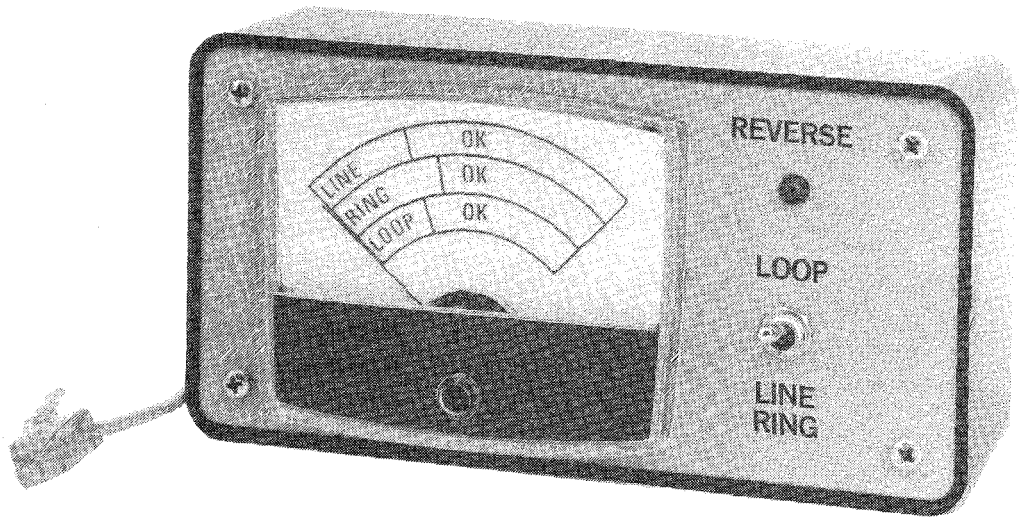

Telephone Line Tester

HERB FRIEDMAN

Beat the telephone service guessing game with this simple yet effective telephone-line tester.

EVER SINCE THE BREAKUP OF AT&T, THE odds of getting a telephone circuit repaired on the first attempt are only 50-50. The problem is that now the telephone lines are the responsibility of your local telephone company, while the receiver itself is the responsibility of its supplier, most often AT&T. If you contact the supplier, and the problem is not in the telephone, they won't help you. Similarly, if you call the local telephone company, and the problem is in the telephone, you are also out of luck. But this time there's a kicker—you can be billed $50.00 or more for a "service" call. And you still won't have a working phone.

One of the ways to avoid playing the telephone-service guessing game, and thus any unnecessary and unconscionable service charges, is to first, conduct your own line tests, using the telephone-line tester shown in Fig. 1. If the telephone line passes its tests, any problems must be the fault of the receiver itself. If the line doesn't pass its tests, you can call in the local telephone company secure in the knowledge they won't—or can't—stick you for a service charge.

The telephone-line tester is intended for the commonly used modular connector system. To use the device you simply unplug the telephone from its modular connector and substitute the tester's connector. It for some reason you want both the tester and telephone to be simultaneously connected, you can use a Y-adapter at the modular jack. If the telephone uses the older 4-pin "block" connector, you can use a modular-to-4 pin block adapter; those are available in both single and Y versions.

What it tests

The telephone-line tester checks the operating parameters of the telephone company's wiring at the modular connector. That includes the open circuit or "on-hook" line voltage; the "loop" voltage, which is the line voltage when the telephone is off hook (when the handset is lifted from its cradle); the ringer voltage, and the polarity of the line. The telephone line's voltage conditions are indicated by a meter, and the polarity of the line connections is indicated by an LED.

Normally, polarity is not a problem because most standard telephones will work regardless of the polarity of the DC voltage on the telephone line. (The purchase of any telephone that is polarity sensitive should be seriously questioned.) However, reversed line polarity can interfere with certain kinds of switching equipment, in particular, some of the low-cost conference and multi-use switchers, so we've provided for that test.

The voltage-level on telephone circuits is 48-volts DC. The wires in the telephone cables are color-coded, with the *green* wire being the positive side, and the *red* wire being the negative side. When there is no load on the line, that is, when all telephones in your home or office are *on hook*, the measured voltage at your telephone's modular connector should be greater than 40-volts DC, give or take a smidgen.

Depending on your particular telephone's repeat coil, your telephone will represent a DC load resistance of approximately 190 to 250 ohms when it goes *off hook*, meaning the handset is lifted from the cradle. Since there is resistance in the wiring between the central office and your telephone, there will be a substantial drop in voltage when your telephone goes off hook. At that time, the voltage at the modular jack might be as low as 5-volts DC. (A Bell System instrument, such as one of the 500 series of telephones, will work even if the line voltage approaches zero volts.) For conventional service a loop voltage of 5 or higher is considered acceptable.

