



Kodaikanal Observatory

Bulletin No. CLIV

Published on... 31.8.58.

OPPOSITIONS OF MARS IN 1954 AND 1956

INTRODUCTION

The recent oppositions of Mars in 1954 and 1956 offered to astronomers all over the world a rare opportunity for studying the planet in detail. Mars came as near as 40 million miles from the earth in June 1954 and about 35 million miles in September 1956. Such close approaches of the planet to the earth are infrequent. (In July 1939 it was 36 million miles away from the earth, and it will come as close as 34.6 million miles only in 1971.)

A detailed study of the planet during the favourable oppositions of Mars in 1954 and 1956 was planned and co-ordinated on a world-wide co-operation basis by the International Mars Committee set up in 1953 under the joint Chairmanship of Drs. A.G. Wilson and E.C. Slipher. The Kodaikanal Observatory is one of those international observatories invited by the Mars Committee to join in a world-wide photographic and visual patrol of the planet; this observatory kept a continuous photographic and visual watch from 23rd June to 15th September in 1954 and from the beginning of August to the end of October in 1956. The weather conditions here during the above periods were often unfavourable. However, observations were made whenever weather permitted. The observational material collected during 1954 and 1956 is necessarily meagre, but nevertheless it has been considered worthwhile to analyse it. The results of this analysis are summarised in the three sections of this bulletin. These observations by themselves do not lead to any new discovery, but they may be expected at least to help to clarify certain points when compared with observations made at other co-operating observatories.

A. K. DAS,

*Deputy Director-General of Observatories,
Astrophysical Observatory, Kodaikanal.*

Dated 2nd July, 1958.

SECTION I

OBSERVATIONS OF MARS DURING 1954 OPPOSITION

by

J. V. NARAYANA,

Astrophysical Observatory, Kodaikanal

This paper gives a report on the surface features of Mars derived from the visual observations made at Kodaikanal during the 1954 opposition.

Introduction (Historical)

The first drawing of the surface features of Mars, such as Syrtis Major, was made by the Dutch astronomer Huygens in 1659, and he was also able to deduce the rotation period of Mars to be about 24 hours. At about the same time the Italian astronomer Cassini also studied the planet and discovered the polar caps. Sir William Herschel, from his drawings of the polar caps in 1777 and 1784, succeeded in determining the inclination of the planet's axis. In 1877, the Italian astronomer Schiaparelli announced the discovery of the 'Canali'—narrow faint lines intersecting the Martian surface. He was responsible for attracting Percival Lowell⁽¹⁾ who took great interest in the study of the planet and built and equipped the new observatory at Flagstaff, Arizona, (7000 ft. a.s.l.) with the specific object of studying Mars in particular, and the other planets in general. Both of them studied the planet at different oppositions; Schiaparelli named the features of the planet and his nomenclature is still in use. Prof. Pickering⁽²⁾ made a further addition to the Areography. Antoniadi,⁽³⁾ in 1909, from a close study of the planet concluded that the details of Mars displayed everywhere an infinitely irregular structure.

In recent times, however, astronomers like E.C. Slipher of the Lowell Observatory, W.H. Wright and R.J. Trumpler of the Lick Observatory have been able to make new deductions from their remarkable photographs of Mars. Recent drawings of Dollfus confirm Antoniadi's conclusion that when the seeing is good, what are called the 'Canals' can be resolved into discontinuous spots. Also in recent times G.P. Kuiper, E. Opik and G. de. Vacouleurs,⁽⁴⁾ and others, have with the help of visual, photographic and spectroscopic observations, contributed materially to our knowledge of the physical nature of the planet.

Observational procedure and equipment

The photographic observations of Mars were made by means of the 20-inch Cassegrain reflector (Bhavanagar Telescope) of the Kodaikanal Observatory giving an effective focal length of 87 ft. with an *f* ratio of 52. All the photographs were taken using a red plexi-glass filter ($\lambda 6000-6600$ A.U) and photometric standards were impressed on each plate by means of a step-wedge. Both the filter and the step-wedge were supplied by the International Mars Committee.

The visual observations were made with the 6-inch refractor attached as a guide to the 20-inch reflector. No filter was employed for the visual observations. All the drawings were made at the telescope and in general the principal details were located within a period of about 20 minutes. No detail was recorded unless positively seen or at least glimpsed repeatedly during the moments of good seeing. The observers were not at all familiar with the appearance of the surface features of the planet and had no idea of the area under examination until the central longitudes of Mars were computed at a later date.

Nature of observations

The seeing conditions during the period of observation were seldom better than 3 on a scale of 5 & never very good⁽⁵⁾. According to our experience Mars was exceptionally difficult to focus critically on most occasions; in fact, we found it better to focus the telescope on another object like the Moon and then point the telescope to Mars. Although the photographic images of Mars revealed a certain amount of detail now and then when the seeing happened to be comparatively good, the quality of the images in general was poor and therefore it was not quite easy to have a continuous study of the features of the planet.

The visual observations, however, enabled us to collect useful data with the smaller telescope even when the seeing was not particularly good. These observations in fact are definitely more advantageous because of the important property of the eye's co-ordination with the brain which sorts out the raw data rejecting all that appears useless and integrating all the interesting bits and finally recording a mental picture which no single photograph can possibly represent. This mental picture will facilitate a better comprehension of the surface features indiscriminately recorded by a poor quality photography. Moreover, there is no danger of over or under exposure in the visual observations and full advantage can be taken to study fine detail and minute colour differences. There have been many cases in the past where poor photographic observations of Mars have given very spurious and illusory results. Only exceptionally good photographs can, therefore, be relied upon for any type of serious study. In the absence of such good photographs of Mars, the available drawings made at Kodaikanal Observatory during the 1954 opposition, have been used in preparing the present paper.

No attempt was made to identify any of the so called tiny canals over the surface of Mars, because the imperfect seeing conditions during the entire period of our observational watch made it difficult even to locate the major markings of the planet very clearly.

Table I which is self-explanatory gives the dates and times of the drawings (*see* plate I) of Mars with the planet's heliocentric longitudes and the longitudes of the central meridian.

Description of the features of Mars

For convenience of description, the observations of the Polar caps have been taken up first and separately dealt with, while the surface of the planet has been studied dividing it into the following four regions as adopted by the International Mars Committee:—

Region I (Central meridian- 0° -Dawes Forked Bay area.)

Region II (Central meridian- 90° -Solis Lacus area.)

Region III (Central meridian- 180° -Between Mare Sirenum and Mare Cimmerium.)

Region IV (Central meridian- 270° -Between Syrtis Minor and Syrtis Major.)

Polar caps

The period of our observational watch was from 23rd June 1954, the date of opposition to 13th September 1954; this happened to be the early part of the spring season in the southern hemisphere of Mars, while it was the monsoon season at Kodaikanal. Because of imperfect seeing conditions the details in general were evasive and faded out towards the limb. The south polar cap however, was visible on almost all occasions. It appeared as creamy or yellowish white in colour up to about 10th July 1954 and seemed to become white later on. The south polar cap definitely appeared to diminish in size although the diminution was partly due to the changing tilt of Mars (0° to $+4^{\circ}$) during the period of observation. This shows that even in this brief period of study it was melting very rapidly. The polar cap appeared bright white on 10th July at 1915 hours U.T. and again on 10th August at 1900 U.T. When the seeing was comparatively bad the appearance of the polar caps and the deserts had an orange red tint.

(It is of some interest to note that the polar cap was never prominent in any of the photographs taken with red filter.)

The dark border around the south polar cap was seen on all the days. It varied in intensity and was fading towards its northern boundary. Whenever the polar cap appeared brighter, the fringe appeared darker probably due to the subjective contrast effect.

Another interesting feature of the south polar cap was that on 10th July a small darkish streak appeared to emerge from its border extending towards north along Hellespontus region. On 10th August it was again noticed and at that time it was much more prominent because it was darker and longer extending further north.

An irregular white marking was often observed in the northern region, but on 10-8-54 at 1900 U.T. an intense white sharp marking, probably the northern polar cap was distinctly seen. Again on 12-9-54 at 1830 U.T. a very bright white spot (lime light) was noticed in the north polar region.

Region I (Dawes Forked Bay area)

Sinus Sabaeus.—Usually dark and prominent. Western end curved towards south into Mare Serpentis, a less darker area.

Deltaton Sinus.—Brighter than Mare Serpentis.

Pandorae Fretum.—Generally faint in the beginning but became little darker towards the end of the period of observation.

Deucalionis.—Bright between Sinus Sabaeus and Pandorae Fretum and very bright between Margaritifera Sinus and Sinus Meridiani.

Sinus Meridiani.—Southern portion darker while the portion near the prongs dusky.

Margaritifera Sinus.—quite dark and sharply pointed.

Noachis.—Not at all defined—a bright patch.

Hellespontus.—Duskily seen to the east of Hellas, and extending towards the polar cap.

Mare Acidalium.—Dark and visible.

Dioscuria.—Visible, quite bright.

Region II (Central meridian 90°)

Aurorae Sinus.—Quite dark, but darker towards northern edge.

Lunae Lacus.—Very faintly visible only once on 9-8-1954 at 1945 U.T.

Solis Lacus.—Blackish and quite prominent. Two dark central spots noticed on 23rd June.

Nectar.—Seen as a diffuse streak towards west of Solis Lacus.

Thaumasia.—Bright.

Phoenicis Lacus.—Could not be identified.

