REPORT ON MARS, No. 11.

WILLIAM H. PICKERING.

Drawings of Mars.

At the close of the coming opposition it is proposed to publish a series of drawings similar to those which appeared in Report No. 8, with the idea of giving to future astronomers the best idea possible of the appearance that the planet presented in 1916. Several well known observers have already promised to send drawings, but as it is possible that some one unknown to the writer may now be capable of producing work of the highest merit, it has been decided to invite not only all of the Associated Observers of Mars, but also all others who may be interested in the project, and who think they are obtaining results more or less comparable to those published in Report No. 8, to send their drawings to the writer, and the best series will be published. Drawings made with a less aperture than five inches will not be likely to show enough detail to be accepted for this purpose. Those interested should carefully read Report No. 8, and study particularly Table 1.

Six drawings are to be sent by each competitor. The central meridians should coincide as closely as possible with longitudes 0°, 60°, 120° 180°, 240°, and 300°. The drawings must be carefully finished, and should measure 3 inches (76mm) in diameter. Each of the original sketches on which the drawings are based must be finished at a single setting, and *no details, canals or lakes inserted on the drawing that are not seen that same night.* This is important, since a complete change in some particular detail may occur within twenty-four hours, and two canals for instance that are never seen at the same time, might thus apear on the same drawing. In each case the date, the times of beginning and ending, the aperture, magnification, and seeing should all be recorded. The observers' initials should be placed upon the back. The drawings should be made between January 10 and March 10, 1916, and all must be mailed to the writer before April 1, addressed Harvard Astronomical Station, Mandeville, Jamaica, B. W. I.

Those drawings not published will be returned at the request of the sender. Since a certain amount of contrast is always lost in publication, allowance should be made for this fact. Indeed, light pencil markings are not shown at all in a reproduction. If it is not possible to obtain a complete set of six drawings, all that are obtained should

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nevertheless be sent, since the whole or portions of the set may still be published, if they are exceptionally good. These drawings it will be noted are *quite independent* of those to be sent regularly by the Associated Observers, which are for study, and which will not in general be published.

Observers are particularly cautioned not to try to see too many canals. Don't insert any of which you are not perfectly sure. It is better to leave out three real canals than to put in one that isn't there. Difficult features are always uncertain, and their delineation is of doubtful value. What we lay stress on is that the obvious features should be drawn correctly. These features are subject at times to marked changes, and it is believed that these changes are of more interest and importance in solving the economic problems of life on the planet than anything else observed upon it. It is because they are so marked, so very much more so in fact than anything that occurs upon the earth, or indeed elsewhere in the universe, as far as our telescopic powers carry us, that Mars has for us such an absorbing interest.

The quality of a drawing therefore will not be determined to any great extent by the number of canals shown upon it, indeed too many canals will certainly count against it. On the other hand unless a certain number are clearly seen by the observer it is of no use to send the drawings. The width of those canals shown is considered to be a matter of considerable importance. The qualification pre-eminently sought however is accuracy of the coarser detail. Dividing the canals and lakes on any given competing set of drawings into three classes (a) those that most of the individually invited observers see, (b) those that a few of them see, and (c) those that none of them see, we may express the method of qualification of the competing drawings mathematically, somewhat as follows:—

Let the quality and accuracy of the drawings of the coarser detail of the competing set, as judged by comparison with the work of the individually invited observers, be represented by Q, then the qualification of the competing set will equal $Q + Aa + Bb + Cc$, where A, B, and C are constants for all the competing sets. Let us make A equal 1, and give B a small positive, and C a large negative value. A high positive value of the combined second and fourth terms will then indicate that a drawing resembles a composite of those furnished by the individually invited observers, while a high value of the third term will place a premium on any improvement shown by the competitor. We may determine the value of C by making the second and fourth terms neutralize one another for the mean of the individually invited observers, that is C will equal $-\frac{Aa}{c}$. It then merely remains for us to

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exercise our judgment as to what values to attach to Q and B.

