## SUNRISE MAXIMA IN THE INTENSITY OF DISTANT ATMOSPHERICS RECEIVED IN MEDIUM FREQUENCY CHANNELS

ANOMALIES in the intensity value of distant atmospherics during the sunrise and sunset periods were known for a long time. Eccles[1] observed a minimum during the sunset time and this was confirmed by other investigators. Potter's[2] work on atmospherics on a range from 5 Mc/s to 20 Mc/s indicated intensity maxima both during the sunrise and sunset periods. Double peaks were also observed by him during the sunrise period on some occasions. The recent investigations in this laboratory[3] on distant atmospherics, on a range from 2 Mc/s to 20 Mc/s, revealed intensity maxima in the early morning, some minutes before the ground sunrise and also in the late evening, some minutes after the ground sunset. Usually one maximum (and occasionally two maxima) was observed before the ground sunrise and one maximum after the ground sunset. An unmistakable maximum was also observed[4] on medium frequency during the sunset period.

The object of the present communication is to present the results of some experiments on 800 Kc/s carried out in early morning, well covering the ground sunrise period. The interpretation of the results and some conclusions therefrom are also given.

The peak method of measurement was employed in the work. A three valve receiver consisting of a H.F. amplifier, a detecting valve and a L.F. amplifier, was worked with a suitable frame aerial. The plane of the frame was directed towards the East-West direction and also towards North-South direction. The receiver was carefully calibrated and the fieldstrength of the atmospherics was estimated from the observed deflection in the balanced galvanometer placed in the anode circuit of the last valve in the receiver. Two typical sets of experimental results on 800 Kc/s are shown in Fig. 1. It should be observed that the intensity variation of the atmospherics about the sunrise time could be of either type A or B in the figure. Usually the fieldstrength was found to diminish rapidly and steadily as in type A long before the ground sunrise when the fieldstrength began to show an increase. In some observations, however, two distinct

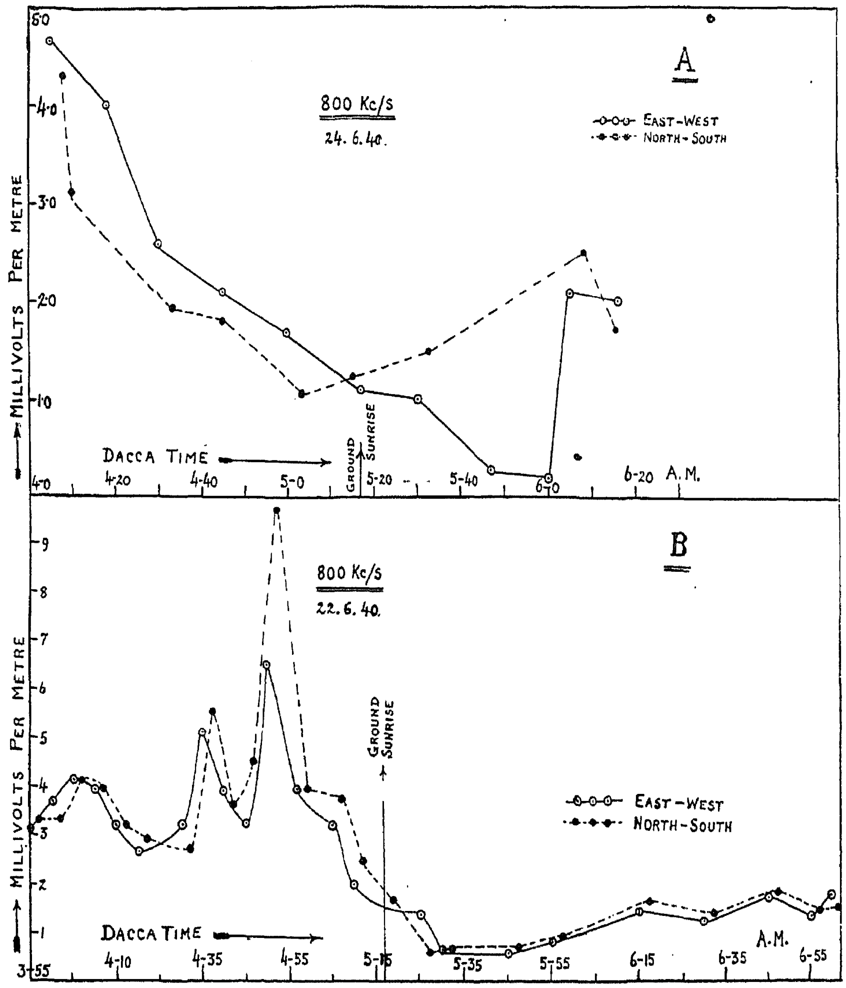


FIG. 1

maxima were observed, as in type B, one after another, both before the ground sunrise. These maxima were followed by a rapid decrease in intensity, continuing for sometime even after the ground sunrise. If the observations are not made at very short intervals, there is liklihood that these maxima would be masked by the extremely rapid fall in the fieldstrength of the atmospherics. The A-type of intensity variation is therefore observed more frequently.

