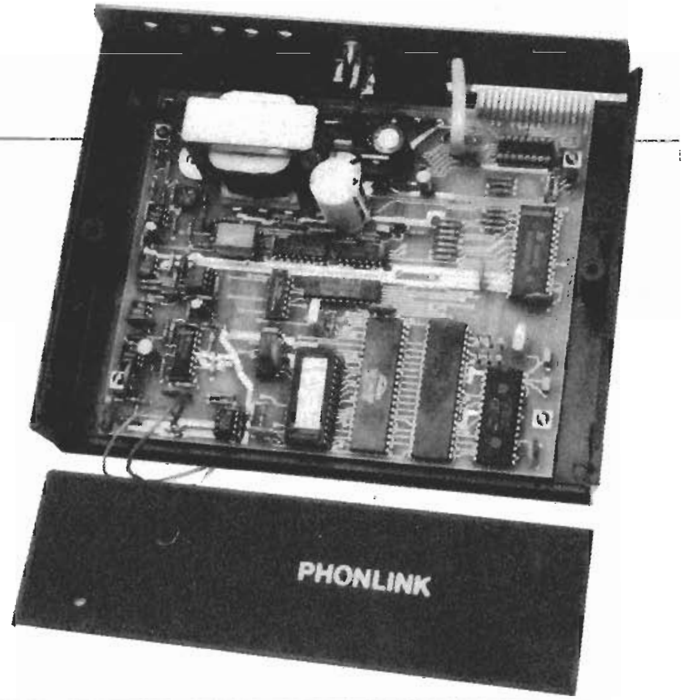
PHONLINK

INTERACTIVE REMOTE CONTROL



Rule the world by telephone!

GENE ROSETH

IF YOU'VE EVER WANTED TO CONTROL AN electronic device, or monitor an electrically measurable quantity from a remote location by telephone, you've probably found that devices to do so are expensive and hard to come by. However, we've got an inexpensive, easy-to-build, yet highly versatile device that both hobbyists and professionals will find useful. It allows you to control as many as eight devices, and it allows you to monitor as many as eight analog or digital quantities, including local temperature. A built-in speech synthesizer reports all values aurally.

A few simple examples will show how useful the controller can be. Suppose you're about to leave work and head home for the day. You pick up the telephone, dial your home, and wait for the controller to respond by saying *activated*. After you enter the access code, the unit gives verbal guidance as you: (1) disable the burglar alarm, (2) turn on the hot tub, (3) enable the garage-door opener, (4) check the house temperature (with the built-in thermometer), (5) turn on the air conditioning, and (6) obtain the state of charge of your solar-energy system. Finally, you activate the built-in microphone for a few seconds to listen for strange sounds.

More technical applications might require transmission of remotely generated analog or digital data using the internal A/D converter. Values are expressed via the built-in speech synthesizer.

How it works

The flowcharts shown in Fig. 1, Fig. 2, and Fig. 3 illustrate the overall function of

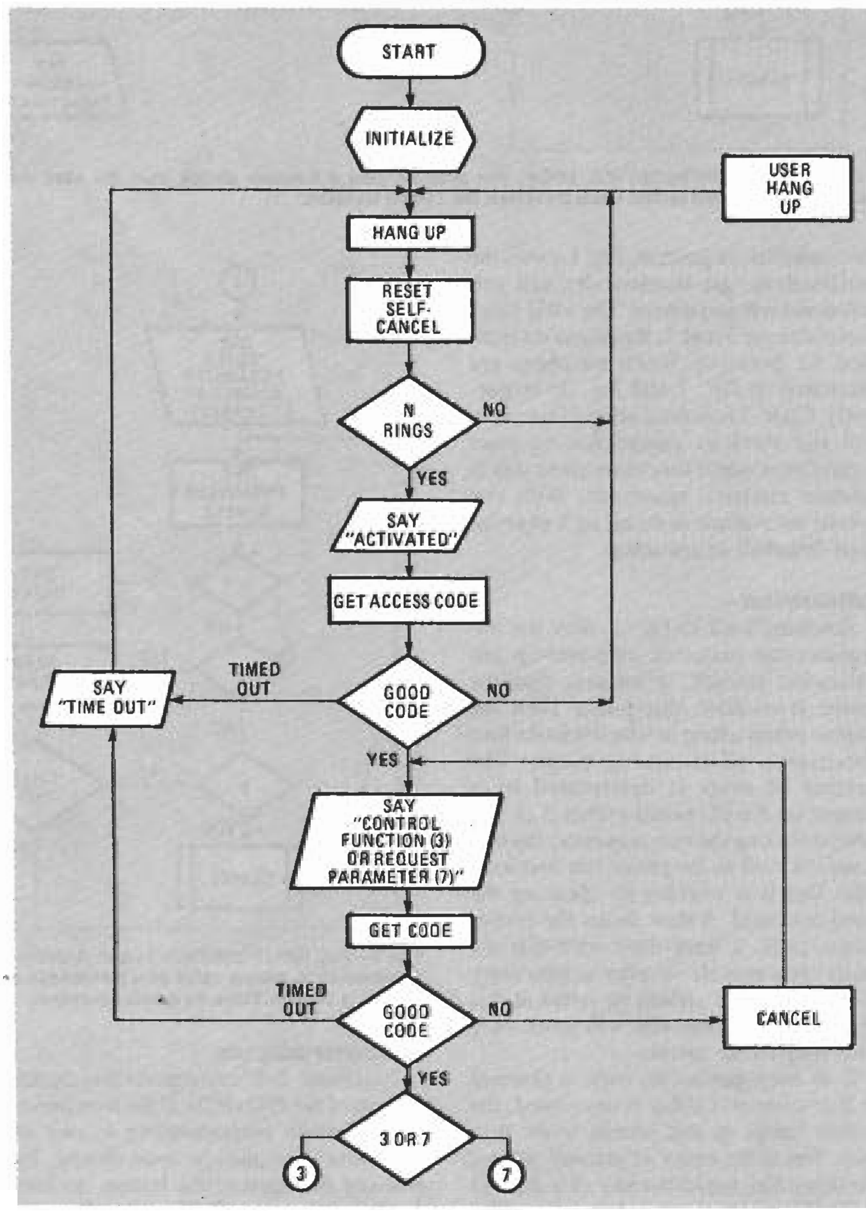


FIG. 1—FLOWCHART OF THE CONTROLLER'S MAIN LOOP: After initialization, the program gets a user-entered code and then transmits data to the user or turns the remote circuits on or off.

