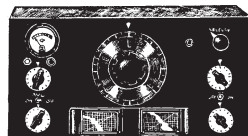


THE COMMUNICATIONS RECEIVER



BY **BARRY WILLIAMS, KD5VC**, 2002 MUSTANG LANE, ROSHARON, TX 77583
E-MAIL: barry.williams@nov.com

The National Flagship NC-400

The NC-400 is one of the more controversial of National's products. It was National's last attempt at marketing a high-end vacuum tube receiver for amateur and commercial use, though a more advanced receiver was built for the military. Competing products using similar designs include the Hammarlund SP-600 series and the Collins R-390/A.

The styling of the NC-400 can be traced to the NC-300/303 series. This design was descended from the long series of NC receivers. In some ways, the electrical design resembles the much earlier Hallicrafters SX-28. Unfortunately the finished product is flawed in several ways. Some of the ergonomics are pretty bad, and actual performance could have been improved at lower production costs.

Most successful engineering projects have a champion whose overall vision guides the efforts of the different design entities. Probably the best known of these "champions" was Arthur Collins. Early in his career he was the complete design team, later he guided the teams, and still later he supported his own "champions." Unfortunately, the NC-400 apparently had no champion.

The inconsistencies in the finished

NC-400 indicate that the designers worked in isolation with little co-ordination. It is possible that goals were changed partway through the design stage. There may have also been conflicting requirements for amateur and commercial users. Some features were well thought out, others were just pulled from existing designs, and a few seem to be hung on as afterthoughts. It is difficult at this point to piece together the various influences on this product.

The best information from serial number data indicates that National built as many as 500 of these receivers. Of that number probably 200 were sold to individuals and the remaining receivers were built for rack mounting only, without the cover, for use by the FBI. One comment from an FBI field office was that they acquired an R-390 as quickly as possible and put the NC-400 back in the box. Does that mean that its performance was unacceptable? It was not markedly inferior to that of competitive receivers, but was somewhat difficult to operate—a feature that was probably more responsible for the poor opinions of the receiver than the actual performance.

The electrical design of the NC-400 in-



The National NC-400.



cludes dual RF stages with three tuned circuits at the signal frequency. The RF stages consisted of new high mu pentodes developed for television. Both RF stages are controlled by the AVC, but under MVC the first stage is at full gain, only the second stage and IF are controlled. Cathode resistors are switched by the band selector to equalize gain over the seven bands used to cover 540 kHz to 31 MHz. In my experience the first stage can go into oscillation unless an antenna is attached. Once connected to an antenna this tendency disappeared.

The RF section is followed by two mixers, the first mixer has an output at 455 kHz for the lower four bands and 1.720 MHz for the upper three bands. On the upper three bands the 1.720 MHz signal goes through three tuned circuits and a crystal controlled converter (2nd mixer) with the output at 455 kHz. There is also an optional crystal calibrator with harmonics at each 100 kHz or 1 MHz as selected by a front panel switch. That switch probably received and deserved more cursing than any other control on the receiver.

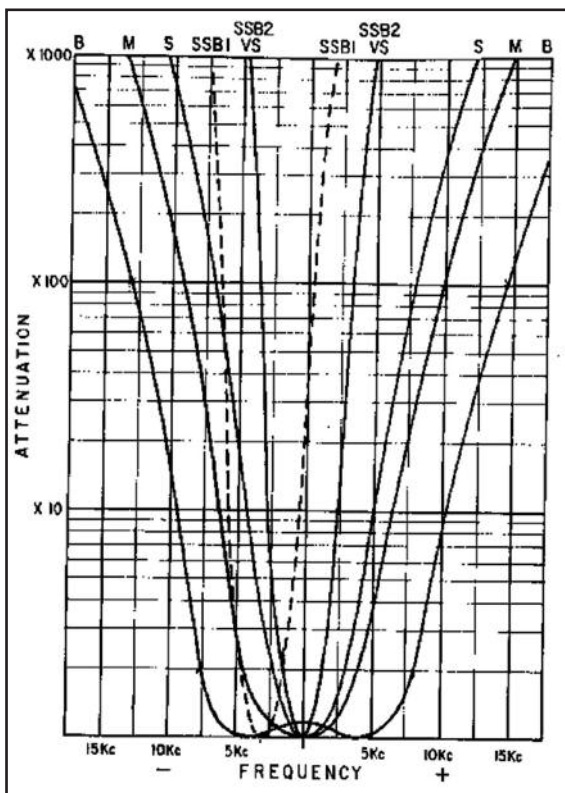
The calibrator control knob is of very small diameter making it difficult to turn. Further the left-most position has nothing to do with calibration. It is to allow the operator to tune the receiver to the frequency determined by the optional crystal controlled or external high frequency oscillator system. The HFO has seven positions, normal, five crystal control positions, and external.

