

The Evolution of the National HRO and Its Contribution to Winning World War II

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Introduction

The National HRO in its many versions (Table 1) is extremely popular with collectors of communications receivers. Because of its unique design features and its critical role in helping the Allies win World War II, it deserves a special place in radio history. Much has been written about the history of the National Company and its memorable receivers. John Nagle's article about the history of National in Volume 1 of the *A.W.A. Review* (p. 65) and Lawrence Ware's article about National's coil-catacomb receivers in Volume 11 (p. 166) are two good examples. The *A.W.A. Old Timer's Bulletin*, and *QST* and other ham publications have also featured articles about National receivers from time to time, with the HRO series being a particularly popular topic. This article documents the evolution of this memorable receiver and should help collectors identify the subtle variations among the many different models.

At the time of the HRO's announcement in 1934 National already offered the AGS and AGSX (Fig. 1), and the reduced cost Model FB-7. (The AGSX is the AGS with a crystal filter.) The AGS was probably the world's best high performance short-wave superheterodyne at that time. Hammarlund, the other radio manufacturer involved in high performance superheterodynes offered the Comet Pro. The FB-7 and Comet Pro did not have an RF amplifier or pre-selection stage, although external pre-selectors were available. A few years after the introduction of the HRO, Hammarlund introduced the Super Pro, another long-lived design quite competitive with the HRO.

The National Company's AGS was developed jointly by government and National engineers. Operating one of these receivers next to an HRO shows that the AGS has several shortcomings that were

Table 1. HRO Models (and approximate year of introduction)

Table Models	Rack Model Equivalent
HRO - 1st (Announced 1934, shipped 1935)	HRO Senior - R 1st
HRO Senior - 2nd (1935)	HRO Senior - R 2nd
HRO Junior - 2nd (1936)	
HRO Senior - 3rd (1936)	HRO Senior - R 3rd
HRO Junior - 3rd (1936)	HRO Junior R - 3rd
HRO Senior - 4th (1938)	HRO Senior - R 4th
HRO Junior 4th (1938)	
HRO-M (1944)	HRO-MRR
HRO-M Junior (1944)	HRO-MRR Junior
HRO-MXTM (WW II era)	HRO-MX
	RAS
	RAW
	RBJ (Could be table model also)
HRO-W (1944)	
HRO-5T (1944)	HRO-5R
HRO-5TA (1945)	HRO-5RA
HRO-5TA-1 (1946)	HRO-5RA-1
HRO-7T (1947)	HRO-7R
HRO-50T (1949)	HRO-50R
HRO-50T-1 (1951)	HRO-50R-1
HRO-60T (1952)	HRO-60R
HRO-500/HRO-500P (1964)	
HRO-600 (circa 1970)	

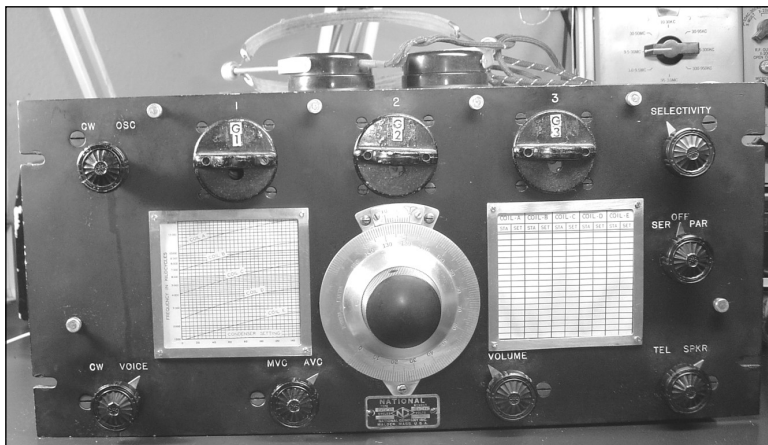
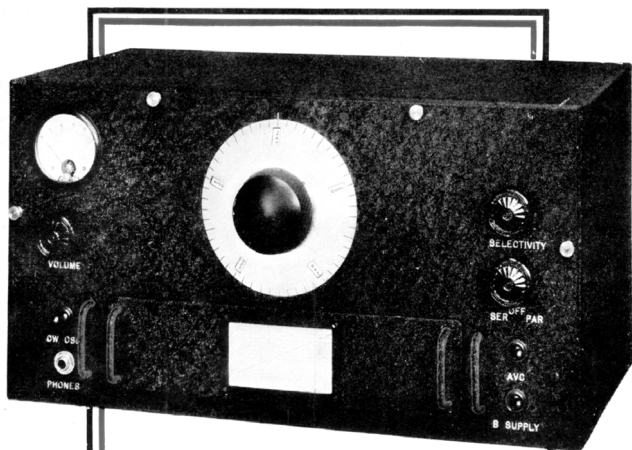


Figure 1. The National AGSX,. This early 1930s receiver was the predecessor of the HRO. (Author's collection.)

corrected in the HRO. The first is the plug-in coil system. The AGS operator has to locate the matching three coils and put them individually in the receiver in the correct order. The February 1996 issue of the *AWA Old Timer's Bulletin* includes a well-illustrated article by William Fizette (p. 11) on the National RH receiver, another early 1930s National design. The RH used a coil module system that improved on the design of the AGS coils, and its coils resemble the coils adopted for the HRO.

The lack of a B+ switch in the AGS means the operator has either to turn off all power to the receiver when changing bands, or change the coils with B+ applied and risk a shock. (Actually, the chance of getting a shock when changing coils was rather remote.) Under typical operating conditions of that era, the nuisance involved in switching bands was probably not serious, as rapid band changing was not a high priority for most users.

The second problem with the AGS is that its tuning system is very fast and quite touchy. The dial uses a vernier scale allowing resetting to one part in 1500. The movement of the main tuning knob required to move the dial by one step is about 0.01 inches. The dial mechanism and the use of rack and pinions to drive the three variable capacitors means that the drive mechanism has to be freshly lubricated to allow smooth movement, otherwise the tuning system moves in small steps that are difficult to control. The last major shortcoming of the AGS was that because of rapidly changing technology at the time, the AGS



THE HRO

TWO STAGES PRESELECTION

TWO AIR-TUNED I.F. STAGES

CALIBRATED BAND-SPREAD

AUTOMATIC VOLUME CONTROL

FOUR-GANG CONDENSER

MICROMETER DIAL

SINGLE-SIGNAL FILTER

ET CETERA

"Et Cetera" is a big phrase, and includes many obvious essentials such as single-control tuning and C. W. beat frequency oscillator, as well as luxuries such as a Vacuum Tube Voltmeter for indicating carrier intensities and an additional model with built-in power supply (for the very few amateurs who prefer it). The National General Catalogue, bound into this magazine, describes the HRO in detail.

NATIONAL COMPANY, INC.

Figure 2. This is one of two ads announcing the HRO that appeared in the October 1934 issue of *QST*. The other ad included lengthy text describing the new receiver. Shipments of the first HRO did not occur until early in 1935.

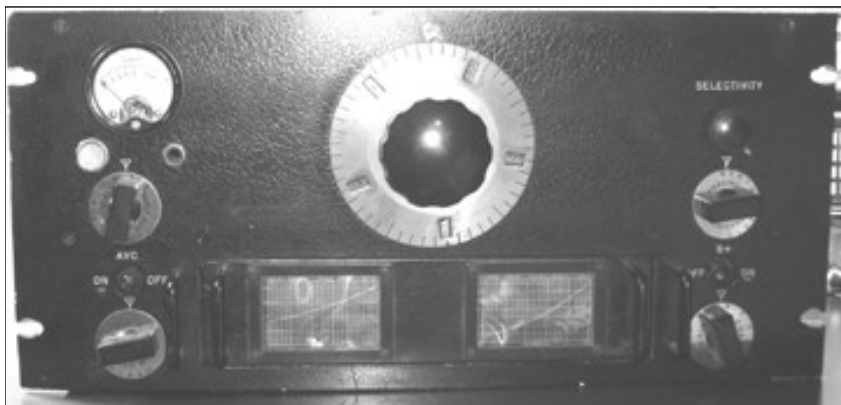


Figure 3. First of the rack model HROs. Note the white pushbutton to enable the S-meter below the meter on the left. (Author's collection.)

did not remain state of the art for very long. Improved vacuum tubes and a growing interest in higher frequencies meant that the AGS needed a major electronic design update after only two years of production. It is notable that the AGS had at least four different tube line-ups during these two years.

National determined that exploiting different manufacturing techniques, state of the art electronics, and improvements in mechanical design could best be addressed by a whole new receiver rather than an update of the AGS. National did attempt to improve the AGS' coil system with a late modification called the AGU. The AGU featured three coils attached to a single plate, forcing the insertion of the matching coils together in the correct order.

The First HRO Appears

The National Company announced the original HRO in October 1934, with deliveries to be made late in 1934. (An October 1934 ad is shown in Fig. 2. Fig. 3 shows a rack mount version of an early HRO.) However, actual first shipments of the new receiver were made in March 1935. The stated reason for the late delivery was that the stability was inadequate given the precision allowed by the new dial mechanism. This was largely corrected prior to shipment of the first units.

The two groups that designed the radio worked together from opposite sides of the country. The mechanical group, at National's

plant in Malden, Massachusetts, which included Graden Smith, was led by James Millen, and the electrical group in California, which included Howard Morgan, was directed by Herbert Hoover Jr.

The impetus for the new design was to provide a high performance superheterodyne to meet the market niche previously filled by the AGS, as well as a new requirement from the Bureau of Aeronautical Commerce, early predecessor of the CAA and FAA. The new specifications required a single module to change coils if such coil changes were required, and improved performance at 14 MHz and beyond. The HRO added a second RF stage, grouped the coils into a single plug-in module, and did not require an engineer to align each unit. The new electrical design broke no new ground, but remained state of the art for quite a few years. The HRO's mechanical design, however, was novel and excellent. The easier assembly along with a reduced cost metal cabinet allowed the HRO to be sold at a price comparable to that of the AGS.

The name of the new receiver came from a note Millen had put on the engineering drawing—"Hell Of Rush." This model was known by the initials HOR until National decided that the mnemonic when pronounced as an acronym was not acceptable. The story was actually changed to state that the original note was "Hell of a Rush Order," so HOR became HRO. (Millen set the story straight in an interview many years later.)

The HRO offered to the public in 1935 was a high quality superheterodyne with two tuned RF circuits, tuned mixer, electron coupled oscillators for the high frequency and beat frequency, and two IF stages with six tuned circuits and a crystal filter. Its electrical design is similar to James Lamb's 1932 "Single Signal Super Heterodyne," and the crystal filter was very much like the one Lamb described in *QST* some time later.

The front panel controls include AF and RF gain, crystal filter selectivity and phasing, BFO, AVC on/off switch, S-meter switch, B+ switch, and the wonderful HRO micrometer dial and precision worm drive mechanism. The front panel BFO control had markings of "Off," and "0" through "10." 0 on the knob indicated a BFO frequency about 5 kHz above the IF frequency of 456 +/- 2 kHz. The IF was aligned to the actual crystal frequency, and National apparently allowed a variance of +/- 2 kHz in the crystal frequency. Zero beat was

approximately 8 on the knob, and 10 indicated a couple of kHz below the IF frequency. The BFO on-off switch was ganged with the BFO pitch control. Turning the BFO control clockwise from 0 activated the BFO, by closing the switch, operated by a pin on the BFO capacitor shaft. Each time the BFO was turned off, the operator had to reset the BFO frequency the next time it was used. A separate switch would have been preferable.

The B+ switch allowed changing the coil modules without the potential for shorting B+ to ground. In the standard HRO with AC power supply there was no fuse protection, so shorting the B+ could easily damage a resistor, choke, or power transformer. The crystal filter did not allow placing the crystal in parallel like on the AGS-X, but only in series. In production a National plug-in crystal was placed on top of the phasing unit. These crystals could easily be disassembled, and contemporary publications recommended periodic cleaning with carbon tetrachloride.

The distinctive micrometer-type main tuning dial was an epicyclic unit with an outer dial marked with 50 graduations and an inner dial marked with the numbers from 0 to 500 in steps of ten. These numbers were visible through five windows in the outer dial. The inner dial was held off center and engaged the outer dial at the bottom position with a set of gear teeth. The inside of the outer dial had matching gear teeth, but a few percent more teeth so that the inner dial moved through a full set of steps for each ten turns of the outer dial.

A micrometer dial was patented in 1934 by William Harding of London, an employee of Sperry Gyroscope Company (British patent number 22-107). His invention may have inspired National to think along the same lines because National's Graden Smith received a U.S. patent in 1936 for a micrometer dial that appears to be very similar to the Harding patent. Smith definitely contributed the precision worm gearbox and capacitor mounting assembly, a work of engineering art, and the heart of the precision attributed to the HRO.

The 20-to-1 ratio gearbox was designed by Smith to eliminate backlash. The end result of this combination is a smooth, large tuning knob with 500 widely spaced graduations, allowing resetting the tuning capacitor to within about one part in 2000 or better. This precision was not surpassed for twenty years. The operator had to convert the reading on the knob into frequency by reading a

calibration curve. The plot showing frequency vs. dial reading was affixed to the front of the coil module, but this tiny graph gave only a general indication of frequency. However, making a note that the BBC on 5975 kHz had been received at 334.5 on the dial (for example) allowed resetting to the BBC with far greater ease than any competing system. The later military versions shipped to the U.K. came either with individual calibration booklets from National, or booklets were created in the U.K. giving the dial reading for each kilohertz. These booklets were columnar, not graphic, and at least some of them had the National emblem.

National believed that a really top performing receiver had to have optimized plug-in coils and an external power supply. (Power supplies for the HROs are described in detail later in this article.) The external power supply provided filament voltage of 2.5 or 6.3 volts as well as approximately 240 volts at 70 milliamperes for B+. The radio would work well with the correct filament voltage and a B+ of 160 volts or greater. Today the old National power supplies often produce 300 volts under no load because the power supply does not have a separate bleeder. (Also, line voltages are higher today than when these supplies were manufactured.) The original "Dog House" style power supply ran very warm. It is difficult to add much bleeder current as the transformer will overheat. When the B+ is turned on there is an immediate drop in voltage caused by the internal voltage dividers. National states in several documents that if you are using B+ batteries, the B+ switch should be turned "OFF" when the receiver is not being operated. (If you turn off the filaments but leave the B+ on, you will continue to drain power from the B+ battery through these voltage-dividing strings.)

