The National HRO Receiver — A Historical Perspective

A flea market find leads the author on a journey back to the first modern receiver.

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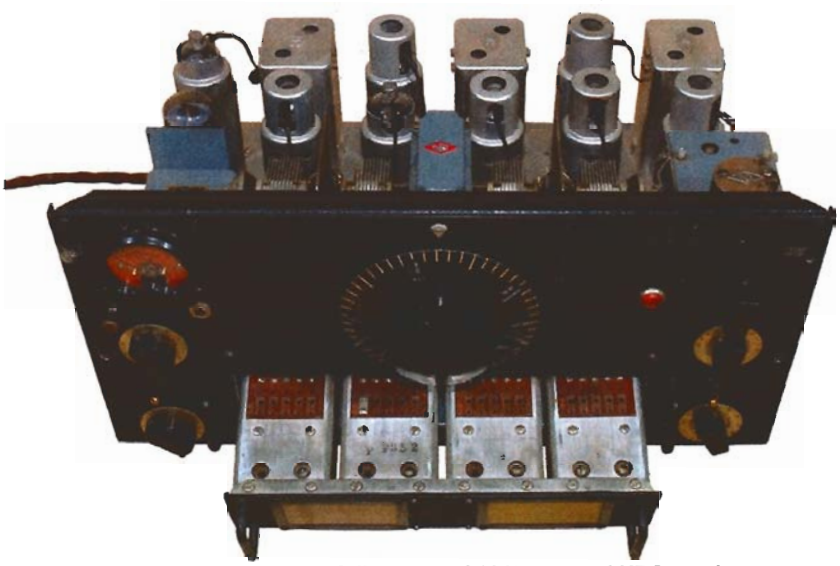
You know you're an engineer when you fall in love with a piece of machinery. My case of what I expected to be forever unfulfilled love occurred during a visit to the Radio Society of Great Britain museum. John Crabbe, G3WFM, curator of the collection, powered up a brilliantly restored National HRO receiver and allowed me to take it for a spin.

All it took was a couple of turns of the precision worm drive tuning dial and I was smitten.

Then one day the inevitable happened — an HRO followed me home. I became the proud owner of a 1942 National HRO receiver that was in great condition considering its age. Fortunately, there was plenty of information on the Internet to help with its restoration, and I quickly learned about replacing time-worn electrolytic capacitors, cleaning the air variables and lubricating the moving parts.

The HRO is the culmination of technical evolution spanning decades. Before we dive into the HRO's (r)evolutionary technology, let's look at ham receiver state-of-the-art on the eve of the HRO's 1935 debut.



After: **The author's fully restored 1942 National HRO receiver.**

Hams Making History

The 1930s were both tremendously exciting for amateurs and equally challenging. The now famous "1929 Hartley" transmitter design predominated into the mid-1930s, although crystal control steadily gained ground. Without the rock solid stability of crystals, a reply to your CQ might appear literally anywhere in the band.

On the receiving end of the equation, battery-powered regenerative receivers (regens) ruled the day. Receiver selectivity, that ability to discriminate between two adjacent signals, has always been problematic with regens. A *QST* writer observed in a 1935 article that "...the slightest movement of the vernier knob of the tuning control caused the signal to disappear and it was possible to hold the signal for any appreciable length of time only when the operator used a vise-like grip on the tuning knob and held his breath."

Superheterodyne receivers existed since they were invented by Captain Edwin H. Armstrong of the US Signal Corps during World War I. The problem was that many hams considered them suitable only for AM reception. Nevertheless, all receivers of that day, whether regenerative or superheterodyne, suffered from the same problem when receiving CW signals. In heterodyning a local beat oscillator with the fundamental or intermediate frequency (IF), two audio tones were ultimately produced, one on each side of zero beat. From the operator's point of view, each CW signal appeared at two places on the dial.

This is the world into which the National HRO receiver appeared in 1935 and became legendary for its stability, selectivity and bandspread. My research quickly led to a series of remarkable papers, mainly from 1932, by James J. Lamb, W1CEI (1900-1986), technical editor of *QST*.

Improving receiver performance was a major theme in the early 1930s and Lamb published no fewer than seven major articles in *QST* addressing the existing deficiencies. [Members can read Lamb's original articles in the ARRL Periodicals Archive at **www.arrl.org/arrl-periodicals-archive-search**. — *Ed.*]

His efforts were joined by the likes of *QST* Assistant Technical Editor Don Mix, W1TS, together with George Grammer, W1DF; Howard Chinn; James Millen, W1HRX (more about him later); J. B. Dow of the Navy Bureau of Engineering; former *QST* Technical Editor Robert S. Kruse, and *QST* Associate Editor Ross Hull. Perhaps only old timers will recognize these names today, but together they represent a Who's Who in 1930s radio engineering. The designs of these engineers had global impact in both the amateur and commercial worlds.

A Great Leap in Receiver Design

Getting back to my National HRO receiver, its technical excellence grew out of a set of three Lamb articles appearing in 1932. His first article was entitled "What's Wrong with Our CW Receivers?"[1] Therein, he explains the problems and details his suggested new approach utilizing three major innovations:

1. A high order of RF selectivity
2. Exceptional stability
3. Audio modulation that doesn't degrade selectivity and stability.

Lamb's first article was the lead article and occupied eight full pages in *QST*, but it was heavily theoretical. Even though he sketched out a plan for a receiver capable of separating signals a mere 500 Hz apart and

[1]Notes appear on page 73.

rigorously defined "single signal" reception, this opening salvo didn't detail the hardware to back up his theory.

