

BUILD THIS

Tele-Toll Timer



GARY McCLELLEN

Saving a buck on your phone bill is not an easy job—especially with rates constantly going up. But this automatic call-timer can help you get a grip on your skyrocketing bills.

IF YOU'RE INTERESTED IN SAVING MONEY on your phone bills (And who isn't?), you don't have to stop making phone calls—but making shorter ones would help (especially if you make lots of toll calls). The simple timing device that we'll describe in this article can help you start saving money right away: It will tell you just how much time you spend on the phone—and it will, we hope, remind you to shorten your calls.

Since the timer will monitor all calls made on a line—even on an extension phone—it's easy to keep tabs on the calls made by your high-school kids as well as your own calls! But don't think that the timer is limited to use around the home; it can also be very useful in the business world—especially for those who use a WATS line (800 numbers).

Inefficient use of a WATS line can cost a business an awful lot of money. And without some type of timer, improving phone-use habits is a hit-or-miss proposition. But with this timer, you can determine how long an employee stays on the phone. Then his or her telephone procedure can be "fine-tuned" for greater efficiency.

Ease-of-use is one of the timer's greatest features. For starters, there are no controls. Any time the phone is picked up, the display lights and the count begins. And

when you've hung up, the elapsed time is automatically frozen on the display, so that you know how long you've been on the phone. After about 20 seconds, the project then resets itself and blanks (turns off) the display. Now that is true hands-off operation!

Not only is the device simple to use—it is easy to build, too. All parts are mounted on two printed-circuit boards, so construction time is reduced to a few hours (once you have the boards, of course). All the parts are easily available, so not only will you have little trouble in obtaining the parts, you'll also have the opportunity to shop for the best prices.

Before we go any further, we should mention a few words about the FCC and your friendly telephone company. The timer, if assembled properly, should meet the FCC's requirements (namely Parts 15 and 68). However, local phone companies may have their own restrictions. Therefore, we suggest that you contact them for their requirements before you begin building this project.

Circuit operation

As shown in the block diagram in Fig. 1, the timer consists of an input-conditioning circuit, a comparator, a 20-second timer, and an inverter. In addition, there are three divide-by-60 counters

(IC5-IC7), three BCD (Binary Coded Decimal) decoder/drivers, three seven-segment displays, and, of course, a power supply.

The conditioning circuit, which is connected to the telephone line, isolates the device from the line and protects the unit from line transients. When the phone is in its cradle, 48 volts appears across the line. Picking up the handset reduces that value to about 9 volts. The conditioning circuit reduces the telephone's line voltage to about 2.1 volts when the phone is hung up and 0.4 volt when it's off the hook.

The output of the conditioning circuit is fed to comparator IC1-a, which compares that output to a 1.4-volt reference. When the handset is picked up, the input immediately drops below the reference and triggers the comparator. That activates the rest of the circuit.

The comparator output drives inverters that, in turn, are used to blank the displays and reset the counters. Three counters, IC5-IC7, generate the timing function: A 60-Hz signal is fed to IC5 and is divided down to 1 Hz for use by IC6 and IC7, which count the 1-Hz pulses. The count is divided internally and then output in BCD (Binary Coded Decimal) form. That BCD output is sent to three BCD-to-seven-segment display drivers, IC2-IC4, which drive the displays, DISP1-DISP3. (Note

