WARCI News

Wisconsin Antique Radio Club, Inc.

Winter Meet — **January 2014**

Location for January 12 Meet

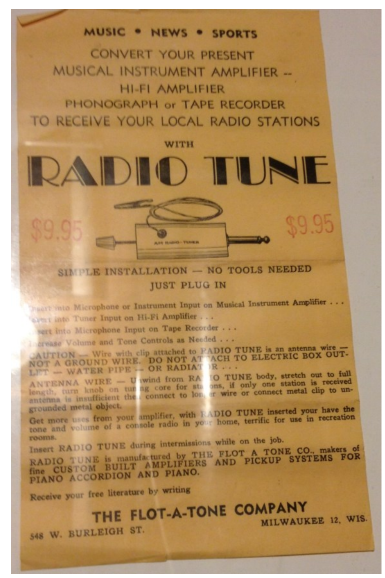
Best Western Plus Milwaukee Airport Hotel and Conference Center at 5105 S. Howell Avenue, at Edgerton Avenue. Exit the Airport Spur at Howell Avenue and go North to Edgerton Avenue.

The meet will be held in the Concourse Room. Buyers use lobby entrance. Follow the signs. Sellers use double doors just west of the lobby for unloading. Tables will be provided. Doors open for set up at 7:00AM, the meet is 8:00 — 11:00 AM.

Crystal Radio Sets - History and Wisconsin

There was a great variety of Wisconsin– made Crystal Sets - see pages 4-5 for more examples.

Western Coil and Electric, Racine (Greg Hunolt)



Flot-A-Tone Co., Milwaukee (Dale Boyce)

Next WARCI Meet:

	Sunday, January 12, 2014; 8:00 – 11:00 AM. Doors open 7:00 AM.
	Best Western Plus Milwaukee Airport Hotel and Conference Center at 5105 S. Howell Avenue, at Edgerton Avenue. Near the Airport.
	Features: 50-50 Raffle

Inside This Issue...

WARCI, Inc.

The Wisconsin Antique Radio Club, Inc. exists to preserve the knowledge of radio, television, and other related disciplines. We have a special interest in the history of radio in Wisconsin, Wisconsin radio companies, radio stations, etc. Our members' interests include radio, television, audio, and antique phonographs.

Officers and Board

President - Greg Hunolt
ghunolt@excel.net
920-893-0422 / 920-918-5027

Vice President – Still Open !!

Treasurer – Bill Engaas
CraftyradioBK@yahoo.com
262-786-8183 / 414-217-6001

Secretary - Mike Sadjowitz
michaels@wi.rr.com
262-544-1468 / 262-352-1148

Board - Jim Menning, Dennis Schrank,
Dale Boyce, Terry Hanney

PR Coordinator - James Michaels
james.michaels@me.com

WARCI News Editor – Greg Hunolt

WARCI Website – Nick Tillich
webmaster@warci.org

WARCI Information

WARCI is incorporated in the State of Wisconsin.

Annual membership dues are $15 for each calendar year, January – December. (Allowance is now made for new members joining in July or September.)

Seller's fee at Swap Meets is $7.00 for members, $10 for non-members.
The next Swap Meet will be held on January 12, 2014, at the Best Western Plus Milwaukee Airport Hotel, 5105 S. Howell Avenue at Edgerton Avenue.

The swap meet times are 8:00AM – 11:00 AM. Doors open at 7:00AM for set-up if we need to be inside.

WARCI News

This newsletter is the official publication of the Wisconsin Antique Radio Club, Inc. It is published four times per year, in January, May, July and September. The WARCI News is free to all paid-up club members.

Articles or material for the newsletter are most welcome and should be sent to Greg Hunolt, ghunolt@excel.net or N5412 State Hwy 57, Plymouth WI 53073. Include your name, address, phone, and email. PC format (e.g. MS Word) by email is preferred. JPEG for images is preferred. Please contact Greg Hunolt for assistance.

Classified ads up to ¼ page are free to WARCI members

The cut-off date for all newsletter material is about the fifteenth of the month preceding publication of the next newsletter (e.g. April 15, 2014, for the May, 2014 issue).

WARCI Website

www.warci.org

The WARCI website features information about WARCI activities, Wisconsin radio, articles, etc. Contributions are most welcome! Contact our webmaster Nick Tillich, at webmaster@warci.org . Thank you, Nick, for your great work.

Voluntary Member Directory
There is a new feature on the website that lets you create a listing for yourself in a club member list. You can describe your interests in radio, etc., and provide contact information. This capability put in place by NARC has provided some good contacts for WARCI members who are also NARC members and have listed themselves on the NARC site. We encourage you to list yourself on our site - it is purely voluntary.

WARCI Headlines

September Meet & Auction Report

The September meet was again great; we had a very large turnout. We did not collect table fees at this meet, nor did we get a good count of sellers. We netted $28 from the 50-50 Raffle.

The main event was WARCI's third Oktoberfest Auction. The auction was a success — WARCI thanks to the auction team.

The auction was about the same size as our first two auctions. We had 27 people participate as buyers and/or sellers, compared to 27 in 2012 and 24 in 2011. Nine people consigned 31 lots, compared to 9 people consigning 23 lots last year, and 10 people and 30 lots in 2011. Fourteen consigned lots sold, 45%, compared to 14 or 61% last year and 15 or 50% in 2011.

We sold 10 donation lots this year, compared to 4 in 2012 and 6 in 2011.

The total price of all lots sold was $1,281 this year, compared to $963 in 2012 and $1,315 in 2011.

We took in $18 in bidders' card fees, $155 in lot fees, and $196 in donation lot sales, for a total of $369.

Although we didn't get bigger this year, and we had a lot of no sales, the auction 'process' went very very well. Again, many thanks to you all, and great work by Jim Menning as floor leader organizing and leading his group, planning the physical layout; creating a separate area for auctioned lots was excellent. Likewise great work by the "desk team".

I think we now know how to do this, how to run a good auction. For next year, we need to think of how we can attract more folks to consign and participate. Jim Michaels had a point – we should advertise all year that we will have an auction at our September meet, not wait until just before the meet.

Once again, we enjoyed the excellent pizza cooked and served by Joe Halser and his staff.

Membership Update

We are now up to 62 paid members for 2013, and 65 active members, beating our club high of last year. We finished 2012 with 58 paid members, which was up very nicely from 44 paid members in 2011.

September Board Meeting Notes

The WARCI board, noting the long gap between our September and January meets, decided to add a sixth meet to be held in November. The board, with Joe Halser, settled on a 2014 meet schedule (see below). Note that because of conflicts with other events, the usual May meet ended up being scheduled for June 1.

Nick Tillich reported on activity on the WARCI website over the past year. We've been getting about 5,000 page views per month (and a similar level of activity on the Facebook page). There were 38,000 page requests for photos or articles, with the most on battery radios and battery radio manufacturers. This suggests that we should have more articles from the newsletter split out as separately indexed and accessible. The board agreed to discuss the website in more depth at the January meet, circumstances permitting.

January 2014 Meet

The January meet will be held on Sunday, January 12, 2014, at the Best Western Plus Milwaukee Airport Hotel and Conference Center at 5105 S. Howell Avenue, at Edgerton Avenue. This is a few blocks north of the interchange with the Mitchell airport spur. This is just a short distance north of our usual meeting place, the Terminal / Landmark.

Thanks to Dennis Schrank for arranging this for us.

WARCI Meeting Dates for 2014

January 12, Best western Plus (see above).

