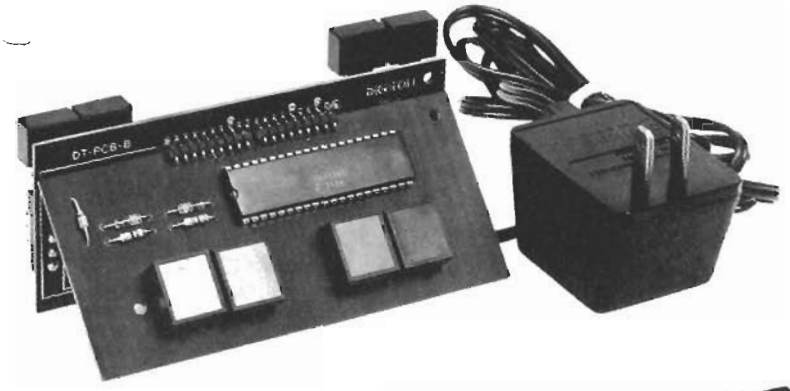
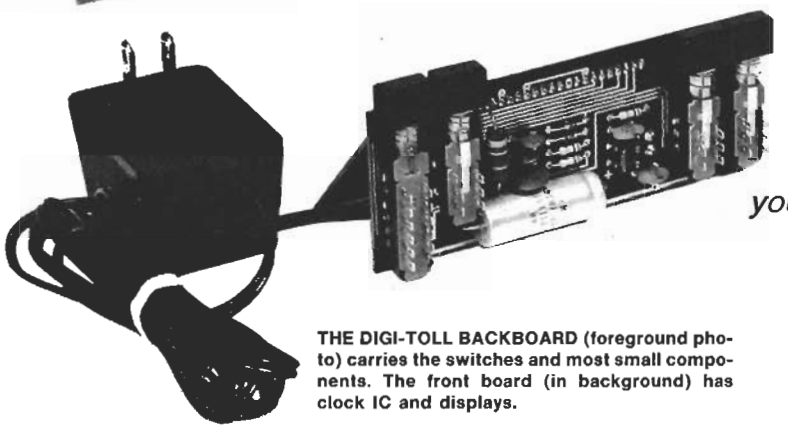
BUILD DIGI-TOLL





THE DIGI-TOLL BACKBOARD (foreground photo) carries the switches and most small components. The front board (in background) has clock IC and displays.

Save On Long Distance Phone Calls

Part II—Special-purpose electronic timer helps you effect considerable savings in telephone toll charges as you time calls the same way Ma Bell does

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BEFORE STARTING TO BUILD ANY OF THE *Digi:Toll* versions, take care in component selection and substitution. Certain electrical parts are critical for maximum performance. For example, components T1, D5 and R6 are carefully balanced to provide maximum within-specification segment current to the displays. Since the 3817 IC can only drive 8 mA-per-segment, specially graded displays (brightness code 08 or 09) are a *must*. Also, D3 and D4 are special low-voltage-drop germanium diodes needed to equalize DIS1 segment brightness.

The *Digi:Toll* circuitry can be hand-wired on perforated board, if desired, using "junk-box" components, but the results will reflect this approach. You can make your own PC boards, as shown in Figs. 3, 4 and 5; however, note that the back board, shown in the foil patterns of Figs. 3 and 4, is two-sided with plated-through holes; this is not exactly a beginner's PC board project. In addition, both boards must be precision-cut when using the *Digi:Toll* enclosure.

Also, several special mechanical components, such as the header strips used to join the PC boards, the specified switches, the extruded aluminum case, the display lens and the screened data plate, are necessary to reproduce a high-quality unit. Since some components may be hard to obtain in single quantities, a complete kit is available.

Assembly of the standard *Digi:Toll* from the complete kit is very simple, and shouldn't take more than an hour. The instructions provided are detailed and complete. However, since you may want to purchase partial kits, or use some of your own components, the construction described in this article will assume you've decided to "roll your own," using the PC boards and critical components specified.

The standard *Digi:Toll* 12-hour display/24-minute elapsed timer does not require any foil breaks or special jumpers. If you plan to construct any of the optional versions, you should first make the specified foil breaks shown on the schematic table of Fig. 2 and in Figs. 6 and 7. You can make the breaks easily using an *X-Acto* knife or a razor blade, being careful not to cut *other* foil traces. All foil breaks, except for F and D, are on the back board, and all breaks on the back board, except for C, are on the *component* side of the board. Do *not* add any jumper wires yet.

