronounced on the 17th, and rather less so on the 18, (see Report No. 6 Figure 2). In February nothing unusual was seen. Another sudden change, although less marked, occurred in the region preceding Solis Lacus (Figures 5 to 8) and is described in Report No. 3. It will be referred to again later. A similar rapid change was observed by Schiaparelli in 1886, in the Lacus Hyperboreus (Flammarion 2, 13).

Such changes however are unusual, and, leaving them aside, it is a matter of interest that the planet should present two distinct kinds of appearance to different observers, the appearance it presents to Messrs. Lowell and Slipher, and the appearance it presents to the other three. It might at first be suggested that this is due to the difference of aperture employed, Figure 20 for instance being drawn with an aperture of 40 inches, and Figure 19 with an aperture of 8. That this is not the true explanation, however, will be seen if we compare Figures 20, 21, 22, and 24. The last three were drawn with apertures of 12, 11, and 14 inches respectively, yet Figure 24 shows the same narrow lines and minute detail represented in Figure 20, drawn with three times the aperture, while it is utterly unlike Figures 21 and 22 where the apertures were very similar.

When the writer erected the first dome and 18-inch telecope at the Lowell Observatory in 1894, he and Professor Douglass saw the canals then exactly as they see them now, as grey markings of appreciable breadth, while Professor Lowell saw them always as fine lines. It is clearly then a question of personality and interpretation of what is seen, not of instrument or atmosphere. Doubtless if Professor Lowell should go to Tucson, he would still see the canals as fine lines, not as Professor Douglass sees them, and *vice versa*. In point of fact the writer holds a somewhat intermediate position between the other two. Sometimes he does see the canals as fine lines, see Figure 6, notably the canal leading to Juventae Fons, which is quite as narrow as anything drawn by Messrs. Lowell and Slipher, about 0″.05. It may be remarked incidentally that the seeing was rather inferior on that night, being only 10, while in Figures 10 and 22, where all the canals are broad, it

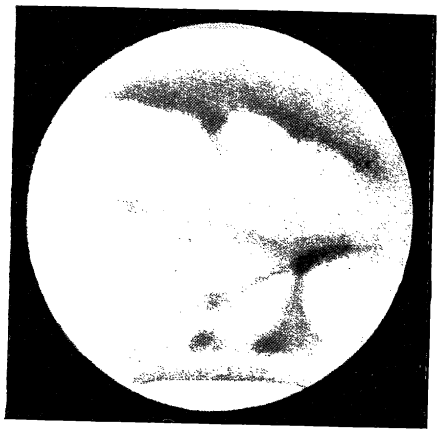

Fig. 13
Phillips D

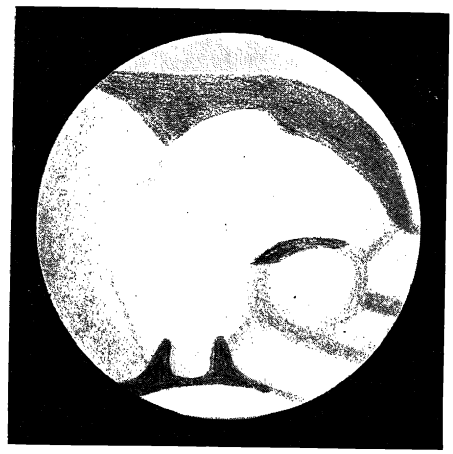

Fig. 14
Pickering D

Fig. 17
Phillips E

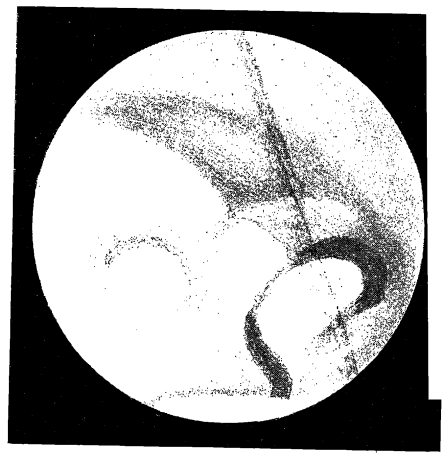

Fig. 18
Pickering E

Fig. 21
Phillips F

Fig. 22
Pickering F

Fig. 15
Douglass D

Fig. 16
Lowell (Sup.)

