sequence of all this is that the duration of totality in a series of eclipses varies slowly from one eclipse to the next, and that we have a series of total eclipses, or of annular eclipses. If the period of rotation of the lunar apse were twelve years instead of nine years, annular and total eclipses would alternate. It might be noted here that as a result of the moon returning to approximately the same distance from the earth after a Saros, its parallax is only slightly altered, and so the eclipse limits only slightly altered.

Let us now consider the series of eclipses to which that of June 29 of this year belongs. At the new moon of May 26, 1873, the central line from the sun to the moon passed just north of the earth and there was a large partial eclipse near the north pole. If we work backwards from this date at intervals of 18 years and 10 or 11 days, we find a series of decreasing partial eclipses near the north pole. Going forwards, we find that on June 6, 1891, the central line passed over the north pole but came to earth in northern Asia, producing an eclipse at midnight. This was an annular eclipse very nearly total, and was the first central eclipse of the series to which the eclipse of this year belongs. Eighteen years later, on June 17, 1909, there was an eclipse which crossed the earth near the pole. This eclipse was just total, although it was scarcely certain beforehand that it would be so. We then come to the total eclipse of this year. Proceeding onwards, we get a series of eclipses gradually lengthening in duration and working equatorwards, while the longitude on the earth where the eclipse takes place moves about 120° westward from each eclipse to the next.

The "Nautical Almanac" gave the semi-diameters of the sun and moon as seen from the centre of

the earth for the eclipses of 1891, 1909, and 1927 as follows :

		Moon.	Sun.
1891 June 6	.	15' 42".2	15' 47".5
1909 June 17	.	43".1	44".3
1927 June 29	.	46".7	44".0

These figures indicate the way in which the apparent diameter of the moon is gradually increasing relative to that of the sun. Also on the eclipse track the apparent diameter of the moon must be larger than from the earth's centre, so that the total eclipses of this series will be steadily lengthening.

The following table indicates the change of position of the point on the earth where central eclipse occurs at noon, for a few eclipses belonging to the series of the eclipse of this year. The longitudes are measured towards the east. It will be seen that the track moves about 8° southward each year and a little more than 100° in longitude. After two hundred years, when the track is near the equator, the movement is about 5° southward and 120° westward each year.

	Longitude E.	Latitude.
1909 June 17	. 187°	+ 88°
1927 June 29	. 84	+ 78
1945 July 9	. 340	+ 70
1963 July 20	. 234	+ 62
1981 July 31	. 127	+ 54
1999 Aug. 11	. 18	+ 46
.....		
2107 Oct. 16	. 39	+ 2
2125 Oct. 26	. 276	- 4
2145 Nov. 7	. 150	- 9
2161 Nov. 17	. 23	- 14

The map (Fig. 1) shows the track of the approximate central line for the eclipses of 1927, 1945, 1963, 1981, 1999, 2017, and 2125, 2143, 2161. In each case the eclipse begins at the western end of its track at sunrise and finishes at the eastern end at sunset.

Future Total Solar Eclipses in the British Isles.

By Dr. A. C. D. CROMMELIN.

AN article by Dr. W. J. S. Lockyer in NATURE for Jan. 15 last described and illustrated the total solar eclipses in the British Isles from A.D. 878 to A.D. 1999. The present article continues this investigation for another thousand years. In view of the very long interval of two centuries that has elapsed since there has been a British totality, it is interesting to determine the average interval between these events. Mr. J. Maguire's list, used by Dr. Lockyer, has a few omissions. I therefore had recourse to the maps in Oppolzer's Canon of Eclipses. These indicate

63 British totalities in 3370 years (1208 B.C. to A.D. 2161), or 19 in a thousand years, giving an average interval of 54 years between totalities. I am aware that the maps in the Canon show the tracks as circular arcs not quite agreeing with the true ones, but for statistical purposes this is of no importance; we clearly gain as many as we lose by the distortion.

As a check I find that Otto Schrader gives 21 eclipses as total in the British Isles in the period A.D. 2133 to A.D. 3045. Four of these are doubtful; the central line lying outside these islands: giving

these half weight, we have 19 in 900 years, or 21 in a thousand years. So we are safe in concluding that the average number in a thousand years is 19 or 20, giving an average interval of 53 years. I have here included the Shetlands in the British Isles. If we exclude them (they were not included in Dr. Lockyer's map, reproduced in Fig. 1) we may take the average interval as about 58 years.

If instead of a large area we consider a point on the earth's surface, we have on the average 3 total

and spread out at another in a manner that recalls the service of tram-cars. The blank period of 203 years that is now ending is the longest between A.D. 800 and A.D. 3100. The gap between A.D. 2200 and A.D. 2381 comes second, and that between A.D. 1433 and A.D. 1598 third.

On the other hand, the most striking example of bunching is between A.D. 2081 and A.D. 2200; we have here seven certain totalities and two others that are likely to reach the shores of Great Britain within 119 years.

The following are the data from which the tracks in the accompanying map (Fig. 2) were laid down:

(1) For the period A.D. 2000 to A.D. 2161 they are from my own calculations, using the elements in Oppolzer's Canon.

(2) For A.D. 2189 from my own calculations, using Hansen's tables of the moon and Newcomb's of the sun. This eclipse was inadvertently omitted by Schrader.

