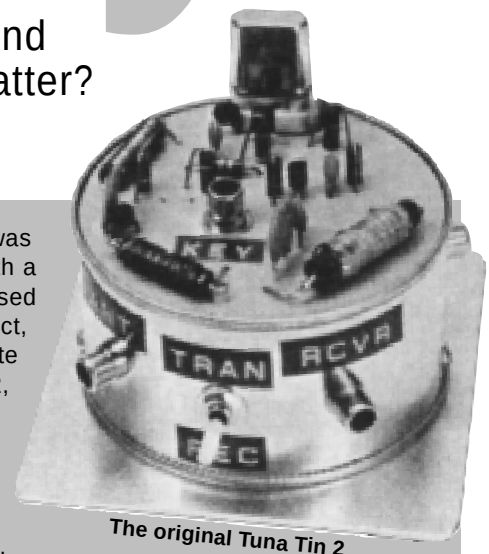
By Ed Hare, W1RFI

The Tuna Tin 2 Today

Ham radio lost its kick? Go QRP with this weekend project! Worked All States with a 40-meter half-watter? **You betcha!**



The original Tuna Tin 2

In the 1970s, the late Doug DeMaw, W1CER/W1FB, ARRL Technical Editor, was one of several Headquarters staff who published homebrew projects, many with a QRP twist. One of those was a simple, two-transistor 40-meter transmitter that used a tuna can as the chassis. Dubbed the "Tuna Tin 2," it was a popular project, introducing many hams to homebrewing and QRP. A series of events, some quite amazing, have come together to keep the magic alive—the original Tuna Tin 2, built in the ARRL Lab, is still on the air and articles, Web pages and kits are available for this famous rig. Some have dubbed the Tuna Tin 2 revival as "Tuna Tin 2 mania"—an apt term to describe the fun that people are still having with this simple little weekend project.

This article has been edited from the original, written by DeMaw and published in the May 1976 QST. You can download a copy in Adobe PDF format from the ARRL Members-Only Web site at: **http://www.arrl.org/members-only/extra/features/1999/0615/1/tt2.pdf**. Some of the original parts are no longer available, so modern components have been substituted, using values that were featured in a column in QRP with W6TOY on the ARRL Web Extra. I think that Doug would have been pleased to see just how popular that little rig still is, almost a quarter century after he first designed it and built it in the ARRL Lab.— *Ed Hare, W1RFI, ARRL Laboratory Supervisor*

Workshop weekenders, take heart. Not all building projects are complex, time consuming and costly. The TunaTin 2 is meant as a short-term, gotogether-easy assembly for the ham with a yen to tinker. Inspiration for this item came during a food shopping assignment. While staring at all of the metal food containers, recollections of those days when amateurs prided themselves for utilizing cake and bread tins as chassis came to the fore. Lots of good equipment was built on make-do foundations, and it didn't look ugly. But during recent years a trend has developed toward commercial gear with its status appeal, and the workshop activities of many have become the lesser part of amateur radio. While the 1-kW rigs keep the watt-hour meters recording at high speed, the soldering irons grow colder and more corroded.

A tuna fish can for a chassis? Why not? After a few hours of construction, 350 milliwatts of RF were being directed toward the antenna, and QSOs were taking place.

Maybe you've developed a jaded appetite for operating (but not for tuna). The workshop offers a trail to adventure and achievement, and perhaps that's the elixir you've been needing. Well, Merlin the Magician and Charlie the Tuna would probably commend you if they could, for they'd know you were back to the part of amateur radio that once this whole game was about—creativity and learning!

Parts Rundown

Of course, a tunafish can is not essential as a foundation unit for this QRP rig. Any $6\frac{1}{2}$-ounce food container will be okay. For that matter, a sardine can may be used by those who prefer a rectangular format. Anyone for a Sardine-2? Or, how about a "Pineapple Pair?" Most $6\frac{1}{2}$-ounce cans measure $3\frac{1}{4}$ inches in OD, so that's the mark to shoot for. Be sure to eat, or at least remove the contents before starting your project!

Although the original project used all RadioShack parts, some of the parts are no longer stocked. The 2N2222A transistor is

Kits and Boards

While the original Tuna Tin 2 can be built from scratch, surprisingly, printed-circuit boards and kits are still available.