Fig. 19
Douglass E

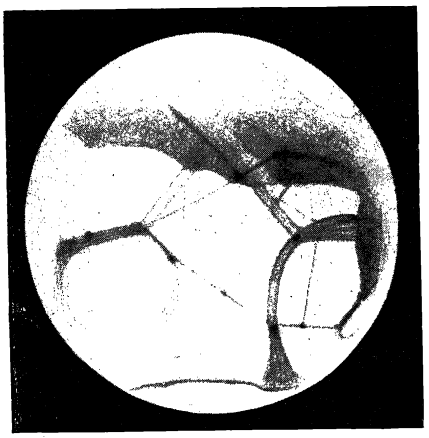

Fig. 20
Slipher E

Fig. 23
Douglass F

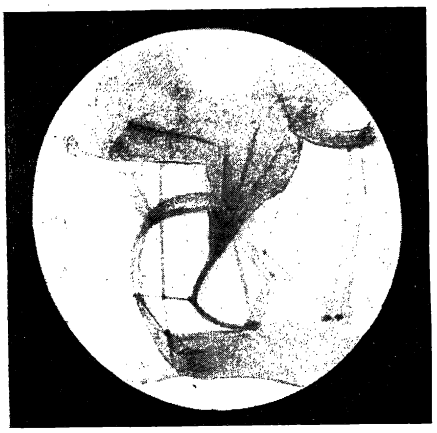

Fig. 24
Slipher F

was 12 and 11. In the writer's case the seeing, if reasonably good, has nothing to do with the appearance, it is a question of the canal itself.

According to his experience the canals are fairly wide markings when they first appear, after the melting of the polar caps, and then gradually narrow as the summer comes on. See Report No. 6. At the next opposition he expects to draw them appreciably more narrow than in his present series of sketches. In the present series it is interesting to note that Messrs. Phillips, Douglass and the writer agree surprisingly well as to their breadth, while Messrs. Lowell and Slipher agree with the others on this point only when they see them double.

In this connection it may be of interest to mention some measures recently made by the writer of the breadth of some of the coarser lunar canals, as a means of testing his Scale of Canals, described in his last Report. The canals selected for measurement were the wide double shown in Figure 1 of Report No. 6, stretching northwest from Tycho, the canal extending northeast from the northern side of Copernicus, and the narrow canal extending from Mare Humorum to Kepler. These were observed with a field glass, the observer being seated at the eye-end of the telescope.

TABLE II.

WIDTH OF LUNAR CANALS..

Canal	Mm	Arc	Miles	Photo	Ratio	Corr	C—P
		"					
Tycho	6.5	72	84	69	.82	70	+1
Copernicus	4	44	51	50	.98	43	—7
Humorum	3	33	38	25	.66	32	+7
Mean					.82		+5

In the table the successive columns give the name of the canals, its width measured on the scale attached to the telescope, this value reduced to arc, and then to miles, the value measured from the photograph in miles, and the ratio of the two. This gives a mean correction to the observed value of one sixth. Subtracting this gives the corrected value, and this minus the photographic value gives the deviations in miles recorded in the last column, which is sufficiently close for measures made at that distance with a field glass.

The number of canals is too few to deduce a reliable correction, the difficulty being that while there are plenty of lunar canals visible with the field glass, when we come to identify them on the photograph, the markings which produce them are of such irregular breadth and shape, that it is very hard to decide what we shall call their real breadth. If the same is true upon Mars, then there is no doubt but this method of measurement gives all the accuracy needed for the work.

In the early days of the discussion as to the reality of the canals, the question was sometimes raised, do the observers who have studied Schiaparelli's maps see the canals in the same places as he, because they have memorized his maps, and have then drawn what they expected to find? Any observer who has seen the canals clearly, would be prepared to indignantly deny such a suggestion as applied to his own particular case. Nevertheless the observations made this year of the point known as Fastigium Aryn lying between the two bays of Sinus Sabaeus indicate that perhaps this suggestion in the case of certain details is not without some basis of fact. Aryn is usually a very conspicuous marking, and as such has been chosen to mark the meridian from which all martian longitudes are reckoned. Some time before the past opposition, the writer made up his mind to make some micrometer measures of the position of this point for comparison with earlier measures made by himself in 1892, and by other observers, in order to determine the period of rotation of the planet. He therefore paid especial attention to the place of this particular marking throughout the opposition, examining it carefully at every opportunity. He did not however clearly see it once. As late as February 14 he recorded "Aryn certainly not visible." It was not until March 21, when the apparent diameter of the planet was reduced to 8″.3, that he was at last able to record "suspect Aryn, but by no means sure of it, on account of distance of the planet." It was then of course too late to measure its position by the micrometer.

