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EXTREMELY LOW FREQUENCY RADIO EMISSIONS IN BAT CAVES

WALTON C. KOEMEL
Route 2, Box 173, Lamesa, Texas 79331

Bats produce very low frequency (VLF) radio pulses and display magnetic qualities. Extremely low frequency (ELF) radio emissions were observed inside bat caves. Ground return currents from 60 Hz AC power systems run through the ceiling of some bat caves.

MATERIALS AND METHODS

I developed a metal antenna tuned radio frequency (TRF) receiver that could be tuned to the radio electric wave to the exclusion of a microphone-detected audio wave (Koemel & Callahan, 1994). It is a wide band receiver, but only frequencies between 20 Hz and 18,000 Hz can be heard in the earphone. Atmospheric radio emission observations were made in an area not affected by 60 Hz AC power systems.

In July, 1993, I began observing extremely low frequency and very low frequency (ELF\VLF) radio emissions in caves and VLF radio pulses produced by flying bats. The pulses produced by bats were observed only during bat flight activity. This article contains preliminary data obtained with the TRF receiver.

METHOD OF RECORDING OBSERVATIONS

I recorded the observed ELF radio emissions by attaching an electric-shielded patch cable from the TRF receiver earphone jack to the microphone input jack of a computer-compatible cassette tape recorder set in the RECORD mode. This connection prevented the tape recorder from recording sound. I held the TRF receiver motionless while recording ELF radio emissions. I kept my body in contact with the TRF receiver chassis ground, while making observations, to prevent static discharges from "hand capacitance".

COMPUTER ANALYSIS OF EMISSIONS

I used a Heath-Zenith digital computer oscilloscope (Model No. IC-4802, Heath, Bent Harbor, MI) driven by a Tandy 1000-HX computer and Tandy JP 250 printer (Tandy, Fort Worth, TX 76102) to analyze the radio emissions. I played the tape recordings into the shielded oscilloscope probe by adapting the probe to the earphone jack of the cassette tape recorder. This connection prevented sound and static from entering the oscilloscope. The oscilloscope used the computer monitor as a display screen and it can freeze the waveform on the screen for analysis. Two movable cursors on the screen enable the operator to read the waveform frequency in hertz. I obtained a print (17.5 by 13.5 cm) of the waveform on the screen by entering the print code into the computer. The oscilloscope prints used in the following figures are from this oscilloscope. I also used an Audio Spectrum Analyzer to identify the frequencies in the observations.

RESULTS

I made observations at Mason Bat Cave on 17 October 1994, in the afternoon, during which time the weather conditions included a partly cloudy sky with rain showers. Figure 1 shows some of the observed ELF/VLF radio emissions in the atmosphere, including a static discharge from a rain cloud in the area near Mason Bat Cave. The waveforms produced by bats (Figs. 8-9) were not found in the analysis of these observations. ELF/VLF radio emissions of different weather conditions produce distinctive frequency spectra. Figure 2 shows radio emissions produced by a sand storm, Figure 3 demonstrates radio emissions produced by a blizzard, and Figure 4 shows radio emissions produced by a clear moonlit night sky. I do not know if the 2,000 Hz pulse in Figure 4 is from a bat. A clear daytime sky is similar to Figure 4.

Atmospheric ELF/VLF radio emissions can be observed inside Mason Bat Cave near the ceiling. Figure 5 indicates observed ELF/VLF radio emissions near the cave ceiling, and Figure 6 shows ELF/VLF radio emissions near the floor of Mason Bat Cave. The radio emissions produced by the bats were not found in the analysis of these observations. Figures 5 and 6 demonstrate no ground return current from 60 Hz AC power systems running through Mason Bat Cave. Figure 7 shows a strong 120 HZ radio emission near the ceiling of Lair Cave near Carlsbad, New Mexico. Ground return currents from 60 Hz AC power systems cause this frequency. The radio emissions observed near the floor of Lair Cave were similar to Figure 6. Mason Bat Cave has a prolific bat population while Lair Cave is sparsely populated.

I observed VLF radio pulses produced by flying bats inside these caves. They produce a "pop" sound in the TRF receiver earphone, and computer oscilloscope analysis shows their waveforms are different from atmospheric static discharges (Fig. 1). These pulses are multi-peaked with frequencies that range from 2,000 to 3,500 Hz. They last from one to three milliseconds (ms). Figure 8 shows a 2,500 Hz radio pulse produced by a flying bat (see cursors) and Figure 9 represents a 2,000 Hz radio pulse produced by a flying bat (see cursors).