The back board

Start by assembling the back two-sided PC board, oriented as shown in Fig. 6. Install a few components at a time into the board in the locations shown. Solder on the bottom side, using a 25- to 50-watt soldering iron and 60/40 resin-core solder, then clip off the excess leads. Save the cutoff leads for jumper wires if you make a modified unit. Install resistors R1, R2 and R3 first, then diodes D1 and D2, observing diode polarity. Next, install the bridge rectifier, making sure the marked pins (+ and −) face capacitor C1. Remove the excess coating from the leads of the small capacitors before installation so that the coating doesn't interfere with proper soldering; twist the coating off with pliers, even with the bottom of the capacitor body. Install capacitors C2, C3, C4, C5 and C6 in the positions shown. Insert resistor R6 into the board and then raise it about 1/8 inch above the board; this resistor runs hot in normal operation and should be given some "breathing" space. Next, install large capacitor C1 (be careful of the polarity!), then the switches. When soldering the switches to the board, make sure that all the terminals are seated in the board holes, that the switch bodies are parallel with the board and that the plungers face upward. After soldering the switches to the board, snap the switch pushbuttons onto the plungers—it takes firm pressure. Next, insert the AC-cord leads from the transformer into the *bottom* of the PC board and solder them on the *component* side. Set this subassembly aside while you work on the front PC board.

The front board

Assembling the front PC board is even

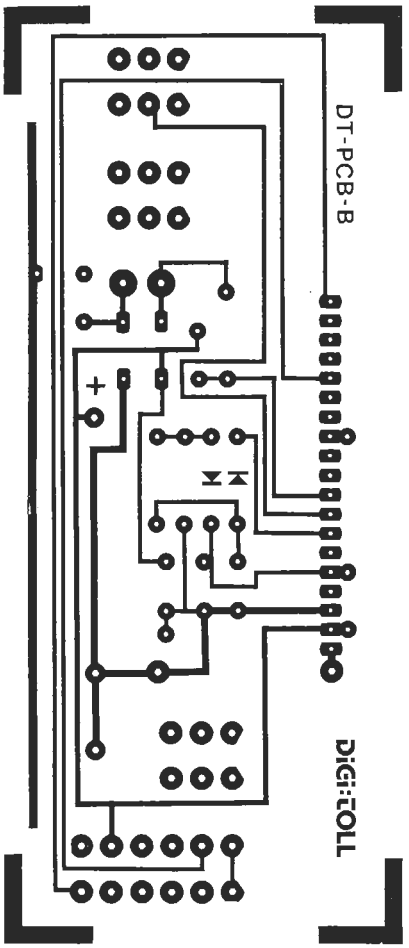

Fig. 3—FOIL PATTERN for rear (solder side) of back board is shown full-size. Switches are on this board.

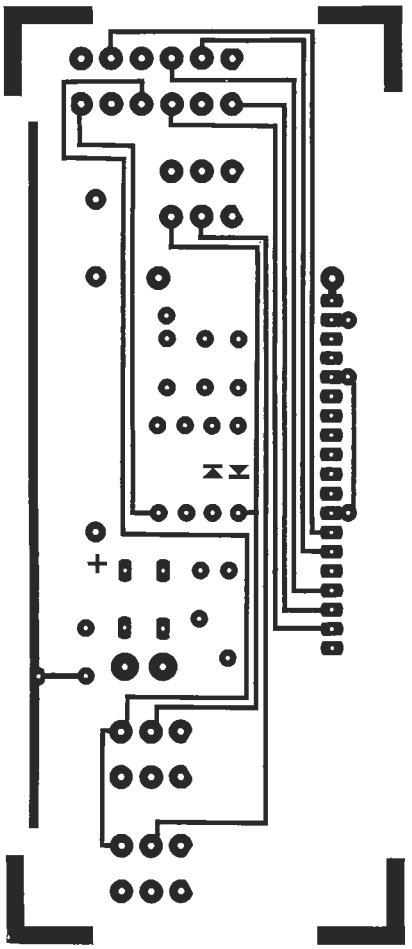

Fig. 4—BACK BOARD component side has this foil pattern (also full-size). Plated-through holes connect front and rear foils.