The second and third articles eliminated all doubt that the future had arrived.[2,3] As Lamb explained, the foregoing theory might lead one to anticipate "a fearfully monstrous machine to put those abstractions to work." He went on to say that the ham could "Chuck that illusion right at the start. The rig that does the business is nowhere near as entangling as the principles on which it is based."

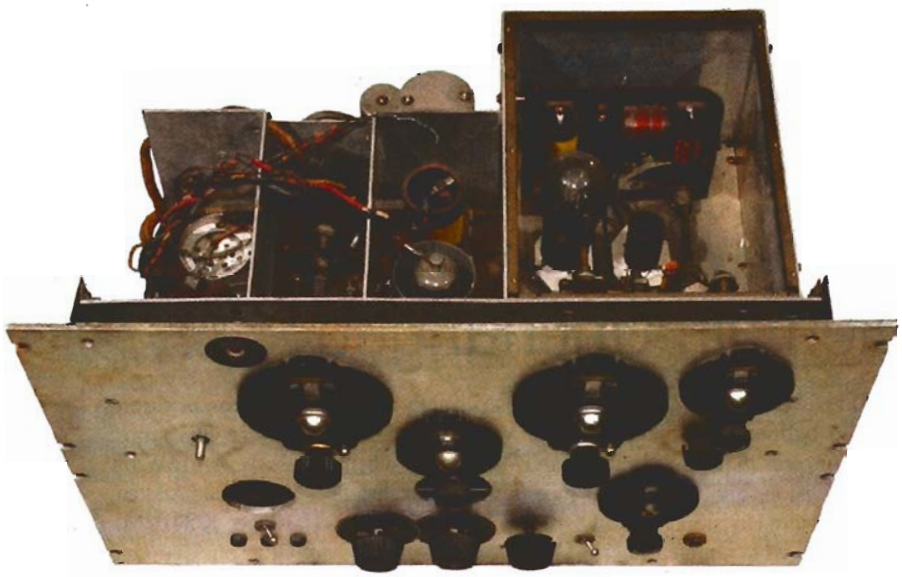
In a nutshell, and hardly doing justice to the magnitude of his innovations, Lamb detailed seven stages of signal processing between antenna and headphones. These included a tuned preselector stage to filter interference while also preventing the HF oscillator in the succeeding detector stage from radiating back through the antenna. This first detector and oscillator heterodyned the input signal to the IF stage where extraordinary selectivity was possible via the crucial contribution of crystal filtration. The IF filter was followed by an IF amplifier and then a second detector that heterodyned a beat frequency oscillator (BFO) for CW reception. The single signal that remained was then fed to an audio amplifier.

Lamb made no claim to have invented these technologies. Indeed, he expresses some surprise that his scheme had not been previously explored and adds, "a pretty thorough search and inquiry of people who ought to know have uncovered no previous disclosure of the combination of features that, coordinated, go to make up what we believe to constitute a new order of c.w. receiver performance."

Lamb's 1932 tour de force, comprising theory, schematics, photographs and the testimony of experienced operators was an obvious revolution in receiver engineering. An editorial note with the third article declared, "Extended experiment with this most recent of Jim Lamb's creations has left us with the firm conviction that it is really the set about which we have dreamed all these years." Now with the perspective of time, I will go so far as to say that this is the most influential receiver design ever published in *QST*. One measure of its influence is that all of the innovations introduced by Lamb in this 1932 marvel were quickly adopted by manufacturers of high performance receivers.

The Original Number 1

Since Lamb's prototype was extraordinary and its importance was fully appreciated at the time, I wondered what had become of it. To explore that mystery, I contacted ARRL Archivist Perry Williams, W1UED. A bit of exploration turned up the original Lamb prototype at ARRL headquarters. At this point in my research, finding the original single signal receiver was like finding a long-lost friend.



Lamb's prototype in the collection of ARRL HQ in Newington. As built, it used an ordinary broadcast receiver for the second IF and audio stages.

Those familiar with the National HRO probably recognize its indebtedness to the Lamb design described above. This is no mere coincidence. The HRO was the product of the extraordinary design team led by James Millen, W1HRX; with Herbert Hoover Jr, W6ZH; Dana Bacon, W1BZR, and others. Millen, at the time, had a close association with several of the leading lights at the ARRL, including Lamb. More than a few ARRL lab projects arose from discussions that took place at Millen's rural bungalow in Middleton, Massachusetts.

The HRO achieves perfection through the use of crystal filtered IF selectivity, a spectacular precision worm drive tuning arrangement and micrometer indicator dial designed by National engineer William Graydon Smith.

In addition, there is an innovative coil tray system that permits the use of precisely calibrated coil sets for each band. The HRO was immediately successful and was produced in staggering numbers for service in World War II.

By emphasizing the contribution of James J. Lamb, I'm not in any sense disparaging the efforts of Millen, Hoover and the HRO design team. The HRO is no mere copy of Lamb's single signal superhet. Indeed, the circuitry of the HRO departs from Lamb's design in a couple of areas. But overall the HRO embodies the groundbreaking, truly revolutionary design principles so coherently articulated by Lamb. If Lamb was the choreographer, Millen, Hoover and the National design team were the dancers who gave us a brilliant performance.

Notes

[1]J. J. Lamb, W1CEI, "What's Wrong With Our C.W. Receivers?" *QST*, Jun 1932, pp 9-16, 90.
[2]J. J. Lamb, "Short-Wave Receiver Selectivity to Match Present Conditions," *QST*, Aug 1932, pp 9-20, 90.
[3]J. J. Lamb, "An Intermediate-Frequency and Audio Unit for the Single-Signal Superhet," *QST*, Sep 1932, pp 9-16.

Photos by Brian R. Page, N4TRB.

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