DISCUSSION

A NEWLY DISCOVERED PERIODICITY OF 16 MONTHS IN THE SUN'S WAVE RADIATION

IN Volume 6 of the *Annals* of the Smithsonian Astrophysical Observatory we disclosed 14 regular periodicities. Their summation, as plotted in Fig. 14 of *Annals* 6, makes up very nearly exactly the variations of the sun's emission of radiation, so far as such variation appears in monthly mean values of the "solar constant" of radiation. All these 14 periods are approximately aliquot parts of 273 months, or $22\frac{3}{4}$ years. This is approximately double the length of the sunspot cycle, and corresponds to Hale's magnetic cycle in sunspots, as well as to a period found by meteorologists in weather, and by Douglass in widths of tree rings.

Many meteorologists, and notably Clayton, have made use of the variation of sunspot numbers, or of sunspot areas, as a supposed measure of solar variation. Strangely, however, we could find no sure indication of a periodicity approximating 11.3 years in the variation of the solar constant of radiation. We so stated in Volume 6 of the *Annals*. Several persons have brought this curious absence of a period of $\frac{273}{2}$ months to my attention. Some have even reflected a little on the accuracy of our more recent solar constant measurements, because the sun-spot period of variation does not seem to appear in them. That period was indeed reported in our Mount Wilson work in the *Annals,* Volume 4, but possibly those indications may have been caused by changes in sky transparency at Mount Wilson. We now occupy at Montezuma, Chile, a much better station than Mount Wilson as regards sky conditions, and have improved our methods of observing. We can not willingly adopt this deprecatory view of our recent work, which comprises nearly 20,000 solar constant values, made under fine conditions.

The matter was brought sharply to my attention by Dr. Schell, of Harvard University, on April 4. Since then Mr. Aldrich, acting director of the Astrophysical Observatory, and others of his staff, have been more carefully searching our solar constant results for some vestige of an 11.3-year periodicity. A paper on their findings will probably issue later.

It occurred to me that a study of the column headed "D" or "B–C" of Table 32 of Volume 6 of the *Annals* ought to reveal the 11.3-year period, if existing. This column gives the residuals remaining when the observed monthly mean values of the solar constant are subtracted from the monthly summations of the 14 known periodicities above referred to.

As a measure tending to eliminate accidental errors of observation, I first computed 5-month running means of the column "D." By adding to the values given in *Annals* 6, results of more recent work, as yet unpublished, I had somewhat more than two complete 11.3-year cycles. The earlier work, 1920 to 1930, yielded a fairly definite indication in these data of a cycle of about 11.3-years, indicating a minimum of the solar constant due to sunspots about the year 1925 or 1926. The amplitude of this cycle is not quite 0.1 per cent. of the solar constant. A second group of smoothed values, of the years 1931 to 1941, was partly of the same trend as the first, but at the latter end inconsistent. However, conclusions should be reserved until the publication of the investigation which Mr. Aldrich and his assistants are now making.

It will be asked by some: If only a trifling (1/10 per cent.) indication of the influence of the sunspot cycle, which has an amplitude of over 100 sunspot numbers, is found in the variation of the sun's output of radiation, how is it that well-recognized meteorological changes are closely in correlation with small sunspot variations? I suggest: It is well known that the sun, like a machine gun, especially in sunspots, bombards the earth, and probably all space, with electric ions. These objects, encountering the earth's atmosphere, further ionize it. Electric charges, as well known for nearly a century, act as centers for the agglomeration of dust and water particles. Thus increased solar activity in the nature of ionic discharges tends to increase haze and cloudiness in the earth's atmosphere. Such obstructions would absorb solar radiation. Thus the atmosphere would be heated when solar bombardments increase. Other meteorological consequences would naturally follow. Again, it may be that 11.3-year periodic fluctuations of the sun's extreme ultra-violet radiation, cut off by ozone in the upper atmosphere, may be many times 1/10 per cent. In such ways the sunspot cycle, and its details of sunspot variation, might have meteorological importance, without being associated with considerable fluctuations of the sun's total output of wave radiation.

But this is not the subject announced in my title. When I had smoothed the residual values "D," or "B–C," of Table 32 of *Annals* 6, and had plotted the 5-month running means, I perceived a saw-tooth appearance of great regularity. It seemed to have about

15 months period. I tabulated the values by successive lines of 15 months in length, and took means. The means of the columns indicated an irregular periodic fluctuation of about 0.0005 calorie in amplitude. As all the 14 periodicities enumerated in Table 31 of *Annals* 6 are nearly aliquot parts of 273 months, I thought it would be better to retabulate the values for a period of $\frac{273}{18}$ or 15.2 months. The resulting curve of this period was smoother than that for 15.0 months, and had a slightly larger amplitude. It then occurred to me to try a period of $\frac{273}{17}$, or approximately 16.0 months. And now I obtained the following series of mean values of the tabulation. The numbers below are given in units of $\frac{1}{10,000}$ calorie.

