A Heathkit "Cantenna" Deep Dive

The Enduring Legacy of the Heathkit Cantenna

by: John White VE7JW, John Schouten VE7TI and others

The Heathkit HN-31 "Cantenna," a name that evokes images of both radio transmission and its containment, stands as a testament to the ingenuity and practicality of amateur radio equipment design. Produced by Heathkit from 1961 to 1983, and later succeeded by the HN-31A, this unassuming device, a dummy load, achieved an almost legendary status, with an estimated 200,000 units sold. Its continued presence in ham shacks across the globe speaks volumes about its reliability, affordability, and enduring utility. This article delves into the history, design, function, and enduring legacy of the Heathkit Cantenna, exploring why it remains a sought-after piece of equipment even in the age of modern electronics.

A brief history of dummy loads

Before examining the Cantenna specifically, it's crucial to understand the purpose of a dummy load. In radio transmission, power amplifiers generate radio frequency (RF) energy. This energy is intended to be radiated by the antenna. However, during testing, tuning, or when the transmitter isn't actively transmitting a signal, it's often necessary to dissipate this RF energy without radiating it. This is where the dummy load comes in. It acts as a "dummy" antenna, providing a resistive load that mimics the impedance of a real antenna, typically 50 ohms. This prevents damage to the transmitter, allows for safe testing and adjustment, and prevents unwanted signal radiation.

Early dummy loads were often rudimentary affairs, sometimes consisting of a resistor immersed in a container of water. These early designs suffered from instability and safety concerns. As radio technology advanced, so too did the design of dummy loads. The advent of more robust resistive components and improved cooling methods led to more reliable and higher-power

John Schouten VE7TI is active on HF, VHF and UHF from both his home station and at the SEPAR training station.

devices. Heathkit, with its focus on affordable and accessible electronics for the hobbyist, played a significant role in popularizing the dummy load with the introduction of the Cantenna.

The Heathkit HN-31 Cantenna: Design and function

The HN-31 Cantenna is a marvel of simplicity and effectiveness. At its core lies a high-power, non-inductive resistor, carefully chosen for its ability to dissipate significant amounts of RF energy without excessive heating or changes in resistance. This resistor is immersed in a specific type of transformer or mineral oil within a sealed metal can. The oil serves two critical purposes: it acts as a coolant, transferring heat away from the resistor, and it also increases the power handling capability of the resistor by improving its heat dissipation.

The choice of oil is crucial *see the next article].* It needs to be a dielectric oil, meaning it's an electrical insulator, and it must have a high flash point to prevent fire hazards. Transformer oil, specifically designed for high-voltage applications, is one type, however, it has been shown to be carcenogenic, making its use undesirable. Over time, the oil can degrade, absorbing moisture or becoming contaminated. This can affect the performance of the Cantenna and even pose a safety risk. Therefore, periodic inspection and, in some cases, replacement with mineral oil is recommended.

The Cantenna's design is elegantly simple. The can itself acts as a heatsink, radiating heat into the surrounding air. The top of the can features an SO-239 connector, a standard coaxial connector used for RF connections. This allows for easy connection to the transmitter output. The compact and relatively lightweight design of the Cantenna made it easy to integrate into any ham shack.

The HN-31A: A simplified successor

Heathkit later introduced the HN-31A as a successor to the HN-31. While it retained the basic functionality, the HN-31A represented a simplification of the original design, likely aimed at reducing manufacturing costs. However, the HN-31's reputation for robustness often made it the preferred choice among hams.

Why the Cantenna Endures

Several factors contribute to the Cantenna's enduring popularity:

- **Reliability:** The simple design and robust components contribute to the Cantenna's remarkable reliability. With proper maintenance, these devices can last for decades.
- **Affordability:** When originally sold by Heathkit, the Cantenna was an affordable option for hams, priced at $9.95. Even today, used Cantennas can often be found at reasonable prices.
- **Ease of Use:** The Cantenna is incredibly simple to use. Just connect it to the transmitter output, and it's ready to go.
- **Power Handling:** While not intended for continuous high-power operation, the Cantenna can handle moderate power levels for testing and tuning purposes.
- **Classic Appeal:** For many hams, the Cantenna represents a connection to the history of amateur radio. It's a piece of equipment that embodies the spirit of DIY and experimentation.

Maintaining your Cantenna

While generally reliable, the Cantenna requires occasional maintenance:

- **Oil Inspection:** Regularly check the oil level and condition. If the oil is dark, discolored, or appears to contain contaminants, it should be replaced.
- **Connector Check:** Inspect the SO-239 connector for any signs of corrosion or damage.
- **Resistor Check:** With an Ohm-meter, the resistance of the internal resistor can be checked. A significant deviation from 50 ohms indicates a problem.
- **Can Inspection:** Check the can for any signs of leaks or damage.