(3) From A.D. 2200 to the end from Otto Schrader, "Die bedeutenden Sonnenfinsternisse und die grossen Mondfinsternisse für Mittel-Europa" (P. Stankiewicz, Berlin, 1913).

It is to be remembered that the lunar tables used by Oppolzer omit many small terms; consequently the eclipse tracks calculated from them are uncertain by about 25 miles at the present time; and since the accelerations used in them differ considerably from those now accepted, the uncertainty becomes markedly greater after an interval of

eclipses, 4 annular ones, and nearly 400 partial ones visible there in 1000 years. But we should have to take several thousands of years to make the average numbers for totality and annularity correct. In shorter periods we find some striking anomalies; thus a small region in Scotland round the point $3^{\circ} 40' W.$, $55^{\circ} 30' N.$, will have three totalities all under favourable conditions within 61 years (A.D. 2381, 2426, and 2442). Also, the grouping of totalities in the British Isles as a whole is much less regular than we might expect as a result of three such uniform motions as the rotation and revolution of the earth and the revolution of the moon. They bunch at one epoch

several centuries either in the past or the future. I understand that the tables used by Schrader are simply an extension of Oppolzer's, so they are subject to similar uncertainty, and tracks several centuries ahead can only be taken as approximate.

A few notes follow on some of the eclipses the central lines of which are shown on the map. The eclipse of A.D. 2081 is a return after seven Saroses of the Philippine Islands' eclipse of 1955, which has the remarkable duration of totality of $7^m 6^s$. If Oppolzer's data are accurate totality should reach the Lizard. Although the central line in A.D. 2090 is some distance from the shores of the British Isles, the track is so wide through foreshortening

FIG. 1.

that the shadow will reach the south-west coast. In A.D. 2142, totality may reach Dungeness. In A.D. 2151, Oppolzer's elements would give totality in London, but those of Hind, Maguire, and Johnson do not; their tracks are farther north. The eclipses of A.D. 2381, 2681, and 2726 are remarkable for long totalities. The latter seems to be a record for Europe, reaching 6 minutes. The Lizard will probably be within the shadow; the Channel Islands certainly will.

The following table gives the dates of all total eclipses that may reach the shores of the British Isles, the approximate hour, the sun's altitude and the duration on the central line. I have diminished the durations given by Oppolzer's and Schrader's elements by 0.2^m, since they use too large a diameter for the moon.

Date.	Hour.	Sun's alt.	Dur.
2081 Sept. 3	7 A.M.	18°	3.5 ^m
2090 Sept. 23	5 P.M.	6	2.8
2133 June 3	9 A.M.	40	3.5
2135 Oct. 7	8 A.M.	7	2.7
2142 May 25	9 A.M.	43	2.9
2151 June 14	6 P.M.	15	2.6
2160 June 4	6 P.M.	22	2.1
2189 Nov. 8	8 A.M.	8	2.5
2200 April 14	5 P.M.	17	0.4
2381 July 22	10 A.M.	48	5.0
2426 Sept. 2	8 A.M.	25	3.9
2442 April 11	9 A.M.	33	1.7
2545 April 12	5 P.M.	15	0.2
2600 May 5	6 A.M.	12	2.7
2681 June 8	2 P.M.	50	4.5
2726 July 21	11 A.M.	58	5.7
2808 Aug. 13	6 A.M.	8	0.3
2817 Sept. 2	4 P.M.	21	0.9
2864 Feb. 28	1 P.M.	29	2.8
2911 Aug. 15	2 P.M.	37	3.0
2927 Mar. 24	2 P.M.	31	3.0
2972 May 4	3 P.M.	37	3.8
2974 Sept. 7	1 P.M.	35	4.1

The central lines of 2081, 2090, 2726 pass respectively 70, 140, and 93 miles south of the Lizard; that of 2974 passes 44 miles north-east of Unst (Shetlands).

In the above list the eclipses of A.D. 2081, 2135, and 2189 illustrate the triple Saros; those of A.D. 2133, 2151, and 2142, 2160 the simple Saros; those of A.D. 2864, 2972 the sixfold Saros: the

intermediate eclipse in 2918 passes north of the Shetlands. Those of A.D. 2081, 2381, and 2681, also A.D. 2142, 2442, also A.D. 2426, 2726, illustrate the 300-year cycle: those of A.D. 2160, 2681 illustrate the 521-year cycle.

Taking the present list and Dr. Lockyer's together, there are two examples of a 2-year interval

FIG. 2.

between British totalities: A.D. 2133, 2135, and A.D. 2972, 2974; three of a 7-year interval: A.D. 878, 885, and A.D. 1133, 1140, and A.D. 2135, 2142; six of a 9-year interval: A.D. 1424, 1433, and A.D. 1715, 1724, and A.D. 2081, 2090, and A.D. 2133, 2142, and A.D. 2151, 2160, and A.D. 2808, 2817.

Meteorological Conditions in Relation to Eclipse Observations.

By R. CORLESS.

THE eclipse of the sun which will occur at about 5 h. 23 m. G.M.T. (6.23 A.M. summer time) on June 29 will appear total to observers stationed upon a strip of country 28 or 29 miles wide, of which the central line stretches from

Criccieth in North Wales to Hartlepool in Durham. The character of the country included in this strip is very varied. There are coastal areas on the Lleyen Peninsula and North Wales, in Lancashire and between Sunderland and Salt-