The Dual-Combo Field-Strength and Source Dip Meter

Versatile test instruments for all your RF projects.

by Martin Beck WB0ESV

Most field-strength meters described in ham literature are coil-capacitor tanks with a diode and a meter. These FSMs are useful, but not sensitive enough for many jobs where the RF is not very strong. I frequently need something better, so I designed the device described here.

The most notable feature of this FSM is that instead of a DC amplifier, it uses an RF amplifier: a grounded-gate FET. After RF amplification, the signal is capacitively coupled to a diode voltage doubler whose output is fed to a 200 µA meter. For those who want the ultimate in sensitivity, a simple bipolar DC amplifier can follow the diode doubler.

More than 20 years ago I used such a system, but it was all bipolar. I took it to the annual Field Day operation of the W6LIE radio club. During a break in operation, I noted that my FSM's meter was reading up and down, but no local signal was being generated. I determined that the FSM was reading 15 meter *received* energy being reradiated from a 15 meter yagi at about 40 or 50 feet up!

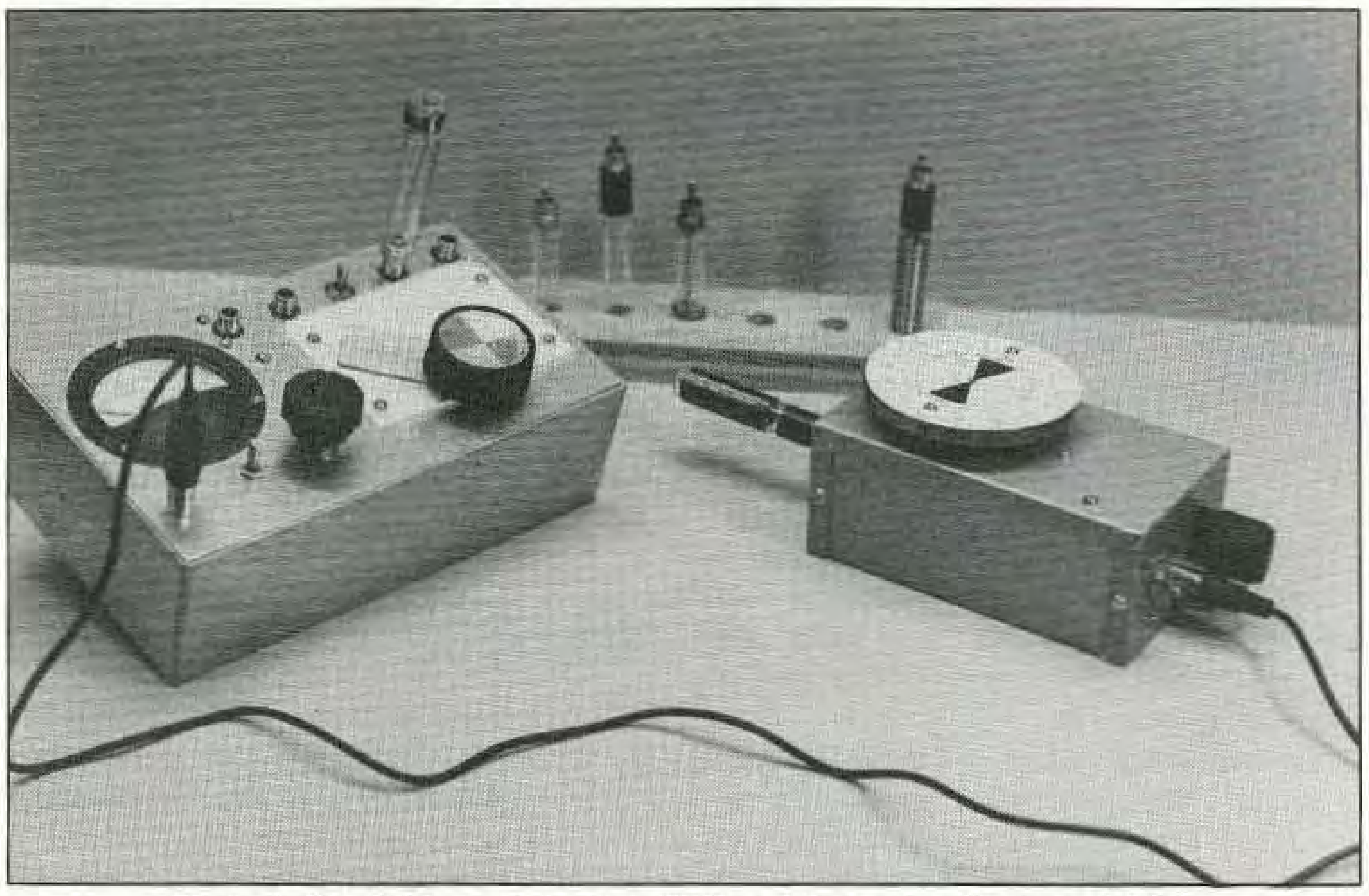

Photo A. The field-strength meter (left) and the source dip meter (right).

Construction Details

The device shown in Figure 1 uses three "tricks." First, the FSM uses the same plug-in coils as the source dipper described later in this article. Second, the dipper uses the FSM's meter. Third, switch S1 not only switches the meter from the FSM to the dipper, but also turns on the power for the FSM's FET when in the FSM meter position. The FSM uses two extra plug-in hairpin loop coils to extend its range a little bit.

Note that in Figure 1 the 365 pF air variable capacitor C1 is not shown. This was for the sake of clarity. C1 is on the opposite side of the board. Two bolts hold it to the board. Any broadcast capacitor will do (from a "junker" AM radio, for example)—just use one section. It does not have to be bolted to the board, but a short heavy lead should be run from its frame to the board. A thin brass strip ¼-inch or wider is good for this. You can often drill and tap a couple of holes for mounting it to the board.