A telephone is made to ring by superimposing a 90-volt, 20-Hz signal on the line. Since a telephone ringer is always connected across the line it represents a continuous AC load on the line. Thus, once again there will be a drop caused by the resistance in the wires between the central office and your phone. A 45-volt RMS equivalent voltage at your telephone is considered acceptable, although 40 volts is sufficient to ring the phone.

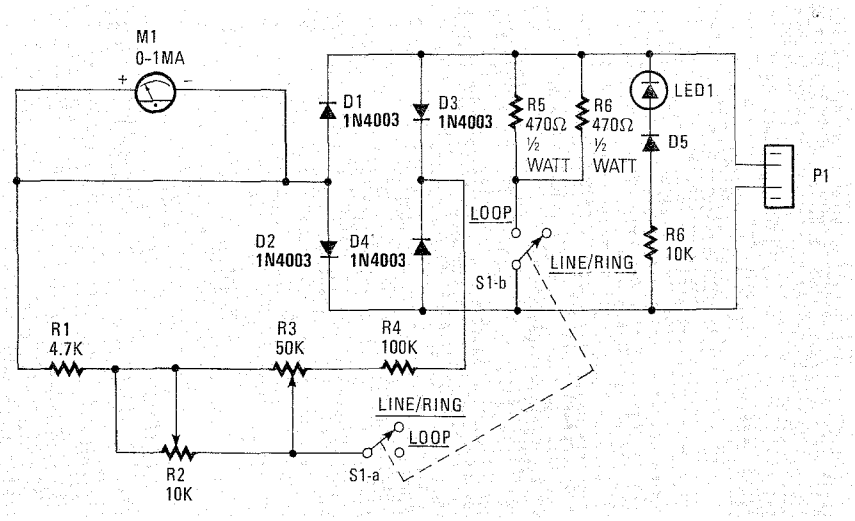

FIG. 1—BY PREVENTING UNNECESSARY SERVICE CALLS, this simple yet effective circuit can save you quite a bit of money.

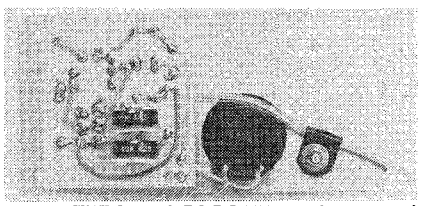

FIG. 2—THE SMALL PC BOARD can be secured to the front panel of the cabinet via S1's mounting nut. The board shown here is the author's prototype.

How it works

The telephone-line tester shown in Fig. 1 is connected to the telephone line through modular connector P1. Although a conventional telephone modular-plug has four connectors, the tester uses only the two inside ones—the red and the green. The yellow and black connectors are not used for normal, single-instrument, two-wire service. Since the tester's LED polarity indicator is always connected when the tester is plugged in, the instant the unit is connected you will have an indication of the polarity. If it is correct—that is, if the green wire is the positive side—and the red wire is the negative side, nothing will happen. If the situation is reversed, the LED will light.

With switch S1 set for LINE/RING, both S1-a and S1-b are open and the meter indicates the condition of the line-voltage. Any line voltage reading in the LINE OK range (more on the meter in a moment) indicates a line voltage higher than 40-volts DC. If the telephone is caused to ring, either by using a ringback number or by dialing from another phone, the meter will indicate RING OK, and the LED will pulse (indicating AC), if the ringing voltage/current is correct. The actual position of the meter's pointer depends on how many ringers are connected across the line. (Three or more of the old-fashioned ringers can excessively load the ringing voltage if the local telephone company has not corrected for your ringer load.)

When S1 is closed the voltage range of the meter is changed and a nominal load resistance of 230 ohms (R5 and R6) is connected across the line to emulate the off hook load of the telephone. If the meter indicates LOOP OK, you can be certain that you have sufficient loop voltage for satisfactory telephone operation. If you place another load on the line, perhaps by taking an extension telephone off hook, the meter reading will almost invariably drop below the LOOP OK range. That is perfectly normal; the line is operating properly when a single loop load results in a LOOP OK meter reading. That, by the way, is how to test telephones for proper connection. If lifting the handset causes the meter reading to drop, you can at least be certain that the telephone's hook switch is working and that the repeat coil is connected to the line.

