SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 76, NUMBER 9

THE BRIGHTNESS OF LUNAR ECLIPSES 1860-1922

BY
WILLARD J. FISHER

(PUBLICATION 2751)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
FEBRUARY 18, 1924

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

THE BRIGHTNESS OF LUNAR ECLIPSES 1860–1922

By WILLARD J. FISHER

After Struve and Döllen had pointed out the advantages in observing occultations of faint stars during lunar total eclipses, and had circulated data facilitating the observations, there was an interest aroused among professional astronomers, who paid much attention to eclipse occultations for a considerable time; but only a few, as Flammarion, Barnard, M. Wolf, paid much regard to lunar eclipse phenomena in relation to the earth's atmosphere. The observation and description of the peculiarities of the earth's shadow, both before and after the occultation campaign, was largely left to amateurs. The organization and growth of great societies, like the Société Astronomique de France and the British Astronomical Association, have greatly increased the number of such observers and the volume of the recorded observations.

The present paper was undertaken with the expectation that in the mass of lunar eclipse literature there would be found evidence of a structure of the earth's shadow corresponding to the known dust layers of the atmosphere.[1] It was found that this object could not immediately be attained; rather, it seemed desirable first to study the brightness of recorded eclipses. This, to be sure, has been done by A. Danjon,[2] in papers in which, from a study of records going back to 1583, he has drawn the conclusion that there is a remarkable relation between the solar cycle and the brightness of lunar eclipses, mostly total. These papers have been destructively criticised by E. W. Maunder,[3] as using partial eclipses illegitimately, omitting details of evidence, such as criteria of brightness, durations, moon altitudes, magnitudes of eclipses, together with all references, making

[1] S. P. Langley, New York Tribune, Jan. 2, 1884; Knowledge, 5, pp. 80-81, 1884; Sidereal Messenger, 3, pp. 21-23, 1884; Nature, 29, p. 324, 1884; A vast dust envelope.

W. J. Humphreys, Bull. Mt. Weather Obs., 4, pp. 397-401, 1912; Dust layers in the atmosphere, and changes in the neutral points of sky polarization.

[2] A. Danjon, C. R., 171, pp. 1127-1129, 1207-1210, 1920; Bull. Soc. Astr. Fr., 35, pp. 261-265, 1921.

[3] E. W. Maunder, Jour. Brit. Astr. Assoc., 31, pp. 346-350, 1921.

no use of observed solar phenomena, and depending in all probability upon a false eclipse cycle.

This paper is not intended to traverse the extensive ground covered by Danjon; the period covered is 1860-1922, the former date having seemed natural, as about that time began the serious application of the spectroscope to astronomy, and also the publication, in the British Nautical Almanac, of more complete elements, convenient for making projections of eclipses.

It was soon obvious that spectroscopy has played but a limited part in the study of lunar eclipses. And so of instrumental photometry; determinations of the brightness of the eclipsed moon, except by rough comparison with stars, have been few. And so too of photography; while innumerable photographs of the eclipsed moon have been taken, apparently little use has been made of the plates. Almost all observations have been made with plain telescopes of all sizes, and with the naked eye; the brightness of the moon has seemed secondary to the moments of contact of the umbra-edge with the moon's limb and with various lunar objects. Seeliger[1] having shown that in all probability the apparent enlargement of the shadow detected by such observations has no objective importance, it is easy to agree with Crommelin that there is little use in piling up more of them.

Due to well-known optical principles, the telescope does not increase the brightness of any extended area, but really diminishes it. However, it is a fact of observation that during a lunar eclipse, objects which may be seen in the shadow with large telescopes are invisible with smaller. It is like the effect of night glasses; or like the fact that newspaper headlines in twilight can be read when the text below is a blurred mass. This suggests a criterion for the brightness of eclipses, usable when the observations are simply telescopic or with the naked eye.

On account of the mixed quality of the data a simple three-step scale of brightness has been adopted.

Grade 2.—When the naked eye sees the "spots" on the eclipsed moon, or the seas and other detail can be seen with hand instruments—opera-glasses, field-glasses, spy-glasses.

Grade 1.—When instruments of aperture of 2 inches up to 6 inches are necessary to show detail on the eclipsed surface. This includes ordinary stand-telescopes, porch telescopes, etc., and some fixed observatory telescopes.

[1] H. Seeliger, Abh. Akad. Wiss. zu München, II Kl., 19 II, pp. 383-448, 1896-97; Die scheinbare Vergrösserung des Erdschattens bei Mondfinsternissen.

Grade 0.—When apertures of 6 inches or more are needed. This covers the larger part of fixed observatory instruments.

Table 1 shows the almanac date of the beginning of totality, the magnitude, the grade on the above scale, and the position of the terrestrial terminator (sunrise-sunset line) at mid-eclipse, for each lunar eclipse 1860-1922 for which data suitable to grade on the above scale have been found—68 eclipses in all. These facts for each eclipse are followed by the name of the observer, the place, a number in parenthesis referring to the list of references placed later in the article, and an abstract of the observations reported, beginning with the condition of the sky and the aperture of the telescope, or some statement about the means employed. Strength of twilight is as stated by the observer, or based on moon's altitude. Under each eclipse the observers are mostly arranged in an order indicated by the column headed Phase—Air Mass. The phases of an eclipse are indicated by

a, e, first and last external contacts.

b, d, first and last internal contacts (lacking in partial eclipses).

c, middle of the eclipse.

The relative air mass along a ray from the moon's center to the observer's eye is given to one decimal; thus 5.3 means an air mass 5.3 times the mass along the zenithal ray of an observer at 45° and sea-level. These air masses were found by three-place computing of the moon's geocentric altitude, corrected for parallax and refraction to about 0.1°; values were then taken from Wolff's table.[1] For a station considerably above sea-level, the tabular number for the refracted zenith distance is multiplied by the ratio of the pressure there to 760 mm., pressures being taken from Humphreys' table.[2]

The code used for brevity in this column may be thus illustrated:

c=1.4, relative air mass at mid-eclipse=1.4.

a=2.3, relative air mass at first external contact=2.3.

b 1.7 c, relative air mass at a moment between first external contact and mid-eclipse=1.7.

The grade of the eclipse, 2, 1, or 0, is derived from a comparison of the observations. The tendency in grading has been to favor brightness, *i. e.,* positive statements of visible details have been preferred in general to statements of the contrary. So that the means of brightness grades are not likely to be too low.

It was expected that the arrangement according to air mass would tend to explain some of the discrepancies among the different reports.

[1] H. Wolff, Beiträge zur Geophysik, 11, table, pp. 412-413, 1912.

[2] W. J. Humphreys, Physics of the Air, 1920, p. 72.

But it helps very little. Some of these discrepancies are extremely puzzling.

Take, for example, the total eclipse 1902 X 16.

Barnard, Yerkes Observatory, air mass c=1.1, reports the darkest eclipse in his experience; no surface details visible to the naked eye, few with a 6-inch telescope, and those dimly. This report, by itself, would justify a grade of brightness=0.

Payne, Northfield, Minn., air mass c=1.2, 5-inch telescope, could easily see all the prominent details of the surface, and recognized many of the lesser ones. This by itself would justify brightness=1.

O'Hailoran, San Francisco, air mass c=1.3, says that the seas and the white streaks so conspicuous at full moon were visible even without magnifying power.

Godden, London, England, air mass a 4.6 b, could see the seas black as soot, both before and after totality began, with a field glass.

The last two were experienced amateurs; their reports agree well enough, and by themselves would justify brightness=2.

Taking these four definite reports together, the only possible courses are, a compromise grade=1 (the course adopted) or to reject the reports of the amateurs in favor of Barnard's or Payne's. To do this latter, however, is practically to disqualify amateur evidence, which, in the case of many an eclipse, is all the evidence.

Again, the total eclipse of 1895 IX 3;

Barnard and Perrine, Mt. Hamilton, air mass c=1.5, the main features visible to the naked eye, and easily seen in telescopes of 2.5-inch and 12-inch aperture; hence grade=2.

Payne and Wilson, Northfield, Minn., air mass b=1.7, at first no markings visible, soon after, many markings in 16-inch, but invisible in 5-inch finder; grade=0.

Campos-Roderigues, Lisbon-Tapada, air mass b=5, with 11.7 cm. aperture was able to see details, maria and craters, continuously. He says that Aristarchus was notable; but L. Swift, Echo Mountain, Cal., says that Aristarchus was a very inconspicuous object. Grade=1.

The amateurs reporting are also in disagreement, as well as the above professionals. The majority of the observers has been allowed to make the grade=2.

It will be noted that the discrepancies between Mt. Hamilton and Northfield in the two eclipses are not due to different air masses, these being about the same, and are opposite in sign in the two cases.

These two instances are not alone; discrepancies occur of a very puzzling character, and can sometimes be resolved only somewhat

arbitrarily. However, in other cases there is unanimity; the eclipse 1903 IV 11 is one—the most certainly dark eclipse in the period studied.

TABLE 1.—*Observations on the Brightness of 68 Lunar Eclipses*

Phase and air mass	
	1860 II 6; 0.812; Grade 2?
c	Pacific, Antarctic ice, Indian Ocean.
	Ward, Dublin, (3); occasional light clouds with halos.
a 1.4 c	N. e. and telescope, size not stated; the seas; Grimaldus shows well; not a trace . . . . of Aristarchus or Plato. . . . . nothing so like as a red hot penny with a little white hot piece at its lower edge.
	Pogson, Hartwell, Engl., (1); sky not stated.
c = 1.4	"With the equatorial," size not stated; actual shadow . . . . indefinite; . . . . visibility—it might almost be termed the brilliancy—of Aristarchus. Kepler and other spots were comparatively lost, or at most barely discernible . . . . in the shadow.
	Schmidt, Athens, (2); very clear sky; occasional light cirrus.
c = 1.8	Means not stated. All parts of the earth's shadow remained without exception completely transparent. (Other details briefly given agree well with Ward.)
	Grade 2, with interrogation point because Ward does not make it absolutely clear that the seas were observed with the naked eye.
	1862 XII 15; 1.415; Grade 0?
c	Portugal, S. Sweden, N. Russia, Siberia, Manchuria, Japan Sea, New Zealand, near Tierra del Fuego, Canary Islands.
a = 5.4	*Cantzler,* Greifswald, Ger., (4); civil twilight most of the time; sky clear, with stars. Means not stated.
a 17.8 b	Eclipsed part invisible.
	d'Arrest, Copenhagen, (5); Means not stated.
———	The moon vanished completely, but its altitude was low and it was seen through heavy haze.
	Grade 0, with interrogation point because of twilight.
	1863 VI 1; 1.224; Grade 0?
c	Bay of Bengal, Asia, Russia, N. Atlantic, Carribean Sea., Antarctic ice, near C. Leeuwin.
	Backhouse, Sunderland, Engl., (6); Clear break in clouds; weak astronomical twilight.
b 4.9 c	N. e. and opera-glass; the greater part of the moon's surface invisible; reflecting telescope, size not stated, Mare Crisium and some other markings, but not the whole surface. Darker than any other that I have seen.
	Bird, (7), place, sky and means not stated.
———	Saw seas and spots, varying with the stage of eclipse; Aristarchus disappeared in the shadow, except at beginning and end.
	Noble, Maresfield, Engl., (8); sky and means not stated.

——— Could see lunar detail at mid-eclipse save just in center of shadow, where everything was obscured.

Tempel, Marseille, (9); small stars and even nebulae visible near the moon.

——— Means not stated; could see various-colored spots, and the mountainous regions clearly.

Grade 0, with interrogation point because Backhouse does not state the aperture of his telescope.

1865 IV 11; 0.196; Grade 1

c S. Pacific, Antarctica.

6.9 *Hoefer,* Beauceron, France, (11); sky and means not stated, moon about 8° high. The eclipsed part was completely obscured, with no trace of red.

Freeman, Menton, (10); clear and serene; the divisions of Saturn's rings and the dusky ring, also 3 satellites, distinctly visible. Bright twilight at mid-eclipse.

c = 17.8 4½ inch; able throughout to distinguish through the shadow the edge of the obscured part of the moon, but could distinguish nothing upon that part.

1865 X 4; 0.344; Grade 1

c Arctic O., Hudson's Bay, E. N. America.

De la Rue, Cranford, Engl., (14); night bright, atmosphere tolerably steady.

c = 1.5 4⅛ inch and 13 inch reflector; details plainly perceptible in the telescope, obscured portion perfectly visible without.

——— *Cantzler,* Greifswald, Ger., (12); sky not stated, means not definitely stated; the eclipsed limb remained continuously visible.

——— *Flammarion,* (13); place, sky and means not stated; the rays of Tycho remained perfectly visible in the middle of the eclipse, as well as the eclipsed amphitheatres and craters.

1867 IX 13; 0.704; Grade 1

c S. Pacific, Antarctica, Indian O.

Ingall, London, (17); sky not stated.

c = 1.8 4½ inch; Aristarchus continued to be well seen till nearly the greatest phase, just before which I saw it as an 8th magnitude star, but after that I did not see it at all.

Browning, London, (16); sky remarkable for its clearness.

c = 1.8 4 inch, and 10½ inch reflector; the whole surface of the moon was at all times to be made out, many of the markings within the shadow being easily visible . . . . some of the ray streaks.

Slack, London, (18); sky not stated, but compare Browning.

c = 1.8 6½ inch reflector; at times the visibility of obscured parts was very striking, [especially at mid-eclipse].

Brothers, Manchester, Engl., (15); sky not stated.

c = 1.9 5 inch; during the whole period of the eclipse some of the brighter points of light within the shadow continued visible, as did also the entire disk, with many of the details of light and shade.

1869 I 27; 0.450; Grade 1

c S. W. Pacific, Antarctic ice, S. Indian O.

Prowde, N. Allerton, Engl., (20); sky not stated.

c = 1.3 2⅝ inch; the shadow was of a blackish-brown color, not so ruddy as . . . . sometimes. The main details of the lunar surface were well visible in the telescope through the shadow, and the bright craters were well marked.

Gribble, Constantinople, (19); sky not stated.

c = 1.5 2⅞ inch and 4¼ inch; all the prominent features of the moon's surface under the shadow were quite distinct through [both telescopes] . . . . strong red hue on the eclipsed limb.

1869 VII 22; 0.559; Grade 1

c N. W. Pacific, Bering's Sea, Siberia, Indus Valley, Indian Ocean.

Tebbutt, Windsor, N. S. W., (21); sky not stated.

c = 1.0 3¼ inch; . . . . irregular and ill-defined character of the shadow. The colour of the shadow was very dark iron grey; the red tint . . . . was not noticed. Even with a power of 30 and the illuminated disk [out of] the field, the details of the obscured part of the surface were perceived only with the greatest difficulty. The eclipsed limb . . . . pretty distinct . . . . .

1870 I 17; 1.664; Grade 1

c Antarctica, W. Indian O., Arabia, C. Europe, Greenland, S. California, Pacific.

Tebbutt, Windsor, N. S. W., (22); remarkably well seen . . . . thin filmy cloud till about 11 h. 43 m.

c = 1.8 3¼ inch; . . . . when the moon shone unclouded, the details of the lunar surface began to be perceptible in the telescope. These became gradually more distinct . . . . disk . . . . copper hue throughout the total phase, and continued distinctly visible both to the naked eye and in the telescope.

1870 VII 12; 1.687; Grade 1

c S. Pacific, W. Australia, Indo-China, N. Sweden, Windward Islands, Peru.

Walker, Teignmouth, Engl., (25); sky not stated, astronomical twilight.

d 4.6 e Binocular and sweeper, not clear which used for the following: At 11 h. 47 m. the configurations on the moon's surface were mostly discernible . . . . .

Noble, Maresfield, Engl., (23); clouds till after end of totality.

d = 5.5 4.2 inch; the shadow . . . . browner than I remember to have seen it before. The lunar detail was strikingly visible through it.

Thompson, Cardiff, Wales, (24); sky apparently mostly clear, but clouds a while during totality; twilight, strong toward beginning of observations.

b = 6.6 3½ inch; the seas were distinguishable before and after totality; at totality, the extreme western limb was scarcely visible.

1871 I 6; 0.693; Grade 1

c W. Pacific, Bering's Sea, Arctic N. America.
Birmingham, Millbrook, Ireland, (26); the sky was good enough for him to observe 6 occultations.

c = 1.5 6 foot [=4½ inch aperture?] The bright parts of the moon had a coppery color, and the dark regions showed a slate blue.

1873 V 11; 1.437; Grade 1

c Missouri and Mackenzie Valleys, Siberia, Siam, Indian Ocean, Antarctic ice, N. Patagonia, far Eastern Pacific, Yucatan.
Tebbutt, Windsor, N. S. W., (27); sky clear.

c = 1.3 4½ inch; at no time during the partial eclipse did the limb or the lunar details become indistinguishable in the telescope, and during the whole of the total phase the moon was plainly visible to the naked eye.

1876 IX 3; 0.341; Grade 1?

c Antarctica, Australia.
Perrotin, Toulouse, (30); interrupted by clouds; means not stated.

c = 2.2 The eclipsed limb was clearly seen, and also the lunar surface, particularly the part near the shadow boundary.
Arcimis, Cadiz, Spain, (28); atmosphere magnificent, not a cloud . . . . extraordinary and exceptional purity.

a 3.1 c 4 inch and d. v. spectroscope; [The inner shadow was too dark to give a spectrum, which was obtainable only near the boundary].
F. R. A. S., (29); place, etc., not stated.

——— I remember myself how very nearly the moon disappeared from the sky on October 4, 1884, and also the notable darkness of the earth's shadow during the partial eclipse of Sept. 3, 1876.
Grade 1, with interrogation point because of indefinite data.

1877 II 27; 1.671; Grade 2

c Antarctica, Pacific, E. Siberia, Greenland, near C. Verde.
v. Sterneck, Vienna, (35); sky not stated.

c = 2.2 6.4 cm. and 9.5 cm.; certain parts of the moon's surface, as Mare Serenitatis, Imbrium, and several others, appeared of a brighter red than their surroundings and stood out clearly from them. Aristarchus too was clearly visible as a shining point after its immersion till 7 h., and for an equal time before its emersion.
Barber, Rome, Italy, (33); the sky was so good that 8 very small stars were visible to him within one diameter distance from the moon, and the Galaxy and Zodiacal Light were brilliant.

c = 2.3 1¼ inch; at the middle of the eclipse the central parts of the lunar disk were especially dark, and the markings upon it were barely to be distinguished; the circumference . . . . was much brighter.
Riccò, Modena, (34); sky not stated.

c = 2.5 The red light of the umbra was so intense, that during totality it produced distinct shadows of the telescopes and other objects illuminated by it.

Arcimis, Cadiz, Spain, (32); clear after beginning of totality; weak astronomical twilight.

c 4.3. d N. e. and telescope, aperture not stated; no details were distinguishable by either.

A. H. S., (31); place and sky not stated.

——— 6½ inch reflector, after beginning of totality; what struck me most was the absence of bright spots, such as Aristarchus.

1877 VIII 23; 1.761; Grade 2

c Antarctica, E. Indian O., Malay Pen., Nova Zemlya, Greenland, Labrador, Carribean Sea, E. S. Pacific.

Johnson, Crediton, Engl., (37); not a cloud throughout.

c 1.4 d 2¼ inch; Mare Crisium, Fecunditatis, Nectaris, Tranquilitatis, Serenitatis in a smoky gloom. . . . .