The September 16, 1999 *QRP with W6TOY* column in the *ARRLWeb Extra* featured a modern version of the Tuna Tin 2[1]. FAR Circuits can supply the printed circuit for W6TOY's version (not built on a tuna tin) as well as the original design PC board.[2]

Those who want to buy everything all in one place can buy a complete kit, including PC board from the NJ-QRP Club[3]. Send a check for $12 postpaid to George Heron, N2APB, New Jersey QRP Club, 2419 Feather Mae Ct, Forest Hill, MD 21050. Doug Hendricks, KI6DS also designed a version of the Tuna Tin 2, for the Northern California QRP Club (NorCal)[4].

JOE BOTTIGLIERI, AA1GW

W6TOY's version of the Tuna Tin 2 design—without the tuna can.

[1]See: **http://www.arrl.org/members-only/extra/features/1999/09/16/1/**.

[2] FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148; **http://www.cl.ais.net/farcir/**

[3]NJ-QRP Club, contact: George Heron, N2APB, 2419 Feather Mae Ct, Forest Hill, MD 21050; **n2apb@amsat.org**; **http://www.njqrp.org/**. NJ-QRP has a section of their Web site devoted to the Tuna Tin 2 revival. See **http://www.njqrp.org/tuna/tuna.html**.

[4]Northern California-QRP Club (NorCal), 3241 Eastwood Rd, Sacramento, CA 95821; tel 916-487-3580; **jparker@fix.net**; **http://www.fix.net/NorCal.html**. Like the NJ-QRP Club, NorCal also has a Tuna Tin 2 revival page at: **http://www.fix.net/~jparker/norcal/tunatin2/tunatin.htm**.

widely available. The original coils have been replaced with inductors wound on toroidal cores. Printed circuit boards are available from several sources and the NJ QRP Club is offering a complete kit of parts. (See the sidebar "Kits and Boards".)

The tiny send-receive toggle switch is a mite expensive. The builder may want to substitute a low-cost miniature slide switch in its place. A small bag of phono jacks was purchased also, as those connectors are entirely adequate for low-power RF work.

Finding a crystal socket may be a minor problem, although many of the companies that sell crystals can also supply sockets (you can locate a number of crystal manufacturers and distributors on the ARRL TISFIND database at **http://www.arrl.org/tis/tisfind.html)**. Fundamental crystals are used in the transmitter, cut for a 30-pF load capacitance. Surplus FT-243 crystals will work fine, too, provided the appropriate socket is used. If only one operating frequency will be used, the crystal can be soldered to the circuit board permanently. Estimated maximum cost for this project, exclusive of the crystal, power supply and tunafish, is under $20. The cost estimate is based on brand new components throughout, inclusive of the

The Tuna Tin 2 on the Road

Those who've read our on-line publication, the *ARRLWeb Extra,* probably saw the article that appeared in the June 15th edition titled "The Tuna Tin 2 Revival." This article told an incredible tale of how the original Tuna Tin 2 was lost from the ARRL Lab and was found years later in a box of junk under a fleamarket table in Boxboro, Massachusetts. The Tuna Tin 2 was refurbished by Bruce Muscolino, W6TOY, and put back on the air by me on June 4, 1999. Since that time, over 400 hams have had the pleasure of working the original Tuna Tin 2, some using their own Tuna Tin 2 rigs built in the 70s (or built anew from the available kits).

California Dreamin'

After making about a hundred contacts from home, I was asked to attend an IEEE meeting in Long Beach, California. My sister, Bev, lives in the area, so I planned a week-long visit. I tossed the Tuna Tin 2 and a G5RV into my suitcase, hoping to give a few West Coast hams a chance to make a contact with the original.

After all the hugs and kisses, I explained to my sister what I was up to. She grinned, remembering the wild days of my youth, climbing trees to string wires all over our property, back when I was WN1CYF. As I looked over the site, though, I was not too hopeful; about the best I thought I could do would be to try a random wire around the balcony, maybe risking a run over to a small tree or two. I looked roofward and sighed, "Gee, it would be nice to get an antenna up on the roof." She made a quick call to Debbie, the building manager and close friend, who winced painfully and said, "Don't fall off!" and, in a classic Schultz accent, "I know nothing!"