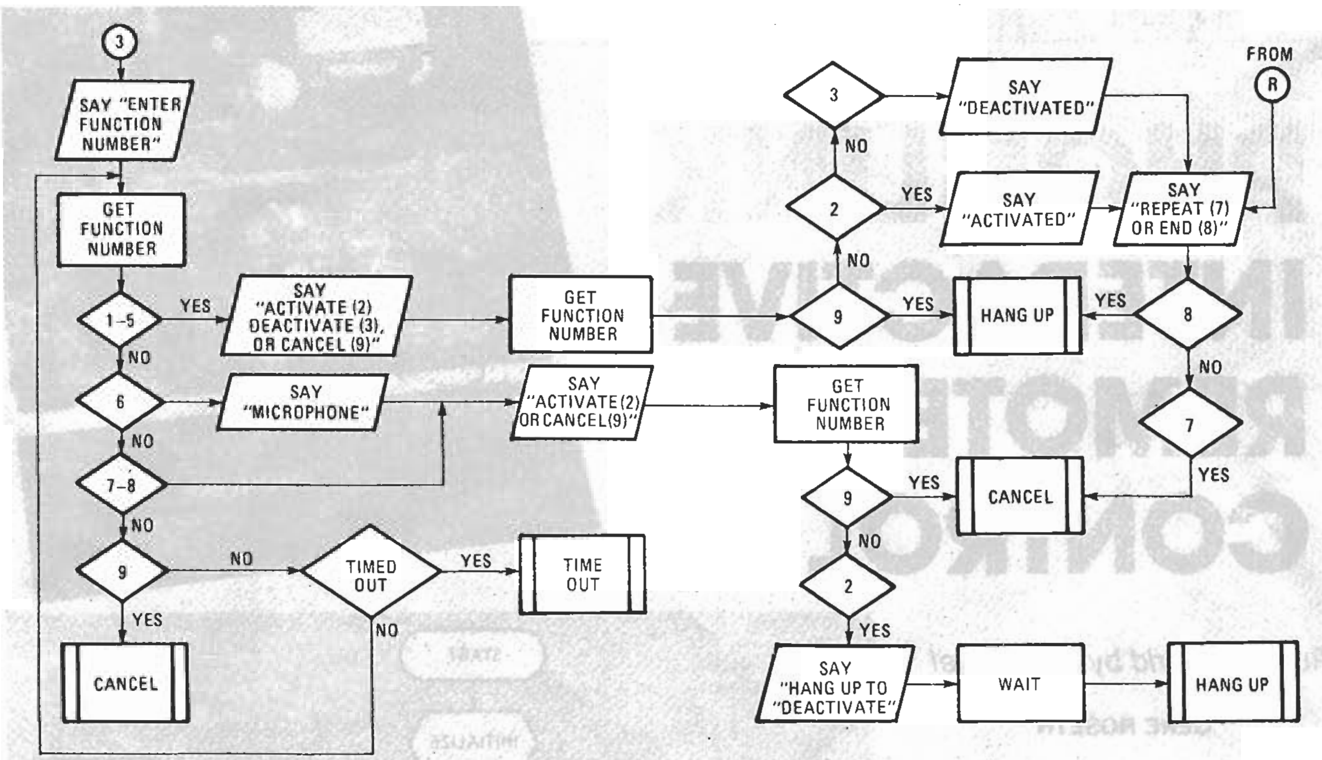


FIG. 2—THE OUTPUT-CONTROL LOOP: The program gets a function choice from the user and performs the desired action. Code 9 initiates the Cancel function.

the controller. In general, Fig. 1 shows the initialization, get-access-code, and get-function-code sequences. The valid function codes are 3 and 7; the functions initiated by pressing those numbers are illustrated in Fig. 2 and Fig. 3, respectively. Code-3 functions allow you to control the devices connected to your controller; Code-7 functions allow you to monitor electrical quantities. With that overall breakdown in mind, let's examine each flowchart in sequence.

Initialization

Referring back to Fig. 1, after the microprocessor performs its power-up initialization routine, it ensures that the phone is on-hook (hung-up). Then the routine enters a loop in which it looks for a succession of incoming rings. The number of rings is determined by a jumper on the PC board (either 3 or 10). After detecting the ring sequence, the unit connects itself to the phone line and indicates that it is working by speaking the word *activated*. It then awaits the proper access code, a three-digit code that the caller must provide in order to gain entry to the system. It should be noted at this point that the controller will work only with *Touch-Tone* phones.

If an improper access code is detected or if an excessive delay is encountered, the system hangs up and returns to the wait loop. But if the caller is granted access, the controller requests entry of a digit (3 or 7). If the user enters a 3, the controller enters the loop outlined in Fig. 2.

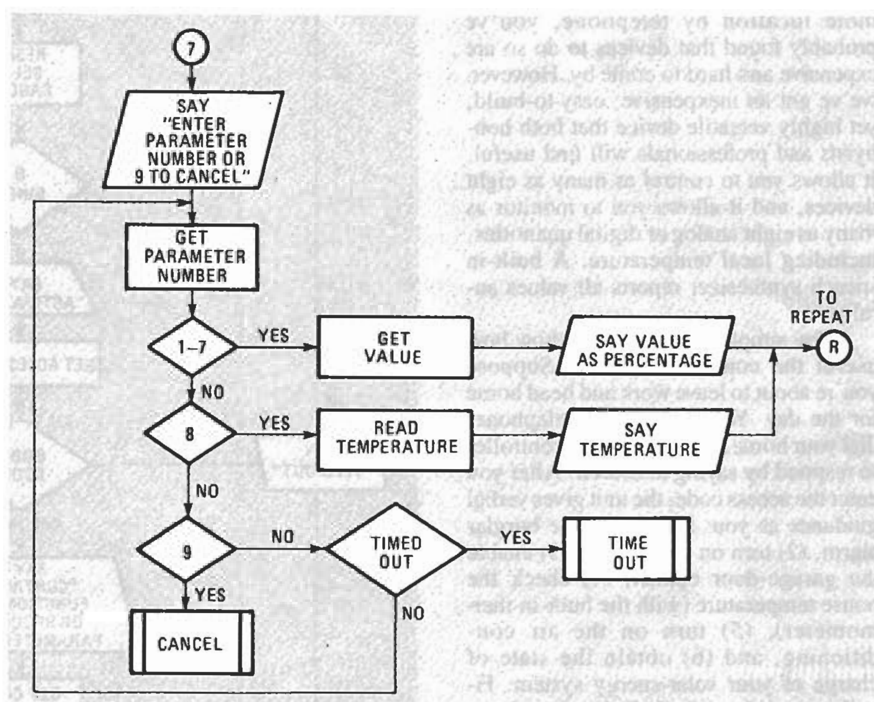


FIG. 3—THE INPUT-CONTROL LOOP: A choice of Code 1–Code 7 causes the program to report the corresponding analog value as a percentage of five volts. Local temperature will be reported when Code 8 is chosen. Code 9 cancels operation.

