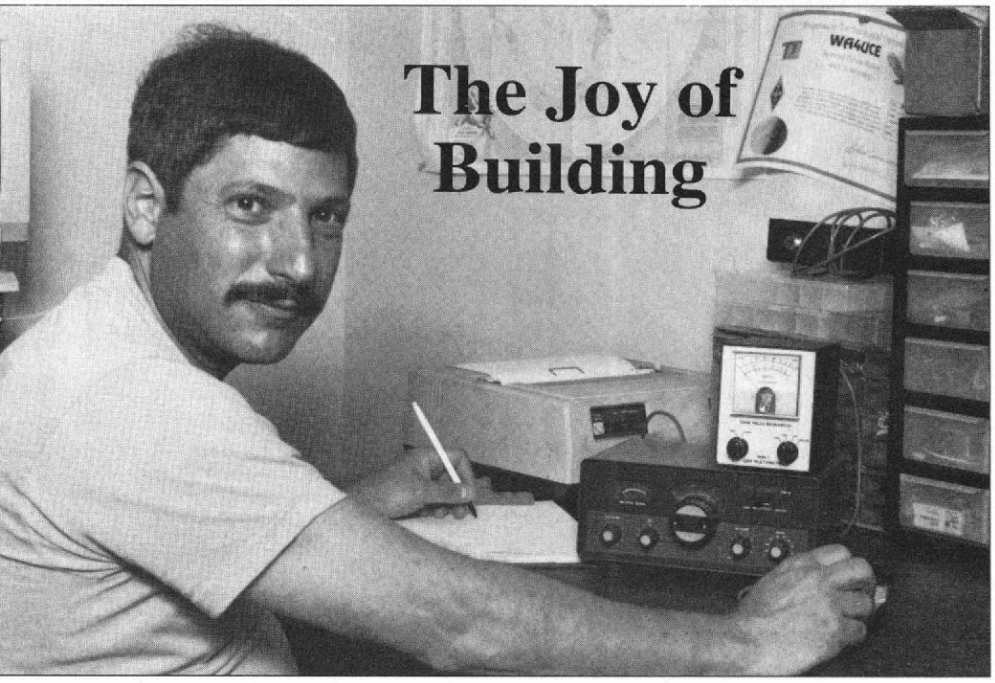

The Joy of Building

Put some extra pizzazz into Amateur Radio by building your own equipment!

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My fingers begin to tremble. I slowly reach for my power supply and place my hand on the switch. I hesitate. I spent most of my free time over the past month building this rig. Do I really want to take the chance of turning on the power and seeing if it will pass the smoke test?

The finished product looks so impressive, maybe I should just leave it on a shelf. No, I have to try it. I turn on the power and . . .nothing happens! I check the connections. The antenna and key are attached and the power light is glowing. Surely I'm forgetting something.

I nervously run through the check list. All the instructions were followed to the letter and I'm sure I put the parts where they belong. I slap myself on the forehead. It's such an obvious mistake! I have the power supply on, but not the rig! (When under stress, I tend to overlook the obvious.)

Well, here I go again. This time I reach for the switch on the rig and turn it to the **ON** position. I hear hissing from the small speaker. I carefully examine the rig and sniff for smoke as a big smile spreads across my face. It's still in one piece!

I change the antenna switch from the dummy load to my vertical. Selecting the 20-meter band, I spin the dial to the lower end of the CW portion. I'm turning the dial a bit too fast, but there's something coming through. I start at 14.000 MHz and slowly tune up the band. Yes, there's something that definitely sounds like CW. I almost fall over backwards as I let out a triumphant yell.

My wife and daughter come running into the room. My wife stops breathlessly and asks, "What's wrong?"

"Wrong? Nothing's wrong. Listen to this!"

With a little tuning I locate a strong, clear signal. I crank up the volume to make sure they can hear the most wonderful sound in the world. They look at me as if I've finally lost my mind. With let's-humor-him smiles, they turn in unison and exit the room.