March 23, The Terminal

June 1, The Terminal

July 20, The Terminal

September 21, The Terminal

November 9, The Terminal

ARCI February Meet

ARCI's next meet will be held on February 9, 2014, at the American Legion Hall, 570 S. Gary Ave., Carol Stream IL. It will be an indoor swap meet, 7:00-11:00 AM, with a donation auction and Boy Scout breakfast. See the ARCI website: **www.antique-radios.org** .

Wisconsin-Made Crystal Sets

Briggs & Stratton, Milwaukee - Dale Boyce

Lakeside Corporation, Milwaukee - Dale Boyce

Sunlyte Radio, Milwaukee -- Dale Boyce

Wisconsin Makers of Crystal Radios:

BASCO - Briggs & Stratton Corp, Milwaukee

Borchert-Manegold Engineering & Mfg., Milwaukee

Clearco Crystal Co., Milwaukee

Hobby Specialties Co., Milwaukee

JASCO - Julius Andrae & Sons Electric Co, Milwaukee

Lakeside Corp., *Milwaukee Pocket Crystal*, Milwaukee

Marinette Electric, *Little Tattler*, Marinette, WI

Sheess, Lake Geneva

Sunlyte, Milwaukee

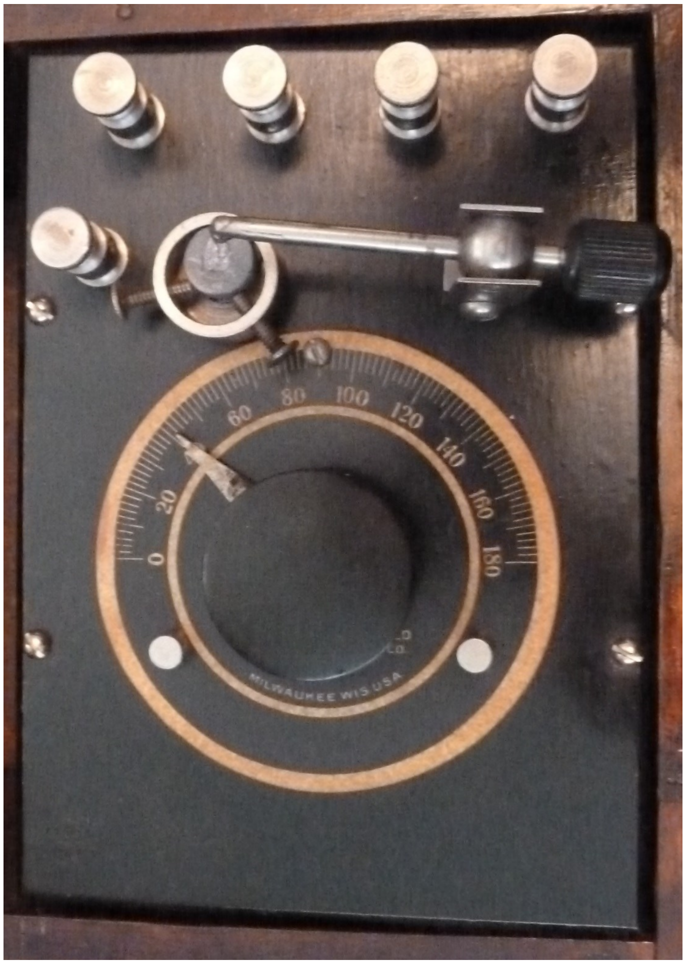
Webster Electric, Racine

Western Coil, Co., Racine

Western Screw & Specialty Co., Racine

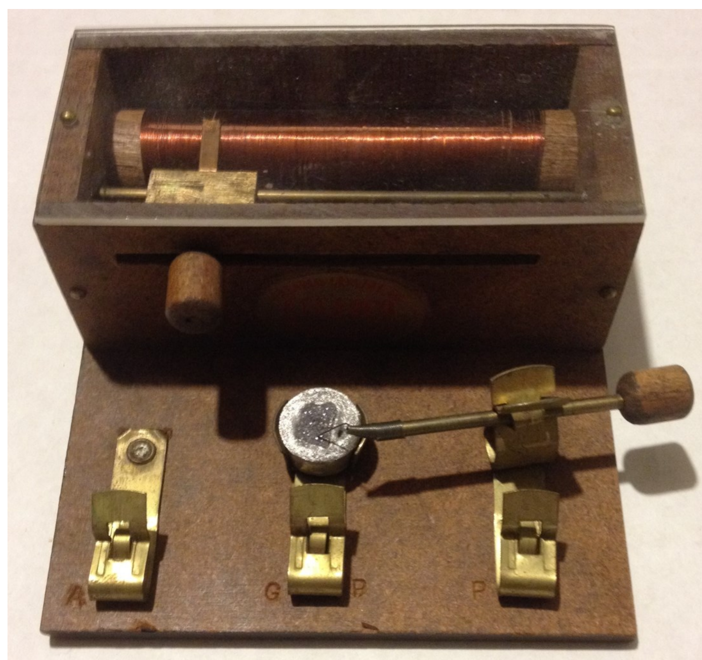
Contributed by Dale Boyce

More Wisconsin-Made Crystal Sets



Borchert-Manegold, Milwaukee - Glenn Trischan

Sheess Mfg., Lake Geneva - Dale Boyce



Clearco Crystal Co., Milwaukee - Dale Boyce

Editor's Note:

The WARCI News is your newsletter.

Your comments and suggestions for the newsletter are most welcome.

Your contributions of articles or other material are urgently needed. Your help is needed to make the WARCI News a success and to ensure that it covers the full scope of the interests of WARCI members.

If you're not seeing articles on topics you are interested in, ***write one.***

You may submit complete articles, but information from which an article can be developed is also welcome.

Don't agonize over format, etc., as I will have to adapt your submission to the newsletter anyhow. Simple text is best. PC format (e.g. MS Word, separate jpegs by email) is preferred, but hardcopy text and photos are accepted.

In this issue we have a feature article on the history of crystal receivers by Brian Belanger, reprinted from *Dials and Channels* (journal of the National Capital Radio and Television Museum, Bowie MD) with his kind permission. This article is accompanied by Brian's note on how the sets work, and by photos of Wisconsin-made crystal sets. (Dale Boyce, Glenn Trischan and I contributed photos.)

In our next issue, for May 2014, we'll have an article on Philco, "Famous the World Over", contributed by WARCI member Greg Van Beek.

We will also cover tube audio and television and other member interests – but we need your contributions of articles or information for articles.

Thank you, and see you at the January meet,

- Greg Hunolt, Editor, WARCI News

WARCI Welcomes!

WARCI welcomes David Derosier of Racine, WI as a new member, *thank you!* We hope you will enjoy being a WARCI member.

Bob Paquette's Microphone Museum

WARCI member Bob Paquette's Microphone Museum features his collection of well over 1,000 different makes and models of microphones as well as related pieces of equipment. The emphasis is on historically important microphones made between 1876 and 1950, and early radios, telephones, and many other communications devices, including an assortment of military gear. Check out Bob's website, http://www.sssmilwaukee.com/Microphone%20Museum.html

Bob always enjoys visitors and will be happy to give a guided tour to individuals or groups. You can call Bob at Select Sound (414) 645-1672 to arrange for your visit. Just ask for Bob Senior. The museum is located on the second floor of Select Sound, 107 E. National Avenue in Milwaukee. Enjoy your visit and allow yourself plenty of time.

Renew Your Membership for 2014!

WARCI membership runs January to December, so it is now time for you to renew for 2014!

Please complete the Membership Renewal form that you received with this newsletter and bring it to the next meet or mail it, with $15, to Bill Engaas, 18265 W. Thornapple Lane, New Berlin, WI 53146 .