Controller outputs

Functions 1–5 correspond to digital outputs of the PIO (IC2). If the user presses the button corresponding to one of those functions, then he must choose, by pressing the appropriate button, to turn that function on or off. The controller will respond *activated* or *deactivated* as appropriate. Then the user will be able to repeat the sequence or hang up.

Function 6 corresponds to the built-in microphone, and functions 7 and 8 correspond to two "self-canceling" functions. Each of those functions is activated manually, and de-activated when you hang up or after a period of about five minutes.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—100,000 ohms
R2—250 ohms, 1%
R3—10,000 ohms, 1%
R4, R17, R24, R27, R32, R34, R35—10,000 ohms
R5–R9, R19, R36, R40, R42, R44, R46, R48, R50, R52, R55—33,000 ohms
R10, R15, R38—47,000 ohms
R11, R12, R14—1000 ohms
R13, R20, R21—220,000 ohms
R16, R28, R54—1 megohm
R18, R25—22,000 ohms
R22—330,000 ohms
R23, R30, R31, R33—100,000 ohms
R26—100 ohms
R29—150 ohms, ½-watt, 5%
R37—470 ohms
R39, R41, R43, R45, R47, R49, R51—51,000 ohms
R53—39,000 ohms
R56—150 ohms

Capacitors
C1, C6, C13–C15, C17–C21—0.1 µF, ceramic disc
C2, C8, C10—1 µF, 16 volts, electrolytic
C3, C4—0.022 µF, ceramic disc
C5, C11—10 µF, 16 volts, electrolytic
C7—2.2 µF, 16 volts, electrolytic
C9, C26—33 µF, 16 volts, electrolytic
C12—0.1 µF, 200 volts, disc
C16—4700 µF, 16 volts, electrolytic
C23—470 µF, 16 volts, electrolytic
C24, C25—22 pF, disc

Semiconductors
IC1—TMPZ84COOP, CMOS Z80 (Toshiba)
IC2—8255A, PIO
IC3—SP0256-AL2, speech synthesizer
IC4—74C04, hex CMOS inverter
IC5—74C02, quad CMOS NOR
IC6—27C64, 8K CMOS EPROM
IC7—74C32, quad CMOS OR gate
IC8—ADC0809CCN, A/D converter
IC9—LM234Z, precision current reference
IC10—M-956, DTMF decoder (Teltone)
IC11, IC22—unused
IC12, IC15—TLC271, op-amp
IC13—LM324, quad op-amp
IC14—4066, quad analog switch
IC16–IC19—4N32A, opto-isolator
IC20—LM7805CK, five-volt regulator, TO3 case
IC21—LM7805CT, five-volt regulator, TO220 case
BR1—200 volts, ½ amp
BR2—50 volts, ½ amp
D1, D3–D5—1N914, switching diode
D6–D8—1N5245B, 15-volt, ½-watt Zener diode
Q1—2N2222, NPN small-signal transistor

Other components
F1—125 volts, ½ amp, pigtail leads
MIC1—Electret microphone (Radio Shack 270-092B or equivalent)
RY1—Relay, five volts, 70 mA, (Radio Shack 275-243 or equivalent)
S01—16-pin DIP socket
S02—34-pin edge-card connector
T1—12.6 volts, 0.6 amp (Tria F-158XP)
XTAL1, XTAL2—3.58 MHz

Note: The following items are available from STG Associates, 2705-B Juan Tabo Blvd. N. E., #117, Albuquerque, NM 87112: Complete kit of parts, including cabinet, PC board, and programmed EPROM (KPL-1), $195; etched, drilled, and silk-screened PC board (KPL-2), $36; programmed EPROM (KPL-3), $19; printout of source code (KPL-4), $8. Add 5% for postage and handling. New Mexico residents add appropriate sales tax.

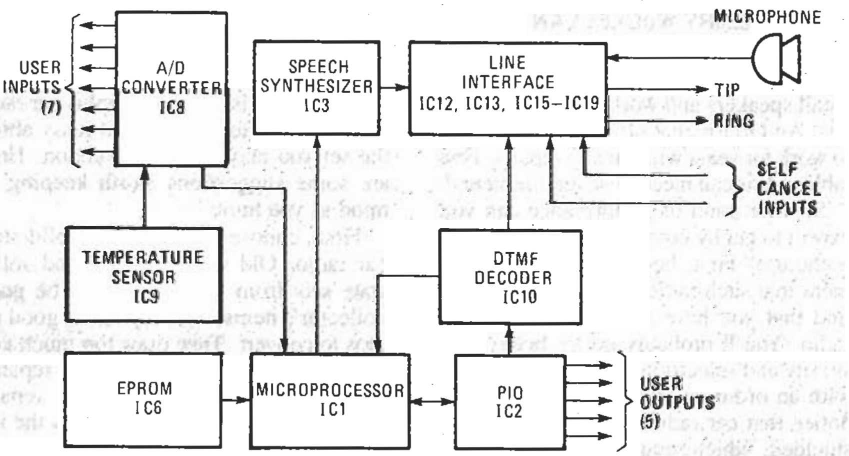


FIG. 4—BLOCK DIAGRAM OF THE CONTROLLER: an analog switch (IC14, not shown) connects the internal microphone, the speech synthesizer, or one of the self-cancel inputs to the phone line.

WARNING

PLEASE NOTE THAT, ALTHOUGH THE CONtroller presented here has been designed to meet the interface requirements of the telephone system, it is not FCC type-approved. Connection of such a device to your operating company's line is subject to the regulations of that company. It is *your* responsibility to ascertain the pertinent regulations for your area.

(Another on-board jumper selects hang-up or time-out.) The automatic hang-up feature would be useful, for example, if you wanted to listen to the sounds picked up by the microphone and just hang up when you were through, without having to explicitly deactivate the function and then hang up. The Hang-up and Cancel routines indicated in Fig. 2 are implemented as jumps to the similarly named routines in Fig. 1.

Controller inputs

If the user had entered a Code 7 from the main loop, he would then enter another code to select the quantity to be reported by the controller. If the user enters Code 1–Code 7, the controller states the value as a percentage of 0–5 volts. Obviously, you'll have to correlate that percentage with the output of your device. If the user enters Code 8, the controller responds with the ambient temperature (in degrees Celsius). Code-9 here (as in the output-function loop) cancels the current operation, returns to the main loop, and allows the user to choose between inputs and outputs (3 or 7).

Circuit overview

A block diagram of the system hardware is shown in Fig. 4. The microprocessor is a CMOS Z80; the program code is stored in an 8K-byte EPROM (a 27C64). The PIO (*P*arallel *I*nput/*O*utput) is an 8255A, which contains three 8-bit ports that interface most of the remaining circuits to the microprocessor. The A/D converter (IC8, an ADC0809) has eight analog inputs. Seven are available for use as desired; the eighth is connected to the built-in temperature-reference, IC9 (an LM334). The speech synthesizer (IC3, an SP0256), the DTMF (*D*ual-*T*one *M*ulti-*F*requency) decoder (IC10, an M-956), and the built-in microphone all interface to the telephone line via an analog switch (IC14, a 4066), several op-amps and opto-isolators.

