LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Prediction of Sunspot Numbers for Cycle 20

In a recent communication, P. Herrinck[1] has given a table of predicted sunspot numbers for the current solar cycle (No. 19), based upon the striking coincidence of values between the two periods 1749–85 and 1918–54. A good fit was obtained by multiplying figures observed 169 years before by a factor of proportion. This means, essentially, that cycles 16, 17, and 18 have been made to correspond with the cycles 169 years earlier, namely, cycles 1, 2, and 3, respectively.

It would appear that a good fit could also be obtained by making cycles 17, 18, and 19 correspond to cycles 1, 2, and 3, thus postulating the existence of a period of 180 years. The importance of this type of speculation may be seen by the fact that for a 169-year period, the maximum of Cycle No. 20 (assuming that it occurs around 1969) would be expected to be extremely low ; whereas, with a period of 180 years, the maximum for Cycle No. 20 would be extremely high. Thus, it would seem that P. Herrinck is entirely correct when he states that, because of the very empirical nature of these predictions, it is essential to keep a close check with observations, and that, without theoretical support, nothing better can be expected for such long-term prediction.

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[1] Herrinck, P., *Nature*, 184, 51 (1959).

Telluric Origin of the Whistler Medium

It has recently become apparent that the ionized medium surrounding the Earth and responsible for the transmission of radio whistlers must be of telluric origin. When radio whistlers were first explained by Storey[1], and it was shown that concentrations of several hundred electrons per c.c. existed at distances of several Earth-radii from the Earth's centre, it was rather generally accepted that the medium must be of solar or interplanetary origin, as it did not seem possible to conceive any extension of the Earth's atmosphere to so high an altitude. Arguments are presented here to show that the medium cannot be of solar or interplanetary origin, and a mechanism is suggested for a telluric origin of the medium.

The most common conception of the whistler medium is probably that it consists of ionized solar gas from an extreme extension of the solar corona or from the solar wind which has in some way penetrated the Earth's magnetic field and become trapped in the same manner that the Van Allen radiation is trapped. This requires that the particles possess a specialized velocity distribution, as particles with velocities oriented along or nearly along magnetic field lines will not be trapped, but will flow into the ionosphere and be lost from the medium. Owing to the prevalence of hydrogen in the solar system, the medium must be expected to consist mainly of protons and electrons in equal numbers if it is of solar or interplanetary origin. The protons would be expected to have an energy of about 10 keV. if they originate in the solar wind, and 20 eV. if they originate in an extended solar corona of the type described by Chapman[2]. A whistler medium consisting of such high-temperature solar gas would cool rapidly to the temperature of the Earth's exosphere, due to the presence of a cloud of neutral atomic hydrogen which surrounds the Earth and extends out from the Earth for a distance of several Earth radii. This hydrogen corona, which was first discussed by Chapman[3], originates through the photo-dissociation of water vapour and methane[4] near an altitude of 80 km. Its distribution and concentration around the Earth have been discussed by Singer[5] and by Johnson[6].

The temperature of the hydrogen corona is the same as that of the upper ionosphere and exosphere, and the value indicated by the rate of orbital decay of the Vanguard satellite, 1958β 2, is about 1,250° K[7]. The manner in which the cooling occurs is by charge exchange between the energetic protons and the thermal hydrogen atoms, yielding thermal protons (1,250° K.) and energetic hydrogen atoms which escape from the vicinity of the Earth. The cross-section for the charge-exchange reaction has been measured[8] for protons with energies up to 20 keV. Combining the cross-section data and the hydrogen-density data, it is found that the lifetime of an energetic proton, for any energy up to 20 keV., is about 1 day[9] for the lowest hydrogen density values which have been proposed, and much less for the larger values. Thus, a solar proton cloud trapped in the Earth's magnetic field would cool to a temperature of 1,250° K., with a time constant of about 1 day or less.

A cloud of thermal protons cannot remain trapped in the magnetic field as a cloud of high-energy protons can. This results from the fact that the collision cross-section is relatively large at temperatures as low as 1,250° K., and collisions are, therefore, rather frequent. Even for concentrations as low as 300 particles cm.$^{-3}$, the collision frequency is 300 day^{-1}. Collisions occurring this rapidly cause the velocity distribution to become isotropic, thus disturbing the specialized distribution of velocities required to maintain the particles in trapped orbits. As a result, there is a flow of protons from the whistler medium into the ionosphere. If we assume a concentration of 10^3 protons cm.$^{-3}$ throughout the whistler medium, we will under-estimate the rate of loss and over-estimate the total number of protons contained within the whistler