ON THE EXISTENCE OF THE *D* LAYER.

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It is well known that the ionosphere is divided into two main regions of ionization, the upper *F* region beginning from a height of about 230–250 km. and the lower *E* region from a height of about 90 km. Besides these regions, which are always present, the existence of another region of ionization below the *E* region, the so-called *D* region, has been suggested from time to time by various investigators. The tendency in recent years, however, has been to discredit the existence of such a region. In the present paper the author discusses briefly the evidence—both of a direct and of an indirect nature—which Prof. S. K. Mitra and he have obtained recently indicating that such a layer is formed below the *E* region during the daytime.[1]

The direct evidence consists in the detection of echoes of wireless waves by the group retardation method of Breit and Tuve from an equivalent height of about 55 km. These echoes, which are very weak and of infrequent occurrence, were observed in April and May last, during the hours 1500 to 1730 Calcutta local time on a wavelength of 150m. The echoes can only be interpreted as due to reflection from a low-lying region of ionization formed during the daytime.

Of the indirect evidence two may be mentioned :

1. It has been found that the equivalent height of the *E* layer shows a tendency to fall at the close of the day, before it begins to rise after sunset when the solar rays are removed and the recombination of ions follows. This fall of the *E* layer height coincides, in time, with the disappearance of the *D* layer (see below) and indicates that the equivalent height of the *E* layer is apparently increased during the daylight hours. This phenomenon may be explained as due to the double journey of the exploring waves through the ionized *D* region with reduced group-velocity.

2. It has been noticed by various investigators[2] that the echoes for long waves returned from the *E* layer are very weak during the daytime and are sometimes totally absent. A detailed experimental study of the phenomenon made by the author at the suggestion of Prof. Mitra showed that during the daytime waves corresponding to a particular frequency band only are returned as echoes from the *E* layer. For waves of frequency above the upper limit of the frequency band, the *E* layer is pierced and the echoes are returned from the *F* layer ; whereas, for those of frequency below the lower limit, no echo is received. The range of the band varies from hour to hour and a typical record of measurements for a particular day is shown in Fig. 25 of the '*Report on the Present State of our Knowledge of the Ionosphere*' (p. 174). The most

natural interpretation of the two curves is that the upper limit of the band is due to penetration of the E layer by the waves and the lower limit is due to absorption by another ionized region below the E layer. It is to be noticed that the lower (absorption) limit of the band begins to form with sunrise and tends to disappear with sunset showing clearly that the formation of the D region is closely associated with solar radiation.

It may perhaps be suggested that the absorption limit is not due to a region distinct from E formed at the low height of 55 km., but that it is due to the E itself,[3] the lower boundary of which becomes diffuse and comes down to a low level where collisional frequency and, hence, absorption is great. Against this hypothesis the following arguments may be adduced. An inspection of the figure shows that the variation of the penetration frequency, corresponding to the maximum ion-content of the E layer, does not show any similarity to the lower curve which is due to absorption. If both the upper and lower curves were due to the same region of the ionosphere, *viz.*, the E region, then both of them would have shown similar variations. This shows clearly that the absorption must have been caused by an ionospheric layer distinct from and lying below the E layer.

There is another reason why the absorption cannot be ascribed to the E layer. It has been shown by many workers that the lower boundary of the E layer is extremely sharp, both by day and by night.[4] The equivalent height as measured by the group-retardation method shows scarcely any variation when the frequency of the exploring waves is varied between wide limits. Consequently it is to be expected that, if the wave for a particular frequency fails to penetrate the E layer boundary and is reflected, waves of all frequencies lower than this will also be reflected. Hence the strong absorption of the E layer echoes cannot be caused by the E layer itself and the hypothesis of a diffuse E layer boundary is untenable.

From these considerations it may be concluded that an absorbing ionized layer—the D layer—is formed at a low height during the daytime. The absorption of the radio waves by this region must be taken into account in order to explain the diurnal variation of the intensity of the wireless echoes.

As to the origin of the D layer nothing definite can be said now except that it is caused by solar rays. One is tempted to associate the layer with the ozonosphere, though recent investigations have proved [5] that the ozone layer is situated at a somewhat lower height, 30 to 40 km.

Discussion of further experimental work on the subject will appear shortly in the *Indian Journal of Physics* (Vol. X, part I).

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