LETTERS TO THE EDITOR

A NOTE ON SUDDEN FIELD ANOMALY PATTERNS (SFA)

ONE of the sudden ionospheric disturbances (SID's) in the sunlit hemisphere, due to the interaction of solar flare produced radiation with the earth's upper atmosphere, is the perturbation in LF field strength (monitored over long paths) designated as Sudden Field Anomaly (SFA). The potentiality of recording the field strength of LF transmissions progagated over long paths as a simple method for solar flare petrol was suggested by Lauter and Sprenger (1958). Experimental investigations of Nestorov (1962), Shirke and Alurkar (1963) and Mitra (1959, 1964) using 164 KHz transmissions from Allouis and Tashkent stations respectively demonstrated this possibility. It is now considered that the LF field strength observation (SFA) is the most efficient method for monitoring and interpreting solar flare effects in the lower ionosphere (Ohle *et al.*, 1974).

Subrahmanyam, Sastri and Deshpande (1974) recently reported the varied nature of the solar flare effect on LF field strength over the Tashkent–Delhi path (path length is about 1600 km) and observed six distinct types of SFA patterns, a typical example of which, with their average size and time structure is shown in Fig. 1. It can be seen that the six SFA patterns can be classified into two categories: Simple and Complex. The simple SFA patterns are Type II and IV wherein the signal strength either increases (Type II) or decreases (Type IV) following the flare and recovers to the normal level. The complex SFA patterns are Type I, I *a*, I *b*, and III wherein the signal strength undergoes a series of increases and decreases. The SFA patterns are noticed to exhibit seasonal trends in that Type IV and I *a* SFA patterns which are essentially attenuation effects of solar flare, on LF field strength occur mostly in winter and autumn and more or less absent in summer while Type II SFA pattern which is an enhancement effect of solar flare on LF field strength occurs mostly in summer and spring months. One of the interesting characteristics of SFA patterns is that the total duration of simple SFA patterns (Type II and IV) is much less than that of complex patterns (Type I, I *a* and III): in fact, the ratio of the latter to the former is of the order of two. This feature can clearly be seen from Fig. 1.