Aonius Sinus.—Duskily seen.

Tempe and Arcadia.—Bright.

Region III (Central meridian 180°)

Mare Sirenum.—Quite dark and darker in the middle, and prominently seen in between Phaethontis and Memnonia.

Memnonia.—Very bright.

Amazonis.—Seen as shaded bright area, less bright than Arcadia.

Mare Cimmerium.—Fairly dark, tapering towards north.

Electris, Eridiana.—Not distinguishable.

Aeolis and Zephyria.—Bright.

Cerberus.—Seen as a dark streak on 20th and 21st July 1954 running north-west from the northern portion of Mare Cimmerium.

Trivium Charontis.—Darker than Cerberus, on 21st July 1954.

Elysium.—Very bright.

Region IV (Central meridian 270°)

Mare Tyrrhenum.—Dark and prominent.

Syrtis Minor.—Clearly seen separated from *Mare Tyrrhenum* on 10th July 1954.

Hellas.—Very bright area.

Libya.—Seen as a bright patch.

Syrtis Major.—Always very dark and prominent with the radiating three streaks *viz.* *Sinus Sabaeus*, *Hellespontus*, and *Mare Tyrrhenum*. On 10th July it gave an impression of having a complicated internal structure within the wedge shaped dark nose pointing towards north.

Thoth Nepenthes.—Broad darkish streak running northwards, wider towards northern end.

Moeris Lacus.—Faint and very small but prominent on 10th July.

Isidis and Neith.—Quite bright regions.

General remarks on the physical nature of the surface features

Before concluding this note on the description of the general surface features of Mars it may be worthwhile to have an idea of the physical nature of the polar caps, the dark and bright areas.

Polar caps.—During 1909 opposition Tikhoff⁽⁵⁾ from colour filter photographs with green, orange and red has indicated that with the arrival of the cold season the liquid existing at the poles begins to freeze into ice and a thin layer of hoar frost forms over the ice later. But with the arrival of the spring the hoar frost begins to vanish first and the polar cap gets a bluish-green colour. He has ruled out the possibility of snow falling in substantial amounts. These results were more or less confirmed by W.W. Scharnow⁽⁶⁾, from his polarimetric studies in 1939. Again G.P. Kuiper⁽⁷⁾ in 1948 from the study of the infra-red spectrum of the polar caps concluded that the polar caps are not definitely composed of CO₂ as was thought in earlier days, but certainly composed of H₂O frost at low temperatures. Further and even more definite evidence was obtained by A. Dollfus⁽⁸⁾ by polarimetric results and he confirmed that the polar caps are made up of a thin deposit of hoar frost condensed at low temperatures during winter and undergo sublimation under the sun's rays during spring and summer.

The Dark areas.—At one time it was believed that the dark areas were seas and were named as such by Schiaparelli. Although these names are still in use it is known that these regions do not contain water. They undergo periodic and complex changes of form, colour and intensity. Some of these changes are seasonal in character and others very irregular and difficult to explain. It was Lowell who suggested that the dark areas were vegetation artificially irrigated. But it was based on an assumption of the existence of a much greater amount of water than is now known to exist on the planet. Recent observations by G. de Vaucouleurs⁽⁹⁾ tend to show that the humidity spreading as dry vapour, through the atmosphere, from the melting polar caps is sufficient to account for the seasonal darkening of the maria. Kuiper⁽⁷⁾ from the study of reflection spectrum of the dark areas, concludes that they may be a form of vegetation of the lichen type which is supposed to be the hardiest form of plant life. E. Opik⁽¹⁰⁾ also has pointed out that the dark areas must represent some type of growth, in the absence of which these areas ought to have been covered long back by the yellow dust storms which are quite common over the planet.

The Bright areas.—About 3/5 of the planet's surface has an orange colour which gives the planet its characteristic appearance. Sir John Herschel was the first astronomer to suggest that the orange areas of Mars might be deserts. In recent times the problem has been studied by several investigators. Rupert Wildt⁽¹¹⁾ has suggested that the orange tint of Mars might be due to the oxidation of the iron of its superficial rocks by ozone. B. Lyot⁽¹²⁾ from polarimetric analysis has concluded that these bright areas must consist of deposits of volcanic ash. But G. P. Kuiper⁽⁷⁾ from infra-red reflectivity curve of volcanic ash thinks that the orange areas cannot be volcanic ash but of felsite (a silicate of aluminium and potassium with quartz). A. Dollfus⁽⁸⁾ from polarimetric measurements concludes that the bright areas are composed of Limonite, (pure ferrous oxide). From all these considerations it is reasonable to believe that the bright orange areas of Mars are deserts of dust or sand from various rocks and also perhaps volcanic ash.

Summing up we may take the view that the hoar frost theory of the polar caps, and the desert theory of the bright areas seem to be well founded, while the vegetative hypothesis of the dark areas needs much more work to be done on it before it can be considered acceptable.

Acknowledgment

It is my pleasant duty to thank Dr. A. K. Das, Deputy Director-General of Observatories, for his kind encouragement during the progress of this work and for the great interest he took in getting all the necessary experimental arrangements ready just in time for the observational programme for the 1954 opposition. My thanks are also due to Mr. K. K. Banerjee, my colleague, who helped me in these observations.

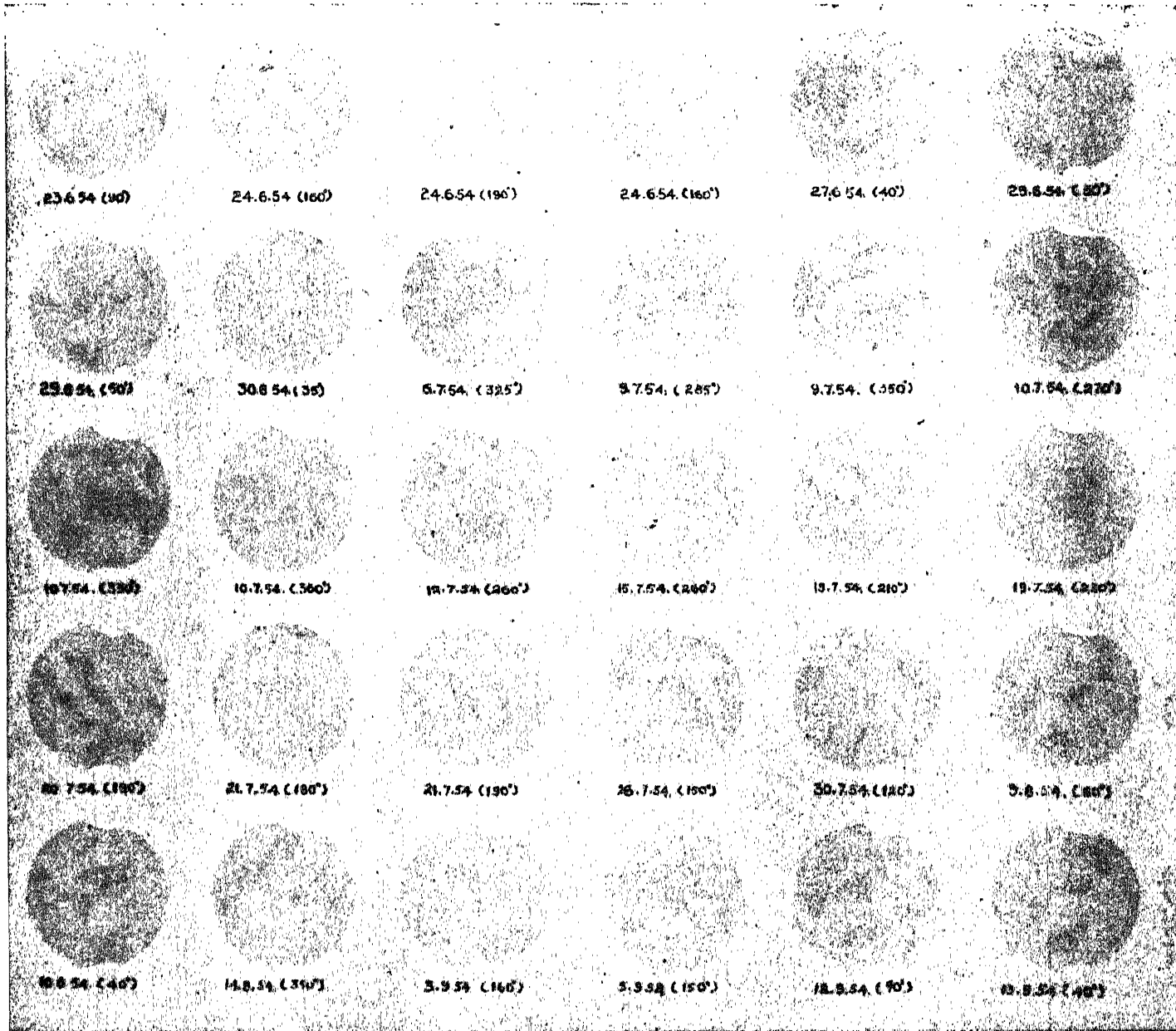
References

- (1) Percival Lowell 'Mars' Boston, New-York, 1896.
- (2) W.H. Pickering Several reports on Mars in Popular Astronomy.
- (3) E.M. Antionadi 'La Planete Mars' Paris, 1930.
- (4) G. de Vaucouleurs 'The Planet Mars'—1949.
- (5) G.A. Tikhoff Mitteilungen der Hauptsternwarte Poulkovo, IV, 6, 1911, No. 42
Pages 73-84.
- (6) W.W. Scharnow Poulkovo Observatory Circular No. 32, 1941 pages 62-73.
- (7) G.P. Kuiper 'The atmospheres of the Earth and Planets' Revised Edition,
Chicago—1952.
- (8) A. Dollfus Comptes Rendus de l' Academie des Sciences **233**, 1951, pp.467-9.
- (9) G. de Vaucouleurs Annales de l' Observatoire du Houga, 1942, pp. 1-75.
- (10) E.J. Opik Irish Astronomical Journal, **1**, 1950.
- (11) R. Wildt The Astrophysical Journal, **86**, 1937, pp. 324-5.
- (12) B. Lyot Annales de l' Observatoire de Meudon, VIII, 1, 1929, pp. 51-62
147-150.

