# LETTERS TO THE EDITORS

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## Electrical Conductivity of the Ionospheric *D*-Layer

RECENTLY, D. F. Martyn[1] has suggested that electric currents in the *D*-layer of the ionosphere must make a contribution to the solar and lunar geomagnetic variations roughly equal to that of the *E*- and *F*-layers. Since theoretical work on atmospheric tides suggests that the tidal motions tend to increase with height, the electric forces causing the currents can scarcely be greater in the *D*-layer than in the *E*- and *F*-layers. Hence Martyn's suggestion implies that the integral conductivity of the *D*-layer must be at least as big as that of the *E*- and *F*-layers combined. This appears to us to be improbable.

The integral conductivity of the *E*- and *F*-layers combined[2] is of order $2 \times 10^{-8} - 10^{-7}$ E.M.U. If electrons in the *D*-layer (taken to be at about 65 km.) were to produce an integral conductivity of this order, they would have to number several million per cm.$^3$. This is, of course, an impossibly high figure: to produce only a reasonable degree of attenuation in waves passing through the layer, only a few hundred electrons can be present per cm.$^3$.

If ions in the *D*-layer produced a similar conductivity, there would have to be at least $3 \times 10^9$ of them per cm.$^3$. This estimate, though large, is easily seen to be correct in order of magnitude; the ion conductivity, for a given number of ions, varies inversely as the gas-density between the *D*- and *E*-layers (that is, about in the ratio 1 : 1,000); the *D*-layer is narrower than *E*; and the *F*-layer possesses a larger conductivity than *E* unless negative ions are numerous in the latter. A density of $3 \times 10^9$ ions per cm.$^3$ is difficult to reconcile with only a few hundred electrons per cm.$^3$; Massey and Bates' work on the *E*-layer[3] suggests that there can scarcely be as many as 1,000 negative ions per electron in the *D*-layer. Moreover, $3 \times 10^9$ ions per cm.$^3$ are enough to reflect waves of wave-length 150 m., and to attenuate waves of wave-length greater than 35 m. to less than a tenth of their strength each time they pass through the *D*-layer. This, then, rules out the possibility of a layer of the required conductivity existing at the assumed height of the *D*-layer, that is, at about 65 km.

There remains the possibility that the conducting layer exists at a greater height, though still definitely below the *E*-layer. To get reasonable values for the attenuation of 200-m. waves the conducting layer must be at a height of more than 80 km.; if in addition the ratio of the numbers of negative ions and electrons is not to exceed 1,000 : 1, the layer must be at least at a height of 95–100 km. Such a height is not far from that of the *E*-layer, and since there are likely to be far fewer than 1,000 negative ions per electron at this level, even this height is likely to be an under-estimate. It appears, therefore, that a layer of the required conductivity can scarcely exist below the *E*-layer.

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Dec. 23.

[1] Martyn, *Nature*, **160**, 535 (1947).
[2] Cowling, *Proc. Roy. Soc.*, A, **183**, 453 (1945).
[3] Massey and Bates, Rep. Prog. Phys., **8**, 62 (1942).

## Frequency Variation of the Intensity of Cosmic Radio Noise

THE intensity of cosmic radio noise (as received on horizontal half-wave dipole antennæ one quarter wave-length above ground) has been measured at 25 Mc. and 110 Mc. by H. V. Cottony, W. Q. Crichlow, J. W. Herbstreit and J. R. Johler at the Central Radio Propagation Laboratory, National Bureau of Standards, using identical noise diode calibration methods. The use of similar antennæ on the two frequencies ensured that comparable weights would be given the cosmic radio noise arriving from various directions in space. Results of these measurements are shown in the accompanying graph in terms of an external noise factor $\overline{EN}$[1]. Results are given on 110 Mc. for antennæ oriented both normal to and parallel to the geographic meridian. These have somewhat different diurnal patterns which compare favourably with the calculated patterns obtained when the cosmic radio noise intensity contours obtained by Reber[2], using highly directional antennæ, are appropriately integrated over the two broad directivity patterns of the dipole antennæ.

After allowing for the portion of the external noise energy radiated from the ground at an assumed temperature of 300° K., and on the assumption that the effective temperature of outer space (weighted in various directions by the dipole directivity) varies in accordance with some power of the frequency, the following expressions have been derived from these measurements for the maximum and minimum external cosmic radio noise factors corresponding to reception at this latitude on half-wave antennæ, one quarter wave-length above a perfectly reflecting ground:

$$\overline{EN}' = 4{\cdot}40 \times 10^5 f_{\text{Mc.}}^{-2{\cdot}41} \text{ maximum;}$$
$$\overline{EN}' = 1{\cdot}58 \times 10^5 f_{\text{Mc.}}^{-2{\cdot}41} \text{ minimum.}$$

Since the effect of absorption in the earth's ionosphere would be expected to be negligible on both 25 and 110 Mc. at night and on 110 Mc. both day and night, the exponent in the above two expressions was derived from the averages of the maximum values for the three nights, while the ratio of maximum to minimum noise was determined from the 110-Mc. measurements. The above expressions having been obtained in such a way as to minimize the effects of both ground and ionospheric absorption, they provide a direct measure of the variation of the mean cosmic radio noise arriving from outer space as a function of frequency. Thus this incident noise is seen to be proportional to $f_{\text{Mc.}}^{-0{\cdot}41}$, after allowance is made for the frequency-squared factor arising from the relative absorbing areas of the two antennæ. The absolute accuracy of the measurements on both frequencies is such that the first significant figure in the above exponent is considered to be accurate while the second is doubtful.

Also shown in these measurements is the occurrence of several short-time bursts of very strong noise radiation which occurred at times when sudden ionosphere disturbances were reported[3]. During the first of these, a burst of radio noise presumably of solar origin occurred on both 25 and 110 Mc. at the onset, followed, on 25 Mc. only, by a period of extraordinarily reduced external noise. In the second, the sudden ionospheric disturbance and reduced external noise on 25 Mc. commenced approximately 7½ min.