"An Analysis of the Results from the Falmouth Magnetograms on 'Quiet' Days during the Twelve Years 1891 to 1902." By CHARLES CHREE, Sc.D., LL.D., F.R.S., Superintendent of the Observatory Department of the National Physical Laboratory. Received November 23,—Read December 15, 1904.

(From the National Physical Laboratory.)

(Abstract.)

The paper contains an analysis and discussion of the results obtained from the declination and horizontal force magnetograms at Falmouth on quiet days from 1891, when the records commenced, until 1902. The discussion proceeds on parallel lines to those followed in dealing with the corresponding Kew* data for 1890 to 1900, and a comparison is instituted in many cases between Kew and Falmouth results.

The total secular changes of declination from 1891 to 1900 at Kew and Falmouth were identical, and the changes from year to year were closely alike. In horizontal force the annual changes recorded at the two stations did not agree so closely, and on the average the change at Falmouth was somewhat the greater.

When discussing the "non-cyclic effect" in the diurnal variation of the declination at Kew, it was pointed out that though so small and irregular as to be possibly attributable to accident, it yet presented features suggestive of a true physical origin. Though differences exist between the phenomena at Kew and Falmouth, still the points of agreement are such as to give strong support to the view that the phenomenon is not accidental.

The data considered being the means from the five selected quiet days a month, out of the 120 months in the 10 years 1891 to 1900 common to the two investigations, there is agreement of sign in the non-cyclic effects at Kew and Falmouth in 69 cases and disagreement in only 22, the effect being nil at one or both stations in the remaining 29 cases. Also at both places the sign of the non-cyclic effect, though prevailingly positive throughout the year, is distinctly negative near midsummer, and the seasonal variations in the two cases are fairly alike.

In horizontal force the non-cyclic effects at Kew and Falmouth are large and closely alike. From 1891 to 1900 there were only 5 months in which the non-cyclic effects differed in sign, as against 99 in which they agreed, and the mean values of the effects at the two stations differed by only about 5 per cent. of the mean value at Kew.

Whilst the mean daily range of temperature at Falmouth—a seaside station—is notably less than at Kew, the daily ranges of declination at

* 'Phil. Trans.,' A, vol. 202, p. 335.

the two places are as nearly as possible equal, and the daily range of horizontal force is somewhat larger at Falmouth.

The annual variation of temperature range is again notably less at Falmouth than at Kew, the winter range at the former station being relatively high, and the summer range low. There is in this case a somewhat analogous state of matters in magnetics, the difference between the diurnal ranges at midsummer and midwinter being relatively less at Falmouth than at Kew, but the phenomenon is less marked than in temperature.

Analysing the diurnal inequality of temperature into harmonic terms of 24, 12 and 8-hour periods, General Strachey* found that the local time of occurrence of the maxima was distinctly earlier at Kew than at Falmouth, the difference being greatest for the 24-hour term, for which it amounted to nearly an hour. When the declination and horizontal force diurnal inequalities are similarly analysed, the local times of occurrence of the maxima are so nearly alike at the two stations that it is impossible to say with certainty which is the earlier. If a difference exists, it is of the order of only one or two minutes of time.

This last result applies to the average year of a sun-spot cycle. It has already been found that the time of occurrence of the first maximum in the 24, 12 and 8-hour terms at Kew varies with sun-spot frequency, being later in years when spots are numerous than when they are few. Thus the sun-spot maximum period 1892 to 1895, as compared to the sun-spot minimum period 1890, 1899 and 1900, showed a retardation of $15\frac{1}{2}$ minutes in the time of occurrence of the maximum in the 24-hour term. The phenomena at Falmouth are closely similar, the retardation in the 24-hour wave in the period 1892 to 1895, as compared to the sun-spot minimum period 1899 to 1902, amounting to 14 minutes.

When the annual variations in the amplitudes of the daily ranges in declination and horizontal force at Kew, and of the 24, 12 and 8-hour terms in the diurnal inequality, were expressed as Fourier series, with an annual and a semi-annual term, there proved to be a remarkably close agreement between the dates of occurrence of maximum in the annual terms, and also in those of the semi-annual terms for the several elements. The same phenomenon appears at Falmouth, and there proves, moreover, to be a remarkably close agreement between corresponding Kew and Falmouth dates. Thus taking for both declination and horizontal force the three most important quantities considered, viz., the amplitudes of the diurnal ranges and of the 24-hour term in the diurnal inequality, and the sum of the 24 hourly differences from the mean for the day, and considering both the annual and semi-annual terms, we have 12 dates for the occurrence of the first maximum at

* 'Phil. Trans.' for 1893.