TABLE I
 LOG OF DRAWINGS OF MARS DURING 1954 OPPOSITION
 Kodaikanal Observatory

Sl. No.	Date	Mean Time U.T. of observation	Seeing conditions	Longitude of central meridian of Mars.	Heliocentric longitude of Mars	Tilt of Mars
		Hrs.		°	°	°
1	23-6-54	1700	3	90	272	+0.6
2	24-6-54	1805	3	160	272	+0.8
3	24-6-54	0010	3	190	272	+0.8
4	24-6-54	2230	3	160	272	+1.0
5	27-6-54	1650	3	40	274	+1.3
6	29-6-54	1610	3	30	275	+1.7
7	29-6-54	1730	2	50	275	+1.7
8	30-6-54	1800	3	35	276	+1.9
9	6-7-54	1630	2	325	279	+2.8
10	9-7-54	1530	3	285	281	+3.2
11	9-7-54	2015	3	350	282	+3.4
12	10-7-54	1515	4	270	282	+3.4
13	10-7-54	1915	4	330	283	+3.5
14	10-7-54	2115	2	360	283	+3.5
15	12-7-54	1530	3	260	284	+3.6
16	15-7-54	1730	2	260	285	+3.9
17	19-7-54	1640	3	210	287	+4.2
18	19-7-54	1810	2	230	287	+4.2
19	20-7-54	1545	3	190	287	+4.3
20	21-7-54	1550	2	180	288	+4.4
21	21-7-54	1620	3	190	288	+4.4
22	26-7-54	1645	3	150	291	+4.5
23	30-7-54	1715	3	120	294	+4.5
24	9-8-54	2045	3	60	300	+4.0
25	10-8-54	1900	4	40	300	+3.9
26	14-8-54	1835	4	350	303	+3.5
27	3-9-54	1745	2	160	315	+0.4
28	5-9-54	1815	3	150	316	.0.0
29	12-9-54	1830	4	90	320	-1.8
30	13-9-54	1600	3	40	321	-1.8

DRAWINGS OF MARS (1954) OPPOSITION KODAIKANAL OBSERVATORY



SECTION II

RELATIVE INTENSITY DISTRIBUTION ON MARS IN RED LIGHT DURING
THE 1954 OPPOSITION

by

KALYAN KUMAR BANDYOPADHYAY,

Astrophysical Observatory, Kodaikanal (India).

ABSTRACT

The relative intensity distribution on the globe of Mars has been surveyed by photographic photometry in the wave-length range 6000 Å-6600 Å. The survey has been carried out by dividing the globe into intervals of thirty degrees of longitude; isophotes have been plotted on the diagrams based on W.H. Pickering⁽¹⁾.

Introduction

The relative intensity distribution on the Martian surface has been visually studied by Percival Lowell and his school⁽²⁾, while direct measurements with a conventional photometer have been made probably by E. Schoenberg⁽³⁾ alone. However, owing to the minuteness of the Martian disc at the focus of an ordinary telescope it is extremely difficult to conduct any direct measurement satisfactorily. The primary aim of the present investigation is to determine by photographic photometry, the distribution of relative intensity across the Martian disc on an arbitrary scale. The results of the measurements are given in the diagrams of the text.

Observational procedure and equipment

In the present work the telescope used for forming the image of Mars was the 20-inch Cassegrain reflector (by Grubb) of this observatory. The system was of 87-ft. effective focal length and worked at $f/52$ giving an image of about 2.4 mm diameter during opposition. Photographs of Mars were obtained on very fast Ilford panchromatic HP₃ plates in combination with a red plexi-glass filter transmitting the wave-length region 6000 Å-6600 Å. A number of images were photographed on the same plate in rapid succession. The exposure times were varied in order to obtain at least some of the images with densities suitable for photometry, the best ones being chosen for investigation. Generally the exposure time was between 0.5 and 3 seconds. Two sets of intensity marks with different exposures (1 second and 3 seconds) were also impressed on each plate using a carefully calibrated photographic step-wedge in combination with the same red filter. The exposure times for the Mars image and the step-wedge image were kept roughly of the same order, so that the SCHWARZSCHILD exponent could be safely taken to be constant. All plates were developed for five minutes in a standard D-19 developer at about 70° F taking the usual precautions.

Results

Each selected photographic image of Mars was traced five times across its disc roughly at equal intervals of space, the central trace coinciding roughly with its diameter, with a Cambridge Recording Photoelectric Microphotometer and the conversion of densities into intensities was done in the usual manner. The image was once again traced at right angles to the original direction, also five times and roughly at equal intervals. (Fig. 0).

It was intended to determine the relative intensity distribution on the photographs of Mars taken roughly at thirty degree intervals of Martian longitudes, starting from near about 0° central meridian. Unfortunately it was not possible to take any photograph of Mars with central meridian near about 90°. Nevertheless, the relative intensity distribution on the Martian globe on an arbitrary scale (each diagram having its own reference zone—with an arbitrary value for it) at the 1954 opposition is shown in figures 1-11. Conclusions of interest that can be derived from these figures are given below and the conditions under which the photographs of Mars were secured are indicated in Table I.

TABLE I

Log of Mars Plates (1954—Opposition) Kodaikanal Observatory

Plate No	U.T.		Martian Central Meridian		Sky		Exposure		P	Q	q	K	d
	Date	Hour	Intended	Actual	Cloud	Seeing	Seconds						
		h m											
KKL—44	15-8-54	18 49	0°(360)	354°.1	Thin Cs	Good	1"—2½"	26°.65	87°.85	1".65	0.904	17".29	
KKL—42	10-8-54	18 00	30°	28°.4	Thin Cs	Good	1"—3"	27°.11	87°.65	1".53	0.915	18".00	
KKL—41	9-8-54	19 15	60°	56°.0	Thin As	Good	1"—3"	27°.17	87°.61	1".50	0.918	18".19	
KKL—40	30-7-54	17 27	120°	121°.7	Thin As	Good	1"—3"	27°.52	86°.29	1".15	0.941	19".57	
KKL—12	24-6-54	22 50	150°	162°.1	As	Fair	1"—3"	23°.96	346°.51	0".01	0.999	21".61	
KKL—31	20-7-54	16 00	180°	191°.0	Thick Cs	Fair	1"—3"	27°.22	83°.32	0".73	0.965	20".81	
KKL—30	19-7-54	16 49	210°	212°.2	Thin Cs	Good	1"—2½"	27°.15	82°.86	0".69	0.968	20".91	
KKL—29	15-7-54	17 20	240°	255°.3	Thin Cs	Fair	1"—3"	26°.83	80°.65	0".51	0.973	21".12	
KKL—23	10-7-54	15 10	270°	268°.3	Thin Cs	Good	1"—2½"	26°.30	77°.05	0".31	0.986	21".66	
KKL—24	10-7-54	16 30	300°	287°.7	Thin Cs	Good	1"—2½"	26°.30	77°.05	0".31	0.986	21".66	
KKL—43	15-8-54	18 08	330°	343°.8	Cs	Fair	1"—3"	26°.65	87°.85	1".65	0.904	17".29	

P Position angle of the axis of rotation measured eastward from the north point of the disc,
 Q Position angle of the points of greatest defect of illumination, measured from the north point of the disc,
 q Angular value of the greatest defect in illumination, as seen from the earth,
 K Ratio of the area of the illuminated portion of the apparent disc to the apparent full disc area (regarded as Circular)
 d Diameter of Mars,

TABLE I

Figure 1 (KKL-44)

- (i) *Mare Australe*.—Appears to be comparatively dark extending up to the southern limb.
- (ii) *Noachis* & *Dioscuria*.—Seems to be brightest in this photograph.
- (iii) *Arabia*.—Although very bright its brightness is not as much as that of *Noachis* or *Dioscuria*.
- (iv) *Ismenius*.—Not so pronounced.
- (v) *Mare Serpentis*.—Appears to be darker than *Sinus Meridiani*.
- (vi) *Polar Cap*.—Seems to be as bright as *Noachis*.
- (vii) *Hellas*.—Is not distinct, which is unusual.

Figure 2 (KKL-42).

- (i) *Mare Australe*.—Rather faint.
- (ii) *Argyre*.—Quite bright.
- (iii) *Chryse* & *Xanthe*.—Seem to be brightest.
- (iv) *Lunae Lacus*.—Appears to be unusually dark.
- (v) *Western Noachis*.—probably is cloudy while *Eastern Noachis* is slightly brighter.
- (vi) *N Polar Cap*.—is discernible.
- (vii) *Mare Acidalium*.—is not distinctly visible.

Figure 3 (KKL-41).

