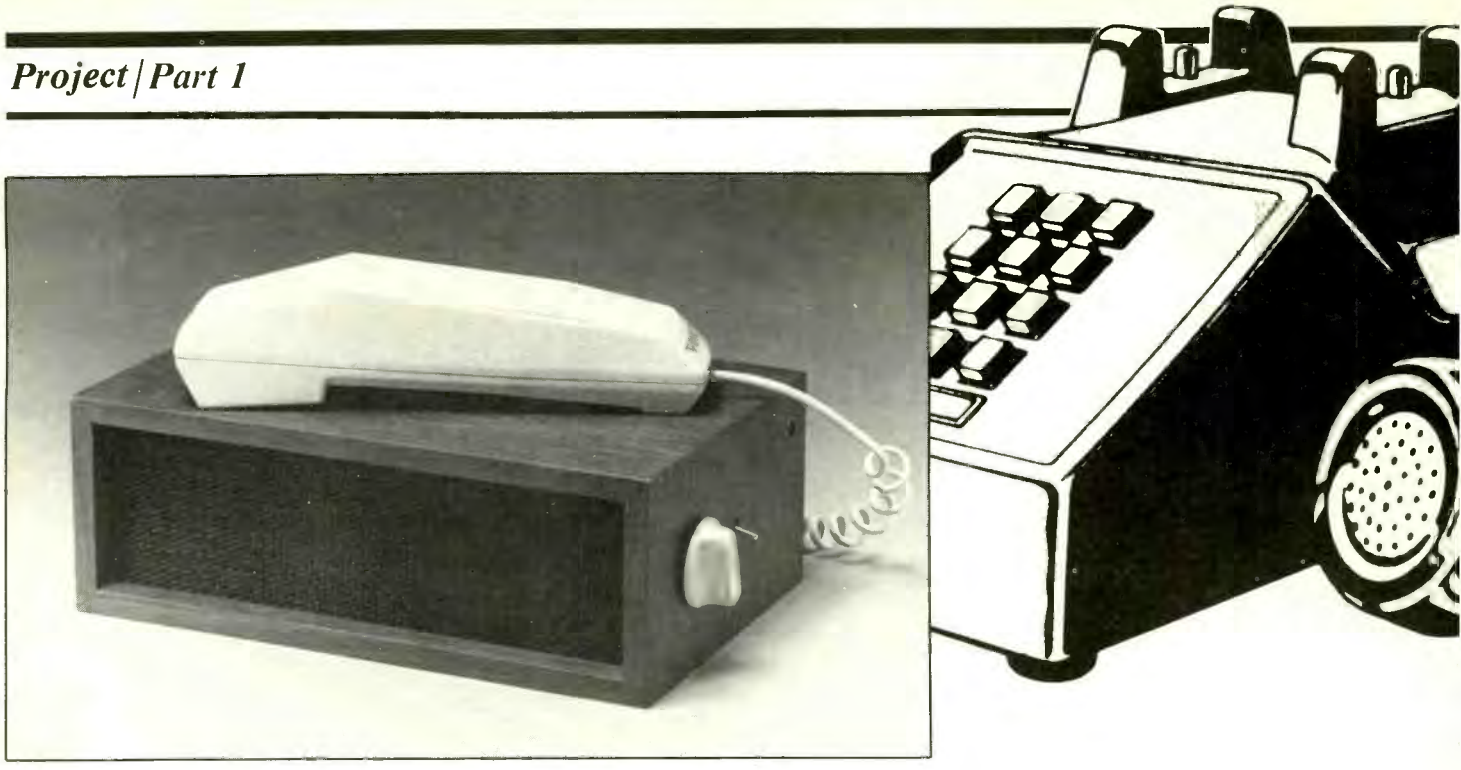


Add a Speakerphone to Your Telephone

Project gives talk/listen "hands-free" telephone communications with upgrade capability for dial-out operation

By Anthony J. Caristi

Telephone amplifier/speaker units give you hands-free conversations. Also, they provide conference conversations since other people in the room can hear the voice(s) at the other phone end and join in if they wish to.