The HRO Coil System

The coil modules used in the HRO were unique. There were two frequency ranges for each unit. In one mode the coil covered a wide frequency range (General Coverage Mode). In the other mode (Bandspread Mode), serial and parallel capacitors were added to reduce the coverage to approximately the width of an amateur band. The mode was changed by moving four shorting screws from one position to the other on each of the modules. The band change module consisted of four coils. Left to right, they were: 1st RF coil, 2nd RF coil, mixer tuning coil, and high frequency oscillator coil. There were four coil modules supplied with the receiver, designated A, B, C, and

D, which covered from 1.7 MHz to 30 MHz in the general coverage mode, and in the band spread mode, the 80-, 40-, 20- and 10-meter amateur bands. These modules slid into the bottom front of the receiver where temperature variations were minimal.

Each coil cover had a molded mica-filled phenolic insulator with the trademark R-39. Apparently this material was developed in 1929, and so National initially called it R-29. Prior to the HRO's introduction the company changed the designation so it would not be defined by the year it was introduced and in subsequent years appear to be old technology. The competing phenolic resin insulators available at that time were filled with hygroscopic material such as sawdust, cloth, or paper. This property caused the cheaper insulators' characteristics to change with changes in humidity.

Each of the R-39 insulators on the National coil had five contact points. These insulators are stamped with the coil range and the position of that coil on the module. The designators were the letter of the coil followed by its position. For example, the A3 insulator should be in the third position from the left (mixer tuning), and it should be in the A coil, which covers the 14- to 30-MHz frequency range or the 10-meter amateur band. Later the RAS coils used the designation letter and a number between 5 and 8. The RBJ and possibly the RAW used the designations 9 through 12.

The electrical contacts on the insulators made contact with matching brush blocks in the receiver when the coil module was inserted. There were matching handles on the front of the coil module and the front of the receiver to ease this operation. The front plate of the coil unit was 3/16-inch thick aluminum, finished either in black wrinkle or gray paint. On the front panel were two steel chart frames containing dial calibration charts. The graph in the left frame gave the general coverage curve showing the frequency vs. dial reading, and the right frame contained a similar curve for the bandspread mode. These scales were placed on the aluminum front plate of the coil module, then a celluloid cover was placed on top of the scales, then the steel frame was installed with four small sheet-metal screws.

Coils to supplement the standard A, B, C, and D units were available to cover the frequencies from 480 KHz to 2.0 MHz and 50 KHz to 430 KHz. These were designated as follows:

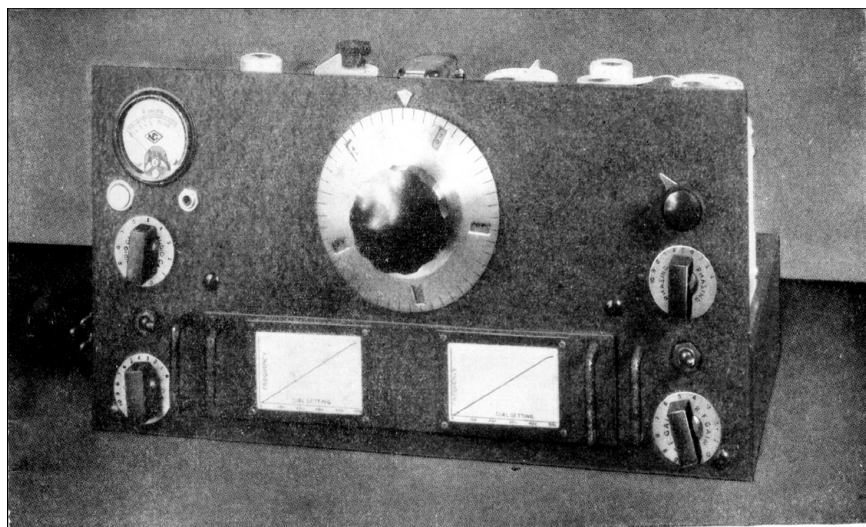
E	0.960 to 2.0 MHz
F	480 to 960 KHz
G	200 to 430 KHz
H	100 to 200 KHz
J	50 to 100 KHz

The E and F coil sets are popular today since they cover the AM broadcast band, with the E coil unit also covering the 160-meter amateur band. The lower frequency coils were primarily for special or laboratory use. These additional coils were designed only for the general coverage mode; the mode-changing screws on the standard coils were missing. The right frame, which normally contained the bandspread chart, fitted over a piece of celluloid with a roughened surface on which the names and dial readings of stations could be penciled in.

National's original documentation mentions only the A through D coils as standard, and the E and F coils as being available as options. Apparently the other coils were not available when the HRO first was marketed. The later military coils did not have the bandspread capability of the early coils made for the HRO Senior. Most of the standard military receivers ordered for use in the U.K. during World War II came with coils A through E, although to indicate that they lacked the bandspread capability they used the prefix J, so that the military coils were JA through JE. It is interesting that there is no difference between the E coil and the JE coil—some coils identified as JE coils were shipped with the postwar HRO-5TA1.

Early Production HROs

National used two different pre-production models for illustrations in their early advertisements. The first had the same small knobs used on the AGS, tube shields unlike those seen in later National products, and controls that reflected the AGS lineage. This model included the single gain control and the serial or parallel connection for the crystal filter. The second prototype (Fig. 4) is shown without a cover. Its front view shows a knob on the top of the BFO can, something like that used in the FB-7. In addition this model has an attachment for the cover similar to that used in the later rack models, which used a special cover with studs extending through the front panel to be secured by brass thumb nuts. The actual early production model used



SINGLE SIGNAL

The completely shielded single signal unit has a front-panel selectivity control with sufficient range for phone reception, as well as a front panel phasing control for heterodyne elimination. The crystal is of a new type, virtually eliminating side peaks. The holder, also new, mounts the crystal vertically, permitting free oscillation. And when turned "off," the unit becomes a conventional I.F. coupling unit which contributes its full share to the remarkable overall selectivity of the HRO.

WORM DRIVE TUNING

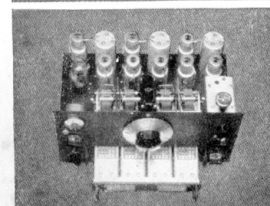
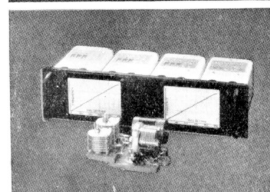
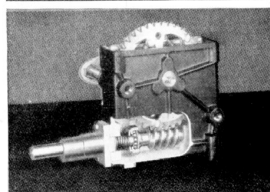
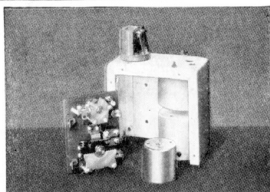
The HRO employs the new PW precision condenser with worm-drive tuning. Smoother and more sensitive than a friction drive, it permits swift, accurate tuning and precise calibration. The micrometer dial has an effective scale length of twelve feet, direct-reading to one part in 500. The electrical characteristics are of the same high order, each of the four sections having low-loss Steatite stator insulation, insulated rotors and individual non-inductive rotor contacts.

GANGED PLUG-IN COILS CALIBRATED BAND-SPREAD

The plug-in coils of the HRO are ganged for easy handling, and individually shielded for stability. Used as general coverage coils, each range includes two amateur bands and the spectrum between. By a simple switching device, the same coils are changed to band spread the respective amateur bands, spreading them over a uniform span of 400 divisions. All ranges are accurately calibrated at the factory.

HIGH PERFORMANCE CIRCUIT

The nine-tube circuit employed in the HRO is remarkable for level gain from 1.7 to 30 mc. Two stages of tuned R.F. amplification preceding the tuned detector provide the notable signal-to-image ratio of 1000 to 1 at 14 mc., as well as exceptional usable sensitivity. The HRO is designed for either double or single wire antenna. Other features include separate audio and R.F. gain control, A.V.C., Beat Frequency Oscillator, Signal Strength Meter, Phone Jack and B-voltage switch.



THE H R O SINGLE SIGNAL SUPERHET

**NATIONAL COMPANY
MALDEN, MASS.**

Figure 4. February 1935 QST ad for the HRO. This ad appeared just before actual first units were shipped to customers.

Table 2. Tube Line-up for Early HROs

Stage	AC Model (2.5-volt tubes)	Battery Model (6.3-volt tubes)
1st and 2nd RF	58	6D6
Oscillator	57	6C6
Mixer	57	6C6
1st and 2nd IF	58	6D6
Detector/AVC/1st Audio	2B7	6B7
BFO	57	6C6
Audio Output	2A5	42

two metal bar inserts to hold the cover in place, even on the rack models that included a full case with hinged top cover and a cover plate screwed to the bottom of the receiver.

The production HRO was available in an AC-operated model and a battery-operated version. At the time National felt that best AC performance could be achieved with 2.5-V filament tubes. Table 2 shows the tube line-ups for both models.

The class A audio output section produced a couple of watts of audio to drive the speaker.

Ceramic tube sockets were used for the high-frequency tubes, including the RF amplifiers, oscillator, and mixer, and phenolic sockets for the lower-frequency tubes, except the detector/first audio, which was also ceramic. National recommended 2.8 volts at the power supply for the 2.5-volt filaments to allow for a voltage drop of about 0.3 volts from the wiring and power cable.

Identifying the Early HROs

The best way to characterize the major changes and to discriminate

among models of the commercial pre-World War II HROs is by serial number. The serial number is stamped into the chassis near the antenna connector insulator. National began production of the HRO with the serial number D1. The D was a batch designation, and the digits that followed identified the particular radio in that batch. The D series may have been only 100 units; the following series were usually about 250 units. The batch designators A, B, C, I, O, appear not to have been used, giving a total of something over 5,000 receivers. When the end of this serial range was reached, National began using the batch number as a suffix instead of a prefix. The last known of the early models is 169L.

I have divided the early HROs into four models. (Actually changes were being made gradually throughout production of the HRO. So there are many "transition" models that include some features of one model and some of the next model.) Obviously the first HRO model was the unit first put in production. The second model accumulates the changes made up to the G or H production run. The third model includes those changes adopted by the P production run, and the fourth model goes from the X production run to the end of the plug-in crystal models.

The first model HRO differs from other generally seen early HROs in several ways. The main tuning knob was polished, and the graduation dial (internal to the tuning knob) had black lettering on a bright metal background. The main tuning pointer had a red "NC" engraved on the diamond, and there was no pilot light to indicate that filament power was being supplied to the radio. The S-meter had five divisions, similar to the "R" readings used to represent signal strength in that period. The S-meter was not in circuit all the time, so a momentary contact white pushbutton was used to enable it. To take a reading, the operator would ensure that the AVC was ON, then press the button. This arrangement proved unpopular. Furthermore, the pushbuttons were electrically noisy.

The knobs on the early HRO were of the bar and skirt design, but the transition from the knob to the skirt was shorter than that used later. This model lacked an external means to disable the B+ for muting purposes when used with a transmitter. The vent openings were quite small—only four rows of ¼-inch vent holes in the rear of the cabinet. The IF coils for these receivers were housed in round shield cans, and the chassis was painted black. The first HROs were

shipped with FB-7 power supplies, labeled “National Velvet-AB Type 5897 AB. Especially designed for the FB-7 receiver.”

Speakers were not advertised at this time, but a rack-mounted speaker was sometimes sold with the early HRO. These included an open eight-inch speaker in an 8¾-inch panel. There may have also been some 10½-inch panels with eight-inch speakers supplied with the AGS and possibly the first HROs. There is a picture of a rack mount first model HRO as early as the July 1935 issue of *QST* magazine. I also have a first model rack mount with serial number E124. The ads indicate that an engraved front plate was available that mounted over the original front panel. The actual units I have seen had a front plate that replaced the normal front panel. I believe that the first production model included serial numbers D1 through D100 and E1 through E250.

These receivers generally used fixed capacitors from an outside supplier, including sealed electrolytic, paper and wax, and mica types, but resistors manufactured by National. These resistors had white bodies with hand-lettered values. Unfortunately many of these have been replaced in the surviving receivers. Apparently the connection between the end cap and the resistance cartridge can become intermittent, and the resistance values drift with age.

The coil modules used in the first model HRO have scales with white backgrounds and black calibration numbers, grid, and curves. By the F1 series the changes to the second model were being incorporated, most notably the S-meter switch was changed from the pushbutton to a push-pull switch, and the calibration scales were being changed to white lettering over a black background. Some have suggested that this lettering change might have been triggered by glue stains showing through the light colored paper. However, I have checked quite a few early scales without finding any evidence of glue problems.

In addition to the new type of S-meter switch, the S-meter in the second model had nine divisions to mid scale. The case had much larger ventilation holes, a pilot light was added, and a terminal block was added to the rear apron to allow the removal of B+ from the receiver when transmitting. (The two screws on this block need to be jumpered for the receiver to operate.) The remainder of the receiver was like the first model, with the change to the longer transition between the bar and skirt on the knob occurring during this model run.

There were additional changes to the main tuning capacitor insulators, and some changes in component suppliers. National no longer supplied the hand-lettered resistors. These receivers include serial numbers starting with F1 and ending around P1. I observed on a rack mount HRO with the serial N31 (Fig. 5) a combination of second and third model features—a gray painted chassis with round IF cans. Apparently the change to square IF cans was made by the P series.

The HRO Junior Is Introduced

The HRO Junior was introduced in February 1936, during the production run of the second model HRO. It was a lower-cost version with the crystal filter and S-meter eliminated, and including one single coil module that worked in the general coverage mode only. When the HRO Junior was introduced, National began referring to the original HRO as the HRO Senior. One fairly sure way to determine whether a model is a Junior is that the Junior tuning capacitors had tabs on the front of the capacitor bank that could be bent to adjust the receiver to the standard coil. These are visible when looking down just behind the front panel. (Fig. 6 shows an early Junior without the tabs.)

The third model of the HRO (Senior) introduced the lighted S-meter, the chassis was painted gray instead of the original black, and the IF coil shields were square. There were additional changes in the tuning capacitor insulators, and cooling vents on the cabinet ends were added. The serial numbers for these radios range from P1 to W250. A fourth model Junior is shown in Fig. 7 and an interior view of a third model is shown in Fig. 8.