In usual operations you may check the calibration at the 100 kHz position, then 1 MHz, and then you turn the calibrator off. If instead you accidentally go the extra switch step and against the stop, the receiver will operate in a bizarre manner until you realize what happened, utter a curse word or two and turn the calibrator to the "Off" position.

The curse words are required

to get your grip tight enough to budge that darn little knob. The manual says "The TUNE position is not used for calibration purposes." Searching carefully we find elsewhere in the manual, under the description of the crystal controlled frequencies, the mention of a "CALIBRATE TUNE switch permits use of the S-Meter to tune the receiver to crystal or external oscillator frequency." It is hard to imagine how this design made it into production.

The IF system of the NC-400 is made up of two different bandwidth systems. The standard receiver comes with a single crystal filter similar to that used in the HRO from the late 5TA1 through the 60. It has 5 selectivity settings or can be bypassed. When in use there is also a control for crystal phasing to remove heterodynes. This module can be removed and replaced by a mechanical filter holder which allows switching between



Selectivity curves for the 5-crystal filter positions.

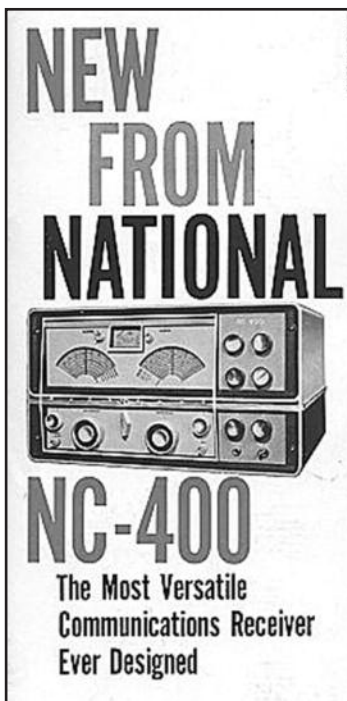
three mechanical filters (Collins, though the Collins name is not mentioned in the book) or by-passing.

After these modules you can select a 3.5 kHz IF strip using 14 tuned circuits at 455 kHz, or a selectable bandwidth wide filter for AM. Bypassing the filter modules and selecting the wide IF strip allows selectivity choices of 16 kHz, 8 kHz, and 4 kHz. The narrow bandwidth IF strip has all 14 tuned circuits centered at 455 kHz. The 6/60 dB shape factor is about 3 to 1 using these circuits.

Since these circuits are not stagger tuned, but tuned "On the nose," the sound of an SSB signal is peaked in the mid range by 6 db with respect to the upper and lower part of the audio signal. It is not unpleasant and probably increases readability slightly. I have heard much worse audio from modern radios which were supposed to have a flat topped response, but due to improper matching of the impedance have several spikes in the passband.

The oddest thing about this IF strip is the method used for sideband selection. Each of the 14 tuned circuits has an additional capacitance that is switched in or out to move the center frequency of the circuits. One of the problems for us today is that the capacitance and inductance values drift with time. The alignment instructions only provide for alignment at 455 kHz, not with the additional capacitance as this is "adjusted at the factory".

Most successful narrow bandwidth IF systems made sideband selection by switching the BFO from one side of the passband to the other. This method does mean that the frequency readout will change by the shift in BFO frequency. With



Detail from a 1957 advertisement.

the resolution of the frequency readout in the NC-400 this shift would be inconsequential. If the optional mechanical filter holder were being used, the NC-400 sideband selection system could not be used. An additional quirk to the operator is that instead of upper and lower sidebands the selection of the two center frequencies is identified as SB1 and SB2.

