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By Gil McElroy, VE3PKD

Opening Lines: A Short History of Coaxial Cable

Do you think the black stuff that feeds your antennas is a recent invention? Would you be surprised to learn that an early form of coax was in use during the time of the American Civil War?

As a typical ham, I have a shack littered with spare coils and pieces of coaxial cable. I feed my backyard dipole with it and the local cable TV provider uses it to supply a wide range of television channels to my house. If I wanted, I could even sign up to have internet services provided via the same cable that supplies the TV signals—without interrupting prime-time viewing in the slightest!

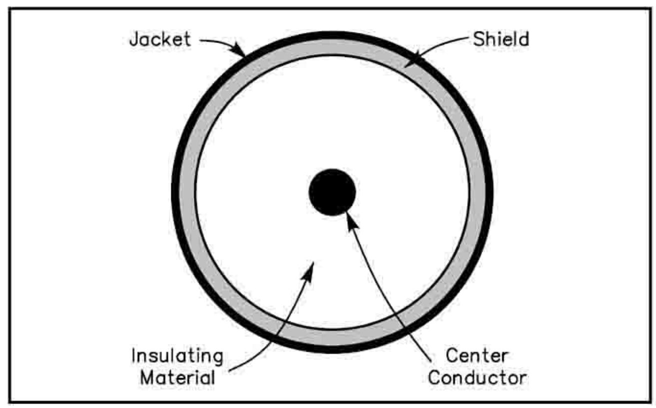
Again, like most hams, I think of coax as a 20th century invention. I remember reading in *Fifty Years of ARRL*, the *QST* anniversary book published in 1965, that coaxial cable really came of age for hams following World War II, when miles of the stuff became available as inexpensive military surplus. From that brief statement I assumed that coax had been a product of military innovation, much like the advances made in other technologies (radar, for example) as a consequence of the war.

Boy, was I wrong! As it turns out, coax is hardly new. In fact, it actually dates back to the 19th century. The geometry of the coaxial structure—one conductor concentrically surrounded by another—lends itself to mathematical analysis by theorists. Because of that, coaxial theory actually dates back to the gloried days of Maxwell and the 19th century explorations of electromagnetism.

But coaxial theory didn't produce a working coaxial cable until engineers were developing transatlantic cable communication in the mid-1800s. The earliest telegraph and the first telephone cables spanning the Atlantic were composed of a central conductor encased in a cylindrical insulating material. In the earliest cables, *gutta percha*, a latex material made from the fluid of Malaysia's Gutta Percha tree, was used as the insulator because of its remarkable abilities to withstand the intense cold and enormous pressures of the depths. These early cables are considered coaxial because the seawater that surrounded them completed their return circuits.

Bandwidths on the earliest transatlantic telegraph cables were extremely narrow—only about 1 to 1.5 Hz! By the early 1920s, however, bandwidths had improved, but only to about 100 Hz. This limitation still posed a big problem for telephonic communication, which required much greater bandwidths and higher frequencies.

Attempts were made to devise a workable coaxial system with greater bandwidth. In 1921, RCA's H. J. Round filed for a coaxial cable patent on a system that was essentially a shield



Coax is made up of a center conductor, which may be either stranded or solid wire, surrounded by a concentric outer conductor. The outer conductor may be braided shield wire or a metallic sheath. A flexible aluminum foil is employed in some coaxes to improve shielding over that obtainable from a woven shield braid. If the outer conductor is made of solid aluminum or copper, the coax is referred to as *Hardline*.

of wire strands—a cage—surrounding and running parallel to an inner conductor. Although the idea was workable for higher frequencies, its use was restricted to a narrow band of frequencies.

Coaxial cable as we know it is actually the invention of two men, Lloyd Espenschied and H. A. Affel, both of whom worked for AT&T. In May of 1929 they filed a patent application on a coaxial cable system and received US Patent No. 1,835,031 on December 8, 1931, for their "concentric conducting system." Their invention had no immediate application in radio. It was intended, rather, for transmitting television signals, which required a transmission line that was broadband enough to transmit a "range of frequencies extending from in the neighborhood of the audible range to such a high frequency as to afford a band sufficiently wide to represent a clearly defined television image."[1] Espenschied and Affix's invention involved placing a central conductor inside a hollow tube and holding it in place with washers spaced equally along the length of the tube. The low-loss dielectric was air.

[1]Notes appear on page 64.

Immediately after World War II, companies such as Amphenol were making coaxial cable available to amateurs. This advertisement was published in the December 1945 issue of *QST*.