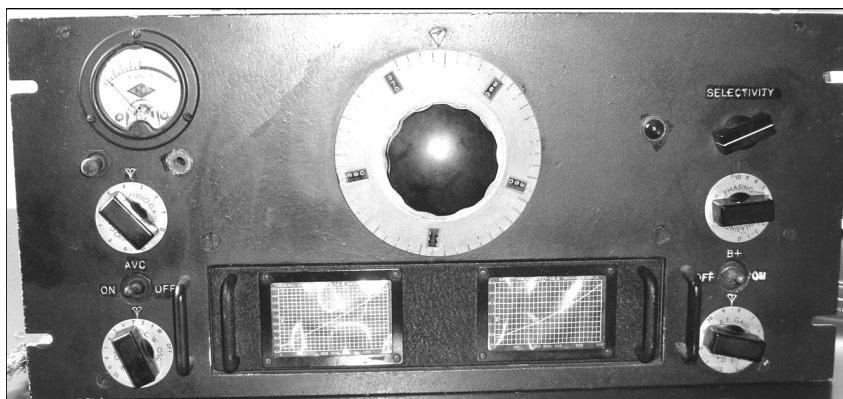


Figure 5. This rack model, serial number N31, represents a transition from the 2nd type to the 3rd type. (Author's collection.)

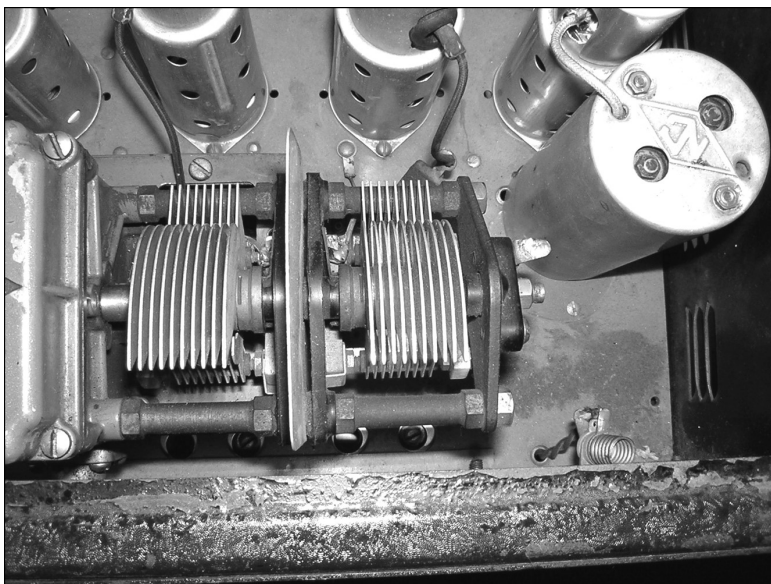


Figure 6. Early HRO Junior, without the tabs on the capacitor.
(Author's collection.)

The primary change in the fourth model was the inclusion of the ID tag on the front panel. The insulators on the main tuning capacitor reached their final form in this model, and on most HROs of this era, a plain rectangular knob replaced the round selectivity knob. Serial

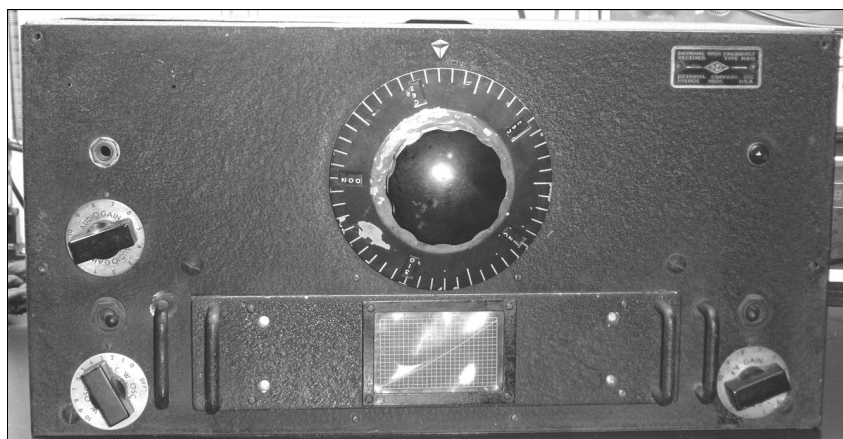


Figure 7. HRO Junior of the fourth type. (Author's collection.)

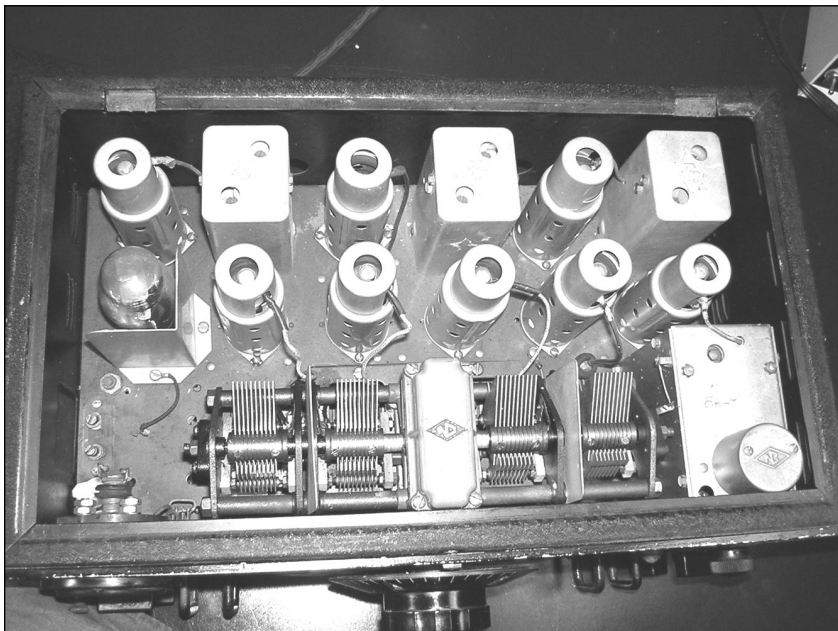


Figure 8. Interior view of an example of the 3rd type early HRO, serial number S63. (Author's collection.)

numbers for the fourth model extend from X1 to the end of production.

As noted above, there are several prototypes for which photos exist that were quite different from any production models. Also, National advertised at least one variation that was never produced—the HRO with internal power supply.

Rack mount versions of the later receivers were available at a slightly higher cost (about \$20 more). The rack-mounted receivers were very similar to the table model HROs. The top cover of the cabinet in the rack models did not have the raised spot in the middle to allow raising the lid without damaging a fingernail because it would have interfered with sliding the unit into the rack. The front panel of the rack models was 3/16-inch thick aluminum plate with engraving to indicate the function of the B+ and AVC switches, "Selectivity" engraved above that control, and engraved pointers for the other controls. The finish on the rack panels was an alligator texture instead of the wrinkle finish used on the table models. A

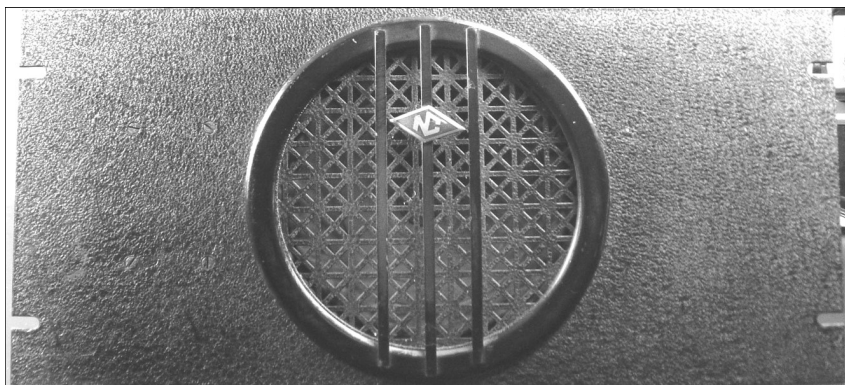


Figure 9. Later version of the rack mount speaker for the HRO. (Author's collection.)

gray version of the rack mount system was available in the later models.

The additional equipment advertised along with the early HROs included the HRO-P panel mentioned above for rack mounting, the RFSH speaker and panel, the RR relay rack, the LRR table mount light rack, and the E and F coils. A slightly later version of the rack mount speaker is shown in Fig. 9.

Shortly after these products appeared, a rack mount coil holder panel became available. The early coil holders were available in two sizes, one that held five coils and one that held ten coils. The ten-coil version (Fig. 10) is extremely rare, and may have been available only by special order. The five-coil version had a simple round knob,



whereas the ten-coil version had a lock as seen on the later military coil holders, such as the RAS coil holder and on the SPC, described below.

In December 1936 the SPC system (Fig. 11)

Figure 10. Interior view of the rare ten-coil coil holder. (Author's collection)



Figure 11. SPC unit, consisting of a coil holder, speaker, and power supply. (Author's collection.)

was first advertised. (Most likely SPC was an abbreviation for Speaker/Power Supply/Coil). It reduced the rack height of the HRO rack mount system by several inches as compared to the separate coil holder, power supply, and speaker. The original SPC advertisements showed a speaker without a grille, a simple non-locking knob for the five-coil holder, and a power supply. Later SPCs included a speaker with grille and National cloisonné emblem, a rack to hold five coils with a lock mechanism, and a power supply mounted on the coil rack and behind the speaker. The National advertisements also indicated that the original power supply, coil holder, and power supply separates were still available. A stand-alone eight-inch table model speaker (Fig. 12.) similar to the one in the SPC could also be purchased during this era.

The third model rack mount HRO appears just like the second from the outside. A quick look inside will show that the round IF cans and black chassis have given way to the square IF cans and gray chassis. The fourth model is very difficult to differentiate, other than having the HRO tag. The best way to identify it is by the serial number.

Returning to the HRO Junior, the wider selectivity of the Junior

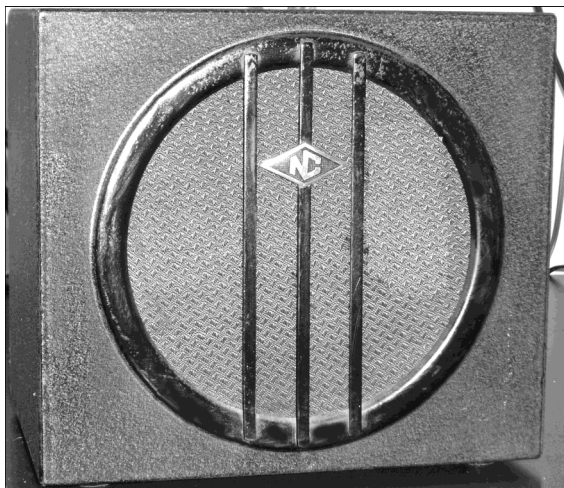


Figure 12. This eight-inch table model speaker was used with many of the prewar HRO models.

model, lacking the crystal filter, was actually almost required by the faster tuning of the general coverage only coil. These receivers actually work quite well. Most HRO Junior users apparently bought the A and C coils sets—the A module for 20 and 10 meters, and the C module for 80 and 40 meters. These coils were not precisely tuned to the receiver with which they were shipped. Instead, they were calibrated to a standard receiver. The front of the coil for the Junior has only a single frame located in the middle of the front plate. It contains the curve for the general coverage position of the coil in use. These coils do not include the shorting screws, but do share the 3/16-inch aluminum front used on the original HRO coils. The first Junior of which I am aware has serial number L63.

The third model Junior has the gray chassis and square IF shield cans. Otherwise it is similar to the second model, maintaining the tabs in front of the tuning capacitors.

There may have been some fourth model Juniors built prior to World War II. It would be difficult to determine which units are of this type except by looking at serial numbers. By this time military personnel, primarily the U.S. Navy, Coast Guard, and Great Britain's forces, had assessed the HRO, found it met their needs well, and so the major thrust for National was shifting to military markets.

HROs in World War II

There were at least a few rack mount HRO Junior type receivers

built by National. Due to the lack of information on military versions of that era, it is possible that these may primarily be military versions produced after 1941, but there is at least one rack mount Junior-type receiver that was made for American Airlines. I know of HRO Juniors in both rack and table mount types, with tags that identify them as HRO-M.

In the late 1940s National made an offer to realign and add an S-meter to the receivers of those who owned units without them. The cost was low (about \$10), so many of the HRO Juniors we see today have postwar factory-installed S-meters.

National's military receivers were listed in one of the company's full-page ads in February 1946. These include the HRO-M, and HRO-MX. These HROs apparently had glass tubes and used an IF frequency of 456 kHz. National also mentions the HRO-5 and HRO-W as having metal tubes and using the 456 kilohertz IF frequency. The company also stated that three receivers similar to the HRO were built strictly to U.S. Navy requirements: the types RBJ, RAW, and RAS. All had glass tubes, with the RAS using an IF frequency of 175 kHz, and the other two, 456 kHz. These receivers are described later in the article.

By September 1939 Great Britain and France were at war with Germany and Italy. Britain's intelligence establishment and their code breakers had a desperate need for high quality communications gear to intercept Axis messages. The British realized that the Marconi receivers that were available were too few in number and did not have the quality needed to serve as intercept and communications receivers. They purchased receivers from several U.S. manufacturers including RCA, National, Hallicrafters, and Hammarlund. Undoubtedly the primary British receiver for the period of the entire war was the National HRO. Approximately 10,000 HROs were used by the British in intercept operation, diplomatic communications, aboard ships, and at shore stations, as well as for clandestine use. An estimated 1,000 standard HROs were purchased by Great Britain prior to the production of the military versions.

The first military HROs were supplied to the U.S. Coast Guard and to Great Britain. The ones I have seen issued to the Coast Guard are standard HRO Seniors marked "RC-105" (Fig. 13.) The British could not buy receivers from the United States at the beginning of the war

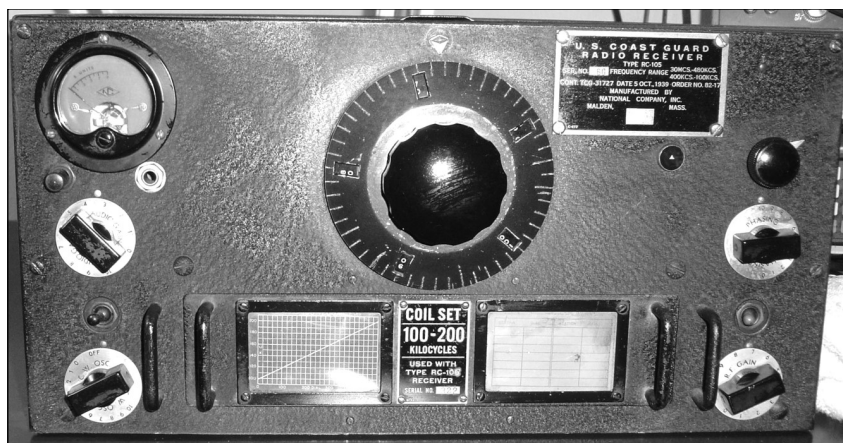


Figure 13. Coast Guard type RC-105. (Author's collection.)

due to our neutrality. Many British personnel stationed in the U.S., such as those in the diplomatic service, were asked to purchase HROs from the same retail stores used by U.S. amateurs and ship them to Great Britain. In Great Britain these units were designated R-106. One of the commercial HROs found at Bletchley Park has the serial number 259J near the antenna connector. When the U.S. adopted "Cash and Carry" and later, "Lend-Lease," Great Britain contracted with National to buy large numbers of military receivers, with orders split between the HRO-M and HRO-MX (R-106), HRO-5 (R-106 Mk II) and HRO-W (R-106 Mk III). I estimate that there were probably about 3,000 HRO-Ms, about 3,500 HRO-MXs, and about 2500 HRO-5s. Very few of the HRO-Ws were delivered prior to the end of World War II.