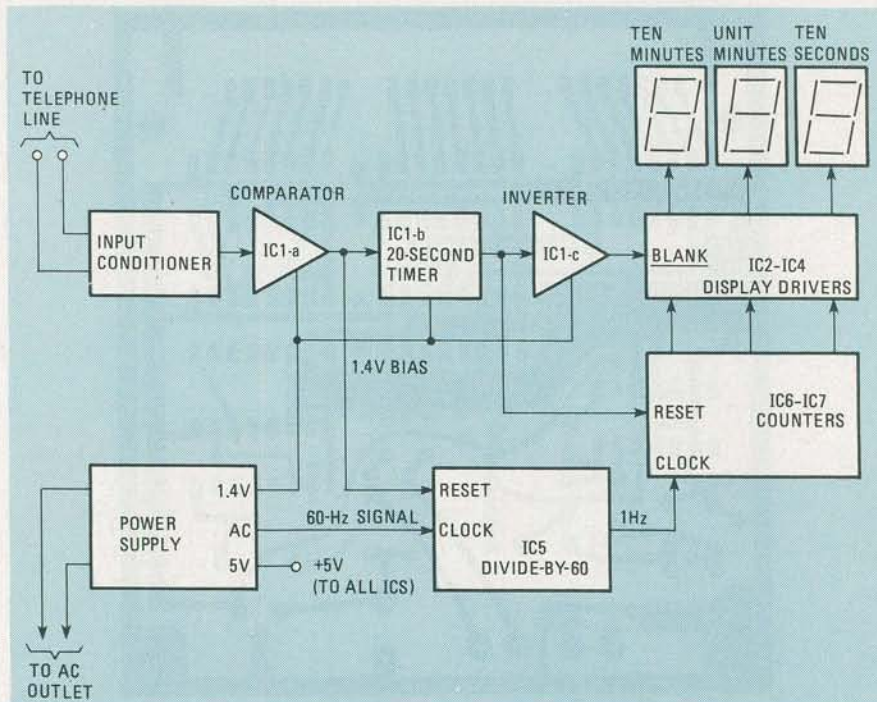


FIG. 1—BLOCK DIAGRAM of the telephone timing circuit showing the various sections of the unit.

that the unit displays tens of minutes, minutes, and tens of seconds. It does not display seconds—that amount of precision is not needed.

When the phone is hung up, the output of IC1-a goes high. That resets IC5 and freezes the time displayed for 20 seconds. (After the 20 seconds, the

timer is reset automatically.) Now, refer to the schematic in Fig. 2 for a more detailed look at the circuit's operation.

In Fig. 2, we see that the input-conditioning circuit consists of diodes D1–D4, capacitors C1–C3, and resistors R1–R3. Diodes D1–D4 form a full-wave bridge rectifier, whose output is filtered by capacitors C1–C3. That's done to prevent damage to the circuit caused by transients (such as those that might be generated by a nearby storm). Resistors R1–R3 provide a high input-impedance to the circuit.

The comparator, 20-second timer, and inverter functions are handled by an LM339 quad-comparator. A voltage-divisor circuit in the supply provides the reference voltage for IC1-a. When the phone is picked up, the output of the conditioning circuit drops below the reference voltage and triggers IC1-a, causing its output to go low, and capacitor C4 to begin charging through diode D5. That causes IC1-b's output to go low, removing the reset from counters IC6 and IC7, and causing the display to light and the timers to begin counting.

When the phone is hung up, the output of IC1-a goes high. That resets IC5 and freezes the time displayed. Capacitor C4 now begins to discharge through resistor R5. When C4 has discharged sufficiently (after about 20 seconds), IC1-b is again