Crystal Radios

By Brian Belanger

WARCI thanks Brian Belanger, editor of "Dials and Channels", the newsletter of the National Capital Radio & Television Museum, for kind permission to reprint this article. The Museum is located in Bowie, Maryland, near Washington DC, and if you are ever out there it would be well worth visiting the museum. I also recommend that even if you are never able to visit the museum that you join and receive the excellent newsletter that Brian puts out. See the box on page 14 for more information.

In his introduction, Brian wrote: "The diverse readers of Dials and Channels *range from radio engineers who welcome technical details to Museum members who enjoy radio programs and TV shows, but could care less about how a radio or TV works. I could not resist the temptation to include a technical discussion about how crystal radios work (or, for that matter, how any AM radio works) but I placed it in a separate section". See page 16 for that discussion.*

My parents were alive in the 1920s when entertainment radio began. They, and most of their peers, knew about crystal radios. I grew up in the 1940s and 50s and, like many youngsters my age, I built a crystal radio from a kit, and enjoyed the experience. When today's kids and young adults visit the Museum, they often have no idea what a crystal radio is. Sometimes I ask visitors "Have you heard of crystal radios?" Some responses involve strange guesses. One boy envisioned a fortune teller's crystal ball emitting radio sounds. A young woman envisioned a radio encased in a beautiful cut-glass cabinet of Waterford crystal.

The majority of *Dials and Channels* readers probably already know what a crystal radio is, but even those who do may not know the details of how crystal radios came to be, or who filed the key patents, so let me borrow the late Paul Harvey's line and present "The Rest of the Story," i.e., how crystal radios work, who invented them, their pros and cons, and their "Golden Age."

This article deals only with AM (an abbreviation for *amplitude modulation*) because crystal radios were developed for AM reception. FM receiving is a different story. AM radio for entertaining the public began in 1920, whereas FM did not come along until the late 1930s. (See the March 2009 *Dials and Channels* for a history of FM.) All the crystal radios in the Museum's collection were intended for AM reception only.

Both crystal and vacuum tube radios were developed prior to WWI. Vacuum tube radios soon proved to be superior to crystal radios, but crystal radios continued to be popular long after vacuum tube radios had been widely adopted, because they were simple and *much* less expensive than vacuum tube radios.

Uncle Al's Radio Shop "Miracle 2," a 1925 factory-built crystal radio on exhibit at the Museum. Of better quality than many other crystal sets of the era, it sold for $12.75.

What is a Crystal Radio, and How Does it Work?

A crystal is defined as a solid material with a regularly repeating structure of atoms or molecules. Familiar crystals range from ordinary table salt to diamonds, but neither is used in radios. Crystals of materials such as silicon can be used in radios, along with a number of minerals, of which galena (lead sulfide) is the most common.

To understand the operation of a crystal radio, you need to understand how any AM radio extracts the program sound from the radio waves that bring that sound to the home. Each radio wave signal that arrives in our homes from an AM broadcast station consists of a "carrier wave," with the program

Crystal Radio continued on Page 8

Crystal Radio - continued from Page 7

content superimposed on the carrier. Think of the carrier wave as a horse, and the program content as a rider on its back. When you tune in a particular AM station on a radio, you are adjusting the receiver to match the frequency of the carrier wave of that particular station and rejecting the signals from other stations transmitting carriers of different frequencies.

At the transmitting station, a device called a *modulator* is used to superimpose the audio frequency sound signal on the much higher frequency (radio frequency) carrier wave. At the receiver, this process must be reversed. A device called a demodulator or detector is used to extract the sound signal from the carrier—to get the rider off the horse. In a crystal radio, the crystal provides this demodulation function. The terms detector and demodulator are often used interchangeably, but there is an important distinction, as will be noted later.

In the early days of radio when no one had yet figured out how to send voice and music through the air, radio signals were limited to the dots and dashes of Morse code. The simplest transmitter for Morse code is just a device capable of generating a carrier wave, with a switch (e.g., a telegraph key) to turn the transmitter output on and off. It turns out that crystal radios have been used for both code and voice reception. Radio pioneer Reginald Fessenden is credited with being the first to successfully transmit voice and music with radio, in 1906. By coincidence, that was just about the time that the crystal detector and the vacuum tube detector were invented.

In a crystal radio the audio frequency signal (the content to which we want to listen) is extracted from its radio frequency carrier wave by a demodulator device that utilizes a crystalline chunk of an appropriate substance. The mineral galena (lead sulfide) is inexpensive and works well, and therefore is most often used in crystal radios. The galena crystal and its associated components serve as the demodulator or detector. In addition to the crystal itself, the complete demodulator device also involves a metallic holder for the crystal, a wire often called a "cat's whisker" that makes contact with the surface of the crystal, binding posts to which the wires to and from the device are connected, and a base upon which the detector components are mounted. Most crystal detectors are open to the air although some are sealed in an enclosure.

From 1920 to 1960 most AM radios utilized vacuum tubes as demodulators. Transistors ultimately replaced vacuum tubes. A few hybrid radios utilized a crystal detector, supplemented by vacuum tubes or transistors to amplify either the radio frequency signals, the audio frequency signals, or both. Today one can buy a self-contained integrated circuit chip containing a detector as well as most of the other components needed for a complete radio.

An inexpensive mid-1920s Howe crystal receiver. Its selectivity was poor, so the tuning knob would have been unable to separate stations close to each other on the uncalibrated 0 to 10 dial. The antenna, ground, and headphone connections were on the back of the set.

The Crystal Detector's Inventors

It is common to find that when a technological development occurs, several inventors were working on the same basic concept simultaneously. That is the case with crystal detectors. The first individual to file for a patent is usually the person whose name shows up in history books, even though others researching that topic may deserve credit as well.

In the late 19th century the coherer detector (typically metal filings in a sealed glass tube) was the device commonly used to detect wireless signals, but it had severe limitations. Multiple researchers were striving to come up with a better detector. Two inventors—G. W. Pickard and H. C. Dunwoody—are commonly cited as having developed the first successful crystal detectors. Some say that Professor Chandra Bose in

Crystal Radio - continued on Page 9

Crystal Radio - continued from Page 8

India independently discovered the galena detector about the same time, but Bose did not receive key patents. Pickard and Dunwoody did.

Greenleaf Whittier Pickard

Born in 1877 in Maine, Greenleaf Whittier Pickard was the grandnephew of the poet John Greenleaf Whittier. After graduating from Harvard and then MIT, he began experimenting with radio, thanks to a grant from the Smithsonian. (Even in those days the federal government was striving to foster science and technology.)

GREENLEAF W. PICKARD

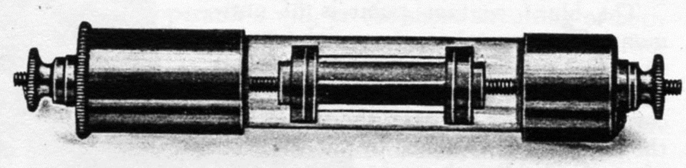
Pickard worked for AT&T for a time as the 20th century began, and in 1906 he became one of the founders of WSA, Wireless Specialty Apparatus (*Dials and Channels,* May 2011). WSA was formed in part to manufacture and market Pickard's innovations, such as the crystal detector. In 1913 he was elected president of the newly formed Institute of Radio Engineers.