The chief object of this proposed competition however is not simply to publish the best set of drawings of Mars, but rather to determine the names of several observers working under favorable conditions in different portions of the world, and having the facilities and capacity for doing the best work, and that most suitable for publication. It is desirable that these names should be discovered at as early a date as possible, and it is therefore hoped that no one will be too modest to send in his drawings, even if he is not one of the Associated Observers. There are indeed so few well known observers of Mars, that he should consider it his duty either to publish his drawings himself, or else to make himself known in this manner, whether his drawings are published or not.

It is a debatable question whether the point of Aryn, within the forked bay of Sabaeus, appeared at all at the last opposition. There is good evidence on both sides of the question. It has been pointed out by Lau, *A. N.* 1915, **200**, 44, that according to the observations of Schiaparelli in 1886 and Comas Sola in 1900-01, that at aphelion oppositions Aryn is never well seen. Lau himself was unable to see it in 1914, but his telescope was rather too small to furnish reliable evidence on so delicate a question. All observers are requested to record the date this winter on which it is first certainly visible to them.

Beginning of Observations.

The observations on Mars began this year at Jamaica on July 18. The aperture of the telescope is 11 inches (28 cm) and the magnification unless otherwise stated 660. The solar longitude ⊙ as seen from the planet was 310°.7 and the corresponding Martian date on the new calendar (see Report No. 10) January 22. The longitude of the central meridian ω was 90°, the latitude of the center $-7°$, and the declination of the sun as seen from the planet $-18°$. The diameter corrected from the ephemeris to that employed in 1914 (see Report No. 10) was but 4″.8. In order to avoid repetition, these data for all of the observations will be found collected in Table I.

The detail observed was insignificant and uncertain, consisting simply of a suspected dark area in the southern hemisphere. In spite of the Martian date, January 22, there was no snow visible near the northern pole of the planet, nor even any brightening due to cloud. Yet on this date the sun reached within 18° of the pole, or to latitude 72 N. This however is not unusual. In 1913 the brightening was first detected on M. D. January 25, or three days later. Little detail indeed had been expected, the purpose of the observation being to test the new blue

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source of illumination, and thus to determine the real color of the planet. A black paper mask with a hole eight millimeters in diameter placed on the record book gave a disk of the proper size.

Using a carbon filament of 2 candle power the correct distance of the light was found to be 9 inches, and the proper color for the paper that of yellow ochre. This was of interest since on three occasions in 1914, ⊙ 25°.1, 50°.6, and 62°.9, white paper itself was found to be too red (see Report No. 9). On substituting tungsten for the carbon filament the only change noted was that the color of the planet appeared redder, and was now best matched by a combination of yellow ochre and raw sienna. It matched in fact very closely the color represented in the illustrations of Report No. 10, which if viewed by a tungsten light should therefore give a very good idea of the appearance of the planet. The combination of blue glasses that had been found to give with tungsten the color of direct sunlight was next tried. This so far reduced the light, that to obtain the proper illumination a 5 c. p. lamp was substituted for the other. Even this had to be placed at a distance of but 2.5 inches from the paper. The effect on the color of the disk was striking. The yellow ochre and raw sienna no longer matched the planet, but we now had to use a sheet of paper colored by a combination of dragon's blood and Saturn red, which nearly matched a moderately dark brick. This then is the true color of the surface of Mars, and is not unlike that of the soil in some of our southern states.

In this connection it may be pointed out that by a species of color analysis, just as white indicates to us snow, yellowish white, cloud; blue, water; green, chlorophyl in vegetation; so red indicates oxygen in the form of iron oxides in the soil,—oxygen the source of all life and growth. There is indeed no compound abundant upon the earth other than an oxide that could give us that striking and characteristic red color. Were it needed, we thus have a strong indication of the presence of this necessary element in the crust of our sister planet.

