sonal contacts and emulation. As a rule, a man of few words, he produced his effect on his pupils by virtue of his example. He lived for and by work, and to those privileged to associate themselves with him he was as stimulating and instructive a master as there could be. This influence, by the very reason of its method, was a restricted one and produced its chief results among his immediate assistants in the Brigham Hospital and in the Laboratory of Surgical Research of the Harvard Medical School. Such an influence could not permeate the entire student body and though his amphitheater clinics were well attended, there were many students who failed to appreciate his historical embellishments and even avoided his exercises except when they covered the nervous system or the ductless glands, in which fields he was so obviously a leader. But within the hospital walls it was different. Here the young assistant saw and recognized at once two great attributes worthy of constant emulation. First, the perfection of his technical methods. Nowhere else could he see such exquisite handling of tissues; in no other clinics did wounds heal so kindly, nor such dangerous procedures go forward with such little difficulty, moribidity and mortality. Secondly, the pupil envisaged the perfect care of the patient; the unsparing efforts to provoke confidence and comfort; the value of thorough records and their proper use. He was taught that no detail which added either to the information about the patient or to the comfort of the patient could be neglected.

Harvey Cushing's life is ended. His great accomplishments are known wherever civilization flourishes and will pass down the ages to benefit the generations to come. He became a chief decoration of every institution he served, brought great merit to them and assisted many young men to assume a way of life certain to bring comfort and happiness to humanity. He himself would like most to be remembered as one who upheld the first tradition of our profession—let nothing be neglected that can benefit a patient! This was his "vade mecum" and made him stand out as a chief physician of his time.

THE PRESENT STATE OF SOLAR ACTIVITY AND ASSOCIATED PHENOMENA

By Dr. HARLAN T. STETSON

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THE rise in solar activity recently reported in SCIENCE[1] has been accompanied by changes in the electrical state of the earth's atmosphere made evident by numerous displays of aurorae and ionospheric disturbances affecting radio transmission. While many sunspots have been conspicuous during the last few months, a study of the sunspot numbers during the last few years shows that the actual maximum occurred in 1937. The graph of sunspot numbers from the minimum of 1933 to date printed herewith (Fig. 1) shows the present state of solar activity with respect to the maximum so recently passed.

The curve has been drawn through individual monthly values derived by taking the moving averages of three months at a time. Inspection will show that the highest three months average occurred in July, 1937, with a Wolfer index of 137. It will be noted that this high was followed by an abrupt drop to the end of the year, with a recovery in 1938 to a three-months high of 131.6 centering in June of last year. The subsequent rise during the early part of this year yielded an index of 111 centered about May, 1939. The maximum passed in 1937 was the highest since the maximum of 1870, when the corresponding Wolfer solar index stood at 165.

The rapid decline in the sunspot numbers during the early part of October indicates a decreasing activity for the next six months and that the major trend will be definitely downward for the next four or five years. The next minimum may be expected to fall in 1943 or 1944.

In reviewing the activity of the sun in recent years, it is interesting to note that the interval between the last two maxima—that of 1928 and that of 1937—has been but nine years, as compared with the mean interval between maxima usually taken as 11.2 years. This is the shortest interval between maxima for over a century. Had we attempted to predict the present maximum by adding the 11.2—year average interval to the last maximum, we should not have expected the present period of heavy solar activity until 1940.

At a meeting of the American Association held at St. Louis in 1935, I ventured to predict on the basis of sunspot activity at that time that the next maximum would occur at the end of 1937 or the very early part of 1938. On the basis of the sun's performance during the subsequent four years, it would appear that the sun anticipated even this prophecy by possibly six

[1] SCIENCE (Supplement), 90: 2337, 9, October 13, 1939.

[2] John Q. Stewart and H. A. A. Panofsky, *Astrophysical Journal*, 88: 4, 385–407, November, 1938.

[3] Newbern Smith, Theodore R. Gilliland and Samuel S. Kirby, National Bureau of Standards Research Paper RP1159, Vol. 21, December, 1938.

months. However, if the top of the curve is smoothed to eliminate the secondary fluctuations, it would appear that the mid-maximum falls very near this predicted time.

The irregularities in the so-called sunspot cycle have presented many difficulties from the point of view of prediction. Attempts to forecast solar behavior on the basis of harmonic analyses of many years of sunspot data have frequently brought disappointing results when projected into the future. Astrophysicists acquainted with the irregular variations in many stars of unpredictable performance have come to believe that no combination of fixed periods can ever safely be used for predicting the future of solar behavior.