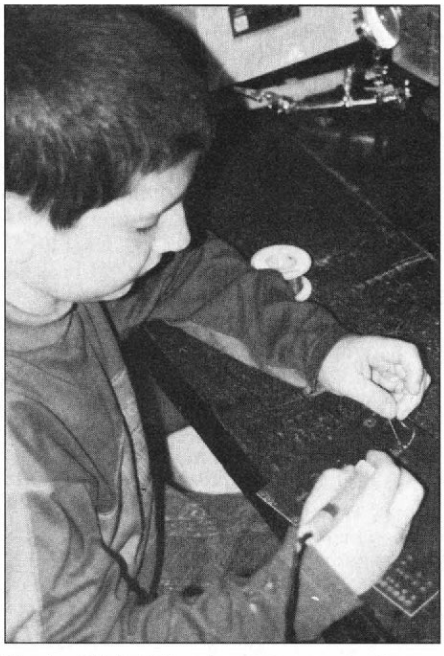

Fig 1—Kit building is so easy, my nine-year-old son (Danny, KD4HQV) mastered the techniques with little difficulty. (*photo courtesy of Leman Marsee, KD4WSJ*)

I tune through the rest of 20 meters. The receiver works superbly. Stumbling into a particularly crowded area of the band, I reach for the narrow-filter slide switch. A tweak of the knob is all it takes to reduce the pandemonium. I get braver and use the RIT (receiver incremental tuning) to get some extra control of the receive signals. It works! I let out more excited yells, but my family chooses to ignore me.

Time to check the transmitter. I set up the QRP wattmeter, which I built from an Oak Hills kit, and switch to the dummy load—making sure that the drive level on the rig is all the way down. I check my straight key with an ohmmeter to make sure I've correctly hooked up the wires to the plug. Since the transmitter is much more likely to smoke than the receiver, I slowly put my fingers on the key and glue my eyes to the wattmeter scale.

I push down the key and I hear something. What was that? I jerk my hand away as though the key was suddenly red hot. My heart is beating rapidly and I'm getting nervous. Calm down! It was just the CW sidetone. I take a deep breath and prepare for another try. This time I key the transmitter and watch the scale. It registers about 3 watts. I try each of the other bands and the output power levels look good.

Nothing has blown up yet, so it's time for the real test. I put the rig back on 20 meters. The band seems active and I don't have much patience at this point. I want to see if anyone can really *hear* me. I find an empty spot and call QRL (is the frequency in use?). I wait and make sure the frequency is clear before I call CQ. As I'm sending, I notice that the output seems steady—and the meter on the rig works just fine. A few calls go unanswered, so I decide to start hunting.

After several minutes of searching, I hear someone calling CQ. I give him a call and he comes right back to me. This time I yell so loudly that the rest of my family can't ignore it. They peek in quizzically.

"It works! Someone is coming back to me!"

Luckily, I have a supportive family and they tolerate my obsession with ham radio. They stick around for a few minutes and pretend to look impressed before finally drifting away.

I have no problem copying the other station. His signal is clear and sounds great on the receiver. When it's my turn to talk, I give him my information and his signal report—and tell him that I'm only running 3 watts.

His astonished reply says it all, "Your QRP is doing fine business! Your signal sounds great!" These are among the most exciting words any kit-builder will ever hear.

The Dream Deferred

I got my Novice license back in 1963 when it was valid for only one year and was nonrenewable. It was a worthy achievement, but I wasn't satisfied. In fact, I didn't want to buy any equipment until I got my General ticket. After some additional studying, I took the train to New York City. Dreams of a General license and a new Heathkit transceiver danced in my head.

It was quite a privilege to go to the big city without my parents. Needless to say, my apprehension level was high. I went straight from Grand Central to the FCC building. Back then, they administered tests in the basement where they had long rows of desks and straight keys. I took the 13-WPM code test and managed to get some of the letters correct. Unfortunately, "some" was not good enough and I failed the exam. It was a l-o-n-g train ride home. I was so upset I didn't try again for 29 years!

In 1992 the ham bug struck again, but this time I passed my General with flying colors. With my license in hand, I picked up a Heathkit catalog. To my disappointment, I found that Heathkit had gone out of the ham business. They held a big sale and cleared out the rest of their kits at the Dayton HamVention. I was one depressed ham. Could there be any Heathkits left? I posted messages on computer bulletin boards and put an ad in the *QST* Ham Ads. With luck, I thought I might find an unassembled Heathkit HW-9 QRP transceiver.

