Letters To The Editor

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THE RATE OF ATMOSPHERIC IONIZATION AND THE AIR-EARTH CURRENT AT POONA

Introduction. The data obtained from some measurements of the potential gradient, electrical conductivity, concentrations of small ions and large ions (nuclei), and of mobilities of the small ions in the atmosphere at Poona have been reported and discussed in a number of previous papers [1–3] from the India Meteorological Department. In the present paper the rate of ionization and the air-earth current at Poona as derived from these atmospheric electric data have been considered and discussed.

Rate of ionization. The rate of ionization *i.e.*, the rate at which small ions are formed is an important factor in the electrical condition of the atmosphere and also helps one to examine the relation between the nuclei concentration and the atmospheric electric elements. An estimate of the value of the rate of ionization can be made from the concentration of small ions and large ions (nuclei) by making use of the relationship between these elements. Monthly values of the rate of ionization q were, therefore, computed according to the linear recombination law by the help of Schweidlar's equation

$$q = \alpha n^2 + \omega n N_A \qquad \ldots \qquad (1)$$

where n is the number of small ions per cc, N_A the number of condensation nuclei per cc, α the recombination coefficient between the small ions and ω is proportional to the recombination coefficient between the small and the large ions. The observed values of n and N_A at 1000 IST were used while the constant ω was taken as equal to 3×10^{-6} as used by Wait[4]. The term αn^2 was neglected, being negligibly small in comparison with the term $\omega n N_A$. The monthly values of q computed in this way are given in Table 1. The average value of q at 1000 IST at Poona works out to be 14.7 ion-pairs cc^{-1} sec^{-1} which appears to be a fairly good estimate and compares well with the normal value of q for land stations. It may, however, be noted that over land q varies considerably from place to place and from time to time.

Air-Earth Current. Determinations of the negative air-current (i_-) at Poona at 1000 IST have been made, using the indirect method, *i.e.*, through the product of the observed negative electrical conductivity of the air (λ_-) and the potential gradient (F). The results obtained have been incorporated in Table 1 for purposes of comparison with the values of q. The mean value for the negative air-earth current (i_-) at 1000 IST works out to be 3.7×10^{-7} ESU while the total air-earth current—being the product of the total electrical conductivity of the air ($\lambda_+ + \lambda_-$) and the potential gradient—is equal to 8×10^{-7} ESU; both these values are in fair agreement with values obtained at Bombay[5] as well as elsewhere[6]. The negative air-earth current is found to be the highest in the winter months (November to February) and the lowest in the summer months (March and April). The increase in the value of the air-earth current with the onset of winter is due to the marked increase in potential gradient during the winter season at Poona. Annual variation graphs for q and i_- at 1000 IST based on the data given in Table 1 are given in Fig. 1. The two curves are found to show fair similarity.

TABLE 1

Mean monthly values of the rate of ionization (q) and the negative air-earth current at Poona at 1000 IST

Month	Rate of ionization (q) in ion-pairs cc^{-1} sec^{-1}	Negative air-earth current (i_-)
January	15.8	4.3×10^{-7} ESU
February	13.8	4.2×10^{-7}
March	11.4	2.7×10^{-7}
April	10.8	3.3×10^{-7}
May	12.5	3.5×10^{-7}
June	15.2	3.7×10^{-7}
July	14.4	3.5×10^{-7}
August	15.6	3.6×10^{-7}
September	14.4	3.4×10^{-7}
October	17.8	3.6×10^{-7}
November	17.6	4.0×10^{-7}
December	16.5	4.3×10^{-7}
Mean	14.7	3.7×10^{-7}

