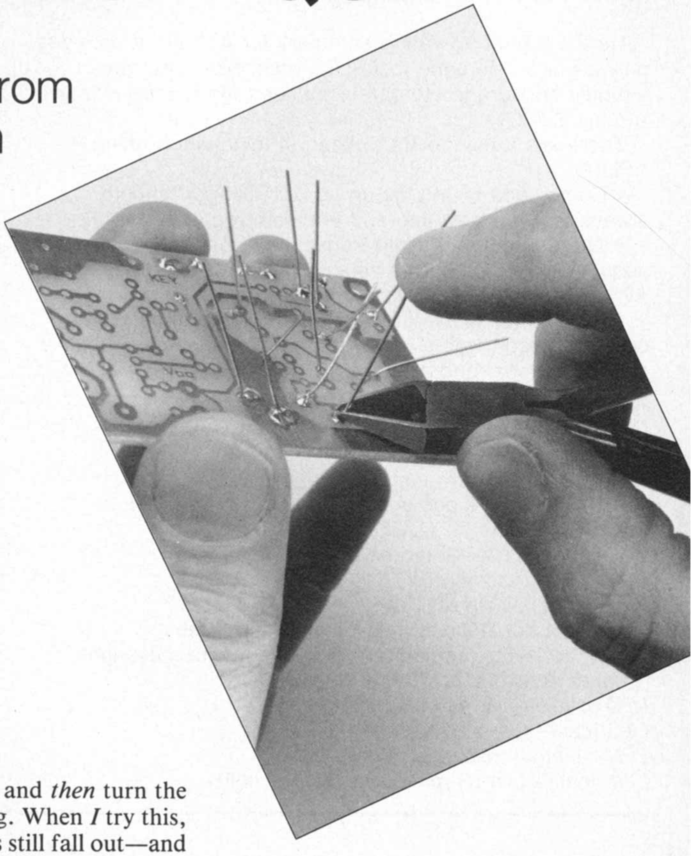
Build It Yourself from *QST*

Part 3: Many hams prefer to go from schematic to finished product with the help of ready-made circuit boards. Here's how to stuff, solder and snip your way to success in PC-board construction.



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In Part 1 of this series, we ordered the parts for Zack (KH6CP) Lau's 20-meter QRP transmitter.[5] Last month, in Part 2, we built the transmitter using ground-plane construction.[6] This month, we're going to build the transmitter with the printed-circuit (PC) board from FAR Circuits.[7]

If you haven't read last month's article yet, do so soon. Much of what I said there applies to PC-board construction as well. You'll need the same tools: needle-nose pliers, diagonal cutters, pocket knife, wire strippers, clip leads and soldering iron. I used the same 30-watt soldering iron from Radio Shack (#64-2067) to build the PC-board transmitter. If you've never used a soldering iron before, you should read last month's soldering sidebar before you start.

Getting Started

Here's the short description of PC-board construction: Stick the components in the right board holes, solder the leads, and cut off the extra lead length. The board's *part-placement diagram* (Fig 11) shows where the components go. Getting the components in the right holes is called *stuffing* the circuit board, and there are a number of ways to do it.

Inserting and soldering one component at a time takes too long. Some people like to put the components in all at once, and then turn the board over and solder all the leads. If you bend the leads a bit after you push them through the board, the components aren't supposed to fall out when you turn the board over, but this never works for me. (Half of them fall out anyway, and the rest fall halfway out so they look stupid when I solder them). Another approach is to put in all the components of one type (resistors, for example) and *then* turn the board over for soldering. When *I* try this, some of the components still fall out—and the remaining leads are so close together that they're difficult to solder.

I like to use a variation on this last approach. I put in *some* components of one type (like the first five resistors) and then solder these in. Then I put in the next five and solder them, and so on. I start with the shortest components (the diodes and resistors). If you start with tall components (like the capacitors), the board will rest on the top of the capacitors when you turn it over, and the resistors can fall out before you solder them (or slip part way down so they're not flat against the board). There are usually more resistors than anything else, too—if you install the resistors first you don't have to balance the board on the capacitors when you install the resistors. You can also use adhesive tape to temporarily hold difficult components in place while you solder.