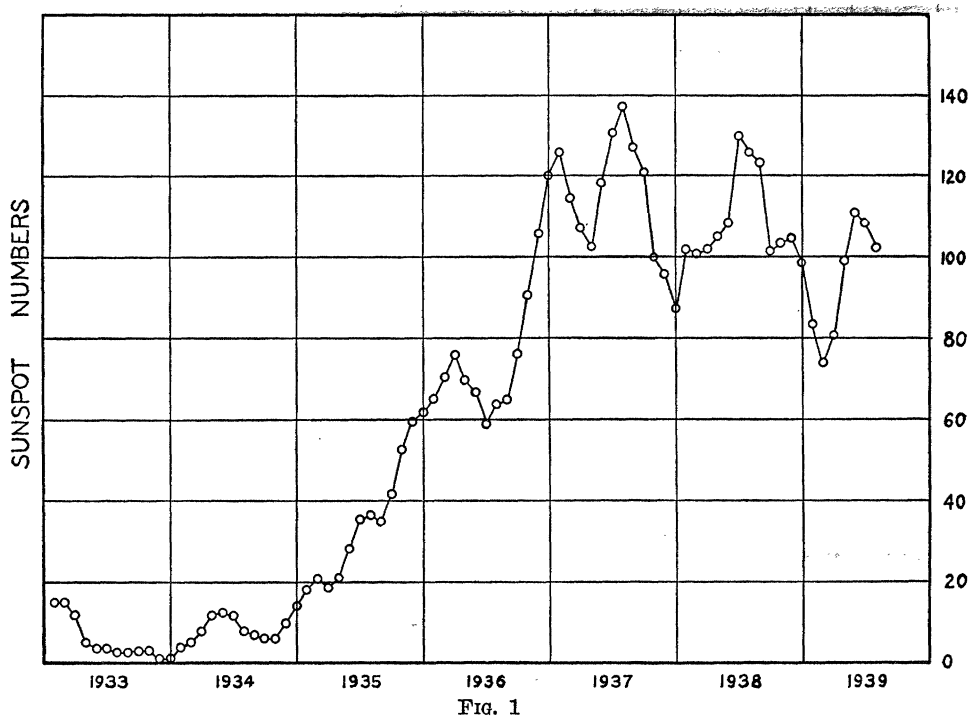

FIG. 1

Abandoning Newcomb's conclusion "that an underlying regularity of period governs the sunspot cycle," J. Q. Stewart and Panofsky[2] have recently made a mathematical analysis of 16 solar cycles from the point of view of the "outburst" hypothesis of Halm and Waldmeier and have derived an expression for the sunspot number R for each given year after an observed minimum. Their quantity R depends upon the general form of the family of curves that appears to be typical of the rise and subsidence of sunspots once a new period of solar activity has started. On the basis of such short-range prediction they have derived an average sunspot number for 1937 as 114.4 agreeing closely with the actual observed value of 115.1.

Still holding to the principle of underlying periods, H. H. Clayton three years ago predicted the date of the coming maximum of sunspots to be 1937.5, a value in extraordinarily close agreement with the subsequently observed data. In making his forecast, Mr. Clayton purposely avoided using any observed data subsequent to 1910 to test the validity of his prediction. The desirability of even short-range prediction of solar activity is coming to be of increasing importance, due to the many now recognized ionospheric changes that parallel so closely the solar cycle.

Among the generally recognized phenomena of a terrestrial nature that show changes with the sunspot cycle, the most obvious are the auroral displays such as have been unusually active during the last two years. Through the courtesy of Director C. H. Brooks, I have examined the records of the Blue Hill Observatory, which have been kept since its inauguration in 1885, and find a very marked tendency for the maximum frequency of brighter aurorae to occur on the average about a year after sunspot maximum (Fig. 2). In treating the data the number of aurorae for a given year was weighted with the observed intensity and the moving averages of three consecutive yearly values taken in plotting the curve.

The delay in the maximum of auroral frequencies with respect to the sunspot maximum calls for some explanation. Differences of opinion exist as to the exact mechanism connecting solar activity with auroral phenomena. Some investigators believe that the ionization responsible for the displays of the polar lights is produced by bursts of ultra-violet light from the sun accompanying the period of maximum solar activity. Dr. Carl Störmer, on the other hand, favors,

the hypothesis that corpuscular emission of some sort emanates from sunspot centers and has been remarkably successful in computing the actual forms of auroral streamers on the basis of the behavior of charged particles coming from the sun and entering the upper atmosphere along paths distorted by the magnetic field of the earth.