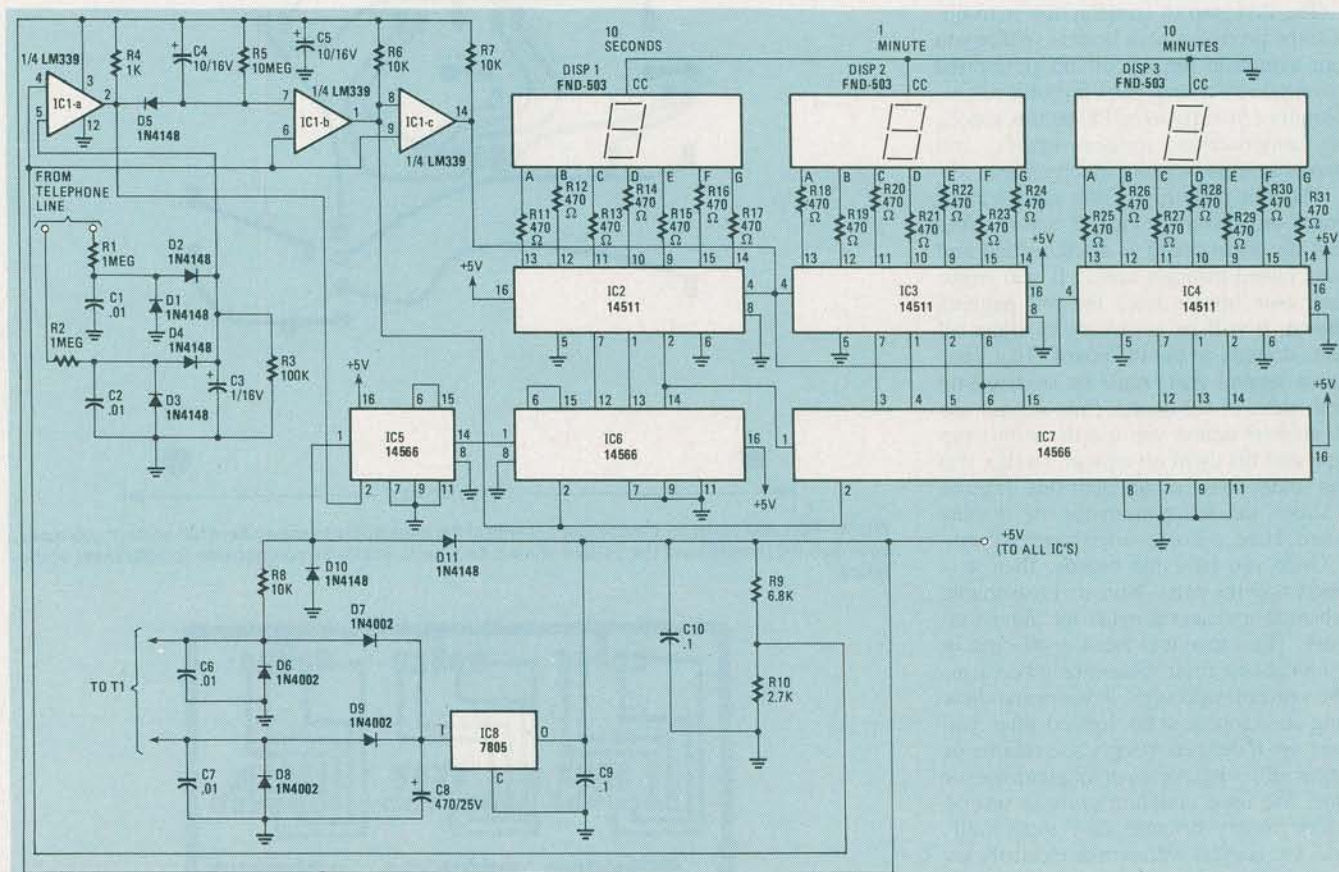


FIG. 2—A DETAILED SCHEMATIC of the timing circuit with all components and their values shown. Note that the comparator, 20-second timer, and inverter functions are handled by an LM339 quad-comparator IC1.

triggered. Its high output resets the counters. Its output is also inverted by IC1-c and fed to the pin 4 terminals of IC2-IC4 to blank the display.

Diodes D10, D11, and resistor R8 condition the 60-Hz output from the power supply by clipping the peaks off the output waveform to produce the squarewave signal. That signal is applied to the CLOCK input of IC5, divided down to 1 Hz and fed to IC6 and IC7.

The BCD outputs of IC6 and IC7 are fed to three decoder/drivers, IC2-IC4. Resistors R11-R31 (at the output of the display drivers) limit the display current to about 10 mA per segment.

The power supply consists of a 9-volt AC wall transformer and diodes D6-D9, (which are configured as a full-wave bridge rectifier). The rectifier output is filtered by C8 and regulated to 5 volts by IC8, a standard LM7805 three-terminal regulator.

The reference voltage that sets the trip point for comparator IC1-a is obtained by dividing the output of the regulator with R9 and R10. The 60-Hz squarewave signal for the timing circuitry is also derived from the power supply.

Now that we have a good idea about how the timer works, it's time to put it together!

Construction

The first step in construction is to obtain the printed-circuit boards. While you can assemble the circuit on perforated construction-board (parts layout is not especially critical), using PC boards speeds up construction, reduces errors, and makes troubleshooting much easier.

The foil patterns for the main circuit board are shown in Figs. 3 and 4. Note that the main board is double-sided and uses plated-through holes. If you make your own boards from the foil patterns shown, it will be necessary to solder all parts directly to the PC board. That's because several parts must be soldered on both sides of the board. (You cannot use IC sockets unless you use the wire-wrap type and lift them up enough so that you can solder on the component side.) Figure 5 shows the foil pattern for the display board. Here, a single-sided board is used.

Once you have the boards, then it is time to get the parts. Note that reasonable substitutions can be made for almost all parts. The capacitors are a good case in point because their values are not critical. The value of capacitor C4 determines how long the display stays lighted after you hang up. If desired, simply use smaller or larger values to shorten or lengthen the ON time. We used tantalum units in several places simply because they were available, but standard aluminum electrolytics should work fine.