Make sure your PC board and component leads are *clean*. The copper on the PC board is tinned, so it shouldn't be corroded, but it can't hurt to clean the solder side of the board with rubbing alcohol. If any of your components' leads look corroded (they'll look dark instead of bright and shiny), use a piece of extra-fine steel wool to brighten the leads before you put them

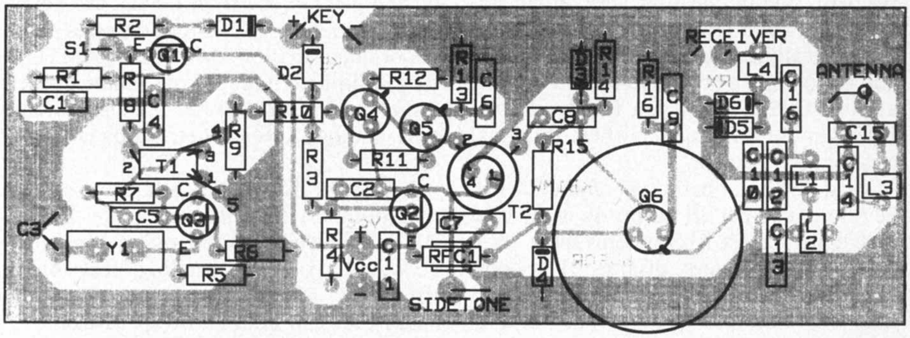

Fig 11—This diagram shows where to install parts on the QRP-transmitter board. It also shows *how* to install certain parts by depicting transistor flats, tabs and/or pinouts; diode and capacitor polarities; transformer wire numbers; and terminal names. This is a *single-sided* board because it has copper on only one side. Unless specifically instructed to do otherwise, mount components on the *foilless* side of single-sided boards.

[5]Notes appear on page 45.

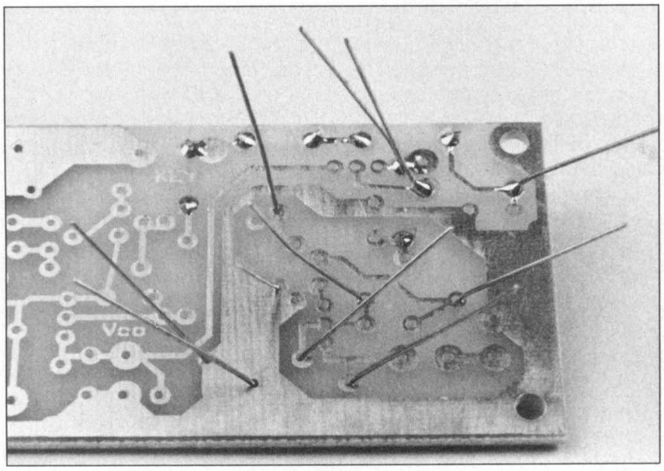

Fig 12—After you stick the component leads through the circuit board, bend them at an angle to keep the components from falling out when you turn the board over. *(photos by Kirk Kleinschmidt, NTØZ)*

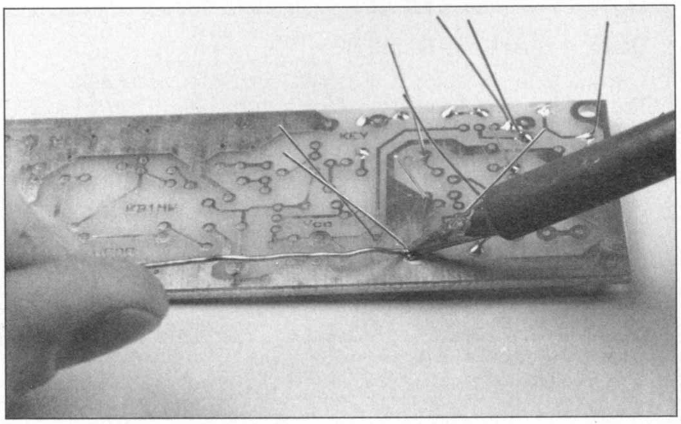

Fig 13—Apply the soldering iron to one side of a component lead and the PC-board pad, heat the lead and the solder pad, and then flow the solder in from the other side.

in the circuit board.