Software

As anyone who has ever designed a microprocessor-based device is all too aware, the majority of work is embodied in the software. The controller's software is written in Z80 assembly language, and, due to space limitations, is not discussed here in detail (there are about 1800 lines of source code). However, both object code (contained in EPROM) and source code are available from the source noted in the Parts List.

That's all the space we have now. Next time, we'll present more complete circuit details. We'll also show you how to build the controller and offer some interfacing tips. Until then, why not use the time to gather parts or to order the kit offered by the supplier? **R-E**

PHONLINK

INTER-ACTIVE REMOTE CONTROL

Rule the world by telephone!

GENE ROSETH

Part 2

NOW THAT WE KNOW A little bit about how our telephone controller works, it's time to look at the circuit in greater detail. So let's get to work.

Circuit details

Figure 5 shows the microprocessor section. The EPROM (IC6) is enabled whenever a read is done to the Z80's memory (not I/O) space. Note that there is no RAM in the system; the abundance of Z80 registers and some careful programming have allowed us to dispense with RAM and associated address decoders.

The gates in the lower-left corner of the schematic (IC4-c–IC4-f, IC5-a, IC5-b, IC7-c, IC7-d) decode the I/O space for the speech synthesizer, the PIO, and the ADC. The Z80's clock input is driven via the clock output of the *Touch-Tone* decoder (shown in Fig. 6).

Figure 6 shows the analog interface circuitry. Data to the speech synthesizer and from the ADC is transferred via the data bus; data from the *Touch-Tone* decoder is transferred via the PIO. The control inputs of the analog switch are driven by the PIO and serve to connect the appropriate signal source to the telephone-line interface circuitry via terminal U13.

The speech synthesizer is a complex device that can be viewed as a storehouse of fundamental speech sounds called phonemes. The microprocessor causes the speech synthesizer to ouput individual phonemes along with appropriate delays to form complete words and phrases.

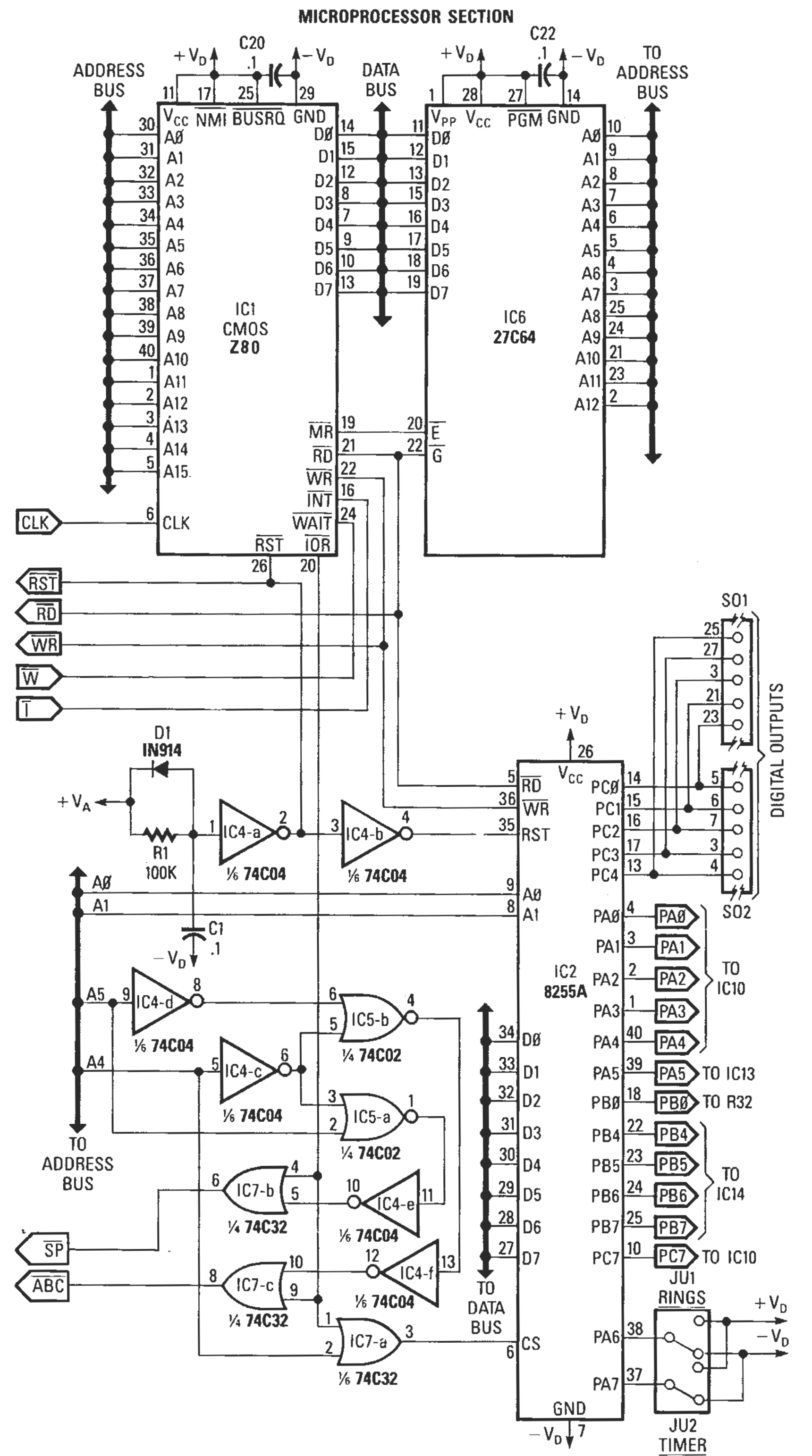


FIG. 5—THE CONTROLLER IS BASED ON A CMOS Z80; the design uses no RAM external to the Z80!