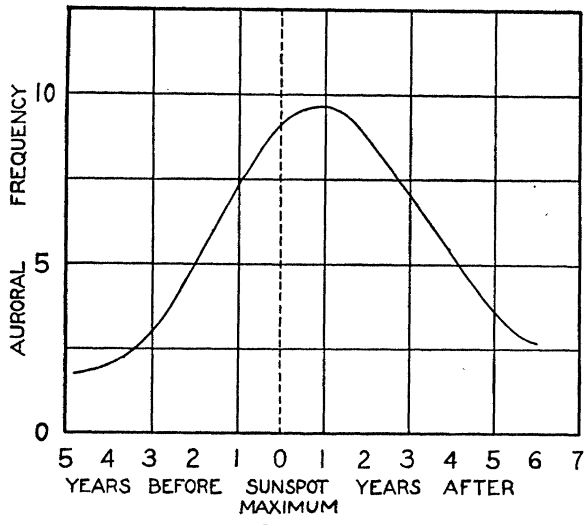

FIG. 2

If aurorae are caused in accordance with the corpuscular hypothesis then it might be expected that the polar lights would be most conspicuous when large sunspots pass near the sun-earth line or are seen close to the center of the sun's disk. The fact that sunspots occur at decreasing solar latitudes as the sunspot cycle progresses suggests that as the more active spots approach more nearly the solar equator they will more frequently cause brilliant aurorae. It should be possible on the basis of more complete data of the last few years to analyze the occurrences of aurorae with respect to the positions of sunspots near the central zone.

By the time spots begin to appear within 5° of the sun's equator, the numbers of sunspots have so appreciably waned as to diminish very considerably the presumable cause for auroral phenomena. Even on the hypothesis of flares of ultra-violet associated with chromospheric eruptions in the vicinity of sunspots, one would expect the latitude effect to be important in the production of aurorae. In either case, therefore, we have a possible qualitative explanation for the maximum in auroral frequency occurring after the actual maximum of sunspot numbers has been passed.

Since it is evident that an increased emission of ultra-violet radiation from the sun and possibly also the emission of particles in the vicinity of sunspots are directly associated with increased ionization of the earth's upper atmosphere, the phenomena of radio transmission may be expected to show variations with solar activity. Field strength measurements of a Chicago broadcasting station made at our suburban laboratory have shown a decrease from a value of more than 300 microvolts per meter at the sunspot minimum of 1933 and 1934 to a value of about 100 microvolts per meter during 1938. Sunspot numbers for the same interval rose from an average of 5 to an average of around 120. Critical frequencies for penetrating the E layer as published by the Bureau of Standards[3] have shown likewise a consistent parallel with the last four-year rise in solar activity, the value rising from 3.05 megacycles in 1934 to 3.75 megacycles in 1938.

Well-known changes in the intensity of the earth's magnetic field following closely changes in sunspots have been recognized for over 100 years. It is now obvious that probably the major contributing factor in the geomagnetic fluctuations is to be found in the ionization changes in the upper atmosphere. Developments in radio technique, therefore, offer new tools for exploration in unlocking the relationship between solar activity and terrestrial, atmospheric and magnetic phenomena.

SCIENTIFIC EVENTS

A DISCUSSION OF FRANKLIN AND HIS TIMES

A DISCUSSION of Franklin and his times entitled "Meet Doctor Franklin" is being held under the auspices of the Franklin Institute with the cooperation of the American Philosophical Society and the Historical Society of Pennsylvania.

The conferences are being held on Fridays at 5:15 P.M., beginning on October 20 and ending on April 19. The program follows:

Opening address, Dr. Carl Van Doren, author and editor, New York City.

"The Philosophical Revolutionist," Bernhard Knollenberg, librarian, Yale University.

"Dr. Franklin: Friend of the Indians," Dr. Julian P. Boyd, librarian and editor, Historical Society of Pennsylvania.

"The Colonies and the Mother Country," Dr. Verner W. Crane, professor of American history, University of Michigan.

"The Diplomat," Dr. Frank, Monaghan, assistant professor of American history, Yale University.

"Self-Portraiture: The Autobiography," Dr. Max Farrand, director, Huntington Library, San Marino, Calif.

"Looking Westward," Professor Gilbert Chinard, professor of French, Princeton University.

"Molding the Constitution," George Wharton Pepper, member of the Franklin Institute, Philadelphia.

"The Printer at Work," Dr. Lawrence C. Wroth, librarian, John Carter Brown Library, Providence, R. I.