Note that in Figure 1, J2, J3, J4, and J5, as well as S2, are mounted on a plastic strip. This is because these phono jacks must have both "sides" (i.e., both sheath and center pin) above ground. The plastic strip is bolted to the inside of the metal face plate and 0.375-inch holes are punched in the face plate to completely clear the phono jacks. The switch just went along for the ride, as it could have been mounted on the metal face plate.

Except for the meter, C1, and the RF choke, I bought all the parts at Radio Shack. The RF choke came out of an AM radio. Anything from 1 to 2.5 mH will do. The chassis box is known to Radio Shack as a "project box," and is about 7½" L x 4¼" W x 2.375" deep. A metal chassis box could also be used. The entire FSM is built on the metal face plate. Simply turn the plate upside down on the box and you will have a convenient holder while you do the work.

For a dial, I used a piece of typing paper held down by a piece of thin, clear plastic. Since the FSM uses the source dipper's plug-in coils, you need an RF source for calibrating the dial. Some signal generators will work. Other options are the use of a friend's dipper or, if you want only the amateur bands, transmit into a dummy load and hold the field-strength meter nearby. As a last resort, you can wind a second set of plug-in coils for the FSM and calibrate it with the source dipper.

Since both the source dipper and the FSM use the same meter, I opted for a 200 µA job. You can use a Radio Shack 50 µA meter (now discontinued), but it is so highly damped that its response is too slow to suit me when using it with the dipper. It does work, but a less highly damped 200 µA meter is better.

Note that most of the circuit is built using phenolic terminal strips. A printed circuit could be equally good.

In Figure 1 you can see that there are both a low band (J2 coil and J3 antenna) and a high band (J5 coil and J4 antenna). Since brass strips are used in conjunction with J4–J5, the inductance is lower, and the FSM's range can be extended. Only the two hairpin loops are used in the high band section. Either antenna can be a two-to-three-foot "spike."

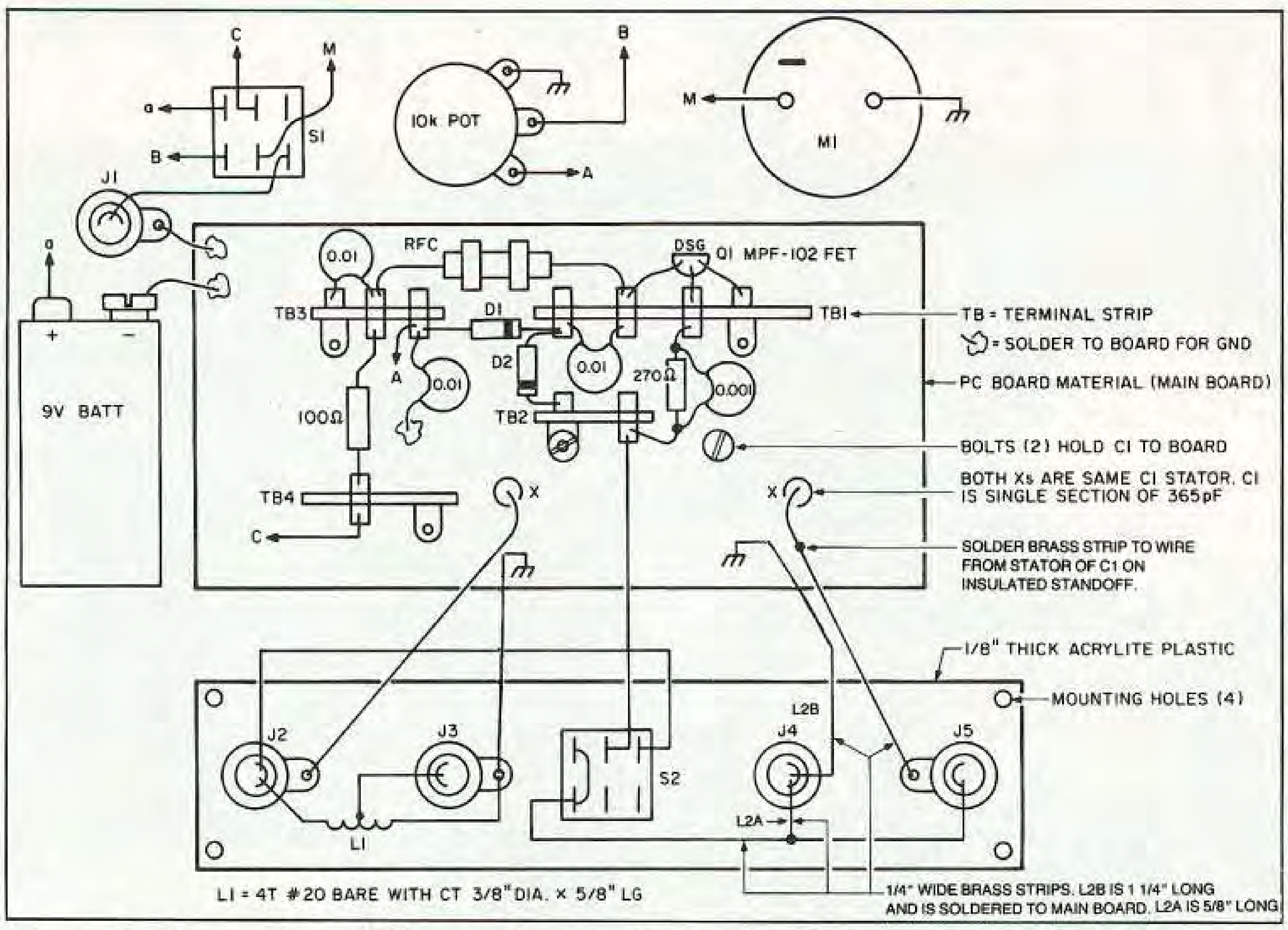

Figure 1. The sensitive field-strength meter. Note: For clarity, parts and subassemblies are shown only in approximate positions. J1 switches the meter to the source dipper. The shield lug of J3 is grounded to the main PC board as shown. Please note that the ground lead marked L2B should be a 1.25-inch-long strip of ¼-inch brass strip. L2A is ⅝" long. The points marked "X" are holes which pass insulated leads from the variable capacitor C1 stator.