Rand Capron, Guildford, Engl., (39); sky not stated.

d = 2.2 8½ inch; as shadow began to pass off . . . . the indistinctness noticeable during approach and continuance of totality gave way to a considerable sharpness of the moon's features as seen through the shadow. The shadowed part glowed with a richer copper tint, on which were seen dark, almost black, spots and patches. . . . . A good field glass rendered them hardly less distinct.

3¼ inch; the dark spots or patches were distinguished to be moon details, but they were remarkably sharp and well-defined. [He says the same of details with 3¼ inch before totality.]

Maunder, Greenwich, (38); sky not stated.

c = 2.3 . . . . to the n. e. the eclipsed part was fairly bright and of a coppery hue, and the details of the surface seen with great distinctness. . . . .

Elger, Bedford, Engl., (36); exceptionally favorable circumstances.

a 2.7 b . . . . details visible in the finder [of the 4 inch].

1878 VIII 12; 0.590; Grade 0

c White Sea, Greenland, Labrador, Florida.

Maunder, Greenwich, (41); sky not stated.

c = 2.5 Finder of the great equatorial; . . . . the eclipsed part completely cut out, the shadow being so dense and black that the outline of the moon's limb could not be traced under it, even in imagination; nor could any features be made out on the eclipsed part, except at the very edge of the shadow.

Slack, Forest Row, Engl., (42); occasional cirro-stratus.

c = 2.5 6¼ inch reflector; Copernicus faintly visible as a pale white spot . . . . most of the umbra coppery, but not bright or transparent. All through the eclipse the umbra was darkest at the approaching margin for a width about equal to that of Copernicus. . . . . Moon's limb always visible, if faintly.

E. E. M., (40); place and sky not stated; probably somewhere in England.

——— 2¾ inch. I could detect the limb of the moon through the shadow almost as soon as it began to creep over the disk. . . . . At 11 o'clock the moon presented a superb spectacle, blood-red. . . . .

1880 VI 21; 1.071; Grade 2?

c S. W. Pacific, Antarctic ice, Antarctic and Indian oceans.
Tebbutt, Windsor, N. S. W., (45); cloudless.

c = 1.0 4½ inch; . . . . badly defined nature of the periphery of the shadow . . . . the eclipsed moon a conspicuous object . . . . unusual brightness for a total eclipse, especially on the southern limb.

c = 1.0 (43); nothing about means or sky; well seen at *Melbourne Observatory* . . . . the usual copper-red colour . . . . the western edge of the moon retained a greater brightness than the rest of its surface during the whole period of totality. . . . . The features of the moon were plainly visible throughout the darkest phases.
Russell, Sydney, N. S. W., (44); air very clear and nearly calm.

c = 1.0 11½ inch; . . . . the red light . . . . more conspicuous, and yet was so translucent that all the conspicuous features of the moon could be seen, even the markings on the inner wall of the Aristarchus, etc.

Grade 2, with interrogation point because dependent so largely on Tebbutt's recollection of previous eclipses.

1881 VI 11; 1.365; Grade 1

c N. Atlantic, Artic N. America, N. Pacific; almost a complete great circle of sea.
Barnard, Nashville, Tenn., (46); sky not stated.

c = 2.1 . . . . the moon was strikingly conspicuous during totality. It was of a beautiful bright cherry red, and the general details of its surface were very noticeable in a 5 inch telescope.
Hall, Washington, D. C., (47); means and sky not stated.

c = 2.6 Nearly all the details of the surface of the moon could be seen during the total eclipse.
Hooper, Harvard, Mass., (48); clear; faint astronomical twilight.

c = 3.3 4 inch; . . . . even during the middle of totality . . . . the most prominent details of lunar scenery were easily made out. Color . . . . a dull orange red.

1881 XII 4; 0.979; Grade 2

c S. Pacific, Antarctic ice, S. Africa.
Piat, Bagdad, (51); very cold; nothing but sky.

c = 1.2 Good opera-glass; in the red region the details were perfectly distinguishable.
Johnson, Bridport, Engl., (50); sky propitious, civil twilight.

c = 6.9 Telescope, aperture not stated; western seas; Aristarchus, a white spot in the coppery disk . . . . continued so.
Rand Capron, (52); place not stated; the moon was low and the night misty; small banks of clouds on the horizon; in England somewhere. 3¼ inch; no red patches or brilliant tints were seen, but the moon's configuration was well made out through the shadow.

1884 IV 9; 1.438; Grade 0?

c Antarctica, Indian O., Burmah, Lena Valley, Mississippi Valley, Yucatan.

c = 4.9 Java, Java Head, astronomical twilight.

c = 2.8 Java, Bantiman, dark.

Ch. Dufour, (53), states, on an authority not given, that the very rare occurrence of a dark eclipse, in which the moon disappears, happened twice in the year 1884, as it was observed, first, Apr. 10, in the island of Java, second, October 4, in Europe. Java Head and Bantiman are extreme maritime positions given in Bowditch's Navigator.

Grade 0, with interrogation point because the original authority is not stated definitely.

1884 X 4; 1.533; Grade 1

c Lena Valley, Arctic Archipelago, New England, Venezuela, E. Argentina, Antarctica, far Western Australia, China Sea.

This eclipse was widely observed in Europe, and has generally been classed with dark eclipses like that of 1816. But the records hardly justify that; while Young's General Astronomy, (1898), p. 254, says, ". . . . the moon was absolutely invisible to the naked eye . . . .," the following observations show that it was brighter, though quite dim. Coming in the period of the Krakatoa phenomena, it was much discussed in that connection.

Parséhian, Constantinople, (63); conditions excellent.

c = 1.2 5.0 cm.; Tycho, like a star of the second magnitude. The moon during totality was feebly but definitely colored in red.

Berge, Romorantin, France, (55); nothing about sky or means.

c = 1.5 During totality the eclipsed moon remained constantly visible, and the Mare Tranquilitatis, Mare Serenitatis, Oceanus Procellarum, etc., were easily distinguished.

Byl, Brussels, (56); atmospheric conditions hardly favorable, sky very cloudy and often completely covered.

c = 1.6 10 cm.; during totality the disk was continuously visible, colored dark red, with a luminous circle around, white within, blue without. The seas were visible as brownish spots, very dark; the peaks, as brilliant points with slight red aureoles.

Guiot, Soissons, France, (60); nothing about sky or means.

b 1.6 c Moon very dark, although sharp; Tycho, Copernicus, Plato and Grimaldi easily seen, but not Aristarchus.

Trépied, Paris Obsy., (65); sky not stated.

b 1.6 c 25 cm.; early in the partial stage the shadow edge was tinted red, and beyond 2′ or 3′ within it nothing was perceptible. Later the shadow suddenly brightened, it became possible to see the limb and the principal details of the surface. On the whole the shadow was completely uniform, of a pale but decided blue.

Spitta, Clapham, Engl., (64); sky cloudless.

c = 1.6 10 inch reflector; during totality the moon was, generally speaking, exceedingly faint . . . . at times barely visible to the n. e., and

presented none of the coppery color usual on these occasions. It was bluish at the lower edge. . . . . No markings were plain enough to be recognized.

Beechey, Downham, Engl., (54); sky and means not stated.

c = 1.7 During totality it presented one equal flat tint of cold grey, through which every feature of the lunar surface was distinctly visible.

Denning, Bristol, Engl., (57); perfectly cloudless sky.

c = 1.7 10 inch reflector; . . . . her sharply circular contour, however, still admitted of satisfactory observation, and many leading features of the surface were recognized amid the prevailing gloom; . . . . interior region the coloring . . . . dark reddish brown.

Guillaume, Perronas, France, (59); nothing about means or sky; the

b 1.7 c seas were all visible.

Lowe, Chepstowe, Engl., (61); sky cloudless, stars very brilliant.

c = 1.7 Telescope, aperture not stated. Having previously observed a number of lunar eclipses, ... the density and blackness of the shadow was far greater than any previous one that I had seen. In all previous eclipses I have been able to trace the outline; in the present case this was quite impossible. The moon had more the appearance of a large star whose light was just able to pierce through a dense haze. [He nowhere in his long account says anything of surface details.]

Muller, Copenhagen, (62), and wife. Nothing about sky or means.

b = 1.8 Immediately after the beginning of totality, saw a bright red copper disk, which lasted perhaps 2 m. Others in Copenhagen agreed as to the color, but not as to intensity; outside of Copenhagen Danish observers noted fainter reds.

Erck, Shankill, Ireland, (58); most favorable circumstances.

c = 1.8 Means not stated. Obscuration so great that the disk could hardly be discerned with the n. e. There were changes in the brightness of the surface, described with sketches.

In his summary, Flammarion says that there are brought out curious and striking discrepancies among the accounts received. This is clear in the above. Such discrepancies seem frequent in descriptions of dim eclipses, of which this was surely one.

1885 III 30; 0.886; Grade 1

c N. Pacific, Bering's Sea, Finland.

Buisson, St. Denis, Réunion, (69); temps splendide; astronomical twilight at beginning.

a 4.3 c 10.8 cm.; the eclipsed limb became invisible at 6 h. 57 m., l. m. t., and

c 1.4 e remained so till near last contact; about 9 h. 15 m., l. m. t., Aristarchus and Mare Crisium were sometimes visible; during a great part of the eclipse the shadowed part was entirely or nearly invisible. Colors not mentioned.

Biggs, Launceston, Tasmania, (67); quotation from Launceston "Examiner"; sky and size of telescope not stated, but he observed constantly for three hours.

c = 1.5 [At most (mid-eclipse) 25° of the eclipsed limb was visible, from the shadow-border inward; with this exception] all within the shadow

was utterly obliterated—lost in the dead slaty tint of the sky. I could not distinguish a single crater after once it was fairly within the shadow. Not the slightest trace of the coppery tint was visible throughout.

Ballot, Rolfontein, Transvaal, (66); detached clouds; astronomical twilight.

a 4.0 c 6 inch; when the shadow line had reached to midway between Plato and Aristarchus, I could plainly trace the limbs of the obscured part all round.

Broune, Odessa, (68); sky pure to the end; bright civil twilight at beginning of observations = mid-eclipse.

c = 18.2 12 cm.; Kepler and Aristarchus shone brilliantly as usual. The eclipsed part was colored blue like the surrounding sky. The eclipsed limb was invisible in telescope and in opera-glass, even quite close to the bright part.

1887 VIII 3; 0.424; Grade 0?

c Siberia, Kara Sea, N. Atlantic.

Rayet, Bordeaux, (73); sky very fine; astronomical twilight at mid-eclipse.

c = 4.4 38 cm.; the whole disk of the moon never ceased to be visible in the telescope, and the eclipsed part showed no coloration at all sensible.

Klein, Cologne, (71); clear sky; astronomical twilight.

c = 4.7 3 foot [= 2¼ inch?] and 6 foot [= 4½ inch?] No details visible in the eclipsed part, except toward the end.

Grade 0, with interrogation point because all observations were made in weak twilight; this weakens the evidence for a dark eclipse, though it would strengthen that for a bright eclipse.

1888 I 28; 1.647; Grade 2

c Antarctic ice, S. W. Atlantic, Pampas, Ecuador, Mississippi Valley, near Pt. Barrow, E. Asia, Cochin China, S. W. Indian O.

Brugière, Marseille, (74); sky not stated.

b = 1.2 Opera-glass; of the lunar surface in the shadow, the seas are dark and the plains are bright, easily visible.

Terby, Brussels, (78); lunar corona in light clouds at beginning, and a halo at end.

c = 1.2 Equatorial and n. e.; remarkable for the intensity of the red coloration, which caused the surface details to be constantly perceived.

L. N(iesten?), Brussels Obsy., (76); advantageous conditions.

c = 1.2 During totality, for 1 h. 38 m., it was not absolutely obscured, but as if covered with a red veil, through which the eye could follow the contours of the principal spots.

——— *Soc. Astr. France,* (77); several members report corroborating the above.

Fromme, Giessen, (75); sky continuously clear.

c = 1.2 The seas easily visible to the n. e. throughout totality.

1888 VII 22; 1.816; Grade 1

c S. Greenland, Arctic Archipelago, near Sitka, Pacific, Wilke's Land, Cape Colony, Gulf of Guinea, Morocco, N. Atlantic.
Barnard, Mt. Hamilton, (79); evening clear.

c = 2.3 6½ inch; details during totality singularly indistinct.
Valderrama, Teneriffe, (82); sky not stated; dawn at mid-eclipse, *i. e.,* strong astronomical twilight.

b = 2.3 2½ inch and opera-glass; during totality the configurations of the
c = 7.7 lunar surface were continuously visible.
Duprat, Constantine, Algeria, (80); sky very pure; dawn a hindrance to color observations; means not stated, but his figure must have been
a = 8.5 made with a telescope. The eclipsed part was absolutely invisible.
——— *G. H.,* New Orleans, (81); and *Romani,* Port-au-Prince, (81a), both had very favorable conditions, but otherwise report very incompletely. Both speak of the copper color and redness of the moon.

1889 I 16; 0.696; Grade 0

c Libya, Black Sea, Russia, Siberia.
Barnard, Mt. Hamilton, (83); sky not stated, but he observed throughout the eclipse.

c = 1.1 12 inch; the obscured portion of the disk was conspicuous to the n. e. throughout nearly all the eclipse, and appeared of a lightish red color . . . . . The prominent objects were easily seen within the shadow [presumably with the telescope].
Mitchell, Chester, Engl., (86); beautifully clear, clouded over before mid-eclipse.

c = 2.5 8½ inch reflector; with a low power the darkened limb was just visible.
Eginitis and *Maturana,* Paris, (85); sky fine at first, completely covered after mid-eclipse.

c = 2.9 Équatorial ouest; the different craters, and in general all the details of the eclipsed part very clearly distinguished.
Stuyvaert, Brussels, (87); favorable weather, image throughout sharp and steady.

c = 3.0 15 cm.; the lunar formations disappeared rapidly as soon as they were invaded by the shadow.
le Cadet, Lyons, (84); sky not stated.

c = 3.2 38 cm.; almost all the details visible in the shadow.

1889 VII 12; 0.486; Grade 0

c N. S. Wales, Antarctic ice, Magellan Str.
Riccò, Palermo, (93); sky apparently clear.

c = 2.9 25 cm.; notable lack of light and color compared with preceding eclipses. Aristarchus visible a while after immersion.
Mascari, with Riccò.

c = 2.9 25 cm.; shadow very dark, Aristarchus hardly visible, in contrast with other eclipses, when it and others were very visible.
v. Gothard, Héreny, (88); sky not stated; astronomical twilight.

c = 4.2 4½ inch; the eclipsed part was very dark, grayish black.
v. Konkoly, O'Gyalla, (89); sky not stated, but a halo stopped observations later; astronomical twilight.

c = 4.2 6 inch; at mid-eclipse could see the eclipsed part only with the bright segment out of the field.
Krueger, Kiel, (90); sky and means not stated.

——— The brilliancy of Aristarchus in the surrounding gloom was very striking.

1891 V 23; 1.306; Grade 1

c N. W. Pacific, Saghalien, N. Russia, Italy, Sahara, near C. Palmas, Graham Land, S. Pacific.
Wooster, Ballarat East, Victoria, (96); beautifully clear.

c = 1.7 8 inch reflector; some of the larger and bolder formations were traceable during the whole of totality. After passing the center of the shadow, though still wholly immersed in it, the N. and E. parts became much lighter, quite a pale ash color, in which Sinus Iridum, Plato, Aristarchus, Grimaldi, etc., stood out boldly.
Jackson, Constantinople, (94); moon rose out of haze and fog; apparently clear thereafter; weak astronomical twilight about end of totality.

d = 3.7 6 inch; [½ hr. before end of totality] Aristarchus and the region immediately north of it became conspicuous, and increased in brightness from that time forwards. The moon was visible to the n. e. throughout.
Lewitsky, Kharkov, (95); cloudless sky, astronomical twilight.

c 5.1 d 3 inch; the whole disk plainly visible, with some formations visible but dim.

1891 XI 15; 1.393; Grade 2

c Antarctic ice, Indian O., B. of Bengal, near Yakutsk, Alaska, Rocky Mountains, near Manzanillo, S. Pacific.
Gore, Ballysodare, Ireland, (98); clear and cloudless sky.

d 1.3 e Binocular; markings on dark part pretty conspicuous.
Power, Cape Observatory, (100); clear.

b = 1.8 N. e., [from context;] the coppery hue characteristic of "bright" eclipses was distinctly visible . . . . there were darker patches on the coppery surface . . . . it resembled drawings of Mars, with patches of darker shade scattered over the moon's surface.

——— *Fenet,* Beauvais, France, (97), and *Decroupet,* Soumagne, both with good sky, used opera-glasses, and report seeing the spots and configurations. Others with larger telescopes agree as to the brightness

——— and visibility of details. But *Leslie,* Southampton, Engl., (99), clear sky, "glasses," says that "the darkness and absence of color of the shaded part of the moon was even more marked in this eclipse than in that of October 4, 1884."

1892 V 11; 0.953; Grade 2

c Antarctic ice, S. E. Pacific.
Codde and others, Marseille, (101); good conditions.

c = 2.2 16 cm.; Kepler . . . . and the principal topographic details are very visible.

Goodacre, Highgate, Engl., (103); weather clear; markings more
c = 3.3 distinct to the n. e. than in the telescope.

Crossley and Gledhill, Halifax, Engl., (102); weather all that could be desired.

c = 3.7 The principal lunar seas, etc., were readily seen and identified with the help of an opera-glass.

Observers at Louvain, (104), saw the seas and the northern region of
——— the moon with the n. e. Others, at various points, with telescopes large and small, report visibility of details.

1892 XI 4; 1.092; Grade 0

c C. Europe, N. Sea, N. Atlantic, Greenland, Baffin's Bay, Queen Charlotte's Sd., S. Pacific, Antarctica, Mozambique Channel, Tripoli.

Gale, Paddington, Sydney, N. S. W., (107); well seen, in spite of haze and light cloud.

c = 2.0 8½ inch reflector; the want of sharpness of objects on the lunar surface was noticeable throughout, although Jupiter was very well defined with power 280. . . . . Detail was only seen near the northern and western limbs during the total phase.

Russell, Sydney Obsy., (110); was occupied with photographs of the
——— eclipse, and makes no report about the visibility of details, except that none were visible for a while after first contact; aperture not stated, breaks in clouds. The coppery color was brilliant, except in early stages. Contrary to the prediction of the Nautical Almanac, he says that this eclipse as observed was certainly not total.

Doberck, Hong Kong Obsy., (106); weather not stated; 2¼ inch
——— binocular; nothing about visibility of details; the early shadow was bluish gray, the later stages brighter.

In France, the moon rose in bright twilight, past totality. *Gio-*
——— *vanozzi,* Florence, (108), and *Cortel,* Chateau Chinon, (105), both say that the eclipsed part was entirely invisible, not distinguishable from
——— the sky. *v. Glasenapp,* Abastuman, (109), emphasizes the varying intensity of the red color, and gives the moment of its disappearance, 5 h. 04 m. G. M. T., which agrees with Russell's statement of 5 h. 03 m. He says nothing of details.

1894 III 21; 0.248; Grade 0

c N. W. Pacific, Mackenzie Valley, Arctic O., E. of Ural Mts.

Rzyszczewski, Minoussinsk, E. Siberia, (111); sky completely pure; twilight over mid-eclipse.

c = 3.0 7.2 cm.; he notes (1), the complete invisibility, even in the field of my telescope, ... of the eclipsed part of the moon . . . . for even the contour of the disk was invisible. (2) . . . . the shadow was like an opaque smoke, completely black, with a slight greenish shimmer. (3) The eclipsed part is much more invisible, both to the n. e. and in the telescope, than the ashy disk of our satellite during the first days of the first quarter. . . . .