In a 1919 article, Pickard credited two others for paving the way for the discovery of the crystal detector—Ferdinand Braun and David Hughes. In 1874 Braun discovered and reported that certain materials such as pyrite and galena exhibited unidirectional conductivity, that is, if a battery were connected to a chunk of such materials, current would flow in one direction, but if the battery were reversed, miniscule or no current would flow in the other direction. Such a device is called a rectifier, and today we know that for a crystalline material to be a suitable demodulator for AM radio signals, it must act as a good rectifier. But in 1874 radio had not been imagined, and Braun saw no useful application for his discovery.

In 1879 David Hughes experimented with carbon microphones and discovered that if such a microphone were connected to a telephone receiver (earphone), a nearby spark discharge somehow affected the carbon microphone and caused a click in the earphone. The carbon microphone was acting as a wireless signal detector, and Pickard remembered that. Ivor Hughes (see Sources) argues that historians have failed to give David Hughes proper credit for his research that served as groundwork for a number of later wireless developments.

The work of these two predecessors led Pickard (and others) to experiment with detectors involving carbon (thanks to Hughes), and minerals displaying unidirectional conductivity such as galena (thanks to Braun).

In 1902 several people in addition to Pickard were experimenting with a detector consisting of a sewing needle or needles resting lightly against blocks of carbon. (In WWII some soldiers built a "foxhole" crystal radio whose detector consisted of a pencil lead on a razor blade—the same basic idea.) While this delicate detector did detect wireless signals, it could not tolerate shock or vibration. Initially it was thought that such detectors needed to have a battery connected in series, but in wireless experiments at Cape May, New Jersey, in May 1902, Pickard removed the battery and was surprised to find that the detector worked better without the battery. Once Pickard realized that a light contact between a metal point and a block of carbon could serve as a detector, he began to wonder whether materials other than carbon might work even better. He resolved to explore Braun's approach, using materials such as galena.



PICKARD CARBON STEEL DETECTOR, 1902

Crystal Radio - continued on Page 10

Crystal Radio - continued from Page 9

Even though in 1902 no one had yet succeeded in transmitting voice and music via radio, several laboratories were striving to understand the process of modulation and demodulation. Pickard's employer, AT&T, was among them, and so from 1902 to 1906 Pickard carried out a systematic effort to find a better detector/demodulator. He reported: "*Suffice it to say that I have found some two hundred and fifty minerals and furnace products which make operative detectors—either against metallic contacts, or in combination with other minerals. The possible combinations of these two hundred and fifty substances, amounting to some 31,250 pairs, have all been tested by me, or my assistants, and many hundred useful pairs have been found.*"

Pickard's early work had focused on silicon detectors, but the less expensive alternative of a cat's whisker resting lightly on the surface of a galena crystal also worked well. It quickly became the most popular crystal detector. Its only downside was its lack of robustness. It was sensitive to jarring, so if the galena-type detector were used on a ship rolling on rough seas, or in any kind of moving vehicle, the wire might be bumped off the "sweet spot" and constantly need to be readjusted. But for home use by consumers, it was fine.

Pickard also developed the Perikon dectector, consisting of two crystals—copper pyrite and zincite squeezed against each other. (Perikon was an acronym arising from "perfect Pickard contact.) Because its contacts were pressed tightly together with spring tension, the Perikon detector was more robust for applications such as onboard a ship.

A home-made crystal set employing a Perikon detector, from the Museum's collection. The two crystalline chunks in the holders at the upper center are held together with spring tension. The operator manipulates the knobs at the ends of the horizontal shaft until a good spot is found.

Pickard continued to be active in radio technology all his life. In 1934 he became consulting engineer to the New England-based Yankee Network. That network later in the decade developed a chain of early FM stations. (*Dials and Channels,* March 2009).

General Henry Harrison Chase Dunwoody

H. C. Dunwoody developed the Carborundum (silicon carbide) detector, a robust device similar to Pickard's Perikon detector. Dunwoody patented it in 1906, about the same time as Pickard's detector. It was widely used in military and commercial radio equipment, although not often in radios intended for consumers.

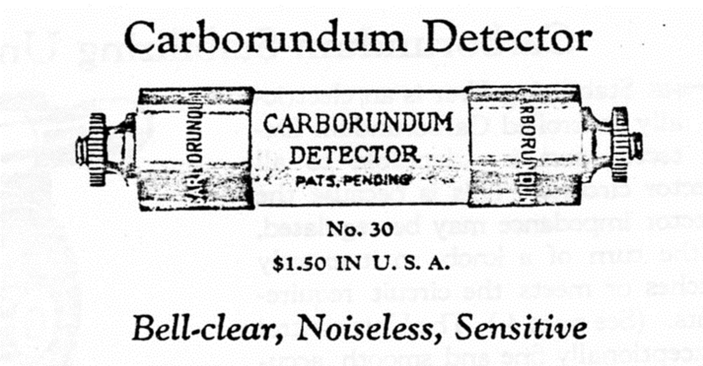
Brigadier General H. C. Dunwoody, who gets credit for inventing the Carborundum detector, another form of crystal detector.

Born in Ohio in 1842, Dunwoody had a distinguished military career. He began college at West Point in 1862 and quickly rose through the ranks of the U.S. Army Signal Corps. For a time in the 1880s he headed the U.S. Weather Bureau. Dunwoody served in Cuba during the Spanish-American War. He was very familiar with the latest developments in wireless for military applications, and had strong science/engineering skills in addition to military leadership skills.

Crystal Radio - continued on Page 11

Crystal Radio - continued from Page 10

Just after retiring from the Army, Dunwoody was hired to be vice president of the American de Forest Wireless Telegraph Company. Dunwoody's 1906 invention of the Carborundum detector saved the day for de Forest. De Forest's company had been relying on an electrolytic detector nearly identical to one invented by Reginald Fessenden. Fessenden had sued de Forest for patent infringement, so de Forest was desperate to find a substitute detector that worked as well or better than the electrolytic detector. Dunwoody's device solved that problem. Even Marconi's operators began to replace their company-issued magnetic detectors with rugged, yet sensitive Carborundum detectors.



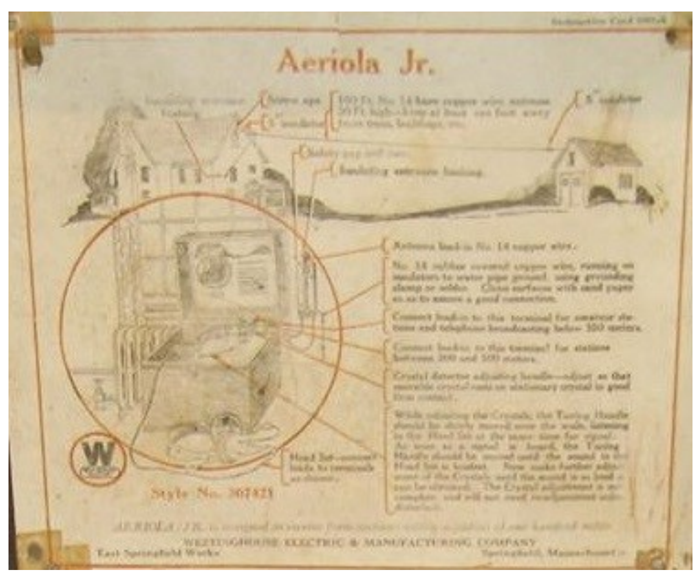
The Golden Age of Crystal Radios

In the early 1920s radio technology was a major research activity of the National Bureau of Standards. People commonly wrote to NBS seeking information about radio. In April 1922 the Bureau published Letter Circular 120, titled, "Construction of a Simple Homemade Radio Receiving Outfit." Providing instructions so that anyone could build an inexpensive crystal set, the publication cost only five cents. Thousands of orders flooded in from all states. Newspapers around the country reprinted it. Countless Americans built crystal sets based on the Bureau's plans, and manufacturers also introduced crystal radios based on the NBS design.