We took the G5RV up to the emergency roof access, walked boldly out, and I proceeded to string the antenna up while Bev stood guard. I got the antenna up, dropped the feedline past the upstairs apartment balcony and hoped for the best.

Sure enough, the "antenna police" were on alert—the tenant right below us heard the noise and wondered what was going on. Just as we got back to the apartment, the phone rang; it was Debbie. She told us of the complaint, told us the excuse she gave and wished us luck.

With Bev watching with great interest, I hooked up the Heath HW-8 I used as a receiver, hooked up the Tuna Tin 2, the code key and antenna tuner, and gave the band a fast listen. Signals were booming in. On June 19, I worked my first contact with the Tuna Tin 2 from the West Coast, W6PRL/QRP. Every evening, after a day of offshore fishing, Bev and I expected to find that the antenna police had confiscated the wire, but somehow, it stayed up the whole week. By the end of the week, 45 new stations were in the Tuna Tin 2 log!

Among the Monsoons and ScQRPions

I was then asked if I would be willing to attend the ARRL Arizona State Convention at Ft Tuthill. That is an annual pilgrimage for many a QRPer; how lucky could I get? I agreed, but warned the ARRL Division Director that I might spend a bit more time away from the ARRL booth than usual. In the meantime, I casually asked Joe Carcia, NJ1Q, the W1AW station manager, if he could arrange for W1AW/7/QRP to be used at the convention. After some consultation with Dave Sumner, a new QRP "first" was in the works. In the meantime, the Arizona ScQRPions[1], an Arizona QRP club, asked me if I would give a presentation at the QRP forum they sponsor at Ft Tuthill every year. I agreed, but with one condition—they had to be willing to host W1AW/7/QRP at their booth. I would have loved to be a fly on the wall as that e-mail was read!

A *great* time was had by all, but W1AW/7/QRP did not go off without a hitch. An operator error (mine) damaged the receiver (the binaural receiver, designed by Rick Campbell). The local QRPers came through, though, and several receivers were made available to the operation to finish the day. Even worse, later in the day, it looked like all was lost! During a quick test of the Tuna Tin 2, one of the resistors emitted a puff of smoke, and the power went to 0 W. I had just blown up the original Tuna Tin 2!

I did a quick troubleshooting job and identified that the output transistor had short-circuited. Special thanks go to Niel Skousen, WA7SSA, who dug into his portable junkbox. (Niel is a real ham's ham! How many hams do you know who bring their junkbox to a hamfest?) He quickly located a 2N2222A. I handed him the Tuna Tin 2 and asked him if he would mind installing it. After that W1AW/7/QRP was back on the air.

After the convention, using a borrowed receiver, I took the Tuna Tin 2 on a whirlwind tour of Arizona, although I only got to operate two