1894 IX 14; 0.231; Grade 2

c Antarctica, S. and C. Africa.
Barnard, Mt. Hamilton, (112); sky not stated, but he observed and made photographs all through.

c = 2.0 12 inch and its finder; in 12 inch, a pale, ashy, dusty shade, with scarcely any boundary line; in finder, outline of shadow quite marked. Limb of the moon and details on the surface seen while in shadow—limb more conspicuous than at same stage in other eclipses. . . . . I think it was lighter than usual.
Comas-Sola, Barcelona, (113); excellent sky; astronomical twilight.

c = 5.2 Opera-glass; there are seen in the shadowed part the principal lunar configurations, as Mare Imbrium, Mare Frigoris, etc. . . . . In spite of dawn and low altitude, the eclipsed part more visible than ever [at about a quarter-hour before end of totality. He observed *no red.*]
Riccò and *Mascari,* Catania, (116), *Pilloy,* Chateau-Thierry, (115), *Ladoux,* Frontignan, (114), agree as to the lead color of the shadow, Pilloy seeing a faint tint of red.

1895 III 10; 1.627; Grade 2

c E. Black Sea, near Nova Zemlya, Alaska, Pacific, Antarctica, Portuguese E. Africa, middle Red Sea.
Observers at Northfield, Minn., (124); sky beautifully clear.

c = 1.7 At the edge of the umbra the light was quite bright, so that the more prominent details of the moon's surface could be seen with the n. e. . . . . Toward the center of the shadow the illumination lessened rapidly . . . . the surface markings could hardly be distinguished [with the n. e.?].
Duménil, Yébleron, France, (119); aureole and halo.

c = 2.3 Marine glass, 5.8 cm.; in the early stages, shadow black like soot, no detail visible. Previous to mid-eclipse, brighter, few details visible, but Mare Crisium pretty plain. Later during totality, the moon was absolutely invisible to the n. e.
Martial, Ploërmel, France, (122); sky of perfect limpidity.

c = 2.3 5.7 cm.; much like the report of Duménil, except that he was not able ever to see any details during totality.
Everett, Greenwich, Engl., (121); nothing about sky.

c = 2.4 Opera-glass; ruddiness confined to lower half of disk; 4 inch; no ruddiness, maria easily seen in telescope.
Bosshard, Winterthur, Switz., (117); clear, except for occasional small thin clouds near the end.

c = 2.6 3½ inch; at beginning of totality, Mare Crisium weakly visible; this and other details were not noted at mid-eclipse; Grimaldi appeared as a dark spot just before end of totality.

c = 2.9 *Perrine,* Mt. Hamilton, (125); haze the entire evening, sufficiently thick to interfere materially, especially with the occultations. The moon's disk was visible at all times, and quite conspicuous except for a brief time at mid-transit, and even then the outlines of the principal dark areas were visible to the n. e.
Eddie, Grahamstown, Cape Colony, (120); sky apparently good; twilight came with beginning of totality.

b = 3.7 Aperture not stated. All lunar detail was completely obliterated, and though it was decidedly a red eclipse, it was undoubtedly a very dark one.

——— *Comstock,* Madison, Wis., (118); perfectly clear sky; noteworthy for the unusual brightness of the moon during totality.

——— *Quélin,* Angers, France, (126); at first a halo, then clear. Aperture not stated; no detail visible in telescope, and, part of the time, moon invisible.

——— *Rudaux,* Donville, France, (127); sky and means not stated, but he observed throughout totality, and no doubt with telescope.
Comparing his sketches of the eclipse with theory, he concludes that the apparent center of the shadow is north of the theoretical center. Whence one may conclude, he says, that the terrestrial southern hemisphere enjoys an atmosphere very pure, refracting the solar light *en entier.* [Sketches not published by editor.]
Newbegin, (123); place not stated, no doubt in England; fine and clear, [last hour of totality].

——— Finder, aperture not stated; the whole outline of the moon and all the details of the surface were most distinct. . . . .

1895 IX 3; 1.557; Grade 2

c Antarctica, S. Atlantic, Ashanti, Morocco, Iceland, near Bering's Str., New Zealand.
Nauwelaerts, Rosario de Santa Fe, Arg., (131); fairly good sky up to totality.

c = 1.3 Aperture not stated; Aristarchus remained visible some time, Kepler, Copernicus and Tycho disappeared almost at the time of contact with the shadow. At totality, to the n. e., the color is reddish. . . . . In the telescope, ... all the selenographic configuration is readily visible. . . . . Certain regions, as the Mare Fecunditatis and Mare Serenitatis, are very dark.
Barnard, Mt. Hamilton, (128); night very satisfactory; observed throughout eclipse.

c = 1.5 2½ inch; in telescope all the lunar details clearly seen. The dark regions seen easily with the n. e.
Perrine, Mt. Hamilton, (133); sky overhead clear, and the air very transparent.

c = 1.5 12 inch. The moon remained plainly visible all through the total phase, the main features being discernible with the n. e., and distinct in the telescope.
Payne and *Wilson,* Northfield, Minn., (132); sky cloudless, hazy at beginning, clear afterwards.

b = 1.7 Shadow at first very dark, to n. e. almost black; . . . . . No details visible till [about 10 m. after second contact] when Aristarchus was dimly seen. Soon after, many markings visible in 16 inch, but invisible in 5 inch finder.
Campos-Roderigues, Lisbon-Tapada, (129); sky not stated; totality began in mid-twilight.

b = 5.0 11.7 cm.; the details of the disk were continuously visible, particularly

c = 17.8 the contours of the maria, and certain craters, notably Aristarchus and Manilius.
Flammarion, Juvisy, France, (130); sky hazy; strong astronomical twilight.

a 7.6 b The half-eclipsed moon hard to see, with n. e. and opera-glass, on the field of the sky.
Roulaud, Drague ville, France, (134); sky and means not stated.

——— The principal spots were visible.
Véréri, Bellevue, France, (136); sky and means not stated.

——— The shadow was entirely black.
Swift, Echo Mt., Cal., (135); cloudless sky.

——— Aristarchus was on this occasion a very inconspicuous object, not noticeable unless looked for.

1896 II 28; 0.870; Grade 2

c Antarctica, S. Atlantic.
Möller, Bothkamp, (138); sky not stated.

c = 2.4 6.0 cm.; the smaller craters were visible after immersion only in the neighborhood of the shadow-edge, and no longer after they had penetrated deeper into the shadow.
W. P (rinz?), Uccle, Belgium, (141); sky almost completely hidden.

c = 2.6 To the n. e., the shadow which covered the moon was reddish, and grayer toward the center of the disk; in it one could distinguish the gray spots of the lunar seas as well as the brilliant crater Tycho.
Duménil, [Yébleron], (137); apparently a pretty good sky between clouds.

c = 2.8 Marine glass, 5 cm.; the light rose-color which covered 8/10 of the surface was admirably transparent. In it there were perceived all the details; continents and mountains, very blue; the seas, a little more gray.
Taylor, S. Kensington, Engl., (140).

c = 3.0 2 inch; the principal lunar seas and formations were easily seen through the red part of the shadow, which was redder to the n. e. than in a 2 inch o. g.
Roberts, Aberdeen, Scotland, (139); sky not stated.

c = 3.2 The maria could be distinctly traced with the n. e.

1898 I 7; 0.157; Grade 1

c Siberia, near Bering's Str., Alaska.
Stuyvaert, Brussels, (145); excellent conditions.

c = 1.1 38 cm.; the shadow was throughout of a uniform slate gray. For a while after beginning, and again before ending, the brilliant ray extending S. E. from Tycho was visible in the shadow. Previous to the middle of the eclipse the immersed limb was seen only with difficulty.
Chèvremont, Congis, France, (142); during the eclipse the sky was perfectly limpid.

c = 1.1 6.0 cm.: about mid-eclipse the shadow is so dense that the details of the surface disappear entirely; but, a curious fact, the bright ray

extending S. S. E. from Tycho is clearly visible throughout its whole extent . . . . with telescope. These conditions persisted throughout the eclipse.

——— *Guiot,* Soissons, (144); says that to n. e. the limb was entirely invisible.

Godden, [London?], (143); night calm and slightly foggy.

c = 1.1 15/16 inch and 3 inch; could see the limb, but no surface detail whatever.

1898 VII 3; 0.934; Grade 2

c Southern Pacific Ocean, Australia.

Saija, Catania, (153); sky clear throughout eclipse.

a 3.0 c 12 cm.; a little way inside the shadow edge the lunar topography is not visible.

Riccò, Catania, (152); sky clear throughout eclipse.

a 3.0 c 15.3 cm.; Aristarchus brilliant, Kepler and Copernicus well seen.

Marckwick, Gibraltar, (150); very favorable circumstances.

c 3.2 e Binocular; possibly many would hardly have noticed there was an eclipse . . . . . The principal markings of the lunar disk seen perfectly well in the shadow.

Moye, Bordeaux, (151); sky not stated.

[About half-an-hour before mid-eclipse] with an opera-glass there are visible in the shadow the Mare Crisium and the principal lunar configurations. . . . .

c 3.5 e [About a half-hour after mid-eclipse] with an opera-glass the Mare Crisium is visible in the shadow, dark on a brighter ground. Proclus shines with a reddish light in the shadow.

Struve, Kharkov, (154); clear at first, clouds during second half.

c = 3.7 6 inch; the eclipsed part of the moon was pretty dark, but in the 6 inch refractor the largest craters could still be recognized in the shadow; but not in smaller telescopes.

Weinek, Prague, (156); good weather, after a while completely clear.

a 3.8 c 9.76 cm.; he mentions various details as visible at different times, particularly Mare Crisium and Aristarchus.

Ambronn, Göttingen, (146); thin filaments of cirro-stratus.

c 4.3 e 8.3 cm.; the more sharply limited seas and craters are also visible in the eclipsed part.

Grein, St. Emilion, France, (148); sky not stated.

c = 5.2 4.3 cm.; at maximum eclipse he could see the principal spots, a little vaguely; with n. e., nothing.

Gaythorpe, Barrow-in-Furness, Engl., (147); breaks between clouds, later clear and observations continuous.

e = 6.1 3 inch, [during latter half]. When the illuminated portion of the moon was moved out of the field, the umbra was sufficiently transparent to show the Mare Crisium, and a few of the neighboring ringplains, such as Cleomedes.

Véréri, Bellevue, France, (155); sky not stated; astronomical twilight.

a 6.4 c The red coloration is particularly intense on the eastern part of the limb; it shades off gradually towards the still illuminated region, and permits the seas of Serenity and Tranquillity to be seen by the n. e. and with an opera-glass.

Hauët, Paris, (149); cleared up sufficiently for good observations. Astronomical twilight.

c = 6.4 At maximum eclipse, with n. e., the contours of the eclipsed portion were clearly visible. The principal spots were equally visible through the shadow. . . . .

1898 XII 27; 1.384; Grade 2

c S. Atlantic, near Santiago, near Vera Cruz, near Sitka, near Bering's Str., near Bangkok, Indian O.

Whichello, Chester, Engl., (169); cleared off before first contact.

c = 1.1 During totality, both by n. e. and in 9 inch reflector, outlines of the maria, etc., could be easily seen.

Staus and *Mündler,* Frankenthal, Ger., (167); clear air during totality.

c = 1.1 3 inch; details mentioned as visible in the shadow, Tycho and Aristarchus.

Bareel, Louvain, (157); bad state of sky and strong wind.

a 1.1 b 6 inch; all the seas visible in the equatorial, but not Tycho.

King, Leicester, Engl., (164); clear breaks in clouds.

d 1.2 e 2 inch; details well seen.

Blacklock, Gateshead, Engl., (158); unclouded and nearly black sky.

c = 1.2 3½ inch reflector; during the whole time the details of the moon's surface were distinctly visible in the telescope.

Gaythorpe, Barrow-in-Furness, Engl., (162); sky clear, strong wind.

b 1.2 c 3 inch; . . . . everywhere sufficiently transparent to allow most of the coarser details to be seen.

Smith, Edinburgh, Scotland, (166); observed the eclipse through intervals in the clouds.

c = 1.2 All through, the dusky surface markings were easily seen with the n. e.

Franz, Breslau, Ger., (161); sky not stated.

c = 1.2 3½ inch; easily visible during totality—Grimaldi, Aristarchus, Sinus Iridum, Plato, Promontorium Acherusia, Manilius, Menelaus.

Ellison, Monkswearmouth, Engl., (159); perfectly clear sky all through.

a-b 4 inch; Grimaldi, Mare Crisium, and other dark spots within the umbra very distinct. . . . . Tycho and rays noted to be very conspicuous.

Fauth, Landstuhl, Ger., (160); occasional cirrus.

c 17.8 cm.; spots, and rays of Tycho, Copernicus and Kepler perfectly clear during totality.

Killip, St.-Anne's-on-the-Sea, Engl., (163); clear sky.

c 5 inch; detail everywhere remarkable. Menelaus and Manilius only a little less bright than Aristarchus. The rays from Tycho very fine.

Stuyvaert, Uccle, Belgium, (168); sky clear.

c 15 cm.; the great configurations of the seas are visible; Aristarchus brilliant. . . . . All selenographic details are very visible.

"*No Sig,*" (165); place not named; moon quite clear, and so remained.

c The features on the moon's surface were discernible with the n. e., the contrast between seas and highlands being well marked. 9 inch reflector; Tycho, Grimaldi, many of the streaks, Plato, and so on.

1899 VI 22; 1.487; Grade 0?

c Siberia, near end of Aliaska Pen., Pacific, W. Antarctica, S. Atlantic, near Antanarivo, Indus Valley.

Bernacchi, Cape Adare, Antarctica, (170); fine and clear, but misty; but small stars in Sagitta and Crux were visible during totality. Aperture not stated; he calls it "the big telescope." Eclipse visible throughout.

c = 1.6 During this time there was absolutely no . . . . detail observable on the lunar surface, and at no time was the whole of the disk visible. . . . . During the first half of totality the western limit was of a dull red color, and the eastern quite invisible. During the latter half it was the reverse.

Grade 0, with interrogation point because of the mist, and the aperture not being given.

1899 XII 16; 0.996*; Grade 2

c Far S. Atlantic and Pacific, Weddell Sea.

Lafitte, Saïda, Algeria, (176); sky not stated.

a 0.9 c Opera-glass; the principal seas.

Saija, Catania, (180); sky clear throughout.

a 1.1 c In the finder, 4 cm., the topography of the eclipsed part is entirely invisible, but in the telescope, 15 cm., well enough.

Daguin, Beyris, France, (172); sky very pure, stars brilliant, the red

a 1.1 c color is bright and sufficiently transparent to allow details to be recognized in it, even without telescope.

Grein, St. Hippolyte, France, (174); sky not stated.

c = 1.1 4.3 cm.; the principal spots were quite visible.

King, Leicester, Engl., (175); clear sky throughout.

a 1.2 c 2⅛ inch; the seas plainly visible.

Luzet, Marcilly-en-Villette, France, (178); exceptional conditions.

c = 1.2 4.3 cm.; the general background during maximum eclipse, bright wine-color, the seas a decidedly bluish ashy color.

Crusinberry, Des Moines, Iowa, (171); sky slightly hazy; aperture not

c = 2.0 stated. At the middle of the eclipse the center of the moon was quite dark, but the "seas" showed up finely in the finder of the telescope, and Tycho was quite easily seen.

Gaubert, Martinique, (173); sky admirable; aperture not stated.

——— The cirques, seas, the lunar topography were perfectly visible during maximum.

Levreau, Santiago del Estero, Arg., (177); sky and means not stated.

——— The form of the seas very visible in the shadow.

Maclachlan, Largs, N. B., (179).

——— 5 inch; the details of the features of the moon were curiously irregular in visibility . . . . without any apparent cause, such as interference by clouds.

* This is treated as a total eclipse in Tables 2, 4, 5.

1901 X 27; 0.228; Grade 1

c Great Slave Lake, Greenland, S. Scandinavia, C. Europe.
Zlatinsky, Mitava, Russia, (181); moon rose out of haze, about a
c = 13.5 half-hour before mid-eclipse; about 10 m. after mid-eclipse, Tycho visible in shadow. 7.5 cm., civil twilight.

1902 IV 22; 1.338; Grade 1

c Antarctic, S. Atlantic, Senegambia, Spain, Sweden, Nova Zemlya, Okhotsk Sea, Pacific, New Zealand.
Khalatov, Tiflis, (185); sky not stated.
b = 2.6 Even with opera-glass, the Mare Serenitatis and Mare Imbrium have the appearance of two black spots. Later, 10.8 cm., various craters; the contours of the principal seas very distinct.
"Mathematicus," Syra, Greece, (186); sky not thoroughly black, yet even the smallest stars visible.
c = 2.8 The color of the moon's disk was very dark, so dark as he has never observed since . . . . October 4, 1884.
Godden, London, Engl., (183); sky gray; astronomical twilight.
d 6.6 e 3 inch; area in shadow invisible. Thinks it as dark as October 4, 1884.
Goodacre, London, Engl., (184); cloudy; astronomical twilight.
d 6.6 e The shadow . . . . very dark, almost black, and quite obscured the eclipsed limb when looked at with a binocular and 3 inch refractor.
Zlatinsky, Mitava, Russia, (189); fine sky, astronomical twilight.
c = 7.2 7.5 cm.; Aristarchus, Copernicus, Kepler, all the seas.
Weinek, Prague, (188); sky cloudless throughout; twilight.
c = 7.9 3 observers, with 9.76 cm., 6.27 cm., 8.37 cm.; within the umbra remarkably little detail was visible.
Allander, Malmö, Sweden, (182); sky not stated; twilight.
c = 14.4 Could see the various maria with the n. e.
Parr, Florence, Italy, (187); sky not stated; twilight.
c > 20 3 inch; seas, etc., visible.
Grade 1 is a compromise among remarkable discrepancies.

1902 X 16; 1.464; Grade 1

c Arctic O., Khamchatka, Pacific, Antarctica, S. Atlantic, Ashanti, near Marseille, Sweden.
Barnard, Yerkes Observatory, (190); favorable conditions.
c = 1.1 [Had observed 6 total eclipses.] The present eclipse was by far the darkest . . . . . For a portion of the time the eastern and western edges could not be seen with the eye . . . . . Very few details were visible in the telescope [6 inch] during totality. Aristarchus and some of the darker regions could be made out dimly. Tycho and the details in its region were not visible . . . . . No details of the surface were visible with the n. e., though at previous eclipses such have been seen.
Payne, Northfield, Minn., (198); broken clouds.
c = 1.2 5 inch; during the last part, all the prominent features of the surface were easily seen, and many of the lesser ones could be recognized.
O'Halloran, San Francisco, Cal., (197); sky not stated.

c = 1.3 . . . . before long the seas were visible, even without magnifying power . . . . the white streaks so conspicuous at full moon were discernible . . . . coppery hue . . . . revealed lunar topography with unexpected distinctness, especially in a telescope. [4 inch.] The color of the seas closely resembled a dull gray object, such as gray paper, on which light through a red lamp falls. The streaks were discernible, even those around Copernicus, and the latter crater was more conspicuous than Tycho. Aristarchus as usual outshone all other features . . . . .

