RESEARCHES IN THE FREQUENCY ANALYSES OF WAVEFORMS OF ATMOSPHERICS-II

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Frequency spectra derived from discharge currents observed by Norinder et al and the frequency spectra of some typical received waveforms of atmospherics were reported in a previous paper.[(1)] Recently our technique of waveform observation has become perfect by the use of the supersonic delay line with 250 microseconds delay time.[(2)] Employing the typical perfect waveforms observed in Sep. 1958, the author tried to deduce the relation between the characteristic of frequency spectrum and the distance of propagation of the atmospherics.

Fig. 1 shows the smooth daytime-type waveforms (sweep 0.9 mili-seconds), and their sferics are nearly at ranges of mentioned distances. As will be seen from these figures, waveforms from distant sources are of longer duration than those of close origins or the number of oscillations increases with increasing distance of origin. This tendency quite well agrees with the results reported by Pierce et al.[(3)] In the case of frequency spectrum derived from each waveform, both amplitude-and phase-frequency spectra are shown under the corresponding waveform photographs. The relation between the frequency of maximum component in the amplitude-frequency spectrum and the propagation distance from origin seems to be rather complicated than that reported by Chapman.[(4)] Although the change of amplitude-frequency spectrum at origin is monotonous to frequency, that of received atmospherics can be considered to show rather a complicated feature, since the amplitude-frequency spectrum may be responsible for contributions of many higher order-mode responses. There is another matter to be noted. As is shown in Fig. 2, the phase-frequency spectrum represents rather clearly the effect of propagation distance. Because of the small change of phase-frequency spectrum against frequency at origin, it would appear that the phase-frequency spectrum of the received waveform depends mainly on the propagation phase shift. Therefore, it is suggested that the feature of the phase-frequency spectrum may be useful to estimate the propagation distance.

Next, the regular peak-type and quasi-sinusoidal-type waveforms (sweep 1.9 mili-seconds) observed at night, together with frequeucy spectra, are shown in Fig. 2 Regular peaked-type waveforms shown in (A), (B), (C), (D) and (E) are originated at a distance of 1000 km—1500 km. Each of these amplitude-frequency spectra have many peaks and the fact that the minimum amplitude at about 2 kc/s is striking. For quasi-sinusoidal-type waveforms shown in Figs. 2 (F), (G), (H) and (I), the amplitude-frepuency spectra of these waveforms show the majority of energy concentrated, roughly speaking, to one peak at about 6 kc/s, and phase-frepuency spectra show comparatively similar characteristics to the smooth daytime type waveforms.

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References

1) K. SAO Proc. Res. Inst. Atm., Nagoya Univ., **5**, 1958, 12.
2) A. IWAI Proc. Res. Inst. Atm, Nagoya Univ., **6**, 1959, 56.
3) P. G. F. CATON and E. T. PIFRCE Phil. Mag. **43**, 1952, 393.
4) F. W. CHAPMAN and W. D. MATTHEWS Nature **172**, Sep. 12, 1953.

