INTERPRETATION OF ECLIPSE EFFECTS IN THE
F-LAYER (*)

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Summary — Using a fit-extended balance equation for the electron-density-variations during a sun eclipse a possibility has been found to confirm by observation the F-layer processes deduced hitherto theoretically. Moreover, the rate of electron-production \(q = q(h)\), of the recombination-coefficient \(\alpha = \alpha(h)\) and a temperature profile \(T(h)\) can be given. These data are self-consistent. The smallness of \(\alpha\) is remarkable, whereby a slow decomposition of the nightly layer can be understand now. Also the computed temperatures coincide with rocket and satellite results.

It has repeatedly been tried to conclude from the behaviour of the ionosphere during a solar eclipse to the character of the processes occuring and the rate of electronproduction \((q)\) and recombination coefficient \((\alpha)\). The values thus obtained were, however, always in contradiction to the results of other measurements and consequently hardly satisfactory. Some time ago, Van Zandt & Co-Workers (1) who evaluated the observations of the eclipse of October 12, 1958, at Danger Islands in the Pacific, found a recombination coefficient which was so high that at night the ionosphere would vanish within a few hours. Also the temperature they obtained by calculations were considerably above 3000 °K, that is far higher than all values that could be recorded by satellites at such a height.

These discrepancies induced us to look for a solution that would be in better accordance with observation data. For this purpose we, too, used observation-

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data of the above-mentioned eclipse of October 12, 1958, which was characterized by even radiation of the entire solar disk and for which a series of very good electron density profiles $N(h)$ has been determined by the National Bureau of Standards in Boulder.

In our reflections we started from the processes usually considered in all discussions of the $F$-layer:

i) Formation of electrons by ionization of atomic oxygen;

ii) Charge exchange in which the positive charge is transferred from the oxygen atom to a nitrous oxide molecule formed by dissociation of molecular nitrogen;

iii) Recombination of the charges with simultaneous dissociation into nitrogen and oxygen atoms:

$$
\begin{align*}
\text{Process} & \quad \text{rate} \\
O + hr & \rightarrow O^+ + e & q \\
O^+ + N_2 & \rightarrow NO^+ + N & \beta \\
NO^+ + e & \rightarrow O + N & \alpha
\end{align*}
$$

The novel feature distinguishing our investigation from the older ones is the — somehow self-evident — idea that it is not only the number of formed electrons that depends on the degree to which the solar disk is obscured during the eclipse, but also the entire course of the three above-mentioned processes. In other words, this means that also the process of dissociative charge exchange and the formation of NO$^+$-ions, as well as their disappearance, are influenced and in some way even governed by the course of the eclipse. The respective formulas are, however, very complicated; they were published recently in another connection by Burkard (2). In order to be able to apply them to the present case without too laborious mathematical operations we have introduced some simplifying assumptions, which — as can be easily proved — will not cause major errors in our calculations.

i) The change in the angle of solar radiation during the eclipse is so insignificant that it can be neglected.

ii) The decrease of solar radiation until the maximum of the eclipse and the subsequent increase of radiation until the end of the eclipse is a simple linear function of time. For easily understandable reasons, this simplification is not permissible at the beginning and at the end of the eclipse; but these periods have not been considered in our calculations.

iii) We assume that during the eclipse a constant pressure level corresponds to a constant height level. This assumption is necessary since the mathematical formulas can be applied only to constant pressure, while observation data are only available for constant heights. For the relatively short time of the eclipse, however, this precondition seems sufficiently met, all the more since for purely calculatory reasons determination of the course of electron concentration was carried out only for the period from the maximum of the eclipse till towards its end.

For a given constant pressure level the following general formula can be employed:

$$
\frac{dN}{dt} = q - \alpha \cdot N^2 + \alpha \cdot N \cdot G \cdot e^{-\mu t} + \alpha \cdot N \cdot e^{-\mu t} \int_0^t q \cdot e^{\mu t} \cdot dt
$$

(1)