Building the unit

The unit is assembled on the metal front panel of a 1⅝ × 2⅝ × 5⅛-inch plastic utility box. Except for the meter, all components are installed on a 2 × 2¼-inch printed circuit board that is self-mounting to the panel through S1's mounting nut (see Fig. 2). An appropriate foil pattern for this project is shown in Fig. 3; the parts-placement diagram for that board is shown in Fig. 4. Note that the size of the PC board and its layout aren't really critical as long as the board fits inside the cabinet without interfering with the installation of the meter or the cabinet's internal panel-support posts.

While it is usually best to make circuit boards using the photographic method, because of its small size, this board is an exception. It is probably best to do this layout by hand, using resist tape and resist donuts. That's because the board's small size and relative simplicity make the photographic method too expensive to justify. That's why we've shown the layout here, rather than in our PC service section as usual.

There's just one catch to that—very thin resist tape is getting harder to find in stores all the time. If you can't find the proper tape, we suggest you replace the trace that sweeps around the S1 contacts with a length of No. 24 or No. 26 solid insulated wire. That substitution has been made in the author's prototype to show you the proper routing of the wire. See Fig. 2.

Potentiometers R2 and R3 are installed on the foil side of the board so that they

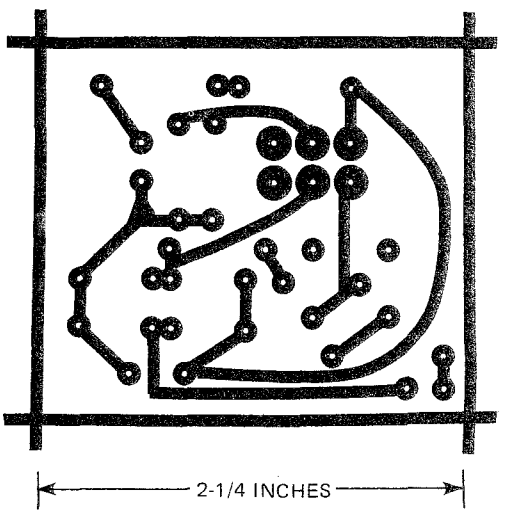

FIG. 3—BECAUSE OF IT'S SMALL SIZE and relative simplicity, the foil pattern for the telephone-line tester is shown here.

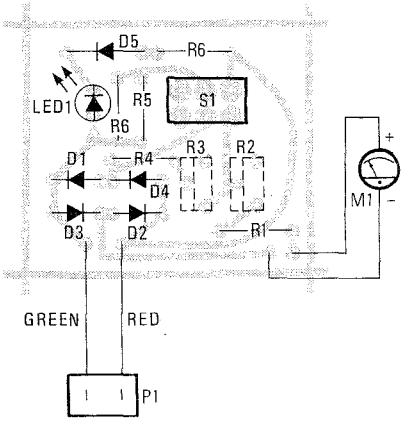

FIG. 4—PARTS-PLACEMENT DIAGRAM for the telephone-line tester. The foil pattern can be found in our PC service section, elsewhere in this issue.

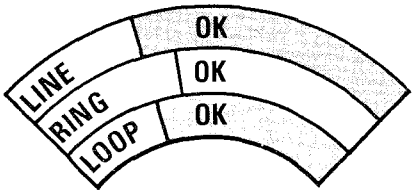

FIG. 5—IF YOU WANT to dress-up the meter, a new scale, similar to the one shown here, can be made. If you choose to do that, be sure that the LINE OK and LOOP OK reference lines fall at the 0.3 mA mark; the RING OK range begins at 0.4 mA.

can be accessed without dismantling the project. All other components are mounted conventionally on the "component" side of the PC-board. To ensure that the LED passes through the panel when the printed-circuit assembly is installed, position the LED so that there is ⅞-inch between the printed circuit board and the bottom of the LED before you solder its leads. When the assembly is secured with S1's mounting nut, ¼ to ½ of the LED will protrude through the front panel.

You might be tempted to substitute a single 230-ohm resistor for R5 and R6. Don't do that! The loop load must be rated for 1 watt, and that is most easily accomplished by using two parallel-connected half-watt standard-value resistors.

Meter M1 in our project is a 0–1-mA DC meter; those are available from almost any electronics supplier. If you want to dress up your project, you can create a meter scale similar to the one shown in Fig. 5. If you do that, the LINE OK and LOOP OK ranges should begin at 0.3 mA. The RING OK range should begin at 0.4 mA. Once you've drawn the scale, remove the meter's plastic cover. Then, taking care not to bend or otherwise damage the meter's needle, glue the new scale in place.