Fig. 1—1

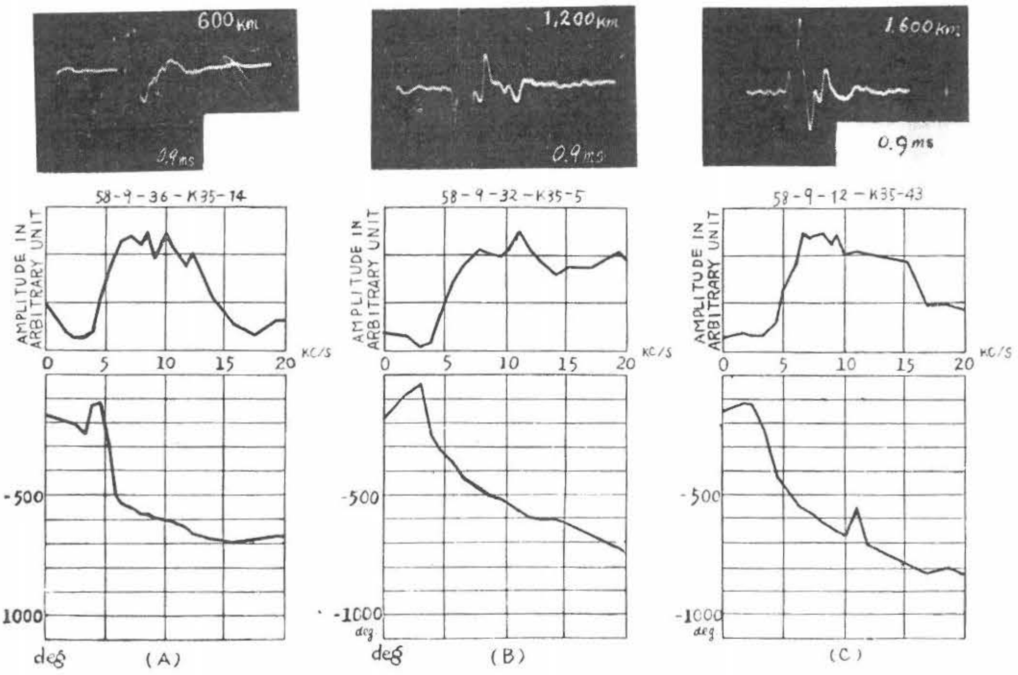


Fig. 1—2

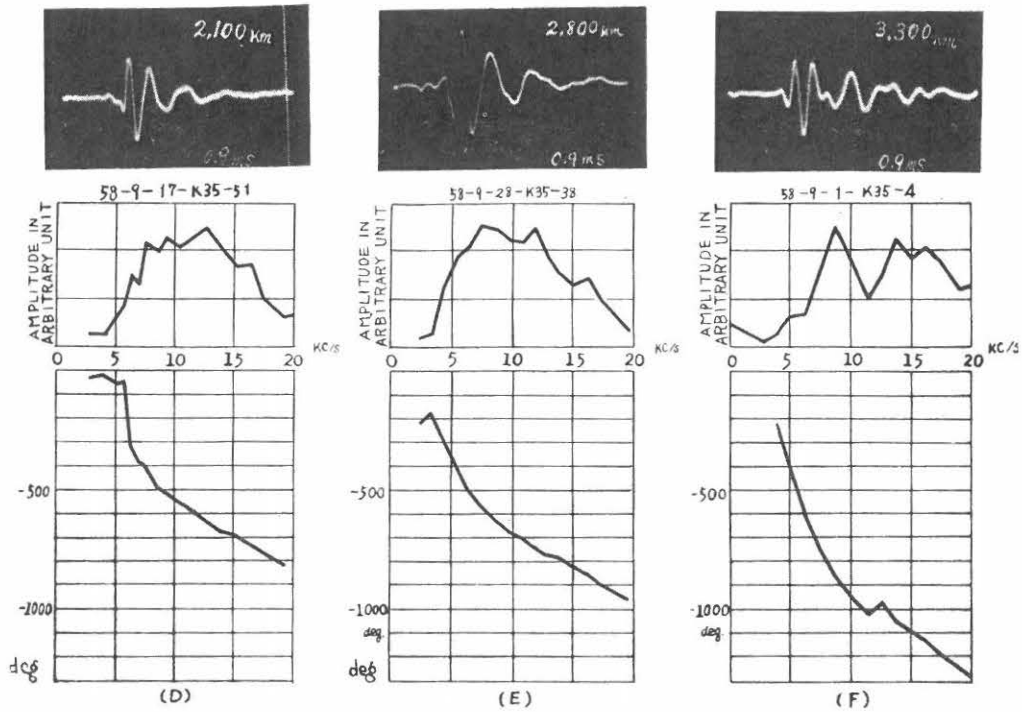

2,100 Km
0.9 ms
58-9-17-K35-51
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(D)
2,800 km
0.9 ms
58-9-28-K35-38
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(E)
3,300 km
0.9 ms
58-9-1-K35-4
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(F)