Finally, Chuck Adams, K5FO, responded to one of my bulletin-board messages. He knew someone who had picked up an HW-9 at Dayton. This person might be in the mood to sell, he said. Chuck contacted the owner and determined that a deal was indeed possible.

Although I was a stranger to Chuck, he drove an hour each way to pick up the HW-9—and even inventoried the parts before shipping it to me! No, he didn't request a fee for his services. It was just a favor from one ham to another.

I used the HW-9 kit to introduce my nine-year-old son to the joys of kit building. (He has his General license.) I first explained the color codes that identify the value—in *ohms*—of a resistor. We made a big chart and played a game to see how long it would take him to identify several resistors.

When it came time to solder, I opted to give him on-the-job experience. I showed him how to solder one or two parts and then let him do the rest (see Fig 1). He finished the kit late one evening and was eager to fire it up. I was cautious and suggested that we wait until the next day in case we needed to do some additional work. My son would not be delayed! He wanted to hear the finished HW-9 *now*.

After hooking up a battery and an antenna, he gingerly pressed the power switch. A reassuring hiss issued from the speaker. We tuned around and found a station. At that moment he jumped in the air and screamed. (I guess this reaction is genetic.)

Many Roads to Kit Building

There are many different approaches to building. You can start by building a simple transmitter to use with a receiver you already have. You can also build a simple transmitter/receiver combination, or even a complete transceiver. Many good kits of each type are currently available. They differ according to completeness (are *all* parts provided?), receiver design, instructions and the quality of the parts.

If you already have some experience, or if you're adventurous, you might want to build your rig from scratch. The *ARRL Handbook* and *QRP Classics* feature QRP projects. If you are interested in learning about the different transmitter and receiver circuits, I recommend *W1FB's QRP Notebook,* which explains the different components and where to find them. It also goes into QRP construction methods, QRP receivers, QRP transmitters and QRP station accessories. All of these books are available from your favorite dealer, or directly from ARRL Headquarters.

Building from scratch is a great way to learn. Locating parts can be difficult, but there are many reliable suppliers. Hamfests also offer excellent opportunities to increase your stock pile. I always pick up parts and cabinets when I attend hamfests.

Some companies sell parts and circuit board packages if you do not require a complete kit. For example, Kanga and 624 Kits both offer transmitter, receiver, transceiver and other QRP parts kits. And Far Circuits makes reasonably priced circuit boards for many of the projects found in *QST*, the *ARRL Handbook*, *CQ*, *73* and other publications.

If you're considering separate receivers and transmitters, don't overlook the T/R (transmit/receive) switch. When you put a transmitter and receiver together, you need a way to switch your antenna between the two. This can be accomplished by using a simple sliding switch, relay or a solid-state switching circuit. If the manufacturer doesn't offer a T/R switch, you may have to build one yourself.

When shopping for a separate transmitter, see if it's crystal or VFO (variable-frequency oscillator) controlled. Crystals are very stable, but it's a pain to pull them out and plug them in whenever you want to change frequency. VFOs allow you to tune through the bands and operate wherever you desire.

Direct Conversion versus Superhet

In many kits you'll find *direct-conversion* (DC) receivers. Direct-conversion receivers are simple to build, but have some limitations. With a DC design, the receiver picks up signal energy above and below a given frequency equally well. For instance, if you are tuning across a signal at 7.040 MHz, the signal will get stronger until you reach a point where it seems to disappear. This is the center frequency or *zero-beat* frequency. As you tune immediately past the signal, it will become strong once again.

If there is interference on the band from other stations (QRM), the menagerie can seem worse than it really is. The DC receiver can also become overloaded by signals from commercial AM broadcast stations.

This doesn't mean that a rig with a DC receiver can't work well. You'll just have to become accustomed to its peculiarities. An advantage of the DC design is that the rig can be made very small, lightweight and inexpensive. If you are planning to use it for portable or backpacking use, a transceiver with a DC receiver may be a good choice.

