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# In the Footsteps of the Ancient Ones

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If the first golden age of amateur radio was the 1920s, then the second golden age was certainly the years following World War II when the surplus market was flooded with a huge variety of military gear. Amongst the mountain of surplus were millions of quartz crystals, the majority of which were likely in the FT-243 form factor. Quartz crystal frequency control was a strategic advantage for the Allies during the war. The Allies, particularly the United States, had control of the high-quality quartz from the mines in Brazil. Quartz delivers rock solid frequency stability, highly resistant to the vibration & temperature extremes that compromise frequency control using tuned LC circuits. For example, some German radios could be used only when stationary.


**Figure 1**

This FT-243 form-factor quartz crystal was manufactured by Daughetee Manufacturing for use by the United States military during World War II. The quartz crystal on the inside was cut for a frequency of 6900 kilocycles, or 6900 kHz using current terminology.

The U. S. government recognized this advantage and created a massive program under the Army Signal Corps to nurture the nascent crystal industry. And they had their work cut out for them. In the early stages the U. S. had only a handful of manufacturers. Cutting & grinding quartz was essentially a *black art* with only certain companies, and in some cases only certain individuals, able to produce crystals of consistent quality. This Signal Corps program ranked with the Manhattan atomic bomb project, and RADAR, as technologies vital to the war effort. The Corps multiplied the chosen few to hundreds of small firms. The full story of the quartz war industry is best found in Richard Thompson's book, *Crystal Clear*, and in his January 2004, *QST* article.

**Figure 2**

The first step in trying to change the resonant frequency of the crystal was to make sure that it was still viable. Although FT-243 packages are tightly sealed, the years have taken a toll on some crystals so that they may no longer function correctly. In this case, the crystal was still spot-on. The difference between 6900 kHz and my reading of 6898.7 kHz is more likely a result of my equipment accuracy.

The challenge for amateurs was that although FT-243 crystals were abundant & cost next to nothing – there are stories of barrels full of crystals being sold for pennies from the stores of Radio Row in New York City – the vast majority of these crystals were nowhere near the amateur frequencies. That's still true today. You'll easily find FT-243 crystals at hamfests, but chances are slim that you will find one cut for a ham band. For hams of that era, the solution was clear: take them apart and grind them down (or rather up) to a usable frequency. Being in the possession of a few dozen World War II vintage crystals, I decided to try my hand at crystal grinding. I began with a crystal cut for 6900 kilocycles, which we today know as kilohertz, kHz, made by Daughtee Manufacturing in Chicago.

To see if this crystal was still viable, I plugged it into my trusty Altoids tin crystal checker and fed the RF to a little frequency counter which registered 6898 kHz, close enough. It's important that I selected a crystal that was *lower* in frequency than my intended target frequency, somewhere, anywhere, in 40-meters, hopefully in the traditional CW portion of the band. Grinding away quartz *raises* the frequency. There is no practical way of lowering the frequency although tales abound of amateurs dusting the quartz with graphite in desperate attempts to do so. The first step was to take the crystal apart. Removing the cover reveals a powerful little spring whose job is to squash the plates in the crystal sandwich tightly together.

The top layer in the sandwich is a thin piece of old-time circuit board material for insulation, followed by a brass electrode that provides electrical connection between the FT-243 pins and the sandwich stack. This must be gently pried away to access the sandwich, a translucent sliver of quartz crystal between two flattening plates.

The ancient ones are probably rolling in their graves, seeing me grind the tiny crystal using an ordinary whetstone. The canonical method specifies the use of fine abrasive powder on an optically flat piece of glass. I tried a bit of that using 250-grit powder that I have on hand for sharpening woodworking planes, but the grit seemed rougher than the whetstone. Since this was just pure experimentation, I persisted with the whetstone.

After about thirty minutes of grinding, the quartz crystal didn't look any different than when I began. Did I mention that I really didn't know what I was doing? It was still thin and appeared very fragile, although I was surprised that it held up well to some rather forceful grinding.

Next, I cleaned the crystal in water and then rubbing alcohol using lint-free cloth. Reassembling the FT-243 crystal holder was just the reverse of that described above. And then came the acid test: plugging it into the crystal checker and reading out the frequency. Woo hoo! Talk about luck! The finished crystal landed on 7036.6 kHz, not only just *somewhere* in the 40-meter band but rather close to the QRP watering hole.