- (i) *Solis Lacus*.—Rather small and faint, also seems to be at a lower latitude.
- (ii) *Polar cap*.—Very bright and conspicuous.
- (iii) *Albus* & probably *Tempe*.—Very bright.
- (iv) *Mare Acidalium* & *Mare Boreum*.—Moderately dark and of comparable intensity.

Figure 4 (KKL 40).

- (i) *Northern Memnonia*.—Brightest.
- (ii) *Castorius Lacus*.—Has a shade of darkness.
- (iii) *Aonius Sinus*.—Is seen extending up to limb.
- (iv) *Phaethontis*.—Is not visible.
- (v) *Mare Sirenium*.—is only moderately dark.
- (vi) The dark zone on the north of Memnonia is *Phrygius Lacus*.

Figure 5 (KKL-12)

- (i) *Memnonia* & *Zephyria*.—quite bright, particularly the former. *Memnonia*'s N-E part is a bit brighter.
- (ii) *Mare Sirenium*.—is seen as a dark patch.
- (iii) *Trivium Charontis*.—is seen as a small black patch.
- (iv) *Polar Cap*.—is seen as a moderately bright zone.
- (v) *Mare Chronium*.—is seen to be extended up to the limb.

Figure 6 (KKL-31)

- (i) In this photograph no detail is visible.
- (ii) *Zephyria*, *Memnonia* & *Elysium*.—seen as a bright patch.
- (iii) *Trivium Charontis*.—is seen conspicuously.

Figure 7 (KKL-30)

- (i) Here only *Elysium* and its surroundings—brightest.
- (ii) *Syrtis Major*.—is seen as a very dark patch.
- (iii) Probably the black patch on the N-W side of *Elysium* is *Utopia*.
- (iv) *Mare Chronium*.—is a vast patch merging with the limb and the South-Pole.
- (v) Probably *Mare Tyrrhenum* is seen as a dark patch, on the S-W side being joined with *Mare Cimmerium*.

Figure 8 (KKL-*29)

- (i) *Elysium*, *Aethiopsis*, *Aetheria*, *Cebrenia*, etc. are brightest
- (ii) *Syrtis Major*.—is quite dark.
- (iii) *Nilosyrtis*.—is also moderately dark.
- (iv) Only a portion of *Isidis Regio* is bright.
- (v) Only a small portion of *Aeolis* is seen as a bright patch.

Figure 9 (KKL-23)

- (i) *Hellas*, *Ausonia* & *Eridania*.—fully conspicuous and bright, but *Mare Hadriacum* & *Zea Lacus* not discernible.
- (ii) *Mare Australe*.—is seen as a dark patch towards the limb.
- (iii) Probably *Syrtis Major* is cloudy and is seen only as a shady patch, naturally the brightness of *Aeria* is hidden.
- (iv) *Aetheria*.—is seen as a bright patch.
- (v) Curiously enough *Utopia* ** is not visible.
- (vi) *Aethiopsis*.—is also visible.

*The photometry for this plate is not absolutely reliable as the photographic density was high.

**It may be recalled that in 1941 opposition, on the same night (November 8), both Mr. W. H. WHITTOME & Mr. B. BURRELL with the same type of optical assistance sketched Mars with exactly the same central meridian, the former saw UTOPIA while the latter did not, since their observation times were different (4).

Figure 10 (KKL-24)

- (i) *Polar cap*.—is very bright.
- (ii) *Hellas*.—also appears to be very bright.
- (iii) Zone of *Nillo-syrtis* seems to be darker than shady *Syrtis Major*.
- (iv) *Isidis Regio*.—is also very bright.
- (v) *Aethiopsis*.—appears as a bright patch.
- (vi) A very bright patch at the Western limb only suggests the presence of a bright patch of cloud.

Figure 11 (KKL-43)

- (i) *Noachis*.—seems to be brightest here.
- (ii) *Arabia & Eden*.—also very bright.
- (iii) The bright patch on the N-W side of the Figure may be *Chryse*.—but it seems to be slightly displaced.
- (iv) *Sinus Margaritifer*.—is not so conspicuous.
- (v) *Syrtis Major*.—is only shady.
- (vi) Northern limb is unusually dark.

N.B.—The dotted lines of Figure-6 and Figure-8 indicate only a probable value—as no data are available in that zone.

Owing to the almost equal rotation periods of the Earth and Mars it is possible to observe closely only one particular region during opposition from this observatory alone; naturally the remainder of the surface could be observed under less favourable conditions. Unfortunately most of the nights of observation at Kodaikanal were not ideal, the “seeing” being impaired by a thin veil of Cirrus or Alto-stratus cloud. As far as practicable photographs of better “seeing” were chosen.

It will be noticed that in many cases the polar Cap was not discernible; probably on those occasions the solid deposit of the Cap was altogether covered with a haze cap, which can even blacken the limb for the long wave lengths⁽⁵⁾.

Acknowledgments

The author wishes to thank Mr. J. V. Narayana of the Kodaikanal Observatory for his co-operation in photographing Mars. The author takes this opportunity to thank Dr. A. K. Das, Deputy Director-General of Observatories, Kodaikanal, for his encouragement and help. Thanks are also due to the International Mars Committee for the supply of Filters, Step-Wedge, and the programme.

References

- (1) W.H. Pickering Popular Astronomy **32** (1924) pp 338.
- (2) Percival Lowell ‘Mars’—pp 92-107.
- (3) E. Schoenberg “On the Illumination of Planets—Publications of the Astronomical Observatory; Dorpat, **24** (1917).
- (4) Memoirs of the B.A.A. (Dealing with Mars Apparition—1941) 37-Part 1 (1951).
- (5) W.H. Wright Publications of the Astronomical Society of the Pacific **51** (1939)pp-292.

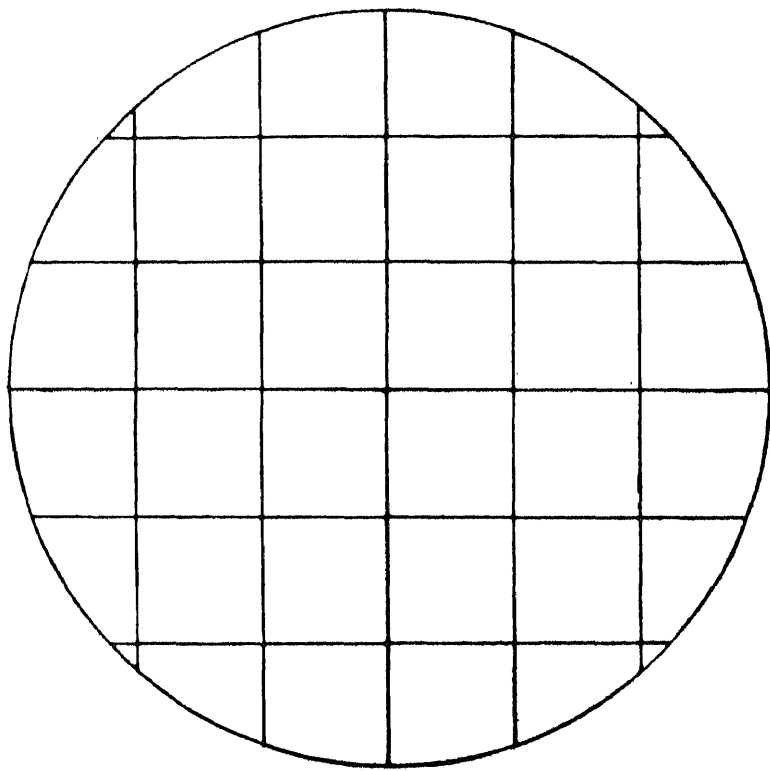


FIG. O.