The next observation was made August 27, corresponding to the revised Martian date of February 5. Central longitude 63°. The most conspicuous feature was the brightening near the north pole, which appeared to be due to cloud rather than snow. In 1913 on September 17 at ⊙320°.9, corresponding to the revised M.D. January 39 (see Figure 1), a broad dark area 400 miles in width followed the course of the Ganges from the northern snow to the southern maria, its direction lying about 20° to the east of south (see Reports Nos. 1 and 2). By October 30, M. D. February 17, Figure 2, it had spread to the east as far as Sabaeus, and had thus broadened to a width of 1500 miles! It clearly connected the dark northern area due to the melting snow, which had already formed, with the southern maria where the vegetation was now developing.

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Its first observer seems to have been Secchi, in 1858, who represented it at that time as curved, and less than 100 miles in width (Flammarion **1**, 138.) It was first seen fairly broad by Dr. Lowell and the writer at Flagstaff, in 1894 (Flammarion **2**, 130, 189). This time it appeared straight and 200 miles in width, but did not reach north of Lunae Lacus. It seems next to have been observed as a broad band by M. Jarry-Desloges in 1909 and 1911 (Observations des Surfaces Planetaires **2** Plates 6 and 7, **3** Plates 7 and 9). He represents it as straight, and reaching from the southern maria to the band surrounding the melting snows, but its breadth never exceeded 400 miles.

It would appear therefore to be a phenomenon of recent development as far as concerns its great size, and clearly one of considerable importance judged by that fact and by its conspicuous character. It probably only escaped general notice in 1913 because it presented itself so early in the season, before most observers had begun work on the planet. By November 30, 1913, ⊙ 359.9, M. D. February 55, Figure 3, it had largely faded out, but its eastern progress had been continued, and it reached from the eastern side of the forked bay of Sabaeus as far west as Margaritifer. It had also shifted its position angle from 20° east of south, to 20° west. To express these changes in another way, it may be said that it had shifted its northern end about one-third way around the polar cap, slowly draining the whole of that sector of the polar snows. It should be particularly noted that it shifted towards the geographical east, that is, to lower longitudes. The polar marshes all shifted towards the west.

As a recently developed Martian phenomenon it was of especial interest to look for it this year, although the planet would be very remote at the time. The favorable solar longitudes in 1913 extended as we have seen from 320°.9 to 359°.8, or practically to the vernal equinox. At the observation made this year, the longitude was 332°.9. With considerable interest therefore it was noted, Figure 4, that the most conspicuous marking on the disk after the polar cap was a broad dark band lying in a nearly north and south direction, but inclined about 10° to the west of south. It reached from the polar cap to the southern maria. Its breadth was about 1200 miles, and its length 1800. Next in visibility came the southern maria themselves, and then a very faint narrow band bounding the cloudy polar zone on the south, and due to the melting snow. Certain of the Associated Observers who were near enough, those located in the United States and Europe, have been informed of this development, and the dates given on which it should be visible to each of them. Should it persist until the next presentation of the planet, it is to be hoped that some of them will secure observations of it.

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At this season of its year the whole atmosphere of Mars is filled with haze, which more than the small size of the disk renders observation difficult. In 1913 the haze disappeared at ⊙ 358° or just before the equinox. It is expected therefore that after the middle of October clearer views of the surface may be obtained.

Our next observations were made on September 8, corresponding to the M. D. February 17, central longitudes 292° and 309°. The most conspicuous feature was naturally the Syrtis Major, but the southern maria and the dark boundary of the melting snow were also visible. The last appeared bluish white, and it was thought to be really snow seen between the martian clouds. In 1913 the first snow between clouds was seen M. D. January 23. As compared with that date, and M. D. February 28 of the same opposition, the dark band connecting the Syrtis and the snow cap was much broader and more marked at the present observation. It reached indeed a breadth of over 600 miles, the region following it being much brighter than that preceding it.

Perhaps the most interesting feature of this observation was the complete change which had taken place in the color of the desert regions of the planet since our first observation, July 18, M. D. January 22. This was shown both by the tungsten and carbon lamps. By the former we found the color of the planet was matched in the first instance by a mixture of yellow ochre and raw sienna. It now was matched by golden yellow. By the carbon lamp the former color was yellow ochre; we now found that even white paper was slightly too red. Both lights therefore showed that the planet had lost much of its red color in the seven weeks which had elapsed. Identically the same lamps were used on both dates, and the same storage battery, which had slightly run down in the mean time. This could not have been sufficient to have affected the result however, as the voltage was practically unchanged, and a considerable difference would have been necessary to produce so marked a change in color.