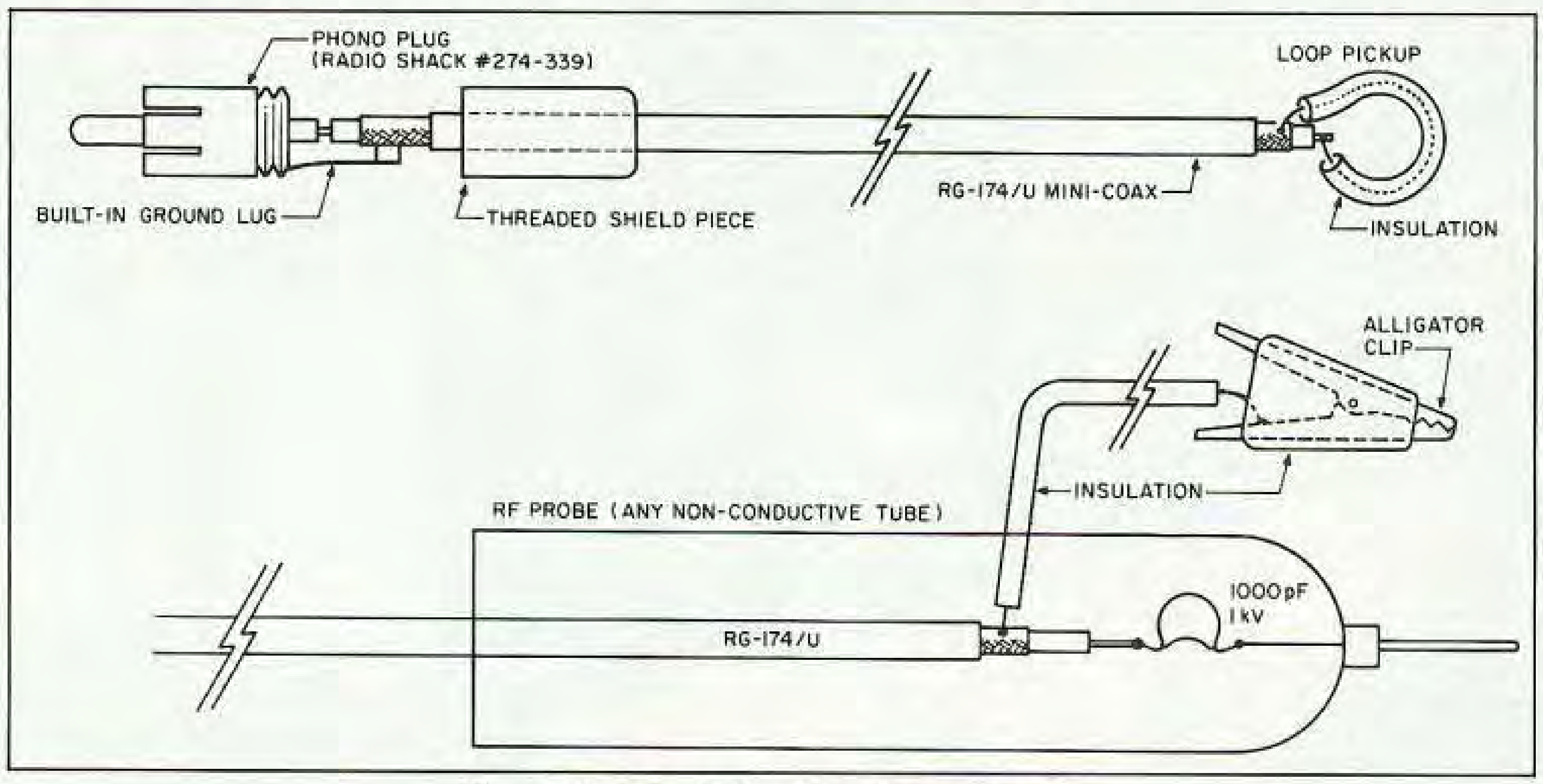

Figure 2. The RF sniffer (two options).

