Carl M. Chernan WA3UER
1135 Constitution Drive
Tarentum PA 15084

In Search of the Elusive SES

—track solar activity with this simple VLF receiver

With the continuing and growing interest in solar flare activity, including the predictions for Cycle 21, radio amateurs and experimenters alike are searching for methods to follow and record this fascinating phenomenon. The SES (Sudden Enhancement of Signal) receiver that I am going to describe in this article provides a simple answer.

Photo A. Finished package with the fine-tune control added.

When a solar flare occurs on the sun, there is a major emission of X-rays. This has the effect of increasing the electron density of the D layer, immediately enhancing the storm noise (or the transmitted signal) to levels about twice normal. The effect is very prominent in the LF and VLF ranges. This enhancement, though it has a rather rapid rise time as seen from the recordings in Fig. 1, has a slow decay time as the D layer reestablishes its normal condition which can take from 30 minutes up to an hour.

Heat generated by the sun in the daytime periods expands the gas in the D layer, lowering its efficiency for radio propagation such a device and did so before anyone else on this planet. That's my claim." He described "considerable distance" as several miles.

James L. Johnson is another unabashed Stubblefield booster. In a 1961 speech, the former executive secretary of the Murray chamber of commerce told the annual convention of The Kentucky Broadcaster Association in Louisville: "'Hello Rainey... Hello Rainey.' These four words, highly insignificant in themselves, were the gateway that opened a fabulous industry in the late 19th and early 20th century. These were the first words ever broadcast by radio. These four words put you people in business."

Following the address, the association presented the chamber of commerce a plaque recognizing Nathan B. Stubblefield as the inventor of broadcast radio.

But Riley Kaye W4LMF holds a different view of the Stubblefield story.

"I think Stubblefield invented the induction telephone. He used loops above the ground. There appeared to be no carrier. He used audio frequencies, and that's where the challenge comes in," said the man who worked for 7 years as chief instructor at RCA and high-frequency development engineer for Western Electric in Chicago.

"There is no proof that he used radiation. There's no proof he used resonant circuits. That would be radio."

Kaye, 9DKN during sparkgap days, added: "Nobody can challenge that he didn't invent the wireless telephone and that he was the first to transmit voice without wires. He deserves a lot of credit and Murray can be proud of him."

Despite its limitations, Kaye believes that Stubblefield's system needs a closer look. "It's not a private system, but it is cheap. It has a range of about five miles and seems perfect for community civil defense and emergencies. That avenue has not been pursued."

(Note that in Stubblefield's patent the ground rods are missing. In his early work, he employed a conduction system of telephony using the earth, but he later switched to an induction system. Evidently, Stubblefield confused the two media, thinking his voice traveled through both of them in a similar fashion.)

Another local ham takes issue with the Stubblefield saga. William Call KJ4W is vice-president and trustee of the Murray State University Amateur Radio Club. "It may have been magnetic induction," he said. "But you won't find that opinion around here much because it offends people. They want to believe he invented radio. On what I've seen," the school's electrical engineer said, "I don't believe he invented radio, but one thing almost everyone agrees on is that Stubblefield was a genius."

That he was.

Assaults on his claims of inventing radio have drawn attention from Stubblefield's other brilliant inventions. In 1888, he patented the first mechanical telephone, and he linked Murray with the system. It worked well until Bell introduced his electrical telephone which was superior in voice quality and reliability. He also invented a new type of primary battery, previously mentioned, whose revolutionary design stepped up dry-cell technology many notches.

So, if Stubblefield didn't invent radio—and it appears from his patent that he really didn't—who did?

According to many experts, another relatively unknown inventor, Reginald Aubrey Fessenden, on December 11, 1906, gave the first public demonstration of voice transmission using Hertzian waves—radio as we know it.