Fig 12 shows the back of a PC board with several diodes and resistors installed. Some of the components are already soldered and clipped. Bend the leads at a slight angle; apply the soldering iron to one side of the lead, and flow the solder in from the other side (Fig 13). Make sure you heat the pad on the circuit board, but don't heat it for too long—the pad can lift off the board if it gets too hot. Soldering takes practice—you need enough heat to melt the solder and vaporize the flux in the solder's core, but too much heat will lift the pads or damage components. Once you've got a nice solder connection, clip the lead flush with the solder (using diagonal cutters, as shown in the title photo). You can install several components, solder the leads, and then clip the leads all at once. Then move on to the next bunch of components.

Special Concerns

Make sure you have the components in the right holes before you solder them. You'll almost never see a component mounted at an angle on a PC board (there are no angle-mounted components on the transmitter board) so make sure all your components are parallel or perpendicular to the edge of the board.

The diodes *must* be oriented as shown on the placement diagram—the line on the diagram shows where the line on the diode should be placed. Otherwise, the circuit won't work properly.

You should have no trouble getting the resistors in the mounting holes. The capacitors may be more difficult—Zack used small monolithic ceramic capacitors, and FAR Circuits designed the board for Zack's capacitors. The capacitors I used are a bit larger, and their leads are too far apart to just stick into the holes on the board. If your capacitors are too large, you may have to bend their leads as shown in Fig 14.

When you get to the transistors, pay attention to the part-placement diagram. The diagram shows how plastic transistors' flats and metal transistors' tabs should be oriented. Remember that the tab marks the emitter of the metal transistors. There are only three holes for the VXO transistor; a plastic '5179 has three leads, but the metal 2N5179 has four—one of the leads is connected to the case, and it does not have to be connected in the transmitter circuit. You can clip this lead off near the transistor body, then align the other three leads so the tab is pointing away from the coil, as shown in Fig 15. Make sure the metal transistor cases don't touch any other components (be extra careful with Q4 and Q5—they must not touch each other).

Fig 8 and its supporting text (in Part 2 of this series) explain how to wind the coils. Make sure you scrape the insulation from the wires before you solder the coils in place.

Don't forget to use heat-sink grease on

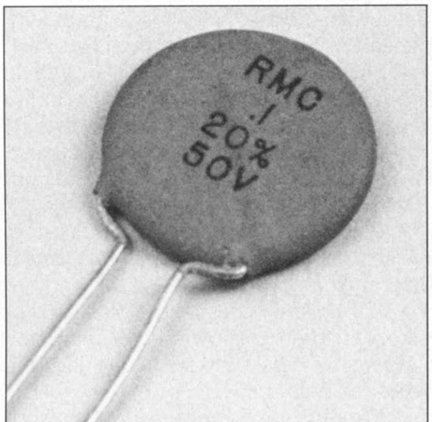

Fig 14—If your capacitors are too large, you may have to bend their leads to make them fit the circuit board.

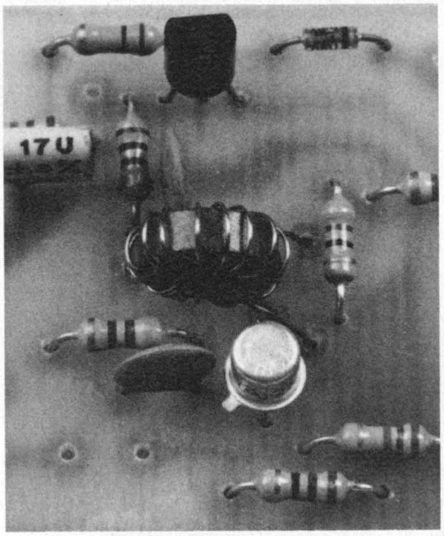

Fig 15—If you use a metal 2N5179 transistor, cut off its case lead and orient the transistor tab as shown. This photo also shows how T1 should be mounted on the board.

