Vacuum Tubes' Last Stand?

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What is this thing that one amateur described as the "cat's meow" when it first came out? It's called the Nuvistor, a tiny, really tiny, vacuum tube announced by RCA in 1959, and popularly believed to be the vacuum tubes' answer to the relatively new & rapidly evolving transistor. Even the name Nuvistor seems to be a take-off on the word transistor.

Figure 1— The Nuvistor

The Nuvistor is about the same size as a 1960s era transistor and is radically different from other vacuum tubes. Indeed, from appearance, it is hard to believe this little device actually is a tube. RCA was a major player in the early days of transistors, perhaps the major player. So why would they invest substantial R&D in a fading technology, surely aware that it would have only a short run before being obsoleted by semiconductors? It turns out there were some specific applications that justified the effort. But before looking at specifics, what exactly were Nuvistors?

An ordinary glass envelope vacuum tube is much like a tungsten light bulb: a high-wattage heating element heats a cathode, causing it to emit electrons which stream across the vacuum space inside the tube, seeking the positively charged plate. A simple tube such as this functions as a rectifier, a diode, allowing current to pass in only one direction. More advanced tubes have grid screens interposed between the cathode and the plate. Relatively small electrical charges on the grid screens control the large current of streaming electrons, thus providing amplification.

Figure 2—Size comparison of ordinary tubes to a Nuvistor (second from right)

That's a barebones description of how tubes work but it is still the essence of the hundreds of different types of vacuum tubes that are all tweaked for different performance characteristics and applications. Most ordinary vacuum tubes are enclosed in glass which has the air removed in the final manufacturing step.

Nuvistors are vastly smaller than ordinary glass vacuum tubes and the small size is only the most obvious difference. RCA had great expectations for their little "hatched" device, as described in a 1959 advertisement:

"RCA Electronics introduces the tube of tomorrow

"Called the Nuvistor, this thimble-sized tube is likely to start a revolution in electronics. RCA engineers scrapped old ideas - took a fresh look at tube design. The result will be tubes that are far smaller, perform more efficiently, use less power, can take more punishment, are more reliable. Developmental models now being tried out by designers will have a profound effect on the size, appearance, and performance of electronic equipment for entertainment, communications, defense, and industry in the future. It is another example of the way RCA is constantly advancing in electronics."

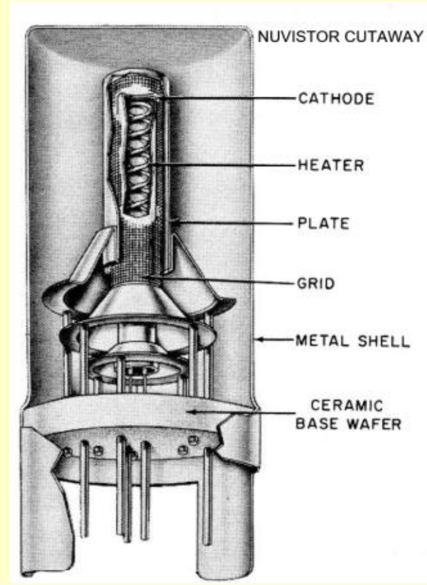

Figure 3—Nuvistor cutaway diagram

Whereas traditional vacuum tubes are constructed with various metals, mica insulating components, glass stems, and often a Bakelite base, Nuvistors are composed of only two materials: metal and ceramic. On the inside, the Nuvistor uses a heating element running up the center, surrounded by cylindrical electrodes. Because of the small size, the Dark Heater, as RCA called the central element, ran hundreds of degrees cooler than conventional heaters. And the small size, with the cathode and plate so close together, made Nuvistors excellent for VHF and UHF (up to 1.2 GHz) applications. Indeed, one of the first and most popular applications for Nuvistors was in television tuners such as the RCA New Vista color TV (see full page ad at http://n4trb.com/Figure4.jpg). But it's hard to believe that RCA revolutionized vacuum tube technology just to create first generation color television tuners. Nuvistor technical specs went far beyond that required for TV.

The manufacturing process was unique and greatly advanced for the time. Instead of spot-welding internal components, Nuvistor elements were brazed "at very high temperatures in a hydrogen atmosphere…" and then out-gassed in a 10-minute process at 1,562-degrees F, followed by vacuum sealing

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at 1,742 degrees F. These processes were automated. One result of this process is that Nuvistors were able to operate in extremely high-temperature environments. In this photo, Nuvistors are lowered into the exhaust and sealing machine.

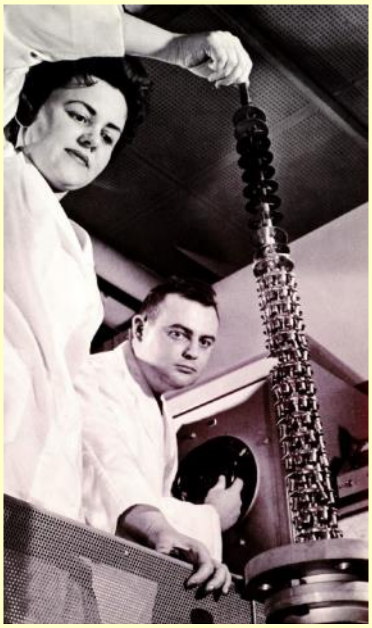


Figure 4—Nuvistor sealing machine

Additionally, Nuvistors were designed to be mechanically rugged, and I do mean rugged. Production devices were tested for shocks at a maximum acceleration of 1,000 G. And not just once, but 20 times. The test-to-destruction reached levels of 3,000 G before device failure. Then came vibration testing in all three X, Y, and Z axes with a constant acceleration of 20 G and a vibration frequency up to 500 Hz. Are you beginning to get the idea that RCA had more in mind than color television? If not, consider this.