As for the resistors, all are quarter-watt units, except for R1 and R2. The reason

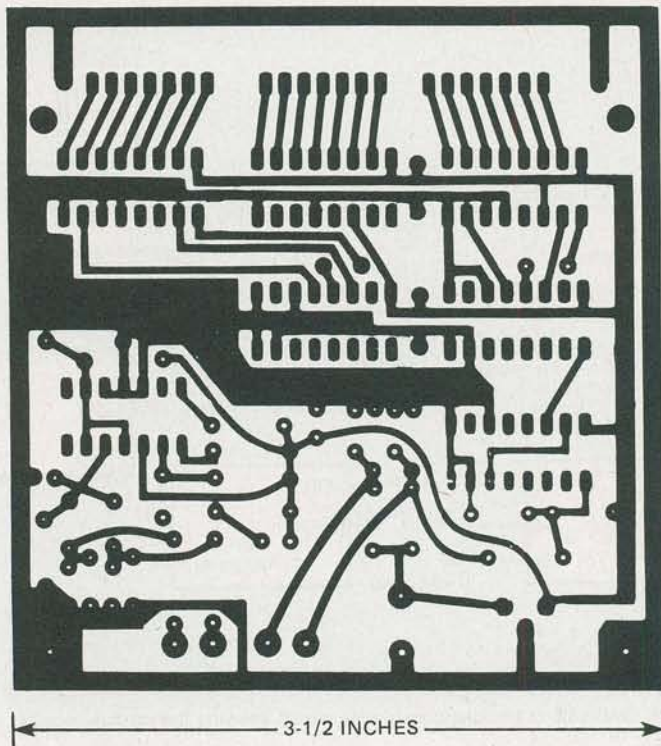


FIG. 3—THE FOIL PATTERN for the underside of main circuit board is shown here full-scale.

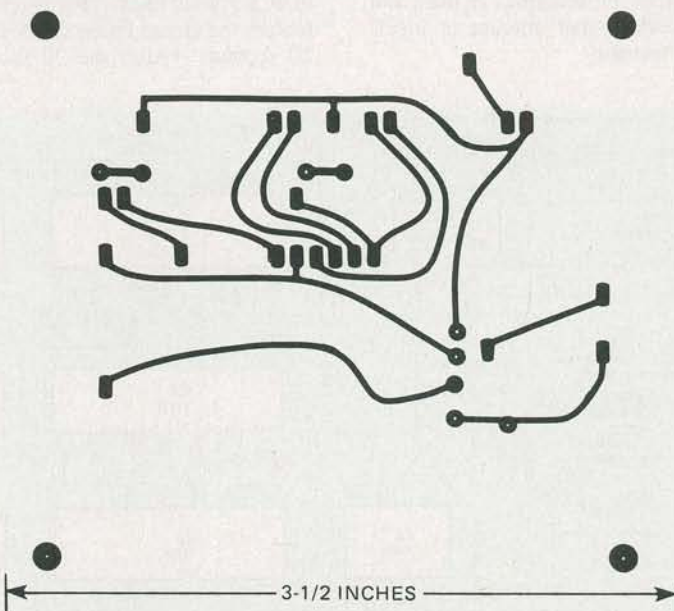


FIG. 4—FOIL PATTERN for the component side of the main board is shown here full-scale. If you make your own PC boards from the pattern shown, be sure to solder all components to both sides of the board.

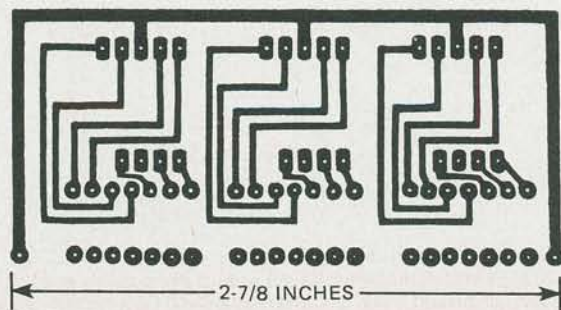


FIG. 5—DISPLAY BOARD foil pattern is shown here.

PARTS LIST

All resistors 1/4-watt, 5% unless otherwise noted.