If you don't have one, the Speakerphone presented here will make a nice addition to any room, whether or not it contains a telephone since it is phone-line powered. Thus, it can be operated wherever you care to run a pair of telephone-line wires since it needs no batteries or ac line power. The device is voice switched so it automatically switches back and forth, depending on which end is talking. Furthermore, a convenient volume control lets the user adjust sound level to his liking.

To answer an incoming call, you simply flip a switch and commence talking. The only drawback is that you cannot initiate a call, but this will be overcome in an article next month that will show you how to add a Touch Tone dialer and electronic ringer to your Speakerphone, making it a complete telephone.

How It Works

A single MC34018 integrated-circuit chip in the Speakerphone contains all amplifier, attenuator, level detector and regulator circuitry required to provide a complete voice-switched telephone circuit. A simplified block diagram of the MC34018 chip is shown inside the dashed-line box in Fig. 1, along with the external driver circuitry that make up this project. The full schematic is shown in Fig. 2.

Two attenuators are used in this circuit—one for the receive and one for the transmit sides. the circuit's half-duplex operation permits voice signals to travel in two directions (transmit and receive) but not simultaneously, thus avoiding acoustical feedback that could occur as a result of the close proximity of the microphone to the speakers.

When one attenuator is at minimum attenuation the other is at max-

imum attenuation. Thus, both are never on or off simultaneously. When no voice signal is present, each attenuator operates at about half gain, in an "idle" condition. A signal received from the microphone or the telephone line causes the attenuators to assume proper gain status according to the source of the received signal. Information from transmit and receive level detectors goes to the transmit/receive comparator, which controls the attenuators to amplify the desired signal and attenuate the reverse signal path.

Logarithmic-response amplifier level detectors provide a wide dynamic range for overload protection to accommodate a wide range of input signal levels. The level detectors respond quickly to any increase in signal level and slowly decay when the input signal is no longer present. This assures fast switching response when the transmit/receive mode must be changed, without causing false switching during short periods of silence, like natural pauses in speaking. The outputs of the transmit and receive level detectors are fed to the transmit/receive comparator that controls the attenuators.

Since some amount of background noise always reaches the microphone, an on-chip signal/noise detector is used to detect the change in audio signal level arriving at the microphone when a person speaks. To accomplish this, a voltage on capacitor *C27* in Fig. 2 is used as a "reference" that represents the average noise level picked up by the microphone. The time constant of this "memory" circuit is about 5 seconds, as determined by the values of *C27* and *R33*.

As long as background noise remains fairly constant, with no sudden increase in sound energy, the signal/noise detector will hold the transmit and receive attenuators at idle. When someone nearby speaks, the increase in voltage generated by the voice signal causes the signal/noise detector to switch state before the voltage on *C27* can increase. This causes the automatic attenuator to go into the transmit mode, coupling the voice signal to the telephone line.

An electret microphone is used to pick up voice signals. Because the output signal from the microphone is relatively low, an amplifier inside *IC1* provides 34 dB of gain so that what is being said can be heard by the party at the other end of the tele-