Fig. 1—3

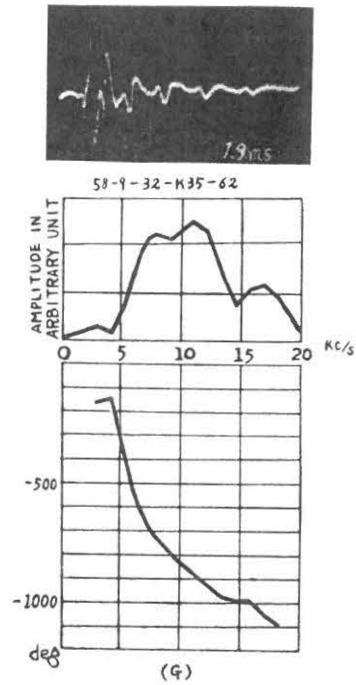

1.9 ms
58-9-32-K35-62
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(G)

Fig. 2—1

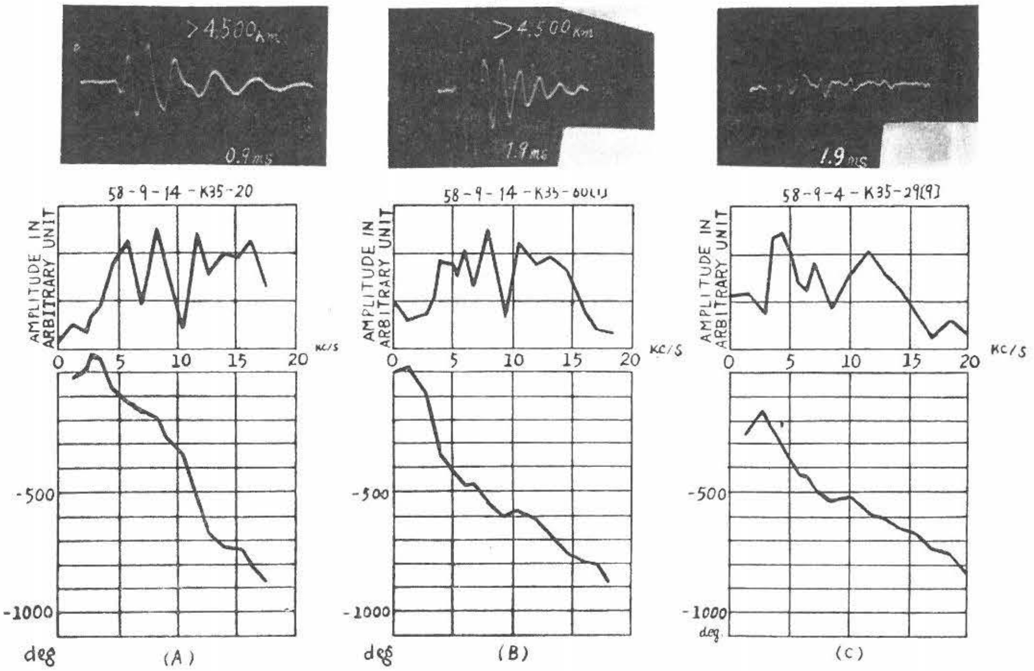

>4,500 km
0.9 ms
>4,500 km
1.9 ms
1.9 ms
58-9-14-K35-20
58-9-4-K35-29[9]
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(A)
(B)
(C)