Our next observation was made September 14, corresponding to M. D. February 23. Central longitude 252°. The color observations were repeated and confirmed, except that with carbon, white paper was now markedly too red, and should even have been tinted a light green. With the standard blue tint, giving the planet's true color, it was found to match a mixture of chrome orange and carmine, giving a much more orange, and less red color than we had found on July 18. That the soil or vegetation growing in the so-called desert regions of the planet really changed its color does not by any means follow. The effect is more likely due, either to innumerable minute and invisible clouds, or else general martian haze, produced by the melting of the snow cap at this season of the year. But whatever the cause, the effect was undoubted and striking.

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The northern polar cap was very faint and thought to be due to cloud, not snow. The south pole was the same color as the rest of the disk. The maria were distinctly grey, not green. In 1913 they did not begin to turn green until M. D. February 44. It was noted that Mars was 0.2 of a magnitude brighter than Pollux, which was near it, and 0.6 fainter than Saturn.

One of the most striking phenomena of the opposition of 1914 was the conspicuous development of the canal Thoth. On September 30, 1913, corresponding to M. D. January 53, it was clearly seen, and by M. D. March 12 was quite as conspicuous as the northern portion of the Syrtis Major. This year however at M. D. February 23, although it should have been nearly central on the disk, the Syrtis alone was visible. The region following the latter was distinctly brighter than that preceding it, confirming the observation of the previous week. This was doubtless due to clouds condensed from the water vapor rising from the marshy Syrtis region, and in process of transit through the atmosphere to the southern maria. Whether Thoth will appear later as opposition approaches will be a matter of interest. Since the Syrtis itself is so broad this year, it is possible that Thoth may not develop at all, or at all events be less conspicuous than in 1913. It is suggested that other observers should record its first appearance, should it later become visible.

Our next observation was made September 22, corresponding to the M. D. February 31, central longitude 195°. At first the seeing was exceptionally bad, owing to an approaching hurricane,—only 4 in the zenith. The air was very dry, and no detail, not even the snow cap, was recognizable. Later the seeing improved materially, and the snow cap came out, together with glimpses of the dark line bounding it. The southern maria were not certainly seen however. In 1913 on M. D. February 28, the snow cap reached its maximum size, extending down to latitude +42° (Report No. 3). At the present observation it reached latitude +41°. It appeared to be really snow, not cloud, judged by its brilliant whiteness. In 1913 the snow was not entirely clear of cloud until M. D. February 55.

It was interesting to note that the clearing away of the clouds from the snow patch was confirmed by the marked change in color of the planet. With the carbon illumination the color of the paper matching the deserts was no longer a light green as in the last observation, but a distinct golden yellow. Reducing this to terms of the standard blue illumination, the color of the deserts had changed back from orange to red. That is to say the clouds partly obscuring them, which it is to be remembered are yellow on Venus, Jupiter and Mars, had now largely cleared away. During the observations this evening it was necessary

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to place the filament of the 2 c.p. lamp at a distance of only 2.5 inches from the paper in order to secure equality of illumination. Possibly the prism or lens in some of the earlier observations was partially dewed. This could not however have affected the color.

TABLE I

Data of the Observations.

No.	1915	⊙	M.D.	Long.	Lat.	Sun	Diam.	Seeing
1	July 18	310°.7	Jan. 22	90°	−7°	−18°	4″.8	7
2	Aug. 27	332.9	Feb. 5	63	+4	−11	5.3	10
3	Sept. 8	339.5	" 17	292	+7	−8	5.6	6
4	" "	"	" "	309	"	"	"	6
5	" 14	342.7	" 23	252	+8	−7	5.6	10
6	" 22	346.9	" 31	165	+10	−5	5.8	5

Acuteness of Vision.