R1, R2—1 megohm, 1/2-watt
 R3—100,000 ohms
 R4—1000 ohms
 R5—10 megohms
 R6—R8—10,000 ohms
 R9—6800 ohms
 R10—2700 ohms
 R11—R31—470 ohms

Capacitors

C1, C2, C6, C7—0.01 μ F, 50 volts, ceramic disc or polyester
 C3—1 μ F, 16 volts, radial-lead tantalum
 C4, C5—10 μ F, 16 volts, radial-lead tantalum
 C8—470 μ F, 25 volts, radial-lead electrolytic
 C9, C10—0.1 μ F, 16 volts, ceramic disc

Semiconductors

IC1—LM339N linear quad comparator
 IC2—IC4—MC14511, BCD to seven-segment latch/decoder/driver
 IC5—IC7—MC14566BCP, timebase generator
 IC8—LM7805CT, 5 volt, 1 amp regulator
 D1—D5, D10, D11—1N4148
 D6—D9—1N4002
 DISP1—DISP3—FND-503 (Fairchild), 0.5-inch, common cathode, seven-segment display

Other Components

F1—0.25-amp, 3AG fuse
 T1—9 volt, 250 mA (or greater) wall-mount transformer (Jameco AC-9004 or equivalent)

Miscellaneous—Circuit boards, cabinet, IC sockets, modular telephone cable, fuse holder, 4 x 1-inch piece of red display filter (see text), mounting hardware, etc..

The following is available from Mendakota Products LTD., P.O. Box 20HC, 1920 W. Commonwealth Ave., Fullerton, CA 92633: Set of the two etched, predrilled printed-circuit boards, part No. TTT-1, 15.00 postage paid. California residents add 6% sales tax. Allow 6-8 weeks for delivery.

half-watt units are used here is to avoid resistor breakdown and telephone-line problems: Quarter-watt resistors are rated at 100 volts; that value is likely to be exceeded when the phone rings.

There are many possible substitutions for transformer T1. If you can't find a 9-volt AC unit with a current rating of 250 mA or greater, try a surplus outlet. Many calculator-type battery chargers contain 9-volt transformers. To use that type, you'll have to pry open the case and remove the rectifier and filter capacitor. Just be sure not to use a 9-volt DC charger, because the timer won't count if you do! (Remember that the 60-Hz signal from the power supply is used as the clock input.)

The red-plastic display filter used on the front panel (to improve contrast) is available from many sources. A quick look through the ads in the back of the magazine should prove that to you. You can also try to get the filter material from a

surplus outlet, or you might want to use red cut-and-peel drafting film over a piece of clear plastic (try a drafting-supply house for the film). Just remember that you need only a 4 x 1-inch piece.

The display board

Once you have the parts, you can start putting the timer together. We'll start with the display board: Refer to Fig. 6 and the parts-placement diagram in Fig. 7. First, pick up one seven-segment display and turn it over so that the pins are facing you; make sure that the ribbed side is on the top as shown. Cut the decimal-point lead off each display; that's the one at the lower left corner of the module with the pins facing you. Now insert the units and solder them in place as shown in the parts-placement diagram.

Next install twenty-one 470-ohm resistors (R11—R31) below the displays (again refer to Figs. 6 and 7) and bend the lower leads straight down before soldering. After soldering, clip off *only the upper leads*. Allow the bottom leads to remain—the resistor leads are used to

make the connections to the main board. Now install two pieces of leftover component lead in the holes at each corner of the display board and bend them down to match the resistor leads. (See Fig. 6.) That completes the display board. Set it aside for now.

The main board

As we discuss the main-board assembly, refer to the parts-placement diagram in Fig. 8. Start by installing the IC sockets, making sure that pin 1 is correctly oriented. (Note that all sockets are installed so that their pin-1 notches point in the same direction.) Install a 14-pin socket at IC1 first. Then install six 16-pin sockets at IC2—IC7. Check your work for shorts and solder bridges; make any necessary corrections before continuing. *Do not* install the IC's at this point.

Now we'll install the diodes. Be careful not to get the 1N4148 and 1N4002 types mixed up. Also be sure to install them with the banded-ends (cathodes) positioned as shown. First go to the IC5 socket and install two 1N4148 diodes (D11 and

