Starting at the bottom of the E layer (approximately 80 km) where the effect of dissociation and ionization of the normal constituents of the atmosphere first becomes apparent, consideration has been given to three different alternatives under which an ionized layer can be formed.

Case 1.—Formation of the well-known Chapman layer.[1] A parabolic layer is formed under the influence of monochromatic radiation causing ionization (or dissociation) of a particular atmospheric constituent supposedly responsible for this layer formation. The temperature and molecular weight remain constant over the region of investigation.

Case 2.—Formation of a rather well-pronounced layer in a narrow region of altitude, a formation which is more in accordance with the findings of the radio scientists. The theory has been worked out by Nicolet[2] under the assumption that the molecular weight remains constant, and that the temperature increases with height.

Case 3.—Formation of a well-defined E layer, where the electron density increases to a maximum, then decreases with altitude to a minimum, and increases again slowly, building up for the formation of the $F1$ layer. This continuous layer formation has been found here under the assumptions that the temperature increases with altitude and, furthermore, that the molecular weight decreases with altitude. These assumptions are supported by many experimental results (see, for example, the Rocket Panel report[3] and Penndorf's[4] investigation of vertical distribution of atomic oxygen in the upper atmosphere).

The layers formed under normal conditions of the sun for all three cases are shown in Fig. 1. The calculations have been carried out on the basis of the theory developed by Chapman.[1] For Case 3, the change in molecular weight with altitude has been calculated from reference 5. It has been assumed that molecular oxygen dissociates between 80 km and 120 km, that O_2 is ionized by radiation corresponding to wavelengths of less than 972A, and that O is ionized by radiation corresponding to wavelengths of less than 910A.

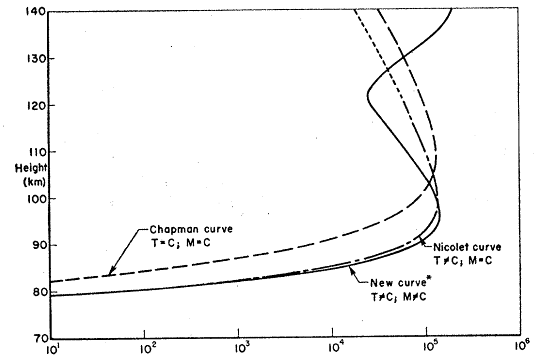

FIG. 1. Ionospheric layer formation. Quiet sun.

A similar investigation has been made for the layer formation under the action of a disturbed sun. For a medium disturbance the increase in intensity in the corresponding wavelength region has been taken from the observed rocket results as reported by Tousey, Watanabe, and Purcell.[6] For a major disturbance, the increase in ultraviolet has been deduced from the observed increase in the visible region of the spectrum (Balmer series). Calculations have been made for all three cases. The result obtained for Case 3 only is shown here (see Fig. 2); but it should be pointed out that the decrease in height of the maximum electron density calculated for a quiet sun, becomes for a greatly disturbed sun about 19 km for the Chapman layer, about 15 km for the Nicolet layer, and about 11 km for the continuous layer (Case 3). Experimental evidence from radiowave investigations indicates that the change in height might be between 5 km and 10 km, depending upon the magnitude of the disturbance.

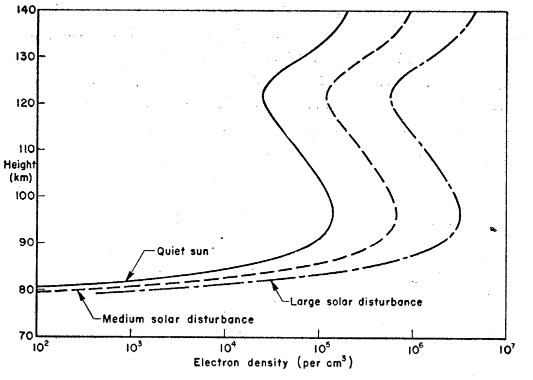

FIG. 2. Effect of disturbed sun upon the layer formation. New curves: $T\neq C$; $M\neq C$.

Although it is believed that the continuous layer formation, as indicated here, represents in principle the physical picture of the ionosphere better than does a discontinuous formation, the diagrams shown here present calculations only for average noontime values of electron densities which correspond to the right order of magnitude of frequencies used by the radio scientists for reflection at the E layer. It is hoped that some of the nonexplainable observations in the ionosphere can be explained on the basis of this continuous layer formation process.

Work on the continuation of the electron density curve to greater altitudes is in progress. It is planned to publish a detailed account of this investigation shortly.

The author wishes to express sincere thanks to Professor Joseph Kaplan for suggesting this problem and for his very helpful interest and advice throughout this investigation.

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The Mechanism of Phosphorescence in Crystal Phosphors

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I WISH to quote here some of the results which are pointed out in my thesis[1] in a more detailed form.

Assuming a monomolecular mechanism,[2] I first deduce the statistical distribution of traps from the experimental law of decay of phosphorescence. Precise experiments are necessary. These experiments have been carried out with various conventional phosphors, ZnS(Cu) and CaS(Bi). The distributions of the lifetimes τ in the traps, for these various phosphors, calculated following Lenard's method,[3] show only a regular decrease when plotted against τ. But the statistical distributions of the depths E of the traps, deduced from the distribution of lifetimes by the well-known formula:

$$\tau^{-1}=s\exp(-E/kT),$$

(s=const) can be analyzed as a sum of several approximately

Gaussian peaks,[1,4] each of them spreading about (and possibly characterized by) a central, well-defined depth.

These discrete depths coincide with the trap-depths given by the "glow-curves" method, but this last method is not accurate enough to show the existence of distributions around these depths.

The study of the decay at different temperatures gives the same depths, and this provides a direct verification of the above fundamental formula.

