Natural Radio

News, Comments and Letters About Natural Radio

August 2014

This month's article comes to you from Creve Coeur, Missouri. I'm on writing my laptop with a starter version of MS Word, so please excuse any weird formatting that might show up. I discovered a 1997 paper by Robert Helliwell where he describes the early days of whistler research leading up to the International Geophysical Year (I.G.Y.) in 1957, so this month I'll share his and some other stories about whistler research in the early 1950's

As I write this I am marveling at the technology that we now consider commonplace and how much it has changed since the early days of whistler research. For the past couple of days, I navigated around St. Louis from hotel, to wedding chapel, to reception hall and everywhere else using a smartphone app called "Waze". My normal mode of navigation is to study a map in advance and build a mental picture of the main roads and landmarks and then maybe use a GPS app to track progress. For whatever reason, my St. Louis map was nowhere to be found, so we navigated by just following the app directions. Waze not only integrates GPS and map data, but allows real-time input from all users to identify traffic congestion, accidents, police presence and so on. It integrates all of this to give you the fastest route to your destination and provide warnings of road hazards. Obviously, the navigator should be using Waze and not the driver, but my wife likes to drive and I like to navigate, so it worked out well. Very slick.

We often take out technology for granted, and even those of us who spent a lot of our developmental years before online connectivity, have a hard time remembering what those times were like. Whistler receivers have not changed all that much since the beginning. They are still high gain audio amplifiers connected to a loop or a piece of wire. But, it's not so much the details of receiver design that makes our hobby possible, but the advances in communications technology. We have access to forums where we can meet with other enthusiasts and ask questions and share information. Digital audio lets us send recordings instantly around the world and even share live audio streams. We have access to real-time satellite data and an endless menu of every other type of information we could possibly want.

Before we were able to connect online, information exchange was slow and research was difficult even if you had access to a first-class university library. Finding information was tough, but even tougher was finding out that the information actually existed. Doing research on whistlers would not be a concern if you've never heard of them.

Before 1950 there was little study of whistlers and the like. Eckersley had done a little research and written some articles, but it wasn't until 1950 when Robert Helliwell was conducting some research on tweeks at Stanford that whistlers were recognized as a phenomenon. One of his students, Jack Mallinckrodt, was doing the recording and monitoring of atmospherics and tweeks at a shack out on Old Searsville Rd. In addition to his monitoring and recording of tweeks, he was periodically hearing "long tweeks" which he recognized as another phenomenon. Helliwell though that Mallinckrodt was spending too many hours with headphones on and maybe just needed some rest, but after Helliwell actually heard them, he knew they were different, his interest was sparked, and the rest is history. Helliwell describes it this way in a paper called "Whistlers" (R. A. Helliwell,

Discovery of the Magnetosphere, History of Geophysics Volume 7, Copyright 1997 by the American Geophysical Union.)

> We started, as I recall, about 8:00 p.m., after sunset, so as to reduce the effects of D region absorption, that tended to smear out the waveform of the tweeks, making the interpretation difficult. The tweeks that night were good and we paid so much attention to the quality of the wave forms that I had almost forgotten the purpose of my visit. Then it happened—a clear descending whistler came from the loudspeaker, lasting 2-3 seconds, and I cried to Jack, "Is that what you've been hearing?", and he said, "Yes, that's it!" After hearing a few more whistlers, I became a confirmed believer and asked Jack to go to the Stanford library to determine whether anyone had reported similar observations. And, they had. There were several references to whistlers of which two were particularly significant.

The two significant references were to Barkhausen's hearing of whistlers on the device he used to listen in on allied phone conversations during WWI, and Eckersley's observations and theory, the so called "Eckersley approximation", for the dispersion of a lightning pulse in the Earth's ionosphere. However, Eckersley couldn't develop a workable model for the path of propagation since it was believed at that time that the atmosphere ended just above the F layer.

Across the Atlantic, Owen Storey was working on his PhD. Dissertation at Cambridge. His recordings showed that "long" whistlers came from lighting strikes within a few thousand kilometers of Cambridge and "short" whistlers originated in the Southern hemisphere. Using the Eckersley approximation, Storey determined by ray tracing, that if the whistler path was aligned to the earth's static magnetic field out to 3 or 4 earth radii, one could get a good fit to the data. Unfortunately at 3 to 4 earth radii, his model required an electron density ~400/cc, which was in total contradiction of the current belief that the atmosphere terminated at an altitude of a few thousand km.