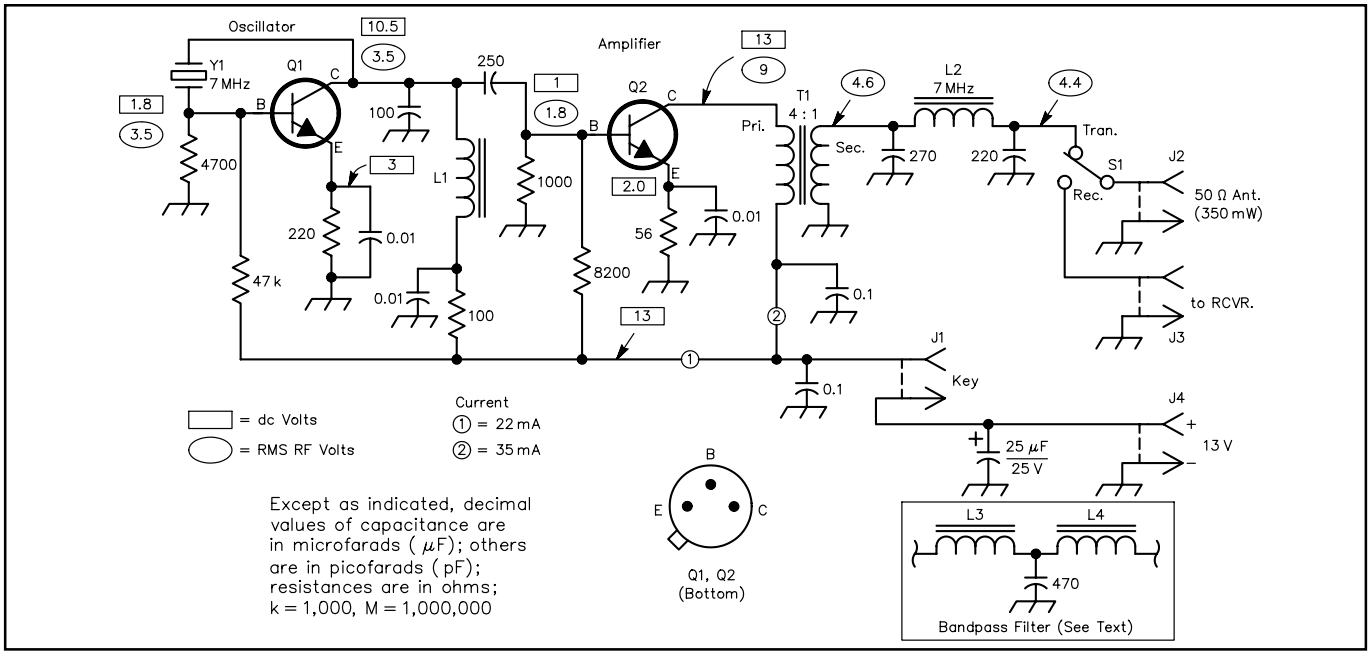


Figure 1—Schematic of the Tuna Tin 2 QRP rig. Note that the polarized capacitor shown in the schematic is an electrolytic.

J1—Single-hole-mount phono jack. Must be insulated from ground. Mounts on printed circuit board.
J2, J3, J4—Single-hole-mount phono jack. Mount on tuna tin chassis.
L1—22 μH molded inductor
L2—19 turns of #24 wire on a T-37-2 toroidal core
L3, L4—21 turns of #24 wire on a T-37-6 toroidal core
Q1, Q2—2N2222A or equivalent NPN transistor.
S1—Antenna changeover switch. Miniature SPDT toggle (see text).
T1—4:1 broadband transformer. 16 turns of #26 wire on the primary, 8 turns of #26 wire on the secondary, on an FT-37-43 toroidal core.
Y1—Fundamental crystal, 7 MHz.

nights from a campsite in Williams. I had brought along my DK9SQ[2] 33-foot portable fiberglass mast, so my antenna went up and down quickly. (Let me tell you, this is one great product. I literally put up my 40 meter inverted **V** in 5 minutes, 33 feet in the air. Taking it down was even faster.) It was monsoon season in Arizona and it rained each night. Despite the downpours, I doggedly squeezed in operating time in between thunderstorms, and added a few new ones to the log.

Hanging Out in the Park

Just two weeks later, I was off to Golden, Colorado for the Colorado State Convention (during which I got to show off the Tuna Tin 2 to the Colorado QRP Club[3]) and the trusty Tuna Tin 2 and portable mast came along with me. I scoped out the hotel area—no good. The noise level from the high-tension lines was just too high. The convention was held in a small park, so after the confab ended I walked a mile back to the hotel, loaded up the Tuna Tin 2, batteries, key, antenna and mast, and trekked back to the park. Fifteen minutes later, the antenna was standing proud and tall, and I made my first CQ. A security guard stopped by, and fearing the worst, I explained what I was doing. "Okay," she said, and drove away. A few minutes later I had a nice surprise—Rod Cerkoney, N0RC, showed up to operate with me!

The Tuna Tin 2 came back home, and I got it ready for the QRP Extravaganza Weekend (my name for it) on Halloween, with the QRP-ARCI/ARRL "Black Cat" party and the NorCal Zombie Shuffle operating event. You can read that tale in Rich Arland's "QRP Power" column in this issue.

Are We Having Fun Yet?

Did I have fun? Do you need to ask? I guess I was just in the right place at the right time, and have been privileged to be the center of all this Tuna Tin 2 activity. What is important to me, though, is that the magic that DeMaw created in the ARRL Lab still lives. It has, in fact, it has taken on a life of its own.