Johnson, Bridport, Engl., (194); sky and aperture not stated.

a 3.1 b . . . . Over one fourth eclipsed, but no details of this part visible. As the moon sank down toward the horizon it could be discerned as a faint ruddy circle until 6 o'clock, when the daylight overpowered the totally eclipsed disk. He thinks it a very dark eclipse.

Marckwick, Devonport, Engl., (195); clear breaks between showers;

b = 4.4 astronomical twilight. He says nothing of details; would call this a "bright" eclipse.

Godden, London, Engl., (192); sky not stated.

a 4.6 b [Just before totality.] In field-glass, margin of eclipsed area very red, the "seas" area black as soot. [Just after totality began] margin coppery, "seas" as black as before.

Crommelin, Greenwich, (191); weather conditions perfect; there was

——— not the slighest difficulty in tracing the moon's limb, even when the sky was quite bright with twilight. He followed the eclipsed disk of the moon low down, even through London smoke . . . . was not a very dark eclipse.

Howe, Chamberlin Obsy., (193); one haze cloud mentioned.

——— First observation, 20 inch, the eclipsed portion was totally invisible. Later, the whole became visible, in 5 inch and to n. e., before visible in 20 inch. Nothing about details.

Amateur observers in Mexico City, (196); good weather; aperture not

——— stated. During the totality it was possible to observe the details of the lunar surface.

Wilson, Goodsell Obsy., Northfield, Minn., (199); sky not stated.

——— Opera-glass; at the beginning of the totality . . . . across the equator was a dark shadow, in which no detail could be seen at all . . . . not due to clouds. [He makes no other reference to detail.]

Almost all observers mention a dark smear across the moon, especially in the early stages. There is disagreement about the visibility of the eclipsed limb in the early stages.

Grade 1 is a compromise among discrepancies.

1903 IV 11; 0.973; Grade 0

c E. Siberia, Kara Sea, Arctic O.

1.5 to 4.5 Many observers, instruments large and small, generally good conditions, within the area Lisbon, Syra, Kasan, Nassjö, Sunderland. All agree, shadow at first black, later dim. No detail observed by anyone.

1903 X 6; 0.869; Grade 2

c Antarctica, S. Pacific.
Johnson, Shepparton, Australia, (207); night fine and clear.

c = 1.4 Means not stated. A very light one. At mid-eclipse the whole outline of the disk, and, on the shadowed part, considerable detail, were clearly visible.
Bordage and *Garsault,* Réunion, (205); breaks in clouds.

c 2.3 e Opera-glass and spy-glass; at mid-eclipse, Aristarchus. Later, the lunar topography clearly seen—eastern border of Mare Humorum, Grimaldi, Oceanus Procellarum.
Dubiago, Kasan, Russia, (206); troublesome clouds.

e = 2.7 24.4 cm.; 9.6 cm. The craters were hardly visible, and the eclipsed part was dark red.
"Mathematicus," Syra, Greece, (208); sky and means not stated.

——— The eclipse was indeed a bright one, as the whole dark border of the moon was clearly visible.

1905 II 19; 0.410; Grade 1

c Southern Ocean, Antartica, S. Atlantic O.
Rengel, Lyons, (220); break in clouds; astronomical twilight.

c = 3.2 7.5 cm.; shadow ashy gray, no details visible.
Larronde, Cénac, France, (216); sky not stated; astronomical twilight.

c = 3.7 Opera-glass; shadow slate gray; in it there were feebly distinguishable the important details in the form of spots just perceptible; like the ashy light just before the first quarter.
Moye, Montpellier, (218); sky not stated; astronomical twilight.

c = 3.3 Eclipsed part was plainly seen with the n. e., even since the beginning. The rosy hue was evident, but perhaps less strongly than usual. With 2 inch I saw in the shadowed part some features of the lunar topography; Aristarchus was shining in the dark as a little star. The eclipse was a bright one.
Crommelin, Greenwich, (213); sky not stated; astronomical twilight.

c = 3.9 Binocular; could see the limb distinctly, but no markings.
Hanbidge, Hackney, Engl., (215); sky not stated; astronomical twilight.

c = 3.9 2⅛ inch; the eclipsed part was very dark . . . . there was not a trace of surface features. Part of the moon's eclipsed limb showed brightly through the earth's shadow. In fact, I could trace it all round, but disconnectedly.
"Meteor," Worthing, Engl., (217); very satisfactorily observed. Conditions as perfect as could be desired. Astronomical twilight.

c = 3.9 3¾ inch; . . . . when the illuminated portion of the disk was put out of the field . . . . the markings on the lunar surface, as well as the dark limb of the moon, could be very plainly seen.
Caron, Lillebonne, France, (211); sky not stated, astronomical twilight.

c = 4.1 Marine glass; limb visible throughout, but no details.
Chèvremont, Quiberon, France, (212); sky not stated; astronomical twilight.

c = 4.5 6.0 cm.; shadow dark or iron gray; no details visible.

——— *Quénisset,* Nanterre, France, (219); with a telescope, [aperture not stated], the umbra so transparent that it allowed all the features of the lunar surface to be seen. Coloration slate gray.

——— *Aymé,* Douai, (209); at mid-eclipse the part in the umbra was invisible to the n. e.; in telescope, [aperture not stated], bluish gray; like the ashy light at first quarter.

——— *Burnerd,* (210); place and sky not stated. A lunar eclipse always calls forth such contradictory statements. Here we have a number of observers favored with clear skies, and most of them in disagreement as to the intensity of the earth's shadow. . . . . To me the eclipse was a decidedly light one—so much so that the obscured portion of the disk was clearly visible to the n. e. With 2¾ inch o. g. and 6 inch reflector, several craters beneath shadow stood out prominently, especially Aristarchus.

Dennett, (214); place not stated.

——— The 2 inch held in the hand . . . . showed the markings within the shadow even.

W. G. T., Southampton, Engl., (221); fairly favorable, occasional passing clouds.

——— 5 inch; the bright crater Aristarchus was visible through the shadow all the time the eclipse lasted.

Grade 1 is a compromise.

1905 VIII 15; 0.292; Grade 1

c British Columbia, Franklin Str., Greenland.

Benoit, Juvisy, France, (222); superb weather; astronomical twilight.

a 3.9 c 10.8 cm.; the shadow is not very opaque; certain details on the disk are visible, and the limb is perfectly visible.

de Perrot, Puy, France, (225); sky very pure; astronomical twilight.

c = 4.1 No details visible on the eclipsed part, either with an opera-glass or the n. e.

Guérin, Marseille,(224); sky pure; astronomical twilight.

c = 5.4 7.5 cm.; the shadow was black without color, and although the eclipsed part of the moon was quite visible in the instrument, the brilliant mountains, even Tycho, disappeared completely.

Bloch, La-Queue-des-Yvelins, France, (223); astronomical twilight.

——— 4.3 cm.; throughout the duration of the observations the obscured part was visible although very weak, and not one detail of topography was perceived in the shadow, which was colorless.

Quignon, Mons, (226); exceptional sky; astronomical twilight.

c = 6.1 4.0 cm., shadow grayish black, no details visible.

Stuyvaert, Uccle, Belgium, (228); favorable weather; twilight.

c = 7.7 15.0 cm.; the shadow is dark . . . . no lunar configuration is visible in the eclipsed part, the limb is hardly distinct.

Winkler, Jena, Ger., (229); twilight.

c = 14.7 4 inch; the eclipsed part of the moon was almost invisible.

Wuillemier, Galway, Ireland, (230); sky and means not stated.

——— Shadow intensely black and indistinguishable from the sky, limb invisible.

Rey, Marseille, (227), *de Sforza,* Trieste, (227a), report that Tycho
——— was visible, even brilliant; means not stated.

1906 II 8; 1.631; Grade 2

c Antarctica, South Island, Hokkaido, Nova Zemlya, Norway, Great Britain, Canary Islands, S. Atlantic.

A. López, Hacienda Santa Rita, Mexico, (234); clear.

c = 0.8 The peculiarities of the lunar surface (the spots) were perceived with the n. e.

E. López, Chignahuapan, Mexico, (235); sky and aperture not stated.

c = 0.8 The peculiarities of the lunar surface are just visible, like dark spots.

Ross, Glasgow, Scotland, (238); sky almost free from clouds, but a thin misty veil appeared from time to time; first contact at end of darkness, beginning of totality in strong astronomical twilight.

a = 3.6 3 inch; Aristarchus, Copernicus, Kepler, after first contact; Aristar-
b = 7.2 chus, Menelaus, before totality.

Macpherson, Johnsburn, Scotland, (236); perfect weather, astronomical twilight.

b = 7.7 2 inch; during the first stages of totality the lower part of the disk appeared brighter than the upper, and on the lower several of the prominent lunar features were noted.

Blum, Paris, (231); breaks in snow clouds; strong astronomical twilight.

8.5 4.0 cm.; the illumination was like the ashy light, but nevertheless insufficient to allow the lunar details to be seen. Aristarchus entered the shadow and disappeared immediately. The moon disappeared in low haze when ⅔ eclipsed.

Rudaux, Donville, France, (239); breaks in clouds; means not stated.

b = 13.5 The moon continued visible with all its details.

Denning, Bristol, Engl., (232); well seen. Means not stated.

——— From the entering of the moon into the earth's shadow until after the total phase was reached, the outline of the whole disk, with a large number of included details, continued very plainly visible.

——— *Díaz,* Guadalajara, Mexico, (233); sky and aperture not stated. In the telescope all the large details of the lunar configuration were seen.

Quénisset, Nanterre, France, (237); atmosphere of perfect limpidity.

——— Equatorial, aperture not stated. All the details of the lunar surface perfectly visible.

1906 VIII 4; 1.786; Grade 2

c Lena Valley, E. India, Indian O., Graham Land, S. E. Pacific, Lower California, Alaska.

Harris, Ngaruawahia, New Zealand; (243); clear between showers.

b 1.1 c Aperture not stated. Not the slightest trace of the moon could be seen with or without the telescope for some time on either side of the

greatest phase, although the lunar markings were very plain just before the moon began to leave the shadow.

Ward, Wanganui, New Zealand, (244); beautifully clear; aperture
b = 1.1 not stated. Brilliancy of the moon was very remarkable . . . . . Principal markings could be made out by n. e., much faint detail was seen in telescope. Aristarchus, which appeared to be wholly obliterated at half immersion in the dusky hue, now shone conspicuously.

Gale, Waratah, N. S. W., (242); perfectly clear.

b = 1.1 10 inch reflector and 3¾ inch; all the gray plains and Tycho visible to the n. e.

le Cadet, Phu-Lien, Indo-China, (240); good conditions.

c = 1.5 7.5 cm.; disk visible throughout, except at beginning. Shadow unequal, generally red, bright enough in south to see details of surface; a dark zone, concealing all detail, enveloped all the northern seas and the Oceanus Procellarum. Eastward of this it brightened during the second hour of totality and appeared darker on the Mare Nectaris, Mare Fecunditatis and Mare Tranquilitatis.

Díaz, Guadalajara, Mexico, (241); good weather; means not stated.

a-b Details of the globe and the general configuration of its mountains and seas were seen.

1907 I 28; 0.711; Grade 0?

c Texas, Hudson's Bay, Caspian Sea.

E. López, Chignahuapan, Mexico, (245); best atmospheric conditions;
a 9.7 c twilight. During the early part of the eclipse the covered part was invisible to the n. e.; this continued as the dawn came on.

Grade 0, with interrogation point because only observations with the n. e. are reported.

1907 VII 24; 0.620; Grade 1

c Mozambique Channel, Antarctic ice, Antarctica, S. Pacific.

Díaz, Guadalajara, Mexico, (247); breaks in clouds.

c 1.5 e 10.2 cm.; the details of the lunar configurations were completely lost, and not before 10.15 [after mid-eclipse] were we able to observe some of the bright and radiant craters involved in the earth's shadow.

E. López, Chignahuapan, Mexico, (248); bad atmospheric conditions
——— at first, later fine. With telescope [aperture not stated] the aspect and color of the shadow is such that all the peculiarities of the lunar surface are very readily distinguishable.

Constantin, Port-au-Prince, (246); magnificent weather; means not
——— stated. Aristarchus continued visible in the shadow.

1909 VI 3; r̊.164; Grade 2

c Persia, Norway, Greenland, Labrador, Mexico, S. Pacific, Antarctic ice, Indian O.

Serrano, Frenda, Algeria, (253); sky not stated.

c = 2.1 4.3 cm.; during totality, all selenographic details easily seen.

Taffara, Catania, (254); sky not stated.

b = 2.6 3.8 cm.; seas, mountains, volcanoes, etc.
Bougourd, Tunis, (250); admirable sky.

c = 2.6 7.5 cm.; seas turned notably dark—Maria Nubium, Humorum, Tranquilitatis, Fecunditatis. Not due to any clouds.
de Roy, Antwerp, (252); breaks between clouds, astronomical twilight.

b = 4.3 4.3 cm.; the N. W. limb was more easily visible, and the principal details of lunar topography were distinguishable, except the Oceanus Procellarum.
Elgie, Leeds, (251); sky not stated; astronomical twilight.

c = 5.1 Although at its first encroachment the shadow was dead black, when the disk was fully eclipsed many features could be perceived by the n. e.
Borelly, Marseille, (249); sky clear.

——— Comet-seeker; Aristarchus remained visible. Many cirques visible in the shadow.
Zlatinsky, Mitava, Russia, (255); excellent atmosphere.

c > 18 9.5 cm.; the lunar details were easily visible in the shadow.

1909 XI 26; 1.372; Grade 2

c Antarctic ice, S. Pacific, near Para, N. Atlantic, Lapland, near Irkutsk, near Shanghai, Gulf of Carpentaria, near Sydney.
O'Halloran, San Francisco, (259); moon shone brilliantly, with no halo near or distant.

c = 1.1 Many of the markings were recognizable without magnifying power, and an opera-glass showed several of the craters.
Ginori, Buenos Ayres, (257); sky most limpid.

b = 2.1 But when half of the lunar disk was covered, ... the general details of the moon were then seen easily across the shadow, with a binocular.
Campariole, Port-of-Spain, Trinidad, (256); sky practically cloudless

c = 3.5 2 inch refractor, prism binocular; the parts first covered by the shadow appeared very dark, but by the time it had crept over about ⅓ of the bright lunar surface, they began to lighten considerably, and the maria stood out well.

1910 V 23; 1.099; Grade 2

c Southern Ocean, Antarctica, Cape Colony.
Campariole, Port-of-Spain, Trinidad, (260); the condition of the atmosphere rendered definition poor, even when the moon was unobscured by clouds.

a 1.2 b 2 inch and field-glass; the eclipse was one of the brightest I have witnessed. Shadow enters Mare Serenitatis . . . . maria, etc., stand out very well.

1910 XI 16; 1.131; Grade 2

c Bay of Bengal, L. Baikal, Alaska, Rocky Mts., W. Mexico.
Amann and *Rozet,* Aosta, Italy, (261); sky clear.

c = 1.1 During totality, to the n. e. the lunar disk appeared of a dark red color, and the principal details could be perceived.
Goudey, Besançon, France, (262); good conditions during totality.

c = 1.1 During totality, to n. e., the moon assumed a dark red color on which the seas stood out in black.
Lafitte, Roanne, France, (263); completely clear.

c = 1.1 During totality the principal spots were visible to the n. e., and especially, the contours of Mare Imbrium and Mare Serenitatis were very distinct.
Nijland, Utrecht, Holland, (264); very clear breaks in snow clouds.

c = 1.2 3 inch; the chief formations of the eclipsed moon remained easily visible.
Other observers agree in describing the brightness of the eclipse.

1912 IV 1; 0.187; Grade 1

c Near Formosa, China, Siberia, Greenland.
Rey, Ajaccio, Corsica, (271); sky not stated.

a = 1.7 The eclipsed part is very dark and almost invisible in an opera-glass.
Libert, Paris, (269); superb sky.

c = 1.9 10.9 cm.; no detail visible; eclipsed part invisible to n. e., or nearly so.
Leroy, Paris, (268); clear weather.

a = 1.9 7.5 cm.; in the shadow of the earth, Tycho was visible like a bright spot standing out in the dark slate gray shadow. Only Tycho seen.
Péneau, Nantes, France, (270); sky and aperture not stated.

a 1.9 c To the n. e., the eclipsed part is almost invisible; in telescope greenish gray.

c = 1.9 *Hauët,* Paris, (267); means not stated; no detail of the lunar surface was visible in the eclipsed part.
Van der Bilt, Utrecht, Holland, (272); weather partly unfavorable, partly very favorable.

c = 2.0 4½ inch; describes the shadow as remarkably dark, with only a ray of Tycho visible in it.
Dennett, Hackney, Engl., (266); eclipse well seen.

c = 2.1 3 inch. The limb within the shadow was easily seen, and some of the objects upon the disk; two rays of Tycho.
Barlow, (265); place not stated; night extremely clear.

——— Binocular and 4½ inch; by putting the bright portion of the lunar disk out of the field of view, the two bright streaks which converge to the east of Tycho from the south, the irregularities of the lunar limb and many of the various markings were plainly visible.

1913 III 21; 1.575; Grade 0

c Close to both poles; through Bay of Bengal and Yucatan.
Ball, Echuca, Australia, (273); sky not stated.

c = 1.6 4½ inch; I should say it was a composite sort of an eclipse, for a part was blue, a part copper color, but the greater part of it was decidedly black.
Jackson, Mannum, S. Australia, (277); ideal weather.

c = 1.7 During totality, there remained visible to the n. e. only a luminous point, not much larger than the planet Mars and of the same color. With a small telescope the whole disk of the moon was visible.

c = 2.3 *Gray,* Eldridge, Cal., (276). I repaired hastily to my telescope house. On the walk thither the eclipse was so thorough that it cost me some trouble to locate the moon, and many on night duty were unable to see the eclipse because of want of knowledge where to look for the moon. I saw the eclipse well. . . . . Used binoculars, finder and telescope. All the instruments revealed the dull, coppery hue of the expanse of the moon's disk. [Apertures not stated.]

Pargoire, Vinhlong, Indo-China, (279); weather and means not stated. Nearly total when the moon cleared the horizon haze.

d = 2.5 The eclipsed part was totally invisible. Later it began to reappear at its eastern limb.

Flint, Madison, Wis., (275); the sky seemed remarkably clear, down to the horizon all around; astronomical twilight.

b = 6.3 Opera-glasses; it was an exceedingly dark eclipse. It is difficult for me to believe that any but a remarkably dark eclipsed moon could have disappeared entirely in the degree of dawn indicated. . . . .

——— *Barnard,* Mt. Hamilton, (274); I think it probable that this was a dark eclipse.

——— *Newton,* Irvine's Landing, B. C., (278); a dark eclipse.

1913 IX 4; 1.435; Grade 0

c Near both poles; near Manzanillo and near C. Comorin.

Kuyper, Medan, Sumatra, (280); sky very pure.

c = 2.8 Means not stated. During totality the shadow appeared of a bluish gray. Later it remained of a reddish brown, very dark.

Schafer, Port Byron, Ills., (281); sky not stated. Civil twilight.

a = 7.0 6 inch; the shadow was very black, and not a trace could be seen of that portion which it then covered.

1914 III 11; 0.916; Grade 2

c Antarctica, S. Pacific.

Nolte, Newton, Mass., (284); very favorable weather conditions.

c = 1.3 At the moment of greatest eclipse, it was light enough to render the chief surface details visible in a field-glass.