Some crystal detectors perform better if a battery of a few volts is connected in series with the detector. That constituted another trial and error chore for early experimenters—determining whether a "bias" battery improved performance, and if so, what the optimum voltage was. Another reason why galena detectors were popular was that they did not require a bias battery.

In the 1920s crystal radios were designed and/or sold by major manufacturers such as Wireless Specialty Apparatus, Westinghouse, Crosley, RCA, and GE, as well as a host of tiny start-up companies. The crystal radio that we like to demonstrate to visitors is a 1921 Westinghouse Aeriola Junior. It sold for $25 in 1921 (about $350 in today's dollars), at a time when a more elaborate vacuum tube radio might have cost four or five times as much.

We demonstrate this 1921 Westinghouse Aeriola Junior crystal set at the Museum. After 91 years, it still works fine.



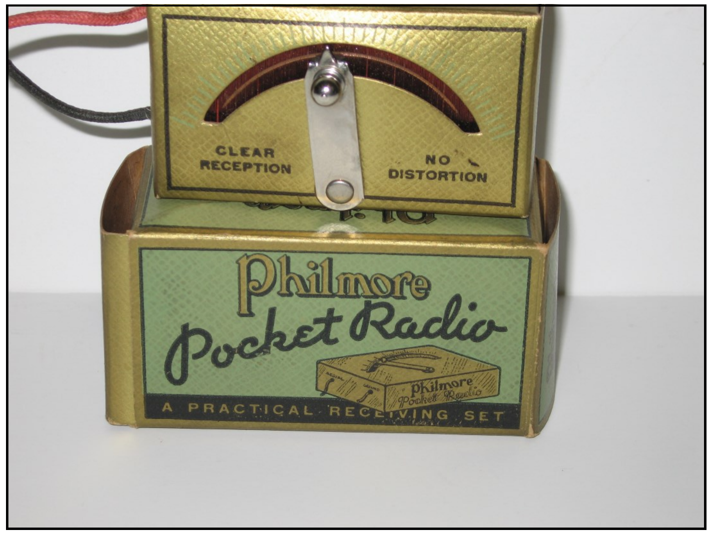
Crystal Radio - continued on Page 12

Crystal Radio - continued from Page 11

Homemade crystal radios often included a tuning coil of copper wire wound around a cardboard cylinder. An oatmeal box turned out to be just the right size. Noting this, the Quaker Oats Company in 1921 offered a crystal radio built into an oatmeal box for only $1 plus two labels from Quaker Oats products. Dwight Heasty built the replica oatmeal box crystal set shown here for the Museum. Tuning is done by sliding the contact on the right side along the coil of wire inside the box. The galena detector and cat's whisker are on top of the box.

By the mid to late 1930s, prices of vacuum tube radios had dropped precipitously, and performance improved dramatically, to the point where no adult would likely want to buy a crystal radio, no matter how cheap it might be. But companies such as Philmore continued to offer crystal radios to kids at low prices. They were advertised in magazines such as *Boys Life* and *Popular Mechanics*.

The tone quality of crystal radios is generally very good. Lacking any means of amplification, signals heard in the earphones are weak. Normally, only one person can listen at a time. But, in the 1920s, a family with a crystal radio tuned to a strong station might put the earphones into a large metal or china bowl and cluster above the bowl so that more than one person might simultaneously hear the incoming program.



This Philmore "pocket radio" on display at the Museum sold for $1 in the late 1930s, but did not perform very well. Like all crystal radios, it requires a long wire antenna and a good ground to pick up stations.

Antennas for Crystal Radios

The greatest limitation of a crystal radio is that it requires a high performance antenna to receive any stations. Modern radios typically have built-in antennas and so today's consumers do not have to climb an extension ladder onto the roof to string a long wire. Museum visitors are often amazed to learn how much trouble it was to erect a suitable antenna for an early crystal set.

The simplest crystal receiver has only a few components. In such a set there is no powered amplification as in a vacuum tube or transistor radio. The feeble signal current that arises when the radio waves impinge on the antenna wire is all the power available. A longer, higher antenna will provide more signal voltage than a short antenna, so makers of crystal radios recommended that users string a wire antenna, perhaps 70 to 150 feet long, as high off the ground as practicable. Also required is a good ground connection, because the feeble signal travels down the antenna lead-in wire, through the radio's input section, and into the ground. The illustration on page 12 (from a Philco antenna kit in the Museum's collection) shows a typical antenna installation of the 1920s or 1930s. (Early vacuum tube radios also relied on outdoor antennas.)