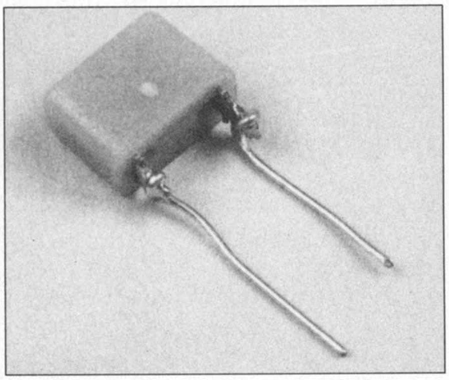

Fig 16—You can use leftover resistor leads to solder the socket to the PC board.

Build a Sidetone Oscillator

A sidetone oscillator is a useful transmitter accessory. The sidetone oscillator from Zack's three-band QRP transceiver (Fig A)* uses a simple op-amp circuit—it's easy to build. If you've built your transmitter using ground-plane techniques, there may be room on the transmitter board for the sidetone circuit. If there isn't room, or if you're using the PC board, you can build the sidetone oscillator on a separate piece of circuit board.

Because an IC has so many pins and determines where other components will be located, it should be soldered in place first. It's best to find at least two pins of an IC that can be soldered to the ground plane so the IC won't move when you solder the rest of the components.

The sidetone's 741 op amp has its V− connection on pin 4 and pin 8 is not connected, so we can solder both of those pins to ground. (I always solder ICs right-side up in a ground-plane circuit because pin diagrams always show the IC from the top. If I solder ICs in upside down, I get confused.)

Once the 741 is soldered to the ground plane, connecting the rest of the components is easy. Fig B shows the parts layout for the sidetone oscillator. Make a good mechanical connection to one end of each component—the grounded components should be soldered to the ground plane first and then to the IC. You'll find more construction tips in Part 2 of this series.—*KB1MW*

*See Note 1, Part 1 (Apr 1992 *QST*, p 36).

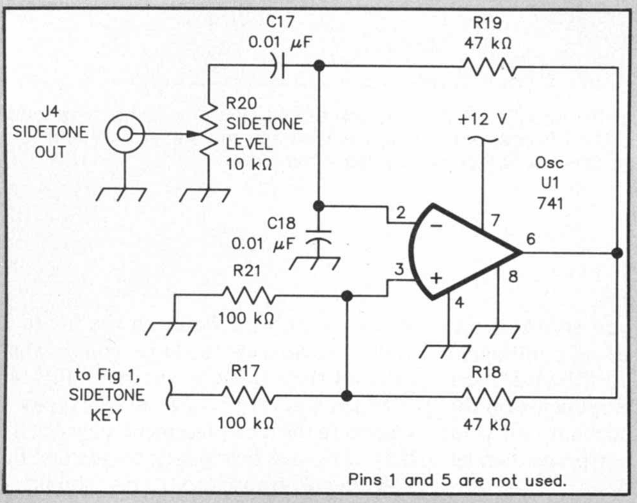

Fig A—A sidetone oscillator for the 20-meter transmitter. Radio Shack carries all of its parts, as do most of the general component suppliers listed in Table 1 of Part 1 (April 1992 *QST*, page 34).

C17, C18—0.01-µF, disc-ceramic capacitor (RS 272-131).
R17, R21—100-kΩ, ¼-W, carbon-film resistor (271-1347).
R18, R19—47-kΩ, ¼-W, carbon-film resistor (271-1342).
R20—10-kΩ PC-mount trimmer potentiometer (271-282).
J4—Coaxial jack (phono suitable) for routing the sidetone signal to receiver circuitry.
U1—741 operational-amplifier IC (276-007).
Miscellaneous—PC-board scrap for ground-plane construction, wire for connecting the oscillator to the transmitter circuitry and J4.