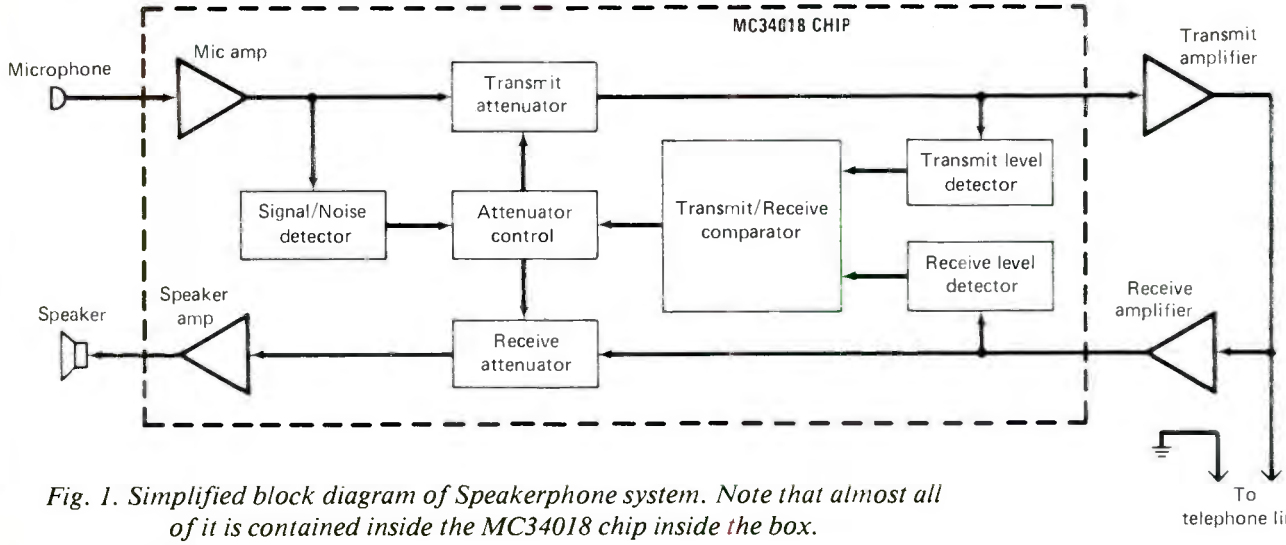
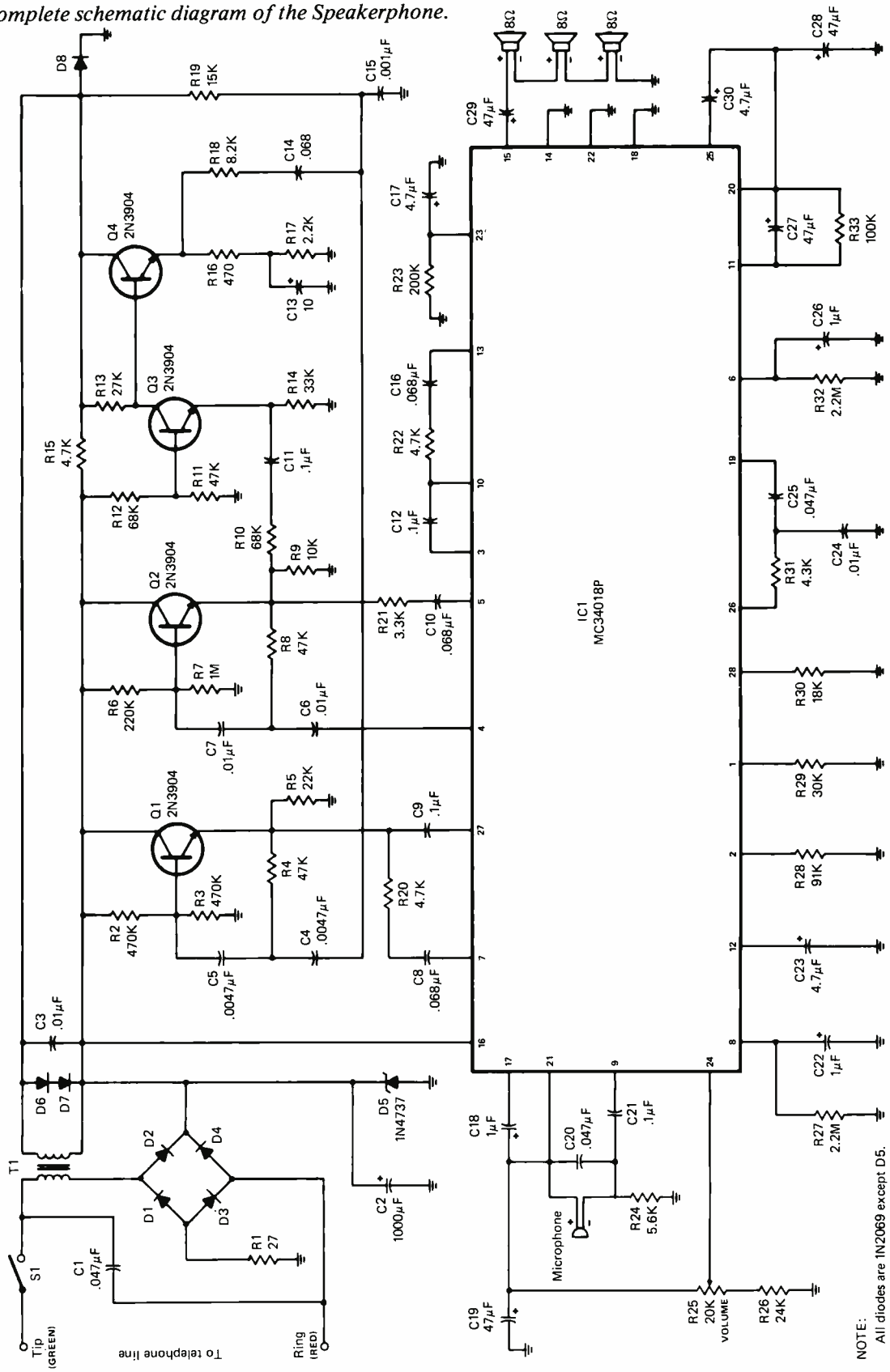