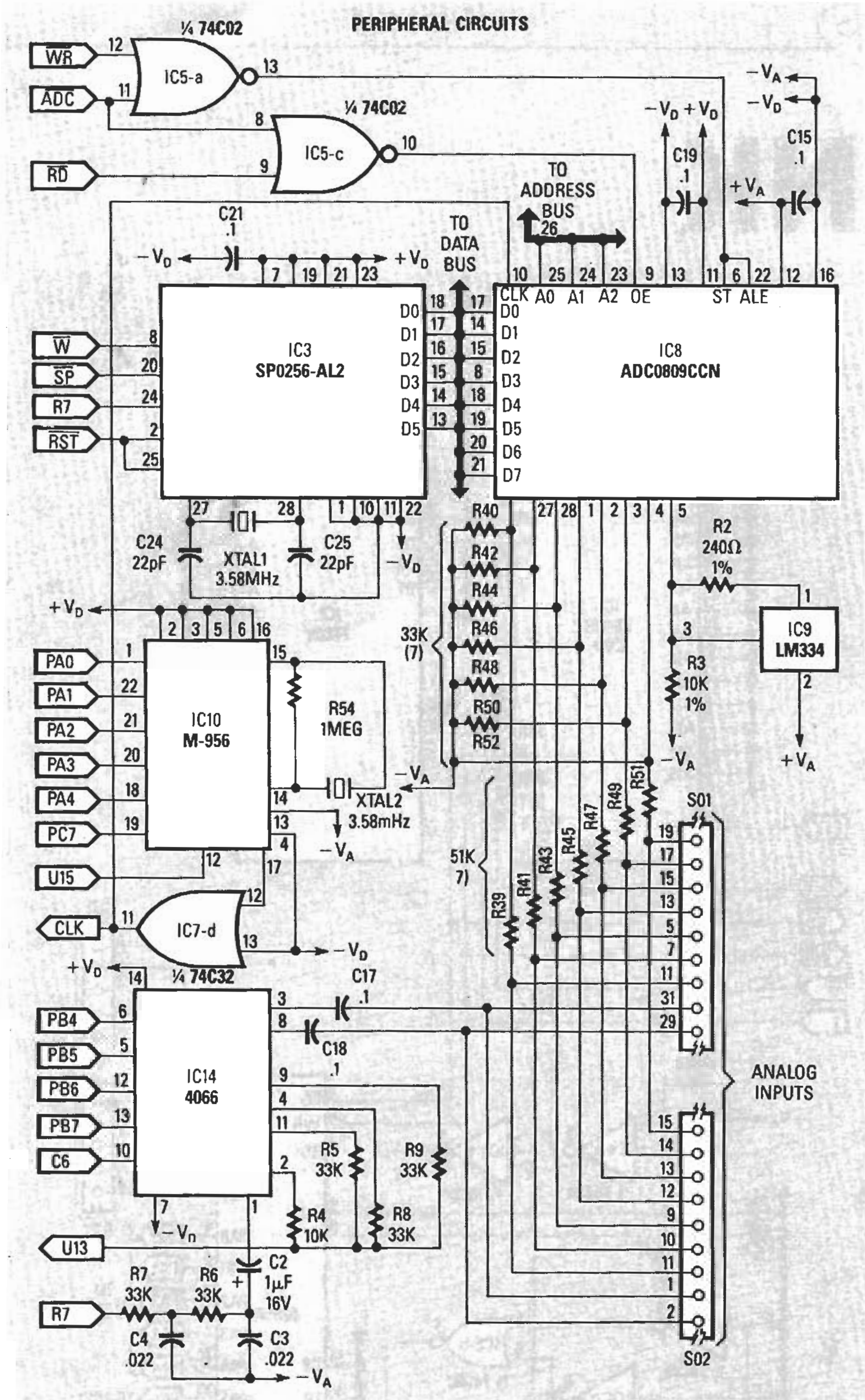


FIG. 6—THE ANALOG-INTERFACE CIRCUITS, including a speech synthesizer (IC3), an A/D converter (IC8), and a DTMF decoder (IC10) are shown here.

The ADC is a successive-approximation type; the resistive voltage divider connected to each of the first seven inputs (pins 1–5 and 26–28) is in the proper ratio to allow the microprocessor to translate a 0–5-volt input to a 0–100 percent output. For other input-voltage ranges, those resistors must be changed accordingly. The eighth input is connected to IC9, a precision current reference that produces a voltage proportional to ambient temperature.

Turning to Fig. 7, note first of all that there are two separate five-volt power supplies, one for the analog and one for the digital circuits. Now you know why the power connections to some IC's in the previous figures are labeled $\pm V_D$ and to others, $\pm V_A$. The analog and digital grounds are connected together, but only at one point; analog and digital ground runs around the board are separate.

The remainder of the circuitry provides the telephone-line interface. Line isolation is achieved through the use of opto-isolators. Opto-isolator IC16 and its associated passive components comprise the ring detector. Each time a ring occurs, a negative-going pulse is generated at pin 5 of IC16; that pulse is applied to pin 2 of IC13-a. The output of that op-amp is then applied to the PIO where it can be detected by the CPU.

Driving the remainder of the interface is BR1, a fullwave bridge rectifier that ensures proper operation of the controller even if the controller is connected to the phone lines backwards. Relay RY1 serves as the hook switch, which is equivalent to the cradle switch on any telephone. The relay is controlled by Q1, which in turn is controlled via the PIO by the Z80.

A closed-loop feedback circuit is composed of IC12, IC17, IC19, IC13-c, and the C9/R16 lowpass filter; that circuit compensates for temperature drift. The data or voice signal is modulated onto the phone line by IC13-c and IC19, but the rest of the feedback loop is needed for stability and to optimize the operating point of IC19. The purpose of IC18 is to detect the disconnect pulse from the tele-

WARNING

PLEASE NOTE THAT, ALTHOUGH THE CONtroller presented here has been designed to meet the interface requirements of the telephone system, it is not FCC type-approved. Connection of such a device to your operating company's line is subject to the regulations of that company. It is *your* responsibility to ascertain the pertinent regulations for your area.

TABLE 1—I/O CONNECTIONS

Function	Pin Number SO1	SO2
Self-cancel function 2	31	1
Self-cancel function 1	29	2
Output 4	27	3
Output 5	25	4
Ouput 1	23	5
Output 2	21	6
Output 3	3	7
Ground	*	8
Input 3	5	9
Input 2	7	10
Input 1	11	11
Input 4	13	12
Input 5	15	13
Input 6	17	14
Input 7	19	15
+5 volts, 200 mA	33	16

*All even numbered pins are grounded.

Note: Pin 1 and pin 9 are not connected.