Lloyd Espenschied

Lloyd Espenschied is perhaps one of the most interesting and under-acknowledged figures of early radio. Born in St. Louis, Missouri, on April 27, 1889, Espenschied became fascinated with wireless in 1904 while attending high school in Brooklyn, New York. Ignoring his school studies, by 1907 he had become an entirely self-taught amateur wireless operator. On March 14 of the same year he attended Lee de Forest's public unveiling of the audion, the first three-element vacuum tube. He later bought one of his own, paying five dollars for it (a princely sum in those days). Espenschield even encountered the very young David Sarnoff, then still an office boy practicing his Morse code to become a wireless operator for the American Marconi Company, where he began his rise to head up RCA.

Espenschied shipped out as a marine operator for the United Wireless Telegraph Company, but quickly decided to return to school. After graduating from the Pratt Institute in 1909, he went to work for the Telefunken Wireless Telegraph Company, which supplied the US Army and Navy with its wireless equipment. By 1910 he was employed by AT&T, where in 1915 he was part of the first transatlantic and transpacific radio telephone experiments. AT&T had combined its engineering department with that of Western Electric to form Bell Telephone Laboratory, and it was there Espenschied would work until his retirement in 1954. He held more than 130 patents, including those for co-inventing coaxial cable, a duplex radio telegraph system, radio altimeter, a system of automatic gain control, and for a crystal filter for use in high-frequency telephone communication. He even anticipated the development of radar, inventing and patenting a system for use on railroads as a safety device.

Espenschied was a founding member of the Institute of Radio Engineers (IRE), and in 1940, he would be honored by the Institute of Electrical and Electronic Engineers (IEEE) with its Medal of Honor for his "accomplishments as an engineer, as a pioneer in the development of radio telephony, and for his effective contributions to the progress of international radio coordination." He rated an entry in Orrin E. Dunlap Jr's *Radio's 100 Men of Science,* published in 1944, where he is called a "Radio Imagineer."

Espenschied had a vast knowledge of both the technological and corporate intricacies of early wireless. He sat in on the 1913 trial of Lee de Forest and others for fraudulent wireless stock dealings, and over the years amassed a priceless archive of early wireless information now held in the Smithsonian Institution in Washington, DC. In his corporate history of early 20th century wireless companies, *Wireless Communication in the United States*, author Thorne Mayes credits Espenschied as the true authority on the subject.

Lloyd Espenschied died in 1986 at the age of 97.

My thanks go to Thomas E. White for his help in compiling this information.—*Gil McElroy, VE3PKD*

(The early cable is similar to modern air-dielectric cables that use a plastic or Teflon helix to keep the center conductor centered in the outer shield/jacket.)

As part of a 1929 field test, AT&T and Bell Labs installed two 2600-foot-long sections of coax in Phoenixville, Pennsylvania, but the first real use of this new transmission medium came in 1936, when an experimental 100-mile-long underground system—two runs of coax, one for each transmission direction with repeaters spaced every 10 miles—was completed between New York and Philadelphia, transmitting voice, telegraph and fax signals. It was publicly demonstrated on November 30, when Frank Jewett, President of Bell Labs, spoke with FCC officials.

A year later, the first field tests using coax for television transmission were made using the upgraded New York-Philadelphia system, culminating in the live broadcast of the 1940 Republican National Convention, held in Philadelphia, to the handful of early television viewers in New York City.

America's involvement in WWII put a temporary stop to work on TV broadcasting, but in 1944, Lloyd Espenschied and Herman Affel received the Television Broadcasters Association medal for their contribution to the field. When the war ended, broadcasting quickly picked up its pace—and coax made it all possible. In 1948, Ed Parsons became the first person to provide TV programming via coax to his neighbors in Astoria, Oregon, who were unable to receive signals by any other means because of the mountainous terrain. The cable TV industry was born.

Coax went on to be used for transatlantic communication. In 1956, TAT-1, the first Transatlantic Telephone cable, went into operation, inaugurated on September 25 with a conversation between the head of AT&T and the British Postmaster General. In all, seven transatlantic coax systems were laid before the switch was made to fiber optics.

Concerning radio applications for coax, the British *Admiralty Handbook of Wireless Telegraphy* for 1938 neatly summed up the state of the art in the days before WWII, noting that coax was "a comparatively new commercial product that has been developed in connection with television." It went on to say:

"It appears possible that this type of cable may find an increasing number of uses. It could be used very conveniently as a transmission line joining a high-frequency aerial system to its receiver."[2]

For many hams, coax was just what the doctor ordered to keep up with advances in antenna technology. By the late 1930s, rotary beams were commercially available, but the big obstacle of how to feed them remained. Many hams circumvented the problem using complex slip ring technology or inductive coupling systems (examples of which regularly appeared in *QST*[3]). The advent of World War II may have put a temporary hold on Amateur Radio experimentation, but it did wonders for spurring the development of new technologies. The needs of the military accelerated the development and production of flexible, solid-dielectric coax. It was at this time that coax acquired its now-familiar RG/U (Radio Guide Utility) numbers.