The simplest crystal radio installation is an antenna, a

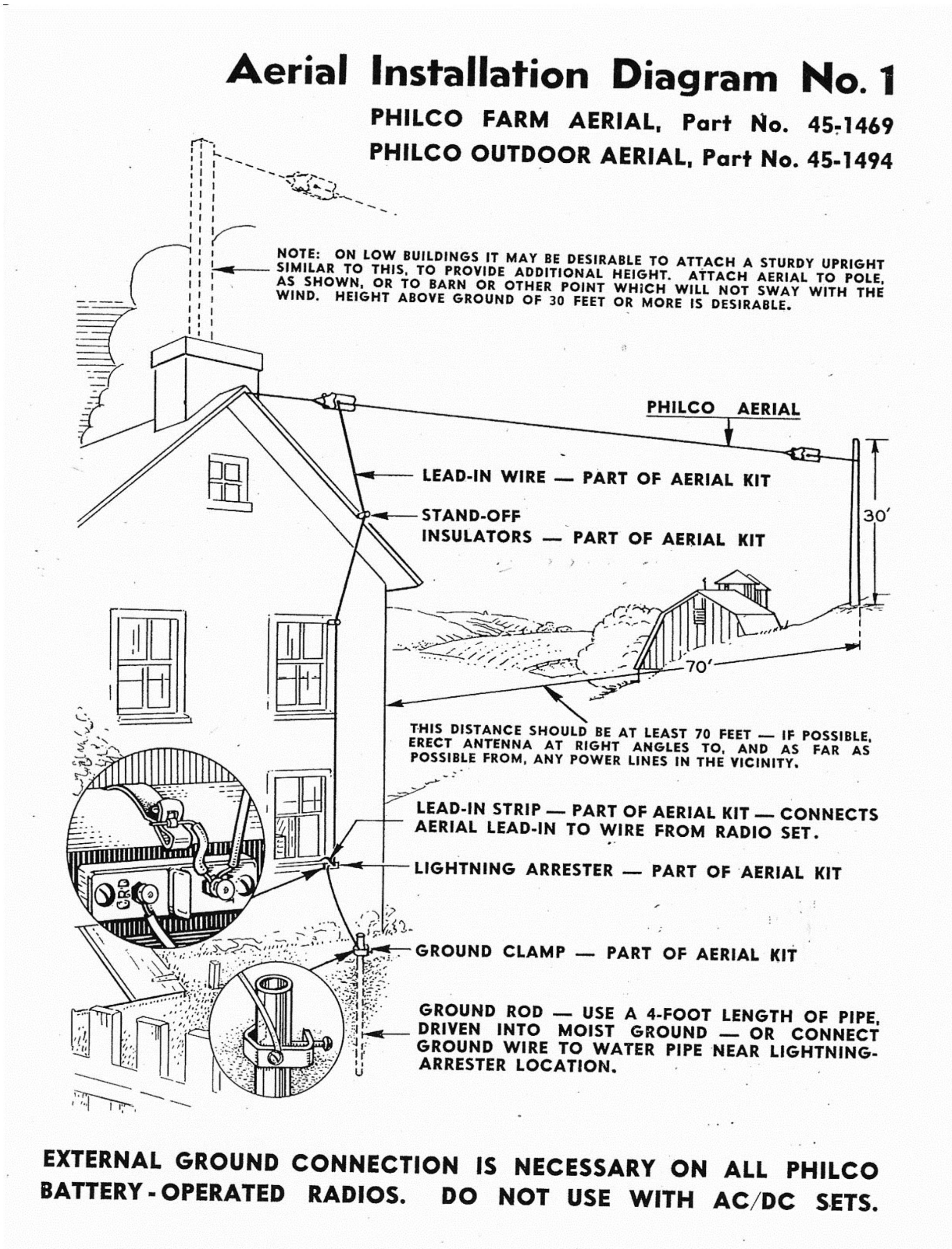
Crystal Radio - continued on Page 13

Crystal Radio - continued from Page 12

ground connection, a basic tuning device such as a coil with a slider, the crystal detector, and a pair of earphones (or "head telephones as they were called in the early days). For decades, simple crystal radios of this kind delighted the kids (and sometimes adults) who built them. But it was the antenna that usually made the difference between good reception and no reception.

In many locations, even with today's much more powerful radio stations, without a good outside antenna nothing can be heard on a crystal set. But if a sufficiently strong signal is present, a makeshift indoor antenna may suffice. Years ago kids, unbeknownst to mom and dad, surreptitiously listened under the covers to a crystal set whose antenna lead was connected to the metal bed-springs.

While today's homes may have a satellite dish on the roof, they do not have a 125-foot long antenna wire



Crystal Radio - continued on Page 14

Crystal Radio - continued from Page 13

stretched from the peak of the roof to the barn or a tree, as radio-equipped homes often did in the 1920s. The lack of such an antenna makes it difficult to listen to a crystal set today. When one of my grandsons was about eight years old I bought him a crystal radio kit. He put it together, hooked it up to a wire antenna strung across the front porch, but no stations were heard. We kept lengthening the antenna, and finally, when we routed it all across the front and way around the side of the house, and hoisted it higher, we heard one station faintly.

We have considered having youngsters come to the Museum and build crystal radios, but unless the family erects a long wire antenna at home, the radio builder will be unable to actually listen to the radio at home, and that is likely to disappoint the young radio fan.

Even if the family of the radio builder chooses to erect an outdoor antenna, there is the problem of lightning protection. If a long wire antenna is left up without adequate lightning protection, it can cause the home to be damaged by lightning, so just stringing up a wire from your bedroom window to a tree without understanding lightning arresters, is a serious safety risk. Also, today many urban and suburban lots are too small for a 125-foot long wire antenna.

Crystal Radios Today

Crystal radio kits are available from a number of companies. Four website examples:

- www.crystalradiosupply.com
- www.elenco.com
- www.midnightscience.com
- www.radiodaze.com

A serious problem in my opinion is that today's AM band does not offer the kind of radio content aimed at kids that was on the air when crystal set building was popular. At my home location, the AM band has foreign language broadcasting (Chinese and Spanish are popular), religious broadcasting, and talk shows featuring angry commentators, none of which are as likely to appeal to kids as the programs I enjoyed on my crystal radio years ago, e.g., "Jack Armstrong the All-American Boy," "Sergeant Preston of the Yukon," and the "Lone Ranger."

Sources

Hugh Aitken, *The Continuous Wave*, (Princeton, NJ: Princeton University Press, 1985).

George Applegate, "A Brief History of Detectors," *The Old Timer's Bulletin*, June 1992, p.7.

Brian Belanger, "Carborundum Detectors," *Radio Age*, April 1999, p. 1

Orrin E. Dunlap, Jr., *Radio's 100 Men of Science*, (New York: Harper & Brothers, 1944).

Robert Grinder, "The Crystal Set: A Centennial of Commemoration," *Electric Radio*, August 2006, p. 39.

Ivor Hughes, "Professor David Edward Hughes," *The AWA Review*, Vol. 22, 2009, p. 111.

Jim Kreuzer, "Crystal Sets," *ARCA Gazette*, Winter 1980, p. 4.

Bartholomew Lee, "How Dunwoody's Chunk of 'Coal' Saved both de Forest and Marconi," *The AWA Review*, Vol. 22, 2009, p. 135.

G. W. Pickard, "How I Invented the Crystal Detector," *Electrical Experimenter*, August 1919, reprinted in *Radio Age*, December 1976, p. 1.

Maurice Sievers, "*Crystal Clear, Volumes 1 and 2*" (Vestal Press: Vestal Press, 1991-92)

Eric Wenaas, From Coherers to Crystal Rectifiers, *The AWA Review*, Vol. 22, 2009, p. 147. ▯

Dials and Channels is the journal of the National Capital Radio & Television Museum (www.ncrtv.org). I am a Museum member, and I belong because I enjoy reading *Dials and Channels* and because of the great work the folks there do with the museum itself.

If you would like to become a Museum member, you can go to their website and join via PayPal. Or, you can just send a check for the $25 dues to:

National Capital Radio & Television Museum

PO Box 1809

Bowie, MD 20717

(Dues are tax deductible if you itemize deductions.)

\- Editor's Note

Scenes from the September 22, 2013 Swap Meet

A Fine Morning at the Swap Meet

A Variety of Radios on Offer

Mike and the 50-50 Raffle Tickets

No, this radio never had a nuclear fusion power supply.

WARCI's 3rd Oktoberfest Auction

Floor Crew and Items Up for Auction

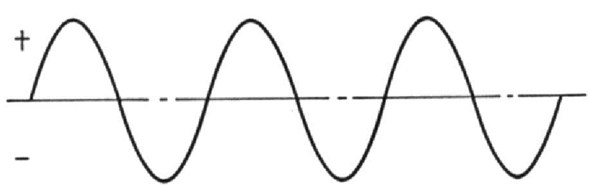
Modulation and Demodulation

By Brian Belanger

This article is the technical discussion about how crystal radios work (or, for that matter, how any AM radio works) mentioned above in Brian's article on Crystal Radios (see page 6). We repeat our thanks to Brian for permission to reprint the article here.

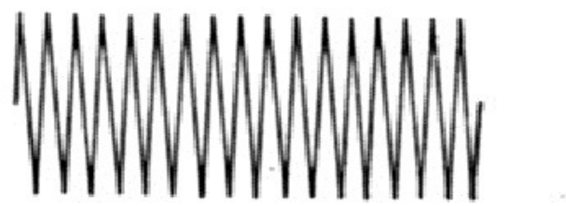
To understand how a crystal detector works (or for that matter, any AM detector) you must understand modulation and demodulation—the process of getting the "rider" on or off the carrier wave "horse."

Waveforms of electrical signals can be viewed on an instrument called an oscilloscope, which resembles a small television set. If you were to hold a tuning fork or any other device capable of producing a pure audio tone of a single frequency in front of a microphone, and connect the microphone output (an AC voltage) to the input of the oscilloscope, the resulting voltage waveform might look like this:



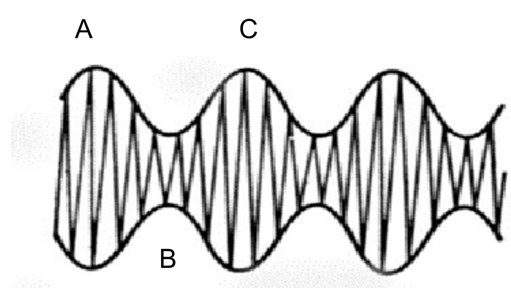
The oscilloscope displays the instantaneous voltage versus time. It increases in the positive direction, reaches a peak at A, smoothly decreases through zero, dips to an equal negative peak at B, rises again to the positive peak value at C, and continues to repeat this cycle. If the tuning fork is middle C, the vibration rate is 262 cycles per second and the frequency of the AC voltage is 262 cycles per second (or 262 Hertz in today's terminology, because the unit of frequency—cycles per second—today is named for 19th century scientist Heinrich Hertz.)