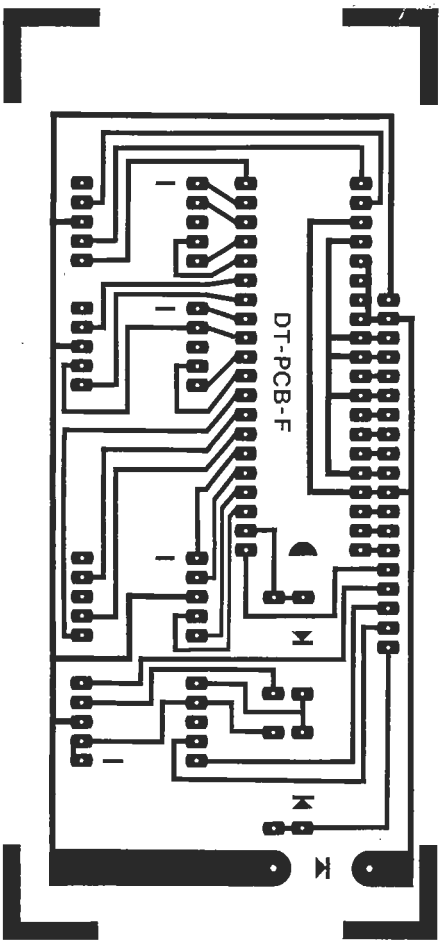

Fig. 5—FULL-SIZE FOIL PATTERN for the front board. This board holds the clock IC and 7-segment displays.

easier. Figure 7 shows the components layout. Insert all components into the blank side of the board, and solder on the foil side of the board. Resistors R4 and R5 are installed first, followed by diodes D3 and D4, and then by diode D5. The colored ends of D3 and D4 are the cathodes (the bars in diode symbols). The cathode of D5 is clearly marked with a black band. Next, solder the wire jumpers into all the 19 holes at the top of the board *except* for the center hole. These jumpers will mate with the back board, so their length and type will depend on whether you intend to place the display a remote distance from the switches that are installed on the back board. You might, for example, want to use some ribbon cable between the boards. You should be aware, however, that this could cause some spurious signals to be generated, and the boards should be as close as your application will allow. The best arrangement is to close-couple the boards using header strips. If you cannot locate header strips, then you must use the more tedious (and structurally inferior) approach of installing individual bare-wire jumpers. The header strips (supplied with the kit) are bent at a right angle at one end, to be used for right-angle panel-mounting (see Fig. 8). If you are using the *Digi:Toll* cabinet, use a bending tool to form the free ends of the jumpers or header strips to a 45-degree angle. Fig. 9 shows how this is done with the bending tool provided in the complete kit. (The header-strip wires are very tough, and while they can be bent with pliers, multiple flexing to achieve just the right angle can cause them to break—hence, we recommend using the bending tool.)

Next, install the displays, being careful to orient them properly; the scalloped edge is the top of the digit, but DIS1 must be installed *inverted* so that its decimal point can be used as an indicator dot.

Install the clock IC last. Be careful when you handle this device, since it can be damaged by static discharges when not in its conductive carrier. Before installing the IC in the PC board, it will first be necessary to make the pins perpendicular to the body (they are manufactured bowed-out). Figure 10 shows how to preform the pins on a flat (and non-charged) surface. When you install this IC into the board, be *very sure* the index notch faces the left side, as shown in Fig. 7, unless you enjoy unsoldering 40 pins simultaneously to remove the IC! A socket was not used in the *Digi:Toll* since it would not allow the unit to clear the extruded custom case; if you use a different enclosure, you could install a low-profile 40-pin socket here.

Joining boards and modifications

The front and back boards are mated by inserting the 18 projecting header-strip pins (or jumper wires) from the front board into the holes at the top of the back board. Do not solder these pins or wires until you align the boards. If you intend to mount the unit behind a panel, as shown in Fig. 8, make sure to provide enough space between the boards so that the display and switches can be properly located behind the panel openings. If you mount the *Digi:Toll* in its custom enclosure, the boards must be properly spaced and aligned at a 45-degree angle, as shown in Fig. 11. The easiest way to insure proper alignment is to use the enclosure itself as an assembly "jig." Insert about ½ inch to 1 inch of the boards into one end of the extrusion, which has slots for the boards, and space the boards 1/32 inch apart at the top, using the two plastic strips supplied with the cabinet.