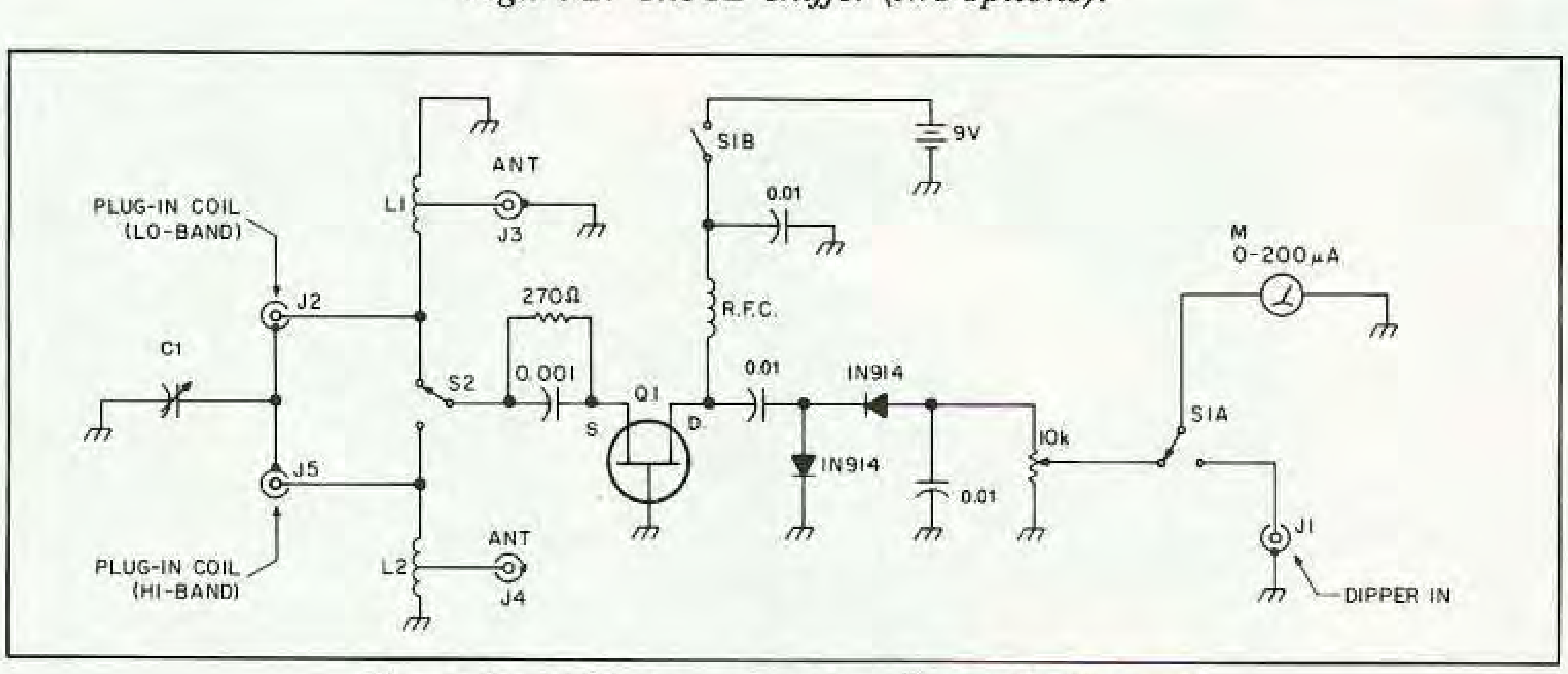

Figure 3. Field-strength meter schematic diagram.

To make a "hot-sniffer" out of the FSM, make a simple adapter, as shown in Figure 2. Using RG-174/U mini-coax, put a phono plug on one end and a small one- or two-turn loop from the center conductor to the braid on the other end. A second option here is an insulated probe that is capacitively coupled. Use a good high-voltage capacitor here! The braid should have a lead soldered to it with an alligator clip for a probe ground. Do not use a diode in the probe.

Since the meter, the 365 pF air variable, and the dial on my FSM were all "scrounged" or homemade, you will have to do the same (see the Parts List for a possible source of the capacitor). However, if you build the circuitry carefully on the plastic strip, the rest of the wiring is not the least bit critical. It is, of course, simply good practice both electrically and cosmetically to use short, direct leads whenever possible. Figure 1 does not show this, but that is because I used an exploded view for clarity. The 9-volt battery in Figure 1 is used only by the FSM; the source dipper has its own battery. Using separate batteries facilitates less switching and fewer interconnecting wires.

Make Your Tinkering Easier

Once you have the dipper and FSM built, operating, and on your workbench, you can investigate both active and passive circuitry. Large or small tank circuits can be checked with equal ease. Instead of repeatedly installing and removing a coil, you can get it right the first time with the dipper. The sensitive FSM will help you hunt down parasitics, check oscillators for output, verify that multipliers are working, sniff out RF leakage from the supposedly shielded chassis and... well—you will think of other uses, I'm sure. At any rate, this dipper and FSM combination will prevent a few gray hairs and add the most important item of all: having fun with your RF-oriented projects and/or troubleshooting!

The Source Dip Meter

A dip meter belongs on every ham's workbench. Before you install that tank circuit, the dipper will tell you what the tank's actual frequency is. A dipper will also ferret out "hidden resonances" for you. In a pinch, it can even be used as a signal generator. It can determine the frequency of antennas, and even the lengths of coax. The list goes on, making the dipper an extremely useful device.

This dipper uses a common FET as the active device and, aside from the variable capacitor and coils, it uses only one pot and six small parts. It uses the meter in the sensitive field-strength meter discussed previously, and shares its plug-in coils with the FSM. It is such a simple circuit that a beginner can easily build it. The only tools required are the usual ones: needle nose and diagonal pliers, a drill motor and a soldering iron. Except for the RF choke and the variable capacitor, all parts or suitable substitutes are available at Radio Shack.

If there is one glut on the market, it is the defunct so-called stereo, and this is where you can get the RF choke and variable capacitor. In fact, except possibly for the 10K pot, you will find all the other small parts in these old clunkers from the Orient. These little variable capacitors always have a number of tapped holes, so they are easy to mount. Just don't lose the original nuts and bolts—they are metric!