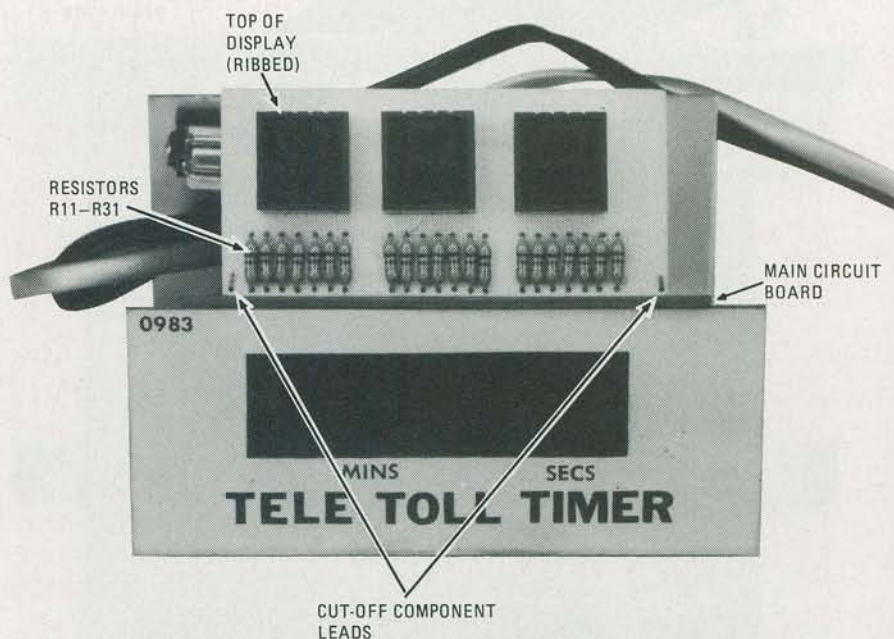


FIG. 6—THE DISPLAY BOARD installed in the main board. Note: The ribbed surface marks the top of the seven-segment displays. Resistor leads are used to make connection between the main and display boards. The leads are also used for mounting support.

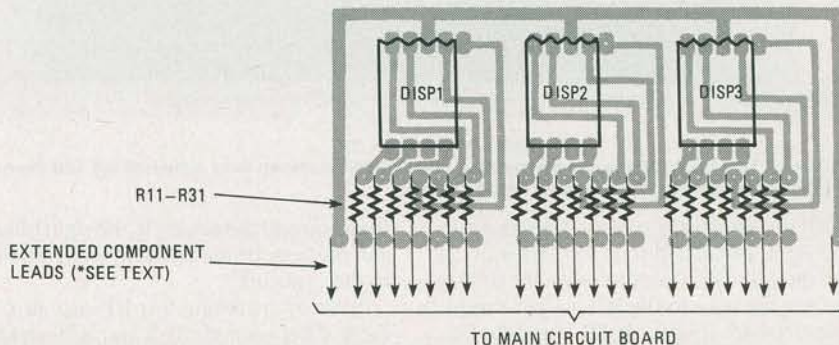


FIG. 7—THE PARTS-PLACEMENT DIAGRAM for the display board is shown here.

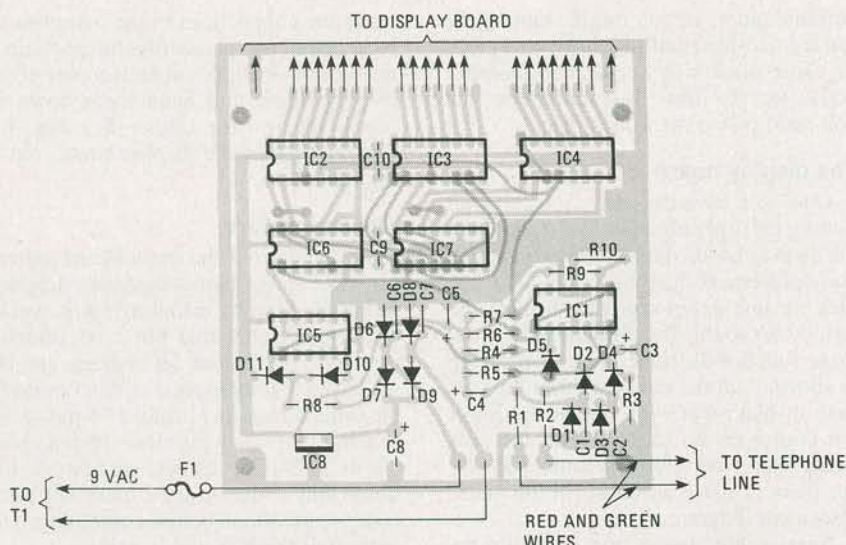


FIG. 8—THE MAIN BOARD's parts-placement diagram. Note that all pin-1 notches of the IC's face in the same direction.

