Thermal Expansion of Ionospheric Layer and Temporary Morning Disappearance of Radio Signals

It is usually assumed that under normal conditions of the ionosphere, if a radio signal is received after ground sunrise, it is likely to maintain its strength until absorption in the ionospheric region becomes pronounced during the day. It has often been found, however, during our observations of fading, that the reception of signals on shorter wave-bands completely ceases for about an hour or more after ground sunrise. The present communication is to show that thermal expansion of the F_2-region may be sufficient to overcome the enhancement of ionization caused by increase in solar altitude with advance of the day. To quote a few typical examples out of many occasions, the signals transmitted from All India Radio, Delhi, on December 28, 1946, on 19-m. band were received in Benares (678 km.) until 0711 hr. I.S.T., when they disappeared for about an hour. A similar disappearance of signal on the same waveband was observed on April 11, 1947, at 0750 hr. I.S.T., lasting for about two hours.

The temporary disappearance of the signal in the morning hours may be attributed to thermal expansion of the F_2-region[1,2], as shown in Tables 1 and 2 below.

Table 1. December 28, 1946; 19-m. band, Delhi

Time (I.S.T.)	Layer condition	Required electronic density (elec./c.c.)	Observed electronic density (elec./c.c.)
0700 hr. Before disappearance	Thin	$1\cdot41 \times 10^6$	$1\cdot60 \times 10^6$
0711 hr. Disappearance	Thick (thermal expansion)	$1\cdot93 \times 10^6$	$1\cdot63 \times 10^6$
0830 hr. Reappearance	,,	$1\cdot91 \times 10^6$	$1\cdot92 \times 10^6$

Table 2. April 11, 1947; 19-m. band, Delhi

Time (I.S.T.)	Layer condition	Required electronic density (elec./c.c.)	Observed electronic density (elec./c.c.)
0720 hr. Before disappearance	Thin	$1\cdot23 \times 10^6$	$1\cdot34 \times 10^6$
0750 hr. Disappearance	Thick (thermal expansion)	$1\cdot76 \times 10^6$	$1\cdot36 \times 10^6$
1000 hr. Reappearance	,,	$1\cdot70 \times 10^6$	$1\cdot71 \times 10^6$

The observed electronic densities shown in the last column of the tables indicate continuous increase of ionization as the day advances. Col. 3 of the above tables, however, shows the calculated electronic densities required for reception of signal, taking into consideration the normal expansion of thickness of the layer[3,4]. Comparison of the values of electronic densities which are given in columns 3 and 4 indicates the inadequacy of electrons in the ionospheric region during the periods of cessation of signals. The slight decrease in the value of required electronic density at the time of reappearance is due to alteration in the height of the layer. It may be mentioned that all such cases of disappearance of signals were preceded by periodic patterns of fading, as expected by Appleton and Beynon[5], and as such they were not due to scattered signals which are likely to be received within the skip distance[6,7].

The calculations for Tables 1 and 2 have been made with the help of ionospheric data and charts supplied to us by the research staff of All India Radio, Delhi, and the National Physical Laboratory, Teddington, to whom our thanks are due.

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Simplified Calculation, suitable for Routine Use, of a Linear Regression

There are many experimental procedures which involve the simultaneous observation of two variables, one of which is dependent upon the other. If the relationship between these variables is linear, then it is possible, by spacing the intervals equally with reference to the independent variable, to calculate the slope of the line, using the method of least squares, with the minimum of arithmetical computation.

A typical procedure of this kind is the estimation of the enzyme cholinesterase, employing the Warburg technique. The method is applicable only if the rate of production of carbon dioxide is linear, and the raw data should be inspected to ensure that the condition of linearity is sensibly satisfied. The slope of the straight line which best fits the data can be determined with the greatest ease if manometer readings are taken at four equally spaced intervals, for example, 15, 30, 45 and 60 min. after tipping.

The slope of the line of best fit is given generally by

$$\frac{\Sigma\ (\Delta t\ \Delta m)}{\Sigma\ (\Delta t^2)},$$

where Δt is deviation of each time observation from the mean and Δm is deviation of each manometer reading from the mean.

Taking the values above, the mean time is 37·5 min. and the deviations are $-22\cdot5$, $-7\cdot5$, $+7\cdot5$ and $+22\cdot5$ min. respectively. To facilitate calculation, the unit of time in this series may be chosen as 7·5 min., in which case the deviations are -3, -1, $+1$ and $+3$.

Let A_{15}, A_{30}, A_{45} and A_{60} be the manometer readings at the times indicated, and let $\bar{A}$ be the mean.

$$\begin{aligned}\Sigma(\Delta t.\Delta m) &= -3(A_{15}-\bar{A}) - (A_{30}-\bar{A}) + (A_{45}-\bar{A}) + 3(A_{60}-\bar{A}) \\ &= 3(A_{60}-A_{15}) + (A_{45}-A_{30}).\end{aligned}$$

On this scale $\Sigma(\Delta t^2)$, too, lends itself to simplifying the calculation, for $(-3)^2 + (-1)^2 + (+1)^2 + (+3)^2 = 20$.

Hence the slope required is, quite simply,

$$\frac{1}{20}\left\{\begin{matrix}3 \times \text{extreme range of}\\ \text{manometer readings}\end{matrix}\right\} \pm \left\{\begin{matrix}\text{intermediate range of}\\ \text{manometer readings}\end{matrix}\right\}.$$

In order to calculate cholinesterase activity as volume of carbon dioxide per N minutes, all that is