Now that Mars will shortly be under observation by many observers, it is thought that it might be of interest to them to be able to test their own acuteness of vision as compared with that of others. On a sheet of tracing cloth seven equi-distant india ink spots were prepared. The mean diameter of the central one, measured under a microscope, was 0.90 mm. The others arranged in a circle about it, diminished in size down to the smallest that could be conveniently drawn with a crow quill. They were located at intervals of half an inch apart, were placed near a window, and viewed at various distances from three to twenty feet, both with the naked eye and with an opera glass. The central spot was visible at the greatest available distance. The results with the others are given in Table II, the first two columns giving the number of the spot and its mean diameter in millimeters, the third and fourth its diameter in arc at the greatest distance at which it could be held clearly in vision, and the resulting deviation from the mean value, and the fifth and sixth its diameter and deviation at the greatest distance at which it could be glimpsed. Both eyes were used. The last four columns give the same results using an opera glass. For some unexplained cause spots 5 and 6 were always more difficult than the others, but there seemed to be no sufficient reason to exclude them from the means. The ratio of the distances "held" and "glimpsed" for both naked eye and opera glass was 0.896. The ratio for the naked eye to the opera glass was 2.71. This seemed to be identical with the magnification of the latter as accurately as it could be determined. The small range of ten per cent between held and glimpsed was unexpected.

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The paper was then tacked on the side of a box and placed at a distance of 1011 feet (308 metres) from the objective of the 11-inch telescope. The distance was measured with the micrometer by means of two crosses placed 60 mm apart on the paper. In deducing the distance, the change in scale due to the change in focus of the telescope for short distances is most easily corrected by leaving the constant of the micrometer unchanged, but considering the distance of the object to be measured, not from the objective itself, but from a point situated at the principal focal distance in front of it. That is, we add the focal length of the telescope to the computed result (Harvard Annals, **32**, 122). The angular diameters of the seven spots seen from the objective are 0″.60, 0.″50, 0″.37, 0″.27, 0″.20, 0″.15, and 0″.10.

TABLE II.

VISIBILITY OF BLACK SPOTS.

Spot	Mm.	Held		Glimpsed		Held		Glimpsed	
		Arc	Dev.	Arc	Dev.	Arc	Dev.	Arc	Dev.
		″	″	″	″	″	″	″	″
2	0.75	30.8	−2.8	27.4	− 2.7	—	—	—	—
3	.55	28.6	−5.0	25.7	− 4.4	—	—	—	—
4	.40	25.8	−7.8	24.6	− 5.5	—	—	—	—
5	.30	43.5	+9.9	33.8	+ 3.7	14.8	+2.4	13.2	+2.1
6	.22	40.6	+7.0	40.6	+10.5	13.3	+0.9	11.9	+0.8
7	.15	32.1	−1.5	28.3	− 1.8	9.2	−3.2	8.3	−2.8
Mean		33.6	±5.7	30.1	± 4.8	12.4	±2.2	11.1	±1.9

In the middle of the day the larger spot is occasionally visible for a few seconds at a time as a light hazy blue, about twice its normal size, but as the afternoon wears on, especially if it is cloudy, some of the other spots come out. About three o'clock spot 3 frequently appears, and an hour later spot 5. This is the smallest one we have been able to hold clearly by daylight. The best magnification to use was found to be 330, but dividing the mean size held by the naked eye, 33″.6 by 0″.20, we find that the highest practical magnification of the telescope with daylight seeing is 168.

To test the scale of lakes attached to the tube of the telescope, we measured with it the size of the spots 1, 3, 4, and 5. Their true sizes were 0″.60, 0″.37, 0″.27, 0″.20, their measured sizes were 0″.52, 0″.32, 0″.26 and 0″.20. The ratios in the four cases being 1.15, 1.16, 1.04, and 1.00. This would seem to indicate that measures of the diameters of the lakes of Mars made by this means should be fairly accurate. Observations were also made at night, using a dark lantern to represent the disk of the planet. The results are incomplete; however, improved apparatus has been devised and it is hoped to publish our results later.