The HRO-M was also designated in some military manuals as the HRO-MTM for table-mount, or HRO-MRR for relay rack mount. An HRO-MRR Junior is shown in Fig. 14. The M-type HROs were quite similar to the HRO Senior fourth model, but were provided with general coverage only coils. They also included special tags displaying the order number and construction information, and had a few internal modifications, such as adding transformers to eliminate the possibility of B+ on the headphones. The serial numbers on most of the HRO-M series were located behind the S-meter gain adjust resistor. The selectivity control was a rectangular knob instead of the round knob and pointer seen on some of the commercial HROs in the U.K. Serial numbers for the HRO-M appear to be similar to those on

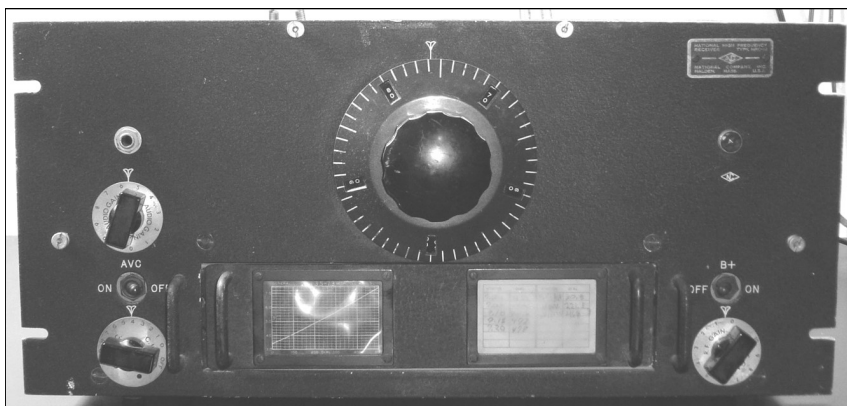


Figure 14. HRO-MRR Junior. (Author's collection.)

the early HROs, with a letter followed by a series of digits. These numbers are normally higher than those seen with the original HRO. Examples from Bletchley Park's communications museum are J457, N820, and E844.

Most of the HRO-M and later military receivers were supplied with a set of four or five coils, although a minority had all nine coils. For military use, bandspread for the amateur bands was not needed, however the coils did continue to have two chart frames, one with the calibration curve, and the other with the rough surface celluloid cover to pencil in favorite frequencies. The front panel of these coils was changed from 3/16-inch aluminum to 0.093-inch steel, due to the shortage of aluminum. The rack version is very similar to the rack mount HRO Senior, but included those changes required by the purchasing entity. The plug-in IF filter crystals were last seen in these models.

A few HRO-M units have been found with crystals manufactured by Bliley. These are either replacements, or National may have purchased them to make up for an internal manufacturing shortfall. According to a statement made by National just after the war, the S-meters in these units depended on whatever National had in stock. Some of the receivers found in Great Britain have 0-1 milliamper meters, some have the standard backlit meters, most had white unlighted meters.

The HRO-MX was the next major model produced by National. It appears that the HRO-MX designation was for the rack model; the

table model was designated HRO-MXTM. These units had a re-worked crystal filter, with the sealed crystal mounted inside the phasing enclosure. They are generally found with the six-volt tubes, as are the HRO-M receivers. Other than the change in the crystal filter, and the adoption of more JAN (Joint Army-Navy) parts, these are very similar to the HRO-M. The serial numbers consist again of a letter followed by one to three digits. Examples are: F42, B93, D519, and E429. It is probable that some of the HRO-MXs were Junior models, without the S-meter and crystal filter. Since the crystal filter was the primary difference between the M and MX, it is difficult to determine whether a military Junior is "descended" from the M or MX. All of the Junior styles have the tabs on the tuning capacitors.

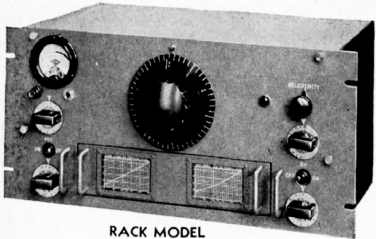
National continued to advertise its receivers in amateur radio publications during the war years, even though they were not available for purchase by hams. Fig. 15 is an example of a National HRO ad from 1943.

The HRO-5 was the next version of the HRO produced by National. The HRO-5 used metal vacuum tubes with octal bases, with the exception of the final audio amplifier, which was a glass 6V6G. The tube complement was:

<u>Function</u>	<u>Tube Type</u>
1 st RF	6K7
2 nd RF	6K7
Oscillator	6J7
Mixer	6J7
1 st IF	6K7
2 nd IF	6K7
Detector/	
first audio	6SQ7
BFO	6J7
Audio output	6V6G

These tubes are more rugged than the glass varieties used in earlier models, and external metal shields required by the glass tubes were eliminated. Often when we encounter the earlier HRO versions with glass tubes, the tube shields are missing. This may allow feedback and reduce stability.

The front panel of the HRO-5s has an added bright metal ring



RACK MODEL

HRO table model, receiver only, complete with four sets of coils (1.7-4.0, 3.5-7.3, 7.0-14.4, 14.0-30.0 MCS). **List \$329.50**

HRO Jr., table model, receiver only, with one set of 14 to 30 mc. coils. **List \$198.00**

COILS

HRO Type E , Range 900-2050 kc	List \$22.00
HRO Type F , Range 480-960 kc	List \$22.00
HRO Type G , Range 180-430 kc	List \$30.00
HRO Type H , Range 100-200 kc	List \$33.00
HRO Type J , Range 50-100 kc	List \$40.00
HRO Jr. Type JA , Range 14.0-30.0 mc	List \$18.25
HRO Jr. Type JB , Range 7.0-14.4 mc	List \$18.25
HRO Jr. Type JC , Range 3.5-7.3 mc	List \$18.25
HRO Jr. Type JD , Range 1.7-4.0 mc	List \$18.25

MCS table model cabinet, 8" PM dynamic speaker and matching transformer **List \$18.25**

697 Table power unit, 115 volt, 60 cycle input, 6.3 volt heater and 230 volt, 75 m.a. output, with tube **List \$29.50**

See our 1942 catalogue No. 500 for relay rack mountings, coil containers and accessories.

NATIONAL HRO

The HRO Receiver is a high-gain superheterodyne designed for communication service. Two preselector stages give remarkable image suppression, weak signal response and high signal-to-noise ratio. Air-dielectric tuning capacitors account, in part, for the high degree of operating stability. A crystal filter with both variable selectivity and phasing controls makes possible adjustment of selectivity over a wide range. Heterodynes and interfering c.w. signals may be "phased out" (attenuated) by correct setting of the phasing control. A signal strength meter, connected in a vacuum tube bridge circuit, is calibrated in 5 units from 1 to 9 and in db above S9 from 0 to 40. Also included are automatic and manual volume control features, a beat oscillator, a headphone jack and a B+ stand-by switch. Power supply is a separate unit. The standard model of HRO is supplied with four sets of coils covering the frequencies from 1.7 to 30 megacycles. Each coil set covers two amateur bands and the spectrum between. The higher frequency amateur band of each range, by a simple change-over operation, may be expanded to occupy 400 divisions of the 500 division PW instrument type dial.

For those who require the high performance of the HRO but do not need its extreme versatility, the HRO Jr. is offered. The fundamental circuit and mechanical details of both receivers are identical, but the HRO Jr. is simplified by omitting the crystal filter, signal strength meter and by supplying coils less the band-spread feature.

The frequency range of both the HRO and HRO Jr. may be extended to 50 kilocycles by using additional coil sets.

All models of the HRO are supplied with 6.3 volt heater type tubes. Table models and accessories are finished in black wrinkle enamel.

A technical bulletin covering completely all details will be supplied upon request.

Figure 15. A National ad for the HRO from the ARRL 1943 Radio Amateur's Handbook.

around the AVC switch and the B+ switch, which is silk-screened with the switch position and use. National also introduced the flanged knob with skirt for the selectivity control, giving a more pleasant appearance. The National tags usually indicate HRO-5T for table models or HRO-5R for rack models.

The coil modules for the HRO-5 include both coils similar to those provided for the HRO-M and MX as described above, plus some coils with a silk-screened bright panel on the front of the coil with the frequency to dial-reading curve and the logging table. These are often referred to as "Silver Front Coils." As noted above, these were typically tagged as "R-106 Mark II". Those radio people in the United Kingdom who acknowledge any difference in HRO models, will usually mention the "Glass Valve HRO" and the "Metal Valve HRO."

The HRO-W was the last HRO model produced by National for military use by the U.K. These receivers were produced on contract

near the end of World War II and are quite similar internally to the HRO-5T. Fig. 16 shows an HRO-W. The primary difference on the units I have seen is that the S-meters are typically the ones calibrated from 0-1 mA. These HROs came with modified rectangular power supplies, not the "dog house"-shaped supplies provided with earlier units, and were "tropicalized."

Production of the HRO-Ws began in mid-1945, and most were never shipped to the U.K. but sold to the public after the end of World War II. The dates of the application of fungicide were usually in the July to September 1945 period. After the war a National full-page technical ad in *QST* discussed the suitability of these units for radio amateurs. Most have six of the "Silver Front" coils as seen with some of the HRO-5s, and some have all nine coils. The six coils provide coverage from 480 kHz to 30 MHz, the additional coils covering 50 kHz to 430 kHz. The square power supplies are designated "697-W," and are of very high quality. The electrolytic capacitor is a plug in unit, the covers are attached with quarter-turn fasteners and they run quite a bit cooler than the doghouse supplies.

HROs by Another Name

There were three special versions of the HRO built for the U.S. Navy as mentioned above. National notes that while they appear similar to the HRO, they are built to Navy specifications. The most

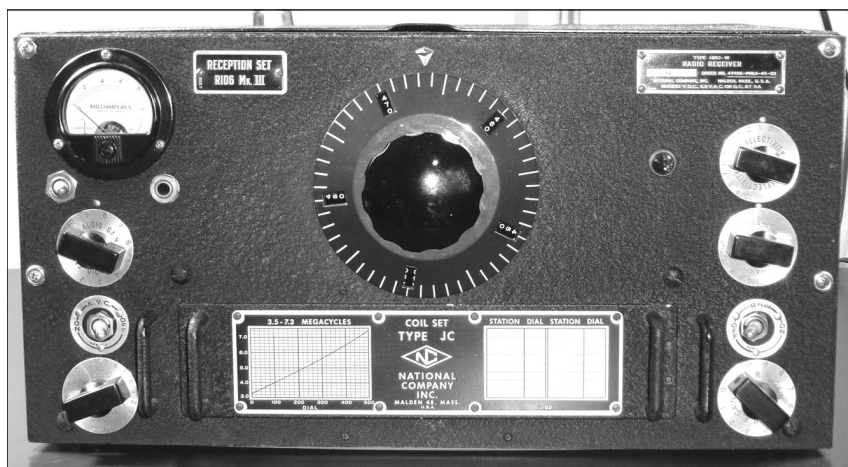


Figure 16. The HRO-W. (Author's collection.)

common of these is the RAS (Figs. 17 and 18.) It was also widely used by the Marines, and in some air communication services. The Navy required that the receiver cover the frequencies between 400 and 500 kHz. The standard HRO could not, as its IF frequency was 456 kHz. To accommodate this requirement, the IF was changed to 175 kHz, allowing full coverage from about 200 kHz to 30 MHz.

The Navy decided that a crystal filter and S-meter were of limited utility in a monitor receiver likely to be exposed to vibration, so they had them removed, making the RAS more like the HRO Junior. The low frequency IF would have given higher selectivity than required by the Navy, so a 1-megohm swamping resistor was added to the secondary of the IF filters, and the secondary of the transformer was tapped down. The Navy also required the addition of a headphone coupling transformer, and that the coils be held in place in the receiver by a locking system.

The Navy further required that the extra coils be held in the coil holder so that the front panel of the coil was visible to the operator. Accordingly, the RAS coil holder was much taller than the standard coil holders produced by National. The RAS came with seven coils that are not interchangeable with the HRO coils. They are differentiated from the standard coils by the two metal plates on the front that are engaged with the locking system, and by the stampings on the coil insulators. As described above, the standard coil insulators were stamped with the coil designator and the position of the coil in



Figure 17. Front view of the RAS. This model has the coil module locks. (Author's collection.)

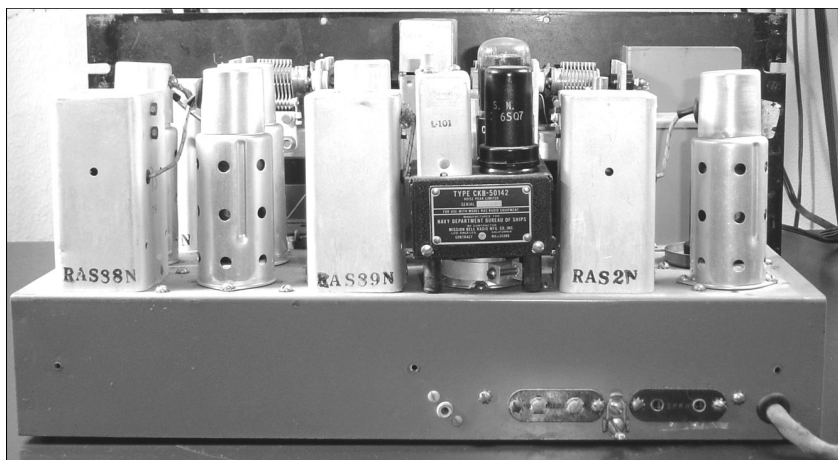


Figure 18. Rear chassis view of the RAS. The noise limiter chassis is the black unit just to the right of center. (Author's collection.)

the pack. On the RAS, the left-most coil is designated 5, and the right-most, 8. Therefore, the highest frequency coil pack that covered 14 to 30 MHz would have stampings as follows: A5, left-most 1st RF; A6, 2nd RF; A7, mixer; and, A8, right-most HF oscillator.