This really was just good fortune. And I neglected to mention that it took me two tries. The first time I ground away for about five minutes, not having the slightest clue on how much grinding would be needed to move up 150-ish kHz. That five minutes hardly moved the resonance. With nothing more than gut feel, I repeated the disassembly and hit the whetstone for another 25-minutes.

As soon as I get the bugs worked out of my classic two-tube 5763 & 6C4 transmitter, you might find me calling CQ rock bound on 7036.6 kHz. Incidentally, when I was first

**Figure 3**

On the inside, FT-243 crystals are a sandwich of insulation, contact plates, and the thin quartz crystal, all pressed tightly together by a powerful little spring.

**Figure 4**

Here the sliver of translucent quartz crystal can be seen resting on the two contact plates. This crystal has a tiny chip on one corner.

**Figure 5**

I used a common whetstone to reduce the thickness of the crystal blank, raising the resonant frequency. Recommendations in publications from the 1950s on this process specified using fine powdered grit on laboratory-flat surfaces. My reckless approach is likely a big contrast to the proper way of achieving the desired result.

licensed, Novice privileges required the use of crystal control. The FCC wasn't sure we could handle VFOs. The 40-meter Novice segment ran from 7150 kHz to 7200 kHz. That little span of 40-meters wasn't just to keep us corralled where we couldn't do much damage. There was a practical reason as well. Since all Novices were rock bound, the chance of someone answering your CQ on your calling frequency was slight, indeed. Once you called CQ, you would have to scan the Novice segment to see if someone responded.

It was just pure chance that the crystal I selected for my little experiment was from Daughtee Manufacturing. But Daughtee was unique, infamous, amongst wartime crystal manufacturers. The Army Signal Corps monitored their contractors and required the use of sophisticated testing equipment for quality control. When the inspectors examined the Daughtee operation, they were appalled. The proprietor, Lew Daughtee, used no precision equipment. Instead, each evening he put that day's batch of crystals in a freezer and left them overnight. The next day that batch was tested, still frozen, to verify they were on frequency. Then he stuffed them into an oven and baked them until they were too hot to touch – and tested them once again. After the Signal Corps witnessed Lew's process, they gave him an exemption. It's kind of cool to think that my homebrew transmitter will use a crystal that is not only a veteran of World War II, but one that is notorious as well.

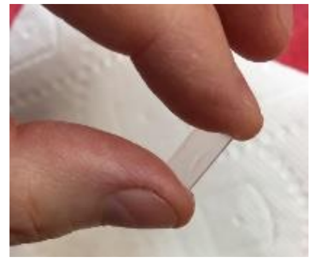

**Figure 6**

In this view you can see how thin the crystal blank appears. Grinding from 6900 kHz to 7036.6 kHz produced no noticeable change in observed thickness to my eye.

**Figure 7**

The acid-test for this little experiment was measuring the final result which fortunately showed success. The crystal ended up well situated in the CW portion of the 40-meter band.

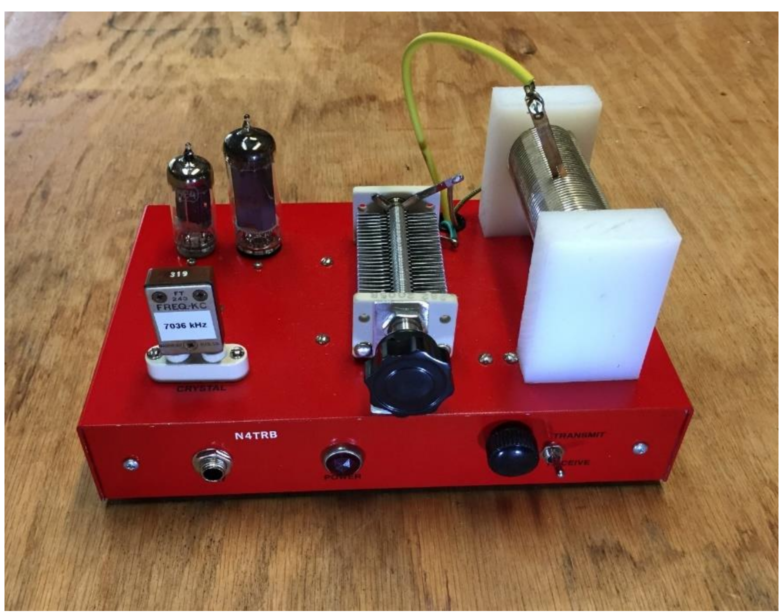


**Figure 8**

Now with a new label, this World War II veteran FT-243 may see service in this little two-tube transmitter.