Fig. 1. Simplified block diagram of Speakerphone system. Note that almost all of it is contained inside the MC34018 chip inside the box.

Fig. 2. Complete schematic diagram of the Speakerphone.



PARTS LIST

Semiconductors
D1 thru D4,D6 thru D8—1N2069 or equivalent silicon diode
D5—1N4737 or equivalent 7.5-volt zener diode
Q1 thru Q4—2N3904 or equivalent npn silicon transistor

Capacitors (10 volts)
C1,C20,C25—0.047-μF disc
C2—1000-μF electrolytic
C3,C6,C7,C24—0.01-μF disc
C4,C5—0.0047-μF disc
C8,C10,C14,C16—0.068-μF disc
C9,C11,C12,C21—0.1-μF disc
C13—10-μF electrolytic
C15—0.001-μF disc
C17,C23,C30—4.7-μF electrolytic
C18,C22,C26—1-μF electrolytic
C19,C27 thru C29—47-μF electrolytic

Resistors (¼-watt, 10% tolerance)
R1—27 ohms
R2,R3—470,000 ohms
R4,R8,R11—47,000 ohms
R5—22,000 ohms
R6—220,000 ohms
R7—1 megohm
R9—10,000 ohms
R10—6800 ohms
R12—68,000 ohms
R13—27,000 ohms
R14—33,000 ohms
R15,R20,R22—4700 ohms
R16—470 ohms
R17—2200 ohms
R18—8200 ohms
R19—15,000 ohms
R21—3300 ohms
R24—5600 ohms
R27,R32—2.2 megohms
R28—91,000 ohms
R30—18,000 ohms
R33—100,000 ohms
R23—200,000 ohms, 5%
R26—24,000 ohms, 5%
R29—30,000 ohms, 5%
R31—4300 ohms, 5%
R25—20,000-ohm, linear-taper potentiometer

Miscellaneous
S1—Spst switch
T1—Microtran No. T2106 transformer
Printed-circuit board or perforated board and soldering hardware (see text); electret microphone (Radio Shack Cat. No. 270-090 or similar); miniature 8-ohm speakers (three in series to make 24-ohm impedance; see text); socket for IC1 (see text); suitable enclosure; stranded hookup wire; machine hardware; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Etched and drilled pc board for $8.75 and MC34018P integrated circuit for $10.00. Add $1.00 for S&H. New Jersey residents, add sales tax.

phone line. There's no on-chip provision for adjusting microphone gain for different microphone sensitivities. However, this can be accomplished externally by selecting the appropriate value for *R24*. The 5600 ohms shown is a good choice for the specific microphone called for in the Parts List.