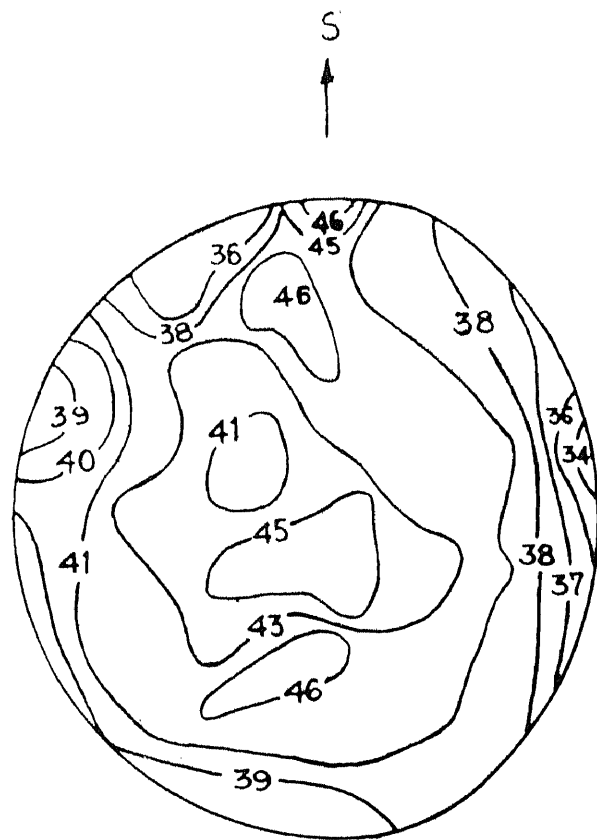


FIG. 1

KKL-44

AUG-15

$\omega = 354^{\circ}1$

$\phi = +4^{\circ}0$

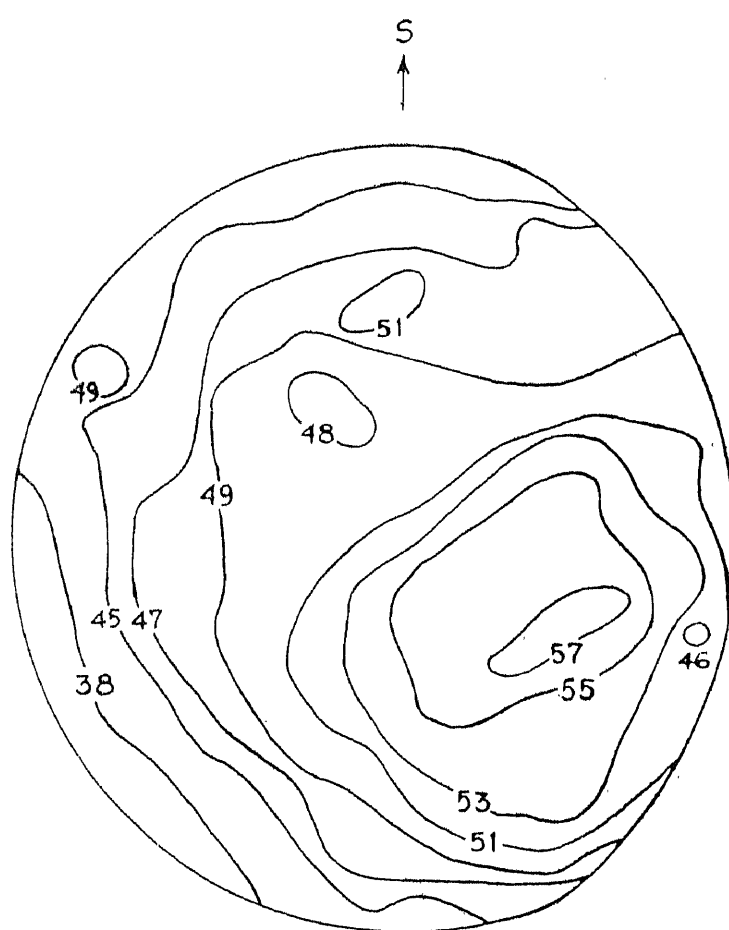


FIG. 2.

KKL - 42

AUG. 10

$\omega = 28^{\circ} 4$

$\phi = +4^{\circ} 0$

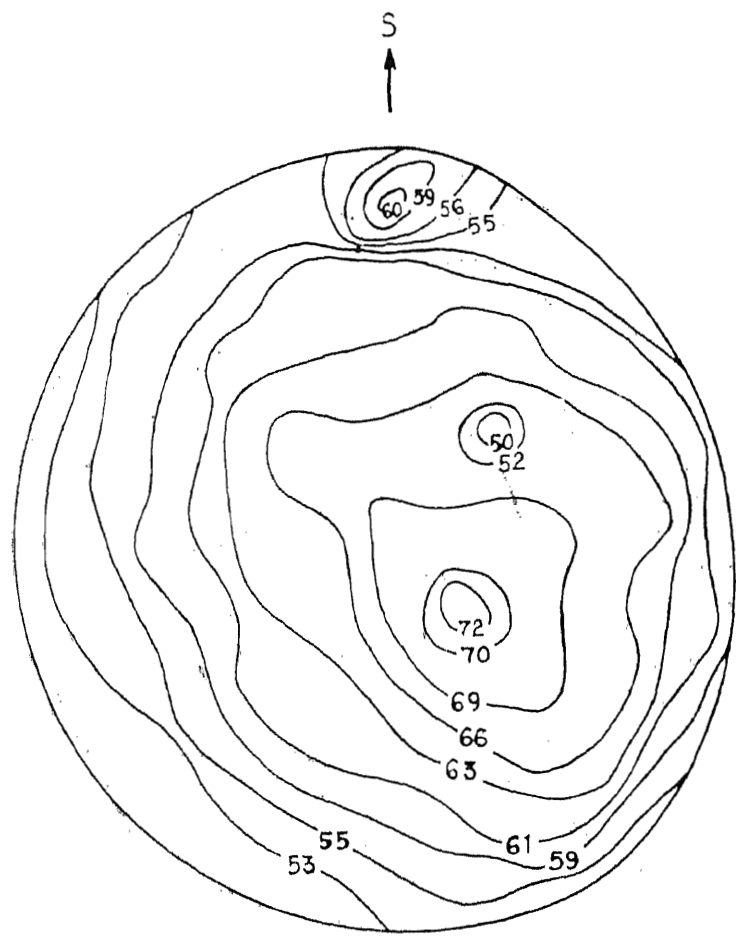
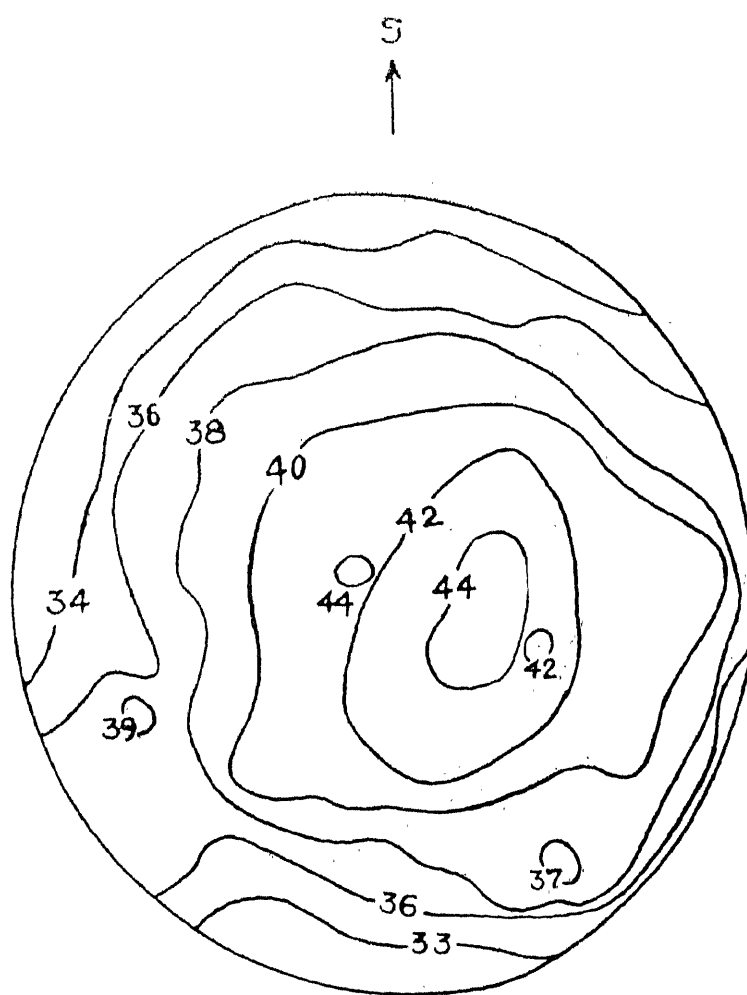