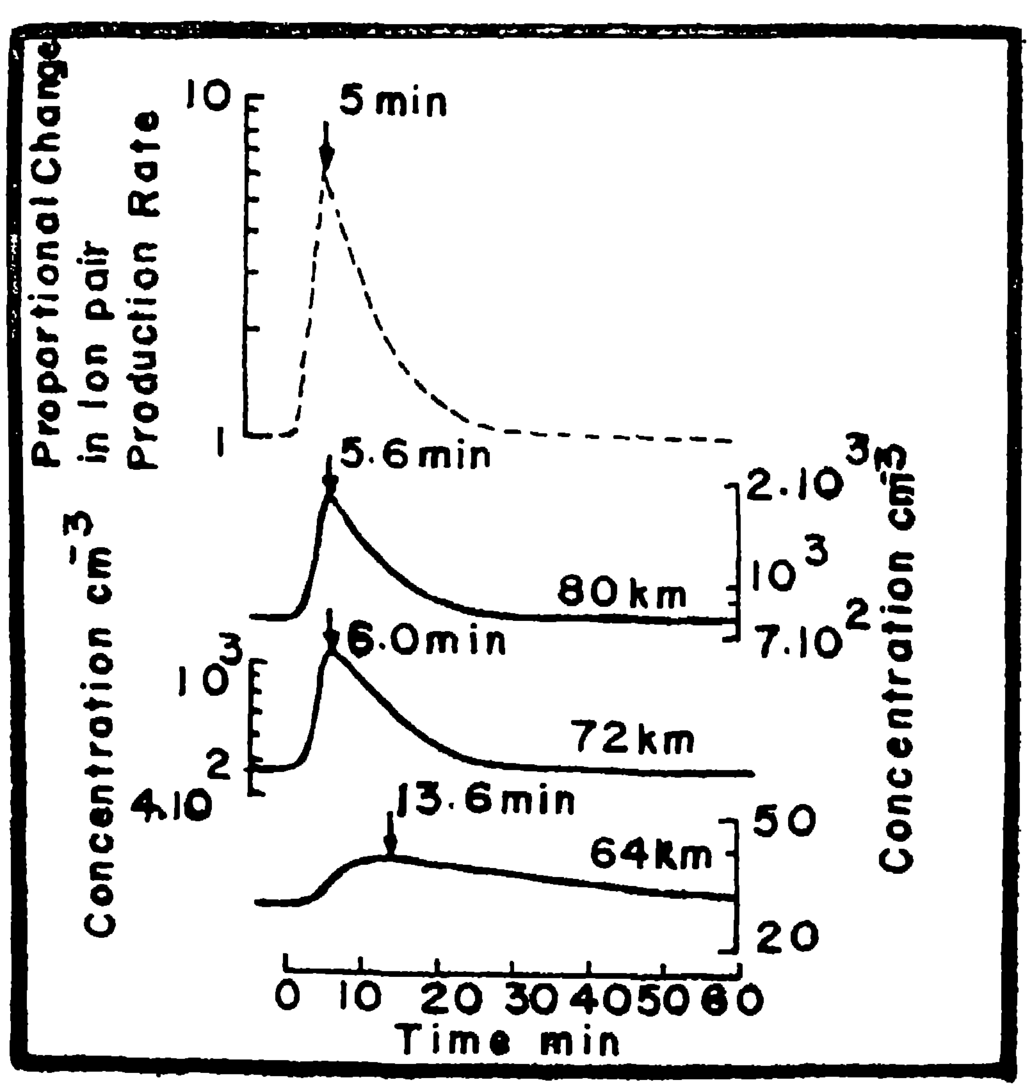

FIG. 1. Typical SFA patterns with their average size and time structure, observed over Tashkent–Delhi path.

This brief communication is devoted to an understanding of the characteristics of SFA patterns mentioned above, *i.e.*, the slow and relatively gradual recovery nature of field strength in complex patterns compared to simple patterns. The interpretation advanced is that the recovery nature is mainly governed by the range of heights over which the excess flare induced ionization is produced due to X-ray flux enhancement in the 1–20 Å band. Following this argument, the Type II and IV SFA patterns may be understood as due to extra ionization at heights below 60 km and above 75 km respectively [as a result of hardening of the X-ray spectrum (1–20 Å) and soft X-ray flux (1–20 Å) enhancement respectively] whereas the complex SFA patterns (Type I, I *a*, III) are due to excess ionization in the height range 60–70 km. Then the recovery nature in complex SFA patterns is governed by the negative ion chemistry of the D-region and the slow recovery nature of the field strength could be due to the slow release of electrons from negative ions by photo-detachment. Support for this interpretation comes from the recent work of Thomas *et al.* (1973), who have studied the role of negative ion changes in the D-region during flare conditions. Using a simulation procedure, with the proportional change in ion pair production rate at each height, represented by an analytical expression (representative of flare effect), with a rise time of 5 min and an exponential decay with a time constant of 5 min they have calculated the variations in concentrations of electrons and negative ions (O_2^-, NO_3^-, CO_3^-) at different heights for two cases: without and with the photo-detachment of electrons from negative ions (NO_3^-, NO_2^-, CO_3^-). They observed that if photo-detachment of electrons from negative ions is taken into consideration, the recovery of electron concentration after its maximum is considerably slowed down and this feature is most striking at a height of 64 km. This can be seen from Fig. 2 reproduced from the paper of Thomas *et al.* (1973).