Also built into *IC1* is an amplifier that can drive a 24-ohm speaker at 100 milliwatts of power. This is sufficient for normal listening volume and can be adjusted as desired with VOLUME control *R25*. To minimize distortion when very large signal excursions are received from the telephone line, the speaker amplifier incorporates a peak limiter that operates as an automatic gain control.

Because 24-ohm speakers aren't commonplace, Speakerphone uses three ordinary 8-ohm speakers connected in series to provide the impedance to match *IC1*'s output circuit. Use of three speakers instead of just one gives the added benefit of providing a more pleasing sound.

Voltages at the outputs of the signal/noise detector and transmit/receive comparator are monitored by *IC1*'s attenuator control section. When no signal is on the telephone line and the microphone is picking up just background noise, the attenuator control causes each attenuator inside *IC1* to run at idle. The circuit is thus ready to swing either way, depending on the source of the first valid signal detected from the telephone line or microphone.

As soon as a signal is detected at either input, the transmit/receive comparator switches state to indicate the presence of one of the signals. The signal/noise detector then permits the attenuator control to set the attenuators to the required state. As a conversation on the telephone line alternates between the parties at either end of the line, the attenuator control quickly switches back and forth to provide proper amplification of the voice signals present on the line.

Construction

Except for the microphone, speakers, VOLUME control and switch, the entire circuit of the Speakerphone can be contained on a printed-circuit board measuring 4″ square or a slightly larger perforated board using appropriate soldering hardware. You can fabricate your own pc board, using the actual-size etching-and-drilling guide given in Fig. 3. Alternatively, you can buy a pc board ready for wiring from the source given in the Note in the Parts List. Whichever construction method you decide to use, parts placement isn't critical.

The layout for the pc board (which can also be followed for perf-board construction) is shown in Fig. 4. Use a socket for *IC1*. If you can't find a 28-pin socket, use two sockets with fewer pins and, after cutting off the excess pins, mate them to make up a 28-pin socket. Solder the socket to the pc board now, but do *not* install the IC in it until instructed to do so.

Make sure all diodes and electrolytic capacitors are properly polarized (see in Fig. 4) before soldering their leads to the pc board's copper pads. Similarly, make certain that the transistor leads are plugged into the correct holes before soldering.