FIG. 3.
KKL-41
AUG-9 $\omega = 56^{\circ} \cdot 0$ $\delta = +4^{\circ} \cdot 1$



JULY-30 FIG. 4. $\phi = +4^{\circ}5$
KKL-40
 $\omega = 121^{\circ}7$

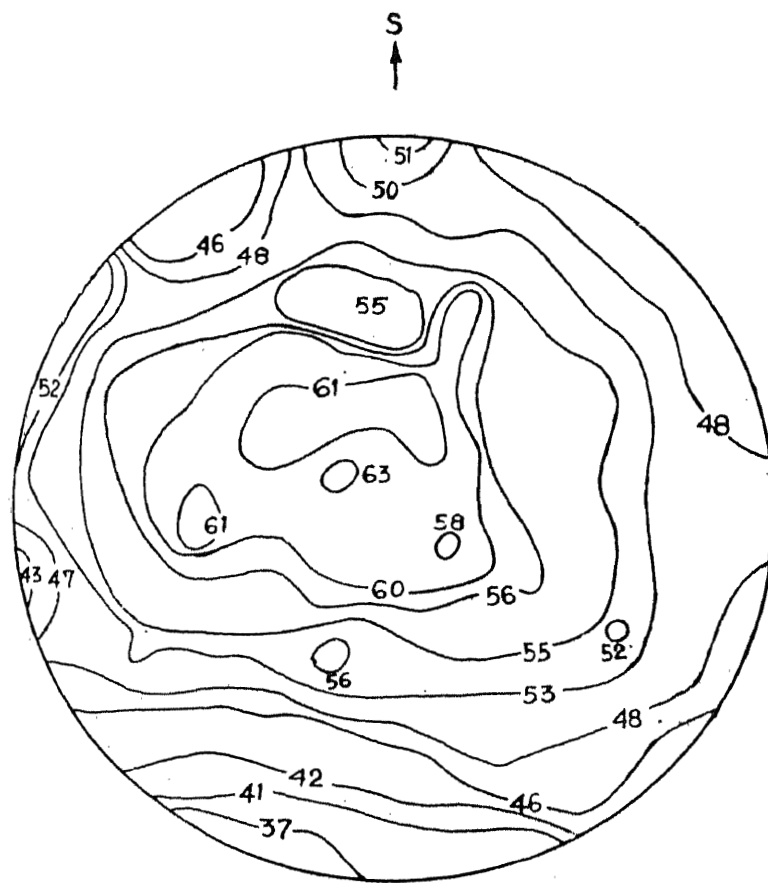


FIG. 5.
 KKL - 12
 JUNE-24 $\omega = 162^{\circ}.1$ $\phi = +0^{\circ}.8$

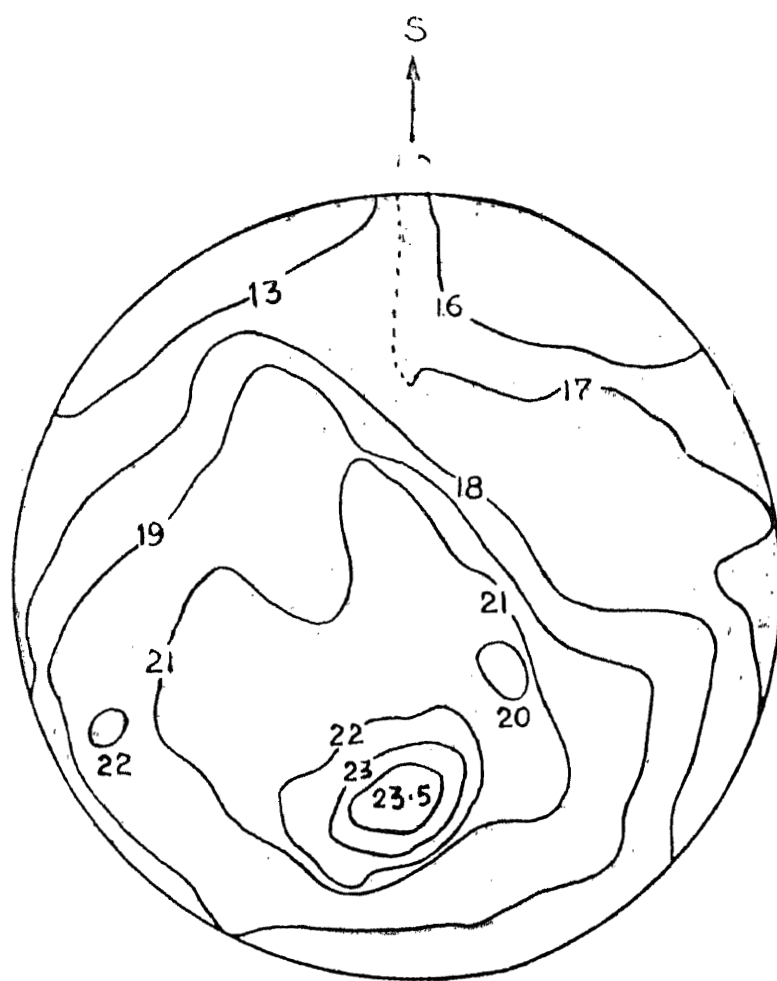


FIG. 6
K.K.L-31
JULY-20 $\omega = 191^{\circ} 0$ $\phi = +4^{\circ} 3$

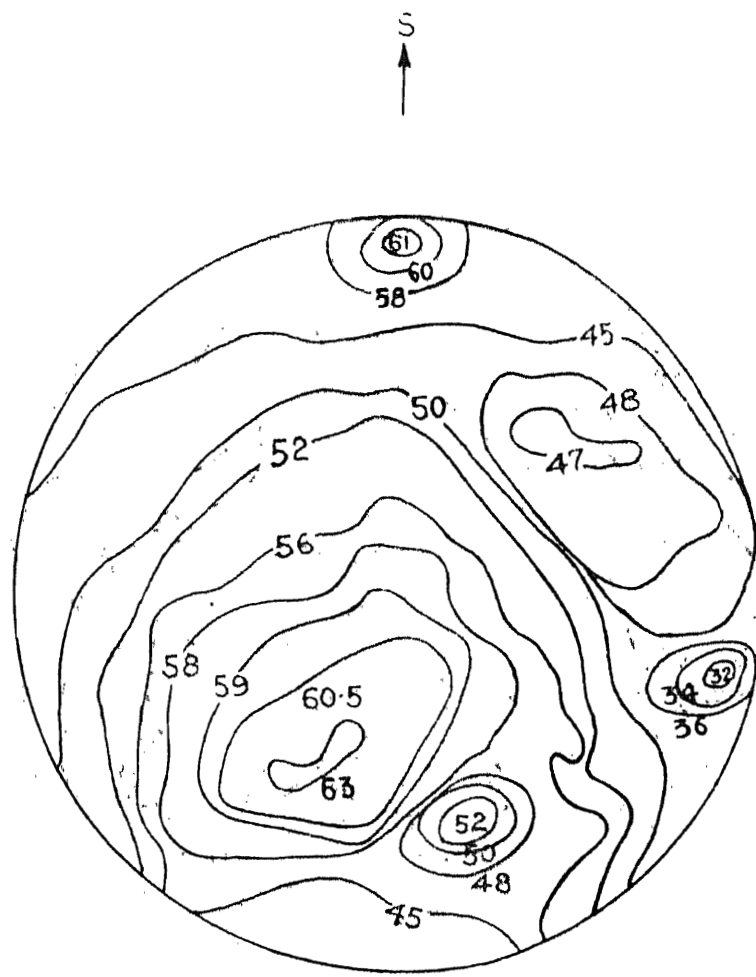


FIG. 7.
KKL-30
JULY-19. $\omega = 212^{\circ}2$ $\phi = +4^{\circ}2$

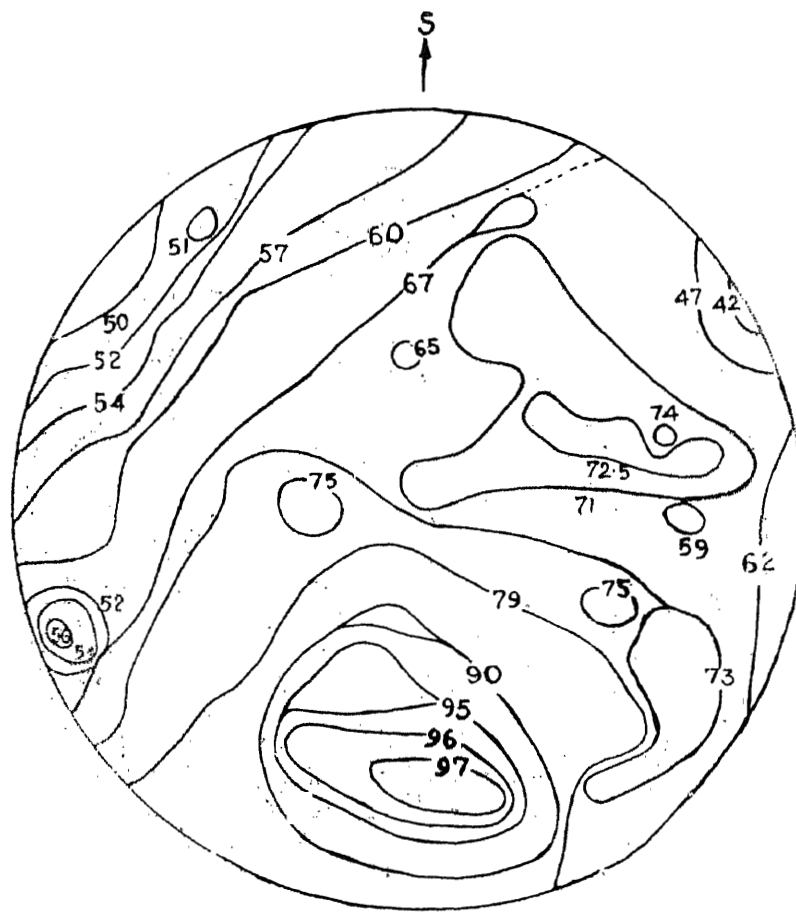


FIG. 8.
KKL - 29
 $\omega = 255^{\circ} 3$ $\phi = + 2^{\circ} 3$
JULY - 15

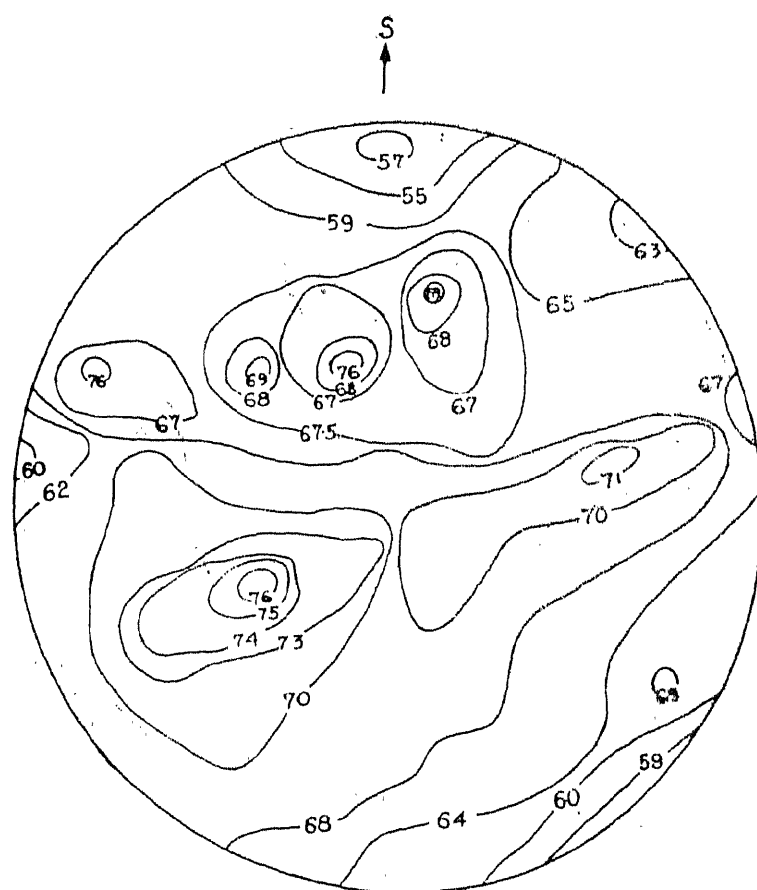


FIG. 9.
KKL-23
 $\omega = 268^{\circ} 3$ $\phi = +3^{\circ} 4$
JULY-10.