Schafer, Port Byron, Ills., (285); the evening was an ideal one. 6 inch; when the shadow had advanced as far as . . . . Mare Serenitatis, ... I could see some of the larger markings, such as Grimaldi, the dark area in Riccioli, the Sinus Iridum, Aristarchus, Copernicus, Plato and Pico.

c = 1.5 At the middle of the eclipse . . . . with a pair of 8-power field-glasses, the maria were plainly visible.

Cordier, Menton, (282); sky not stated.

b = 1.9 With n. e., noted the redness of the disk, and the visibility of the plains and the seas.

Tramblay, Montpellier, France, (286); exceptional sky.

c = 3.0 At mid-eclipse, with an opera-glass, and especially with 7.5 cm., Aristarchus, Kepler, Copernicus white, Grimaldi and Plato dark.
Leboeuf and *Chofardet,* Besançon, France, (283); sky not stated.
c = 3.4 Opera-glass and n. e.; limb and principal details quite visible.
Several other observers, with larger telescopes, or who do not state aperture, corroborate the visibility of details.

1917 I 7; 1.369; Grade 2

c Spain, White Sea, near Yokohama, Pacific, near Wellington, Antarctic ice, S. Atlantic, near C. Blanco.
Prior, Hayling Id., Engl., (288); sky clear; civil twilight.
b = 6.9 4½ inch and binocular; the lighter formations visible in binoculars
c = 18.7 throughout.
Ellison, (287); place not stated; most favorable of weather conditions; so clear that he saw Venus on the horizon edge.
——— 5¼ inch; Proclus was hardly visible, Aristarchus not much more so, Pliny and Menelaus were conspicuous, and a small crater . . . . a point on the rim of Dionysius . . . . shone like a small star for some time after entering the shadow.

1917 VII 4; 1.625; Grade 2

c Lapland, N. Atlantic, Guiana, near Santiago, S. Pacific, Tasmania, near Manila.
de Paolis, Rome, (292); splendid weather.
c = 2.8 13.5 cm.; the lunar topography was easily recognizable, even during totality.
Rey, Marseille, (293); sky pure.
d = 2.8 With field-glass, a few details visible.
Ellsworth, Lyons, (289); at first much cloudiness, later clear; astronomical twilight.
c = 3.8 5.8 cm.; could see certain details of the surface.
Grabowski, Lemberg, (290); good weather; astronomical twilight.
c = 3.7 12.2 cm. and 7.2 cm.; the shadow was pretty bright, so that even within it the details of the moon's surface were for the most part clearly visible.
Weber, Leipzig, Ger., (294); sky not stated; civil twilight.
c = 4.7 14 cm.; around, but not in, the darkest region, certain details visible.
Nodon, Bordeaux, (291); sky very pure; apertures used not stated.
——— The principal peculiarities of the lunar surface remained perfectly visible during the duration of the eclipse.

1917 XII 27; 1.011; Grade 2

c S. E. Pacific, Antarctic ice, Tasmania.
Reichelt, Honolulu, (295); sky not stated.
c = 1.0 The dark and light spots and the familiar markings on the moon's surface were almost as easily distinguishable during totality as under ordinary conditions.

1919 XI 7; 0.184; Grade 0

c N. Pacific, near Bering's Str., Baffin Land, N. Atlantic.
Quénisset, Juvisy, France, (297); clear spell between clouds.

c = 1.1 24 cm.; the shadow was very transparent and of a slate gray tone.
Fock, Frederiksvaerk, Denmark, (296); air free of clouds, slightly hazy, a faint ring around moon.

c = 1.3 16.2 cm.; the long ray of Tycho in the direction of Longomontanus remained visible during the whole eclipse [till clouds stopped observing].

1920 V 2; 1.224; Grade 2

c Southern O., Antarctica, S. Pacific.
Bougourd, Tunis, (299); sky not stated.

a 1.9 b 7.5 cm.; putting out of the field the part still bright, all the lunar geography is easily distinguished.
Raymond, Antibes, France, (306); clear sky.

a 2.2 b Opera-glass, and telescope, aperture not given. Telescope shows all the details, which are also visible, a little, with the opera-glass.
Perse, Angers, France, (305); sky not stated.

a 2.3 b 7.0 cm.; the craters are visible, as well as the seas.
Herzog, La Ferrière, Switz., (303); occasional breaks in clouds, aperture not stated.

a 2.4 b No detail visible, even with the telescope.

a 2.6 b *Hestin,* Compiègne, France, (304); clear.

c = 3.2 The contour of the seas in the eclipsed part is visible to the n. e.
Geneslay, Fay, France, (301); sky not stated.

c = 2.9 7.5 cm.; toward the middle of totality the red light weakens, the gray predominates, the details of the surface disappear.
Chouard, Melun, France, (300), fine weather.

c = 3.0 7.0 cm.; the larger features of lunar relief were very visible.
Roguet, Péronne, France, (307); sky clear.

c = 3.3 The dark spots of the disk remained clearly visible during the whole duration of the observations, which were made with the n. e.
Hauptmann, Uccle, Belgium, (302); sky not stated.

c = 3.5 The great visibility of the disk during totality; all the seas were recognizable by the n. e.
de Roy, Antwerp, (308); favorable conditions.

c = 3.5 All the seas were visible to the n. e.
Bartrum, Hampstead, Engl., (298); almost cloudless.

——— At all times even minute details could be made out in the shadow [but with which of 5 telescopes and several field-glasses, or with the n. e., is not made clear.]
The visibility of details is corroborated by others, who do not state conditions, means, etc.

1920 X 26; 1.404; Grade 2

c N. Atlantic, near Petrograd, E. Black Sea, Gulf of Aden, Indian O., Antarctica, Pacific near Los Angeles.
McIntosh, Auckland, New Zealand, (309); light clouds, becoming heavier and hiding moon about totality.

a 1.1 b Aperture not stated. Umbra of a slate gray color, like earth-shine on the moon 4 or 5 days old . . . . . In it I suspected seeing Oceanus Procellarum, Tycho, Aristarchus and Copernicus.
Stephenson, Jhansi, India, (310); weather very fine.

c = 2.1 The chief maria in eclipsed portion visible to n. e.; [this noted several times during the eclipse].
Tomkins, Barrackpore, India, (311); clear, occasional passing clouds.

a 2.8 b The shadow was of a dull copper color, and details were visible in it all over the moon, and especially so with the aid of the telescopes.

1921 IV 21; 1.074; Grade 0

c N. Atlantic, Arctic Archipelago, Bering's Sea..

c = 2.1 *Sanner,* Guadaloupe, (313); at totality, the eclipsed part was no brighter than the ashy light. With a small telescope, like the fingers viewed against sunlight.
Blundell, New Plymouth, New Zealand, (312); sky not stated.

b = 3.2 6 inch; near the S. E. limb . . . . at no time could any object be detected. Grimaldi could be seen with difficulty, but Aristarchus was plainly visible. Tycho and some of its rays were observed before totality, but the latter disappeared entirely later.

1921 X 16; 0.938; Grade 2

c Antarctica, S. Indian O.
Honnorat, Barcellonette, France, (320); sky not stated.

c = 1.1 Prism field-glass; details with difficulty visible; somewhat better during the second half.
Lagarrigue, Rodez, France, (321); sky not stated.

c = 1.2 4.3 cm. and Foucault telescope 12.5 cm.; at first, no details visible; later, certain details visible.
Fabry, Marseille, (316); sky not stated.

c = 1.2 Opera-glass; like the ashy light a little after new moon. The dark spots on the lunar surface are quite easily visible.
16.0 cm.; *Jasse* observing; no mention of details; the limb is weakly visible, disappearing later.
26.0 cm., *Michkovitch* observing; at the middle of the eclipse, the details of the lunar surface and the limb of the moon are readily visible.
Vetter, Yverdon, Switz., (324); sky not stated.

a 1.3 c With n. e. and opera-glasses, the principal configurations in the shadow are easily distinguished.
Croste, Bayonne, France, (314); sky not stated.

c = 1.3 Opera-glass; at mid-eclipse, the shadowed northern part brick-red, allowing the details of the surface to be seen.
Trarieux, Chamboulive, France, (323); sky not stated.

c = 1.3 Seas visible, but not Copernicus, Plato or Tycho, after entry into the shadow.
Curtis, Winchester, Engl., (315); sky perfectly clear most of the time, then haze

c = 1.4 6½ inch reflector; during mid-eclipse all maria were conspicuous both in telescope and to n. e. Most of the brightest craters, including Tycho and his ray system, Copernicus and the Alps, were easily seen with the telescope.

Heath, Kingsbridge, Engl., (319); at first, haze and corona; later clear.

c = 1.4 3⅜ inch; all the lunar maria prominently visible in the eclipsed portion. Tycho . . . . . neither it, nor most of its bright streaks, became invisible at any time.

Meyermann, Göttingen, Ger., (322); good air conditions.

c = 1.4 13.8 cm.; even during the maximum phase of the eclipse all seas were clearly recognizable, particularly notable Mare Humorum and Mare Tranquilitatis. Grimaldi was a very noticeable dark spot. Censorinus, Menelaus, Manilius, Aristarchus, Tycho, of which two rays were especially bright, were easy to make out; Copernicus and Kepler, difficult.

Since Kepler, the visibility of the totally eclipsed moon has been laid to refraction of light by the earth's atmosphere into the geometrical umbra; of late years, since the researches of Tyndall, Raleigh I and others on the blue of the sky, scattering of light into the umbra by dust and air molecules has been added. At the time of the Krakatoa sunsets the attention of all was directed to the results of dust in the air; the dim eclipse of 1884 X 4 caused the suggestion to be made by several[1] that the classical explanation of dark eclipses—cloudiness along the terrestrial terminator—should be at least supplemented by opacity due to the same causes which produced the strange twilight glows. Dufour and Johnson[2] called attention to the coincidence of dark eclipses with volcanic dust haze, as in 1816, after Temboro, 1815. The dark eclipse of 1903 IV 11, after the West Indian and Guatemalan eruptions of 1902, brought this explanation to the fore. But other suggestions for the varying brightness of the eclipsed moon have been made; the moon's varying distance, from perigee to apogee; the moon's longitude, whereby, she being near an equinoctial point, vernal or autumnal, the refracted light comes largely from the Arctic and Antarctic polar regions, supposed to have purer and more refractive air, while, near a solstitial point, the terrestrial terminator passes close to the Arctic and Antarctic circles of latitude, and the light comes through more cloudy regions of the atmosphere. This sugges-

[1] I do not know to whom priority should be assigned; S. J. Johnson, Mon. Not. Roy. Astr. Soc., 45, pp. 43-44, 1884-5, and G. F. Burder, Nature, 30, pp. 590-591, 1884, were among the first.

[2] Ch. Dufour, Bull. Soc. Astr. Fr., 1, pp. 58-60, 1887, L'Astronomie, 7, pp. 28-30, 1888.

S. J. Johnson, Mon. Not. Roy. Astr. Soc., 63, pp. 400-402, 1903.

tion seems to be due to Smith,[1] 1825. Finally, the transparency of the air being affected in some way by emanations from the sun, there should be a relation between the brightness of the eclipsed moon and the solar cycle.[2]

The effect of volcanic eruptions being supposed non-periodic and desultory, in a long series of well-reported eclipses it should average out. So the proposed astronomical causes of variation in brightness will be examined first.

The results of table 1 are arranged in table 2. The eclipses are grouped in three columns, headed North, including eclipses in which the moon passed wholly north of the geometrical center of the shadow, Central, in which the moon passed over the center, South, in which the moon cleared the center on the south side. Each group has columns headed Magnitude and Grade. At the foot the magnitudes and grades are averaged. This is a rough arrangement according to the moon's latitude, the center of the shadow lying on the ecliptic.

The footings show that south eclipses, mean grade 1.62, have been during 1860-1922 decidedly brighter than central eclipses, mean grade 1.32, and these again than north eclipses, mean grade 0.64; the mean magnitudes, south 0.77, north, 0.71, show that the difference between north and south eclipses can hardly be laid to differences in the moon's immersion. In this connection 13 pairs of consecutive eclipses are collected in table 3. The footings of this table show that while the mean magnitudes, 0.68 and 0.72, are not far from equal, the mean grades are wide apart, north 0.54, south 1.54.

From these two tables the conclusion lies near that during the period 1860-1922 in general the southern zone of the earth's shadow has been brighter than the central, and this again than the northern.

Credit for first noticing this inequality must be yielded to the French amateur Rudaux (127), whose observations and sketches of 1895 III 10 showed the center of darkness to be displaced northward from the geometrical center of the umbra. This inequality shows itself in a very marked way in the photograph of 1909 XI 26, taken by Metcalf, (258), figures 2 and 3 at end of this paper. For Rudaux's conclusions, see table 1.

Table 4 shows a comparison of the brightness of every *total* eclipse in table 1 with the moon's equatorial horizontal parallax at opposition.

[1] M. Smith, Phil. Mag., (1) 66, p. 168, 1825.

[2] This idea appears, but without suggestion of novelty, in an unsigned note, Nature, 46, pp. 64-65, 1892.

According to Young's General Astronomy, 1898, p. 259, the mean parallax is 57′ 02″. In the table the 37 eclipses are grouped in three columns, the center column including parallaxes within 02′ of this mean, or from 55′ 02″ to 59′ 02″. This begins with the break—doubt-

TABLE 2.—*68 Lunar Eclipses Arranged According to Position of Moon's Path*

North			Central			South		
Date	Magn.	Gr.	Date	Magn.	Gr.	Date	Magn.	Gr.
1863 VI 1	1.22	0?	1862 XII 5	1.42	0?	1860 II 6	0.81	2?
1865 X 4	0.34	1	1870 I 17	1.66	1	1865 IV 11	0.20	1
1869 VII 22	0.56	1	1870 VII 12	1.69	1	1867 IX 13	0.70	1
1871 I 6	0.69	1	1873 V 11	1.44	1	1869 I 27	0.45	1
1878 VIII 12	0.59	0	1877 II 27	1.67	2	1876 IX 3	0.34	1?
1881 VI 11	1.37	1	1877 VIII 23	1.76	2	1880 VI 21	1.07	2?
1885 III 30	0.89	1	1884 IV 9	1.44	0?	1881 XII 4	0.98	2
1887 VIII 3	0.42	0?	1884 X 4	1.53	1	1889 VII 12	0.49	0
1889 I 16	0.70	0	1888 I 28	1.65	2	1892 V 11	0.95	2
1891 V 23	1.31	1	1888 VII 22	1.82	1	1894 IX 14	0.23	2
1892 XI 4	1.10	0	1891 XI 15	1.39	2	1896 II 28	0.87	2
1894 III 21	0.25	0	1895 III 10	1.63	2	1898 VII 3	0.93	2
1898 I 7	0.16	1	1895 IX 3	1.56	2	1899 XII 16*	1.00	2
1901 X 27	0.23	1	1898 XII 27	1.38	2	1903 X 6	0.87	2
1903 IV 11	0.97	0	1899 VI 22	1.49	0?	1905 II 19	0.41	1
1905 VIII 15	0.29	1	1902 IV 22	1.34	1	1907 VII 24	0.62	1
1907 I 28	0.71	0?	1902 X 16	1.46	1	1910 V 23	1.10	2
1909 VI 3	1.16	2	1906 II 8	1.63	2	1914 III 11	0.92	2
1910 XI 16	1.13	2	1906 VIII 4	1.79	2	1917 XII 27	1.01	2
1912 IV 1	0.19	1	1909 XI 26	1.37	2	1920 V 2	1.22	2
1919 XI 7	0.18	0	1913 III 21	1.58	0	1921 X 16	0.94	2
1921 IV 21	1.07	0	1913 IX 14	1.44	0			
			1917 I 7	1.37	2			
			1917 VII 4	1.63	2			
			1920 X 26	1.40	2			
Sums	15.53	14		38.54	33		16.11	34
No. eclipses .	22	22		25	25		21	21
Means	0.71	0.64		1.54	1.32		0.77	1.62

less due to the accidents of observers' reports—between 54′ 48″ and 56′ 11″, and extends to the beginning of 59′, in which there are only two records. (It is rather odd that the observations should be accidentally so condensed into the apogee and perigee minutes of parallax.)

TABLE 3.—*Comparison of Path-Position and Brightness of 13 Pairs of Consecutive Eclipses*

North			South		
Date	Magn.	Gr.	Date	Magn.	Gr.
1865 X 4	0.34	1	1865 IV 11	0.20	1
1869 VII 22	0.56	1	1869 I 27	0.45	1
1881 VI 11	1.37	1	1881 XII 4	0.98	2
1889 I 16	0.70	0	1889 VII 12	0.49	0
1892 XI 4	1.10	0	1892 V 11	0.95	2
1894 III 21	0.25	0	1894 IX 14	0.23	2
1898 I 7	0.16	1	1898 VII 3	0.93	2
1903 IV 11	0.97	0	1903 X 6	0.87	2
1905 VIII 15	0.29	1	1905 II 19	0.41	1
1907 I 28	0.71	0?	1907 VII 24	0.62	1
1910 XI 16	1.13	2	1910 V 23	1.10	2
1919 XI 7	0.18	0	1920 V 2	1.22	2
1921 IV 21	1.07	0	1921 X 16	0.94	2
Sums	8.83	7		9.39	20
Means	0.68	0.54		0.72	1.54

TABLE 4.—*Comparison of Horizontal Parallax and Brightness of 37 Lunar Total Eclipses*

H. P.	Date	Gr.	H. P.	Date	Gr.	H. P.	Date	Gr.
53′ 58″	1895 IX 3	2	56′ 11″	1899 XII 16*	2	59′ 13″	1902 X 16	1
58	1913 IX 14	0	20	1917 XII 27	2	23	1884 X 4	1
54′ 00″	1877 VIII 23	2	36	1909 VI 3	2	60′ 03″	1891 XI 15	2
02	1862 XII 5	0?	47	1891 V 23	1	11.5	1909 XI 26	2
06	1898 XII 27	2	59	1873 V 11	1	17	1917 VII 4	2
10	1917 I 7	2	57′ 36″	1921 IV 21	0	25	1899 VI 22	0?
17	1910 V 23	2	58′ 01″	1906 II 8	2	33	1881 VI 11	1
34	1884 IV 9	0?	04	1920 X 26	2	41	1863 VI 1	0?
40	1902 IV 22	1	11	1888 I 28	2	47.5	1877 II 27	2
48	1920 V 2	2	21	1870 I 17	1	53	1895 III 10	2
			31.5	1870 VII 12	1	59	1913 III 21	0
			43	1888 VII 22	1	61′ 19″	1880 VI 21	2?
			54.5	1906 VIII 4	2	28	1892 XI 4	0
						28	1910 XI 16	2
Sums		13			19			17
No. eclipses		10			13			14
Mean grades		1.30			1.46			1.21

The mean grade of 10 eclipses in the apogee group is 1.30; in the middle group of 13, 1.46; in the perigee group of 14, 1.21. In so far as the arithmetic mean averages out errors and non-periodic causes, this would indicate that at middle distances the totally eclipsed moon has been somewhat brighter than at greater or less, near apogee or near perigee. This differs from the anticipation of L. Günther,[1] that dark eclipses occur at perigee, bright at apogee. But the differences are small, considering the coarseness of the grading, and it can only be concluded that varying distance has not caused much difference in brightness.

Table 5 shows a comparison of the brightness of every total eclipse in table 1 with the longitude of the center of the umbra at opposition. The longitudes are in four groups, each in a quadrant of the ecliptic, for the seasons as indicated. The quadrants are not separated by the equinoctial and solstitial points, as it was found by plotting and trial that a quadrant from 82° to 172° gave a mean grade greater than any other; a division based on this comes near, however, to a strict division according to the seasonal points.