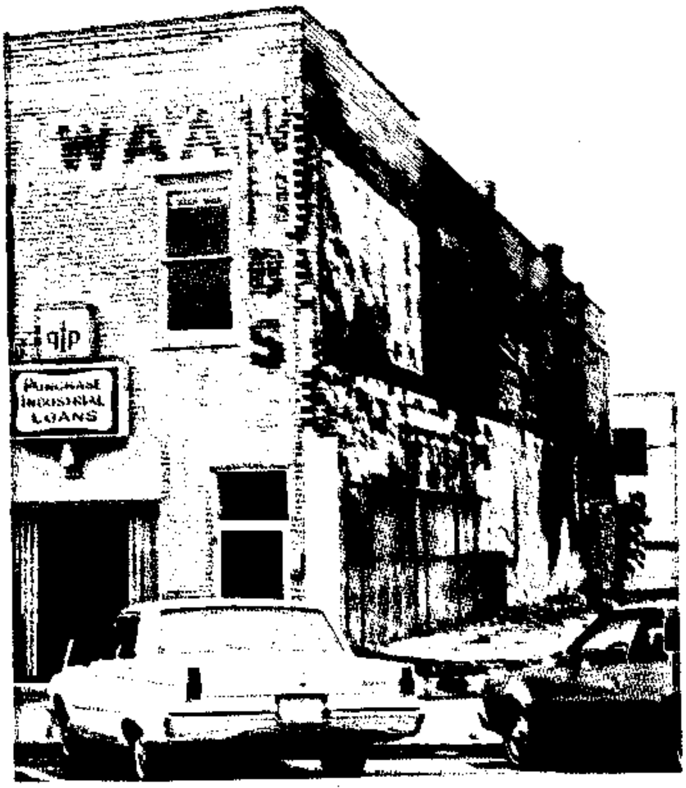

Photo H. Built in 1948, radio station WNBS was the first broadcast station in Murray. Its call letters were chosen to honor Nathan B. Stubblefield.

The exhibition by the one-time chief chemist of Thomas Edison's lab took place at Brant Rock, Massachusetts. He reportedly told a journalist in 1915 that he had been toying with the invention for some time and perfected it in December, 1900. He gradually increased the transmission range until, in 1904, he could cover 25 miles. Then he offered it to the Navy for development.

Fessenden was born October 6, 1866, in East Bolton, Quebec, and died July 23, 1932, in Bermuda.

So, it appears that although Stubblefield didn't invent radio, he was indeed the first person to send wireless voice transmission and suggest that it be employed in a moving vehicle such as a boat or horseless carriage.

But he holds another title, too. He was the first to transmit wireless voice from a ship.

In a 1971 thesis paper for Florida State University titled "The Contribution of Nathan B. Stubblefield to the Invention of Wireless Voice Transmission," author T. Morgan wrote: "Nathan B. Stubblefield was not the father of radio broadcasting. Stubblefield was the first man to successfully transmit and receive the human voice without wires. Therefore, let him be called the father of wireless voice transmission, for this title is truly his."

Perhaps I should drive to East Bolton and see if the residents there agree. ■

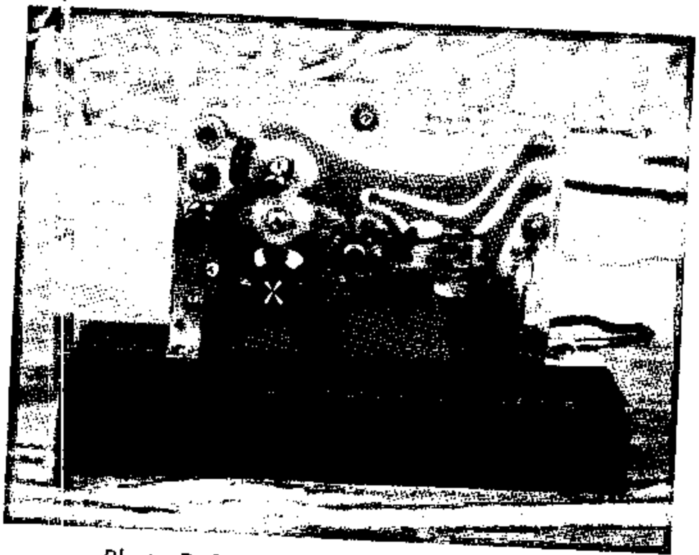

Photo B. Prototype receiver—front view.

