## NEW STATISTICAL METHOD OF PREDICTING SUNSPOTS

THE prediction of solar activity, which greatly affects radio communication and is evidenced by spots on the sun, has been advanced through the application of a new statistical method, by A. G. McNish and Virginia Lincoln of the National Bureau of Standards, Washington. The new technique, depending on available sunspot data for a number of previous 11-year cycles, has a sounder scientific basis than former methods of prediction. Moreover, it is expected to be applicable to a wide variety of cyclical phenomena, such as long-term weather variations and climatic changes (*cf.* Ramamurthi, *Curr. Sci.*, 1947, p. 213).

Long-distance radio transmission is made possible by the ionosphere, a series of layers in the atmosphere 50 to 250 miles above the earth. Radio waves sent out near the earth's surface travel in straight lines until they reach the ionosphere and are reflected back to the earth, just as light striking a mirror is reflected. This reflection of radio waves is due to the fact that the ionosphere is made electrically conducting as a result of the ionization of gas molecules in its layers by ultraviolet light from the sun.

With the discovery of the close relationships existing between radio propagation and sunspot activity, the prediction of sunspot numbers assumed great practical importance. In the development of a satisfactory sunspot-prediction formula at the National Bureau of Standards, it was assumed that (1) in a time series exhibiting cyclical tendencies, a first approximation to a future value is the mean of all past values for the same stage of the cycle, and (2) this approximation can be improved by adding to the mean a correction proportional to the departure of earlier values of the same cycle from their respective means. The second assumption is justified by the observed tendency in sunspot numbers for annual deviations from the mean to have the same sign and similar magnitudes in consecutive years.

The prediction formula then becomes

$$R_n' = \bar{R}_n + k_{n-1} \triangle R_{n-1} + k_{n-2} \triangle R_{n-2} \cdots$$

where $R_n'$ is the predicted value in a particular cycle, $R_n$ the mean of all corresponding values in preceding cycles, $\triangle R_{n-1}$ the deviation of the particular $R_{n-1}$ for this cycle from the mean of all $R_{n-1}$'s from previous cycles, and the $k$'s are proportionality constants.

The least-squares criterion that the sum of the squared deviations from the mean be a minimum was used in evaluating the proportionality constants. Upon comparison of observed values with those predicted by this method, it was apparent that the best prediction is usually obtained by setting all of the $k$'s except in one for the previous year equal to zero, and this procedure is followed in most cases.

The sunspot number is obtained by counting the number of sunspot groups, multiplying by ten, and adding to the result the number of individual sunspots in each group. This statistical convention was adopted at the Zürich Observatory in the middle of the nineteenth century, and since that time has been standard all over the world. The highest monthly average sunspot number in over 100 years, and one of the highest of all time, occurred during May 1947.

The importance of sunspot prediction is shown by comparison of radio transmission in 1944 with that in 1947. In 1944 sunspots were at a minimum, the ionosphere was weakly ionized, and the higher frequency radio waves passed out into space without reflection. During the year, transmission across the North Atlantic was rarely possible for frequencies above 20 megacycles. For 1947, on the other hand, the extremely high annual sunspot number of 126 is predicted, and already transmissions using frequencies above 50 megacycles have been logged over this path.

Daily "soundings" of the ionosphere are taken all over the world by an international network of 58 ionosphere stations, 14 of which are operated or supported by the Bureau. These daily soundings measure the critical frequency (the limiting frequency for reflections back to the earth), absorption of radio energy (an indication of the power required to transmit a given frequency over a particular distance), and the heights of the various layers (determined through the use of radar-like echo equipment). The sunspot predictions are correlated with this information to provide the working data used at the Bureau in predicting radio propagation characteristics.

Groups now using the service include airline companies, steamship lines and the merchant marine, television and radio schools, American and foreign universities, radio and telegraph companies, manufacturers of communication equipment, research laboratories and geophysical exploration organizations.

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## ATOMIC PILE PRODUCTS TO REPLACE SURGERY

MEDICAL physicists, in dozens of the United States laboratories, are working to-day on what promises to develop into the first evolution of therapy and surgery through atomic fission. The process that fascinates the pioneers of nuclear medicine is the so-called "selective localisation" of radioactive elements in the human body. Its perfection, in simple terms, would amount to the destruction of diseased body tissue, not by the surgeon's knife, but by the radioactivity of chemicals taken internally. The key to the evolution lies in the radioisotopes, those radioactive twins of normal elements which are produced in the atom-smashing cyclotron or in the atomic pile.

At the University of California in Berkeley, one of the foremost centres of medical physics in the United States, Dr. John L. Lawrence has been working with radioactive isotopes for more than twelve years.