Separate detector systems are provided for AM and CW/SSB signals. The AM detector is a standard diode detector which can be used with an automatic noise limiter or the noise limiter can be bypassed. AGC is supplied by the standard AM detector circuit. For SSB signals the BFO and

product detector are used. This is followed by a manual noise limiter. The AGC circuit from the AM detector is still used, but is modified for a faster attack and longer "hang" time. The BFO is adjustable, with the capability of being crystal controlled. The CW detection is like that for SSB, but the AGC is grounded.

The two stage audio amplifier system ends with a single ended 6AQ5 beam power tube. This provides adequate power, and relatively good fidelity. The wide IF capability begs for the push pull audio used in earlier National receivers. There are two output windings on the built-in audio-output transformer, the first for a 600 ohm line output and the second for a 3.2 ohm speaker.

The tuning system used in the NC-400 uses strings, springs, pulleys, plastic knobs and dials. This was pulled directly from the dual dial NC receivers and reflects their low cost design criteria. One critic of the era mentions paying \$895 and getting plastic knobs. The left dial is for quickly tuning

across the bands. The right hand knob controls a second four gang tuning capacitor of much lower variable capacitance that covers something more than the amateur bands.

As in almost all of the dual dial receivers, the right hand dial is set to a band edge marker then, with the calibrator on, the main tuning dial is then used to set the band edge at the correct spot (denoted by a colored hash mark. After this the calibrations on the right hand dial help you get to a point in the band with repeatability that was on the order of 5 to 10 kHz. Compared to some receivers we have seen this may be considered pretty good, but it was poor when compared to gear of the era and unacceptable when compared to today's transceivers. Why National used that tuning system 25 years after the excellent HRO design is hard to fathom.

The weight of this receiver is on the order of 80 pounds. It is almost two feet square by a foot tall with the power supply near the rear. I have always lifted radios with the front panel against my body (that soft part in front is specially suited for cushioning radio equipment). But in this case most of the 80 pounds has a couple of feet of leverage.

Heavy as it was, that weight did not make this receiver physically stable; bumping the table or moving one of the switches will move the frequency by several kHz in the worst case. National claims frequency stability of .002%, or 20 PPM. I did not run long term stability tests, but after a long warm up the frequency change probably was near that figure when measured over an hour.

Options listed for the NC-400 include the crystal calibrator, the mechanical filter holder, crystals for control of the HFO and BFO, the NTS-2 Speaker and a kit for diversity reception. The mechanical filter adapter must have been a late addition.

As we mentioned, the crystal filter is removed and the new module installed. In place of the six-position switch and phasing control, the filter holder has a single three-position switch. National supplied a button cover to place over the hole for the phasing control. This option also made about ten of the fourteen 455 kHz tuned circuits superfluous.

The BFO had a single crystal socket. I

think a more elegant solution would have been to place a four position switch on the mechanical filter holder: first position for no crystal to allow variable BFO followed by three positions for LSB, USB and CW. The receiver could have been supplied with the mechanical filter holder and an SSB filter. Crystals for the BFO could have been added as the owner found need, and additional mechanical filters could have been added for CW and any other requirements.

I have an SP-600 JX-21 and Collins R-390A. These two receivers are probably good indicators of the state of the art when the NC-400 was produced. In comparing those receivers with the NC-400, the NC-400 is the only one that you can (with more effort than expected) tune in and properly demodulate a SSB signal without an external adapter.

The frequency stability of the R-390A is best of the group, the feel of the SP-600 dial is much like that of the HRO. With a more advanced tuning system, and more attention to physical stability the NC-400 may have achieved the status of the other two receivers. The NC-400 is much sought after by National collectors, especially in the condition shown. This is mostly due to the rarity of the receiver and not for its performance.

In this column we have made a 30 year jump from the pre-1930s receivers. There were a lot of developments between those years. In 1929 we were worried about staying within a MHz, now we are faulting a receiver for not reliably getting us within a kHz.

At what point is a receiver old enough to be considered within the interest of the AWA? National's next high end receiver was the famous and quite popular all solid state HRO-500, which has been reviewed in this column. I have had the pleasure of owning and operating a number of solid state commercial or military receivers (Racal, McKay, Collins, Drake, JRC, and ICOM) that are considered obsolete and have been available to the hobbyist as surplus for periods approaching 25 years. Should we consider any of these receivers for inclusion here? Thanks again for your interest.

73, Barry