The modular connecting cord can be salvaged from some old telephone gear, or you can get a replacement cord at your local telephone store. With rare exceptions, the cord will have four wires; you will use only the green and red ones, as previously mentioned. Cut the cord to the length you want and then carefully trim the insulation from the free end of the green and red wires. Those of you who haven't worked with old headsets or telephone equipment are in for a surprise, because the wires will appear to be a strand of copper wound around a cotton, polyester or silk thread. That's exactly

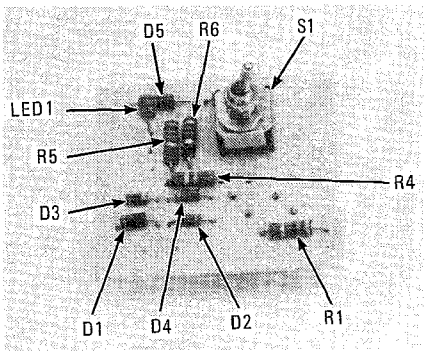

FIG. 6—THE COMPLETED PC board is shown here.

what it is. That type of wire is called "Litz" wire; it is very flexible, but it is almost impossible to solder because the fibers actually burn up before the connection is made. To install the Litz wires on the printed-circuit board, lightly tin the wire using a low-wattage (about 25 watts) soldering iron. Then clip off the very end of the wire so there's no loose strand and pass the wire(s) through its hole in the printed-circuit board. Fold the wire flat against the foil and then quickly solder it in place. If you use too large an iron, or too much heat (you keep the iron on the connection too long), the wire will burn up (turn black) and you'll have to repeat the whole thing until the Litz wires are properly soldered to the printed-circuit foils.

Once you've assembled the board (see Fig. 6), install the meter in the panel, solder the two pieces of wire that will be used to connect the circuit and the meter to the PC board, and then secure the printed-circuit board to the panel, using S1's mounting nut. Finally, connect the free ends of the wire you previously installed to the meter; be sure to observe the proper meter polarity. To prevent the modular cord from eventually breaking at the soldered Litz-wire connections, secure the cord with a plastic cable clamp at one of the meter's mounting screws.

Calibration

Set R2 and R3 to about mid-range, set S1 to the LINE/RING position and then connect a small variable DC power source across the telephone line input. Adjust the power supply for about 40-volts DC and see if the LED turns on. If it does the power supply connections are reversed. If it does not turn on, check its operation by reversing the power connections. If the LED still doesn't turn on you have probably made a wiring error. Once you've determined that the polarity indicator is working normally, return the power-supply connections to normal (LED off).

Next, set the power supply to 5-volts DC, flip S1 to the LOOP position, and adjust R2 until the meter's needle moves to the LOOP OK reference line (reads 0.3 mA). Next, flip S1 back to the LINE/RING position, adjust the power supply for 40-volts DC, and adjust R3 until the meter pointer is on the LINE OK reference line.

Testing the line

To test a telephone line simply set S1 to the LINE/RING position and connect the tester to the telephone line. If the LED lights, the telephone company's wiring to the connector is reversed (it does happen). Note the meter reading—the pointer should rest anywhere in the ok range (read 0.3 mA or greater). Next, flip S1 to the LOOP position; again, the meter should read in the ok area. Finally, once again set S1 to the LINE/RING position and cause the line to ring (perhaps by dialing from another phone). The meter should read in the RING OK range (greater than 0.4 mA) and the LED should blink because the voltage applied to the polarity-tester circuit is AC. If any of the tests produces anything but the expected results, the problem most likely lies in the telephone lines rather than in the phone itself.

If you want to check out extension telephones, set S1 for a LOOP test and then lift the handset of any phone; the meter should indicate less than the OK reading when the telephone goes off hook. As we said earlier, that is normal and shows that the telephone is at least connected to the line.

The telephone-line tester we've described is limited; it can not tell you precisely what's wrong with your telephone service. But it can at least tell you roughly where the trouble lies, and hence who to call to have repairs done. Considering the high cost of an unnecessary service call, that puts you way ahead in the game. **R-E**

PARTS LIST

R1—4700 ohms, ¼ watt, 5%
R2—10,000 ohms, trimmer potentiometer.
R3—50,000 ohms, trimmer potentiometer.
R4—100,000 ohms, ¼ watt, 5%
R5, R6—470 ohms, ½ watt, 5%
D1–D5—1N4003 silicon diode
LED1—jumbo red LED
M1—0–1-mA DC panel meter
S1—DPST, miniature, PC mount
P1—Modular telephone connector.
Miscellaneous—Cabinet, PC board, wire, solder, etc.