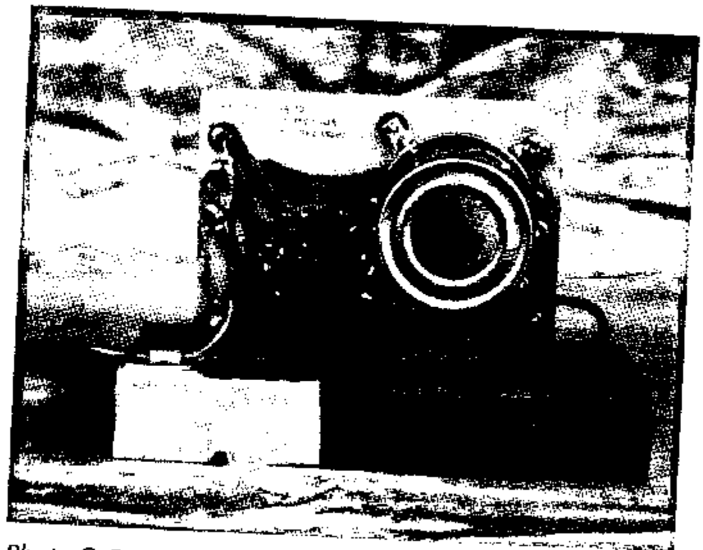

Photo C. Prototype receiver—rear view, showing the shielding method used.

during the day. Similarly, the cooling of the layer allows the gas to contract, increasing its efficiency; this, of course, is the reason that AM radio stations are received at greater distances at night. There also are seasonal effects which occur as the Earth heats or cools, depending upon the angle of the sunlight as it strikes the Earth.

Receivers used to record these enhancements come in two categories. The first is an SEA receiver that is tuned to an unused frequency spectrum in the VLF range—hence the name, Sudden Enhancement of Atmospherics. The second type is tuned to a transmitted signal in the VLF range, and is the SES receiver—referred to above. SES receivers are easier to tune, and you do not have to be an expert to interpret the recording charts.

Building the SES Receiver

A proven circuit for building a tunable SES receiver is shown in Fig. 2. It is basically a high-gain amplifier which is tunable from 17.8 to 35 kHz. If you use the exact components shown on the schematic, the frequency range will be from 17.8 to 23 kHz. This circuitry is then followed by a detector and integrator and finally by a dc amplifier which brings the dc signal-related current up to a proper level to operate an analog meter or a recording device.

The recorder recommended is a model 288 Rustrak (0-100 uA) with a chart speed of 1" per hour, although I have used Esterline Angus 0-1-mA chart recorders successfully. The receiver has more than enough gain to peg a 0-1-mA meter.

All of the parts used in the construction of the receiver are standard, with the exception of the inductor coils. These inductor coils (Miller 6319) are high-Q types and are Litz-wire wound. They can be obtained from Bell Industries, J. W. Miller Division, 19070 Reyes Avenue, PO Box 5825, Compton CA 80224.

Wiring of the circuit is not critical; however, I suggest that a socket be used to mount the IC amplifier. A