If no modifications are being incorporated in the version you build, solder all the header-strip pins, or jumper wires, on the component side of the back board. If

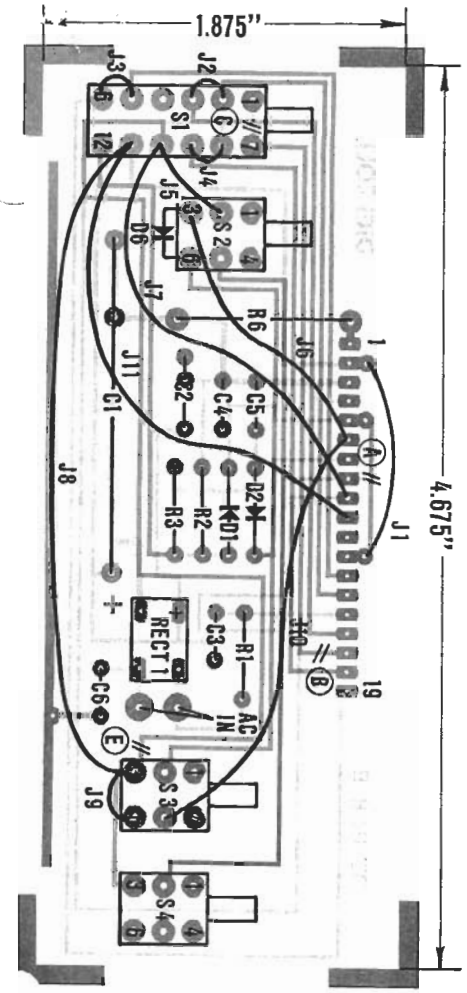

Fig. 6—COMPONENT PLACEMENT for the back board. Check locations of jumpers and foil breaks used in the various *Digi-Toll* options.

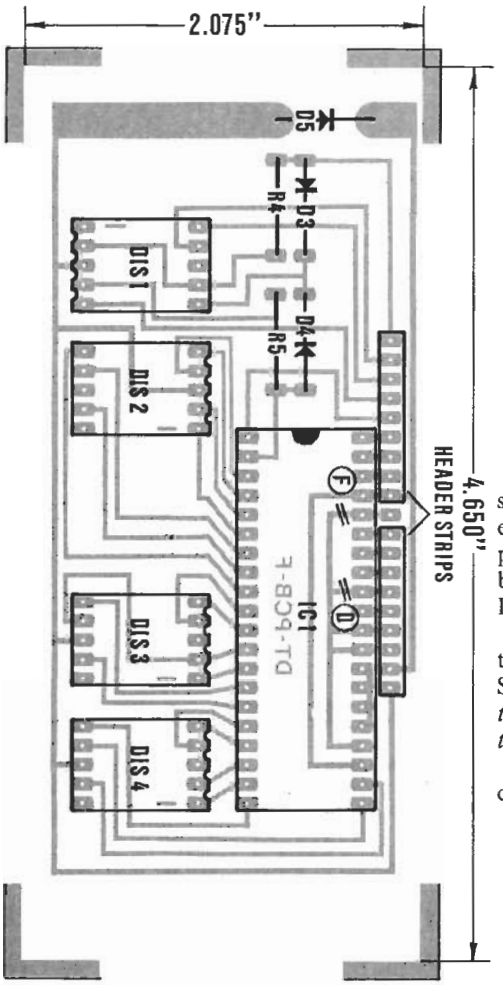

Fig. 7—THE CLOCK IC, four displays and five other components are on the front PC board.

modifications *are* being made, do not solder those pins that connect to modification jumpers.