Fig. 2—2

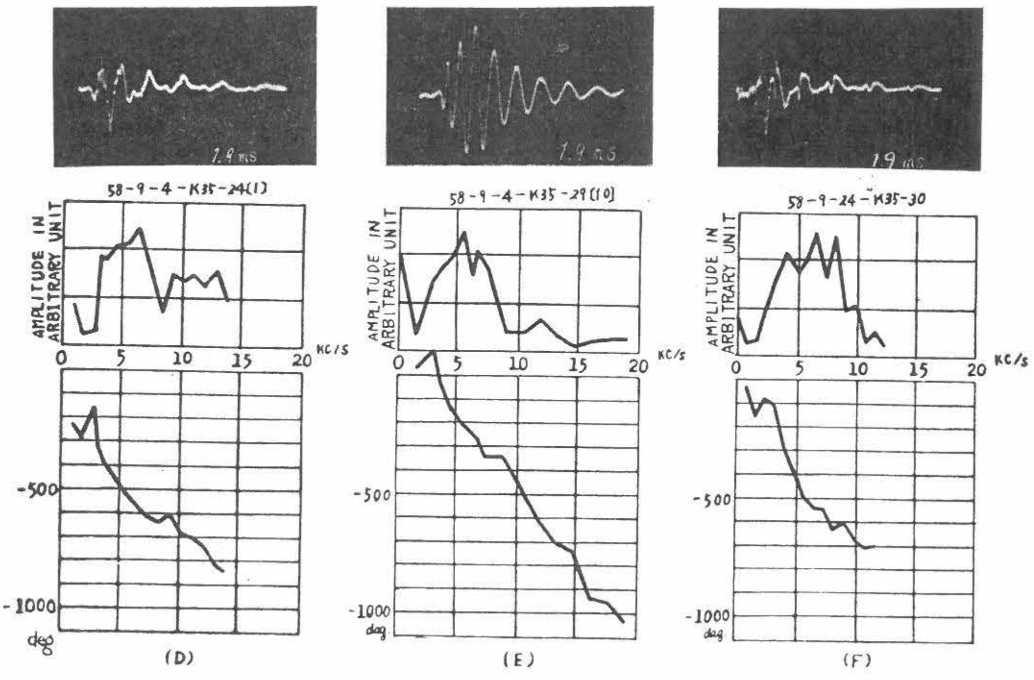
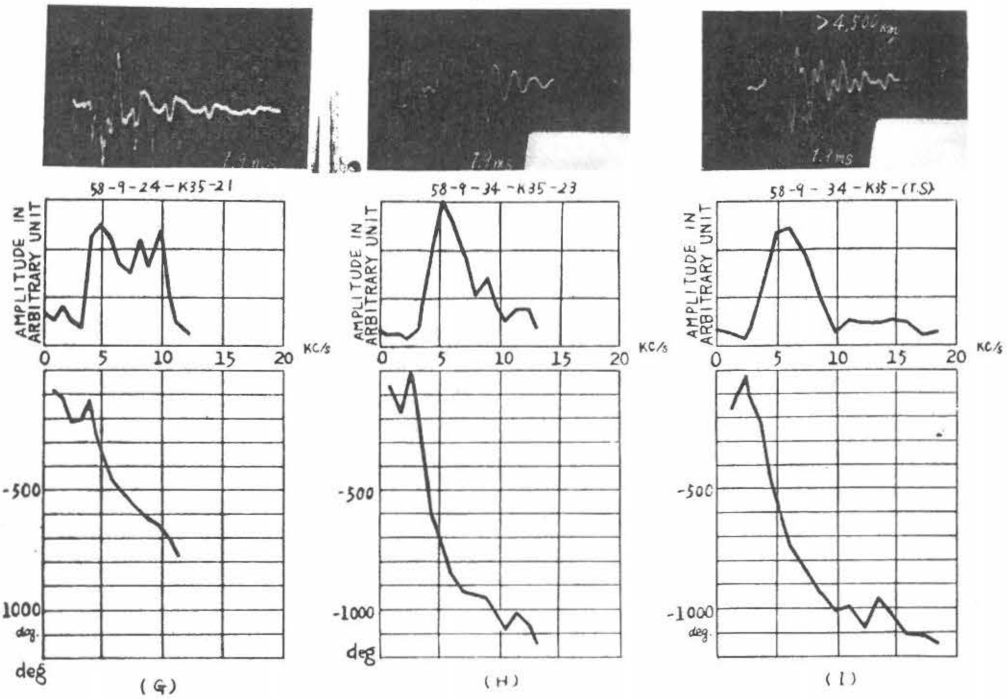

1.9 ms
1.9 ms
1.9 ms
58-9-4-K35-24(1)
58-9-4-K35-29(10)
58-9-24-K35-30
AMPLITUDE IN ARBITRARY UNIT
0 5 10 15 20 KC/S
-500
-1000
deg
(D)
(E)
(F)

Fig. 2—3


58-9-24-K35-21
58-9-34-K35-23
58-9-34-K35-(T.S)
>4,500 km
1.9 ms
AMPLITUDE IN ARBITRARY UNIT
0
5
10
15
20
KC/s
-500
-1000
deg
(G)
(H)
(I)