Some comments are needed regarding the variable capacitor. First, use a magnifying glass to determine whether the spacing of plates (rotors and stators) is the same on both sections. Take care because this difference in spacing will be subtle. The capacitor I used

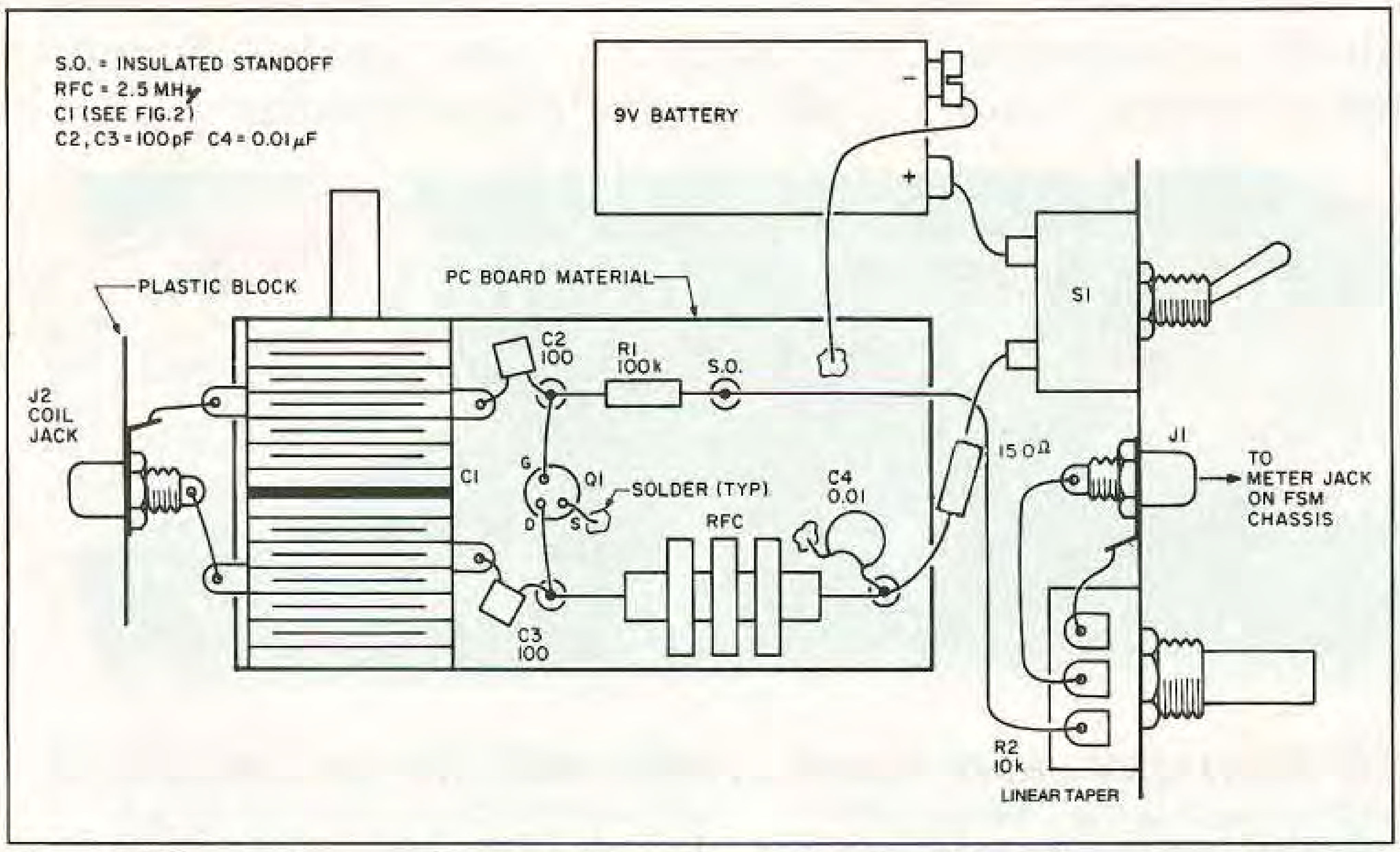

Figure 4. The simple source dip meter. Notes: For clarity, the off-board components are only in their approximate positions. The PC board is 3-9/16" L x 1-¾" W. The chassis box is 5-¼" x 3" x 2-⅛" (L.M.B. #780). J1 and J2 are Radio Shack phono types.