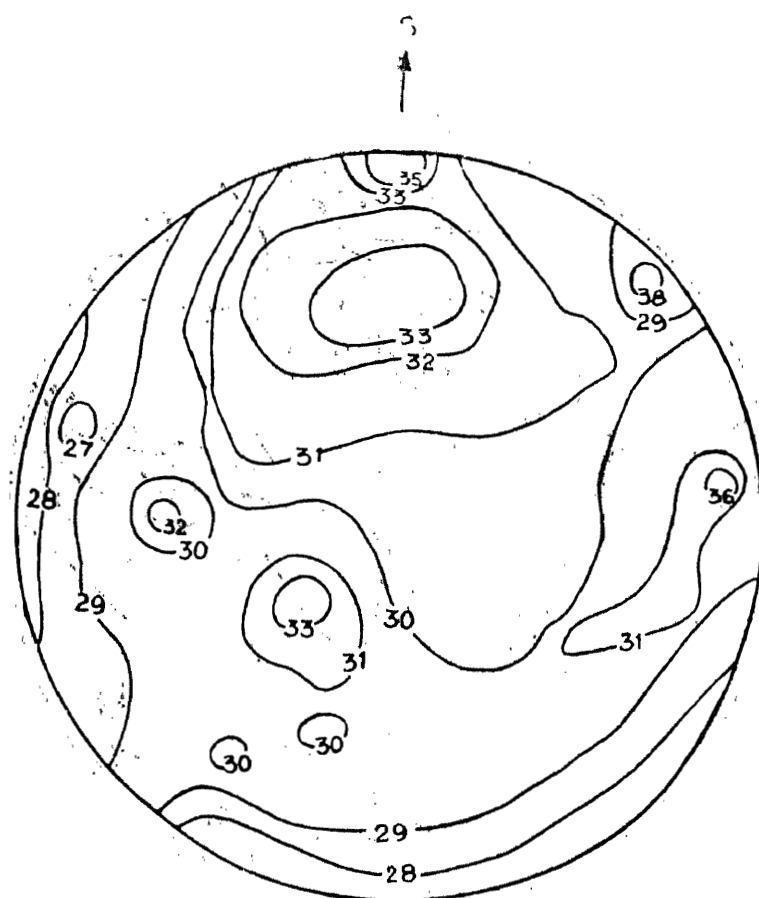


FIG 10
KKL-24
JULY-10 $\omega = 287^{\circ}7$ $\phi = +3^{\circ}4$

25

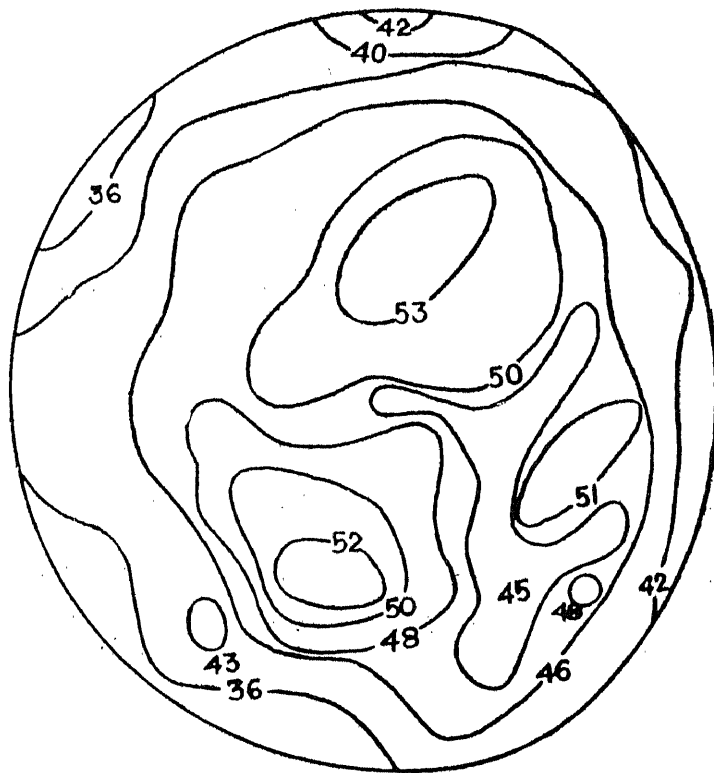


FIG. 11

KKL- 43

AUG. 15 .

$\omega = 343^{\circ} 8$

$\phi = +4^{\circ} 0$

SECTION III

OBSERVATIONS OF MARS AT KODAIKANAL DURING THE 1956 OPPOSITION.

by

J. V. NARAYANA

&

N. VISWANATHAN,

Astrophysical Observatory, Kodaikanal

Observational procedure.—As in 1954 the equipment used for the photographic observations of Mars during the 1956 opposition was the 20-inch Bhavnagar Reflector using the Cassegrainian arrangement giving an effective focal length of about 87 feet and working at $f/52$. For the visual observations however an 8-inch reflector by Cooke was employed in addition to the refractor of 6-inch aperture attached to the Bhavnagar reflector. Whenever weather permitted, some 10 to 15 images of Mars were photographed on a single plate in quick succession by carefully sliding the plate-holder which is specially designed to have movement in two directions at right angles. The times of exposures for each image varied from about $1/2$ second to 2 seconds. The best image from each plate is selected for the study of the planet. Also, images of Mars were photographed in light of different wavelengths using specially sensitized photographic plates. Kodak 103-E, 103-G type plates were used with red and yellow filters respectively while the blue sensitive 103-O type plates were employed when no filter was used. Every photographic plate had two sets of photometric calibration marks made with the help of a step-wedge.

Results and Discussion.—The observational material for 1956 was very meagre because of unfavourable weather. During the entire period of our observational watch of Mars commencing from the beginning of August 1956 till the end of October 1956 the 'seeing' was never better than 4 on a scale in which 5 is the best.

Some interesting features noticed from the photographs of Mars secured on certain dates of reasonably satisfactory observing conditions are given below. The identification of Martian surface details was made with the help of the map of Mars constructed principally from visual and photographic observations made by Slipher, Lyot, Camichel and Gentili and G. de Vaucouleurs (1). The times of observations were also converted to longitudes of the central meridian of Mars, ω according to the table given in the Handbook of the British Astronomical Association for 1956.

1. 1956 September 5.—Time 1735 U.T., $\omega=247^\circ$, seeing about 3, with yellow filter.

South polar cap not seen. Syrtis Major, Mare Serpentis and Mare Tyrrhenum just visible. Mare Sirenum, Mare Cimmerium and Trivium Charontis obscured by a bright patch—most probably some yellowish cloud over that region of Mars.

2. 1956 September 6.—Time 1649 U.T., $\omega=227^\circ$, seeing 3, yellow filter.

South polar cap was still not discernible. The central region of Mars showed more detail than that of the previous day. Probably the yellowish dust cloud of the previous day had cleared to some extent. Mare Sirenum seen clearly although Mare Cimmerium and Mare Tyrrhenum did not seem to be well separated suggesting some yellowish dust haze still present over the region. Syrtis Major, Nuba Lacus, Nodus Aleyonius were also seen though the latter two appeared somewhat dim.

3. 1956 September 7.—Time 1808 U.T., $\omega=238^\circ$, seeing 3, yellow filter.

The polar cap was still not visible (probably obscured by cloud). Mare Cimmerium, Trivium Charontis and part of Mare Sirenum *i.e.* almost all portions left of Mare Tyrrhenum except a little portion of Mare Sirenum seemed to be covered by yellowish haze. Mare Tyrrhenum, part of M. Sirenum and Syrtis Major appeared clearly while Nuba Lacus and Nodus Aleyonius could be seen with difficulty.

4. 1956 September 12.—Time 1649 U.T., $\omega=174^\circ$, seeing about 3. Red filter with Kodak 103-E type emulsion. The south polar cap was still covered by cloud. Only Mare Sirenum, and part of Mare Cimmerium were seen.

5. 1956 *September* 16.—Time 2255 U.T., $\omega=228^\circ$, seeing about 3 Kodak 103-0 type plate.

The south polar cap was seen as a small whitish oval patch. Mare Sirenum, Mare Cimmerium and Mare Tyrrhenum were clearly visible while Syrtis Major, Nuba Lacus and Nodus Aleyonius appeared dim.

6. 1956 *September* 19.—Time 2245 U.T., $\omega=199^\circ$, seeing about 3. Red filter with Kodak 103-E type emulsion.