Wire the board as shown. Off-the-

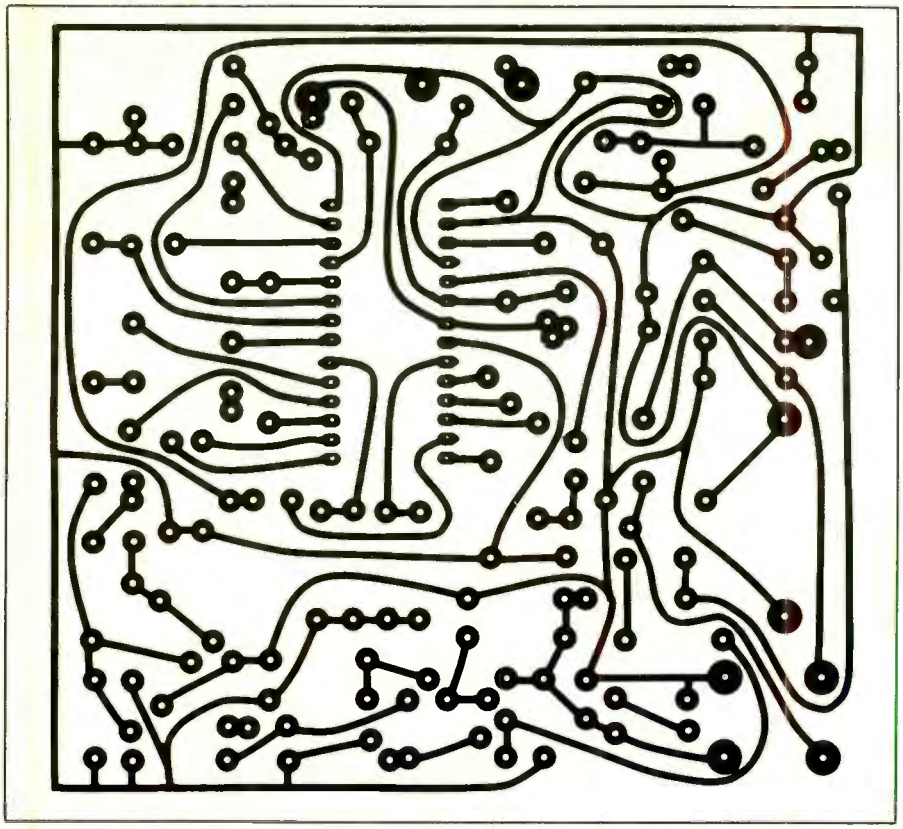


Fig. 3. Actual-size etching-and-drilling guide to use when making your own printed-circuit board.

board components *R25, S1,* the speakers and the microphone connect to the board via stranded hookup wire soldered to the indicated pads. Make these wires as short as practical for final assembly.

Use a cabinet that's large enough to accommodate the circuit board, speakers and microphone. Locate the microphone as far as possible from the speakers to avoid interaction (acoustical feedback) between them if you plan on operating the Speakerphone at or near the maximum volume setting.

The three speakers must be wired in-phase with each other. So before you wire them in series with each other (see Fig. 2), check the polarities of each, even if all three appear to be identical or have their "hot" lugs identified with a + sign or paint dot.

The simplest way to check speaker phasing is with an AA or C cell in a battery holder, with clipleads connected to the holder's lugs. Clip the lead connected to the negative (−) lug to one lug of one of the speaker's lugs and touch the cliplead connected to the holder's positive (+) lug to the other speaker lug while observing the direction in which the cone moves. Outward cone movement, tells you that the lead connected to the holder's + lug is the hot lug on the speaker. Inward movement tells you that the lead connected to the holder's − lug identifies the hot lug. After determining which is the speaker's hot lug, put a + sign or a dot of paint near the lug.

Test each speaker in the same manner. Then wire the speakers in series as shown in Fig. 2. Connect and solder the speaker wires coming from the circuit board to the appropriate lugs.

Connections to the telephone line are made at the points identified as "tip" and "ring" in Fig. 2. Telephone company wire coding for these are greed and red, respectively. (The yellow and black telephone wires aren't used in the Speakerphone.) Note that *S1* is in series with the green telephone wire and the "tip" connection on the board.

The Speakerphone's full-wave diode bridge at the telephone-line input, automatically applies the correct polarity signal at this input. Be sure to use a modular connector, as required by FCC regulations, to connect the Speakerphone to the telephone line.

Checkout and Use

Make sure *IC1* is *not* in its socket. Connect a dc voltmeter, set to a 10-to-20-volt full-scale range, across *C2* (observe proper polarity). Plug Speakerphone's modular connector into a telephone receptacle and close *S1*. The meter should read approximately 7.5 volts.

Remove the positive voltmeter lead from the positive lead of *C2* and use is to measure the voltage at pin 16 of the IC socket. The reading should once again be about 7.5 volts. Then use the same lead to check the voltage at pins 14, 18 and 22 of the IC socket; the meter should indicate 0 volt at all three points. Disconnect the Speakerphone from the telephone line. If you don't obtain the proper reading at any or all points, rectify the problem before proceeding to installation.