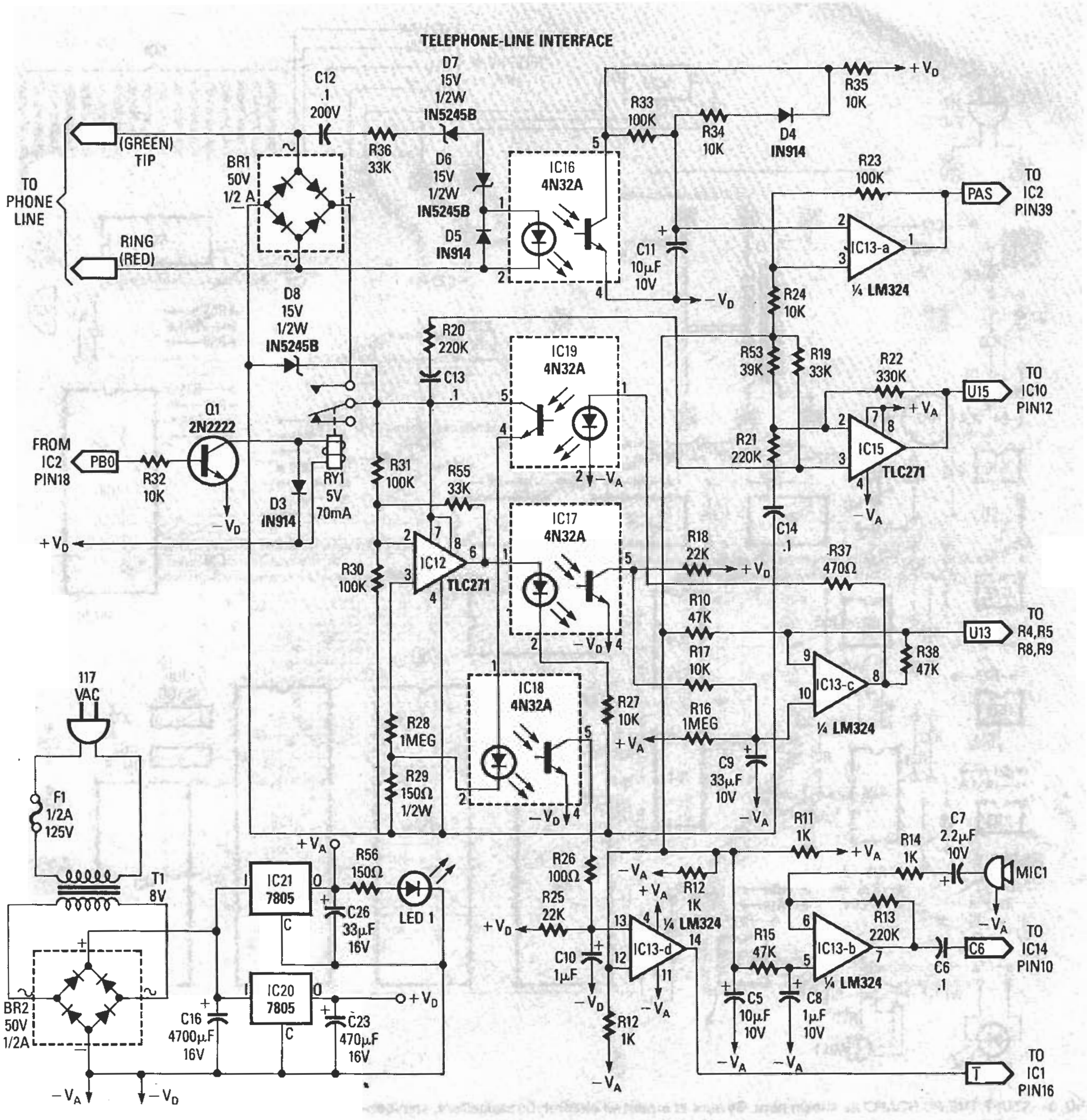


FIG. 7—THE POWER SUPPLY AND TELEPHONE-LINE INTERFACE are shown here. There are separate supplies for the analog and digital circuits.

phone exchange if the caller hangs up. That pulse causes an interrupt to the microprocessor, which then terminates the current session, re-entering the program near the top of the flowchart that was shown in Fig. 1 last time (**Radio-Electronics**, May 1987).

Software

The controller's software is written in Z80 assembly language; it comprises about 1800 lines of code. Due to space limitations, we can't print the listing here, but we have posted it on our BBS. The file is called PHONLINK.AQM, and it has been squeezed, so you'll have to unsqueeze it to use it.

LISTING 1

```
;               *ENTER8* MODULE
;
ENTER8  LD      A,04H           ;PA5
        OUT     (SPCHPT),A      ;PRE-DELAYS
        OUT     (SPCHPT),A      ; "    "
        OUT     (SPCHPT),A
        OUT     (SPCHPT),A
        OUT     (SPCHPT),A
        LD      HL,RTRN85
        JP      ENTER           ;"ENTER"
RTRN85  LD      HL,RTRN86
        JP      EIGHT           ;"EIGHT"
RTRN86  LD      HL,RTRN87
        JP      TWO             ;"TO"
RTRN87  LD      HL,RTRN88
```