Consider a radio transmitter generating a carrier wave at a frequency within the AM broadcast band. If its output is displayed on the oscilloscope, we would observe a much more rapid up and down pattern of voltage, similar to the next figure.



Actually, the above sketch is not to scale. It should have many more ups and downs. A carrier wave in the middle of the AM broadcast band might have a frequency of, say 1 megahertz or 1 *million* cycles per second. On the same scale as the picture of the tuning fork's waveform (which has three complete cycles) the carrier wave would go through roughly 11,000 complete cycles in the same time interval, which cannot be drawn clearly on the same scale.

Consider what happens if the transmitter contains a modulator section that takes the audio frequency voltage signal from the microphone and changes the amplitude of the carrier wave corresponding to the wave shape of the audio signal. The result might look something like this:



When the modulating voltage is at a positive peak it increases the amplitude of the carrier wave to a maximum, as at point A. When the modulating voltage is at its most negative point, it decreases the amplitude as at point B. Point C is a repeat of point A. Of course the up and down motion of the carrier would be at a much higher frequency relative to the audio frequency signal in a real life

Mod and De-Mod - continued on Page 17

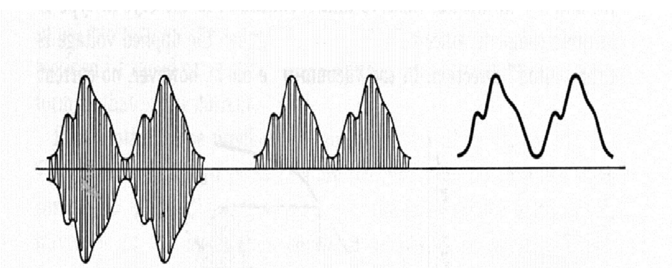
Mod and De-Mod - continued from Page 16

example. Also, in a real life example, the audio signal would not be a pure single frequency tone. If, for example, a trumpet solo is being broadcast, the audio signal would be more complicated, with bumps and dips on the waveform corresponding to the overtones (harmonics) that a musical instrument produces.

If the carrier wave as modulated above is sent to the antenna, a radio signal will be emitted and the carrier wave takes the audio signal (the tuning fork tone) along with it, like the horse takes the rider along.

When the signal reaches the receiver, the trick is to take the audio signal off the carrier. Once that is done, the radio can discard the carrier since its work is done.

Much experimenting a century ago convinced radio engineers that the best way to recapture the audio signal (demodulation) was to run the modulated carrier through a device called a rectifier—a device that allows current to flow only in one direction. As Braun had observed in 1874, certain crystals act as rectifiers. Those that do can demodulate.



A modulated carrier is shown at the left in the sketch above. If it passes through a rectifier, current flows only when the voltage across the rectifier is positive, and so the output of the rectifier is the waveform in the middle. With a waveform like that, it turns out to be easy to separate out the carrier, leaving just the audio portion of the signal, as in the waveform on the right, which is what we hoped to accomplish. The rectifier enables getting the rider off the horse.

You might be thinking, "Why is it necessary to rectify the signal to extract the audio signal from the carrier? Isn't there a way to separate the audio signal from the carrier when the signal has both the positive and negative parts? To avoid an even lengthier explanation, let me just say that it is easy to remove the carrier from the audio once the signal is only positive (or only negative).

Headphones reproduce sound by having a diaphragm that can vibrate at audio frequencies. Diaphragms cannot vibrate at the high frequencies of the carrier wave. (They can respond to the rider but not to the horse.) Even if they could, our ears do not respond to frequencies that high.

Why is the carrier wave even necessary to bring the audio signal through space?

When an announcer speaks into a microphone, the microphone converts the announcer's voice into an audio frequency electrical signal (actually, the signal is a hodge-podge of various audio frequencies that make up normal speech). The frequency range captured depends on the pitch of the person's voice and the quality of the microphone, but for broadcast radio roughly 100 cycles per second to a few thousand cycles per second suffices to capture the human voice, or, 100 Hertz to a few kilohertz (kHz).

It would be convenient if one could just apply the audio frequency electrical output from the microphone to an antenna and transmit radio signals that way. It turns out that low frequency electrical signals do not readily launch into space as radio signals. Huge antennas and complicated transmitters are necessary to successfully transmit very low frequency radio signals. Navies of the world sometimes use extremely low frequency transmitters for sending coded messages to submerged submarines because low frequency radio waves can penetrate into deep water, but navies can afford much more expensive installations than consumers. So for transmitting AM radio programs to U.S. consumers, a carrier wave is generated by the radio station's transmitter at a frequency in the AM band assigned to the station by the Federal Communications Commission, and the program content is superimposed on that carrier. As an aside, the process of modulation creates additional new frequencies clustered around the frequency of the carrier wave (called sidebands), and so the radio transmitter must transmit the carrier frequency plus these additional frequencies.

You could argue that turning the carrier wave on and off as in a Morse code transmitter is a form of amplitude modulation because the amplitude of the carrier is either high during a dot or dash, or zero

Mod and De-Mod - continued on Page 18

Mod and De-Mod - continued from Page 17

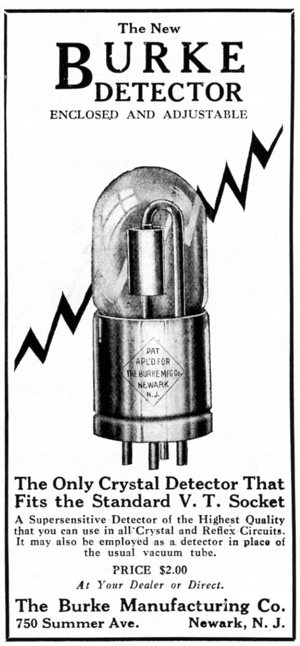
during the space between the characters. An engineer would describe it as pulse width modulation because the signal from the transmitter is a string of pulses of radio energy of either shorter (dot) or longer (dash) time duration. But in the case of AM radio, modulation means varying the carrier's amplitude in sync with the audio frequency voltage.

When radio was limited to the dots and dashes of Morse code, the simplest receiver was just a detector of radio signals connected to a device that allowed the receiving operator to see the incoming dots and dashes (e.g., with a Morse inker, such as the model at the Museum that prints out the code message on a paper tape), or to hear the incoming short tones (dots) and longer tones (dashes) with an earphone. In that era, a detector needed to be nothing more than a simple yes/no device to detect the presence or absence of a pulse of radio energy and its length. Because there were no AM voice signals at the time, there was no requirement for the detector to separate the voice signal from the carrier.

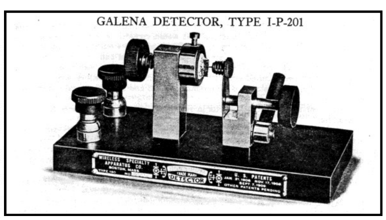
But once AM broadcasting of voice and music began, a receiver needed a detector that could function as a genuine demodulator, to separate the audio signal from the carrier wave. The crystal detector/demodulator did that new task well, in addition to serving as a detector for code signals. The distinction between a detector and a demodulator then became important.