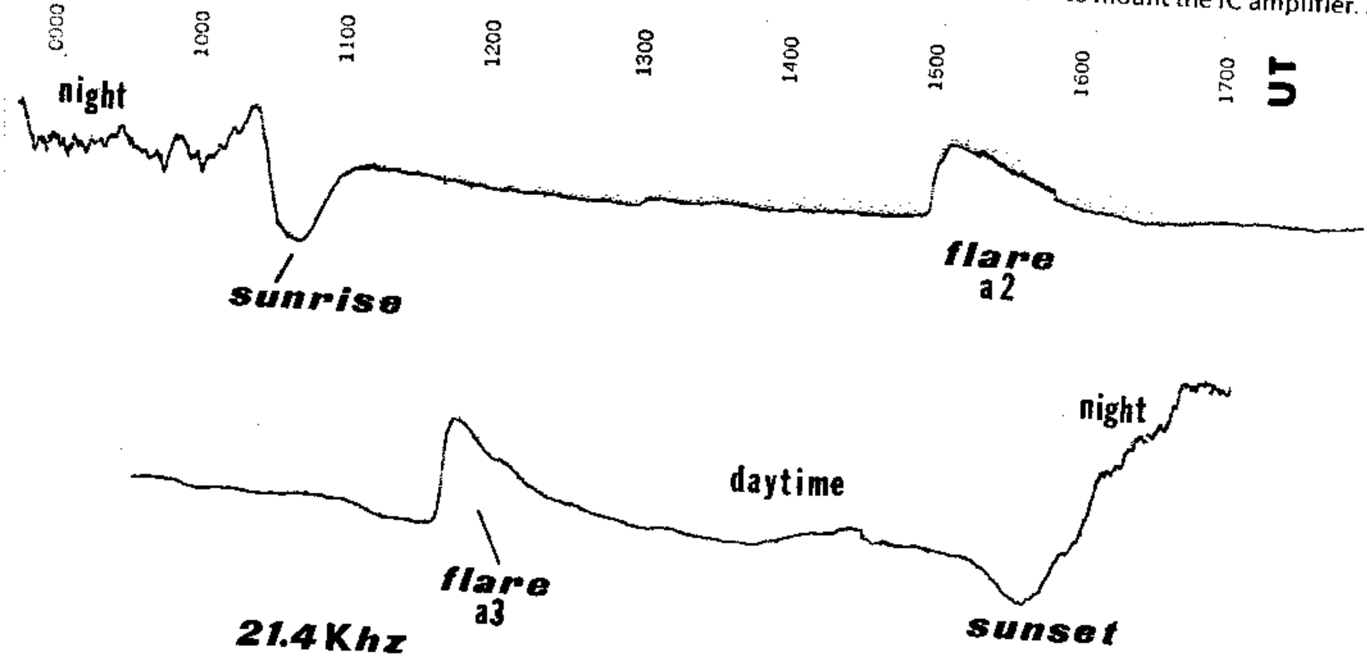

Fig. 1. Actual recordings showing characteristic fast rise/slow decay times.

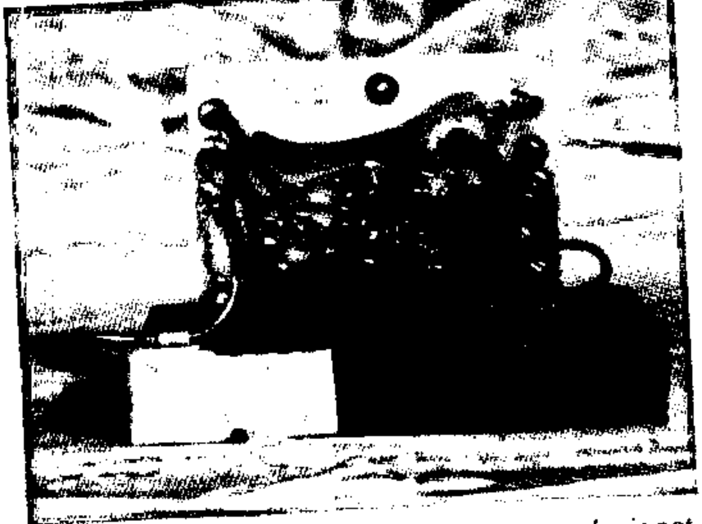

Photo D. Shield removed to show coils, L1, L2, and gain pot.

substitution for the RCA CA3035 amplifier array is the more-readily-available Sylvania ECG-785. Both wideband amplifier arrays are made up of three individual ultrahigh-gain amplifiers. These amplifiers have low noise characteristics, can be operated either independently or in cascade, and have excellent high cascade voltage gain—129 dB at 40 kHz. The output transistor (RCA SK3019) can be replaced with either a Sylvania ECG-108 or a GE-214. Power supply requirements are 9.3 V dc for optimum operation, but any well-regulated 12-volt power supply can be used. The higher the voltage, the "choppier" the trace will become on the recording.