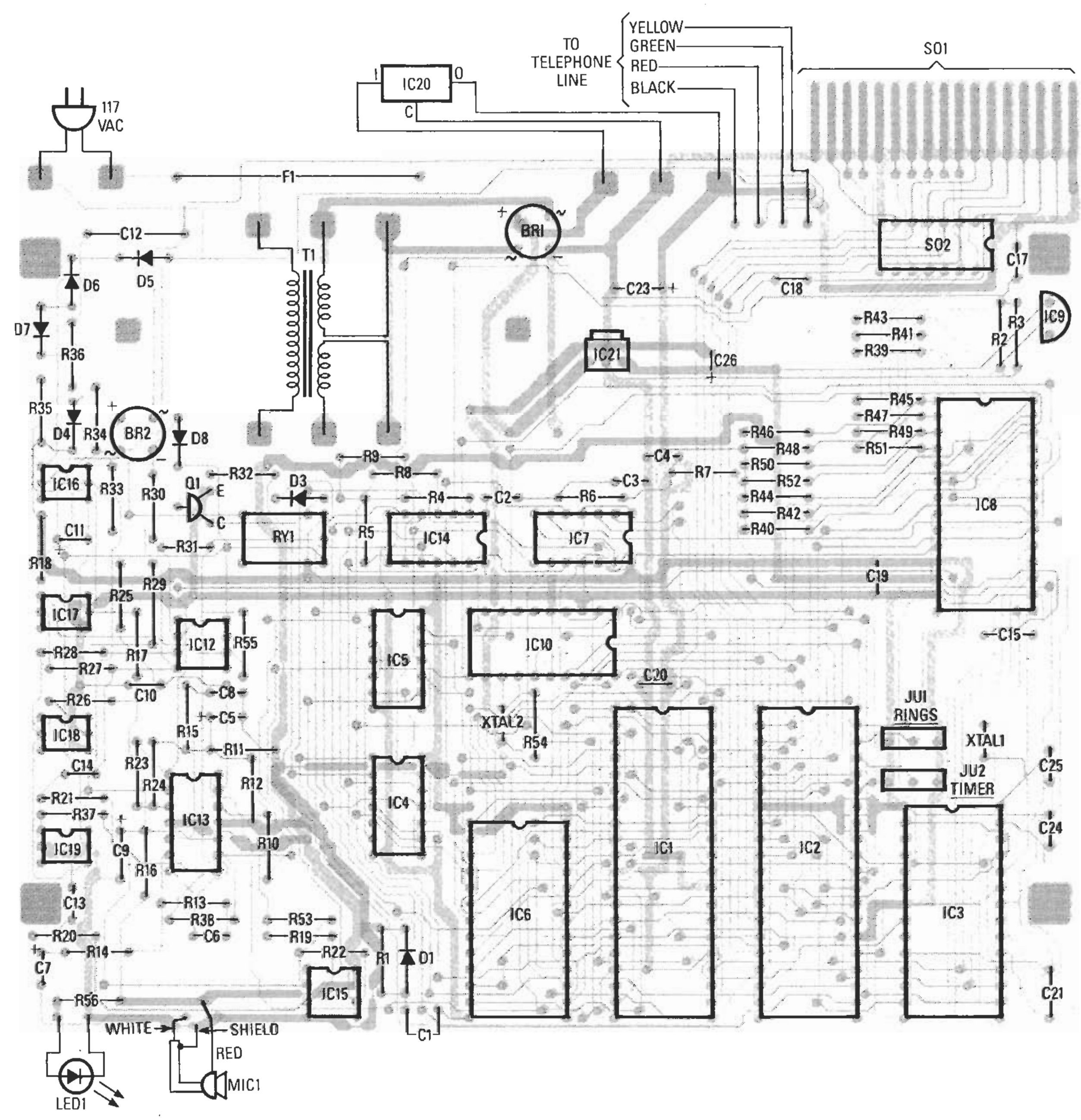


FIG. 8—STUFF THE PC BOARD as shown here. Be sure to mount all electrolytic capacitors, semiconductors, and the power transformer in the correct orientation.

To get an idea of how we use the Z80's registers rather than RAM to store subroutine return addresses, examine the routine in Listing 1.

The routine shown there causes the speech synthesizer to say "Enter eight to end or seven to repeat." After executing several delays (by outputting a 4 to the speech port), the address of the routine that speaks the word *Enter* (RTRN85) is loaded in the HL register. Then the program jumps to the routine that pronounces the word.

That routine returns to the location pointed to by HL—the next line in the routine shown in Listing 1. It in turn calls the routine that speaks the word *eight* and continues in the same manner.

Construction

Use of a PC board is not absolutely necessary, but is strongly recommended, in order to minimize crosstalk and other problems. The commercially available PC board is double-sided, has plated-through holes, and is silk-screened, which greatly simplifies construction. Alternatively, you can etch your own board using the patterns shown in PC Service.

To stuff the board, follow the parts-placement diagram (shown in Fig. 8). Observe all polarity markings and make sure that the transformer is mounted correctly! Mount IC20 (the 7805 regulator that supplies power to the digital circuitry) on the rear panel of your case, or some other heatsink. The power-on indicator (LED1) and the microphone (MIC1) should be inserted through holes in the front panel. Don't forget to solder the two jumpers in the desired positions.

Interfacing

There are two basic approaches to interfacing the controller with external circuitry. The simpler method, which is suitable for small, low-power circuits, is to mount a small piece of perfboard inside the cabinet. The board can be secured to the top half of the cabinet with #4 screws. DIP connector SO2 on the main board allows an easy interface to the user board. The pinouts of SO1 and SO2 are shown in Table 1. The wires connecting the user board to the real-world inputs and outputs

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—100,000 ohms
R2—250 ohms, 1%
R3—10,000 ohms, 1%
R4, R17, R24, R27, R32, R34, R35—10,000 ohms
R5–R9, R19, R36, R40, R42, R44, R46, R48, R50, R52, R55—33,000 ohms
R10, R15, R38—47,000 ohms
R11, R12, R14—1000 ohms
R13, R20, R21—220,000 ohms
R16, R28, R54—1 megohm
R18, R25—22,000 ohms
R22—330,000 ohms
R23, R30, R31, R33—100,000 ohms
R26—100 ohms
R29—150 ohms, ½-watt, 5%
R37—470 ohms
R39, R41, R43, R45, R47, R49, R51—51,000 ohms
R53—39,000 ohms
R56—150 ohms

Capacitors
C1, C6, C13–C15, C17–C22—0.1 µF, ceramic disc
C2, C8, C10—1 µF, 16 volts, electrolytic
C3, C4—0.022 µF, ceramic disc
C5, C11—10 µF, 16 volts, electrolytic
C7—2.2 µF, 16 volts, electrolytic
C9, C26—33 µF, 16 volts, electrolytic
C12—0.1 µF, 200 volts, disc
C16—4700 µF, 16 volts, electrolytic
C23—470 µF, 16 volts, electrolytic
C24, C25—22 pF, disc

Semiconductors
IC1—TMPZ84COOP, CMOS Z80 (Toshiba)
IC2—8255A, PIO
IC3—SP0256-AL2, speech synthesizer
IC4—74C04, hex CMOS inverter
IC5—74C02, quad CMOS NOR
IC6—27C64, 8K CMOS EPROM
IC7—74C32, quad CMOS OR gate
IC8—ADC0809CCN, A/D converter
IC9—LM234Z, precision current reference
IC10—M-956, DTMF decoder (Teltone)
IC11, IC22—unused
IC12, IC15—TLC271, op-amp
IC13—LM324, quad op-amp
IC14—4066, quad analog switch
IC16–IC19—4N32A, opto-isolator
IC20—LM7805CK, five-volt regulator, TO3 case
IC21—LM7805CT, five-volt regulator, TO220 case
BR1—200 volts, ½ amp
BR2—50 volts, ½ amp
D1, D3–D5—1N914, switching diode
D6–D8—1N5245B, 15-volt, ½-watt Zener diode
Q1—2N2222, NPN small-signal transistor

Other components
F1—125 volts, ½ amp, pigtail leads
MIC1—Electret microphone (Radio Shack 270-092B or equivalent)
RY1—Relay, five volts, 70 mA, (Radio Shack 275-243 or equivalent)
S01—16-pin DIP socket
S02—34-pin edge-card connector
T1—12.6 volts, 0.6 amp (Tria F-158XP)
XTAL1, XTAL2—3.58 MHz

Note: The following items are available from STG Associates, 2705-B Juan Tabo Blvd. N. E., #117, Albuquerque, NM 87112: Complete kit of parts, including cabinet, PC board, and programmed EPROM (KPL-1), $195; etched, drilled, and silk-screened PC board (KPL-2), $36; programmed EPROM (KPL-3), $19; printout of source code (KPL-4), $8. Add 5% for postage and handling. New Mexico residents add appropriate sales tax.