The Cantenna in the modern ham shack

Even with the availability of modern electronic dummy loads, the Cantenna continues to hold a special place in the hearts of many amateur radio operators. Its simplicity, reliability, and classic appeal make it a valuable tool for any ham shack. Whether it's used for testing and tuning transmitters, providing a load for amplifier adjustments, or simply as a reminder of the rich history of amateur radio, the Heathkit Cantenna remains a testament to the enduring power of good design and practical engineering.

It's a classic that continues to serve the amateur radio community, a symbol of a time when ingenuity and resourcefulness were hallmarks of the hobby. The Cantenna's legacy extends beyond its functional purpose; it represents a tangible link to the past, a reminder of the enduring spirit of amateur radio.

~ John White VE7JW

Testing Cantenna oil

Heath sold transformer oil in gallon plastic bottles at its retail stores for use in the Cantenna. It is important that the oil be filled to the right level so oil can circulate up the tube surrounding the resistor as the oil near the resistor heats the oil in its proximity.

Firstly, you should test your cantenna to determine if it contains mineral oil or transformer oil (PCBs) by dropping a few drops of water in a sample. This method is a **qualitative field test** that relies on the density difference between water and oil. While it can provide a rough indication, it is **not a definitive or reliable method** for detecting PCBs. Due to the PCB scare, Heathkit announced that the oil they sold in their stores was PCB free. If you buy a used Cantenna, you might want to get assurance that the transformer oil is not PCB based

Here's how the test works, and its limitations:

How the Water Drop Test Works

1. **Density of Water vs. Oil**:
   - Water has a density of about **1 g/cm³**.
   - Mineral oil has a density of about **0.8-0.9 g/cm³**, so water will sink in mineral oil.
   - PCBs are denser than mineral oil, with a density of about **1.2-1.5 g/cm³**, so water will float on top of PCB-containing oil.
2. **Procedure**:
   - Take a small sample of the oil from your dummy load and place it in a clear container.
   - Carefully drop a few drops of water into the oil.

     • *Observe whether the water sinks or floats:*

     • *If the water sinks, the oil is likely mineral oil (less dense than water).*

     • *If the water floats, the oil may contain PCBs (more dense than water).*
3. **Limitations of the Water Drop Test**
   - **False Positives/Negatives**:

     • *Some mineral oils or other dielectric fluids may have additives or contaminants that affect their density, leading to misleading results.*

     • *PCBs are not the only substances denser than water, so other contaminants could cause water to float.*

- **Not Definitive**:
    - *This test does not confirm the presence of PCBs; it only suggests a possibility based on density.*
    - *PCBs must be confirmed through laboratory testing (e.g., gas chromatography or mass spectrometry).*

4. Safety Concerns:
Handling oil that may contain PCBs without proper precautions can expose you to hazardous substances.

Recommendations

- If the water floats, treat the oil as potentially containing PCBs and proceed with caution.
- For a definitive answer, send a sample of the oil to a certified laboratory for PCB analysis. Locally, BC Hydro subsidiary, Powertech, was (and probably is now) capable of testing for PCB content and disposal.
- Always follow safety protocols when handling unknown oils, including wearing gloves, goggles, and working in a well-ventilated area.

Sources and related content

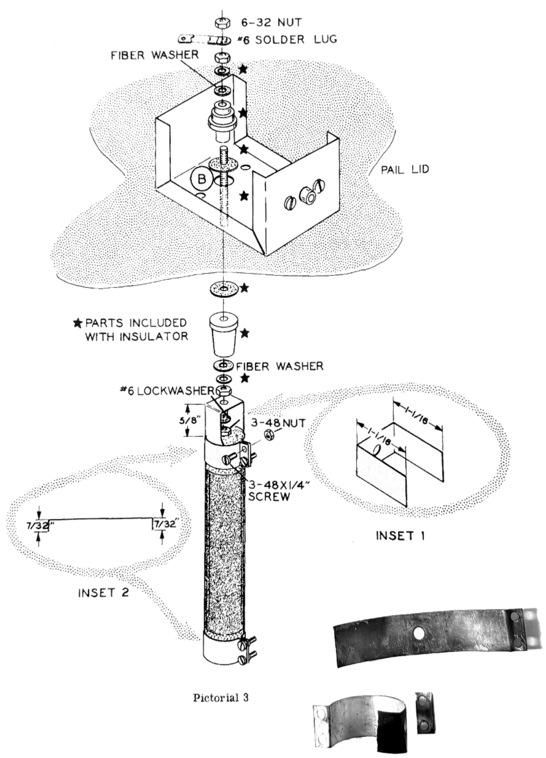
Heathkit of the Month: by Bob Eckweiler, AF6C www.w6ze.org

The Cantenna Rebuild

When you use a dummy load to test your transceiver, you should expect to see a 1:1 match, but what if you hook it up and you get an unusually high SWR?