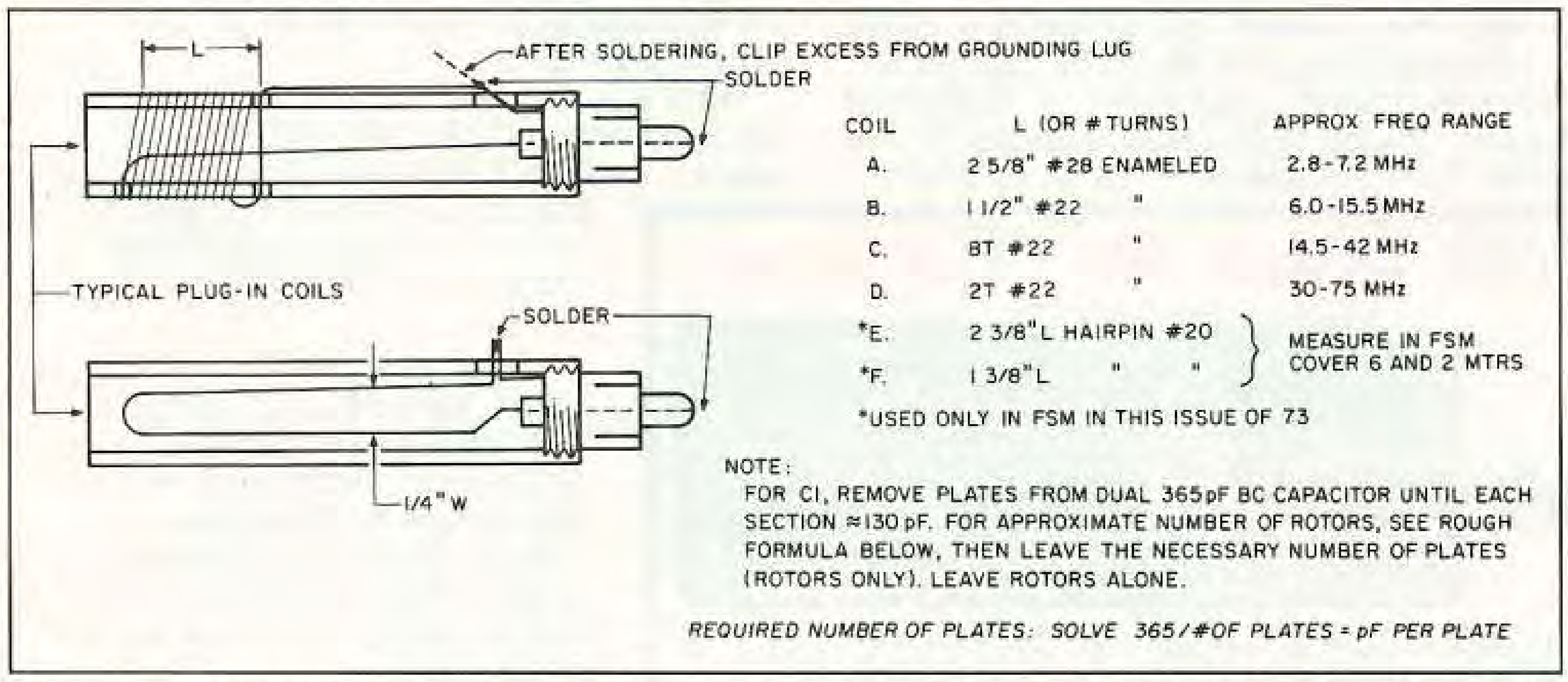

Figure 5. Dimensions of the coil forms. Note that coils E and F are used only for the field-strength meter. Use ½" o.d. Acrylite tubing (2-¾" long for coils A–E and 1-¾" long for coil F).

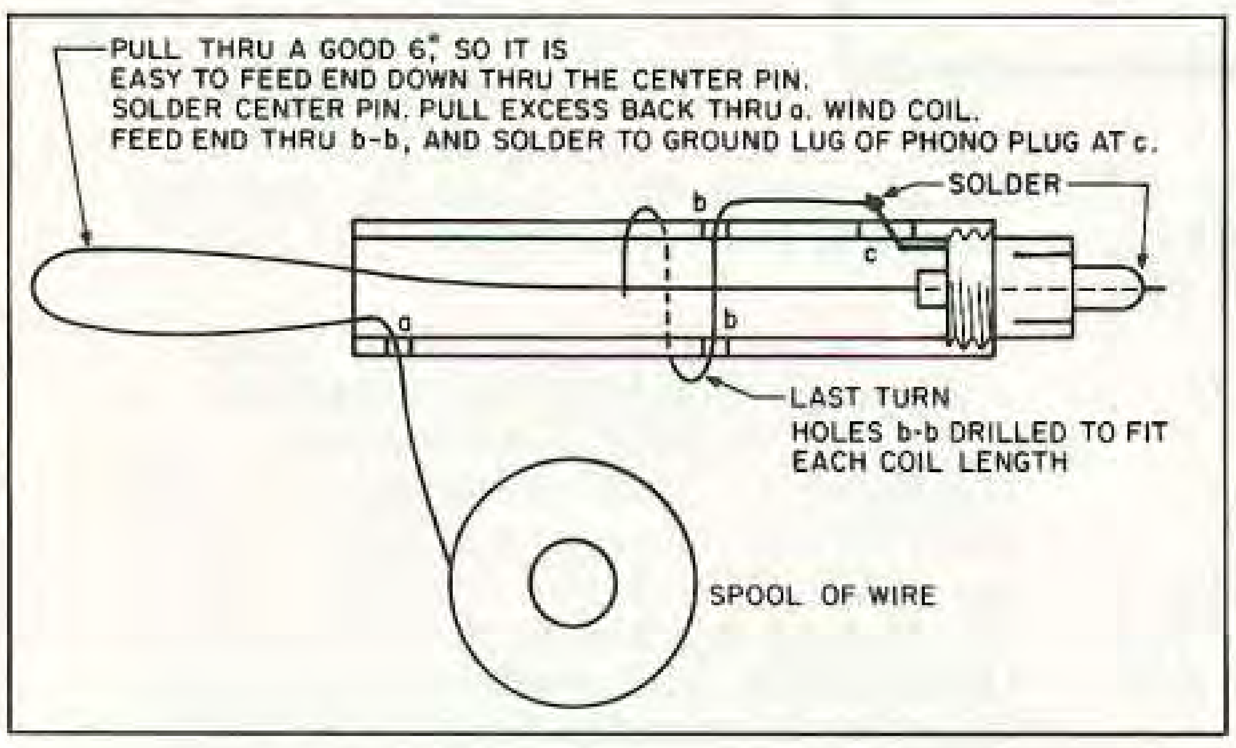

Figure 6. Winding details of the coil form.

required that only one plate be removed from the wide-spaced section, but seven plates had to be taken from the close-spaced section. The thing then becomes a dual 130 pF variable capacitor. If both sections are identical, you can use the approximate formula in the box in Figure 2. Above all, don't be concerned about hitting the 130 pF value on the nose; anything in the range of 100 to 150 or so will do just fine. *[Ed. Note: If you use the Antique Electronic Supply variable capacitor # CV-471, you need only use two of the three sections with no modifications; their model CV-240, although smaller, requires you to remove several plates in each section.]* This is because you have to calibrate your own dial, anyway. Exact ranges can be obtained by adding or removing turns on the plug-in coils. Have no fear—this is all very easy. By the way, you can remove or simply ignore the two small FM sections of these variables. I just bend their stator tabs down and solder them to the PC board as a board mounting method. If you remove those outer FM rotor plates, there is room on the front of the frame to drill and tap mounting holes (in case you did lose those metric bolts).