South polar cap not seen well. Mare Sirenum, Mare Cimmerium, Mare Tyrrhenum and Trivium Charontis could be identified with difficulty since the contrast between the dark and bright areas was exceedingly low. This might have been due to the Martian atmosphere as a whole having become very dust-laden.

Also, on the photographs (negatives) taken on the 6th, 7th and 12th September 1956 with red and yellow filters, the south polar region appeared generally as a dark patch while on photographs taken without filter on blue sensitive plates it seemed somewhat less dark suggesting the presence of some reddish-yellow obscuring matter over the region. This photographic observation, though not conclusive by itself, was supported by the visual observations made at about the same time. According to the visual observations on the 6th, 7th, 12th and 13th September 1956 the south polar cap was not discernible, but on the 14th and 17th it was clearly visible as a white oval patch which was quite small as was to be expected from the consideration that the period of observation corresponded with the end of spring and the beginning of summer on the southern hemisphere of Mars.

Photographs taken with yellow and red filters between the 5th and the 17th September showed the development of dust storms moving rapidly across the region from Mare Sirenum to Syrtis Major. This exceptional display of dust storms as one of the most striking features of the 1956 opposition of Mars has also been pointed out by Kuiper (2) from his analysis of the visual observations of Mars made by him and his assistants during 1956.

Particularly interesting in this context was the fact that no 'blue-clearing' was noticed near about the date of opposition, *viz.* 7th September 1956.

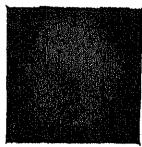
Acknowledgment

In conclusion the authors wish to express their great indebtedness to Dr. A. K. Das, Deputy Director-General of Observatories for his kind interest and encouragement during the progress of this work.

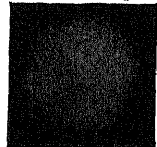
References

- (1) Gerard de Vaucouleurs, 'The Planet Mars', 1949.
- (2) Gerárd P. Kuiper, *Astrophysical Journal*, Vol. 125, March 1957, pp. 307-317.

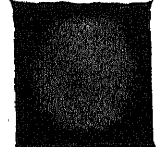
MARS PHOTOGRAPHS
1956 OPPOSITION



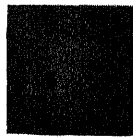
SEP. 5th
 $\omega=247^\circ$



SEP. 6th
 $\omega=227^\circ$



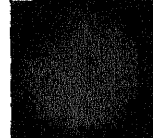
SEP. 7th
 $\omega=238^\circ$



SEP. 12th
 $\omega=174^\circ$



SEP. 16th
 $\omega=228^\circ$



SEP. 19th
 $\omega=199^\circ$

E R R A T A.

KODAIKANAL OBSERVATORY BULLETIN NO. CLV.

Part I.

Page.	Line.	for	read.
1	11	second half 1957	second half of '57.
16	July 19, last Col.	F	H
16	July 25, Col.3.	09 55	07 55
17	Septer. 4, Col.3.	10 34	10 37
17	September, 17.	07 44 good H	Delete this entry.
17	September, 17.	07 40	07 49
23	July, 21, Col.4.	-8	-08

Part II.

Page. No.	Table No.	Date.	Column.	for	read.
48	4	19	13	33.8	37.5
51	5	25	22	24.0	34.0
55	7	12	23	406	506
58	9	12	04	523	623
58	9	against mean	04	500	554
59	9	11	Mean.	510	548
72	16	5	07	292	291

Part III.

JULY 1957.

Page. No.	Table No.	Date/line	TIME	Parameter	for	read.
80	1	17	00	foF2	U0.75	U9.7S
87	2 (Contd)	28	16 30	foF1	L	LH
90	3 (")	22	11 30	foE	A	B
91	" (")	23	17 30	foE	D2.7	2.7
92	4	31	08	foE _s	10.8S	10.3
101	6	26	23	f _{min}	E1.4F	1.4
106	7 (")	30	11 30	h'F2	LH	L
107	" (")	30	12 30	h'F2	LH	L
107	" (")	28	16 30	h'F2	L	360H
107	" (")	against 'Count'	16 30	h'F2	3	4
110	8 (")	12	01 30	h'F	U355	355
110	" (")	13	01 30	h'F	V400F	U400F
110	" (")	24	11 30	h'F	210 H	200 H
115	9 (")	4	14 30	h'E	A	105
115	" (")	against 'Count'	14 30	h'E	7	8
115	" (")	4	15 30	h'E	A	100
115	" (")	against 'Count'	15 30	h'E	10	11
115	" (")	3	13 30	h'E	blank	A
119	10 (")	16	15 30	h'E _s	100	110
120	11	1	02	(12000)F2	2.7	2.70
120	11	3	02	(12000)F2	E2.70S	2.75

Contd.....2,

JULY 1957.

(2)

Page.No.	Table No.	Date/line.	TIME	Parameter	for	read.
120	11	3	09	(M3000)F2	E2.6E	E2.60R
120	11	4	06	(")	E2.9E	E2.90F
120	11	5	09	(")	E1.8W	E1.80W
120	11	7	09	(")	E2.3W	E2.20W
120	11	9	00	(")	E2.5E	E2.50E
120	11	9	02	(")	2.6	2.60
120	11	10	11	(")	D2.1W	D2.10W
120	11	14	06	(")	U3.0S	U3.00S
120	11	21	05	(")	E3.3R	E3.30R
120	11	22	11	(")	U2.1W	U2.10W
120	11	23	10	(")	D2.0W	D2.00W
120	11	27	05	(")	3.2V	3.20V
120	11	27	06	(")	U3.0S	U3.00S
121	11	2	15	(")	U2.0W	U2.00W
121	11	2	18	(")	D2.1S	D2.10S
121	11	3	20	(")	U2.2S	U2.20S
121	11	4	17	(")	U2.2S	U2.20S
121	11	4	18	(")	D2.2S	D2.20S
121	11	5	14	(")	2.1H	2.10H
121	11	6	18	(")	E2.1S	E2.10S
121	11	6	20	(")	E2.0E	E2.00E
121	11	7	20	(")	E2.0E	E2.00E
121	11	8	20	(")	E2.0E	E2.00E
121	11	9	19	(")	E2.2S	E2.20S
121	11	9	20	(")	D2.1S	D2.10S
121	11	13	17	(")	U2.4S	U2.40S
121	11	15	18	(")	U2.6S	U2.60S
121	11	18	19	(")	U2.3S	U2.30S
121	11	19	15	(")	U2.2S	U2.20S
121	11	20	18	(")	2.5H	2.50H
121	11	20	19	(")	2.3H	2.30H
121	11	29	18	(")	U2.4S	U2.40S
123	11(Contd.)	against 'median'	19 30	(")	2.15	2.20

AUGUST 1957.

124	12	10	02	foF2	U9.8F	U9.8S
125	12	21	18	foF2	13.3S	U13.3S
127	12(Contd.)	22	20 30	foF2	U10.8S	F
127	12(")	23	20 30	foF2	F	U10.8F
143	16(")	2	15 30	h'Es	A	...
160	21(")	14	09	h'Es	100	90
164	22	23	02	(M3000)F2	U2.95F	U2.95S

SEPTEMBER 1957.

169	23	10	12	foF2	10.6	10.3
169	23	24	19	foF2	10.1	10.2
169	23	27	12	foF2	11.3	11.8
172	24	7	06	foF1	blank	C
183	26(Contd.)	10	22.30	foEs	blank	2.2
183	26(")	10	23.30	foEs	blank	5.4
186	27(")	8	08.30	fbEs	13.9C	13.9C
188	28	12	11	fmin	3.0	3.9
189	28	18	20	fmin	E1.8S	U1.8S
191	28(")	against 'mean'	15.30	fmin	3.0	2.9
193	29(")	5	17	h'F2	blank	A
197	30	24	22	h'F	340	240
197	30	26	22	h'F	250	290
210	33(")	5	04 30	(M3000)F2	3.20F	U3.20F

Contd.... 3.

(3)

Page No.	Table No.	Date/line.	Time	Parameter.	for	read
211	33(Contd.)	14	12 30	(M3000)F2	2.5	2.05

OCTOBER 1957.

226	37(")	19	against 'mean'03 30	foEs	S	blank.
227	37(")		against 'mean'21 30	foEs	4.9	4.5
231	38(")		Top Centre -	fbEs	Table 38 C td	Table 38(Cont)
238	40(")	1	05 30	h'F2	L	blank
238	40(")	1	06 30	h'F2	blank	L
241	41	18	13	h'F	230H	230
241	41	22	14	h'F	230	235
245	42	against 'Count'	16	h'E	3	13
250	43(")	27	07 30	h'Es	110	100
252	44	6	01	(M3000)F2	U3.00S	U3.00F
252	44	12	11	(M3000)F2	2.05	2.00
253	44	30	15	(M3000)F2	2.00	2.05

NOVEMBER 1957.

267	47(")		against 'median'	foE	2.7	U2.7
267	47(")		against 'mean'	foE	2.7	U2.7
277	50	15	12	fmin	2.8	3.8
290	53(")	19	09 30	h'E	A	C
290	53(")	20	09 30	h'E	C	A
297	55	10	21	(M3000)F2	U2.05F	U2.05FS

DECEMBER 1957.

300	56	21	06	foF2	U10.6F	U10.3F
318	60(Contd)	4	13 30	fbEs	4.3	4.2
324	62	27	07	h'F2	L	blank
334	64(")	18	09 30	h'E	110	100