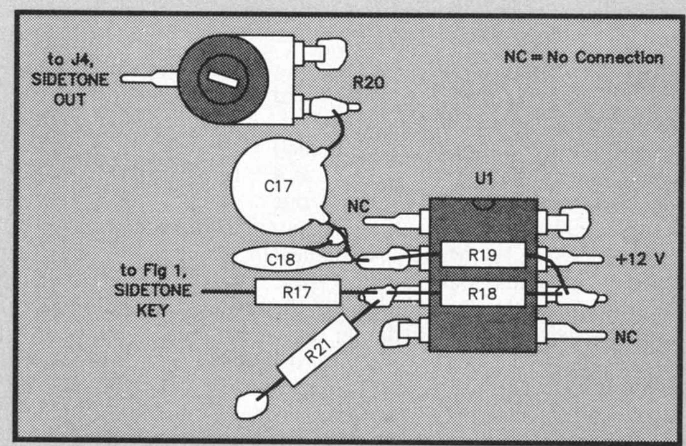

Fig B—The sidetone schematic turned into hardware. Even if you build your transmitter using a ready-made PC board, how about ground-planing a sidetone oscillator? Once you try it, you may want to build your *next* project using ground-plane construction!

the outside of Q6. Put a small amount of grease on the transistor, slip the heat sink over the case, and then wipe the grease off your fingers.

If you're using the FM-5 crystal (with wire leads), you can solder it directly to the board. If you're using the HC-16 crystal and a socket, you can solder leftover component leads to the socket and use them to solder the socket to the PC board, as shown in Fig 16.

That's All There Is

That's the long description of PC-board construction. Start with the smallest components (the resistors and diodes) and work through the transistors and capacitors and finish with the coils. Fig 17 shows the completed PC board. Here's a final checklist:

- The only holes left on the board should be the connections for +12 V, ground, key, sidetone key, antenna and receiver. If you have extra holes, something is missing! Check the part-placement diagram again.
- Do the diodes point the right way?
- Do the tabs on the metal transistors line up as shown on the part-placement diagram?
- Are the flat sides of the plastic transistors lined up as shown on the diagram?
- Are the metal transistors touching each other, or anything else?
- Are there any *solder bridges* between adjacent circuit-board traces? Solder bridges (Fig 18) occur when solder spans a copperless board area to connect traces or pads that aren't supposed to be connect-

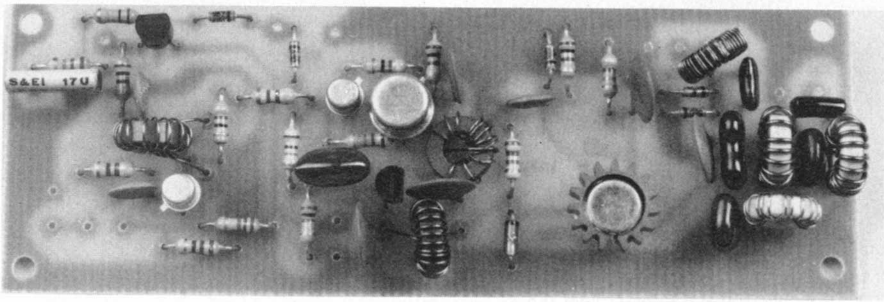

Fig 17—The completed circuit board. Use this as a guide when you check your board.