One example of a well-designed DC-based rig is the Oak Hills Research *Sprint* (see Fig 2). This single-band transceiver has a high performance DC receiver with many useful features. The original design was created by Roy Lewallen, W7EL, and published in the August 1980 *QST*. A similar design is also found in the *ARRL Handbook*. The kit comes complete. It features a plated-through, silk-screened circuit board. All coils are pre-wound and the kit even includes a painted cabinet.

The *Sprint* runs on 12-volts dc, doesn't draw much current and puts out about 1.5 watts. You need to provide a 12-volt dc power source, an antenna and headphones.

Fig 2—The Oak Hills *Sprint* kit, out of the shipping box and ready to build! (*photo by Conard Murray, WS4S*)

The 40-meter version can be aligned to tune any 100-kHz segment of the band. It can be tuned for Novice privileges, and then easily retuned if you upgrade. The transceiver works well and has a smooth transmit/receive circuit that allows full break-in (QSK) CW keying. You have to remember that it is a direct-conversion receiver and use it accordingly. You also have to remember that if the band is crowded, the interference can seem more horrendous than it really is. This little rig was easy to build and has provided many good QSOs. I use mine for portable operation with a small key and a 4-Ah gell cell. The *Sprint* sells for $109.95.

Another common receiver type is the *superheterodyne*. This type of receiver offers single-signal reception. As you tune across a signal, it gets louder and then drops off—just like you're accustomed to hearing with AM broadcast receivers (they're superheterodynes, too). These receivers are easier to operate and less likely to become overloaded by nearby AM broadcast stations. However, they are also more complex to build, larger and more expensive.

I've found a number of sources for superheterodyne transceiver kits. Gary Breed wrote an article for *QST* (Dec 1990, Jan 1991, *ARRL Handbook*, 1992 and 1993) concerning a transceiver he designed for backpacking. The transceiver has VFO tuning, AGC (for easier listening), 5 watts output, semi-break-in QSK and a signal strength ("S") meter. The rig can be set for any 50-kHz portion of the band. An experienced builder can collect the parts and build it right from the article.

624 Kits offers a superheterodyne transceiver kit complete with silk-screened board, large parts overlay and all the parts that go on the board. With this kit you will need to provide your own enclosure and connectors. These items are readily available at hamfests or Radio Shack stores. (I purchased a nice enclosure at a hamfest for a dollar.) When the kit arrived in the mail, I had no idea what to expect. I opened the box anxiously. I removed the parts bags and the instructions. The first item I pulled out of the parts bag was the circuit board. The quality was good and the board was clearly silk screened.

Next, I started to go over the directions. I didn't expect much from a parts-only kit, but I was pleasantly surprised. The instructions were very complete. There is a parts list and overlay for each circuit board. The schematics and parts overlay are computer generated making them clear and easy to read. The directions are broken up into two sections—one for the receiver and one for the transmitter. You build and test the receiver *before* you start on the transmitter. I really like this approach. The kit sells for $109.

A&A Engineering sells a complete Gary Breed Transceiver kit including a silk-screened enclosure and speaker. The directions start with a copy of the two original articles by Gary Breed from *QST*. There are some additional notes on final assembly and suggested tune-up procedures along with schematics and small parts overlays. All the information you need to build the kit is there, but I suggest going over it a few times before you start. This is definitely not a kit for beginners. The kit sells for $159.95

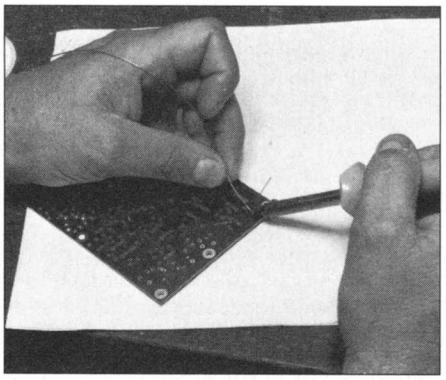

Fig 3—When soldering components, hold the iron at a 45° angle to the board. Apply the solder on the opposite side of the hole from the tip. Allow the heat to melt the solder; don't apply the solder directly to the iron. (*photo by Conard Murray, WS4S*)

The Oak Hills *Spirit* is another high-quality kit with a superheterodyne receiver. The receive audio is superb and selectivity is outstanding. When you tune in a signal, you hear that station only—unless the bands are extremely crowded. The QSK is full break-in and quite smooth. This is also not a beginner's kit, although I found the directions very clear and easy to follow. The receiver board is jammed full of parts and they are fairly close together. If you have some building experience, the *Spirit* is not hard to assemble and align. The plated-through circuit boards really make the soldering job easier. This rig is a little larger than the A&A Gary Breed Transceiver. It would be too big for backpacking, but small enough for portable use. You need an external speaker or headphones. The price of the kit is $198.95 and it includes a built-in Curtis iambic keyer.

