ON HARMONIC COMPONENTS OF TWEEKS

Jinsuke OHTSU and Mizuo KASHIWAGI

Tweeks are atmospherics which generally occur at night and sound as a decending tone of a sharp and short duration. When the tweeks are analysed with a sound spectrograph, they show a trace continuing for a few milliseconds to several tens of seconds, approaching exponentially to a certain limiting frequency lying around 1.8 kc/s. This limiting frequency is the cut-off frequency of the tweeks. We may call this portion of the tweeks as the fundamental component of the tweeks.

On some occasions we can find branches separating from the fundamental component, whose frequncies are in higher harmonic relations to the fundamental component of the tweeks. These portions of the tweeks may be called as second, third, ------ harmonic components of the tweeks.

Several years ago the author showed (1) that the existence of the lower limiting frequency and the characteristics of propagation time against frequency of tweeks can be well explained by the attenuation factor and the group velocity obtained from numerical study based on waveguide mode theory. And, as the extension of this theory, it could also be shown that each harmonic component of the tweeks corresponds to each order of the mode.

However, as to the observed higher harmonic components of the tweeks, there

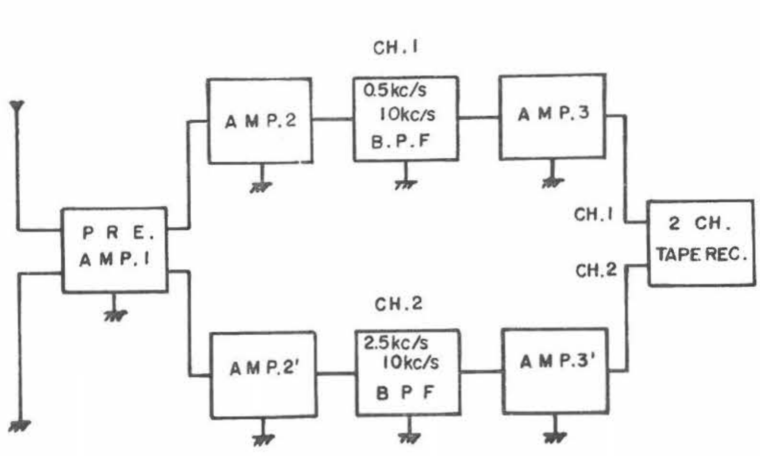

Fig. 1 Receiving system of atmospherics.

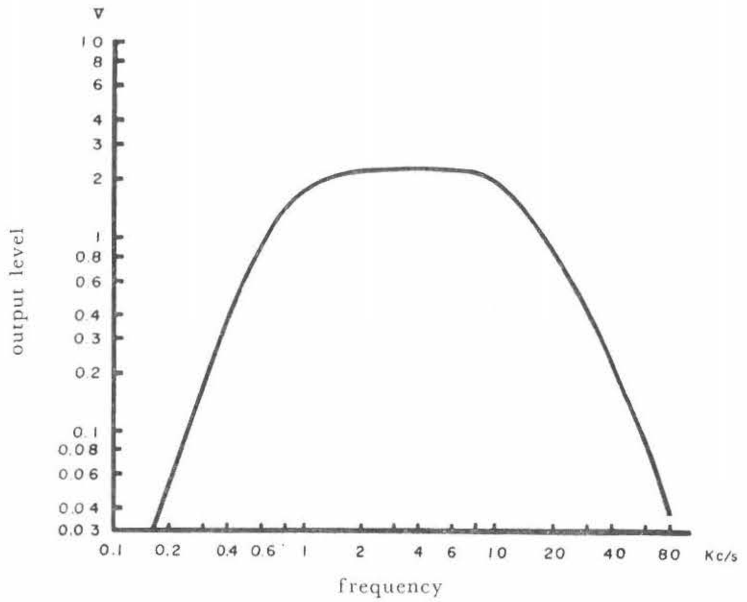

Fig. 2 Frequency response of Channel 1.
Input level: 30 mV

would be an objection that they could have been caused by the saturation of amplifiers in the receiving system due to the intense signal strength of the fundamental component of the tweeks. This short note briefly describes some results obtained from an experiment carried out for clearing away this suspicion.