It is possible to retune the higher frequency RAS coils to work in the HRO since the difference in the high frequency oscillator frequency (279 kHz) is small compared to the actual frequency (from 14 to 30 MHz on the highest frequency coil). These receivers were used to monitor the 500-kHz emergency frequency in Coast Guard stations until well into the 1970s.

One option for the RAS was a noise limiter, which replaced one of the IF amplifier tubes. It is bolted in place and appears to be wired into the circuit (Fig. 19), so it is not a plug-in option, but rather was likely installed at a service depot. These noise blankers were built by Mission Bell Radio Manufacturing Co., Inc., and are designated CKB50142.

The standard setup of the RAS system required a 31-inch rack and consisted of the receiver, a power supply, the coil holder, and a speaker. The major difference in the circuitry of the RAS was that a 6F8 dual triode was used as the second detector and AGC amplifier. This replaced the dual diode/triode or dual diode/pentode found in the HRO. Due to the change in AF gain caused by elimination of the first

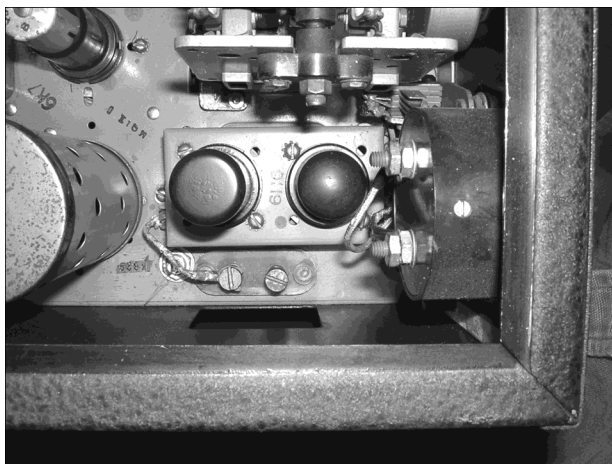


Figure 19. The add-on noise limiter chassis described in the text included two tubes, a 6H6 and a 6J5.

audio amplifier, and substitution of the triode detector for the diode detector, the final audio tube was changed to the 6V6G, which, like the 6F8, used an octal socket.

The second Navy model was the RBJ, also produced during World War II. These appear to be quite rare. It is similar to the RAS, but uses the standard 456 kHz IF. Since the standard HRO had nine available coils, the RBJ versions were stamped as 00, 0, and 1 through 7, with

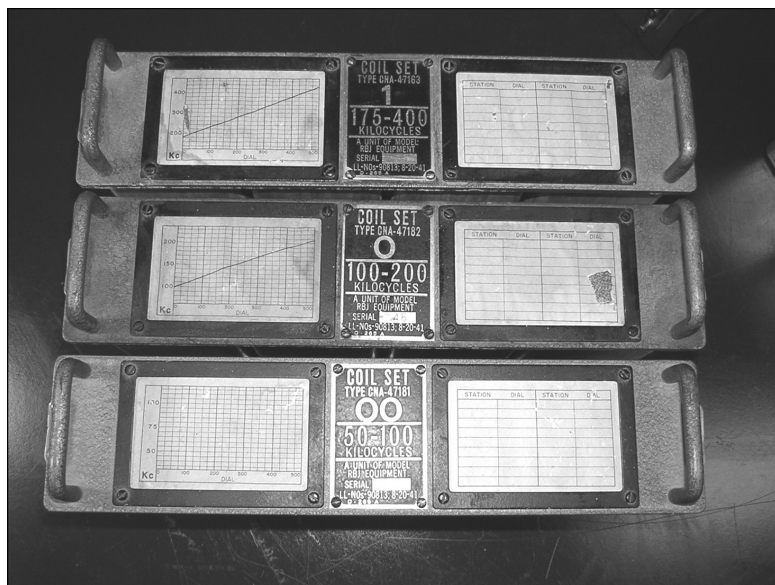


Figure 20. Coils for the RBJ receiver. (Author's collection.)



Figure 21. This close-up of the RBJ 00 coil insulators shows how a typical HRO coil module was constructed. (Author's collection.)

the 00 coil covering 50 to 100 kHz and the 0 coil covering 100 to 200 kHz. RBJ coils are shown in Figs. 20 and 21. This receiver is said to have the same tube line-up as the HRO, and does have the coil locking mechanisms as used on the RAS.

The last variant for the Navy was the RAW. It used the 456 kHz IF and glass tubes. The only information I can find indicates that it is the same as the RBJ. If there are differences, they must be minor. RAWs must also be quite rare.

Other Modifications of the HRO

One very rare HRO variant was produced as a panoramic receiver for signals intelligence. This system used plug in coils like the HRO, but the characteristic tuning knob was gone. In its place was a motor used to rotate the special tuning capacitor through its full range and back. The output was fed to a panoramic display. This unit also had a built-in power supply.

In addition, the British modified the HRO-M and HRO-MX to better

suit the requirement for a direction-finding receiver. These units had a panel over the normal antenna inputs to accept inputs from a direction-finding antenna (usually the Babcock type), and a sense antenna. Some of these models had a front panel switch to allow standard, DF and sense antenna switching. The coils for these receivers were not intended to be usable in the standard HRO, probably because they were modified for a low-impedance antenna input.

The R-140 was developed for the Signal Corps by modifying the HRO-M, MX, and the HRO-5 for use in a frequency measuring system. The modifications included removing the B+ from the speaker terminals, and allowing an audio signal to be introduced to the second detector plate. To remove the B+ from the speaker terminals, a resistor was placed between the lines normally located on the speaker terminals, one of the speaker terminals was grounded, and the other connected to the audio amplifier plate by a 0.1 μ F capacitor. To provide a signal to the detector, the leads to the B+ terminals on the rear of the receiver were removed and tied together. One of these terminals was connected to ground and the other to the plate of the detector.

HROs During the 1945-1949 Era

National's HRO-5A was produced after the end of World War II, supposedly shipping in January 1946. This was the original HRO-5 receiver supplied with amateur bandspread coils. Some of the first versions came with the four standard HRO Senior coils covering the frequency range from 1.8 to 30 MHz. Very shortly after this receiver was introduced to the civilian market National began producing the HRO-5A-1, marked HRO-5TA-1 for the table unit and HRO-5RA-1 for the rack mount unit. This receiver included a noise limiter, adding 6H6 and 6J5 metal tubes to the tube lineup, but was otherwise very much like the HRO-5A.

There were actually three versions of the HRO-5TA-1. The first used the round S-meter seen on all the earlier HROs, and used the earlier crystal filter unit introduced on the HRO-MX. The early HRO-5TA-1 crystal filter had two variable capacitors—one for the phasing and one for the bandwidth. The bandwidth control was on the top right corner, and the phasing control directly below it. This version has been seen with four standard HRO Senior coils, but more

often with the later "Silver Front" coils that have the bandspread capability added. These coils had the standard and bandspread frequency curves on the bright metal plate. Additional coils were available as options.

The second version used a new crystal filter unit with a five-position selectivity switch that eliminated the variable capacitor and instead switched fixed capacitors into the circuit. The phasing control was moved to the upper right corner with the selectivity switch directly under it. The late HRO-5TA-1 used a different marking system and serial number series. These serial numbers were impressed into the chassis on the right side of the chassis top, opposite the antenna connectors. The chassis on the earlier models were painted gray, in the later models they are bright metal.

The third version of the HRO-5TA-1 was actually an HRO-W modified at National by adding a sub-chassis under the S-meter, which included the noise limiter and the provision of a different S-meter in place of the 0 – 1 mA. unit. From the advertisements it appears that the early version came out in 1945, with the modified HRO-W produced in late 1945 or early 1946, and the square S-meter version being introduced in mid-1946.

These three versions differ very little in outward appearance. An early model 5TA-1 is shown in Fig. 22, and a late model 5TA-1 in Fig. 23.

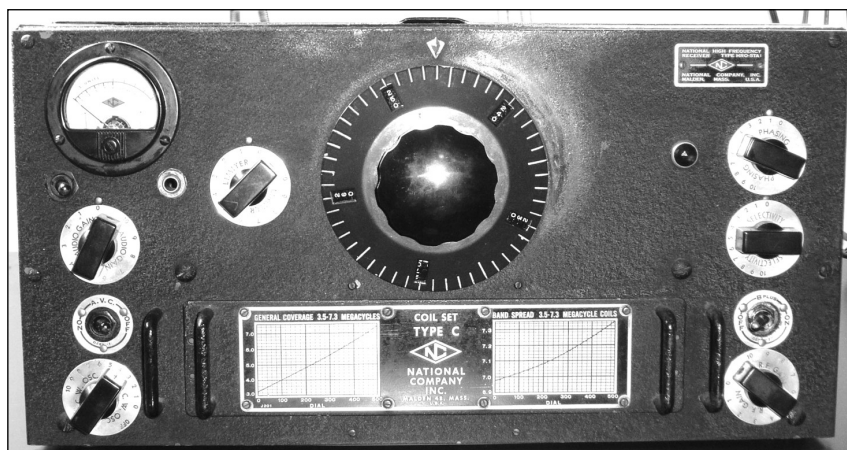


Figure 22. Early HRO-5TA-1. (Author's collection.)

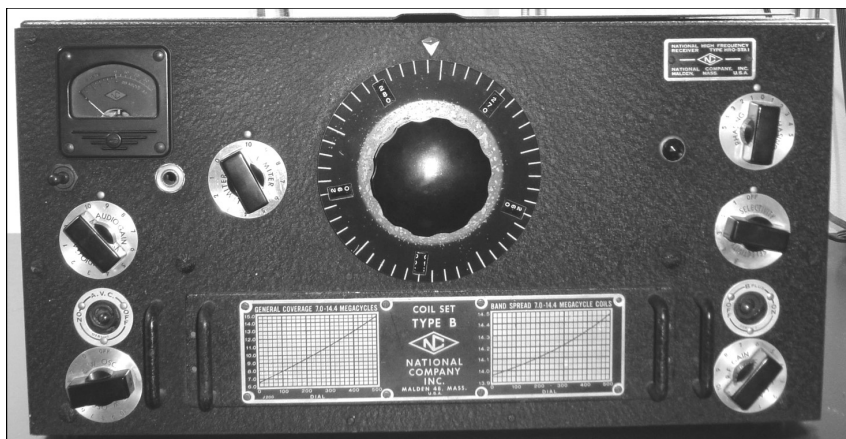


Figure 23. Late model HRO-5TA-1. It has the more modern S-meter. (Author's collection.)

The HRO-C in Fig. 24 is a combination of the 5RA-1 and the SPC.

Some information indicates that National produced an HRO-6 receiver, similar to the HRO-5A-1 but with a different limiter circuit.

The HRO-7 (Figs. 25 and 26) was the first departure in styling from the black wrinkle finished rectangular box HRO that had been in production with minor changes for more than ten years. This HRO was built in a gray enclosure with rounded corners. I have seen a couple of HRO-7s with a dark blue finish, but I have been unable to determine whether that finish was available



Figure 24. The HRO-5C, a combination of the HRO-5RA-1 and the SPC. (Author's collection.)

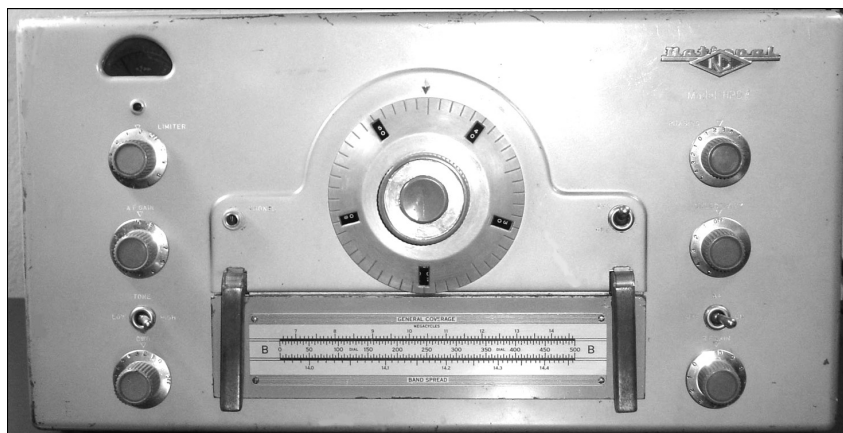


Figure 25. Table Model HRO-7. (Author's collection.)

from the factory, or if these sets were repainted professionally. The ones I have seen have matching blue coils, speakers, and power supplies.

In the HRO-7 the main tuning knob was changed from black to a matched gray knob with an inserted bright ring. The new circuit incorporated a voltage regulator and a triode high frequency oscillator. The location of the noise amplifier and the first audio amplifier were switched. The front of the coils now had a slide-rule-

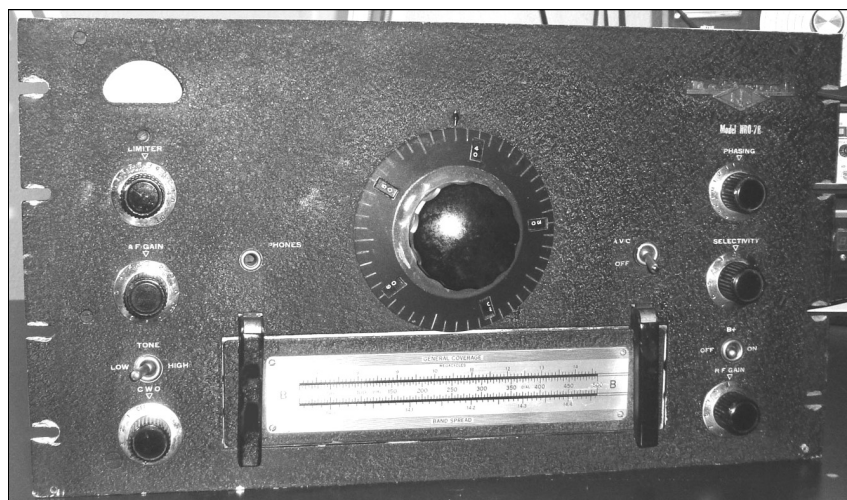


Figure 26. Rack mount version of the HRO-7. (Author's collection.)

type scale, spreading the frequency curve over a large portion of the coil front. The handles were gone from the front panel and the coil, replaced by two coil locks that eased the insertion and removal of the coil pack.