The plug-in coils use phono plugs, and both sides of the plug must be above ground. Therefore, I punched a 0.625-inch hole in the coil end of the mini-box to clear the phono jack. The latter is mounted on a 1½" x 1½" piece of acrylite plastic. When bolting on the plastic, be sure the phono jack is centered in the 0.625-inch hole, so the outer conductor of the jack is not grounded. Radio Shack's phono jacks come with a "grounding" lug. It is used here as a tie point for one side of the wires from the two sections of the variable capacitor, as is clearly shown in Figure 1.

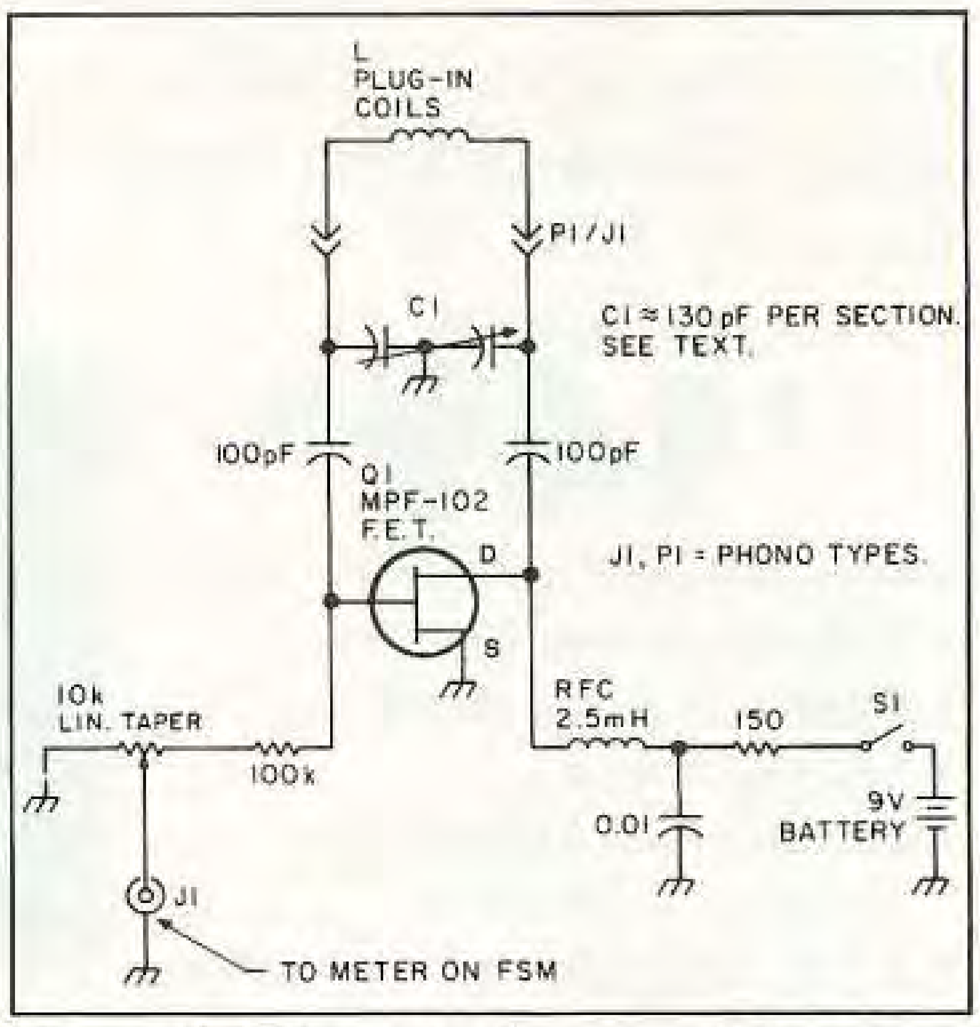

Figure 7. Schematic diagram of the source dip meter.

Wiring

For wiring the board, I used tiny insulated standoffs (phenolic terminal strips could be used as well) and a FET socket (optional). Of course, the ultimate way to go is to just etch a little printed circuit. The way I see it, you would only need six "islands," and they could even be located where my standoffs are! A small Z-shaped clip can hold the battery in place. See Figure 1 for details.

For the dial, I used a disc of ¼-inch thick acrylite clear plastic. The original knob on the capacitor had a brass insert with a setscrew, so I shattered the plastic off of the insert, then epoxied the insert into the plastic dial. No knob is used; the dial itself *is* a knob and offers superior control when tuning.

To achieve "one-hand" operation, a ¼-inch wide strip of coarse sandpaper is epoxied to the edge of the dial. The dial has a pair of 4-40 nuts and bolts 180 degrees apart on the outer rim, to hold on a piece of white poster board for the actual calibration marks. Use a friend's dipper or your own receiver to calibrate the dial. Do not try for too many numbers, i.e., 7.05, 7.06, etc. Use numbers only on every 1 to 5 MHz, and suitable marks between, for example: 7.0, 8.0, etc. Use pencil lightly for calibration. Then remove the poster board only—not the plastic dial. With the poster board removed, it is far easier to ink over the light pencil marks. If you use India ink, here's a little trick: Use black for all frequency marks except the amateur bands; use red for these bands. Then when your buddy borrows your dipper (and refuses to return it), he will find it easy and quick to use.