A diagram of the receiving system is shown in Fig. 1. The signals picked up by a vertical antenna are led into the pre-amplifier and then they are divided into two channnels of different pass-bands. The outputs of these two channels are recorded separately in a two-channel magnetic-tape recorder. The total gain in the pass-band of both channels is nearly the same, which has a value of about 55 db. As shown in Fig. 2, the channel 1 has a pass band from 500 c/s to 10,000 c/s. Accordingly, the fundamental component of the tweeks can go through the circuit of channel 1 without being attenuated, together with the higher harmonic components. While. in the channel 2, a band-pass filter of 2,500 to 10,000 c/s is inserted, so that the attenuation due to this filter for the lower cut-off band amounts to about 35 db as can be seen in the frequency response curve in Fig. 3. Thus the signal intensity of the fundamental component of the tweeks may be heavily attenuated for frequencies below 2,500 c/s, while the higher harmonic components can go through without being attenuated.

Before starting to record, the field intensity of the tweeks was roughly measured with a cathode-ray oscillograph. And it was confirmed that the intensity did not exceed 10 mV at the input of the pre-amplifier. The gain of each amplifier had been carefully adjusted so as not to cause saturation.

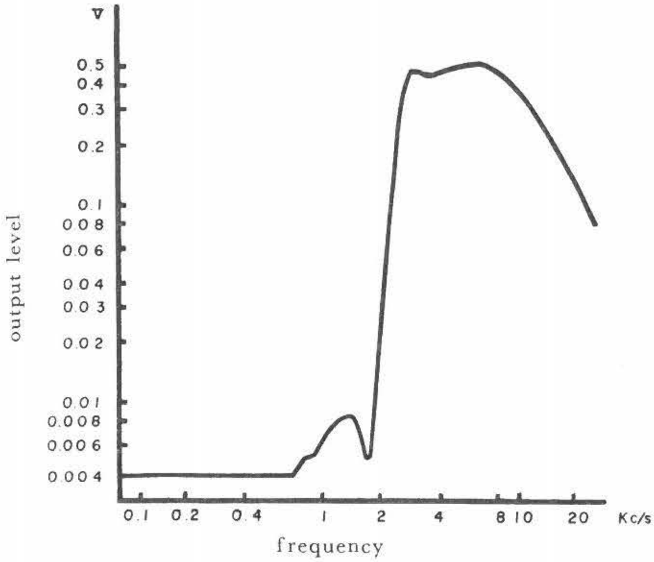

Fig. 3 Frequency response of Channel 2.
Input level: 10 mV

The tweeks observed through this experiment were analyzed with a sound spectrograph, which are shown in Figs. 4 and 5. In each Figure, the tweeks received through the channel 1 are shown in the lower side and those through the channel 2 are shown in the upper side. The fundamental and the second harmonic components of the tweeks can be seen on the record through channel 1 in Fig. 4. But in the same Figure, the exponential portions of the fundamental component of the tweeks can not be found on the record through channel 2. The same result can be seen on the traces in figure 5, where the higher harmonic components up to the fourth order can be found. This experiment clearly indicates that the higher harmonic components of the tweeks have never been caused by saturation of amplifiers in the receiving system due to the intense signal strength of the fundamental component, but they have been generated from the propagation characteristics of VLF waves radiated by lightning discharges. And the existence of the higher harmonic components of the tweeks is a good evidence to verify the adequacy of waveguide mode theory for the VLF propagation between the earth and the ionosphere.

Reference

(1) Ohtsu, J. : Numerical study of tweeks based on waveguide mode theory, Proc. Res. Inst. Atmospherics, Nagoya Univ., 7, 58 (1960)