Month	1	2	3	4	5	6
Values	−62	−74	−74	−118	−158	−154
Month	7	8	9	10	11	12
Values	−180	−162	−144	−92	−70	−44
Month	13	14	15	16		
Values	−14	+40	+48	+13		

This defines a curve, which, as the reader may see by plotting the values, is very smooth, has its maximum at month 15, which corresponds to June, 1921, and minimum at month 7, which corresponds to November, 1920.

I have recomputed the 16-month period from unsmoothed values of the residuals "D." A slightly different and less perfect curve of about the same amplitude resulted. Recalling that "D" stands for *synthetic minus observed* solar constant values, and giving partial weight to the phases found in computations from unsmoothed data, I now set the initial dates of maximum and of minimum of the solar constant for the 16-month periodicity at October, 1920, and May, 1921, respectively. The amplitude, 0.00228 calorie, is 0.12 per cent. of the solar constant. This amplitude gives the new 16-month periodicity a standing of 1.7 times the importance of the periodicity of 9.79 months, and 1.3 times the importance of the periodicity of 8⅛ months, as they are listed in Table 31, *Annals* 6.

C. G. Abbot

Smithsonian Institution

QUININE FROM REMIJIA BARK

A report on cinchona exploration in South America recently appeared in your columns.[1] In this, surprise was expressed at finding in the bark of *Remijia pedunculata* "up to 3 per cent. of quinine sulfate (*sic*) with very little admixture of other alkaloids."

I should like to direct attention to the well-documented fact that this and related species of *Remijia* have for about seventy-five years been known to be quininiferous.[2] Indeed, for several years beginning in 1879 many thousands of tons of the bark of these trees were exported to Europe for the extraction of quinine. Most went to England, some being transshipped to the Continent. F. A. Flückiger stated[3] that in 1881, out of 100,000 bales (*surons, colli*) of quinine-containing barks shipped into London, 60,000 bales of 50 kilos weight each consisted of "Cuprea Bark" (*Remijia* species), or a total for that one year alone of 3,307 tons. Of the approximately seven and a half thousand tons of bark shipped from northern South America in 1881, cuprea bark was the chief part.[4]

It appears that after several years the trade in cuprea or *Remijia* bark waned as a result of the depletion of readily available forests. Thus, in the course of a comparatively few years, little heed was paid to this once important botanical raw material until the exigencies of war have again focussed attention on it.[5]

Species of *Remijia* were introduced into India to furnish raw material to the quinine industry (Sikkim plantations, *ca.* 1888).[6]

George M. Hocking,
Chief Pharmacognosist

S. B. Penick and Company
New York, N. Y.

1 W. C. Steere, Science, n.s., 101: 177–8, 1945.

2 F. A. Flückiger, *Vorwerks Neues Jahrb. f. Pharmacie u. verwandte Fächer*, 36, 1871.

3 "The Cinchona Barks," p. 52, 1884.

4 *Ibid.*, p. 55.

5 D. Howard and J. Hodgkin, *Pharm. Jour.*, (3) 12: 578–9, 1881; *idem, Jour. Chem. Soc.*, 41: 66–8, 1882; Whiffen, *Pharm. Jour.*, (3) 12: 497, 1881; Triana, *Jour. de Pharm. et de Chim.*, (5) 5: 565–75, 1882; Arnaud, *ibid.*, (5) 5: 560–4, 1882; G. Planchon, *Jour. de Pharm. et de Chim.*, (5) 10: 329–336, 419–432, 1884; Watt's Dictionary of the Economic Products of India, II, 289–316. *ca.* 1896.

6 Watt's Dictionary of the Economic Products of India, II, pp, 314, 5.

CENTENNIAL OF WOOD'S "CLASS-BOOK OF BOTANY"[1]

The year 1870 was not only the birth year of the Dartmouth Scientific Association but also the twenty-fifth anniversary of an event closely associated with the scientific interests of Dartmouth. The year 1945 is therefore the centennial of that scientific event—the publication of the first edition of Wood's "Class-Book of Botany" at Claremont, N. H. Before the end of its usefulness, this famous text-book and manual had gone into its fiftieth edition and been sold to over a hundred thousand students.

Dartmouth has a double claim for recognition of its contribution to the development of this book—the first botany text to be approved by the American public.

1 Read at the meeting of the Dartmouth Scientific Association on March 21, 1945.