The Modification Table of Fig. 2 defines which jumper wires are required for each version. The longer jumpers are made from an appropriate length of insulated wire, with 1/16 inch of insulation stripped from each end. The shorter switch jumpers can be bare wire, or salvaged cutoff component lead wires. Figure 6 shows all 11 jumpers; but use only those that are required for the chosen modification! Diode D6 (used only with modification "L") and the jumpers going to the switches should be connected to the solder lugs on the switches. Jumpers going to pins 6 and 9 on the header strips should be wrapped once around the header pin and soldered. The top end of jumper J11 can be soldered in the empty hole (position 10). Keep jumper J1 clear of the top of the board by at least 1/8 inch so that it does not interfere later on with installation into the custom cabinet.

Testing & final assembly

The unit should be tested before being installed in a cabinet or behind a panel. For the unmodified units, follow this procedure:

1. Place switch S1 in the up (time-mode) position and plug in the transformer. The display should light up, with the dot indicator blinking to indicate a power interruption. Pressing either switch S3 or switch S4 (SLOW-SET or FAST-SET) will stop the blinking.
2. Set the proper time using switches S3 and S4, checking the segments as the time advances to see that they all light up when they should.

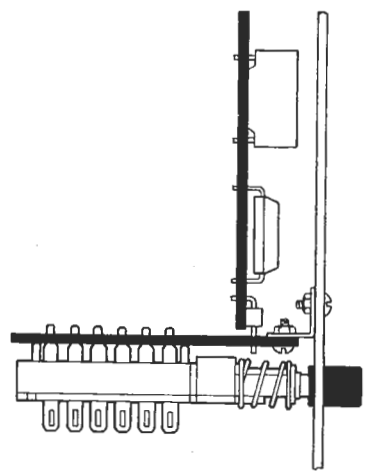

Fig. 8—THE *DIGI-TOLL* can be panel-mounted if desired. This is a suggested installation scheme.

3. Press switch S1 once so that it stays down (elapsed-time mode). The indicator dot should disappear and the display should count seconds.
4. Press switch S2 to reset the elapsed-time display to 00 00.
5. After several minutes, return switch S1 to the up position by pressing it again. The time-of-day and indicator dot should reappear, and should have advanced to the current time. Pressing S1 down again should display the elapsed time at the point where it was stopped, and seconds-counting should continue from that reading.

For version "T," the test procedure is similar to that for the standard unit, except that there is no dot indicator, and power interruption is signaled by the blinking of one or more segments of DIS1.

Version "L" is the same as modification "T," except that depressing switch S2 (ELAPSED-TIME RESET) while in the *time* mode (switch S1 is up) will reset the *time* display to 00 00.

For modification "W," the testing procedure is somewhat different:

1. Place switch S1 in the up (TIME) position and plug in the transformer. The display should light up, and power interruption is indicated by one or more missing segments in DIS1 (the segments do not blink, since counting is inhibited). The display should *not* change until the elapsed timer is used.
2. Place switch S1 in the down (ELAPSED-TIME) position and the display should start counting seconds.
3. Reset the elapsed-time display by pressing switch S2. The display should go to 00 00 and resume seconds-counting when switch S2 is released. Allow the unit to run for 20 minutes to verify that all segments light up when they should.
4. Return switch S1 to the up position. The display should read the total time that the elapsed timer was on. This display should *not* change (you must watch it for more than a minute to verify this). When the elapsed timer is used again (switch S1 is down) it will "add" to the total-time display (S1 is up), thus accumulating (or totalizing) the individual elapsed times to 23 hours and 59 minutes, and then repeat.
5. When switch S1 is up, pressing switches S3 and S4 *simultaneously* should reset the *total-time* display to 00 00.

Modification "P" does not change any of the operating modes, therefore testing is the same as that for any of the above versions. When operated on a 50-Hz line with the recommended transformer, the display may dim a little, and the transformer will become warmer than when

the unit is operated on a 60-Hz line. Finally, it should be noted that a power failure in the elapsed-time mode (switch S1 is down) is indicated by flashing DIS1 segments on all versions.

If problems develop in testing, the display indicates the symptoms, and Fig. 2 can be used for examination and diagnosis. Be particularly wary of incorrect polarity of RECT1, capacitor C1 and all the diodes. Also, make sure the IC1 index

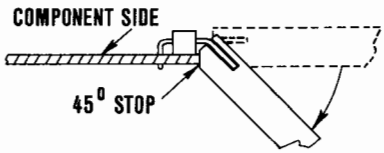

Fig. 9—A SPECIAL BENDING TOOL—supplied in the complete kit—is recommended for forming the header strip lugs.