Set *S1* to OFF and use a 10- to 100-ohm resistor to completely discharge *C2*. Then install *IC1* in its socket. Make sure the IC is properly oriented and that no pins bend under its case as you push it home.

With *S1* set to OFF and VOLUME control *R25* set to center of rotation, connect Speakerphone to the telephone line. If you have a true Touch-Tone telephone, dial or call out after you set *S1* to ON. If you have a ro-

tary-dial or "pulse" phone, dial a number and then set *S1* to ON. Once *S1* has been set to ON, hang up your telephone. You should now hear the ring signal through Speakerphone's speakers. Adjust the VOLUME control for a comfortable listening level. When your call is answered, you can carry on a conversation just as you would normally hold one with someone in the same room with you.

Coming Next Month

As mentioned, Speakerphone is not a complete telephone instrument. It merely adds hands-free talk/listen capability to an existing telephone. However, next month, in the conclusion of this article, we'll tell you how to add a Touch Tone pushbutton dialer and an electronic ringer that *will* make Speakerphone into a complete instrument. **ME**

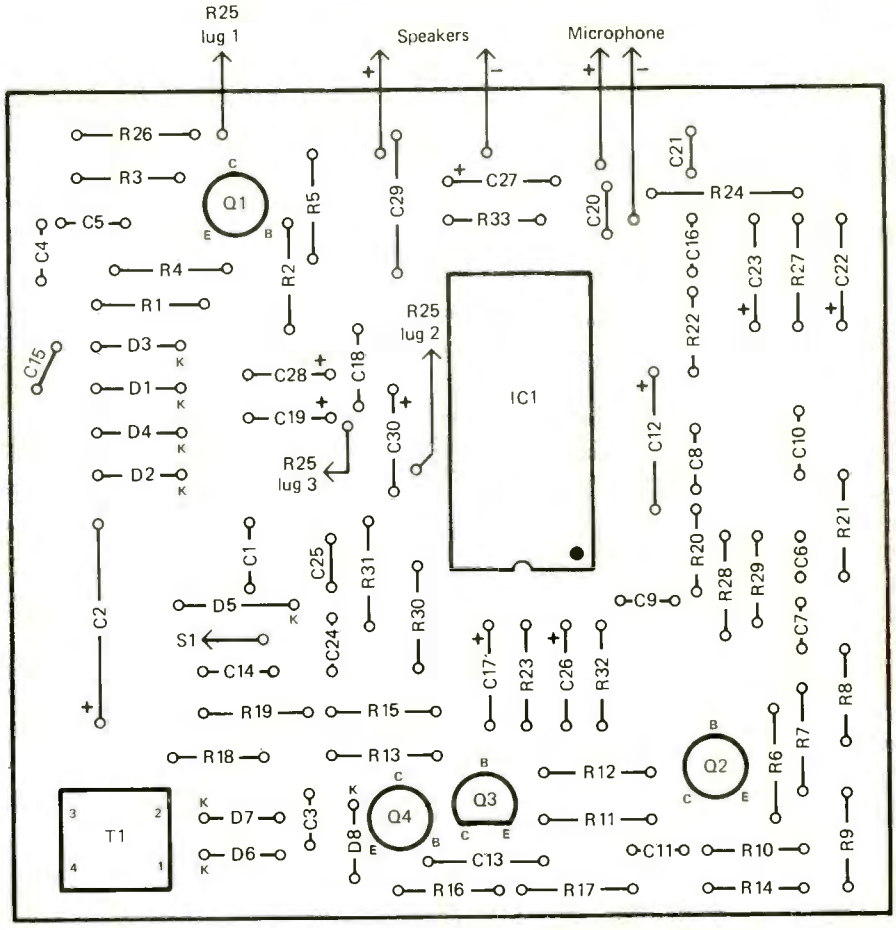


Fig. 4. Components-placement and orientation diagram.

Completed project just prior to mounting circuit board. Note that speakers are mounted on front panel, microphone and switch on side.