That's what happened recently at the OTC and even more recently to me. I hooked up my dummy load to do some testing on my new Xiegu G90 HF transceiver but the SWR wouldn't match with its built-in tuner. This was highly unusual because I have found that this tuner will match almost anything. Out came my analyzer and I found exactly the same issue, an SWR greater than 10:1.

I have owned this Cantenna for over 30 years, although it is probably 20 years older, and I had opened it only once to test the type of oil. Upon inspection I found that it had suffered exactly the same fate of the Cantenna at the OTC; the contacts around the resistor had broken resulting in an open circuit. With the cause of the failure confirmed, I set out to Google similar experiences, but found none. Thankfully John VA7XB had performed the repair on the OTC Cantenna and had a solution.



Cantenna internals and the broken contact strips I removed.

I noticed two significant problems. The first was a broken contact clamp at one end of the working resistor, and the second related to poor contacts of the external connector with the large resistor itself. Due to the mechanical construction of the coaxial cylinder that is placed around the working resistor (in order to equalize the impedance), the ground contact of the connector with the resistor passes through several mechanical connections: the contact layer of the resistor, a silvered metal ring, four brass screws, the coaxial cylinder - cylinder holder - tin container - indicator housing, and the connector.

Over time, the oil on the walls of all the above elements created a thin insulating film, and in places it also penetrated between the screw connections, which weakened this contact in many places.

Note: Replacement clamps shown before paint stripping

I carefully removed the resistor assembly, a messy job as it was saturated with oil. I disassembled it, and as I did so, the second clamp fell apart. They are obviously very brittle, I presume as a result of age.

Using two 2cm (13/16") hose clamps, I made two new contact clamps for the resistor, removed the black paint, and cleaned all the contact surfaces. I carefully replaced the old silvered brass strips under the new clamps, a frustrating exercise as spacing is very limited. I also replaced the brass screws that were impossible to clean, and finally measured the actual resistance of the assembled resistor. That was 48 Ω, well within the 10% rated tolerance. All contacts were now electrically sound without their creating additional resistance.

The VSWR was measured, but I could not confirm the manufacturer's specifications that the VSWR is up to 1.5 for frequencies up to 300 MHz, or up to 2.0 for frequencies up to 400 Mhz because I don't have the gear to accurately do so. For measurement up to a frequency of 60 MHz, the VSWR did not exceed the value of 1.1, so this dummy load is certainly excellent for HF.

Up to a frequency of 180 MHz, the VSWR did not exceed 1.5, which makes it usable for the 2-meter band. Factory specs indicate that this dummy load is not recommended for frequencies above 180 MHz.

With repairs completed and tested, I'd say that this fifty-year-old dummy antenna is still quite usable for shortwave transmitters with a power of several hundred watts. In addition, the Cantenna HN-31 is a piece of amateur radio history, and the only old radio relic that I retain… it is worth keeping.

~ John VE7TI

A Better Heathkit "Cantenna"

- Improved metering circuit for an old standby

by H.C. SHERROD W5ZG (SK)

Make your dummy load smarter

The Heathkit "Cantenna" dummy load, Model HN-31, consists of a 50-Ohm dummy load resistor, R1, immersed in oil, and an indicating circuit consisting of resistors R2 and R3, capacitor C1, and diode D1. Figure 1 shows the schematic diagram. The indicating circuit provides for the connection of a direct current meter to the jack marked DC OUT. This arrangement provides a means of indicating relative power.

With the circuit shown in Figure 1, an amount of power at 3.5 MHz applied to the dummy load will produce a certain meter deflection. If the same amount of power is applied to the dummy load at 29.7 MHz, the meter deflection will be considerably greater.

By modifying the indicator circuit to that shown in Figure 2, the indicating meter can be made to read the same value for a given amount of power whether it be at 3.5 MHz, 29.7 MHz, or at any frequency between these values. When this has been accomplished, the indicating meter may be calibrated in Watts and will provide a satisfactory indication of transmitter output power at any frequency between 3.5 MHz and 29.7 MHz.

The basic difference between the indicator circuits shown in Figures 1 and 2 is that the circuit shown in Figure 2 incorporates a frequency-compensating network. In my case, an indicating meter that would read 200 Watts full scale was desired.

The first operation was to modify the circuit shown in Figure 1 to that shown in Figure 2. Note that in Figure 2 the value of resistor R3 has been changed from 1000 Ohms to 2500 Ohms. It will be noted that Figure 2 includes the additional components noted in Table 1 *[next page]*.