The footings for the columns give as average grades, Autumn, 1.25, Winter, 1.89, Spring, 0.91, Summer, 1.33. So that, in the period studied, winter total eclipses have been very bright, spring eclipses only dim, autumn and summer eclipses intermediate and not much different. Then the longitude effect suggested by Smith exists, but its maximum phase is quite 45° away from that which he expected. Jenkins (49) says: ". . . . of the seven recorded eclipses in which the moon disappeared, none was later than June 15: May 15, 1110, June 15, 1601, April 14, 1642, May 18, 1761, June 10, 1816, June 1, 1863 . . . . middle of April and the middle of June . . . . it is only in this period when the earth is approaching aphelion that the phenomenon is possible." This fits in well with the dimness of the spring group of table 5, but must be considered in connection with volcanic dust.

The curve of mean solar radiation published by Kimball[2] shows the mean relative intensity of received solar radiation, as measured at a variable number of stations (all in north temperate latitudes) for every individual month, 1882-1918. This mean is expressed as a percentage of the mean for the like named months for the whole period; *e. g.*, the mean for February, 1900, is divided by the mean for all the Februaries of the period to get the relative intensity. The

[1] L. Günther, Weltall, 1, pp. 101-103, 112-116, 127-131, 137, 1900-01.
[2] H. H. Kimball, Mon. Weath. Rev., 46, pp. 354-355, 1918.

TABLE 5.—*Comparison of the Longitude of the Shadow and Brightness of 37 Lunar Total Eclipses*

Long. 352°–82°			82°–172°			172°–262°			262°–352°		
	Date, Autumn	Gr,		Date, Winter	Gr.		Date, Spring	Gr.		Date, Summer	Gr.
12°	1884 X 4	1	85°	1899 XII 16*	2	180°	1913 III 21	0	269°	1880 VI 21	2?
23	1902 X 16	1	96	1917 XII 27	2	199	1884 IV 9	0?	272	1899 VI 22	0?
34	1920 X 26	2	96	1898 XII 27	2	211	1902 IV 22	1	282	1917 VII 4	2
43	1892 XI 4	0	107.5	1917 I 7	2	212	1921 IV 21	0	290	1870 VII 12	1
53	1891 XI 15	2	117	1870 I 17	1	222	1920 V 2	2	301	1888 VII 22	1
54	1910 XI 16	2	128	1888 I 28	2	226	1873 V 11	1	311	1906 VIII 4	2
64.5	1909 XI 26	2	140	1906 II 8	2	242	1910 V 23	2	331	1877 VIII 23	2
74	1862 XII 5	0?	159	1877 II 27	2	242	1891 V 23	1	342	1895 IX 3	2
			170	1895 III 10	2	251	1863 VI 1	0?	350	1913 IX 4	0
						254	1909 VI 3	2			
						261	1881 VI 11	1			
Sums		10			17			10			12
No. eclipses		8			9			11			9
Mean grades		1.25			1.89			0.91			1.33

curve is drawn amid a cloud of observation points, and its form is unavoidably somewhat arbitrary. As the depressions count in forming the denominators, the curve rises often above 100 per cent. Beside minor variations, there are three very deep depressions, which follow certain volcanic catastrophes, and are named from them:

Krakatoa depression, 1883 VIII to 1886 XII.

Pelée depression, 1902 VII to 1904 X.

Katmai depression, 1912 III to 1924 VI.

On account of the peculiarities of the method, the dates of beginning and ending of these depressions can be only roughly stated; *e. g.*, the Krakatoa depression seems to have been well started by the end of 1882, though Kimball begins it with the month of the eruption.

This curve is copied in figure 1 of this paper.

During these volcanic depressions there were lunar eclipses as shown in table 6.

TABLE 6.—*Relation of Volcanic Haze and Brightness of 10 Lunar Eclipses*

Depression	Date	Path	Magn.	Grade
Krakatoa	1884 IV 9	C	1.44	0?
	1884 X 4	C	1.53	1
	1885 III 30	N	0.89	1
Pelée	1902 X 16	C	1.46	1
	1903 IV 11	N	0.97	0
	1903 X 6	S	0.87	2
Katmai	1912 IV 1	N	0.19	1
	1913 III 21	C	1.58	0
	1913 IX 14	C	1.44	0
	1914 III 11	S	0.92	2

Summaries; Eclipses 1880-1922

	Number	Sum of grades	Mean grade
I. All included:			
In depressions	10	8	0.80
Not in depressions	42	57	1.36
II. Southern excluded:			
In depressions	8	4	0.50
Not in depressions	28	33	1.18
III. Southern only:			
In depressions	2	4	2.00
Not in depressions	14	24	1.73

Taking all the 10 eclipses occurring during depressions, mean grade 0.80, and comparing with the 42 eclipses, mean grade 1.36, not in depressions but in the period 1880-1922 which surrounds the depressions, the eclipses in the depressions average much dimmer than those without. But 2 of those within are southern eclipses,

both of grade 2. This suggests a similar comparison, II, of the eclipses in and out of depressions, excluding all southern eclipses, and III, including only southern eclipses.

The results of comparison II are, mean grade of eclipses in depressions, 0.50, without depressions, 1.18; of comparison III, mean grade of eclipses in depressions, 2.00, without, 1.73. So that the effect of volcanic haze has been practically confined to the northern zone of the shadow.

As to the suggested effect of the solar cycle of sunspots, etc.; during the period considered there is no obvious way in which such an effect could be disentangled from the effects of dust.

Dust is continuously blowing into the air from the deserts and seasonal drought areas of Asia, Africa, North and South America and Australia, whence it goes far, as in the trade wind belts of the North Atlantic and on the Pacific to leeward of the loess areas of China.

Then, the number of known volcanic dust eruptions, big enough to send clouds well up toward the stratosphere, is considerable, and in the past there have doubtless been very many great unknown eruptions; an illustration is the great volcanic dust fall of 1907, over the Seward Peninsula and the Yukon Valley, but of unknown origin; this coincides well enough with one of the minor depressions in Kimball's curve. The details of many known eruptions, the height of the cloud and the spread of the ash, are ill-reported. Thus, an eruption ascribed at first to one of the craters of Skaptar Jökull was seen at Reykjavik, Jan. 9, 1873, and " for days thereafter the cloud stood high in the sky." Thoroddsen assigns this to the Kverkfall, which is 162 miles from Reykjavik; whence the cloud must have been over 15,000 feet high to be seen there at all; how much higher it was is unknown; and the spread of the ash outside of Iceland is unknown. This must have been a very important eruption.

The pyrheliometric observations at Arequipa, Peru, showed no effect of the great Katmai depression. Whence we may conclude that probably volcanic dust from either temperate zone has little effect on atmospheric transparency the other side of the equator. As the greatest deserts and a very large number of the dust-producing volcanoes are in the northern hemisphere, it may be that the darkness of the northern part of the earth's shadow is due to desert and volcanic dust.

The observations do not yield any very definite conclusion as to a difference in brightness of the eastern, or sunrise, side of the umbra,

and the western, or sunset side. In the scanty allusions to this point, observers frequently disagree about identical eclipses, or record the phenomena in some cases one way, sometimes the other; and some definitely state that no difference was observed.

Figure 1 is an attempt to show some of the preceding relations graphically. The abscissas are time, in years; the date number stands for Jan. 1 in each year, so that the year interval extends to the right of each number. The upper curve is Kimball's radiation curve, with per cents as ordinates. The next (broken) line connects points

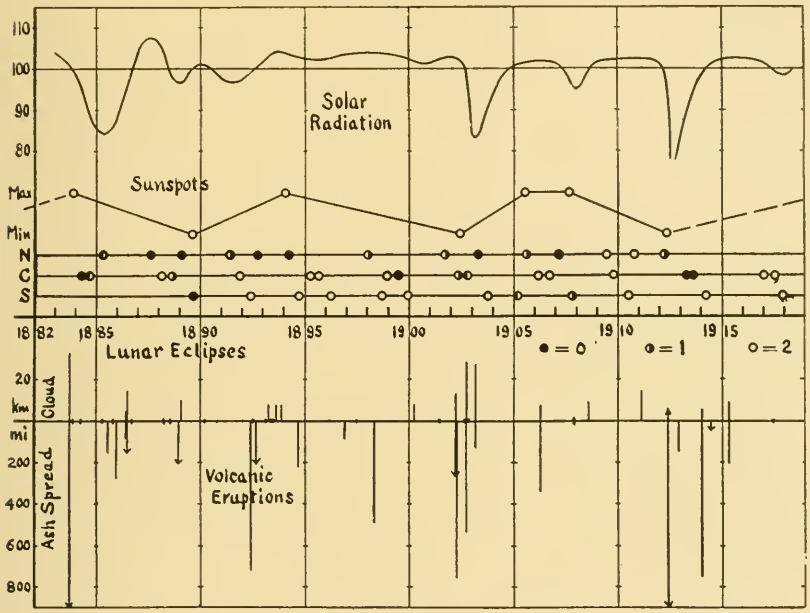

FIG. 1.

representing solar maxima and minima, from Wolf-Wolfers and See; there is no attempt to represent amplitudes of the true sunspot curve. Three lines marked N, C, S, carry circles representing lunar eclipses, north, central and south; a black circle represents grade 0, a half-black, grade 1, a white circle, grade 2. Volcanic eruptions are marked with dots on a horizontal base line; where data could be found, the height of the eruption cloud in kilometers is represented by a line drawn upward from the base, the maximum spread of the ash-fall in statute miles by a line drawn downward; arrowheads on either of these upward or downward lines indicate that the amount represented is doubtless too small. Thus, the Katmai cloud was seen at Cook Inlet.

whence it must have been at least 3.4 km. high, to be seen over the earth's curve—but how much higher cannot be guessed; so the upward line for Katmai is tipped with an arrowhead at about 5 km.

In conclusion, thanks are gladly rendered to Dr. Harlow Shapley, Director of the Astronomical Observatory of Harvard College, for the privileges of the Observatory Library; to the Librarian of Harvard University, and to Mr. W. B. Briggs, Assistant Librarian, for privileges granted in the University Library; to the staff of the Boston Public Library; and to Mr. L. Campbell and Miss I. E. Woods, of the Harvard Observatory, for assistance freely and often given.

Professor Alexander McAdie, Director of Blue Hill Observatory, and Dr. Shapley, have been very generous in the matter of conferences. But for selection of data, for methods, results and conclusions, and for errors in this paper, the writer alone is responsible.

SUMMARY

The observational data on lunar eclipses, published by professional astronomers and amateurs for the period 1860 to 1922, have been read, and have been collated, as far as possible, without reference to any theory of the illumination of the eclipsed surface.

A scale of brightness adapted to the data has been devised, consisting of three grades; grade 2, details on the eclipsed surface visible with hand instruments or to the naked eye; grade 1, details visible with apertures of 2 to 6 inches, but not with less; grade 0, apertures of 6 inches or more necessary to show detail. In assigning grades the writer's bias has weighted positive statements of visibility.

This scale has been applied to all suitable data for each eclipse. On account of curious discrepancies in the reports of both amateur and professional observers, the grading has frequently been somewhat arbitrary.

In the hope that the varying masses of air along the ray might prove to have an effect in causing these discrepancies, the relative air mass has been computed for each important report used in grading, and the reports under each eclipse have been arranged in order of increasing air mass; but there seems to be no well-defined connection.

Assuming that the grades thus assigned are significant, the data have been selected and arranged in several sequences, to test the relations of various astronomical and accidental causes to the brightness of the eclipsed moon.

It is found that the position of the moon's path with regard to the center of the shadow is significant; when the moon passes clear of the center on the south side, the shadow is brighter; when it passes over the center, less bright; when it clears the center on the north side, decidedly dim, on the average. This is shown not only for all 68 eclipses, but also for 13 pairs of consecutive eclipses.

In 37 total eclipses there seems to be no very decided effect of distance; on the average, the shadow at middle distances is perhaps somewhat brighter than at perigee or apogee.

In 37 total eclipses there is a marked effect of the seasons, which are implied in the longitude of the shadow; winter eclipses have been bright, spring eclipses dim, summer and autumn eclipses intermediate and not very different, on the average.

The effect of volcanic dust haze in the 3 great atmospheric disturbances named for Krakatoa, Pelée and Katmai has shown itself in the average dimness of 10 included eclipses, as compared with 42 eclipses, 1880-1922, not in the disturbed periods.

If all the southern eclipses occurring in the disturbed periods were removed, the discrepancy between the brightness of the eclipses in the disturbed periods and of those outside them would be increased. It is as if the northern part of the shadow were specially affected by these disturbances, and were in general darker than the southern part.

The average difference between winter and spring total eclipses is perhaps increased by the absence of winter eclipses during the disturbed periods.

During the period discussed there is no discernible relation between the solar cycle and the brightness of lunar eclipses. And, given the effects of north latitudes and volcanic dust hazes as proved, and acknowledging ignorance as to the magnitude, or even the occurrence, of suitably great volcanic eruptions, it is doubtful whether an effect of solar activity can ever be disentangled from dust effects, in records prior to 1880, all the more as the earlier records show greater gaps and fewer detailed statements.

It is to be hoped that in the future eclipses of the moon may be studied with more respect, by astronomers and meteorologists, professional and amateur; and especially, in western North America, in South America, in the Hawaiian Islands, Japan, the Philippines, East Indies, Australia, New Zealand, the islands of the South Sea, and even the Arctic and Antarctic; and that results may be published in accessible scientific periodicals, without biassed and destructive editing. Anybody with good eyesight and a watch can make valuable

additions to knowledge, stating where, when, how and what he sees during a lunar eclipse.

NOTE ON FIGURES 2 AND 3

Figure 2 is a reduced half-tone reproduction of the original lunar eclipse photograph made by J. H. Metcalf (258) at Taunton, Mass., 1909 XI 26. The lens used was his 12-inch doublet; scale of plate 93″ = 1 mm.; exposure from 20 h. 13 m. 30 s. to 21 h. 34 m. 00 s., G. M. T.; the telescope was guided on a star and the moon allowed to trail through the earth's shadow between internal contacts.

FIG. 2.

Of course the shadow also trailed among the stars a little; and on the plate the moon, and the shadow taken at the moon's distance, are displaced among the stars by parallax; they being seen from Taunton, N. 41° 54′, with the moon's zenith distance changing from 52° to 66°, and not from the center of the earth.

Figure 3 is a diagram on about the same scale as figure 2, roughly showing these geometrical relations. The corners of the rectangle of hour and declination circles were marked approximately on the negative, and a blue print made; on this were drawn the necessary lines, hour and declination circles, ecliptic and orbit, and the outline of the moon trail. On the orbit, the points α and β are the geocentric positions of the moon's center at beginning and ending

of the exposure; α' and β' are the same, displaced by parallax. On the ecliptic, a and b are the geocentric positions of the center of the earth's shadow at beginning and end of the exposure; a' and b' are the points where the axis of the shadow pierces a plane at the moon's distance; they are displaced from a and b by parallax. As, at Taunton, the parallax of the moon increased during the exposure, nearly as the sine of the zenith distance, and so not in proportion to the time, the parallactic displacements of corresponding points are greater and differently directed at the end of the exposure. This partly accounts for the departure of the upper and lower limbs of the moon trail from parallelism with the orbit, and for the curvature of these limbs, slight but real in the dim northern limb, easily seen in the southern limb.

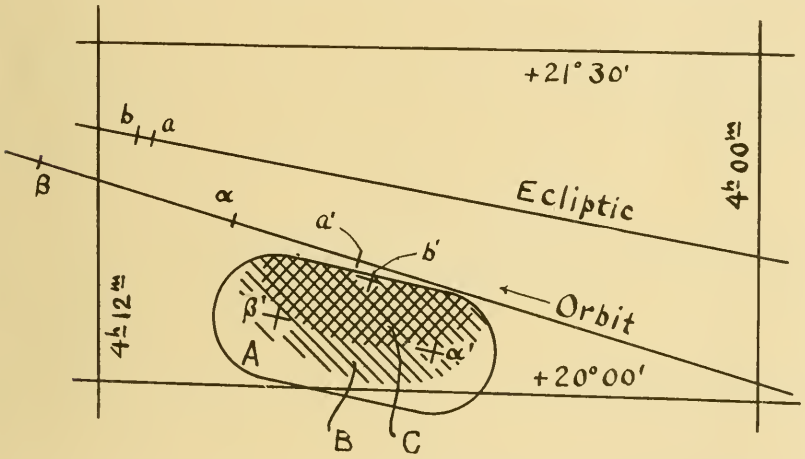

FIG. 3.

Mr. Metcalf also points out another cause—enlargement of the moon's image by irradiation.

The half-tone shows gradations of brightness in the umbra, which are more easily seen in the original. In the diagram these are distinguished as in three zones; A, an outer bright zone; B, an intermediate dimmer zone, single hatched; C, an inner dark zone, double hatched. The boundary of A is, of course, the outer edge of the umbra, not shown; the boundary of B is roughly concentric with the center of the shadow, which lies from a' to b'; C is markedly elliptical, or flattened on its south side. These peculiarities cannot be due to lunar surface features, which are hard to make out anywhere on the negative; the Mare Frigoris made a faint streak, and faint stripes due to one or two other seas, etc., can barely be traced.

This is the only photograph of a lunar eclipse ever taken by this method, so that we have no similar data about the form of C on the north side of the shadow center. If we suppose that C is oval, with the point of the oval northward, then Rudaux's statement (127), that the center of darkness, 1895 III 10, was displaced northward from the geometrical center of the umbra, is seen to agree well with this photograph.

Thanks are rendered to Rev. J. H. Metcalf, for permission to use the original negative; and to Dr. Shapley, for having it suitably marked, and for conferences regarding its interpretation.

The photograph for figure 2 was kindly loaned by Popular Astronomy.

ADDITIONAL NOTE.—After reading proof, I learned that another photograph of the lunar eclipse of 1909 XI 26 was made at the Harvard Observatory, with the 8-inch Draper telescope. A print (kindly handed me by Prof. E. S. King) might easily be taken for a reduction to ⅔ size of Rev. Mr. Metcalf's photograph. It was at his suggestion and by his method that this photograph was taken.—W. J. F.

TABLE 7.—*References for Table 1*

1860 II 6

1 N. Pogson, Mo. Not. Roy. Astr. Soc., 20, p. 218, 1859-60.
2 J. F. J. Schmidt, Astr. Nachr., 52, pp. 233-234, 1860.
3 M. Ward, Recreative Science, 1, pp. 279-283, 1860.

1862 XII 5

4 Cantzler, Heis Wochenschr. f. Astr., Met. u. Geog., n. s. 6, pp. 84-86, 1863.
5 H. d'Arrest, Astr. Nachr., 59, p. 92, 1863.

1863 VI 1

6 T. W. Backhouse, Astr. Reg., 19, pp. 143-144, 1881.
7 Bird, Les Mondes, 2, pp. 385-386, 1863.
8 W. Noble, Mo. Not. Roy. Astr. Soc., 23, p. 251, 1862-3.
9 Tempel, Les Mondes, 1, p. 511, 1863.

1865 IV 11

10 D. A. Freeman, Mo. Not. Roy. Astr. Soc., 25, p. 273, 1864-5.
11 F. Hoefer, Cosmos, (2) 1, pp. 428-429, 1865; Astr. Reg. 3, pp. 169-170, 1865.