As an example of a detector that is NOT a demodulator, consider the Hertz experiment demonstration at the Museum where a single loop of wire with a light bulb connected across a small gap is used to indicate the presence of a spark signal. When the spark transmitter key is pressed, radio waves pass through the loop and generate enough electricity to light the bulb. By watching the bulb light up and noting how long the pulse of light is, the observer can detect the presence of an incoming dot or dash. The loop of wire is a simple detector, but it is NOT a demodulator because it is incapable of separating an audio signal from a carrier wave.

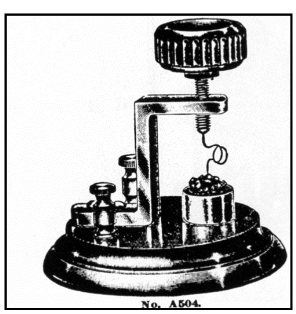
It is unfortunate that the term detector has come to be used interchangeably with demodulator. The crystal in an AM radio should be described as a demodulator rather than a detector, but common usage has blurred this distinction, and people invariably speak of "crystal detectors" rather than "crystal demodulators." At least *Dials and Channels [*and now *WARCI News]* readers now know "the rest of the story."



In 1924 Burke introduced an enclosed crystal detector that would plug into a vacuum tube socket. The advantage of such an approach seems dubious.



A circa-1920 galena detector made by Boston-based Wireless Specialty Apparatus, based on G. W. Pickard's patents. It sold for $10 (about $130 in today's dollars).



A Crosley crystal detector. Most radio manufacturers offered crystal detectors and/or complete crystal radios during the 1920s.

GE's first crystal receiver for consumers, the Model ER-753. Marketed by RCA, it sold for $18 when introduced in 1922 ($250 in today's dollars).

WARCI Radio Services

We now have a list of WARCI members who would be willing to provide repair / restoration services, advice or research for folks who contact WARCI looking for help. If you would like to be added to the list, please let me (Greg) or one of the Board members know.

Name	Email	Telephone	Service Available
Dwight Church	(none)	414-545-6972	Radio repair – electronics only.
Bill Engaas	CraftyradioBK@yahoo.com	262-786-8183	Speaker Repair.
Ralph Larsen	radioralph@hotmail.com	414-278-7981	Repair, including Television.
Mike Lewis	deepheart@att.net	608-835-7193	Repair, restoration, training.
Ben Bensaid	Ben@badgerconsignment.com	262-581-5453	Repair and restoration.
Greg Hunolt	ghunolt@excel.net	920-893-0422	Research, especially on 1920's radios.

Classified Ads

***WANTED*: by Dale Boyce, Email: radioman@wi.rr.com, 414-353-0734 / 414-840-4146**

1. Briggs & Stratton Corporation, Milwaukee, WI (BASCO) Radio Equipment from 1922-1937. Catalogs, Complete or incomplete crystal radios, tube type radios, radio frequency transformers, earphones, tube sockets, crystal detectors, vernier rheostats, fixed resistors, multi-plate variable condensers, fixed capacitors, literature, advertising, parts boxes, Battery Eliminators (Radio Power Units types "A", "B", "A+B"), push-button tuners, promotional items, etc. Please check your boxes of radio parts and your literature files. Also wanted: radios such as Globe Electric, Monroe McKillip and others which utilize BASCO radio parts.
2. 1920's tube type radios, amplifiers and radio parts, parts boxes, advertising, promotional items, etc. made by Allen Bradley Co., Milwaukee, WI.
3. 1920's Crystal radios, tube type radios, advertising and promotional items made by Sunlite Radio, Milwaukee, WI.
4. 1920's Julius Andrae and Sons Co (JASCO) Crystal radios, Radio Catalogs, Radio Equipment and promotional items made by ANDRAE Electric, Milwaukee, WI.
5. 1920's Horn and Cone type Radio Speakers made by Milwaukee companies including: G&G Radio Co, GEMCO, Granolite Art Products, Yahr-Lange, and others.
6. Individual and boxed sets of 1920's Brightson Blue Radio tubes distributed by Yahr-Lange, Milwaukee, WI.

Classified Ads

WANTED: All things Hallicrafters! Receivers, transmitters, accessories, television sets, test equipment, signs, books, etc. Also Silver-Marshall (1933-34) and Echophone.
Stan Broome, 108 East Main Street, Sun Prairie, WI 53590, 608-520-6290.

HELP NEEDED: Would like to contact owners of 1920's battery sets, literature, and equipment made by Globe Electric Company of Milwaukee, WI, to survey existing model types and variations for development of a company history. All responses will be kept confidential. Thanks.
Glenn Trischan, P.O. Box 240022, Milwaukee, WI 53224. E-mail: gnets142@att.net.

WANTED: Any set made in Plymouth, WI, by the Plymouth Radio and Phonograph Co., and Arlington, Alkire, or other sets made by the Wells Manufacturing Co. of Fond du Lac, WI. Also, I am looking for a Kennedy 525 Amplifier! Greg Hunolt, N5412 State Hwy 57, Plymouth, WI 53073, Email ghunolt@excel.net or 920-893-0422.

TRAINING & SERVICE: Michael Lewis -- Radio Restoration Education & Consultation

I'm available to refurbish (90 day guarantee) or fully restore (1 year guarantee) your antique radios. Estimates can usually be provided in 2-3 weeks from the time you drop off your set at my shop in rural Oregon, WI (a bit SW of Madison). The cost for an estimate is $25, which can be applied towards a final bill if you hire me to work on your radio. Full restoration includes testing all tubes, capacitors, and resistors, with replacement as needed. Power supplies are modified to operate safely at 120 VAC. Chassis are dusted off, variable capacitors are flushed with residueless cleaner, and switches & pots are treated with contact cleaner. Moving parts are lubricated. Sets are aligned with digital RF generators, tested for proper operation, and "burned in" to reveal any intermittent problems.

I have over 30 years' experience in electronically restoring antique radios (I don't restore radio cabinets). For most of this time I've also taught others how to do radio restoration. I can be hired for 4- or 8-hr. blocks of bench time. You will have access to DMMs, digital audio and RF generators, capacitor and inductor analyzers, power supplies, and much other test equipment. I stock 1/4, 1/2, 1, 2, 5, and 10W resistors. Capacitor stock includes 75 values of mylars; micas & ceramics; electrolytics from 25 WVDC to 450 WVDC. Tubes are available to my students, as well as technical literature including Rider, Beitman, and Gernsback manuals, factory manuals, and Sams Photofacts. Whether you've never soldered before, or regularly restore radios & are stuck on a "tough dog," chances are I can help.

Michael Lewis, 6070 County Road D, Oregon, WI 53575, Phone: 608-835-7193, Email: deepheart@att.net

WANTED**:** DeForest Plug-In Butterfly Coils **–** Terry Hanney, 414-545-6425

WANTED**:** Sylvania lamps NE-23-N5A1-5AB with starting voltage 60-90 volts, maintaining voltage 59 volts, current 0.03 mV. Tom Palmer 262-789-7177

FOR SALE**:** Rayon cloth-covered line cord for the Antique Radio Builder. Colors black or brown, cost is $1.26 per foot for brown, $1.38 per foot for black. Paul Dorobialski, Email: thebulbguy@yahoo.com .

Remember that classified ads up to about ¼ page are free to WARCI members.

The cut-off date for all newsletter material is about the 15th of the month preceding publication of the next newsletter (e.g. April 15, 2014 for the May 2014 issue). Send ads by email or letter to Greg Hunolt, WARCI News, at ghunolt@excel.net or N5412 State Hwy 57, Plymouth WI, 53073.