The Tuna Tin 2 will be on the air on 40 meters a lot over the rest of the winter, spring and summer. You'll hear it from W1RFI, from W1AW, and possibly some other station locations. I do have one more "special event" in the works, but I am sworn to secrecy. The Tuna Tin 2 will play a part in it. I won't tell you what call it will use, but I will say that you will know it when you hear it. And when you do, you will know that the magic is still alive.

I hope that lots of hams build some of the various Tuna Tin 2 replicas, and that they get a chance to work the original. I will do my best to keep it on the air. I am sure that Doug DeMaw would approve.—*W1RFI*

[1]See the Arizona ScQRPions site on the Web at: **http://www.extremezone.com/~ki7mn/sqrppage.htm.**
[2]The DK9SQ mast is available for $99 plus $5 shipping and handling from Kanga US, 3521 Spring Lake Dr, Findlay, OH 45840; tel 419-423-4604; **kanga@bright.net**; **http://www.bright.net/~kanga/kanga/**.
[3]Colorado QRP Club, PO Box 371883, Denver CO 80237-1883; **rschneid@ix.netcom.com**; **http://www.cqc.org/.**

Ed Hare, W1RFI, operating the TT2 from his sister's apartment in Los Angeles.

TT2 Performance

Keying quality with this rig was good with several kinds of crystals tried. There was no sign of chirp. Without shaping, the keying is fairly hard (good for weak-signal work), but there were no objectionable clicks heard in the station receiver. There is a temptation among some QRP experimenters to settle for a one-transistor oscillator type of rig. For academic purposes, that kind of circuit is great. But, for on-the-air use, it's better to have at least two transistors. This isolates the oscillator from the antenna, thereby reducing harmonic radiation. Furthermore, the efficiency of oscillators is considerably lower than that of an amplifier. Many of the "yoopy" QRP CW signals on our bands are products of one-transistor crystal oscillators. Signal quality should be good, regardless of the power level used.

The voltages shown in Figure 1 will be helpful in troubleshooting this rig. All dc measurements were made with a VTVM. The RF voltages were measured with an RF probe and a VTVM, The values may vary somewhat, depending on the exact characteristics of the transistors chosen. The points marked 1 and 2 (in circles) can be opened to permit insertion of a dc milliammeter. This will be useful in determining the dc input power level for each stage. Power output can be checked by means of an RF probe from J2 to ground. Measurements should be made with a 51- or 56-Ω resistor as a dummy load. For 350 mW of output, there should be 4.4 V_{rms} across the 56-Ω resistor.

Operating voltage for the transmitter can be obtained from nine Penlite cells connected in series (13.5 volts). For greater power reserve one can use size C or D cells wired in series. A small ac-operated 12- or 13-V regulated dc supply is suitable also, especially for home-station work.—*W1FB*

[Although this rig met all the Part 97 surious emission requirements when built in 1976, additional filtering is needed to meet today's rules. A bandpass filter for 40 meters is shown as an inset in Figure 1. It can be installed between S1 and the antenna jack.—*W1RFI*]

left-over parts from the assortments. Depending on how shrewd he is at the bargaining game, a flea-market denizen can probably put this unit together for a few bucks.

Circuit Details

A look at Figure 1 will indicate that there's nobody at home, so to speak, in the two-stage circuit. A Pierce type of crystal oscillator is used at Q1. Its output tickles the base of Q2 (lightly) with a few mW of drive power, causing Q2 to develop approximately 450 mW of dc input power as it is driven into the Class C mode. Power output was measured as 350 mW (1/3 W), indicating an amplifier efficiency of 70%.

The collector circuit of Q1 is not tuned to resonance at 40 meters. L1 acts as an RF choke, and the 100-pF capacitor from the collector to ground is for feedback purposes only. Resonance is actually just below the 80-meter band. The choke value is not critical and could be as high in inductance as 1 mH, although the lower values will aid stability.

The collector impedance of Q2 is approximately 250 Ω at the power level specified. Therefore, T1 is used to step the value down to around 60 Ω (4:1 transformation) so that the pi network will contain practical values of L and C. The pi network is designed for low Q (loaded Q of 1) to assure ample bandwidth on 40 meters. This will eliminate the need for tuning controls. Since a pi network is a low-pass filter, harmonic energy is low at the transmitter output. The pi network is designed to transform 60 to 50 Ω.