Now the interesting feature of this seeming digression lies in the fact that in six of the drawings, numbers 1, 3, 4, 8, 9, and 21, Aryn is distinctly, and sometimes conspicuously shown. Three of the other observers therefore apparently saw it clearly. Moreover their representations are confirmed by some observations and drawings recently sent me which were made by Mr. McEwen of Glasgow. To me the appearance was always as in Figure 2,—a perhaps novel, and certainly unusual form. The question the writer wishes to raise is this: Did four other practiced observers, knowing how Aryn ought to look, and that it generally presented the same appearance, draw it as they thought it should appear, or was the writer especially blind to that particular conspicuous marking? Was this a case of seeing double what was expected to be double, or was it not?

Aryn is so conspicuous between the two bays of Sabaeus in the drawings of both Messrs. Douglass and Slipher, that if they are correct in their representations of it, it does not appear possible that the writer could have overlooked it, even if he had not been searching for it. But it was not that he simply missed it, he was able to use a higher magnification to advantage than they did, and saw and drew something

different. While he admits his minority position, he thinks that he is right in this matter, and feels that he cannot assert too strongly his belief that no observer, no matter how practiced, should take anything for granted on Mars. The more conspicuous and constant a marking is, the more necessary it is to follow this precept.

The writer would point out in this place that in Figure 18 the boundary line between the dark and bright regions near the center is clearly too far to the north, as is shown by the three other drawings of this region. This statement is corroborated by other drawings of the writer, notably one made two nights later. The error amounts to about 1″.2, and is exceptionally large. In Figure 14 the boundary appears to be too far to the south by about half this amount, but this is largely explained by the fact that it was drawn in December when the south pole was more turned away from us than in January, when the other drawings were made. Errors exceeding 1″ do not often occur in latitude in carefully made drawings, at least none other has been found by the writer in the twenty drawings of standard regions here shown and this may be taken as a general statement of fact. Larger errors may occur in longitude however, and would be harder to detect. These might be due in part to phase, and in part to the rapid rotation of the planet, amounting to 550 miles per hour at the equator or 2″ to 3″ at different oppositions, so that unless the main features of the disk are quickly drawn, and the details filled in later, errors will occur from this source.

It is generally supposed that incomplete canals do not exist upon the planet, that every canal both begins and ends either in some other canal, or in some definite dark region. That this is not strictly true is indicated by Figures 9, 13, and 14, where canals terminate near the center of the disk in the open desert regions.

In this connection a list of the canals seen by the different observers may be of interest. Three sets of drawings are nearly complete. Drawings of only three of the required regions were furnished by the Lowell Observatory, and for this reason it was decided, with some regret, not to include them in this investigation. It may be said however that in those regions they indicated more canals than either of the other drawings. The supplementary drawings are also excluded. The identification was made in each case by the writer. This was quite necessary, since different observers would be likely to differ in the case of certain canals. For example Professor Douglass in a list which he transmitted did not include either Nepenthes or Thoth, two canals very conspicuous in his drawings. The explanation is that he apparently did not consider the former to be a canal, on account of its width, and the latter he identified as Amenthes.

Thus in comparing the lists of canals identified by different astronomers it is very necessary to compare their maps at the same time. The writer employed primarily Schiaparelli's map, Report No. 1. Those canals not found on it were identified by the map of the opposition of 1896,7, Annals Lowell Observatory **3**, 100.

TABLE III.

CANALS RECORDED BY MESSRS. PHILLIPS, PICKERING, AND DOUGLASS.