1865 X 4

12 Cantzler, Heis Wochenschr. f. Astr., Met. u. Geog., n. s. 8, pp. 356-357, 1865.
13 C. Flammarion, Cosmos, (2) 2, p. 398, 1865.
14 W. De la Rue, Mo. Not. Roy. Astr. Soc., 25, p. 276, 1864-5.

1867 IX 3

15 A. Brothers, Proc. Manchester Lit. and Phil. Soc., 7, pp. 52-54, 1867-8.
16 J. Browning, Astr. Reg., 5, p. 217, 1867.
17 H. Ingall, Astr. Reg., 5, p. 240, 1868.
18 H. J. Slack, Intellectual Observer, 12, pp. 226-227, 1867. Annual Encyclopedia, 1867, p. 65.

1869 I 27

19 C. B. Gribble, Astr. Reg., 7, pp. 114-115, 1869.
20 R. Prowde, Astr. Reg., 7, pp. 90-91, 1869.

1869 VII 22

21 J. Tebbutt, Mo. Not. Roy. Astr. Soc., 30, p. 26, 1869-70.

1870 I 17

22 J. Tebbutt, Mo. Not. Roy. Astr. Soc., 30, pp. 159-160, 1869-70; Astr. Nachr., 75, p. 379, 1870.

1870 VII 12

23 W. Noble, Astr. Reg. 8, p. 200, 1870.
24 G. C. Thompson, Nature, 2, p. 236, 1871.
25 G. J. Walker, Astr. Reg., 8, p. 174, 1870.

1871 I 6

26 J. Birmingham, Astr. Nachr., 77, p. 206, 1871.

1873 V 11

27 J. Tebbutt, Mo. Not. Roy. Astr. Soc., 34, pp. 72-73, 1873.

1876 IX 3

28 A. T. Arcimis, Mo. Not. Roy Astr. Soc., 37, p. 12-13, 1876.
29 F. R. A. S., Engl. Mech., 77, p. 297, 1903.
30 Perrotin, C. R., 83, p. 571, 1876.

1877 II 27

31 A. H. S., Engl. Mech., 25, p. 33, 1877.
32 A. T. Arcimis, Mo. Not. Roy. Astr. Soc., 37, p. 400, 1877.
33 J. T. Barber, Astr. Reg., 15, p. 100, 1877.
34 A. Riccò, Mem. Soc. Spett. Ital., 18, p. 152, 1889.
35 R. v. Sterneck, Astr. Nachr., 89, p. 191, 1877.

1877 VIII 23

36 T. G. Elger, Engl. Mech., 25, p. 609, 1877.
37 S. J. Johnson, Mo. Not. Roy. Astr. Soc., 37, pp. 467-468, 1877.
38 E. W. Maunder, Observatory, 2, p. 197, 1878.
39 J. Rand Capron, Observatory, 1, pp. 216-218, 1877.

1878 VIII 12

40 E. E. M., Engl. Mech., 26, pp. 9-10, 1878.
41 E. W. Maunder, Mo. Not. Roy. Astr. Soc., 38, pp. 514-525, 1878.
42 H. J. Slack, Astr. Reg., 16, p. 256, 1878.

1880 VI 21

43 Melbourne observers, Engl. Mech., 31, p. 580, 1880.
44 H. C. Russell, Observatory, 3, pp. 565-568, 1879-80.
45 J. Tebbutt, Astr. Reg., 19, pp. 20-21, 1881.

1881 VI 11

46 F. E. Barnard, Astr. Nachr., 161, pp. 81-84, 1903.
47 A. Hall, Observatory, 4, p. 282, 1881.
48 W. L. Hooper, Engl. Mech., 33, p. 403, 1881.
49 B. G. Jenkins, Astr. Reg., 19, pp. 120-121, 1881.

1881 XII 4

50 S. J. Johnson, Astr. Reg., 20, p. 16, 1882.
51 L. Piat, La Nature, p. 190, 1882 I.
52 J. Rand Capron, Mo. Not. Roy. Astr. Soc , 42, p. 262-263, 1882.

1884 IV 9

53 C. Dufour, L'Astronomic, 7, p. 29, 1888.

1884 X 4

54 Beechey, Observatory, 7, pp. 336-339, 1884.
55 Berge, in C. F., L'Astronomie, 4, pp. 23-30, 1885.
56 Byl, in L. Niesten, Bull. de Brux., (3) 8, pp. 361-369, 1884.
57 W. F. Denning, Mo. Not. Roy. Astr. Soc., 45, pp. 42-43, 1884-5.
58 W. Erck, Nature, 31, p. 28, 1884.
59 Guillaume, in C. F., L'Astronomie, 4, pp. 23-30, 1885.
60 Guiot, in C. F., L'Astronomie, 4, pp. 23-30, 1885.
61 E. J. Lowe, Nature, 30, p. 590, 1884.
62 Kj. Muller, in C. F., L'Astronomie, 4, pp. 23-30, 1885.
63 J. Parséhian, L'Astronomie, 4, pp. 69-70, 1885.
64 E. J. Spitta, Mo. Not. Roy. Astr. Soc., 45, p. 154, 1884-5.
65 Trépied, C. R., 99, pp. 562-563, 1884.

1885 III 30

66 J. Ballot, Engl. Mech., 41, p. 277, 1885.
67 A. B. Biggs, Journ. Brit. Astr. Assoc., 13, p. 28, 1902-3.
68 O. et S. Broune, L'Astronomie, 4, p. 227, 1885.
69 E. du Buisson, L'Astronomie, 4, pp. 376-378, 1885.

1887 VIII 3

70 B. J. Hopkins, Engl. Mech., 45, p. 558, 1887.
71 H. J. Klein, Sirius, 20, pp. 193-4, 1887.
72 E. Lescarbault, C. R., 105, pp. 370-371, 1887.
73 G. Rayet, C. R., 105, p. 305, 1887.

1888 I 28

74 H. Brugière, L'Astronomie, 7, p. 107, 1888.
75 Fromme, Sirius, 21, pp. 61-62, 1888.
76 L. N(iesten,) Ciel et Terre, 8, p. 559-561, 1887-8.
77 Observers of Soc. Astr., France, in P. Gerigny, L'Astronomie, 7, pp. 98-103, 1888.
78 F. Terby, Bull. de Brux., (3) 15, pp. 349-350, 1888.

1888 VII 22

79 E. E. Barnard, Publ. Lick Obs., No. 4, pp. 117-121, 1891.
80 Duprat, L'Astronomie, 7, p. 428, 1888.
81 G. H., L'Astronomie, 7, p. 351, 1888.
81a J. F. Romani, L'Astronomie, 7, p. 351, 1888.
82 J. Valderrama, L'Astronomie, 7, pp. 350-351, 1888.

1889 I 16

83 E. E. Barnard, Sidereal Mess., 8, pp. 137-138, 1889.
84 G. le Cadet, C. R., 108, pp. 129-130, 1889.
85 D. Eginitis et Maturana, C. R., 108, pp. 130-132, 1889.
86 J. Mitchell, Observatory, 12, p. 126, 1889.
87 E. Stuyvaert, Astr. Nachr., 121, pp. 135-138, 1889.

1889 VII 12

88 E. v. Gothard, Astr. Nachr., 122, pp. 351-352, 1889.
89 von Konkoly, Sirius, 22, pp. 197-200, 1889.
90 A. Krueger, Astr. Nachr., 122, p. 263, 1889.
91 A. Mascari, Mem. Soc. Spett. Ital., 18, pp. 151-152, 1889.
92 A. Nikolajewitsch, Sirius, 22, pp. 199-200, 1889.
93 A. Riccò, Mem. Soc. Spett. Ital., 18, pp. 151-152, 1889.

1891 V 23

94 W. E. Jackson, Journ. Brit. Astr. Assoc., 1, p. 463, 1890-91.
95 G. Lewitsky, Astr. Nachr., 128, pp. 137-138, 1891.
96 W. H. Wooster, Journ. Brit. Astr. Assoc., 2, pp. 44-45. 1891-2.

1891 XI 15

97 L. Fenet, L' Astronomie, 10, pp. 464-470, 1891.
98 J. E. Gore, Journ. Brit. Astr. Assoc., 2, pp. 88-89, 1891-2.
99 R. C. Leslie, Nature, 45, p. 53, 1891.
100 J. Power, Journ. Brit. Astr. Assoc., 2, pp. 127-128, 1891-2.

1892 V 11

101 Codde et al., C. R., 114, pp. 1099-1100, 1892.
102 E. Crossley and J. Gledhill, Mo. Not. Roy. Astr. Soc., 52, pp. 560-562, 1892.
103 W. Goodacre, Journ. Brit. Astr. Assoc., 2, p. 414, 1891-2.
104 Louvain observers, in L. Niesten and E. Stuyvaert, Ciel et Terre, 13, pp. 145-152, 1892-3.

1892 XI 4

105 E. Cortel, L'Astronomie, 12, pp. 13-18, 1893.
106 W. Doberck, Astr. Nachr., 131, pp. 399-400, 1893.
107 W. Gale, Journ. Brit. Astr. Assoc., 3, p. 140, 1892-3.
108 Giovanozzi, L'Astronomie, 12, pp. 13-18, 1893.
109 S. v. Glasenapp. Astr. Nachr., 131, pp. 399-402, 1893.
110 H. C. Russell, Mo. Not. Roy. Astr. Soc., 53, pp. 125-126, 1893.

1894 III 21

111 A. Rzyszczewski, L'Astronomie, 13, pp. 192-193, 1894.

1894 IX 4

112 E. E. Barnard, Astronomy and Astrophysics, 13, pp. 705-706, 1894.
113 J. Comas Sola, L'Astronomie, 13, pp. 390-392, 1894.
114 M. Ladoux, L'Astronomie, 13, pp. 390-392, 1894.
115 Pilloy, L'Astronomie, 13, pp. 390-392, 1894.
116 A. Riccò and A. Mascari, Mem. Soc. Spett. Ital., 24, pp. 12-14, 1895.

1895 III 10

117 E. Bosshard, Sirius, 28, p. 152, 1895.
118 G. C. Comstock, Astron. Journ., 15, p. 39, 1895.
119 A. Duménil, Les Sciences Populaires, 9, pp. 104-105, 1895.
120 L. A. Eddie, Pop. Astr., 2, pp. 449-452, 1894-5.
121 Everett, Journ. Brit. Astr. Assoc., 5, pp. 291-294, 1894-5.
122 Martial Les Sciences Populaires, 9, pp. 103-104, 1895.
123 G. J. Newbegin, Journ. Brit. Astr. Assoc., 5, pp. 349-350, 1894-5.
124 Northfield observers, Pop. Astr., 2, p. 384, 1894-5.
125 C. D. Perrine, Publ. Astr. Soc. Pacific, 7, pp. 110-112, 1895.
126 J. Quélin, La Nature, p. 270, 1895 I; Ciel et Terre, 16, pp. 67-68, 1895-6
127 L. Rudaux, Les Sciences Populaires, 9, pp. 174-176, 1895.

1895 IX 3

128 E. E. Barnard, Pop. Astr., 3, pp. 102-103, 1895-6; Astr. Nachr., 161, p. 81-84, 1903.
129 Campos Roderigues, Astr. Nachr., 165, pp. 193-199, 1904.
130 C. Flammarion, Bull. Soc. Astr. Fr., 9, pp. 317-320, 1895.
131 A. Nauwelaerts, Les Sciences Populaires, 9, p. 372, 1895.
132 Payne and Wilson, Pop. Astr., 3, pp. 101-102, 1895-6.
133 C. D. Perrine, Publ. Astr. Soc. Pacific, 7, pp. 289-291, 1895.
134 P. Roulaud, Bull. Soc., Astr. Fr., 9, pp. 317-320, 1895.
135 L. Swift, Pop. Astr. 3, pp. 103-104, 1895-6.
136 S. Véréri, Bull. Soc. Astr. Fr., 9, pp. 317-320, 1895.

1896 II 28

137 A. Duménil, Les Sciences Populaires, 10, pp. 96-97, 1896.
138 J. Möller, Astr. Nachr., 140, pp. 373-374, 1896.
139 C. Roberts, in T. G. Elder, Journ. Brit. Astr. Assoc., 6, pp. 252-255, 1895-6.
140 C. A. Taylor, in T. G. Elder, Journ. Brit. Astr. Assoc., 6, pp. 252-255, 1895-6.
141 W. P., Ciel et Terre, 17, p. 18, 1896-7.

1898 I 7

142 Chèvremont, in G. A., Bull. Soc. Astr. Fr., 12, pp. 97-106, 1898.
143 W. Godden, Journ. Brit. Astr. Assoc., 8, pp. 194-195, 1897-8.
144 L. Guiot, in G. A., Bull. Soc. Astr. Fr., 12, pp. 97-106, 1898.
145 A. Stuyvaert, Ciel et Terre, 18, pp. 570-571, 1897-8.

1898 VII 3

146 Ambronn, Astr. Nachr., 148, pp. 245-248, 1899.
147 S. B. Gaythorpe, Engl. Mech., 67, p. 502, 1898.
148 Grein, in G. A., Bull. Soc. Astr. Fr., 12, pp. 397-399, 1898.
149 Hauët, in G. A., Bull. Soc. Astr. Fr., 12, pp. 348-365, 1898.
150 E. E. Marckwick, Engl. Mech., 67, p. 524, 1898.
151 Moye, in G. A., Bull. Soc. Astr. Fr., 12, pp. 348-365, 1898.
152 A. Riccò, Mem. Soc. Spett. Ital., 27, pp. 153-158, 1898.
153 G. Saija, Mem. Soc. Spett Ital., 27, pp. 157-158, 1898.
154 L. Struve, Astr. Nachr., 147, pp. 323-328, 1898.
155 S. Véréri, in G. A., Bull. Soc. Astr. Fr., 12, pp. 348-365, 1898.
156 L. Weinek, Astr. Nachr., 148, pp. 55-58, 1898-9.

1898 XII 27

157 V. Bareel, Bull. Soc. belge d'Astronomie, 4, pp. 108-110, 1898-9.
158 A. W. Blacklock, Engl. Mech., 68, p. 491, 1899.
159 W. F. A. Ellison, Engl. Mech., 68, p. 612, 1899.
160 Ph. Fauth, Astr. Nachr. 148, p. 305, 1899.
161 J. Franz, Astr. Nachr., pp. 397-400, 1899-1900.
162 S. B. Gaythorpe, Engl. Mech., 68, p. 491, 1899.
163 R. Killip, Engl. Mech., pp. 490-491, 1899.
164 A. King, Engl. Mech., 68, pp. 491-492, 1899.
165 "No Sig," Engl. Mech., 68, p. 514, 1899.
166 C. F. Smith, in W. Goodacre, Journ. Brit. Astr. Assoc., 9, pp. 148-156, 1898-9.
167 A. Staus u. M. Mündler, Astr. Nachr., 149, pp. 391-394, 1899.
168 E. Stuyvaert, Ciel et Terre, 19, pp. 567-571, 1898-9.
169 H. Whichello, in W. Goodacre, Journ. Brit. Astr. Assoc., 9, pp. 148-156, 1898-9.

1899 VI 22

170 L. Bernacchi, in C. E. Borchgrevink, First on the Antarctic Continent . . . . 1898-1900; p. 136, p. 139.

1899 XII 16

171 W. A. Crusinberry, Pop. Astr., 8, p. 55, 1900.
172 E. Daguin, in Em. T., Bull. Soc. Astr. Fr., 14, pp. 76-82, 1900.
173 G. Gaubert, Bull. Soc. Astr. Fr., 14, pp. 129-131, 1900.
174 A. Grein, in Em. T., Bull. Soc. Astr. Fr., 14, pp. 76-82, 1900.
175 A. King, Engl. Mech., 70, p. 469-470, 1900.
176 Lafitte, in Em. T., Bull. Soc. Astr. Fr., 14, pp. 76-82, 1900
177 J. Levreau, Bull. Soc. Astr. Fr., 14, pp. 129-131, 1900.
178 Luzet, in Em. T., Bull. Soc. Astr. Fr., 14, pp. 76-82, 1900.
179 N. Maclachlan, Engl. Mech., 70, p. 493, 1899.
180 G. Saija, Mem. Soc. Spett. Ital., 28, pp. 230-231, 1899.

1901 X 27

181 V. Zlatinsky, Bull. Soc. Astr. Fr., 15, p. 520, 1901.

1902 IV 22

182 A. Allander, in Em. T., Bull. Soc. Astr. Fr., 16, pp. 513-517, 1902; and in M. Hauptmann, Ciel et Terre, 38, pp. 117-119, 1922.
183 W. Godden, Engl. Mech., 75, p. 248, 1902.
184 W. Goodacre, Journ. Brit. Astr. Assoc., 12, pp. 275-276, 1901-2.
185 S. and D. Khalatov, in Em. T., Bull. Soc. Astr. Fr., 16, pp. 513-517, 1902; and in M. Hauptmann, Ciel et Terre, 38, pp. 117-119, 1922.
186 "Mathematicus," Engl. Mech., 75, p. 336, 1902.
187 W. A. Parr, in W. Goodacre, Journ. Brit. Astr. Assoc., 12, pp. 275-276, 1901-2.
188 L. Weinek, Astr. Nachr., 160, pp. 9-12, 1902.
189 V. Zlatinsky, in Em. T., Bull. Soc. Astr. Fr., 16, pp. 513-517, 1902. .

1902 X 16

190 E. E. Barnard, Astr. Nachr., 161, pp. 81-84, 1903.
191 A. C. D. Crommelin, Observatory, 25, pp. 395-396, 1902.
192 W. Godden, Engl. Mech., 76, p. 230, 1902.
193 H. A. Howe, Pop. Astr., 10, pp. 549-550, 1902.
194 S. J. Johnson, Journ. Brit. Astr. Assoc., 13, pp. 27-28, 1902-3.
195 E. E. Marckwick, Engl. Mech., 76, p. 250, 1902.
196 Mexico City observers, Bol. Soc. Astr. Mexico, 1, pp. 62-66, 1902.
197 R. O'Halloran, Pop. Astr., 10, p. 551, 1902; Publ. Astr. Soc. Pac., 14, pp. 188-189, 1902.
198 W. W. Payne, Pop. Astr., 10, pp. 480-486, 1902.
199 H. C. Wilson, Pop. Astr., 10, pp. 503-504, 1902.

1903 IV 11

200 A. Allander, in C. F., Bull. Soc. Astr. Fr., 17, pp. 223-231, 1903.
201 T. W. Backhouse, Observatory, 26, p. 213, 1903.
202 D. Dubiago, Astr. Nachr., 166, p. 289, 1904.
203 "Mathematicus," Engl. Mech., 77, p. 276, 1903.
204 F. Oom, Astr. Nachr., 165, pp. 197-200, 1904.

1903 X 6

205 E. Bordage et A. Garsault, C. R. 137, pp. 897-898, 1903.
206 D. Dubiago, Astr. Nachr., 166, pp. 295-298, 1904.
207 P. H. Johnson, Engl. Mech., 78, p. 334, 1903.
208 "Mathematicus," Engl. Mech., 78, p. 448, 1903.