Ll is a 22-μH molded inductor. L2 is made with 19 turns of #26 wire on a T-37-2 core. Final adjustment of this coil (L2) is done with the transmitter operating into a 50-Ω load. The coil turns are moved closer together or farther apart until maximum output is noted. The wire is then cemented in place by means of hobby glue or Q dope

T1 is made with 16 turns of #26 wire on the primary, 8 turns of #26 wire on the secondary, on an FT-37-43 ferrite core. This is good material for making broadband transformers, as very few wire turns are required for a specified amount of inductance, and the Q of the winding will be low (desirable).

Increased power can be had by making the emitter resistor of Q2 smaller in value. However, the collector current will rise if the resistor is decreased in value, and the transistor just might "go out for lunch," permanently, if too much collector current is allowed to flow. The current can be increased to 50 mA without need to worry, and this will elevate the power output to roughly 400 mW.

Construction Notes

The PC board can be cut to circular form by means of a nibbling tool or coping saw. It should be made so it just clears the inner diameter of the lip that crowns the container. The can is prepared by cutting the closed end so that 1/8 inch of metal remains all the way around the rim. This will provide a shelf for the circuit board to rest on. After checkout is completed, the board can be soldered to the shelf at four points to hold it in place. The opposite end of the can is open.

Summary Comments

Skeptics may chortle with scorn and amusement at the pioneer outlook of QRP enthusiasts. Their lack of familiarity with low-power operating may be the basis for their disdain. Those who have worked at micropower levels know that Worked All States is possible on 40 meters with less than a watt of RF energy. From the writer's location in Connecticut, all call areas of the USA have been worked at the 1/4-W power plateau. It was done with only a 40-meter coax-fed dipole, sloping to ground at approximately 45° from a steel tower. Signal reports ranged from RST 449 to RST 589, depending on conditions. Of course, there were many RST 599 reports too, but they were the exception rather than the rule. The first QSO with this rig came when Al, K4DAS, of Miami answered the writer's "CQ" at 2320 UTC on 7014 kHz. An RST 569 was received, and a 20-minute ragchew ensued. The copy at K4DAS was "solid."

If you've never tried QRP before, the first step is easy. Just contact the QRP Amateur Radio Club International (QRP-ARCI), 848 Valbrook Court, Lilburn, GA 30047-4280; **http://www.qrparci.org/**. QST

Fishy Excitement at the Meriden ARC

Renewed interest in the Tuna Tin 2 transceiver prompted the Meriden (Connecticut) Amateur Radio Club to build these classics as a club project. Bob Stephens, KB1CIW and Jamie Toole, N1RU secured components for 20 kits. Tim Mik, WY1U, supplied 20 cat food cans, cleaned and stripped of labels. (We had to assume that each can had, in fact, contained tuna flavor cat food. We didn't want to stray too far from the original design!) Tim also brought along his original Tuna Tin 2, which he had built as a newly licensed teenager over 20 years ago.

Several of the more experienced members were quite helpful in assisting those less knowledgeable in the arcane arts of schematic reading and toroid winding. Counting the number of turns, especially on the transformer, is not quite the simple task that it seems at first. Other tips on soldering and building in general were freely passed on from the veterans.

Honors for the first contact went to MARC president Bill Wawrzeniak, W1KKF. After finishing his rig, he brought it home, connected an antenna and almost immediately made contact with a California ham. With his new Tuna Tin 2, WY1U worked Ed Hare, W1RFI, operating the W1AW special event at ARRL HQ on Halloween. Most of the other kits were completed and put on the air over the next several weeks.

Building the Tuna Tin 2 is a terrific activity for any club. It can be completed in one or two evenings. The circuit is simple enough to provide an excellent springboard for education in electronic and RF theory without getting bogged down in too many esoteric topics. Building the kit is a great way to learn or sharpen construction skills. And, of course, there's no substitute for the pride and satisfaction of telling the station at the other end of the QSO, "RIG HR IS HMBRW TT2".—*John Bee, N1GNV,* QST *Advertising Manager*

CATS BY GIL, W1CJD