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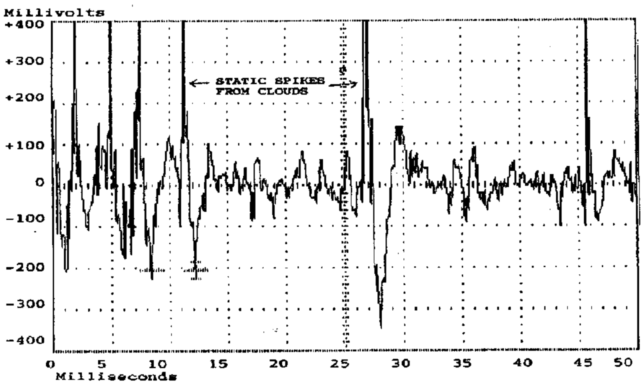

Figure 1. Oscilloscope recording of radio emissions in the atmosphere near Mason Bat Cave.

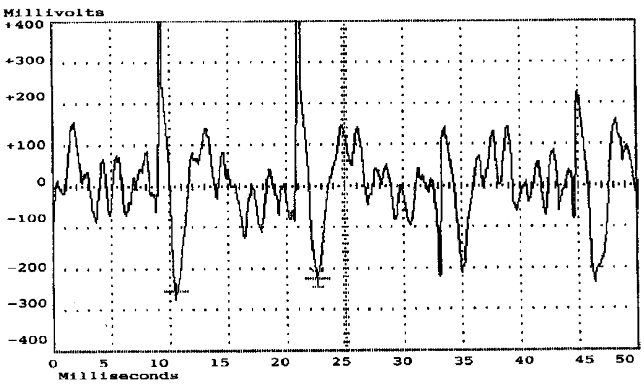

Figure 2. Oscilloscope recording of radio emissions produced by a sand storm.

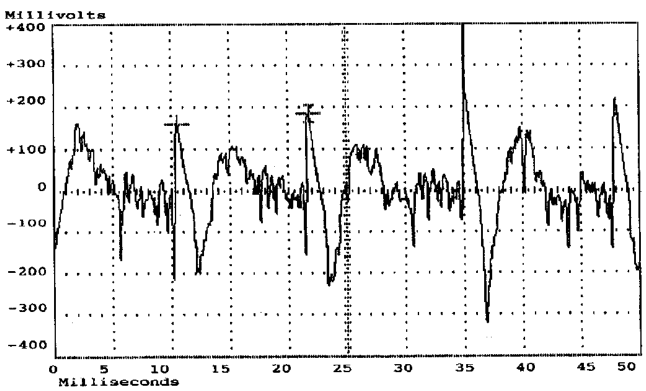

Figure 3. Oscilloscope recording of radio emissions produced by a blizzard.

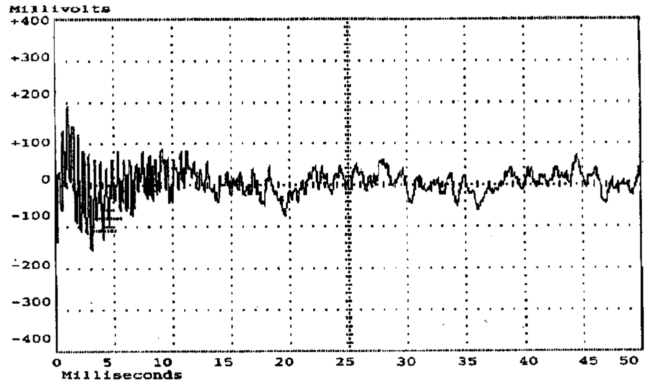

Figure 4. Oscilloscope recording of radio emissions produced by a clear moonlit sky.

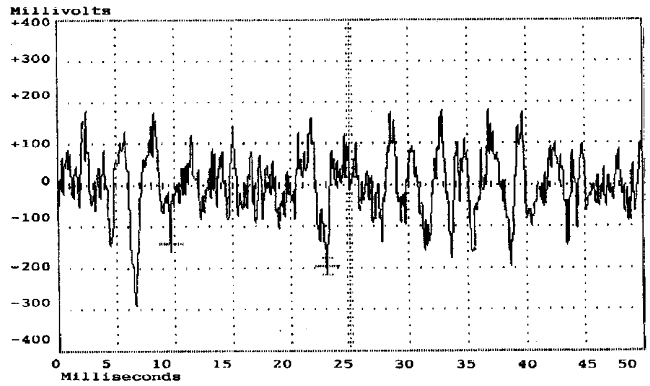

Figure 5. Oscilloscope recording of radio emission near the ceiling of Mason Bat Cave.