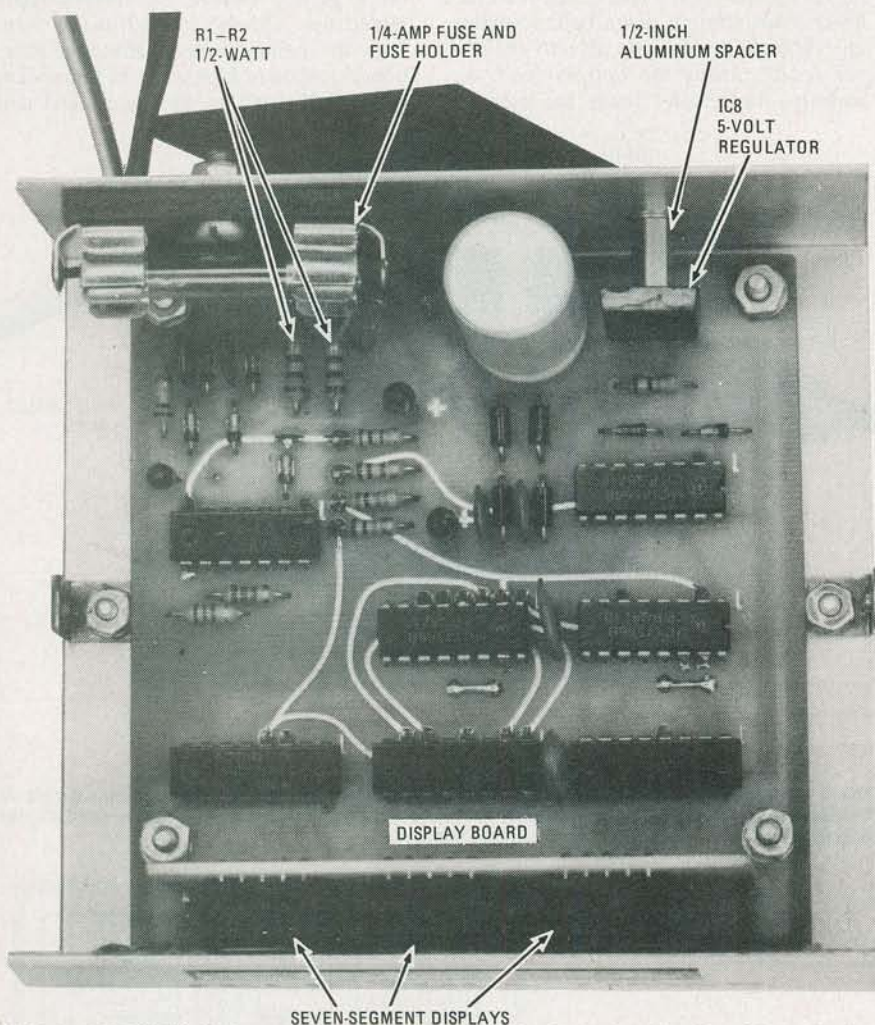


FIG. 9—A TOP VIEW OF the completely assembled circuit is shown here. Note that IC8 and the fuse holder are secured to the rear panel of the cabinet.

D10) just below the socket. Then move to the right and install four 1N4002 units at D6 through D9. Continue with the diodes by moving over to the IC1 socket. Install five 1N4148 diodes at D1 through D5. When done, check your work carefully to

make sure all diodes are in the right places and properly oriented. Now, let's move on to the capacitors.

Start by installing a 0.1-F disc at C10 located between the IC2 and IC3 sockets and another at C9, directly below as

shown. Next install a 470- μ F electrolytic capacitor at C8 (at the bottom of the board). Be sure to double-check the polarity of that capacitor. After that, install two 0.01- μ F units at C6 and C7 to the right of the IC5 socket.

Continue by installing a 10- μ F tantalum unit at C5, again double-checking that the positive lead is correctly oriented. Likewise, install another 10- μ F tantalum at C4. Moving to the right, install 0.01- μ F capacitors at C1 and C2 (between the diodes). Then finish up the capacitors by installing a 1- μ F tantalum unit at C3. Next we'll install the resistors.

Start by installing a 10,000-ohm unit at R8 (below the IC5 socket). Then move over to the socket for IC1 and install a couple of 10,000-ohm units at R6 and R7. After that, install a 1000-ohm resistor at R4. Finish the row by installing a 10-megohm unit at R5. Next install a 2700-ohm unit at R10 and a 6800-ohm resistor at R9. Move to the right edge of the board and install a 100,000-ohm resistor at R3. Then finish up the resistors by installing two 1-megohm, 1/2-watt units at R1 and R2.