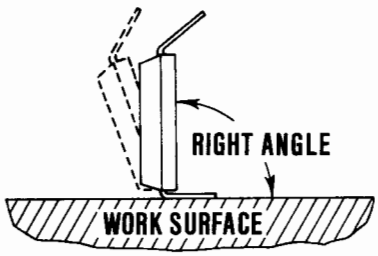

Fig. 10—HOW IC PINS ARE PREFORMED so they are perpendicular to the body before the device is mounted on the PC board.

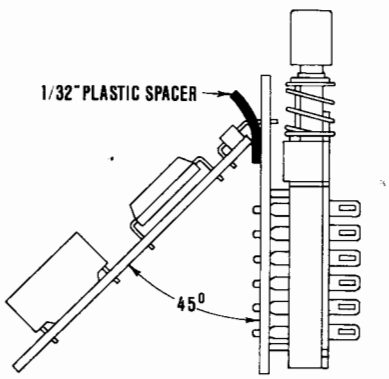

Fig. 11.—HOW THE PC BOARDS ARE ALIGNED prior to mounting in the custom *Digi-Toll* cabinet.

notch and all the display digit notches are properly located. Remember that DIS1 is inverted! If all the components are properly installed, check for bad solder joints—continuity checks should find those. Of course, there is always the possibility of a defective component, but this is less likely than the troubles just described.

When your checkout is complete, you must provide a suitable enclosure or mounting. If you mount the unit behind a panel (Fig. 8) be careful not to short-out or drill through any circuit paths when making mounting holes in the PC boards.

If you use the *Digi:Toll* custom case, slide the completed and tested assembly into the right end of the extrusion with the line cord extending to the right. The display should face you. It is necessary to slightly depress switches S3 and S4 when they reach the end of the right-hand switch notch so that the assembly can continue to slide into the case. You can use the long plastic strip provided with the case to protect the switches from scratches. Insert the strip from the left end of the extrusion and fit it between the pushbuttons of switches S3 and S4 and the underside of the extrusion as you move the pushbuttons into the case and slide the strip along with the buttons until they pop up into the left-hand case notch.

Using screws, attach the left-end cap loosely. Slide the plastic data plate into the upper slots. Remove the protective covering from the display lens and insert it into the lower front slots, making sure the antireflective dull side of the lens faces out. Now, screw on the right-hand end cap with the two remaining screws, dressing the power cord through the notch in the rear of the right-hand end cap. Before tightening each end cap, make sure the display lens is properly seated in the end-cap pockets. Finally, attach the four adhesive foam feet to the bottom of the cabinet near the corners.

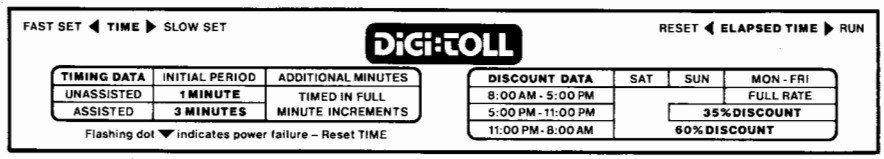

Fig. 12—DATA PLATE helps you save 15% or more when you use it while making long-distance calls.

Put it to work

With or without a *Digi:Toll*, the real key to significant telephone savings is for you to understand the phone company timing and discount schedules and use them to the best advantage. Just timing calls for logging purposes, or using a timer to become aware of the seconds and minutes, is not enough! It is how you use this timing data that will *really* add up to dollars saved.

The timing and discount schedules are summarized in the data plate in Fig. 12. It is not only how *long* you talk that's important, but *when* you place the call. For example, if you originate a long-distance call between 8:00 AM and 5:00 PM, local time in your area, on Monday through Friday, you pay the *full* rate. On Saturday and Sunday, however, during the *same* hours, you are only charged 40% of the full rate—a 60% discount. The same applies to calls made from 11:00 PM to 8:00 AM *any day*, and from 5:00 PM to 11:00 PM on Saturdays. On all other days (Sunday through Friday), the 5:00 PM to 11:00 PM calling period costs only 65% of the full rate (35% discount); so, obviously, there is a considerable savings in placing calls at the best time of day, and in taking advantage of East-West time differences (i.e., when it is 5:30 PM in New York (35 % discount) it is only 2:30 PM in California). Conversely, Californians dial New York early (before 8:00 AM) and reach New Yorkers at work at the lowest possible rates!