This agreement between theory and experiment may be considered as a proof of the monomolecular mechanism involved. Precise experiments are indeed not consistent with the hyperbolic decay law, which is deduced, as is well known, from the assumption of a bimolecular mechanism. However, the derivation of the $1/t^2$ law implies also the assumption that there is a unique trap depth,[5] and the discrepancy may, at first sight, be attributed to this over-simplification. I have shown that for long times of decay the $1/t^2$ law should then be obtained whatever the distribution of traps may be, and so the discrepancy between the results and the bimolecular mechanism is actual.

Thus the experiments are consistent with a monomolecular decay, at least as a first approximation. This may be explained if a great number of traps are situated in the neighborhood of the activator centers. But the existence of photoconductivity and recapture implies the possibility of a more or less important bimolecular perturbation. The above results show that this perturbation is weak during the decay.

If the electrons in the conduction band have high energies, they are not stopped by the defects of the crystal, and in these conditions an approximately bimolecular mechanism is valid; this is the case if excitation or stimulation takes place, or if the electrons are accelerated by an electric field; it may also be the case during the first stage of the decay[6] (10^{-2} sec), when the electrons in the conduction band are coming out of very shallow traps. However, during the long-period phosphorescence caused by the release of electrons from deeper traps, the conduction electrons have very low energies because of the need of a thermal activation (wave mechanical calculations[7] show that these energies are less than kT). They cannot then go far from the traps, and they often fall into the next center, in agreement with an approximately monomolecular decay.

Even in this case of monomolecular decay, however, retrapping takes place if different traps are situated around the same center; the possibility of a bimolecular perturbation also involves recapture. I have studied theoretically the way in which the decay depends on this phenomenon. Analogies appear between the refilling of shallow traps by electrons escaped from deeper traps, and chains of successive radioactive disintegrations. For instance, the quick decay of the glow curves obtained when the time elapsed after the end of the excitation increased is *not* an evidence against recapture, exactly as the activity of a mixture containing comparable weights of radium and radon decreases first with the period of radon (not of radium), and this is not a proof that radium disintegration does not produce radon.

Experiments show indeed that recapture takes place during spontaneous decay[8]; but the phenomenon is found to be much more important under infrared stimulation,[9] and the better the crystallization, the more pronounced is the phenomenon, in agreement with the views expressed above.

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Formation of the *D* Layer

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Of the several processes suggested for the formation of the *D* layer, the following appear to have the strongest support:

$$O_2+h\nu\ (900\text{–}1000\text{A, spectral region } A)\rightarrow O_2^{+}+e, \qquad (A)$$

$$NO+h\nu\ (1100\text{–}1300\text{A, spectral region } B)\rightarrow NO^{+}+e. \qquad (B)$$

Recently, Mitra[1] has reported a detailed calculation to show that the *D* layer is produced by process *A*, which was originally proposed by Mitra, Bhar, and Ghosh.[2] On the other hand, Bates and Seaton,[3] after examining various processes, have shown that the *D* layer may very well be formed primarily by process *B*, which was suggested earlier by Nicolet.[4]

Spectroscopic data seem to show that the *D* layer cannot be produced chiefly by process *A*. As pointed out by Bates,[3] spectrograms by Hopfield[5] show that a 4-mm layer of air completely absorbs radiation in spectral region *A*. Tanaka,[6] who used higher dispersion, confirms Hopfield's results and estimates from pressures used that the windows in region *A* are about two orders of magnitude less transparent than those in region *B*.

Using a vacuum monochromator and photoelectric detection, absorption cross sections of O_2 were obtained[7] in the spectral region 1050–1900A. These data, partly reproduced in Fig. 1, show that the absorption cross sections of the oxygen windows in the region 1100–1250A are about 10^{-20} cm². Moreover, the absorption cross section for the continuum just below 1100A is about 10^{-19} cm², and should be still higher in region *A* on the basis of the data obtained by Hopfield and Tanaka. A reasonable value for air in the spectral region *A* would be 10^{-19} cm² rather than $10^{-20}-5\times10^{-22}$ which were used by Mitra.[1] If the higher value is accepted, process *A* would be placed in the lower *E* layer.

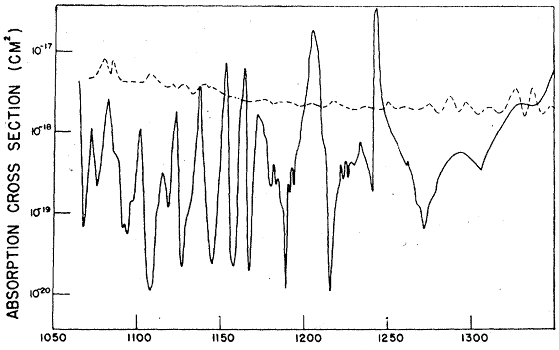

FIG. 1. The absorption cross sections of molecular oxygen (solid curve) and nitric oxide (dashed curve).

In contrast, process *B* has the very attractive feature that NO can be ionized by Lyman alpha which has now been observed[8] in the *D* layer as a strong, solar emission line. However, the concentration of atmospheric NO is not known. If the tentative estimate made by Bates[3] from a rocket spectrogram[9] is the correct order of magnitude, our absorption data for NO seem to indicate that the major part of the production of *D* layer can be attributed to process *B*.

Using NO samples (impurity less than 0.1 percent), the absorption intensity of this gas was measured[10] in the region 1070–2300A. A moderately strong absorption continuum was found in the region below 1400A. The absorption cross section is shown in Fig. 1 by the relatively flat curve, a continuum with a number of weak diffuse bands.

A preliminary photoionization experiment using a vacuum monochromator showed that the ionization current appeared