Next install the LM7805 voltage regulator at IC8. Note that the IC is soldered directly to the board. Be sure to position it so that the metal tab is facing toward you (or to the nearest edge of the board).

With that done, it's time to double-check your work. Once you are sure that you have no solder bridges or other errors, you can install the assembled display board.

Installing the display board takes a little patience. Make sure that all the resistor leads on the display board are bent straight down and then slide them through the holes on the main board. When the two boards touch, solder in place and trim all leads.

Install the IC's next. Be sure to install them in the right places with pin 1 oriented as shown. Install three MC14511 BCD decoder/drivers at IC2, IC3, and IC4. Then install three MC14566 counters at IC5-IC7. Lastly, install an LM339 quad-comparator at IC1. That completes the main-board assembly.

Prepare the cabinet by making a 2 1/2 by 3/4 inch cutout for the display, and drilling a 3/8 inch hole at the rear of the case to feed the line and telephone cords through. It's a good idea to use a strain relief (or grommet) to prevent stripping the wires accidentally. If you use a grommet, you can secure the cords to the case with a small cable-clamp. That will prevent the wires from pulling free of the board. Drill screw holes at the rear of the case for mounting hardware (see Fig. 9.) The size of those holes depend on your mounting hardware.

Next mount the display filter in place. (We taped the edges first and then ran a bead of silicone sealer around the exposed

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TELE-TOLL TIMER

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edges so that the filter stays in place.) Now feed the telephone and supply cords through the hole in the panel and strip away some insulation. The telephone cord will have four color-coded leads; clip off the yellow and black leads (they are not needed), and solder the red and green leads to the points indicated in the parts-placement diagram of Fig. 8.

Using a piece of hook-up wire, solder one end to the fuse holder and the other to the main board as shown in the parts-placement diagram. Solder one side of the line cord to the free end of the fuse holder and the other to the board. Then mount the holder.

Install the boards in the cabinet. Figure 9 shows the installed unit as viewed from the top: Note that the regulator (IC8) is secured to the rear panel. That grounds the cabinet and also allows the cabinet to be used as a heat sink. Press-on letters can be used to label the project to improve its appearance. Now, it's finally time to test the unit.

Testing and use

Verifying the operation of the unit is easy. Simply plug T1 into any nearby AC

outlet. The display should light showing "000," and then start counting. If it doesn't, first check the power supply and the wiring of IC1. Once you get the correct readout, insert the modular plug into your telephone jack. The elapsed time shown on the display should then freeze and, after about 20 seconds, go out. If it doesn't, again check the IC1 wiring. If everything is OK, your telephone timer is ready for use.

Now, anytime the phone is picked up, the display will light and the unit will begin counting. By periodically checking the display (during your conversation), it's easy to hold down the time you spend on the phone—just think about how much each minute costs as you are reminded by

bright LED's about just how much time you're spending talking (or listening)!

We should note that, in addition to timing phone calls, the unit is great for other timing tasks around the house as well. To use the unit as a simple timer, just disconnect the telephone plug and it starts counting. To reset the timer, unplug T1 and plug it in again when you are ready to start timing. Of course, it's also easy enough to add a manual reset switch for that purpose.

As a side note, try timing the next sales call you get. You'll be amazed at how long some of them last—five minutes or more. Surely there are better things to do with your time than listen to sales pitches over the phone!

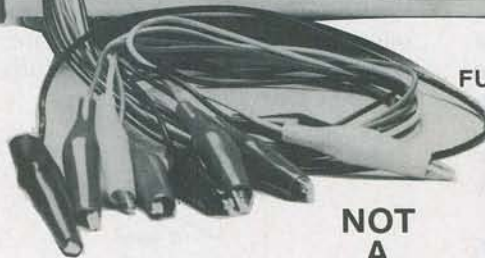
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Impedance: 10.9 K
Input Voltage: ± 5 V peak (diode clamped to ± 5 Volt supplies)
Output: Staircase waveform summed with input signals, 0-800 mV full scale
Step Amplitude: Variable 0 to 150 mV/step
Signal Voltage: Variable 0 to

150 mV/step @ 5V Input
Multiplex Rate: Switch selectable, 40 KHz or 4 KHz
Impedance: 50 Ohms
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