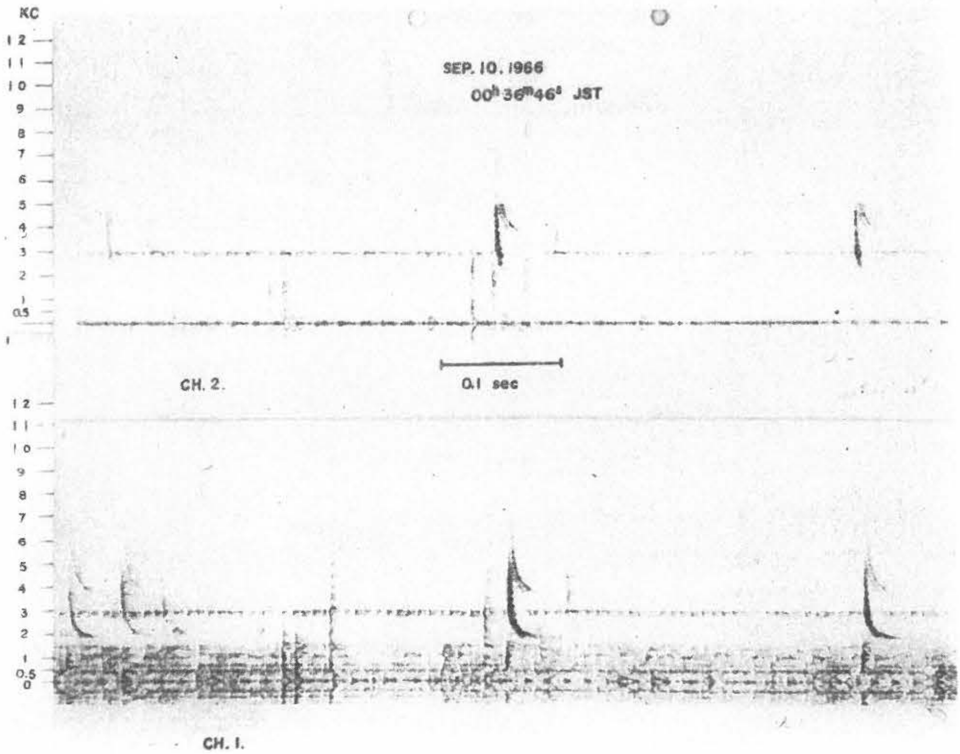

Fig. 4 Tweeks (Saku Shima Island)
upper: received through a 2.5-10 kc/s band-pass filter.
lower : received through a 0.5-10 kc/s band-pass filter.

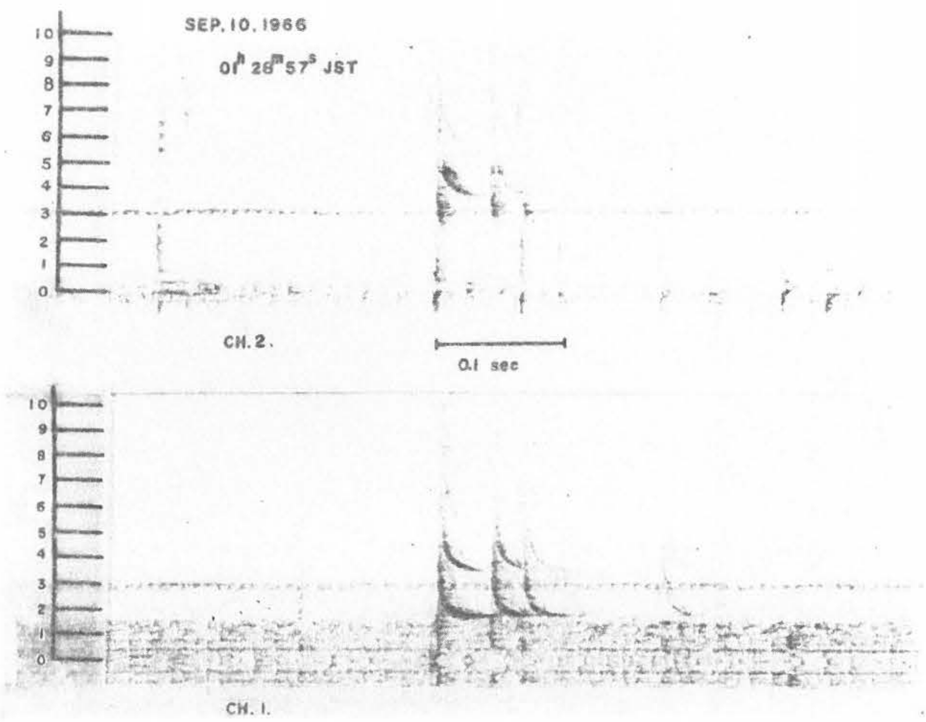

Fig. 5 Tweeks (Saku Shima Island)
upper: received through a 2.5–10 kc/s band-pass filter.
lower: received through a 0.5–10 kc/s band-pass filter.