Nuvistors were certified to work in nuclear radiation environments, both pulse (as in an atomic blast) and steady state (as in a reactor). After the radiation pulse, Nuvistors would return to normal functioning in 0.5 milliseconds. Such shock and radiation exposure would destroy competing transistor technologies of the time. Ordinary vacuum tubes were also unlikely to withstand such punishment. Is it a coincidence that Nuvistors came along as the Cold War was underway in earnest with the military needing avionics for ballistic missiles and intercontinental nuclear bombers? Oh, and spacecraft?

Nuvistors found their way into a number of pioneering spacecraft. For example, the U.S. got its first close look at the moon with the series of Ranger probes beginning in 1964. The Ranger spacecraft were designed to photograph the lunar surface, like this picture from Ranger VIII, its last image taken 2 seconds before impact.

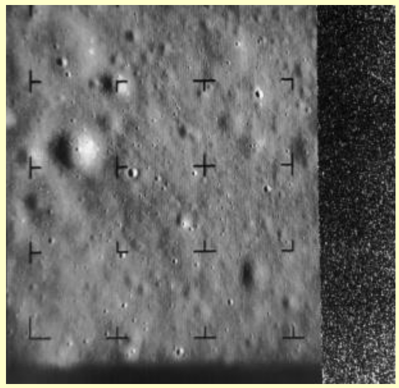


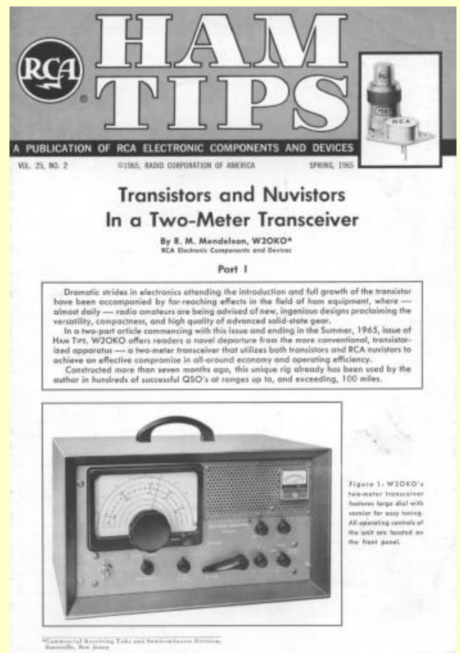
Figure 5—Ranger VIII Moon photo

The RCA video subsystem used Nuvistors. Tiros, the first weather satellite, used Nuvistors. On a larger scale, the Saturn V rocket that launched Apollo to the moon used Nuvistors. Apollo may be renowned for the first large-scale use of integrated circuits in the Apollo Guidance Computer, but in the launch vehicle where high vibration, temperature extremes, and potential radiation exposure were possible, Nuvistors filled the bill.

Figure 6—AS-501 Saturn V Mission

Aside from space exploration, the good bandwidth, low noise, and high gain characteristics of Nuvistors made them popular into the 1970s in high-end audio equipment such as studio recorders, microphones, and other test equipment where small size, high-performance, and the low-power specs were desired.

Amateurs also found use for Nuvistors, mainly in VHF/UHF converters. QST published a flurry of articles using Nuvistors in the early 1960s. *RCA Ham Tips*, of course, published several Nuvistor projects, like this fancy 2-meter transceiver in the Spring 1965 issue.



RCA HAM TIPS

A PUBLICATION OF RCA ELECTRONIC COMPONENTS AND DEVICES

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Transistors and Nuvistors In a Two-Meter Transceiver

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Part I

Dramatic strides in electronics attending the introduction and full growth of the transistor have been accompanied by far-reaching effects in the field of ham equipment, where — almost daily — radio amateurs are being advised of new, ingenious designs proclaiming the versatility, compactness, and high quality of advanced solid-state gear.

In a two-part article commencing with this issue and ending in the Summer, 1965, issue of Ham Tips, W2OKO offers readers a novel departure from the more conventional, transistorized apparatus — a two-meter transceiver that utilizes both transistors and RCA nuvistors to achieve an effective compromise in all-around economy and operating efficiency.

Constructed more than seven months ago, this unique rig already has been used by the author in hundreds of successful QSO's at ranges up to, and exceeding, 100 miles.

Figure 1: W2OKO's two-meter transceiver features large dial with vernier for easy tuning. All operating controls of the unit are located on the front panel.

*Commercial Receiving Tube and Semiconductor Division, Somerville, New Jersey

Figure 7—Front Cover, Spring 1965 *RCA Ham Tips*

Commercial gear by Hallicrafters and Heathkit employed the little tubes too. My own Nuvistor came to me mixed in with a bag of vintage transistors that I bought at a hamfest for a few bucks; but if you have a desire to build some retro gear, Nuvistors are still readily available on eBay with reasonable prices, although you might have more trouble finding Nuvistor sockets!

So, were Nuvistors the last dying gasp of vacuum tubes desperately trying to maintain a sliver of market share in the face of the transistor tsunami? You decide.