J.A. Ratcliffe, Storey's Ph.D. advisor at Cambridge, reported that his density prediction was probably wrong because of this contradiction. As it turned out Storey's density was in good agreement with later satellite and other whistler measurements. The result was Storey discovered the *thermal* magnetosphere well ahead of the discovery of the radiation belts by Van Allen in 1958.

Now, there was little or no amateur activity at this time, just because no one had any way of knowing about whistlers unless they had contact with the researchers at the universities. With no Internet, this type of news didn't travel fast.

John Davis wrote about ***Popular Electronics*** magazine and its influence last month. This magazine shaped the beginning of amateur involvement in whistler research when it brought the subject into the public eye. Magazines like ***Popular Electronics*** and ***Scientific American*** were the only source of news for the amateur scientist and electronics enthusiast. ***Popular Electronics*** was also instrumental in kindling my interest in electronics and radio. I got my introduction to the magazine when, at the tender age of 10, I pulled several neatly tied bundles of them from my neighbor's trash. They came from his wife's brother, and when they found out I was interested in them, they delivered them directly to me and I no longer had to trash pick. That was certainly a part of my early electronics education and took me well beyond the meager collection of electronics books in the public library. You can only go so far with Alfred P. Morgan's ***The Boy's Second Book of Radio and Electronics***.

Popular Electronics also introduced me to whistlers. The I.G.Y. was making its way into the popular press and the December, 1956 issue of ***Popular Electronics*** had two articles relating to whistler research:

"Thunderbolts and Whistlers", Don Gleason, ***Popular Electronics***, December 1956
"How To Hear Whistlers", Don Gleason, ***Popular Electronics***, December 1956.

Most of the information on whistler research revolves around Helliwell, probably because of his book, ***Whistlers and Related Ionospheric Phenomena,*** Stanford University Press, 1965, which is still the bible for amateurs interested in whistlers and the other sounds that originate in the ionosphere. But, also important is the organization he built at Stanford which is still one of the premiere organizations researching atmospheric emissions and space weather.

Nevertheless, there was plenty of research being carried out on the east coast in the early 1950's. Don Gleason's stories were the result of a visit to the Naval Research Lab where whistlers were being studied. The U.S. Naval Research Laboratory, the first modern research institution created within the United States Navy, began operations in July of 1923 after Thomas Edison urged that such a research center should be established. Many innovations in radio and science came out of this lab, one of the most important ones being radar.

The lab's VLF expert at that time was Harold E. Dinger who joined the Naval Research Laboratory in Washington, DC, in 1940 where he made substantial contributions in the fields of radio propagation, radio interference reduction, frequency management, and geomagnetics.

Dinger wrote a book in 1956, titled "Whistling Atmospherics" which was published by the NRL. The abstract of Dinger's book summarizes what the laboratory was doing in the early 50's:

> Since 1953 NRL has been observing and recording audio-frequency atmospherics and their correlation with other geophysical phenomena. Beginning in April 1955, the diurnal variation in both whistler activity and the occurrence of "dawn chorus" has been determined. Whistler coincidence at several locations has been recorded in an attempt to prove L.R.O. Storey's theory on the mode of propagation of these atmospherics. Many whistlers of unusual character have been spectro-analysed for the purpose of extending present theory to cover the general case. Plans have formulated for synoptic observations at a number of selected locations during the International Geophysical Year.

Gleason's "Thunderbolts and Whistlers" article laid out the basic theory of Whistlers and the sounds you might hear. He cites the work of Barkhausen, Eckersley and Storey, but doesn't mention Helliwell,

Also at that time, the NRL was collaborating with Dartmouth College and Prof. Millet Morgan. In the December 2006 issue of ***The Lowdown*** I wrote about Professor Millet Morgan and some of his recordings. He produced several recordings in cooperation with Emory Cook at Cook Laboratories. These are probably the first commercial Natural Radio recordings ever produced.