Following the end of the war, the reopening of the ham bands went hand in hand with the availability of military surplus hardware, and with miles of cheap coax available for pennies on the dollar, hams began using it as never before. Although coax was lossy when compared to twin-lead or open-wire feeders, its advantages, especially for hams with rotary antennas, were obvious. As the late Ed Tilton, W1HDQ, former VHF Editor for *QST,* wrote:

> Tape it to a steel tower, or bury it; let it wrap around the tower and unwrap again as the beam is rotated—the loss will stay the same, almost regardless of conditions that adversely affect other types of lines.[4]

In fact, the losses made a lot of hams look seriously at lower-loss—though much more expensive—air-dielectric cable. Some even took to making their own hardline![5]

Some half a century after hams first got their hands on it, coax has become a ubiquitous fixture of our hobby. But the times they are a changing. In many areas where coax was king, fiber optics now rule, and it's only a matter of time before fiber optic technology itself becomes commonplace in ham shacks increasingly filled with digital equipment. Today's cutting edge research involves coaxial waveguides that combine the best features of coaxial cable and fiber optics.

Stay tuned.

Notes

[1]Lloyd Espenschied and Herman A. Affel, "Concentric Conducting System," United States Patent Number 1,835,031. Affel and Estill Green, both of AT&T, received another patent for a coaxial cable system in 1930.

[2]*Admiralty Handbook of Wireless Telegraphy* (London: His Majesty's Stationery Office, 1938), Section R37-38.

[3]Robert E. Mumma, W8ORI, "Another Inductive Coupling System for Rotary Beams," *QST*, Sep 1950, pp 20-24.

[4]Edward P. Tilton, "V.H.F. Antenna Facts and Fallacies (Part II)," *QST*, Feb 1964, pp 50-53.

[5]See *Hints and Kinks*, "Homebuilt Air-Dielectric Coaxial Lines," *QST*, Jul 1950, pp 57, 102, 104.

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NEW PRODUCTS

2001 PRODUCT SELECTION GUIDE FROM ANTENEX

◊ Antenex has recently released a *2001 Product Selection Guide.*

The company designs and manufactures mobile, portable and fixed location antennas for amateur, commercial, GPS, data telemetry, cellular, PCS, PCN and SMR applications. The catalog describes their entire line of products—including antennas, mounting kits (for both vehicle and fixed installations) and related accessories.

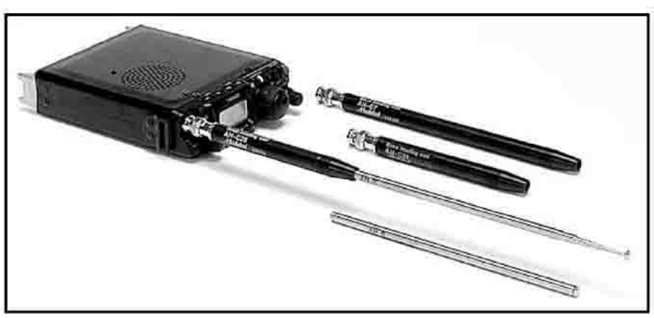
The 44-page full color guide can be downloaded in PDF format directly from their Web site. The file size is approximately 2.6 Mb.

If you would prefer a printed copy, contact Antenex, 2000-205 Bloomingdale Rd, Glendale Heights, IL 60139; tel 800-323-3757 or 630-351-9007, fax 630-351-9009; **www.antenex.com**.

YAESU FT-817 HF ANTENNAS FROM NCG

◊ NCG Co is now marketing a line of Maldol HF antennas and components that are specifically designed for use with Yaesu's subcompact FT-817 portable multiband transceiver (see photo).

Two single band antenna component packages and optional substitute parts are available that allow operation on 10, 15, 20 or 40 meters. The component packages contain a BNC-terminated base loading coil and a removable stainless steel telescoping whip element. The coil/whip assemblies measure around 52 inches when extended and about 16 inches when collapsed. Weight is approximately 3 ounces.



The two package offerings are the Maldol AH-28 and the AH-14. These include coil/whip combinations for 10 or 20 meters respectively. Substitute loading coils to add 15 or 40-meter operation (the AH-C21 or the AH-C7) and replacement—or substitute—coils for 10 or 20 meters (the AH-C28 or the AH-C14) are sold individually. The universal telescoping whip element (the AH-R) is also available separately.

For further information visit your favorite Amateur Radio Products dealer or contact NCG Co, 1275 N Grove St, Anaheim, CA 92806; tel 800-862-2611, fax 714-630-7024; **micks@cometantenna.com**; **www.cometantenna.com**.

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STRAYS

BILL EDGAR, N3LLR

QST Congratulates...

◊...Dennis Silage, K3DS (right) who received the ARRL Atlantic Division Technical Achievement Award from Atlantic Division Director Bernie Fuller, N3EFN, in Rochester, New York.

Next Strays