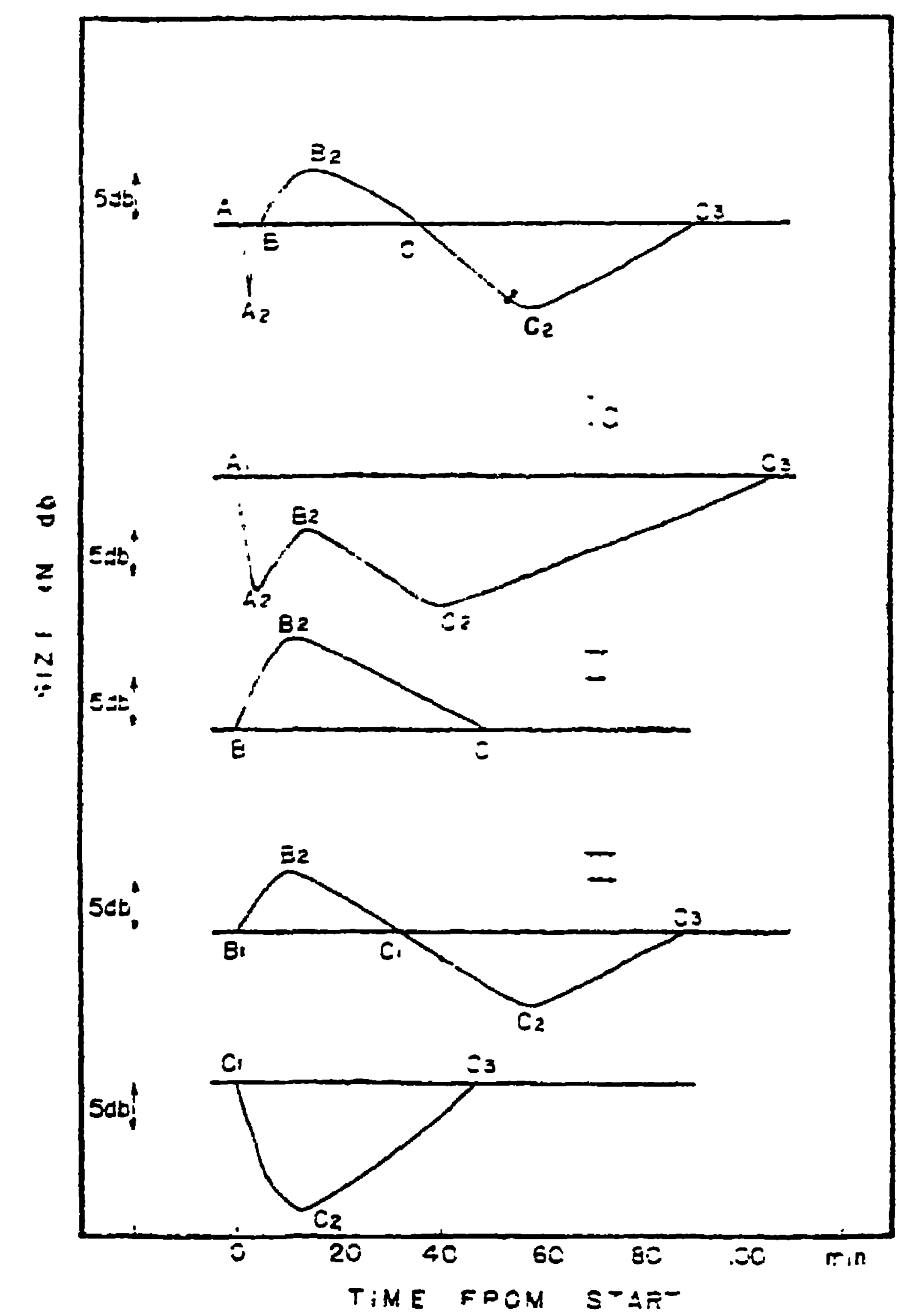

FIG. 2. The proportional change in ion pair production rate at all heights during a flare and the resulting variations of electron concentrations computed for 80, 72, and 64 km in the presence of photodetachment of electrons from ions CO_3^-, NO_2^-, NO_3^- according to the rates shown in Table I of Thomas *et al.* (1973) (after Thomas *et al.*, 1973).

It is to be emphasized however that the work of Thomas *et al.* (1973) is based on the assumption that the proportional change in ion pair production rate is the same throughout the D-region, which is an idealised condition. Further work is therefore necessary for a better understanding of the influence of negative ion changes on the recovery nature of field strength in complex SFA patterns by analysing specific events with the help of X-ray flux data, now available from SOLRAD satellite.

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