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There is another test for the eyesight which, in an approximate manner, is more readily applied than that of the dots. Suspend a small weight, such as a tack, by a human hair in an open window or doorway, so that it shall have the open sky for a background, with no glass interposed. Hairs vary somewhat in size, and so do different parts of the same hair. If the hair is used within a few inches of the root, and a microscope is not available with which to measure it, approximate results may be obtained by assuming the diameter at 0.085 mm. The outer extremity of a long hair may not exceed 0.045mm. The writer found that by using both eyes the hair could be held in steady vision at 50 feet, could be glimpsed at 60 feet, occasionally glimpsed at 70, but was invisible at 80. With his best or observing eye alone, it could be held at 50 feet, with the other at 29 feet.

TABLE III.

VISIBILITY OF FINE LINES.

Feet	Arc	Remarks	Arc	Remarks
	″		″	
50	1.15	Held	1.13	Perfectly visible
60	0.97	Continually glimpsed	0.96	Visible but not easy
70	0.82	Occasionally glimpsed	0.83	Visible but difficult
80	0.72	Not visible	0.73	Well glimpsed

In Table III in the first three columns are given the distances at which the hair was observed, its angular diameter, and the remarks upon its visibility. It is not possible to determine the distances closer than to five per cent, since the eye varies constantly in acuteness. The fourth and fifth columns are extracted from a Table published in Bulletin No. 2 of the Lowell Observatory, and describe Dr. Lowell's observations on an iron wire 0.0726 inches in diameter, which was viewed from distances varying from 500 to 2100 feet. Considering the difference in the methods employed, the results may be said to confirm one another satisfactorily, although it would appear that Dr. Lowell felt a little more certain of what he saw than did the writer. Dr. Lowell states that his assistant Mr. Lampland almost exactly concurred in his results. These figures may therefore be considered as fairly representative of the eye-sight of three practical Martian observers. A few persons without any astronomical training were tested, and were found able to hold the hair in steady vision at distances ranging from 14 to 42 feet.

The difference in angular size of the equally visible line and dot is very striking. The ratio is 31. Two pinholes a millimeter apart in a

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piece of black paper placed against the light could be separated, that is black could be seen between them, when their distance was eight feet, giving an angular separation of 86″. One felt uncertain of the separation of two parallel lines when their angular distance was reduced to 69″ (Harvard Annals **32**, 151).

Two hairs were next stretched across the illuminated disk at night, and viewed with the telescope. Magnifications of 330 and 430 were about equally satisfactory but on neither of the nights tried was the seeing on the disk as good as it often is in the heavens. At intervals the hairs could be clearly seen. The larger one measured 0″.053 the smaller 0″.029. It was recorded one afternoon that the larger hair was midway in difficulty between the third and fourth spots, diameter 0″.32. Ratio of diameters 6.0. Applying these results to Mars, when at such a distance that its diameter measures 15″, the smallest lake visible, 0″.20, would be 60 miles (96 km) in diameter, and the narrowest canal nine miles (14 km). Ratio 6.7. Too much stress must not be laid on these values however, since the seeing on Mars is often better than it was on the disk, and on the other hand neither the lakes nor canals of Mars are absolutely black, like the dots and hairs. These will serve as preliminary figures, but we should really wait until the planet comes nearer us, and the finer lakes and canals are well seen. They can then be compared with the scales of dots and lines attached to the side of the telescope, and we may by this means hope to secure fairly reliable results. In Bulletin No. 2, Dr. Lowell estimates the breadth of the narrowest canals visible at three-quarters of a mile. This expressed in arc would be 0″.0025.

There is still a third test of acuteness of vision which requires no apparatus at all. If the full moon be viewed with the naked eye, or through spectacles if necessary, there are besides the conspicuous features, certain others which stand out with more or less clearness The finest details are seen when the moon is not very far above the horizon, as it is then less dazzling, and the position of the observer is not too constrained. Twelve objects have been selected upon its surface of increasing degrees of difficulty, those that are dark being followed by a D. They are as follows:—

TABLE IV.