Figure 12 summarizes the three least known facts about company billing:

1. The initial period rate for *unassisted* calls (no operator), such as direct-distance-dialed calls, is for only *one* minute, not three minutes, as generally thought. Although this first minute costs more, you are *not* charged this rate for additional minutes.
2. On operator-assisted calls, the initial period rate is for *three* minutes, so any amount of time up to three minutes cost the *same*.
3. Additional minutes are timed in full-minute increments.

In other words, you pay for a full minute even if you are on the phone for only one second of that minute! For example, a five-minute, one-second call is billed as six minutes. Hang up a few seconds sooner, and you save the charge for one whole minute. At 15¢ to 40¢ per minute, this can add up!

Now, with this information, you can use your *Digi:Toll* to save yourself a lot of money. When using the standard *Digi:Toll* on a long-distance or timed local call, first select the time-of-day display and check the discount data on the data plate (Fig. 12) to see if you should reschedule your call to a discount period, or to a *higher*-discount period. Then, *immediately* after dialing, push switch S1 down (into the elapsed-time mode) and *hold down* the RESET pushbutton, switch S2, until the other party *answers* (or when conversation starts on person-to-person calls). When you release switch S2, the count starts and you have synchronized the *Digi:Toll*'s elapsed timer with phone company timers.

Since the *Digi:Toll* now tells you exactly how long you've been on the phone, you can use several methods to save money: (1) You can limit your call to some pre-established average maximum length. (2) You can eliminate unnecessary additional minute charges by trying to complete calls before a new minute begins. (Telephone company timing ends when *either* party hangs up.) (3) You can use time that you have paid for but, without a seconds timer, would normally lose to the telephone company. If you must begin a new minute or do so accidentally, take advantage of the unused portion of the minute by making sure you've covered everything you want to and avoid

making another call.

When the call is completed, record the elapsed time in a long-distance log if you use one and return switch S1 to the up (time-of-day) position. If you can't log the call immediately, the "memory" feature allows you to recall the elapsed time by just pressing switch S1 down when you want it displayed. It will, of course, continue counting from that point as long as switch S1 is down.

If the elapsed timer of a standard unit is used when the *real* time goes from 12:59 to 1:00, it is possible for the nondisplayed time-of-day to be altered because the internal clock logic doesn't know whether to go to 1:00 or 13:00. To minimize this possibility, return the unit to the time-of-day mode when the elapsed timer is not actually in use. (On any modified unit, such a condition will not occur since all display modes are in the 24-hour format.)

When you use the 24-hour modification "T," cost-cutting techniques are similar. However, ham radio operators can set the time-of-day display to Greenwich Mean Time (GMT) for international contacts, and can use the elapsed-time display to remind them to identify their station every 10 minutes, or to time "phone-patch" calls out of the local area. For international phone calls, a time chart can help you determine the best times for the best discount, yet not call someone in the middle of the night at their end!

The modification "L" *Digi:Toll* can be used for long-distance calls just as a standard unit, but you can also use it for timing conferences and consultations, or for time periods longer than 24 minutes. These timed periods can be used for billing or other record-keeping purposes. This modification also makes an excellent research or test-lab 24-hour elapsed timer. At the beginning of the timing period, just press RESET pushbutton S2 while in the time mode, and the display will go to 00 00 and start counting and displaying hours and minutes. Of course, the time-of-day function is temporarily lost, but can be reset whenever desired by using switches S3 and S4.

Modification "W" provides you with a 24-hour totalizing timer that is valuable on "limited WATS" calls where telephone time is purchased in blocks (soon *all* WATS time will be limited this way). When the 24-minute timer is used in the usual fashion, the 24-hour totalizing timer will keep a continuous record of how much block time has been used or how much remains. At the end of your specified accounting period, just zero the totalizer with switches S3 and S4 and start totalling a new accounting period.

With this minicourse in telephone charges and a *Digi:Toll* to put you in "sync" with Ma Bell's billing equipment, you can now pick up your phone, sit back, put your feet up on the desk and start saving your money! **R-E**