I've only talked about a few of the transceivers that I've built myself. For a more complete list of kit suppliers, see "Lab Notes" in the August 1993 *QST*.

The Best Band for QRP?

Which band is best for QRP? This question is similar to asking for your favorite color. The decision is mostly based on personal preference, including your location and the type of operating you prefer. I suggest staying away from 80 and 160 meters at first. These bands tend to be noisy (especially in summer) and extra power is often required to make contacts. My favorite bands for QRP are 40 and 20 meters because they are frequently open and I can work most of the people I hear. For Novices, I recommend 40 meters.

Kit-Building Tips

When your kit arrives, be careful opening the box. There may be parts or instructions hidden in the protective packing. Check all the parts and label them on a piece of paper. Stick the wires of the components through the paper to hold them in place. Make sure all the parts have been shipped and familiarize yourself with each one. Check the parts once while you're going through the list and again before you place them on the board. Insert about five parts on the circuit board at a time and solder all the leads. Clip the wire leads close to the board.

Use only high-quality rosin-core solder and a soldering iron with a thin pencil tip. A power rating of 25 or 30 watts should be adequate. Oak Hills Research recommends 25 watts, but I use a 30-watt iron for my building. Make sure the tip of the iron is sharp and clean.

Keep some desoldering braid (Radio Shack 64-2090) or a "solder sucker" nearby in case you put a part in the wrong place or accidentally create a solder bridge. When removing parts from plated-through boards, a desoldering tool (Radio Shack 64-2120) is very helpful.

The key to proper soldering is how and where you hold the iron. Hold the soldering iron at about a 45° angle and make sure you're heating both the hole and the wire. Apply the solder with your opposite hand on the opposite side of the hole from the soldering iron (see Fig 3). Allow the heat from the iron to melt the solder. *Don't apply the solder to the iron.* If you allow the solder to flow off the iron, a poor solder joint may result. The two most common causes of kit failure are incorrect parts placement and cold solder joints.

The final alignment instructions of many of the transceivers suggest using a frequency counter to adjust oscillator circuits such as the VFO. I don't own a frequency counter, so I use my Yaesu 757GX transceiver as my alignment tool. You can use any general-coverage receiver in the same way. (Many modern rigs have general-coverage receivers.) I take a piece of copper wire and stick it in the 757GX's antenna jack. The other end of the wire is placed near the oscillator circuit. I set the 757GX to the desired oscillator frequency and simply tune the oscillator coil or capacitor while listening. I've successfully used this method to tune many rigs.

To set the transmit frequency, I use a manufactured transceiver that has a digital frequency meter. (Most modern transceivers include this feature.) I put both rigs on dummy loads and transmit on the manufactured rig while setting the kit dial to match the transmitted frequency. I then transmit *with the kit,* adjusting it until its signal reaches maximum strength on the other radio.

Slugging it Out with 5 Watts

I finished assembling my *Spirit* QRP transceiver kit the night before the 1993 WPX CW contest. What better test of a new, low-power transceiver than to go head-to-head with the big-gun stations? To my surprise, I worked over 125 stations with my 5 watts and vertical antenna during the contest. I contacted several Russian, Italian and French stations as well as Alaska and a number of islands. I worked coast to coast and many places in between.

QRP doesn't mean inferior performance and QRP kits are not poor-quality rigs. You'll quickly discover that you can work the world with a low-power station you've built with your own hands. There's nothing like the satisfaction of talking to someone on a radio *you've* put together. In fact, I've sold all but one of my assembled rigs. My pulse still races and I smile as I send, "Rig here is homebuilt and power is 5 watts...." QST