LUNAR TEST OF ACUTENESS OF VISION.

1	Copernicus	5	Gassendi region	9	Medii D
2	Nectaris D	6	Plinius region	10	Sacrobosco region D
3	Humorum D	7	Vaporum D	11	Huygens region D
4	Kepler	8	Lubiniezky region	12	Riphaen Mts.

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The relative visibility of the objects varies with the proximity of the terminator. Therefore it is better in general to observe when the moon is nearly full. It was necessary to select objects at some little distance from the limb, to avoid the effect of libration. One should have an opera glass at hand, as well as a map of the moon, in order to determine exactly what one should expect to see. Most of these markings need little description in order to identify them. Medii appears as a narrow line running east and west, and situated to the west of a very dark spot. The Sacrobosco region is a faintly shaded area whose diameter is equal to the length of Crisium. The Huygens region is a dark spot north-east of the Apennines. Knowing it was there, I was able to glimpse it readily, but should not have discovered it otherwise. The Riphaean Mountains are difficult. It is questionable if they are visible to the naked eye. The first ten objects should be discovered, however, and clearly seen by anyone having really good eyesight.

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Owing in part to the pressure of other work, and in part to the lack of an entirely satisfactory available map, it has not been possible as yet to complete the discussion of all the data secured at the last opposition. In the meantime observations of the coming opposition have already begun, and since ten Reports have now been issued, it appears desirable to supply a table of contents, index, a list of authorities and of illustrations, and a table of errata up to date. The volume and two page numbers appear in each case, the first two referring to POPULAR ASTRONOMY, and the last to the reprints. The number of the Report is also given in each table, the two series of numbers being separated by a dash when necessary. The paper on the Double Canal in the Lunar Crater Aristillus is also included in these tables, since it may be considered as a supplement to Report No. 5. It is indicated in the tables by an A.

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ERRATA AND DEFECTS.

Since on account of the distance of the Harvard Station in Jamaica from the publication office in Northfield it is impossible for the writer to see a proof of his Reports, more errors and also more misprints occur than would otherwise be the case. The more important ones are corrected below.

Vol.	**22**,	1,	line	3	Report	**1**,	1	line	3	*For* 33′ *read* 30′.5
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Vol.	**23**,	293	line	18	Report	**9**,	9	line	18	*Omit* seen
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"	"	472	"	11	"	"	12	"	11	" canal " canals

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A few defects have occurred in the illustrations. Thus in Report No. 6, Figure 3, several of the canals B, E, and G, do not show sufficient contrast to give results corresponding to the text. It may perhaps be mentioned here that in the paper on the Meteorology of the Moon, published in the number for March 1915, although not included in this series of papers, the Figures in the frontispiece do not show nearly enough contrast, and that Figure 9 is printed as a negative, i. e. the snow is black and the rocks white. This last error was corrected on page 323, and in the Reprints that were distributed later a correct Figure was inserted, but in this last case the Figure showed altogether too much contrast, making it difficult to compare it with the other eight Figures. The publishers cannot be held responsible for errors in securing the proper contrast in the Figures, and it is only on rare occasions that there is anything to complain of, but it is one of the disadvantages under which the writer labors in not being able to see a proof of his articles.

CHRONOGRAPHIC REGISTRATION OF RADIO TIME SIGNALS.

FRANK D. URIE.

The Elgin National Watch Company, Elgin, Ill., is now obtaining chronographic records of the Arlington Radio time signals at a distance of 700 miles.

The recording apparatus, which was devised by the writer, is entirely automatic in operation,—the incoming radio signals controlling the movement of the chronograph pen.

The following is a brief description of the apparatus. The T-shaped antenna consists of four wires, each 280 ft. long and 150 ft. high. To this antenna is connected a Telefunken Receiving Set, which is of the inductively coupled transformer type using galena detector.

The rectified detector current is led to a series of amplifiers which intensify the Arlington signals sufficiently to operate a very sensitive relay, the back points of which control a 5 ohm pony relay, which in turn controls the chronograph circuit. Experience showed that the

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