The actual recordings were done by Professor Millet Granger Morgan (W1HDA) from Dartmouth College in Hanover, New Hampshire. A press release from Dartmouth on his death in 2002 summed up his career:

"In the early 1950s Prof. Morgan established a research program to use the newly discovered phenomena of naturally occurring audio-frequency radio waves produced by lightning and the aurora as a tool to study the properties of space plasma in the vicinity of the earth, a region now known as the upper ionosphere and the magnetosphere. These studies made it possible to gain insights about the properties of this region of near-earth space in the years before space craft began to make direct observations. Prof. Morgan recorded the naturally

occurring signals, referred to by descriptive names such as "whistlers" and "dawn chorus," at a network of receiving stations, and interpreted them to obtain some of the earliest measurements of the density of free electrons many thousands of kilometers above the earth. His work provided experimental foundations for early studies of how the earth and its magnetic field interact with the solar wind."

Ionosphere was released in 1955 and contains simultaneous Natural Radio recordings made in Hanover, NH near Dartmouth College where Professor Morgan was on staff and Washington, DC. Hanover and Washington are separated by about 415 miles or 665 km. which generates some very wide spaced stereo. I assume that this recording was done in cooperation with the NRL and likely Harold Dinger.

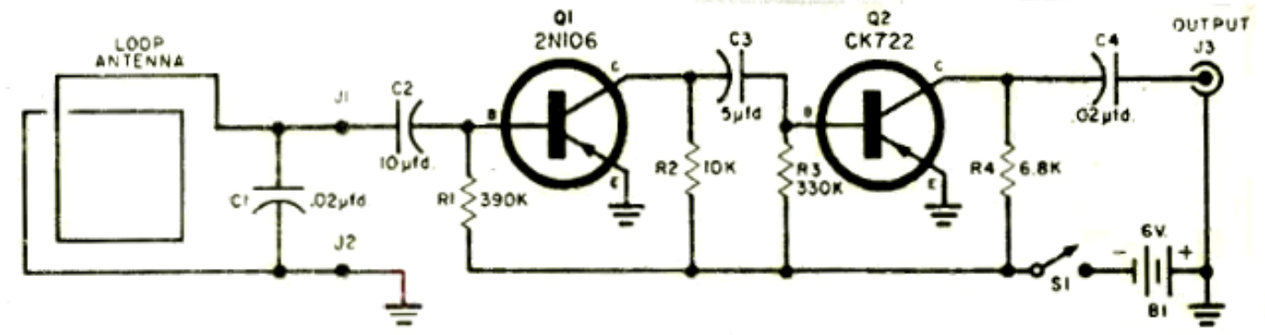
In that same December 1957 issue, the world of Natural Radio was opened to all interested hobbyists. Don Gleason's article, "How to Hear Whistlers" laid out the plans for a simple whistler receiver. The radio was based on a loop antenna. The instructions went like this:

> To make the antenna, get 300 to 600 feet of any small-diameter insulated copper wire, either solid or stranded. Wind it into a large coil, 20 to 50 or more closely spaced turns using the outline of an opened door as a temporary coil form. Bind the turns together with string or insulating tape at short intervals along the coil to make a single closely packed winding. Remove the coil from the door, and open it up into an approximately square shape. Using strings, suspend it in a vertical plane from the ceiling…

The ends of the wire were connected to the magnetic input of a phono pre-amplifier. Then you placed a simple RC filter between the preamp and the power amp to filter out the 60 Hz. Hum. You rotated the loop to find a null for the hum and you listened. It was a simple, but effective method of reception for loud whistlers. This was probably the first construction article for a whistler receiver.

In April of 1957 in John T. Frye's "Carl and Jerry" column, Jerry builds the whistler receiver described above, and picks up strange signals from what turns out to be a set of wireless earphones.

A couple of years later, Popular Electronics published: "Build the Black Box that Hears Missiles", C. Welch, ***Popular Electronics***, April, 1959. Although the article was written to pick up the VLF signature of a missile, the author stated that if you could hear whistlers and tweeks, you had enough sensitivity to pick up a missile. The unit consisted of a loop antenna and a two-transistor preamp, which was probably the first solid state whistler receiver. The preamp used two cascaded, capacitor coupled, PNP germanium transistors stages wired for maximum. It was primitive design by today's standards, but this was the beginning.



If would like to read these old articles and your archival file for old ***Popular Electronics*** magazines is lacking, I found a great online source for old radio and electronic magazines and literature at **AmericanRadioHistory.com**

And that was the beginning of serious whistler research and the introduction of the hobby to amateur scientists and radio enthusiasts. If anyone knows of any other earlier articles on building a whistler receiver, I'd love to hear about it.