National introduced the Select-O-Ject, basically a high-performance audio filter, at about this time. The HRO-7 had a plug-in socket for the accessory. Another accessory, actually a complete receiver, was added to the product line at this time. The HFS receiver could be used as a stand-alone super-regenerative receiver from 27 MHz to 250 MHz, or it could be used as a converter to 10.7 MHz. For the amateur interested in VHF and UHF, the HFS used as a converter in front of an HRO was a very good choice.

The original 1930s HROs used an electron-coupled high frequency oscillator. If carefully designed this type of oscillator is relatively insensitive to voltage variations and load variations. Nevertheless, to improve the performance of the oscillator section in the HRO-7, National used a voltage regulator tube to reduce voltage variations and hence drift. Also, the triode oscillator was fitted with a frequency compensating capacitor. Many of the early HRO-7s were built on the HRO-5A-1 chassis. The factory simply riveted a plate over the chassis hole for the oscillator tube and put the miniature socket on the new plate. An original factory modified oscillator section should have the tube types stamped adjacent to the tube sockets and should be riveted. The new miniature tubes were a 0A2 VR tube and a 6C4 oscillator.

As shown on the preceding page, the HRO-7 was available in either table or rack mount versions. The rack mount version (HRO-7R) still had the 3/16-inch thick aluminum front panel and was finished in black wrinkle paint. The matching speakers for the table model were usually eight-inch diameter speakers and included a newly designed cabinet and a five-pin speaker plug. This plug change eliminated a problem with earlier HROs, namely, damaging the audio output tube by removing its plate voltage while leaving the screen voltage on the tube. Many people don't realize that when running the earlier HROs without a speaker the audio output tube should either be removed or the output terminals should be jumpered.

A new coil module (designated the AC coil) became available about this time to allow bandspread-only coverage of the new 15-meter amateur band. National also produced these coils for earlier receivers, for example the HRO-5A-1. Versions for the earlier receivers

included the handles, but used the new front scales. Additional coils offered by National at the time included the AA coil, which covered the 27 to 30 MHz range, and the AB coil, which covered from 27 to 35 MHz. The HRO-7 was the first National HRO to allow reception of narrow-band FM signals by the addition of the NFM-07 adapter instead of tuning the signal off frequency and using slope detection. The HRO-7 had an external audio input and an optional tilt base.

National appears to have printed manuals for a model HRO-12S, but it is not clear how many (if any) actual such receivers were made. This model appears to be similar to the circuit used in the RAS, including the 175-kHz IF frequency and no crystal filter. It did have an S-meter and came with a 12-volt DC power supply. It should have come with A, B, C, D and G (230 to 515 kHz) coils. It was also supplied with a speaker and shock mounts. This may have been intended to replace the RAS units that were in use well after this time. If they were made, they were most likely sold primarily to Canada.

The HRO-50 and HRO-60

The HRO-50 followed the HRO-7, around 1949. This model added an internal power supply and added push-pull audio output. It came with four coils—the AA, bandsread coil for 11 and 10 meters (27 to 30 MHz), along with the standard B, C, and D coils. This HRO could be used as a phonograph amplifier, and the available ten-inch table mount speaker and five or six watts of clean audio from the two 6V6Gs sounded rather good. The primary change in this model was the addition of a direct-reading frequency scale. All earlier HROs had required that the operator read the setting of the dial and look at a curve to estimate the frequency. With the earlier system, estimating the frequency to within 25 kHz was not really possible on some frequencies. Now the extra step of reading the dial and then converting by use of the frequency curve was eliminated.

The HRO-50 used the same IF system used in the HRO-5 and HRO-7. The tubes in the HRO-50 front end were miniatures. The original 6D6s, or 6K7s, were replaced with 6BA6s, and the mixer was changed to a 6BE6. Other minor changes were made, and sockets were added for a crystal calibrator and narrow band FM adapter. At the end of the run, the AA coil was replaced by the A coil.

By mid-1951 the HRO-50-1 (Fig. 27) replaced the HRO-50. It carried the conversion to modern tubes a bit further, replacing the

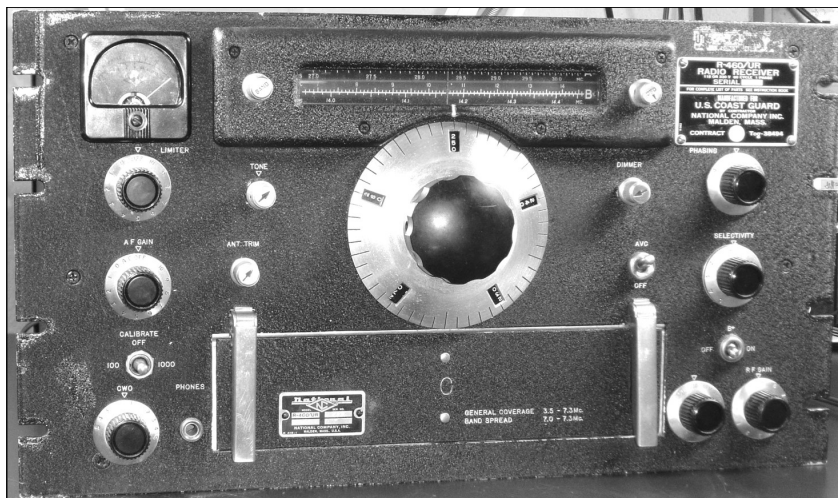


Figure 27. The rack mounted HRO-50R-1, an improved version of the HRO-50R. (Author's collection.)

BFO and IF amplifier tubes with more modern versions. The more important change was in the IF circuit. It now included dual-tuned transformers, giving greatly improved skirt selectivity, and three stages of IF amplification employing 6SG7 tubes. The twelve tuned circuits gave a pass band acceptable for SSB, although the detector and AVC required special procedures for listening to SSB. The HRO-50-1 was also available in two models: rack mount (the HRO-50R-1), and standard table-top unit (the HRO-50T-1). The rack version was the last of the black wrinkle-finished HROs. A few HRO-50R-1s were made with gray finish. The military version of the HRO-50R-1 was called the R-460/UR.

While the HRO was an expensive receiver, amateur radios operators did buy quite a few of them, and those who did tended to be enthusiastic about their performance. Fig. 28 is a National ad from the 1951 ARRL *Radio Amateur's Handbook*.

The coils available for the HRO-50 (Fig. 29) and later HRO-60 included the four standard ones—the A, B, C, and D coils—plus the following additional coil sets:

- AA (27 to 30 MHz)
- AB (27 to 35 MHz)
- AC (15-meter ham band)

HRO-50

\$359*

(including coils A, B,
C, D. Less speaker.)



Latest and Finest Version of the World- Famous HRO Series!

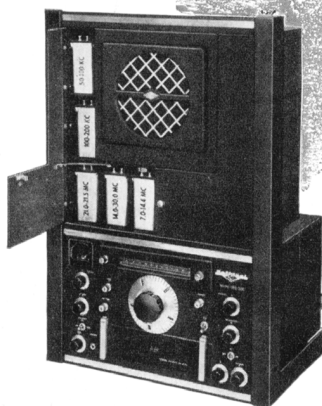
Compare the characteristics and features of the new HRO-50 and see why, once again, the HRO sets the standard of receiver performance! You'll appreciate the convenience of the new HRO-50, too — the new edge-lighted, direct reading dial and the insulated, heavy-duty, built-in power supply section. For thrilling performance, be sure to see and try the new HRO-50!

COVERAGE: 50-430 kc., 480 kc.-35 mc. Voice, CW, NFM (with adaptor).

FEATURES: Sensitivity of 1 mv. or better at 6 db. sig./noise. Selectivity variable from 13 kc. overall to app. 1200 cps. at 40 db. Negligible drift after warm-up. Micrometer dial for logging. Provision for crystal calibrator unit. Variable ant. trimmer. Lively S-meter. Min. tubes in front end and high freq. osc. Osc. circuits not disabled when receiver in send position. High-fidelity push-pull audio with phono jack. BFO switch separated from BFO freq. control. Dimmer illumination control. Accessory socket for Select-O-Ject.

CONTROLS: Bandswitch, Oscillator, Tone, Ant. Trimmer, Dimmer, AVC, Limiter, AF Gain, Calibration, CWO, Phasing, Selectivity, On-Off, RF Gain, AM-NFM-PHONO.

TUBE COMPLEMENT: 6BA6, 1st r.f.; 6BA6 2nd r.f.; 6BE6, mixer; 6C4 h.f. oscillator; 6K7, 1st i.f.; 6K7 2nd i.f.; 6H6 det. & a.v.c.; 6H6, a.n.l.; 6SJ7, 1st audio; 6SN7, phase



HRO-50C

(HRO-50 receiver with rack, speaker and 10-roll compartment. Coils A, B, C, D included.)

splitter and S-meter amp.; 6V6GT (2) p.p. audio; 5V4G, rect.; 6J7, b.f.o.; OB2, volt. reg. Accessories: Crystal Calibrator, 6AK6; NFM Adaptor, 6SK7, i.f. amp., 6H6, ratio det.; Select-O-Ject, 12AT7 (2).

SIZE: Table 19 $\frac{3}{4}$ " wide x 10 $\frac{1}{8}$ " high x 16 $\frac{1}{2}$ " deep. Rack: 19" wide x 10 $\frac{1}{2}$ " high x 17 $\frac{3}{8}$ " from rear of front panel incl. 1 $\frac{1}{8}$ " handle.

Write for list of accessories.

*Slightly higher west of the Rockies.

Figure 28. HRO-50 ad from the 1951 ARRL *Radio Amateur's Handbook*.



Figure 29. Coils for the HRO-50. These coils are sleeker looking than those for earlier HROs. (Author's collection.)

AD (6-meter ham band)

E (upper AM broadcast band and the 160-meter ham band)

F (lower AM broadcast band)

G, H, and J (50 kHz to 460 kHz)

The AD coil for the HRO-50 is very rare and may have been a special order only. Available accessories include the NBFM adapter, a crystal marker with output at 100 kHz and 1.00 MHz, the Select-O-Ject, an external DC power supply for six-volt input, an eight-inch rack mount speaker, a combination rack mount speaker and coil holder, and eight-inch and ten-inch table speakers.

One interesting note on the crystal marker oscillator was that the 100-Hz output could be adjusted to WWV, whereas the 1.00 MHz. output was not adjustable. The speaker for the HRO-50 was the same as that used for the NC-173. There were National advertisements that stated that the company was willing to build coils to cover any frequency as long as the requirement was large enough to justify the run.

Fig. 30 shows an interior view of the HRO-50R-1. Like other HROs, this model employed rugged mechanical construction and careful shielding.

In 1952 National introduced the HRO-60 (Fig. 31), the last of the vacuum tube-equipped HROs. The HRO-60 was basically the same as the HRO-50-1 with one exception—dual conversion above 7 MHz. Accordingly, the coils for frequencies above 7 MHz. (A, B, AA, AB,

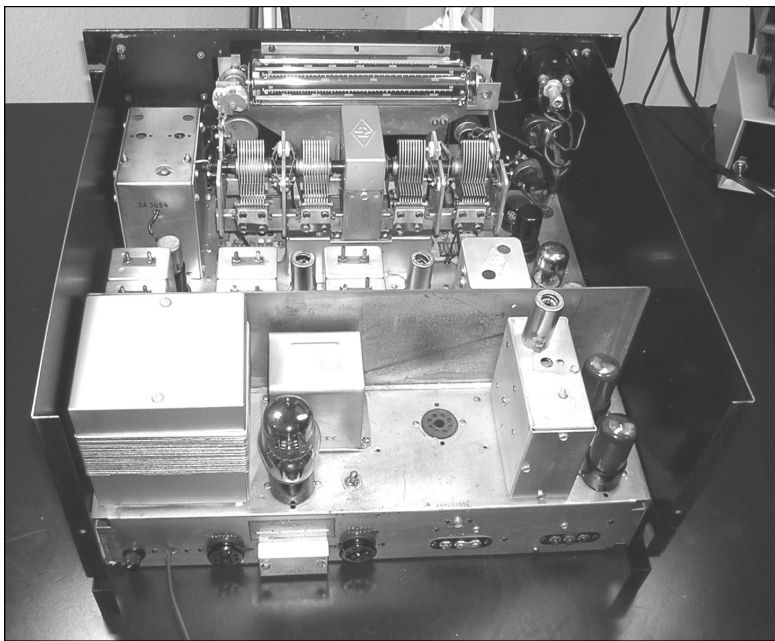


Figure 30. Interior view of the HRO-50R-1. The sturdy mechanical construction of the HRO receivers is impressive. (Author's collection.)

AC, and AD) were not interchangeable with the earlier coils. The HRO-60 coils cannot be used in earlier receivers, but it is possible to use HRO-50 coils in the HRO-60 by bypassing the first converter. In the HRO-60 regulated current was supplied to the high frequency oscillator and mixer filaments. The 4H-4C filament current regulator tube is now quite rare, and many owners are using the 6V6 indicated in a National *Service Bulletin* as a substitute.

The rack mount version of the HRO-60, the HRO-60R, came with a front panel painted the same gray as the tabletop model. Accessories for the HRO-60 were the same as those for the HRO-50. The HRO-60 remained in production until 1964 as National's top-of-the-line receiver.

The HRO Goes Solid-State

The vacuum tube HRO-60 was replaced by the solid-state HRO-500, available either in a portable version designated the HRO-500P, with a case, internal speaker and rechargeable Ni-Cad batteries, or in a



Figure 31. The HRO-60, introduced in 1952, was the last of the vacuum tube HROs. A full set of coils for an HRO takes up a lot of space, as this photo shows. (Author's collection.)

table model. A rack mount adapter was also available for the HRO-500. This new receiver covered from 0 to 30 MHz without plug-in coils, and with constant 1-kHz. divisions on the familiar micrometer dial. It used a phase locked loop, locked to the harmonics of a crystal oscillator, and a linear VFO that covered 500 kHz. National wrote several one-page *QST* advertisements in 1964 describing the operation of the new phase locked loop. The HRO dial included an internal reduction system allowing either fast tuning (10 turns for 500 kHz) or, using an added vernier knob on the main tuning knob, about 30 turns for the full range of the VFO. Some of the main tuning knobs have a spinner attached and some do not.