No.	Canal	Pl	Pk	D	No.	Canal	Pl	Pk	D
1	Achates L		F	EF	41	Hades			CD
2	Achelous L	E	DE	DE	42	Heliconius	E	DE	DF
3	Agathodaemon	B	BC	BC	43	Helisson L			D
4	Ambrosia			C	44	Hephaestus		DE	EF
5	Anian		D	E	45	Hiddekel	F		FA
6	Araxes		C	C	46	Hyblaeus	E	DE	DE
7	Arsanias L			A	47	Hydraotes	B		
8	Astapus			E	48	Hylias L			F
9	Ausonium L			EF	49	Indus			AB
10	Baetis L		B		50	Isis L			C
11	Boreas	D	D	D	51	Jamuna			B
12	Boreosyrtis	E	EF	EF	52	Jobares L			B
13	Caicus L		B	B	53	Laestrygon			DE
14	Catarrhactes L			C	54	Labadon L	B	C	C
15	Callirrhoe	FA	A	FA	55	Leontes L			D
16	Casuentus L			F	56	Nectar	B	BC	BC
17	Cerberus	DE	DE	DE	57	Nepenthes	EF	EF	EF
18	Chrysorrhoas	B		C	58	Nilokeras	AB	AB	B
19	Coprates L		B	B	59	Nilosyrtis	F	EF	E
20	Cyaneus L			D	60	Nilus			B
21	Daemon L	B	BC	C	61	Orcus	D		CD
22	Dardanus	B			62	Orontes	F		
23	Dargamanes L		B	B	63	Oxus			A
24	Deucalionis	FA	A	A	64	Phison	F		A
25	Deuteronilus	FA	A	A	65	Phlegethon	D		C
26	Dyras L			EF	66	Polyphemus			
27	Eosphoros		C	C	67	Protonilus	F		F
28	Erebus	D		D	68	Pyriphlegethon			CD
29	Erymanthus L			E	69	Scamander			D
30	Eumenides			C	70	Sonus L			B
31	Eunostos	E	DE	DE	71	Styx	DE	DE	DE
32	Euphrates	F		A	72	Tanais	B	B	B
33	Eurotos	DB			73	Tartarus	D	D	D
34	Galesus L			E	74	Thoth	EF	EF	EF
35	Ganges	B		B	75	Titan		D	D
36	Garrhuenus L		B	B	76	Tithonius L	B	B	C
37	Gigas	B	D	D	77	Triton		E	EF
38	Gihon	F		A	78	Xanthus			E
39	Glaucus L		B	C	79	Anonymous			A
40	Gyndes			CD	80	"	E		

In Table III the first two columns give the number and name of the canal. In case it is taken from Lowell's map the name is followed by an L. The remaining columns indicate the work of the three observers, the letters in these columns indicating the drawings on which the

canals appear. Of the 80 canals observed 52, or two-thirds, were given by Schiaparelli, 26 are taken from Lowell's map, and 2 are anonymous. Of these last, one shown in Figure 3 lies south of Deucalionis, and is in part confirmed by Figures 1 and 2. The other shown in Figure 17 is extremely faint, and is situated south of Cerberus and nearly parallel to it. Mr. Phillips "strongly suspected" it on several occasions, and it is corroborated as a duplication of Cerberus by a drawing of Schiaparelli made in 1883, 4 (Flammarion **2**, 5).

But besides recording all the canals seen at an opposition, it is a matter of interest to record those that are characteristic of it. With this end in view Table IV has been compiled. The first column gives the number of observers by whom the various canals were identified, the second, third, and fourth, the number of canals represented by each observer, and the last the total number. Thus Mr. Phillips saw 24 canals confirmed by the other two observers, he saw none confirmed by the writer alone, but 9 that were confirmed by Professor Douglass. He saw 5 which neither of the others was able to confirm, 38 in all. The last column indicates that there were 24 canals seen by all three observers, 21 seen by only two, and 35 seen by only one, 80 in all. Professor Douglass saw many more canals than either of the others. The writer saw the fewest, moreover two of his canals were located in region **C** not observed by Mr. Phillips.

TABLE IV.

SUMMARY OF CANALS VISIBLE.

Observers	Phillips	Pickering	Douglass	Total
3	24	24	24	24
2	0 Pk	0 Pl	9 Pl	—
"	9 D	12 D	12 Pk	21
1	5	1	29	35
Total	38	37	74	80

It is possible that the writer was too conservative in deciding what canals he should enter on his drawings. He believes that it is always well to discover too little, rather than too much, and he made it a point to draw nothing that he could not hold in steady vision for as long a time as he chose to look at it. As a result he has but one canal that is not confirmed by one or both of the others, and that one Baetis, leading to Juventae Fons in Figure 6, is confirmed by Mr. Slipher in Figure 8. He feels convinced that all the canals he drew were really there, but at the same time he is quite prepared to admit that all that the others drew, and that he himself did not see, were there also.