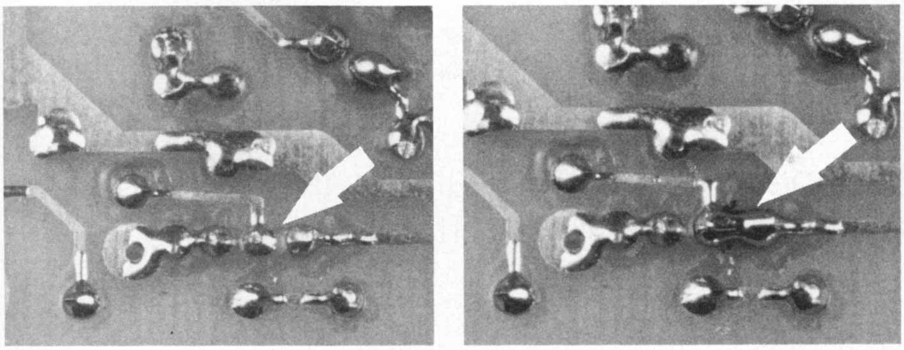

Fig 18—A slip of the iron, or applying too much solder, sometimes creates a *solder bridge* between circuit traces not intended to be connected. Remelting the bridge usually clears it. A toothpick may be useful in clearing stubborn shorts.

ed. Inspect the board's foil side carefully. Solder's silvery glints can hide bridges and poorly soldered connections, so breathe on the board to dull the highlights. If you find a bridge, remelt it and the adjacent trace or traces to allow solder's surface tension to absorb it.

If everything checks out, you're done. Next month, we'll put your board in a box and get it on the air!

Notes

[5] B. Hale, "Build It Yourself from *QST*," *Part 1*, *QST*, Apr 1992, pp 31-36.

[6] B. Hale, "Build It Yourself from *QST*," *Part 2*, *QST*, May 1992, pp 35-39.

[7] See Note 2 (Apr 1992 *QST*, p 36).

Getting Started in Digital Communications

(continued from page 41)

CLOVER is still under development, but recent tests have proven that CLOVER modems pass HF data at least ten times faster than AMTOR or HF packet under typical band conditions. When conditions are especially good, CLOVER can be even faster! CLOVER uses digital signal processing (DSP) technology to achieve this level of performance.

Food for Thought

AMTOR is really not as hard to use or understand as it may appear. In fact, it takes longer to read this article than it takes to get on AMTOR and work someone! By taking the plunge into AMTOR, you'll enjoy one of the most fascinating HF digital modes available—and you'll be taking your first steps into the future of Amateur Radio!

Within the next few years, technological innovations like CLOVER will allow us to communicate with ever-increasing speed on the HF bands. Similar advances will offer ultra-high-speed amateur communications on VHF and UHF as well. As Steve Ford, WB8IMY, suggested in the first part of our series, it won't be long before hams begin to digitize speech itself. The data will be sent through high-speed modems and processed by specialized software at the receiving stations. Noise and interference will be discarded, resulting in clear, natural-sounding voices. Commercial telephone companies and the military are far ahead of us in this area, but their systems are extremely complicated and expensive. It's up to hams to find a way to make it cheaper and simpler!

Just as spark yielded to CW in recognition of its inherent superiority, I believe analog communications must eventually yield to digital. As amateurs we have an obligation to explore every possible avenue that may lead to an improvement in our ability to communicate. Digital technology is a tool we can use to make a gigantic leap forward!

I hope you've enjoyed our digital communications series, and I strongly encourage you to try packet, RTTY or AMTOR. No matter how old you may be, these modes will rekindle your child-like sense of awe and wonder. Put aside your microphone or key this weekend and try something different. There's no better time than now to "think digital!"

Notes

[1] CCIR Recommendation 476-4 (1986), "Direct-Printing Telegraph Equipment in the Maritime Mobile Service", *Recommendations and Reports of the CCIR, 1986*, Volume VIII-2, Maritime Mobile Service, Geneva; International Telecommunications Union, pp 60-69.

CCIR Recommendation 625 (1986), "Direct-Printing Telegraph Equipment Employing Automatic Identification in the Maritime Mobile Service", *Recommendations and Reports of the CCIR, 1986*, Volume VIII-2, Maritime Mobile Service, Geneva; International Telecommunications Union, pp 5-59.