All these additional components are installed within the small metal box which is attached to the lid of the Heathkit "Cantenna."

The indicating meter employed had a 200-microampere full-scale movement with an internal resistance of twelve hundred Ohms.

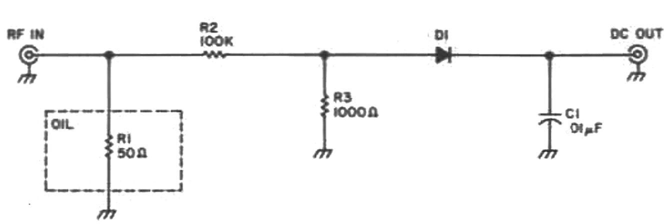


Fig.1.Schematic of the Heathkit "Cantenna."

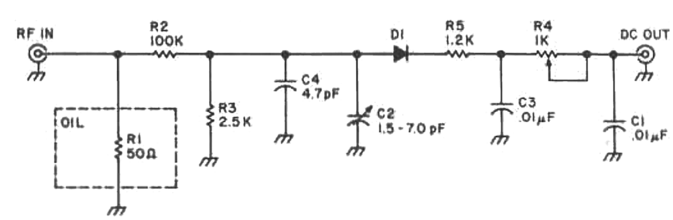


Fig.2.Modified schematic of the Heathkit "Cantenna."

This meter was directly connected to the DC OUT jack of the Heathkit dummy load. An indicator that will show the amount of power applied to the dummy load is necessary for proper adjustment of the frequency compensating network. Either an ammeter or a wattmeter of known accuracy may be employed. The setup for frequency adjustment for proper compensation is shown in Figure 3.

Parts List

- C2 1.5-7.0 pF glass, piston-type variable capacitor
- C3 .01-uF disk ceramic capacitor
- R4 1000 Ohm miniature micro-potentiometer, Bourns trimpot 120-14-E1000
- R5 1200 Ohm, ¼ Watt resistor, 10% tolerance
- C4 4.7-pF disk ceramic capacitor

Adjustment

The adjustment procedure is as follows:

1. Set C2 at minimum capacity and set R4 at maximum resistance.

2. Set the transmitter on 3.5 MHz. Gradually increase the power level until the ammeter reads two Amperes or the wattmeter reads 200 Watts. Decrease the resistance of R4 until the indicating meter reads full scale.

3. Set the transmitter on 29.7 MHz. Gradually increase the power level until the ammeter reads two Amperes or the wattmeter reads 200 Watts. Note that the indicating meter will read full scale before the ammeter reads two Amperes or the wattmeter reads 200 Watts. Reduce the reading of the indicating meter by increasing the capacity of C2 until the indicating meter reads full scale when either the ammeter reads two Amperes or the wattmeter reads 200 Watts.

4. Repeat steps 2 and 3 in sequence until the indicating meter reads full scale when the ammeter reads two Amperes or the wattmeter reads 200 Watts, whether the applied frequency is 3.5 MHz or 29.7 MHz.

If a wattmeter was employed in the adjustment setup, the indicating meter may be directly calibrated from the wattmeter readings. If an ammeter was employed in the adjustment setup, the Watts corresponding to the ammeter reading are shown in Table 2, and the indicating meter may be calibrated from this data.

~ W5ZG (SK)

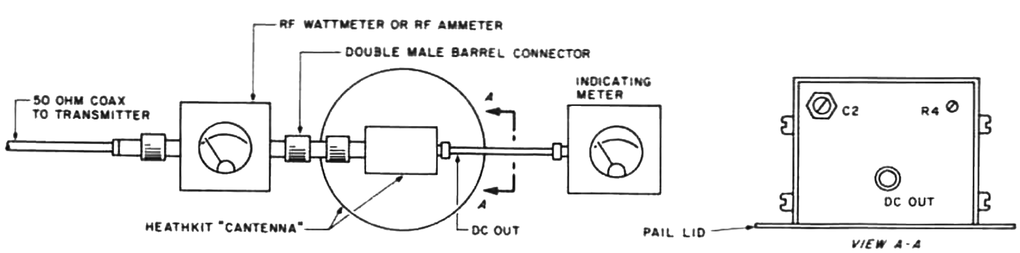


Fig. 3. Setup for frequency-compensation adjustment.

Ammeter Reading, Amperes	Indicating Meter, Watts
.4472	10
.6325	20
.7746	30
.8944	40
1.0000	50
1.0955	60
1.1832	70
1.2649	80
1.3416	90
1.4142	100
1.4832	110
1.5492	120
1.6125	130
1.6733	140
1.7320	150
1.7889	160
1.8439	170
1.8974	180
1.9494	190
2.0000	200

Table 2