The 24 canals that were so clearly seen and accurately drawn by all three observers that there seemed to be no question of their identity in the drawings, have been identified by the writer as Achelous L, Agathodaemon, Boreas, Boreosyrtis, Callirrhoe, Cerberus, Daemon L, Deucalionis, Deuteronilus, Eunostos, Gigas, Heliconius, Hyblaeus, Lapadon L, Nectar, Nepenthes, Nilokeras, Nilosyrtis, Phlegethon, Styx, Tanais, Tartarus, Thoth, and Tithonius L.

Of these the five Boreosyrtis, Cerberus, Nepenthes, Nilosyrtis, and Thoth were markedly conspicuous. Callirrhoe, Heliconius, and Tanais merely marked the southern border of the melting northern polar cap, and for that reason should perhaps hardly be classed as canals. At all events they differed from the others.

The twenty-one canals which were seen or suspected by two observers are Achates L, Anian, Araxes, Caicus L, Chrysorrhoas, Coprates L, Dargamanes L, Eosphoros, Erebus, Euphrates, Ganges, Garrhuenus L, Gihon, Glaucus L, Hephaestus, Hiddekel, Orcus, Phison, Protonilus, Titan, and Triton. The thirty-five canals seen by only one observer are Ambrosia, Arsanias L, Astapus, Ausonium L, Baetis L, Catarrhactes L, Casuentus L, Cyaneus L, Dardanus, Dyras L, Erymanthus L, Eumenides, Eurotas, Galesus L, Gyndes, Hades, Helisson L, Hydraotes, Hylias L, Indus, Isis L, Jamuna, Jobares L, Laestrigon, Leontes L, Nilus, Orontes, Oxus, Polyphemus, Pyriphlegethon, Scamander, Sonus L, Xanthus, and two anonymous canals. A number of these faint canals doubtless owe their presence on this list solely to inaccuracy of the drawings. Had they been more clearly seen, and therefore better drawn, they would have been found to coincide with some of those on the preceding list. On the other hand it must be remembered that these lists do not by any means contain all the canals observed at this opposition, even here in Jamaica, but only those found on a few selected drawings made durings a period extending a little over six weeks. Other drawings by the writer confirm several of the canals mentioned in this last list.

The question may now be properly raised how many canals is it worth while to observe. To know the ten, twenty, or forty most conspicuous and characteristic canals of an opposition is a matter of interest, but to print a list of a couple of hundred is of no interest at all. The writer recommends that in future observers who see great numbers of canals should divide them into two lists, one list containing forty or fifty canals that can be steadily held, and the other list the more difficult ones that can only be glimpsed.

Allied to this discussion is the question of how many canals it is proper to name. There are now several hundred names on our lists, and until recently they have been rapidly increasing. It is worse than

the case of the asteroids, because we know at least that the latter when once named are all there. Some of the canals on our lists should certainly be identified with other recognized canals. This is in part due to different observers giving different names to the same canal, in part to errors of identification, and in part to the occasional transverse or angular displacement of the canals themselves. Thus the same canal when occupying two slightly different positions or presenting two different position angles will receive two different names. The writer would recommend that at each following opposition all canals that have not been seen for fifteen years should be dropped from our lists. The problem would thus gradually solve itself, at least in part.

An interesting illustration of shifting canals similar to those mentioned in Reports Nos. 6 and 7, is shown in Figure 14, where Gigas and Tartarus join Titan just below Sinus Titanum, instead of joining the Sinus directly, as is usually the case. This drawing was made December 17, and is confirmed by others on December 18, 19, 22, and 23. By January 13 however, in Figure 13, Mr. Phillips shows Tartarus in its usual position. In Figure 15, January 25, Professor Douglass shows both Gigas and Tartarus as they are usually drawn, and this is corroborated by a drawing of the writer made February 1. The canals apparently travelled some 300 miles across country in about three weeks, that is at a speed of 15 miles a day. In that time they traversed their full breadth.

An early observation of shifting was recorded by Schiaparelli in the case of a straight nearly meridional canal, measuring 3000 miles in length, and designated by him as Euphrates-Arnon-Kison. This canal which in 1886 had pointed to the left of the northern polar cap, in 1888 pointed to the right of it, a shift of some 400 miles at the cap (Flammarion 2, 18). Such observations, while perhaps favorable to the idea of intelligent direction upon Mars, do not strengthen the theory of irrigating ditches.