1905 II 19

209 Al. Aymé, Bull. Soc. Astr. Fr., 19, pp. 191-193, 1905.
210 F. Burnerd, Engl. Mech., 85, p. 129, 1905.
211 G. Caron, Bull. Soc. Astr. Fr., 19, pp. 240-243, 1905.
212 Chèvremont, Bull. Soc. Astr. Fr., 19, p. 191-193, 1905.
213 Crommelin (presiding), Journ. Brit. Astr. Assoc., 15, pp. 189-190, 1904-5.
214 F. C. Dennett, Engl. Mech., 81, p. 85, 1905.
215 H. R. Hanbidge, Engl. Mech., 81, p. 65, 1905.
216 C. Larronde, Bull. Soc. Astr. Fr., 19, pp. 240-243, 1905.
217 "Meteor," Engl. Mech., 81, p. 65, 1905.
218 M. Moye, Observatory, 28, p. 141, 1905.

219 F. Quénisset, Bull. Soc. Astr. Fr., 19, pp. 191-193, 1905.
220 A. Rengel, Bull. Soc. Astr. Fr., 19, pp. 240-243, 1905.
221 W. G. T., Engl. Mech., 81, p. 85, 1905.

1905 VIII 15

222 A. Benoit, Bull. Soc. Astr. Fr., 19, pp. 389-391, 1905.
223 A. Bloch, Bull. Soc. Astr. Fr., 19, pp. 389-391, 1905.
224 R. Guerin, Bull. Soc. Astr. Fr., 19, p. 462, 1905.
225 E. de Perrot, Bull. Soc. Astr. Fr., 19, p. 462, 1905.
226 A. Quignon, Bull. Soc. Astr. Fr., 19, pp. 389-391, 1905.
227 H. Rey, Bull. Soc. Astr. Fr., 19, pp. 389-391, 1905.
227a G. de'Sforza, Bull. Soc. Astr. Fr., 19, p. 462, 1905.
228 E. Stuyvaert, Ann. Obs. roy. de Belg., n. s., Ann., Astr., 9, pp. 74-75, 1906.
229 W. Winkler, Astr. Nachr., 171, p. 123, 1906.
230 H. Wuillemier, Bull. Soc. Astr. Fr., 19, pp. 389-391, 1905.

1906 II 8

231 G. Blum, in C. F., Bull. Soc. Astr. Fr., 20, pp. 192-194, 1906.
232 Denning, Observatory, 29, pp. 144-145, 1906.
233 S. Díaz, Bol. Soc. Astr. Mexico, 5, pp. 749-753, 1906.
234 A. López, Bol. Soc. Astr. Mexico, 5, pp. 748-749, 1906.
235 E. López, Bol. Soc. Astr. Mexico, 5, pp. 741-747, 1906.
236 H. Macpherson, Engl. Mech., 83, p. 36, 1906.
237 F. Quénisset, Bull. Soc. Astr., Fr., 20, pp. 140-142, 1906.
238 A. D. Ross, Journ. Brit. Astr. Assoc., 16, pp. 206-207, 1905-6.
239 L. Rudaux, La Nature, p. 224, 1906 I.

1906 VIII 4

240 G. le Cadet, Bull. Soc. Astr. Fr., 22, pp. 544-546, 1906; C. R., 143, pp. 509-510, 1906.
241 S. Díaz, Bol. Soc. Astr. Mexico, 5, pp. 852-854, 1906.
242 W. F. Gale, Journ. Brit. Astr. Assoc., 17, pp. 33-34, 1906-7.
243 W. B. Harris, Journ. Brit. Astr. Assoc., 17, pp. 31-32, 1906-7.
244 J. T. Ward, 17, pp. 32-33, 1906-7.

1907 I 28

245 E. López, Bol. Soc. Astr. Mexico, 5, pp. 957-960, 1907.

1907 VII 24

246 Constantin, Bull. Soc. Astr. Fr., 21, p. 451, 1907.
247 S. Díaz, Bol. Soc. Astr. Mexico, 6, pp. 85-88, 1907.
248 E. López, Bol. Soc. Astr. Mexico, 6, pp. 88-91, 1907.

1909 VI 3

249 Borelly, C. R., 148, pp. 1499-1500, 1909.
250 H. Bougourd, Bull. Soc. Astr. Fr., 23, pp. 476-477, 1909.
251 J. H. Elgie, Nature, 80, pp. 502-503, 1909.
252 F. de Roy, Ciel et Terre, 30, p. 248, 1909-10.
253 J. Serrano, in (T.), Bull. Soc. Astr. Fr., 23, pp. 331-336, 1909.
254 L. Taffara, Mem. Soc. Spett. Ital., 38, pp. 155-156, 1909.
255 V. Zlatinsky, in (T.), Bull. Soc. Astr. Fr., 23, pp. 331-336, 1909.

1909 XI 26

256 P. C. Campariole, Engl. Mech., 90, p. 468, 1909.
257 N. V. Ginori, Revista di Astronomia, etc., 4, pp. 30-31, 1910.
258 J. H. Metcalf, Astr. Nachr., 184, p. 10, 1910; Pop. Astr. 18, pp. 87-90, 1910.
259 R. O'Halloran, Pop. Astr., 18, pp. 61-62, 1910.

1910 V 23

260 P. C. Campariole, Engl. Mech., 91, p. 452, 1910.

1910 XI 16

261 Amann et Cl. Rozet, C. R., 151, pp. 1104-1106, 1910.
262 Goudey, in E. Touchet, Bull. Soc. Astr. Fr., 25, pp. 29-32, 1911.
263 Lafitte, in Em. Touchet, Bull. Soc. Astr. Fr., 25, pp. 56-66, 1911.
264 A. A. Nijland, Astr. Nachr., 188, pp. 131-134, 1911.

1912 IV 1

265 E. W. Barlow, Engl. Mech., 95, pp. 275-276, 1912.
266 F. C. Dennett, Engl. Mech., 95, pp. 275-276, 1912.
267 G. Hauët, in Em. T., Bull. Soc. Astr. Fr., 26, pp. 248-251, 1912.
268 Th. Leroy, in Em. T., Bull. Soc. Astr. Fr., 26, p. 248-251, 1912.
269 L. Libert, Bull. Soc. Astr. Fr., 26, p. 284, 1912.
270 J. Péneau, in Em. T., Bull. Soc. Astr. Fr., 26, pp. 248-251, 1912.
271 H. Rey, Bull. Soc. Astr. Fr., 26, p. 284, 1912.
272 J. van der Bilt, Astr. Nachr., 194, pp. 47-48, 1913.

1913 III 21

273 W. Ball, Engl. Mech., 97, p. 331, 1913.
274 E. E. Barnard, Pop. Astr., 21, pp. 277-278, 1913.
275 A. S. Flint, Pop. Astr., 22, pp. 425-427, 1914.
276 E. Gray, Pop. Astr., 21, pp. 276-277, 1913.
277 G. Jackson, Bull. Soc. Astr. Fr., 27, p. 262, 1913.
278 H. P. Newton, Pop. Astr., 21, p. 376, 1913.
279 Pargoire, Bull. Soc. Astr. Fr., 27, p. 262, 1913.

1913 IX 14

280 H. A. Kuyper, Bull. Soc. Astr. Fr., 27, p. 512, 1913.
281 J. J. Schafer, Pop. Astr., 21, pp. 651-652, 1913.

1914 III 11

282 N. Cordier, in (T.), Bull. Soc. Astr. Fr., 28, pp. 234-238, 1914.
283 Leboeuf et Chofardet, in (T.), Bull. Soc. Astr. Fr., 28, pp. 234-238, 1914.
284 G. F. Nolte, Pop. Astr., 22, p. 372, 1914.
285 J. J. Schafer, Pop. Astr., 22, pp. 253-254, 1914.
286 G. Tramblay, in (T.), Bull. Soc. Astr. Fr., 28, pp. 234-238, 1914.

1917 I 7

287 W. F. A. Ellison, Engl. Mech., 105, p. 10, 1917.
288 J. C. Prior, Journ. Brit. Astr. Assoc., 27, pp. 119-120. 1917.

1917 VII 4

289 J. Ellsworth, Bull. Soc. Astr. Fr., 31, pp. 294-300, 1917.
290 L. Grabowski, Astr. Nachr., 205, pp. 128-139, 1917.
291 A. Nodon, C. R., 165, pp. 176-177, 1917.
292 A. dePaolis, Bull. Soc. Astr. Fr., 31, pp. 330-333, 1917.
293 H. Rey, Bull. Soc. Astr. Fr., 31, pp. 294-300, 1917.
294 J. Weber, Astr. Nachr., 205, pp. 133-134, 1917.

1917 XII 27

295 C. A. Reichelt, Mo. Weath. Rev., 45, pp. 575-576, 1917.

1919 XI 7

296 A. Fock, Astr. Nachr., 210, pp. 293-294, 1919-20.
297 Quénisset, Bull. Soc. Astr. Fr., 33, pp. 522-523, 1919.

1920 V 2

298 C. O. Bartrum, Journ. Brit. Astr. Assoc., 30, pp. 250-252, 1919-20.
299 H. Bougourd, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
300 P. Chouard, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
301 E. Geneslay, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
302 M. Hauptmann, Revue du Ciel, p. 870, 1920, July; Ciel et Terre, 38, pp. 121-123, 1922.
303 J. L. Herzog, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
304 Hestin, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
305 A. Perse, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
306 G. Raymond, Bull. Soc. Astr. Fr., 34, pp. 262-263, 1920.
307 D. Roguet, in E. T., Bull. Soc. Astr. Fr., 34, pp. 249-263, 1920.
308 F. de Roy, Ciel et Terre, 36, pp. 126-127, 1920.

1920 X 26

309 R. A. McIntosh, Engl. Mech., 112, p. 266, 1921.
310 G. E. B. Stephenson, Journ. Brit. Astr. Assoc., 31, pp. 63-64, 1920-1.
311 H. G. Tomkins, Journ. Brit. Astr. Assoc., 31, pp. 108-109, 1920-21.

1921 IV 21

312 O. Blundell, Journ. Brit. Astr. Assoc., 31, p. 333, 1920-1.
313 L. Sanner, Bull. Soc. Astr. Fr., 36, pp. 15-16, 1921.

1921 X 16

314 R. Croste, Bull. Soc. Astr. Fr., 36, pp. 31-40, 1922.
315 A. C. Curtis, Engl. Mech., 114, p. 168, 1921.
316 L. Fabry, C. R., 173, pp. 687-688, 1921.
317 L. Grabowski, Astr. Nachr., 215, p. 247, 1921-2.
318 M. Hauptmann, Revue du Ciel, pp. 1198- . . . . , 1921; Ciel et Terre, 38, pp. 123-126, 1922.
319 M. B. B. Heath, Engl. Mech., 114, p. 168, 1921.

320 M. Honnorat, Bull. Soc. Astr. Fr., 36, pp. 31-40, 1922.
321 J. Lagarrigue, Bull. Soc. Astr. Fr., 36, pp. 31-40, 1922.
322 B. Meyermann, Astr. Nachr., 215, pp. 34-35, 1921-2.
323 J. Trarieux, Bull. Soc. Astr. Fr., 36, pp. 31-40, 1922.
324 J. Vetter, Bull. Soc. Astr. Fr., 36, pp. 31-40, 1922.

TABLE 8.—*References on the Photometry of Lunar Eclipses*

1863 VI 1	G. B. Airy, Mo. Not. Roy. Astr. Soc., 24, p. 67, 1863-4. Extra-focal (short-sight) images of stars.
1863 VI 1	C. Flammarion, Popular Astronomy, p. 187. Comparison with stars.
1870 VII 12	C. Flammarion, Popular Astronomy, p. 187. Comparison with stars.
1877 VIII 23	J. J. Plummer, Observatory, 1, pp. 197-199, 1877. Rumford photometer and candle.
1884 X 4	G. L. Tupman, Mo. Not. Roy. Astr. Soc., 45, pp. 41-42, 1884-5. Comparison with stars.
1888 I 28	Dorst, Sirius, 21, pp. 241-242, 1888. Comparison with stars.
1888 I 28	C. Flammarion, Popular Astronomy, p. 188. Comparison with stars.
1888 I 28	E. C. Pickering, Ann. Harv. Coll. Obs., 18, pp. 73-83. Photographic.
1888 I 28	G. Tramblay, L'Astronomie, 7, pp. 103-106, 1888. Comparison with stars.
1888 I 28	W. G. B., Engl. Mech., 46, p. 554, 1888. Extra-focal (short-sight) images of stars.
1888 VII 22	E. S. Holden, Publ. Lick Obs., 4, pp. 107-121, 1891. Lines of equal illumination traced in focal plane of 36-inch.
1891 XI 15	W. H. Pickering, Ann. Harv. Coll. Obs., 32, pp. 255-256. Photographic.
1891 XI 15	Safarik, Astr. Nachr., 129, pp. 397-400, 1892. Extra-focal (short-sight) images of stars.
1895 IX 3	F. W. Very, Astrophys. Journ., 2, pp. 293-305, 1895. Special photometer.
1898 XII 27	G. W. Hough, Science, 10, p. 794, 1899. Photographic.
1898 XII 27	W. Láska, Astr. Nachr., 149, pp. 137-140, 1899. Extra-focal (short-sight) images of stars.
1898 XII 27	W. H. Pickering, Ann. Harv. Astr. Obs., 32, pp. 256. Photographic.
1903 IV 11	Ruhmer, Weltall, 3, pp. 200-202, 1902-3. Selenium cells.
1910 XI 16	J. Elster u. H. Geitel, Phys. Ztschr., 11, pp. 1212-1214, 1910. Photoelectric cell.
1921 X 16	A. Danjon, C. R., 173, pp. 706-708, 1921. Special polarizing photometer.
1921 X 16	J. Hopmann, Astr. Nachr., 215, pp. 269-274, 1921-22. Special photometer.

TABLE 9.—*References on the Spectroscopy of Lunar Eclipses*

1865 IV 11	W. Huggins, Astr. Reg., 3, pp. 169-170, 1865. " Spectroscope."
1865 X 4	College Romaine, Les Mondes, 10, pp. 183-184, 1866. " Spectrum."
1866 III 30	A. Poey, C. R., 63, pp. 353-357, 1866. " Spectrum."
1867 IX 13	Chacornac, C. R., 65, pp. 501-502, 1867. " Spectroscope."
1870 VII 12	J. Browning, Student and Intellectual Observer, 5, p. 368, 1871. 12 inch and spectroscope.
1876 IX 3	A. T. Arcimis, Mo. Not. Roy. Astr. Soc., 37, pp. 12-13, 1876. 4 inch and spectroscope.
1877 II 27	J. Rand-Capron, Engl. Mech., 25, p. 64, 1877. 3¼ inch and d. v. spectroscope.
1877 II 27	N. v. Konkoly, Observatory, 1, p. 370, 1877. 4 inch and 5-prism d. v. spectroscope.
1877 VIII 3	M. Ashley, Observatory, 1, p. 177, 1877. 3¼ inch and McLean star spectroscope.
1877 VIII 23	J. Rand-Capron, Observatory, 1, pp. 216-218, 1877.
1877 VIII 23	W. H. M. Christie and E. W. Maunder, Mo. Not. R. Astr. Soc., 37, pp. 469-470, 1877. Greenwich equatorial and 1-prism spectroscope.
1878 VIII 12	E. W. Maunder, Mo. Not. Roy. Astr. Soc., 38, pp. 514-525, 1878. Greenwich equatorial and 1-prism spectroscope.
1880 VI 22	H. C. Russell, Observatory, 3, pp. 565-568, 1879-80. 11½ inch, spectroscope with measuring appliances.
1884 X 4	C. Trépied, C. R., 99, pp. 562-563, 1884. 25 cm. and d. v. spectroscope.
1887 VIII 3	G. Rayet, C. R., 105, p. 305, 1887. 38 cm. and 3-prism spectroscope.
1888 I 28	Copeland, Observatory, 11, pp. 157-158, 1888. " Spectroscope."
1888 I 28	S. J. Perry, Mo. Not. Roy. Astr. Soc., 48, pp. 276-279, 1888. Spectroscope with 1 or 2 prisms.
1888 I 28	C. Piazzi-Smyth, Observatory, 11, pp. 157-158, 1888. " Spectroscope."
1888 I 28	C. Trépied, C. R., 106, pp. 408-409, 1888. 50 cm., 1-prism spectroscope.
1888 VII 22	J. E. Keeler, Publ. Lick Obs., 4, pp. 115-116, 1891. 12 inch and 5-prism d. v. spectroscope.
1889 VII 12	A. Riccò, Mem. Soc. Spett. Ital., 18, pp. 151-152, 1889. " Spettroscopio registratore."
1891 XI 15	A. Riccò, Mem. Soc. Spett. Ital., 20, p. 176, 1891. 6.5 cm., McLean star spectroscope.
1895 III 10	A. F. Miller, Trans. Astr. and Phys. Soc. Toronto, 6, pp. 20-23, 1895. 4 inch and d. v. spectroscope.

1895 IX 3 A. F. Miller, Trans. Astr. and Phys. Soc. Toronto, 6, pp. 93-94, 1895.
4 inch and d. v. spectroscope.

1914 III 11 V. M. Slipher, Astr. Nachr., 199, pp. 103-104, 1914.
Spectrophotograph.

TABLE 10.—*List of Periodicals Consulted*

Ind. = General index to volumes indicated;
v. = Indices of individual volumes as indicated.

Annual Encyclopedia		v. 1861–1868
Archives des Sciences (Bibliothèque Universelle)		v. 1859–1879
Astronomische Nachrichten	Ind. 41–150	v. 151–217
Astronomische Rundschau		v. 1–10
L'Astronomie		v. 1–13
Astronomical Journal		v. 1–32
Astronomical Register	Ind. 1–20	v. 21–24
Astronomy and Astrophysics	Ind. 1–3	
Astrophysical Journal	Ind. 1–25	
Boletino de la Sociedad Astronomica de Mexico		v. 1–13
Bulletin Astronomique		v. 1–31, n. s. v. 1–2
Bulletin de la Société Astronomique de France		v. 1–36
Bulletin de la Société Belge d'Astronomie		v. 1–10, 15–21
Ciel et Terre		v. 1–38
Comptes Rendus	Ind. 32–121	v. 122–175
Copernicus		v. 2–3
Cosmos		v. 18–25, (2) 1–7
English Mechanic		v. 6–116
Fortschritte der Physik, (especially III)		v. 16–74
Heis Wochenschrift für Astronomie u. s. w.		v. 1–11, n. f. 1–8
Himmel und Erde		v. 1–26
Jahresbericht der Astronomischen Gesellschaft		v. 1–17
Journal of the British Astronomical Association	Ind. 1–17	v. 18–32
Kleins Jahrbuch		v. 1–23
Memorie della Societa degli Spettroscopisti Italiani		v. 1–2, 5–39, n. s. 1, 2, 5
Monthly Notices of the Royal Astronomical Society,	Ind. 20–70	v. 71–82
Les Mondes		v. 1–31
Nature		v. 1–110
La Nature	Ind. 1873–1912	v. 1913–1921
Observatory		v. 1–45
Popular Astronomy	Ind. 1–16	v. 17–29
Publications of the Astronomical Society of the Pacific,	Ind. 1–25	v. 26–32

Recreative Science; The Intellectual Observer; The Student and Intellectual Observer of Science.....v. 1859–1871
Revista di Astronomia, etc.,.....v. 1–7
Revista do Observatorio.....v. 1–6
Royal Society of Canada, Journal.....v. 1–16
Sidereal Messenger .....Ind. 1–11
Sirius .....v. 8–55
Transactions of the Astronomical and Physical Society of Toronto .....v. 1890–1901
Vierteljahresschrift der Astronomischen Gesellschaft. Indices through 1921 .....
Das Weltall .....v. 1-22