In a recent note by one of us,[5] the intensity maxima of the distant atmospherics observed before the ground sunrise and after the ground sunset have been explained. The early morning maximum has been associated with the ionization minimum in the E-layer observed in the small hours of the morning. Before the ionization minimum, it is evident, there is a gradual decrease in electron density in the layer. The collision frequency in the layer and hence the attenuation, diminishes gradually causing a gradual fall in the intensity of the downcoming waves, till there is a maximum when the E-layer ionization is minimum. After this minimum, the ionization *rapidly* increases during the sunrise period. This causes a large fall in the intensity of the downcoming waves owing to:—(1) higher attenuation due to larger collision frequency in the layer, and (2) larger deviation of the rays due to higher electron density. An early morning maximum is thus explained. The work of Mitra and his students[6] on the early morning increase of the E-layer ionization has, however, shown that the ionization begins to increase only when the solar rays strike the layer by grazing the top of the Ozonosphere which is at a height of 35 Km. from the earth's surface. In order to produce ionization in the layer, the solar rays must pass over the ozone region or else the shorter wavelength constituents of the sun's rays which cause ionization would be absorbed by the ozone.

If we denote the angular distance between the source of atmospherics and the receiving point (both being supposed on the surface of the earth in the East-West plane) by $\theta$ and the angle contained between the two tangents on either side of the Ozonosphere drawn from the point where the ionospheric reflection takes place be given by $(180°\text{-}2\phi)$, it can be shown that the instant when the solar rays would begin to produce ionization in the layer would be earlier or later than the ground sunrise at the receiving point according as $\phi >$ or $< \theta/_2$. It can also be shown that the difference between the instant of ground sunrise at the receiving point and the instant when the ionization begins to increase in the region, where the ionospheric reflection takes place, would be given by

$$t = 4(\phi \mp 2\theta) \text{ minutes.}$$

The upper difference sign is to be used, when the receiving point is to the east of the source of atmospherics and the lower positive sign when the receiving point is to the west. Thus when $\phi > \theta/_2$, the sunrise maximum is expected $(4\phi \mp 2\theta)$ minutes before the ground sunrise at the receiving point. When however $\phi < \theta/_2$, *i.e.*, when the source of atmospherics is *very* distant, the sunrise maximum should appear $(2\theta \mp 4\phi)$ minutes after the ground sunrise.

With the higher frequency components there would be penetration of the E-layer and reflection would take place from the F-layer. Following similar arguments we would expect another intensity maximum at $(4\phi' \mp 2\theta)$ minutes before or after the ground sunrise according as $\phi' >$ or $< \theta/_2$, where $\phi'$ for the F-layer corresponds to the angle $\phi$ in the case of the E-layer. The time interval between the two maxima associated with the E- and the F-layers respectively would then be given by $\Delta t = 4(\phi' - \phi)$ minutes. Taking the E-layer reflection height to be 80 Km. and the F-layer reflection height (for 800 Kc/s) to be 150 Km., we get $\phi = 6°{\cdot}9$ and $\phi' = 10°{\cdot}8$, so that $\Delta t = 16$ minutes. In the particular set of observations (type B) for the East-West direction shown in Fig. 1, the two maxima appeared 42 minutes and 27 minutes respectively before the ground sunrise. The time interval between the two observed maxima was therefore 15 minutes. The agreement is thus extremely satisfactory.

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1 Eccles, *Handbook of Wireless Telegraphy and Telephony*, 1918, p. 176.

2 Potter, *Proc. I.R.E.*, 1931, Oct. 19, 1731.

3 Khastgir and Innas Ali, Communicated to *Ind. Jour. of Physics*.

4 Khastgir and Rao, *Proc. I.R.E.*, 1940, Nov. 28, 511. Khastgir and Ray, *Science and Culture*, 1940, June 5, 772.

5 Khastgir, Communicated to *Science and Culture*.

6 Mitra, *Science and Culture*, 1938, March 3, 496. Ghosh, *Ind. Jour. of Physics*, 1940, April 14, part 2 101.