Winding the Coils

I used ½-inch Acrylite plastic tubing for the coil forms. See Figure 5 for dimensions for each frequency range. Note that all coils are used for the field-strength meter. However, coils E and F are not used for the dip meter. After cutting each coil form to the desired length, I drilled a 3.16-inch hole in the side of each coil form about ⅜-inch from the plug end. Now drill 1/16-inch holes at "a" and through the tube at the points marked "b," as shown in Figure 6. Holes "a" and "b" mark the beginning and end of the coil itself. Hole "a" is drilled about a ¼ inch from the top end of the coil form in each case. See the chart in Figure 5 for the dimensions for each coil.

Next, mount an RCA phono plug in the end of each form. Use only the Radio Shack plug (RS# 274-339) with the metal shield. Remove the shield and toss it. Next, dab some epoxy on the threads of the plug and place it securely into the end of the coil form with the ground lug sticking through the hole in the side of the form as shown in Figure 5.

After the epoxy has set up, you're ready to wind the coils according to the chart in Figure 5. First, route the wire down the center of the coil form, through the center conductor of the phono plug, and solder it in place. Figure 6 shows the winding procedure. The last turn passes through the holes marked "b" and pulled down to point "c" and soldered in place on the phono plug's shield lug. Be sure to cut off the excess grounding lug. Being careful not to short the lug to the center pin, push the lug in a bit until it is about flush with the outside of the tube. It can be pried in and out several times without breaking. Once the coil winding is adjusted to the range you want, you can slip some heat-shrink tubing over the lower (plug) end, or for that matter, over the entire coil. Once the wire is fed through holes B–B, pulled tight and bent down to the plug's ground lug, the coil will not unravel. The dipper coils are all close-wound. You should use the #28 enameled wire for the lowest band's coil, but you can substitute #22 enameled wire for the #21 I used (because I had it). Note that, except for the lowest band coil, a few extra turns should be used as it is easier to remove than add turns when adjusting frequency. Be sure that when the coils are finished, there is overlap of the ranges. For example, the lowest frequency of coil C should be lower than the highest frequency of coil B. I always try to keep all of an amateur band on one range, to avoid having to plug and unplug coils.

My dipper is stable, easy to use, and gets more use than my old 110V Millen dipper. The source dipper has its own "power supply" and can go anywhere. Once you have one, you will wonder how you ever got along without it.

One note: Make sure you use the proper size of Acrylite tubing (½" o.d.) that will mate with the phono plugs. For the location of an Acrylite distributor, you can call Cyro Industries at (800) 223–2976.

If you can't find a source of the tubing, I can supply a full set of pre-cut and drilled coil forms with phono plugs permanently installed (send to address at end of article). These forms are suitable for many other purposes than these two projects. The package includes a pre-cut and drilled acrylite plate with the coil's jack permanently installed. The set is $39.95, including postage. If you can do your own drilling and epoxying-in of the phono plugs, the set of coil form parts is $29.95, including postage.

Contact Martin Beck WB0ESV at 1637 Hood, Wichita KS 67203.

Field Strength Meter Parts List

Q1	MPF102 FET (RS# 276-2062)
D1,D2	1N914 diode
S1,S2	SPDT switches
R1	10k panel mount potentiometer
R2	270 ohm resistor
J1–J5	RCA phono jacks (RS# 274-346)
RFC	1 to 2.5 mH RF choke (Antique Electronic Supply #PC-1535B)
TB1,TB2,TB3	2-terminal strips
TB4	4-terminal strip
BT1	9-volt battery
L1	4 turns #20 bare wire with center tap (⅜" diameter by ⅝" length)
L2	¼" wide brass strips mounted as shown in Figure 1
M1	200 µA panel meter
C1	365 pF variable capacitor (from AM broadcast radio or Antique Electronics Supply #CV-230)
C2	0.001 disc ceramic capacitor
C3,C4,C5	0.01 disc ceramic capacitor
Misc.	Case, mounting hardware, a ⅞"W x 4⅞"L Acrylite support plate (⅛" thick) and a 2"W x 4"L piece of single-sided PC board material for mounting components

Source Dip Meter Parts List

Q1	MPF102 FET (RS# 276-2062)
RFC	2.5 mH RF choke (Antique Electronic Supply #PC-1535B)
C1	Dual section 150 pF variable capacitor (Antique Electronic Supply #CV-900 or #CV-240)
C2,C3	100 pF ceramic disc capacitor
C4	0.01 µF ceramic disc capacitor
4	insulated standoffs
J1,J2	RCA phono jacks, RS# 274-346
R1	100k resistor
R2	10k potentiometer
R3	150 ohm resistor
S1	SPST switch
BT1	9-volt battery with clip
6	RCA phono plugs (for coils), RS# 274-339
Misc.	Battery clip, PC board material for mounting components (1¾"W x 3½"L), small plastic block (1.5" x 1.5") to support J2. ½ inch diameter Acrylite tubing for the coil forms. Lengths of #28, #22 and #20 wire for the coils.
Source:	C1 and the RF choke for both the Field Strength Meter and the Source Dip Meter are available from Antique Electronic Supply, 6221 S. Maple Ave., Tempe AZ 85283. Phone (602) 820–5411.