While by far the most marked change that occurred while these observations were being made is shown in Figures 22 and 23, yet unfortunately comparatively few other drawings were obtained at this time, to indicate to us exactly how it happened. We are more fortunate regarding the minor change exhibited in Figures 5 to 8, 10 and 11, and certain other drawings. In Figures 5 and 10, made December 21 and 25, there are no sharply defined lakes, although in the latter a lake bordering the southern cloud cap is beginning to form. In Figure 11, made December 29, this lake, another preceding it, and Solis Lacus are clearly defined. An unpublished drawing by the writer made the next night confirms the first and last of these, shows Tithonius Lacus forming, and Juventae Fons sharply defined. The southern cloud cap had

entirely disappeared, but there is an indistinct light hazy band of cloud, described as resembling a causeway, in the interior of the *mare*, where the lakes and canals appeared the next night. In Figure 6, made December 31, these lakes and canals are clearly shown, where the previous night, with better seeing 12, none at all were visible. Figure 7, made January 3, shows Solis Lacus and the lake to the north of it identical with Figure 6, but the remaining lakes are all reduced in size, while the anonymous interior one to the south of Auri is replaced by two smaller ones. A drawing by the writer made January 5 shows no trace of Auri or the interior lakes, and this is confirmed by Figure 8 made the next night by Slipher. The most natural explanation seems to be that the lakes were marshes which quickly formed and evaporated under the low atmospheric pressure.

TABLE V.

LAKES RECORDED BY MESSRS. PHILLIPS, PICKERING AND DOUGLASS.

No.	Lake	Pl	Pk	D
1	Acidalius			A
2	Acube			DE
3	Ambrosia L		B	B
4	Anonum L			B
5	Auri L		B	B
6	Bathys L		C	C
7	Juventae		B	BE
8	Lemurum			E
9	Minor L			B
10	Protei L	B		
11	Messeis L	B		
12	Moreh L	D		
13	Niliacus	A		
14	Propontis	D		
15	Triv. Charontis	E		DE
16	Solis	B	BC	BC
17	Syrenius L			C
18	Titanus			D
19	Tithonius		B	B
20	Anonymous		B	
21	"	D		D
22	"	E		E

Table V is arranged like Table III, and gives a list of all the lakes recorded by Messrs. Phillips, Pickering and Douglass. Only Solis Lacus was seen by all three observers, eight lakes were seen by two, and thirteen by a single observer.

In conclusion certain facts stand out as a result of this comparison of drawings of identical regions made under diverse conditions, which should I think be more or less encouraging to the amateur. The first is the high quality of the results obtained by Mr. Phillips under an

English sky, as is indicated not merely by the large number of canals seen, but also by the accuracy of the general detail represented. Moreover, in a note he writes that the seeing was unusually poor at this opposition. Whether he can do equally well relatively to the southern stations, at the next two oppositions, when the canals become narrower, will be a matter of interest.

Another interesting point is the comparison of Figures 19, 16 and 20, made respectively with apertures of 8 and 40 inches. While differing in the style of representation as already mentioned, there is no canal or other feature common to Figures 16 and 20 not shown by Professor Douglass in Figure 19. Outside the dark regions each drawing shows two or three canals peculiar to itself. Within the dark regions Professor Douglass, who specializes on this portion of the planet, shows a number of canals not seen by the others. Regarding the duplication of the canals, Schiaparelli discovered it with an aperture of 8 inches; Douglass declines to admit its existence even when seen with an aperture of 24. One of the main objects of this investigation, as stated in the original circular, was to determine the importance of very large apertures. Dr. Lowell and the writer have always claimed that for the study of bright planetary detail they were of little if any advantage. Thanks to Dr. Lowell's coöperation, I believe that we have proved such to be the case. The proof is more complete than the writer had originally planned, because here we have an expert on Mars at each telescope.

Thirdly it is thought that the public, who have been brought up to believe that the canals of Mars always appeared as straight spider lines, will be a little surprised to find that most of the representations of them show them as broad, hazy and curved bands. Except in curves of great radius they are never sinuous.

Finally, the writer wishes to express the opinion that future observers of Mars should specialize more on the constantly changing details of the larger features of the planet, and devote less time to the very faintest canals. It is believed that our knowledge of life on the planet will be more rapidly advanced by studying those remarkable changes, whether their accomplishment requires days or years, than it will be by mapping one hundred canals, twenty of which are so faint that no other observer can fully corroborate them, and which, even if they are there, are of no particular consequence.