Kew and at Falmouth. Of the differences between these 12 pairs of dates only three were as large as 2 days, and the mean of the differences taken algebraically was only about 2 hours. The agreement in short was well within the limits of probable error.

This result again applies to the average year of a sun-spot cycle. Comparing Falmouth results from the two periods, 1892 to 1895 and 1899 to 1902, it was found that a small but decided difference existed between the dates of occurrence of the maximum in the annual terms in both declination and horizontal force, and in the semi-annual term in declination. The dates proved to be *accelerated* in the sun-spot maximum period as compared to the sun-spot minimum period. To make certain that the result was not peculiar to Falmouth, a similar comparison was instituted between the Kew data for the two periods 1892 to 1895 and 1890, 1899 and 1900. The results were closely similar to those obtained at Falmouth. Thus the average results for the acceleration in the sun-spot maximum as compared to the sun-spot minimum period from the ranges, the 24 differences from the mean, and the 24-hour term in the diurnal inequality, were as follows:—

	Annual term.		Semi-annual term.
	Declination.	Horizontal force.	Declination.
Falmouth	3·5 days.	11·1 days.	6·4 days.
Kew	3·4 ,,	10·3 ,,	7·0 ,,

The phenomenon emphasises the importance of employing contemporaneous data when comparing two stations.

Applying Wolf's formula $R = a + bS$, associating the range R of a magnetic element with sun-spot frequency S, results are obtained for the variation of b and b/a throughout the year at Falmouth very similar in character to those previously obtained for Kew. On the whole the Falmouth values of b/a are distinctly the higher, *i.e.*, sun-spot influence is greater at Falmouth than at Kew.

Taking the above formula, but making S represent not merely Wolfer's sun-spot frequency, but in turn the areas of whole sun-spots, umbræ and faculæ as observed at Greenwich, Mauritius, and Dehra Dun, and given by the Astronomer Royal in the 'Monthly Notices of the Royal Astronomical Society,' values are calculated for a and b in the case when R represents the range of declination or horizontal force in the mean diurnal inequality for the year. A comparison is then instituted between the ranges for individual years of the 12-year period as calculated from the values of a and b thus found, and the Astronomer Royal's mean yearly data on the one hand, and as actually

observed on the other. When S represents areas of whole sun-spots or of umbræ, the agreement between observed and calculated ranges is nearly though not quite as good, especially in horizontal force, as when S represents Wolfer's sun-spot frequencies; but when S represents areas of faculæ the agreement is much inferior, especially in years of sun-spot maximum. The mean differences between the ranges calculated from Wolfer's frequencies, and from either the spot areas or the umbræ is considerably less than between any one of the three sets of calculated ranges and the observed ranges. Also the differences between the observed ranges and those calculated from Wolfer's frequencies nearly always possess the same sign at Kew and Falmouth.

Both phenomena point to the conclusion that the differences between observed magnetic ranges at individual stations, and those calculated from any of the above measures of solar disturbance, though small, cannot be regarded as wholly fortuitous.

"The Effect of Liquid Air Temperatures on the Mechanical and other Properties of Iron and its Alloys." By Sir JAMES DEWAR, F.R.S., Hon. M.I.C.E., and ROBERT ABBOTT HADFIELD, M.I.C.E., President elect Iron and Steel Institute. Received November 24,—Read December 8, 1904.

As many iron alloys have shown anomalous results in their physical behaviour at ordinary temperatures, it became advisable to ascertain the exact effect of very low temperatures upon such bodies, and, accordingly, a series of tests were carried out on standard iron and iron alloyed with other elements, the specimens being selected from a large collection made by one of the authors, which is located at the Hecla Works, Sheffield. In the course of the enquiry some 500 specimens have been examined, and the detailed description of each test will appear later on in a special Monograph. In the meantime the more important results are submitted to the Royal Society.

For the purpose of the experiments, the irons were taken in the form of forged bars, and the iron alloys in the form of cast ingots $2\frac{1}{2}$ inches square. They were then carefully heated to the required forging temperatures and reduced to rods $\frac{1}{4}$-inch diameter, and from these rods finished test-bars 0·180 inch diameter were accurately machined to the following sketch :—