77. Possibility of the Radio Transmission being disturbed by Meteoric Showers.

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The part played by the Kennelly-Heaviside layer on the transmission of radio waves to long distances is well known, but the disturbance to which it is subject has not yet been much discussed. The existence of the ionised layer is attributed to the bombardment of electrons emanating from the sun and the ionising action of the ultraviolet portion of sunlight, so that the solar activity is the principal factor in changing the ionised state of the layer from this point of view. Of course the disturbance of the atmospheric electricity in the stratosphere and troposphere may have some influence in altering the ionisation. It seems to me that we have hitherto neglected the effect of meteoric shower as one of the agents in changing the condition of the Kennelly-Heaviside layer.

From observations by Denning of 8 Dracoids, 7 Virgoids, 7 Lyrids, 10 Capricornids, 7 Aquarids, 76 Perseids, 34 Leonids, and 9 Geminids, we obtain the following values:—

Mean height at beginning :	114.4 km.
„ „ „ end :	79.6 „
„ length :	91.2 „
„ speed :	44.0 „

On the supposition that the paths in the atmosphere are straight, the inclination to the horizon is $20^{\circ}.8$. The mean height of 97 km. is almost coincident with that of the Kennelly-Heaviside layer.

Following another classification of meteors into swift and slow fire balls, radiants in horizon, swift and slow shooting stars, following values are obtained from the observations of Denning:—

Mean height at beginning :	114 km.
„ „ „ end :	73 „
„ length :	119 „
„ speed :	40 „
„ inclination to horizon :	$25^{\circ}.4$.

The mean height is 94 km., which is practically the same as that above

cited. Taking 30 of the Leonids and 40 of the Perseids only, the mean height is 111 km. Thus we can conclude that *meteors generally appear at the mean height of about a hundred km., which is usually accepted as that of the Kennelly-Heaviside layer.* The great luminosity of the meteors is perhaps much influenced by the highly ionised state of the medium through which they pass with an average speed of about 42 km./sec., which is that of parabolic comets. According to the estimate of Denning, 20 millions meteors are visible in a day while 400 million are telescopic. Assuming the mean length of the path in the atmosphere to be 110 km. as stated above, the total length of the tracks of visible meteors is daily about 2.2×10^7 km., equivalent to 55000 times the circumference of the earth. This number is much increased during meteoric showers.

As to the constitution of the meteors, it is rather speculative; we can only judge from the meteorites and the spectral analysis of light emitted by the passing meteors, which according to Lindemann and Dobson are heated to temperatures at which most elements evaporate. The observed lines of spectra show the presence of Mg, Na, K, Li, CO, while meteorites contain Fe, Ni, Co, Cu, Ti, Al, Si, Ca, Mn and other elements. It is probable that the meteors mostly consist of pallasite, chrysolite, enstatite, maskelynite, weinbergite, asmanite, moissonite, cohenite, schreiberite and other minerals. Many of them can be turned into minute dust particles.

What interests us with respect to the present problem are the fine dusts which are scattered in the upper atmosphere by the disintegration of meteors. Judged from the comparatively small size of the meteors and the length of the trails, the dusts dispersed in the ionised air must be much finer than those projected by volcanic eruption into the upper part of the atmosphere. The volcanic dusts are of the order of a micron or two, so that the meteoric dusts can be estimated at a tenth or a hundredth of a micron. The fall by the action of gravity must be very small, as the modified formula of Stokes for such a case shows at a glance, since the coefficient of viscosity is almost independent of pressure. As it is however dependent on temperature, the rate of fall is more rapid in the upper atmosphere; in spite of this, the dusts will take years to fall to the surface of the earth.

The great commotion caused by the meteors in the ionised layer calls forth vortices in it, and tends to disperse the dusts about the paths. The speed of passage is generally sufficient to cause ionisation in the air, and as the atmosphere is already highly ionised, the fine particles form nuclei for collecting the ions from the surrounding. The condition of the ionised layer is thus temporarily disturbed, and ap-

parently introduces discontinuity in the transmission of the radio waves which impinge on the layer. *The irregular and diffuse reflections from the ionised layer are the general result.* The effect is somewhat analogous to the reflection of light from a mirror with numerous scratches made in a disorderly confused manner. If the paths of meteors be straight and horizontal, the effect would not be complicated, but as it is inclined at more than 20° and actually to a certain degree curved, the diffraction caused by long discontinuities and the scattering of waves by dust particles generally tend to weaken the intensity of radio waves, and especially to disturb the directional transmission. But singular cases may occur in which there is focussing of waves over a small portion of the earth's surface by diffraction. For a meteoric shower from a radiant point, it is possible that a directional transmission is favoured by it, but as the disturbance of the Kennelly-Heaviside layer is rather promiscuous by the passage of numerous meteors, it is quite likely that the transmission is obstructed during meteoric showers. Examination of transpacific communications for the preceding three years with special reference to the appearance of meteors of cometary origin, as Lyrids, Aquarids, Draconids, Perseids, Leonids, and Andromeds, has shown that there are evidences of the disturbances, which can be traced to meteoric origin. The data were kindly placed at my disposal by Mr. T. Nakagami of the Ministry of Communications.

How long such disturbances continue cannot be easily answered. The dusts gradually lose electrification by recombination, and afterwards simply intercept the passage of electrons and ultra-violet rays, which are the principal sources of ionisation of the upper atmosphere already made somewhat turbid by the dusts. This cannot be of appreciable amount, as the particles are dispersed by the action of terrestrial magnetic force while they are electrified, and also by light pressure, which is more effective in scattering them. The former motion is horizontal and the latter varies with the altitude of the sun, being more horizontal than vertical in high latitudes. Thus the disturbances are probably of short duration.

The turbulent motion in the Kennelly-Heaviside layer by the passage of the meteors must produce electric disturbances, which may be felt as a special kind of the atmospherics on the earth's surface. The existence of such disturbances can be tested by taking continuous records of atmospherics for a course of few years, and examining them whether there is concurrence with meteoric showers. Mr. E. Yokoyama has obtained such record during the appearance of the Leonids on November 14, 1928.

The above view can only be confirmed after a number of years of observation. The present paper is confined to the discussion of the principal features of the disturbances, which are likely to be observed in connection with wireless telegraphy.