Initial Tuning Procedure

Run the cores of L1 and L2 completely in. Proceed to turn the gain control (R1) ¼ turn clockwise. Connect the antenna (preferably an 18-foot vertical or an 8-foot CB whip) to the receiver input jack. Ground the receiver using a good earth ground. Connect an oscilloscope (using the vertical input) to the test-point jack on the receiver. Turn out L1 one full turn. A large sine wave will appear on the screen, showing a prominent "hump."

If you have used the components specified in the schematic, this will be a signal coming from 17.8 kHz (NAA, Coutler, Maine). The format of this transmitted signal is such that it cannot be used in solar flare studies, so continue to turn the core of L1 out. The 17.8-kHz signal should drop out and a small hump will appear. This will be 18.6 kHz—NAA's 1-megawatt station. If the signal has good strength, by all means record it. If the signal is weak, as in my case, continue with the turning by opening the core of L1 until it's almost fully open or until a large signal reappears on the screen.

This signal will be 21.4 kHz (NSS) radiating a 200-kW signal. This station is an excellent choice for flare propagation recording for a number of reasons. First, it is easy to access (you cannot mistake the signal) and tuning is straightforward. Second, my records, along with the records at the AAVSO (American Association of Variable Star Observers) show that a lot of small flares are recorded at this frequency while they are often completely missed at other low frequencies.

If an oscilloscope is not available for tuning, the receiver can be tuned with a 0-200 uA meter placed across the receiver's recorder output terminals. When coil L1 is turned, a prominent peak will indicate that you have tuned the signal.

Final Tuning Procedure

Disconnect the oscilloscope or tuning meter and place a recorder at the designated terminals. Turn up gain control R1 to give you a mid-scale reading of either 50 uA or close to 1 mA if you are using a 0-1-mA recorder. By turning L1 in and out a few threads, peak the signal. Fine-tune the signal with 5-6 turns of L2. In some cases, it will show a prominent increase; in others, it will not. (Since all coils are not the same, the tuning of L2 may vary.) To test for oscillation, disconnect the antenna; the signal on the recorder should drop to zero or almost to zero. When the ground is disconnected, the signal definitely should drop to zero.

Other Hints and Correlation Ideas

The receiver itself can be housed in any standard metal or wood enclosure, but be sure to make use of adequate shielding around the inductor coils to ensure proper mixing. I use small, lined aluminum cans attached to brackets which are mounted to the circuit board. These make excellent shields.

Good correlation on an official basis for flare recording and verification may be obtained by sending for a weekly solar data bulletin (free) printed by the government. Write to the Space Environment Services Center, Space Environment Laboratory ERL, NOAA, Boulder CO 80302. Ask for the preliminary report and forecast of solar geophysical data.

Circuit boards for building the receiver are available from me for $8.00 each, plus postage.

For those further interested in solar flares and flare recording, my *Handbook of Solar Flare Monitoring and Propagation Forecasting* is available from Tab Books. ■

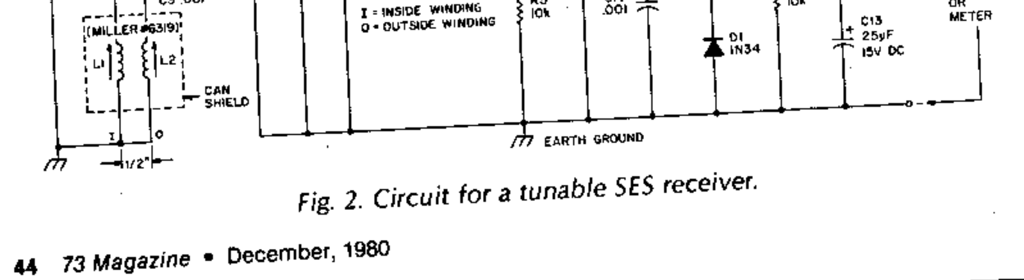

Fig. 2. Circuit for a tunable SES receiver.