[2] P. Martinez, "AMTOR, an Improved Error-Free RTTY System," *QST*, Jun 1981, pp 25-27. For more information about AMTOR, also see: P. Newland, "An Introduction to AMTOR," *QST*, Jul 1983, pp 11-13, and P. Newland, "A User's Guide to AMTOR," *QST*, Oct 1985, pp 31-34.

[3] B. Henry, "Getting Started in Digital Communications—*Part 3*," *QST*, May 1992, pp 41-47.

[4] B. Henry, "New AMTOR Mode," *CQ*, Nov 1989, pp 36-40.

[5] H. P. Helfert and U. Strate, "PACTOR—Radioteletype with Memory ARQ and Data Compression," *QEX*, Oct 1991, pp 3-6.

[6] R. Petit, "CLOVER-II: A Technical Overview," *ARRL Amateur Radio 10th Computer Networking Conference Proceedings (1991)*, (Newington: ARRL, 1991), pp 125-129.

Strays

INTERNATIONAL EVENT ORGANIZERS

☐ The Friendship Amateur Radio Society Inc (FARS) put on the Friendship Radio Games (FRG-91) in Portland, Oregon, with more than 100 participants from the US, USSR and Japan and through the SeaPac convention. The group is compiling information on their experience in sponsoring international radio-sporting games. If you're interested in putting on such competition, contact FARS, PO Box 13344, Portland, OR 97213.

CW COMPETITION

☐ The Friendship Amateur Radio Society (FARS) joins with SeaPac to host a world-class CW competition June 13. Harry Lewis, W7JWJ, of Seattle, will attempt to set a new record for receiving code. Competition categories include CW sending, receiving and pile-up operation. Top scorers will be eligible for the US team in the third FARS Sport Games next summer in Victoria, British Columbia, Canada, where US, Canadian, Russian, Japanese and Canadian hams will compete in CW, DF and DX events. Contact Stan (W7NI) or Pat (KA7UFG) Griffiths, 18955 SW Blanton, Aloha, OR 97007.

COINCIDENCE

☐ I just had a CW contact on 20 meters with Morley Taylor, K7UM, in Salt Lake City. I was using my old Vibroplex Speed-X semi-automatic key. My father bought me the "bug" from Walter Ashe Radio in St Louis in August 1934. Taylor was also using a Vibroplex Speed-X his father had bought for him from Walter Ashe Radio in St Louis!

His father paid $15 for his in the 1950s, and I still have the package mine came in with the $5.75 price penciled in on the end of the box.—*Robert Lynn, W9PYA, Rolling Meadows, Illinois*

Feedback

◊ In B. Hale, "Build It Yourself from *QST*," Part 3, *QST*, Jun 1992, pp 42-45, the emitter (**E**) and collector (**C**) labels for Q1 in Fig 11 (p 42) are transposed. **C** should be left; **E**, right. Q1 works correctly if inserted as pictured, however.—*WJ1Z*

◊ In J. Makhinson, "A High-Dynamic-Range MF/HF Receiver Front End," *QST*, Feb 1993, pp 23-28:

The circled numbers in the upper object in Fig 9 appear in incorrect order (①②③④⑤). Configuring T5, T6, T9 and T10 this way turns the pre- and post-amplifiers into oscillators. The correct order is ①②⑤④③.

The Si8901's design originated with Robert Zavrel, W7SX, and not Ed Oxner, KB6QJ, as stated in the text.

The spectrum display on the article title page may be confusing because its caption does not fully characterize the conditions under which the photo was obtained: at the mixer *output*, *without* the preamplifier, and with mixer loss added. Page 3 of the information package called out in the article's Endnote 2 details the calculations.

Transformers T3, T4, T7 and T8, called out in the Parts List as Mini-Circuits T1-1T (tapped secondary) units, can be T1-1 (untapped secondary) units in this application.

As called out in the Parts List, transformers T1 and T2 are indeed Mini-Circuits T4-1 units, and (per Mini-Circuits) have center-tapped secondaries despite the untappedness seemingly implied by the absence of the suffix *T* in their model designator.—*WJ1Z*