Figure 32. The solid-state HRO-500. (Author's collection)

Selectivity for the HRO-500 operating at the new 262-KHz IF frequency was provided by cup core coils variable from 500 Hz to 6 kHz in bandwidth. This receiver caused quite a sensation when it was introduced and it is still popular today, though the number produced was not very great due to its high cost. Many HRO-500s were used by communications companies. For example, Tropical Radio and Telegraph had several of these at each operating position. For very low frequency use National produced the LF-10 which included a VLF tuner and amplifier as well as a provision for adding an audio filter.

The HRO-500 (Fig. 32) was almost as large as the original HRO, and its weight of 26 pounds was not far away from that of the original. The semiconductors used were a combination of germanium and silicon transistors. Performance, compared to modern solid-state receivers, was fairly poor, especially in strong signal conditions, but compared to other receivers of similar vintage, it performs quite well. The frequency read-out, pre-selector, and stability were very good.

The HRO-600 was the last of the HROs produced by National. I will not comment on it here because I have not had the opportunity to

study one. These fully transistorized receivers are extremely rare today.

The HRO and its Special Role in Signals Intercept During World War II

The HRO had a long and illustrious career, with the greatest amount of use in World War II occurring in Great Britain. The estimate most normally quoted in references to signals intelligence during World War II was that effective signals intelligence and cryptanalysis shortened World War II by approximately two years. The scholarly book *Action This Day* acknowledges that without the availability of the excellent American receivers, primarily the HRO, the cryptanalysts and traffic analysts would have not been able to provide this intelligence.

Two books on this topic that I recommend highly are *England Needs You* by Joan Nichols, and *The Secret Wireless War* by Geoffrey Pidgeon. Nichols, a young lady who became an intercept operator at Beaumanor during World War II, includes a lot of information concerning the daily life of the operators, along with the problems they faced. Pidgeon describes in detail the equipment used for communication with the clandestine agents, at the intercept stations, and for distribution of the Enigma intelligence. Both books reference David White, the curator for the diplomatic wireless station and "Y" station at Bletchley Park (Figs. 33 and 34). David has been kind enough to provide a large amount of information to me concerning the HRO at war. He worked for the Diplomatic Wireless Service after World War II until his retirement in 1992. HROs continued in operation in the Diplomatic Wireless Service until 1957, and at some of the embassies until 1959. They were replaced by Eddystone 730 receivers, which the operators thought were inferior to the HROs.

Bletchley has a collection of twenty or so HROs, of which David keeps a dozen or so fully operational. Normally there are five or six HROs in the Diplomatic Wireless Hut and six more in the "Y" station. Most of the HROs used in Great Britain did not come with National power supplies or speakers. These were provided by local builders in the United Kingdom. The speakers are simple metal enclosures with perforated front grille. The power supplies built in the U.K. by two different companies were much more substantial than the "Doghouse" supplies normally seen with HROs in the U.S. These power supplies



Figure 33. David White, Curator of the communications aspects of Bletchley Park, along with vintage equipment on display. If you visit this site, do try to meet David. (Photo from David White.)

are marked G5NI, Birmingham, and PSEI Limited. With the limited shipping space available during the war years and the requirement for 240-volt "mains" power, the local construction of these accessories was a very good option.

Early in the war the government of Great Britain recruited many of the Britain's licensed amateurs to listen for clandestine transmissions from inside the country. These were called Voluntary Interceptors or VI. Later in 1939 they were recognized as the Radio Security Service, or RSS. The VI and RSS operator had to make do with what was available until the HROs arrived in large enough quantities for this vital work. After the war these surplus receivers were sold to the VI/RSS operators for 5£ each. Some VI operators recalled using two-tube regenerative receivers until being issued an HRO. Apparently many of the HROs purchased for the VI/RSS operators were commercial units with nine coils including the standard bandspread coils.



Figure 34. Y Station replica at Bletchley Park, with an array of six working HROs. (Photo from David White.)

The largest use of receivers in Great Britain during World War II was by the intercept stations that monitored German and Italian traffic outside Great Britain. There were a few intercept stations that used the Marconi and Eddystone receivers, but most used HROs. Examples include the Navy stations at Scarborough, which used 80 HROs, and Flowerdown, with 40. Hanslope used 66 HROs in 32 listening positions, 30 having two HROs each, and two positions having three HROs each. Other stations and the numbers of HROs at each were:

Forfar	60
Gilnahirk	12
Nash	8
St. Erth	12
Thurso	14
Weald	8
Whaddon	30

To eliminate power line noise, Nash and Weald used DC power supplies for the receivers and had diesel generators to charge the

batteries. The other stations used "mains" power. There were some listening operations in India, Ceylon, and Australia during WW II; some used HROs and some used the RCA AR-88. The first listening station at Bletchley (Station X) used a pair of RCA AR-77s. One of the original receivers has been returned to the small room in the attic of the mansion.

Working Conditions for the Intercept Operators

While their HRO receivers were state-of-the-art for the time, intercept operators faced difficult listening conditions. The Germans transmitted noise or music very near the frequency of their code transmissions (in British jargon, "wireless telegraphy" or "W-T" transmissions) to reduce the probability of intercept outside the intended communications radius. Signals from the remote Axis forces were generally weak and drifting in frequency, and messages were normally keyed manually. Recognizing a particular operator's "fist" allowed the intercept operators to follow the transmitting stations and operators when they changed call signs and frequencies. Sometimes call signs were changed daily, and the transmitting frequencies changed even more often. Transmissions were coded groups and had to be copied perfectly. At times more than one operator would be assigned to insure perfect copy. When operators missed part of a transmission they would write in probable letters with a question mark, and make dashes to indicate the number of letters missed. Often this allowed the reconstruction of a complete transmission from the combination of two or more partial intercepts. Under these demanding conditions, the quality of the receivers used made a huge difference between success and failure.

A typical intercept station such as Beaumanor might have several receiving set huts, or "Set Rooms." A typical set room resembled a schoolroom, with the operators facing a control operator seated at the front of the room facing the operators. There would be a central aisle with operators and sets on each side of the aisle. The control operator would assign most sets to monitor particular frequencies and would connect the sets to the antennas deemed preferable for that frequency and distance.

The antennas were primarily V-beams and rhombics at heights of 50 to 75 feet. There would be multiple antennas for each band of frequencies pointed toward different locations from Africa to the

Arctic. Each antenna was fed to a wide-band amplifier that distributed the signal to as many as twenty HROs. These amplifiers were designed by the General Post Office and used type 807 vacuum tubes as class A RF amplifiers.

Once the operator was assigned a frequency by the control operator they would then use the calibration book for their receiver, or a "cheat sheet" attached to the front of the receiver and marked with something like "remove under threat of death" to tune the correct frequency. The operator might then wait for hours until some action occurred. Unless they were quite familiar with the station, the operators would have to determine whether the station was part of a network, and if so, the type of network – star or circle. In the circle network everyone transmitted on the same frequency; the star had two frequencies – one for the control station to transmit on, and one for everyone else. The star network would either require a dual receiver setup, or two operators. Operators would copy the preamble at the top of the "Red Sheet" (Fig. 35) and the coded groups below.

PRECEDENCE		DEFERRED		FIA HOC 8	
FROM	914 100			PREFIX	GR
TO	HQ 2	MARK -		SECURITY CLASSIFICATION	
15 40 RPLPF. 15 45 15 56/46				Most SECRET.	
INFO	76182 35967 68973 67831			ORIGINATOR'S NUMBER	
74810 11654 19654 97162				P1307	
15249 36521 34610 52691					
41692 64398 21984 43643				11164 32480 98641	
39461 29656 34569 35462				94561, 15496 25619	
64329 94846 43210 64105				19632 25864 43261	
24637 24874 61954 76913				13248 68426 69211	
69342 87642 51185 13697				34982 73642 86599	
88934 49364 81248 11298				43523 87486 11249	
94536 56382 48953 64813				87647 31469 11368	
43176 61792 41253 58213				69329 73869 96896	
39427 86828 65422 87925				65327 53216 43973	
48321 43257 32168 36543				29932 31219 18312	
21935 18935 28951 73514				11223 82155 38297	
77868 72297 31326 32184				57365 36217 53167	
25474 25461 25467 46591				63491 25694 49654	
54681 36951 34692 64328				46210 56238 41245	
Page 1 of 3 pages		REFERS TO MESSAGE ☒ YES ☐ NO		DRAFTER'S NAME R WHITE	
OFFICE M16		TEL NO.			
FOR OPS USE	DATE 1954/1/16	TIME 1105	SYSTEM F	OPERATOR D	DATE 13/05/44
RELEASING OFFICER'S SIGNATURE			RANK		

Figure 35. A Bletchley Park "Red Sheet," no doubt received on an HRO. Copying code groups was tedious, yet the critical nature of the task meant the intercept operators could not allow their concentration to lapse. (Photo from David White.)

For some coded messages such as Enigma, the cryptanalysis required approximately 100 messages per day. Given the dozens of codes being used, the volume of coded messages intercepted was huge—at times several hundred thousand coded groups per day. Several good books concerning the breaking of the German and Italian codes are available, including Winterbotham's *The Ultra Secret*, the first book to reveal the secret of the success of cryptanalysis in Great Britain during WW II, and David Kahn's *The Codebreakers*. I recommend a visit to the Bletchley Park Internet site: www.bletchleypark.org.uk as well as Tony Sale's Codes and Ciphers internet site www.codesandciphers.org.uk. If you have an opportunity to visit the United Kingdom, it is well worth the time and the 10£ entry fee to visit Bletchley Park. Expect to spend a full Saturday or Sunday there, and you will wish for additional time.

There were thousands of W-T intercept operators in the United Kingdom during World War II. Most were young women who knew nothing about radio or W-T until after induction into their particular branch of the service. The stress on the intercept operator was severe. Missing part of a critical message could mean additional Allied casualties. At times a stressed operator might have been taken off intercept service and assigned to search operations where they would tune over a band of frequencies looking for new stations; this was thought less stressful than intercept operation. In the worst case an over-stressed operator would be reassigned to radio direction finding.

The operators mentioned a couple of problems. One was the possibility of contacting the uncovered B+ terminals on the back of the receiver. A second was that the power supplies were located on the floor, and periodically operators would accidentally kick the supplies' on-off switches and turn them off. Joan Nichols mentions that the male operators never accidentally turned off the supplies. She wondered, "what did they do with *their* feet?"

Having just read a description of the operating conditions you can see why the HRO was referred to as "the Remarkable HRO," "the Cadillac of Receivers", and "the Best Receiver Money Could Buy", by many of the operators quoted in *The Secret Wireless War*. The stability and excellent capability of returning to a particular frequency were better than any other receiver available in the United Kingdom until the early 1960s.

In order to distribute "Ultra" intelligence, Special Liaison Units and

Special Communication Units (SCUs) were formed. The Special Communications Units were equipped with a standard British Mark III transmitter and an HRO., (Fig. 36). These were mounted in various vehicles until the Dodge ambulance chassis (Power Wagon) was found to be the best available vehicle. The Mark III was a 2-tube crystal-controlled transmitter of about 30 watts output power. They were assigned to the various commanders, and units in the field were required to keep in contact with the home units in Great Britain in order to pass new intelligence to the commanders as quickly as possible. These very successful communications teams had to be ingenious in finding suitable locations for their wire antennas that allowed reliable communications while having to move frequently—sometimes up to three times a day.

One illustration of the skill of the SCU operators in using their transmitters and HROs occurred at the end of the war when there were several different communications systems located within one of the

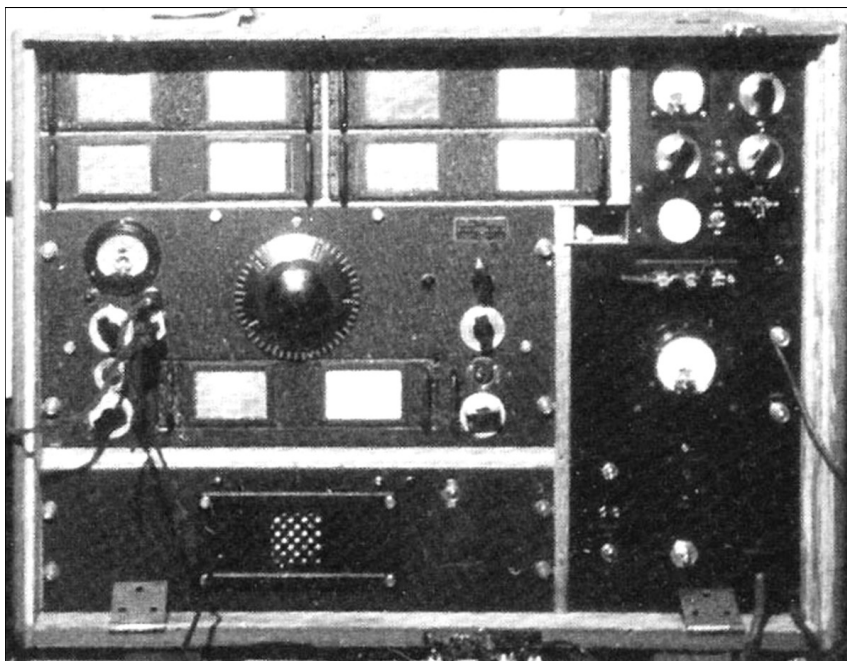


Figure 36. Special Communications Units (SCUs) used this portable system, called a “coffin” set, consisting of an HRO, a Mark III transmitter, power supply, and coils. (Photo from David White.)

stadiums in Germany. The SCU offered to send messages for a General whose own communications unit had not been successful. The General visited the SCU and asked to see their equipment. When they showed him the 30-watt Mark III, he became enraged because he could not understand how they could stay in communication with England when his own unit with 500-watt transmitters could not get his messages through. Several of the SCU operators commented on the high reliability of their HROs. Some reported not having to do any maintenance—even so much as replacing a vacuum tube—during the period spent traveling through Europe between D-Day and VE-Day.

HROs in the U.S. Military During WW II

In the United States the HRO and its variants were also widely used during World War II, primarily by the Navy, Coast Guard and Marines. These sets include the RAS, and the "reverse Lend-Lease" version of the HRO built by Amalgamated Wireless of Australasia Ltd.—the table mount AMR-100 and the rack mount AMR-101 (Fig. 37). I have seen pictures of the control station for the Coast Watchers in the Solomon Islands (call sign KEN) prominently showing an RAS; the AMR-100 can be seen in a late 1945 *QST* article concerning the *U.S.S. Apache*, a communications ship used by McArthur in the Philippine Islands. You will also see banks of RAS receivers in pictures taken at locations such as Albro Lake, as well as other communications and training stations.