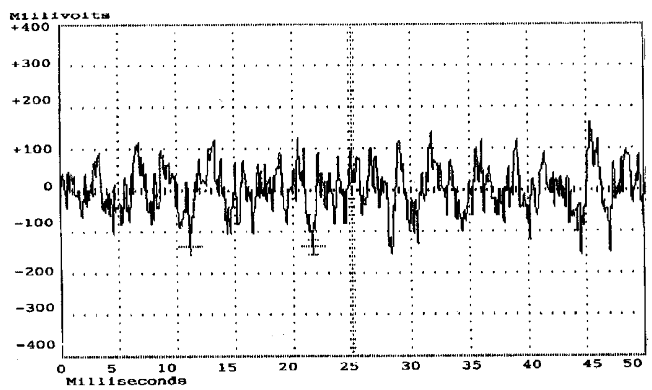

Figure 6. Oscilloscope recording of radio emission near the floor of Mason Bat Cave.

Bats have magnetic remanence (Buchler & Wasilewski, 1985). The magnetic rotation in the northern hemisphere is counter-clockwise, and clockwise in the southern hemisphere. Bats display magnetic qualities by flying in a counter-clockwise rotation as they exit caves in the northern hemisphere, and by flying in a clockwise rotation as they exit caves in the southern hemisphere.

CONCLUSION

Bats can use atmospheric radio emissions to detect weather conditions from inside a cave. Bats may be affected by 60

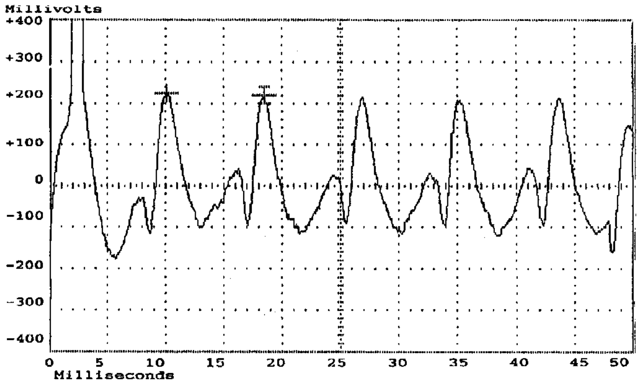

Figure 7. Oscilloscope recording of radio emission near the ceiling of Lair Cave.

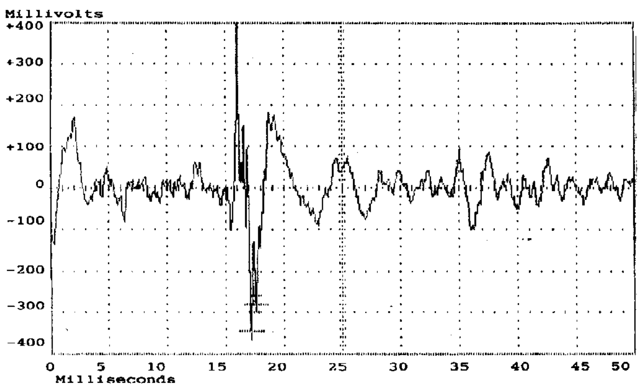

Figure 8. Oscilloscope recording of 2,500 Hz radio emission produced by a flying bat (species unknown) (see cursors).

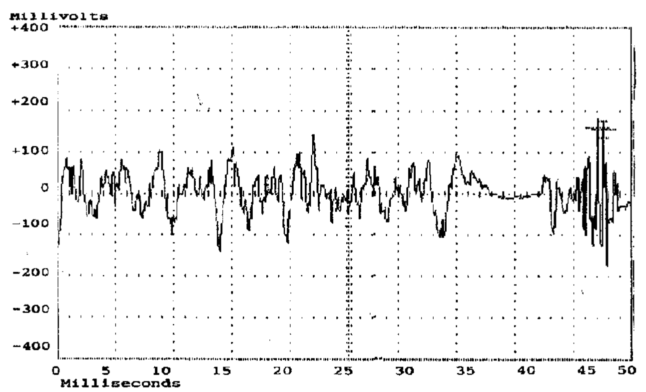

Figure 9. Oscilloscope recording of 2,000 Hz radio emission produced by a flying bat (species unknown) (see cursors).

Hz ground return currents in caves.

The VLF radio pulses produced by flying bats might be used to paralyze insects electronically immediately before catching them during predation. Another possible use for these VLF radio pulses is in a far-infrared imaging system. ELF radio and audio frequencies cause molecules to emit their far-infrared molecular spectrum (Callahan, 1989). This would enable a bat to locate its young inside a cave. The bat's whiskers and configurations on the bat's nostrils make perfect waveguides for microwave and far-infrared receptors (Callahan, 1975). Bats orient themselves to the earth's magnetic field at the cave entrance, enabling them to locate the cave entrance in total darkness.

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