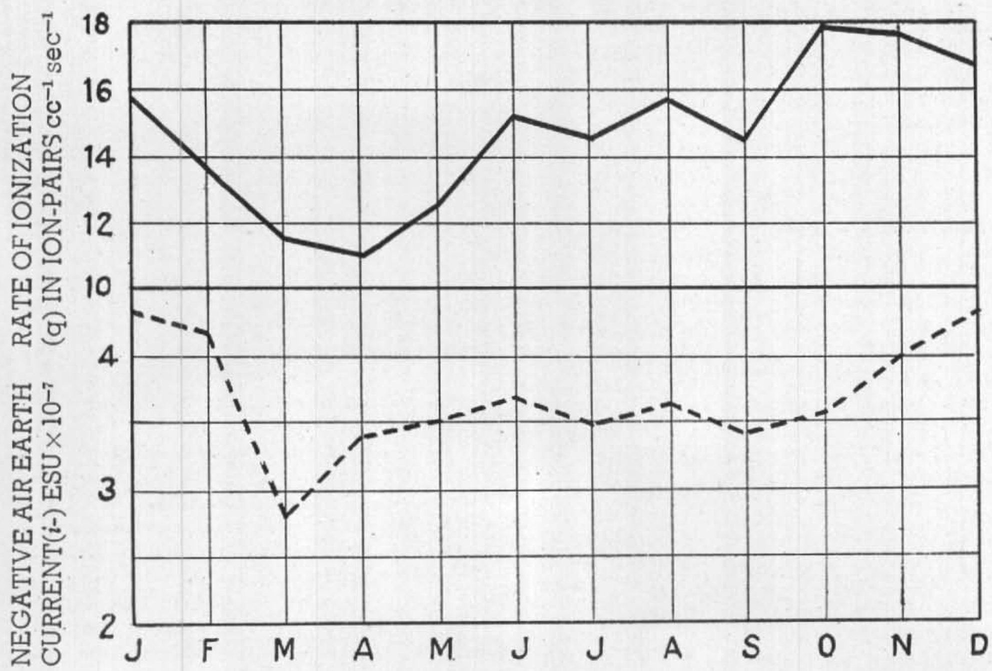
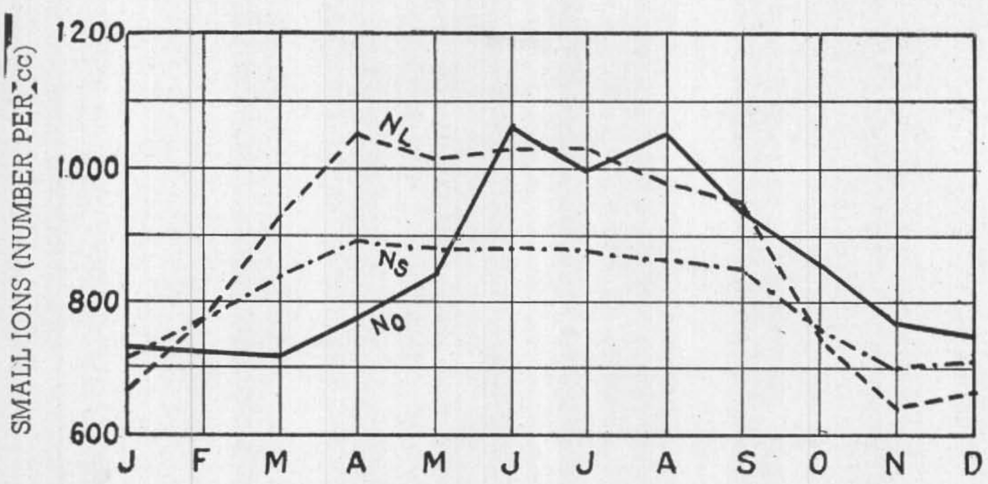


Fig. 1



N_L - - - CALCULATED VALUES BASED ON LINEAR RECOMBINATION LAW

N_S — CALCULATED VALUES BASED ON SQUARE ROOT LAW

N_O -·-·- OBSERVED VALUES $\left(\frac{N_+ + N_-}{2}\right)$

Fig. 2

Comparison of computed and observed values

Data obtained by some workers indicate that the simple expression for equilibrium in the form of equation (1) may be taken adequately to represent the relationship between q, n and N_A, provided the value of the rate of ionization q is small, which is not always the case. Nolan and Cilian O'Brolchain[7] found that q as calculated from the linear recombination law increased with increasing number of nuclei. This led to the suggestion that a different law of combination and of attachment probably applies. Nolan[8] has suggested a square root law instead of linear recombination law so that the values of q may vary more slowly with the concentration of condensation nuclei. Nolan's square root equation takes the form

$$q = \alpha n^2 + \varepsilon n \sqrt{N_A} \qquad \ldots \qquad (2)$$

Assuming $q = 14.7I$* and $\varepsilon = 2.4 \times 10^{-4}$ and making use of the observed values of N_A, monthly values of n were computed on the basis of equation (1) as well as equation (2). The *computed* results so obtained have been plotted in Fig. 2 together with the mean *observed* values of $n\left(=\frac{n_+ + n_-}{2}\right)$. A comparison of the two computed curves with the curve of the observed values does not clearly indicate as to which one of the two equations should be considered to represent the conditions of ionization better.

Effect of smaller value of mobility of the ions

In a pervious paper[3] by the author the mean values of the mobilities of the positive and negative small ions at 1000 IST at Poona were found to be 1.06 cm^2 $volt^{-1}$ sec^{-1} and 1.09 cm^2 $volt^{-1}$ sec^{-1} respectively. The value of the constant ω in equation (1) was taken as 3×10^{-6} on the assumption that the sum of the mobilities of positive and negative small ions is about 3 cm^2 $volt^{-1}$ sec^{-1}; with a smaller value 2.15 cm^2 $volt^{-1}$ sec^{-1} for the sum of the mobilities, the values of q will work out to be somewhat smaller than those given in Table 1 and Fig. 1.

K.S. AGARWALA

Meteorological Office, New Delhi
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*The symbol I is used to denote ion-pairs cc^{-1} sec^{-1}

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