At the beginning of WW II you will find references to patriotic owners turning in their HROs for use during the period that the military demand for receivers outstripped supply. I know of several early HROs (including HRO Juniors) built in 1937 or 1938 that have military acceptance markings. We can be fairly sure that at least some of these were privately owned before finding a place to serve during the war years.

National supplied a much larger number of NC-100/NC-200 variants than HROs to the U.S. military during WWII.

Modifications to HROs

The wide availability of the HRO, and the fact that they were often available inexpensively as postwar war-surplus items led to these receivers being highly modified by amateur radio operators. Not many

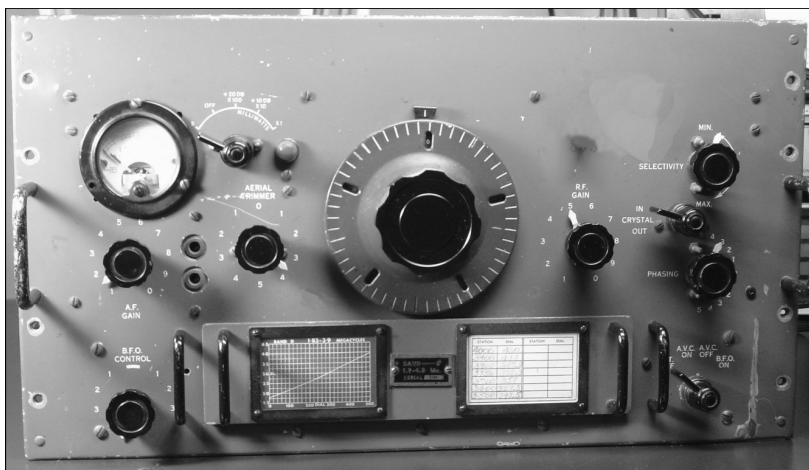


Figure 37. The AMR-101, built by Amalgamated Wireless. (Author's collection.)

hams thought that the HRO they picked up for a song in surplus stores in the late 1940s or early 1950s might be worth twenty times as much today as they paid for it if they had not modified it. Of course there were numerous articles in ham publications on how to improve the performance of older receivers and in those days no one worried about keeping early receivers original.

The modification most often seen on early HROs is the change of the older oscillator tube (6C6 or 6J7) to a miniature 6C4 triode oscillator, and the addition of a voltage regulator such as the 0A2—the same change National adopted with the HRO-7. The next most often seen modification is the addition of the noise blanker as adopted by National on the HRO-5A-1. Normally this modification consists of the addition of a 6H6 and a 6J5. Typically if you see a 6H6 in an HRO earlier than the 5-TA-1, then a limiter has been added. Usually there will also be an additional control between the S-meter and the main tuning dial.

The third most popular change was to replace the earlier vacuum tubes with later versions. Depending on when the modification was performed, this might be octal vacuum tubes in place of the six-pin glass tubes, or miniature vacuum tubes in place of either the octal or six-pin glass vacuum tubes. Normally the modifications will be in the RF amplifiers, mixer, and oscillator. The miniature tube modifications usually upset the gain distribution in the receiver. Today when serious

National collectors find one of these modified receivers they frequently restore it to its original circuit, in spite of the fact that the voltage regulated high frequency oscillator and noise limiters were improvements in these receivers.

If you are lucky enough to own an HRO receiver, perhaps this article will allow you to see it in a different light. It was a landmark in the development of the superhetrodyne receiver, and a great contributor to the Allied war effort during World War II. Many intercept operators will state that it was the best intercept receiver available during the war, and for quite some time after the end of the war. It was stable, rugged, simple to operate, and the dial mechanism allowed resetting to a particular frequency much better than any other available receiver.

Reverse Engineered HROs

During and after the period spanned by World War II the HRO received sincere flattery by being copied by the Germans and the Japanese. There are two German copies of the HRO, one made during the war, and one made after the war in East Germany for supply to the Chinese. The Japanese made a copy of the dial and drive mechanism, complete to the emblem on the top, and also supplied a number of receivers with a different dial mechanism, but with the general layout and plug-in coils introduced by the HRO (Fig. 38).

There were also three versions made in Allied countries, one in New Zealand, and two in Australia. Probably the best of these was the extremely well-made Amalgamated Wireless of Australia Models AMR-100 and AMR-101. The Kinglsey AR-7, also made in Australia, used a single tube for the converter stage, and would have suffered from oscillator pulling.

The Collier and Beale Model 941 SWB built in New Zealand is a very close copy of the HRO, actually using imported dial mechanisms manufactured by National. The information available on these copies indicates that the Australian versions operated very well, and the German versions met the specs of the original HRO, but were easier to overload. There is an operational Japanese HRO at Bletchley Park, but I did not have time during my visit to compare it side by side with the original HROs.

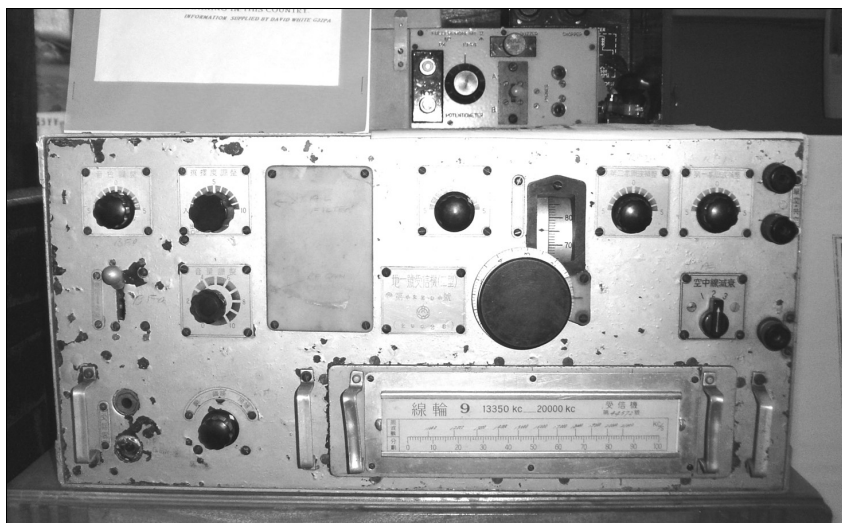


Figure 38. A Japanese attempt to copy the HRO. (Photo from David White.)

HRO Power Supplies

The evolution of power supplies for National receivers is somewhat involved. Prior to the AGS National built the SW-3, the AC version of which required 2.5 volts for the filaments of its three vacuum tubes and 180 volts at about 40 mA for B+. This was provided by the Model 5880AB power supply. National ads indicated that the 5880AB could be used with the FB-7, though it is not recommended. This power supply is really too light for the FB-7, even if the final audio amplifier tube is removed.

There were two correct power supplies for the FB-7: the 5887AB and the 5897AB. The 5887AB had outputs of 2.5 volts for the filaments of the seven-tube FB-7, along with about 180 volts of B+ at something like 60 mA. This smaller of the two supplies allowed the operation of the FB-7 at lower listening levels, where "room filling loudspeaker sound" was not required. The heavier-duty Model 5897AB provided 2.5-volt filament voltage with sufficient current to supply the nine vacuum tubes in the HRO, and provided about 240 volts of B+ at 70 mA to allow full output from the audio output tubes in either the HRO or the FB-7.

For the AGS, National supplied the Model 5886AB which was also

supplied with the National SRR receiver. This power supply (Fig. 39) provided filament voltage at 6.3 volts, adequate for nine vacuum tubes, along with 240 volts B+ at 70 mA. National also offered a single rack mount supply, Model GRSPU, available with either 2.5- or 6.3-volt filament voltage, and adequate output for several watts from the audio amplifier. These may have been designated as GRSPU-2 and GRSPU-6, although I have seen one GRSPU with 2.5-volt filament output marked only "for HRO."

The second National rack mount power supply, the Model GRDPU, was capable of providing power for two receivers. Basically it was two GRSPU internal units in a single rack panel. These dual units were available with filament voltage outputs of 2.5/2.5, 6.3/6.3, or 2.5/6.3.

By late 1940 National introduced the Model 697 power supply (Figs. 40 and 41), which provided the proper current for an HRO with 6.3-volt filaments. I have seen a few rack mount power supplies marked 697. With the exception of the rack model, the power supplies mentioned above were all built into small enclosures commonly called "Doghouse" style power supplies.

Early in 1945 National produced the 697-W, a heavier duty external supply with a plug-in electrolytic capacitor. Because they were sometimes used in humid tropical climates, they were treated with fungicide between early 1945 and September 1945. National had also announced a vibrator-type external DC supply for the HRO in November 1939. It fed the battery voltage to the filaments and used a

vibrator pack to provide approximately 180 volts B+ at 50 mA. The vibrator pack was normally supplied by Mallory.



Figure 39. The Model 5886 power supply. (Author's collection.)



Figure 40. The Model 697 power supply.

National's announcement stated that these units were built to order, and not normally stocked.

The AC supplies described above employed a type 80 full-wave rectifier and a capacitor-input dual-section filter. The pi-section filter typically used a triple-section eight- μ F electrolytic capacitor and a choke of approximately ten henrys. One of the electrolytics was

connected across the output of the rectifier. The pulsating DC then passed through the choke, and to the other two sections of the capacitor that were connected in parallel across

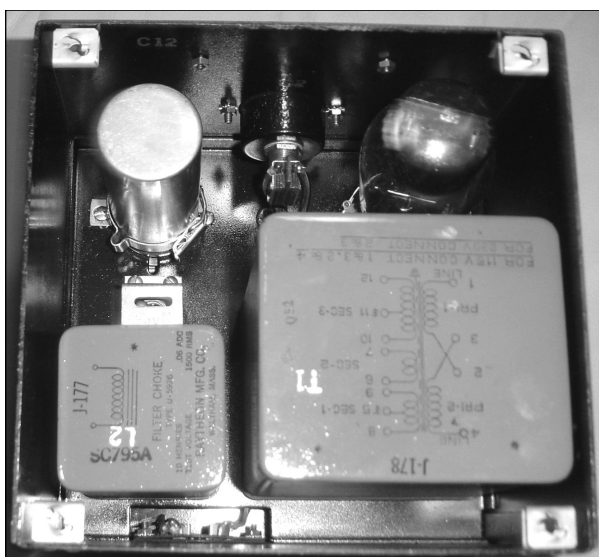


Figure 41. Interior view of the Model 697 power supply.

the output of the choke. In the 697 supply the rectifier is typically a 5Y3 although the Rider schematic (page 14-35) shows an 80. The early supplies included a pair of small RF bypass capacitors. These 697 supplies may also contain a variable resistor with the tap grounded and the two ends connected to the filament lines. The HRO moved this resistor to the receiver chassis, making it more effective, as the power supply chassis is not normally connected to the receiver chassis.

During most of the HRO years, corresponding rack mount versions of the power supplies were available. Fig. 42 is an example of an early rack mount power supply.

National published an advertisement showing the following as dates that the models listed below were first available:

SW-3	August 1931
AGS	July 1932
FB-7	February 1933
SRR	April 1933
HRO	January 1935

In addition, the first ads for the following models appeared in *QST* magazine on the dates listed.

HRO-Rack Mount	July 1935
HRO Junior	February 1936
SPC	December 1936

I have tried to avoid factual errors in researching and writing this article and accept responsibility for any that have crept in. Please feel

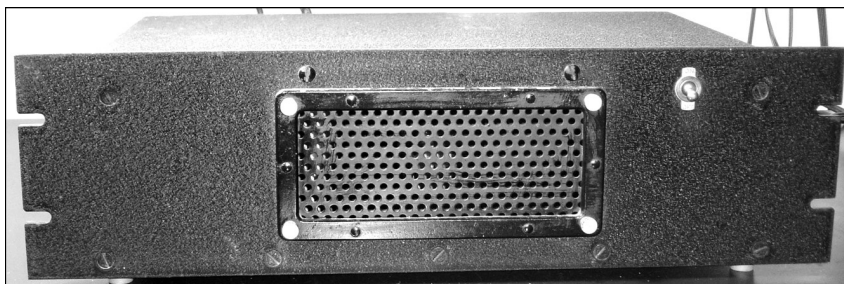


Figure 42. Early rack type HRO power supply. (Author's collection.)

free to contact me concerning errors, additional facts, and particularly observations that do not agree with this article.

Acknowledgment

I want to thank a large number of people for providing information for this article. David White provided a wealth of information and guidance concerning the military use of the HRO in the United Kingdom as well as the view of an intercept and point to point W-T operator using the HRO. He not only helped me, but also was instrumental in getting Joan Nichols and Geoffrey Pidgeon to write their excellent books. I also appreciate the help of my friends at the RAF museum in Henlow, including Dave Thompson and Vic and Mike who help keep the museum in great condition. Closer to home, John Orohood, Greg Gore, Rob West, and Henry Hand at the Western Historic Radio Museum have all produced excellent information and guidance. Most of all, I must not forget my mentor on all things electronic, Max Busick (SK), W5GJ until his passing, and his son Don Busick, K5AAD, last of the line.

About the Author:

Barry Williams' grandmother encouraged him to get an amateur radio license at an early age. When he was 11 years old, she purchased a Hallicrafters S-38E for him, which he kept until age 14, when he acquired a better-performing BC-348Q receiver. By the early 1960s, he had read everything he could about radio and had achieved 13 w.p.m. copying CW. At the time he lived in a small East Texas town and would have had to travel 130 miles to Dallas to take the FCC exam, so obtaining a ham license had to wait for a more opportune time.

After majoring in industrial engineering at Texas A&M, marrying, and getting his career in order, Barry once again turned his attention to radio and obtained an Advanced Class ham license. His call, which he has held ever since, is KD5VC. He owns modern ham gear, but still enjoys listening to old boat anchor receivers. Barry has written other articles on radio topics for publications such as *QST*.

Barry has had a keen interest in National HROs for quite some time. His HRO collection currently numbers about forty (including parts sets). He has researched their characteristics, has been in frequent

contact with other HRO collectors, and has even traveled to England to research the use of HROs by the British in World War II.

Barry is Manager of New Product Development at Varco Tuboscope in Houson. He and his wife have been married for 35 years, and have four children and five grandchildren. In the photo below Barry is flanked by his two oldest grandchildren, Kennedy Rose Williams on the left, and Timothy Reichert on the right.■