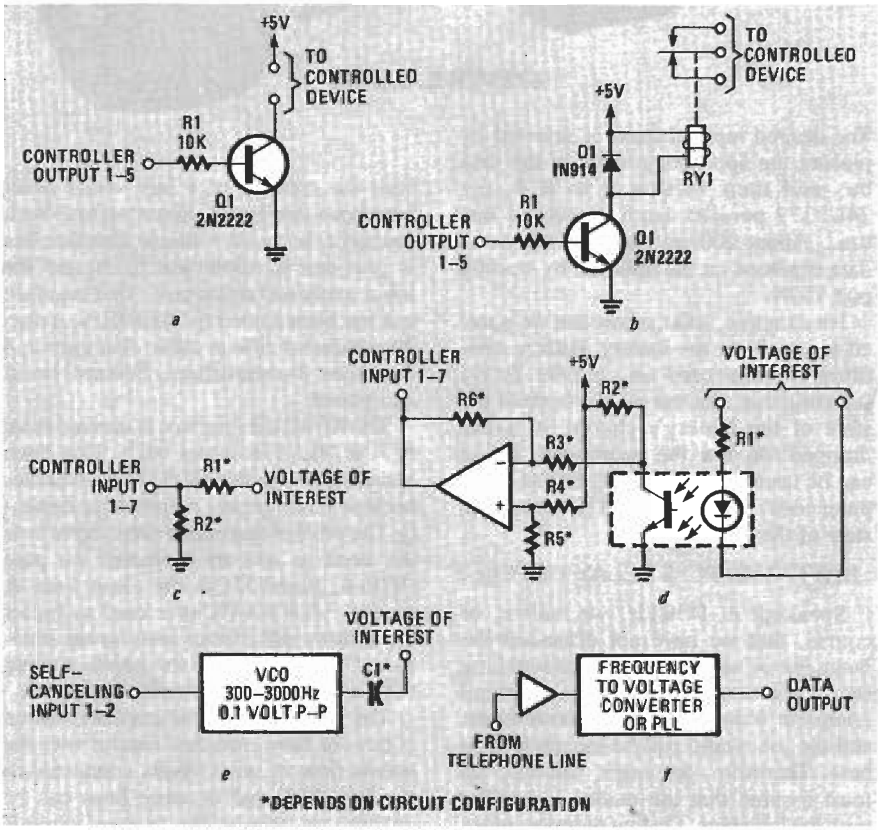


FIG. 9—A VARIETY OF INPUT/OUTPUT CIRCUITS: at *a*, an unisolated digital output; at *b*, an isolated digital output; at *c*, an unisolated analog input, at *d*, an isolated analog input. Shown in *e* and *f* are one means of transmitting digital data over the phone lines.

can be routed out an opening in the rear panel. The internal power supply can provide a maximum of about 200 mA to user circuitry. If that's not enough for your applications, use another method.

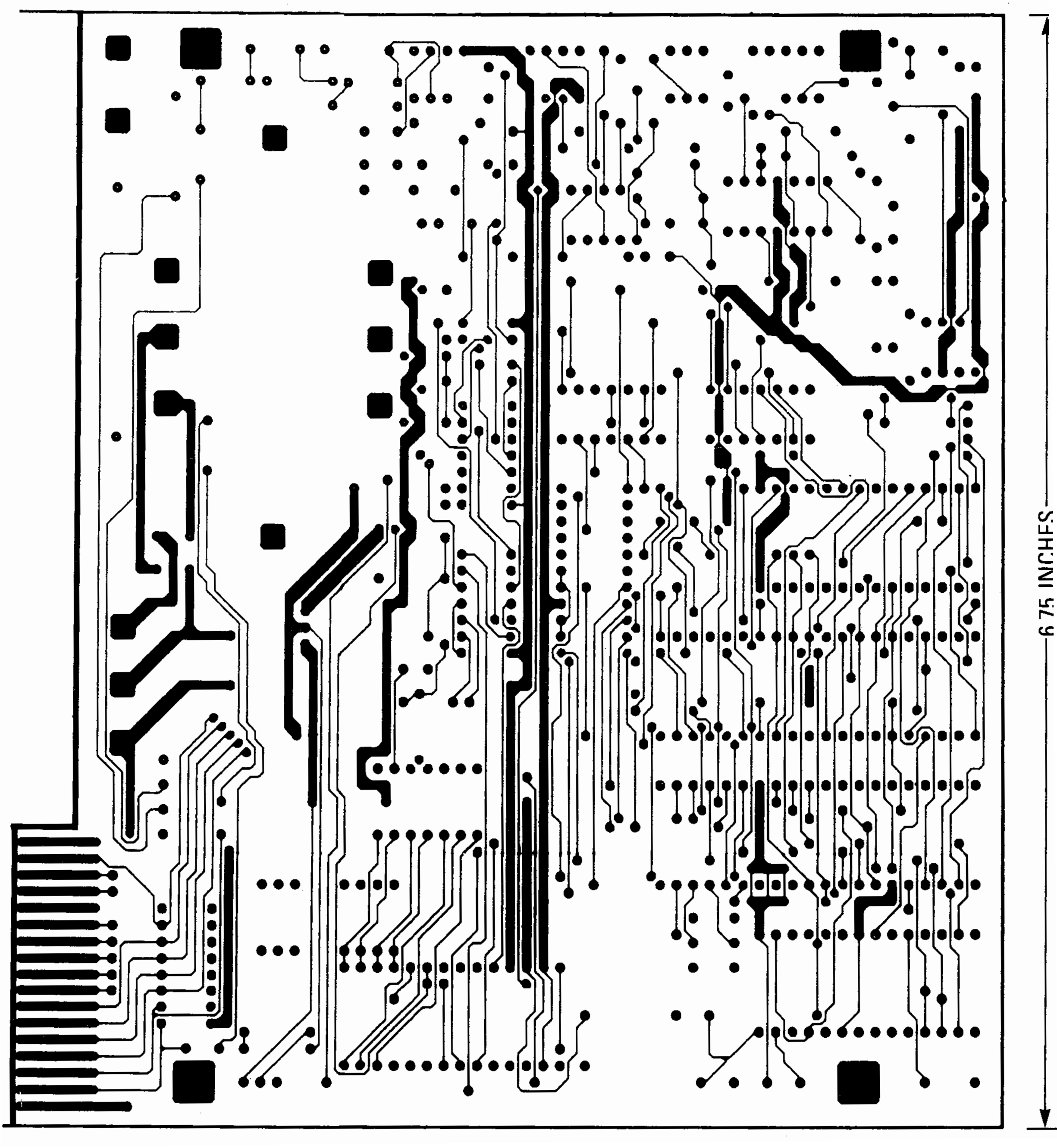
The other method of interfacing is required when the application demands devices that are too big or too power-hungry to be mounted internally. Here a separate box should be built that contains its own internal power supply. The edge-card connector identified as SO1 in the schematics can be used to connect the controller to the interface box.

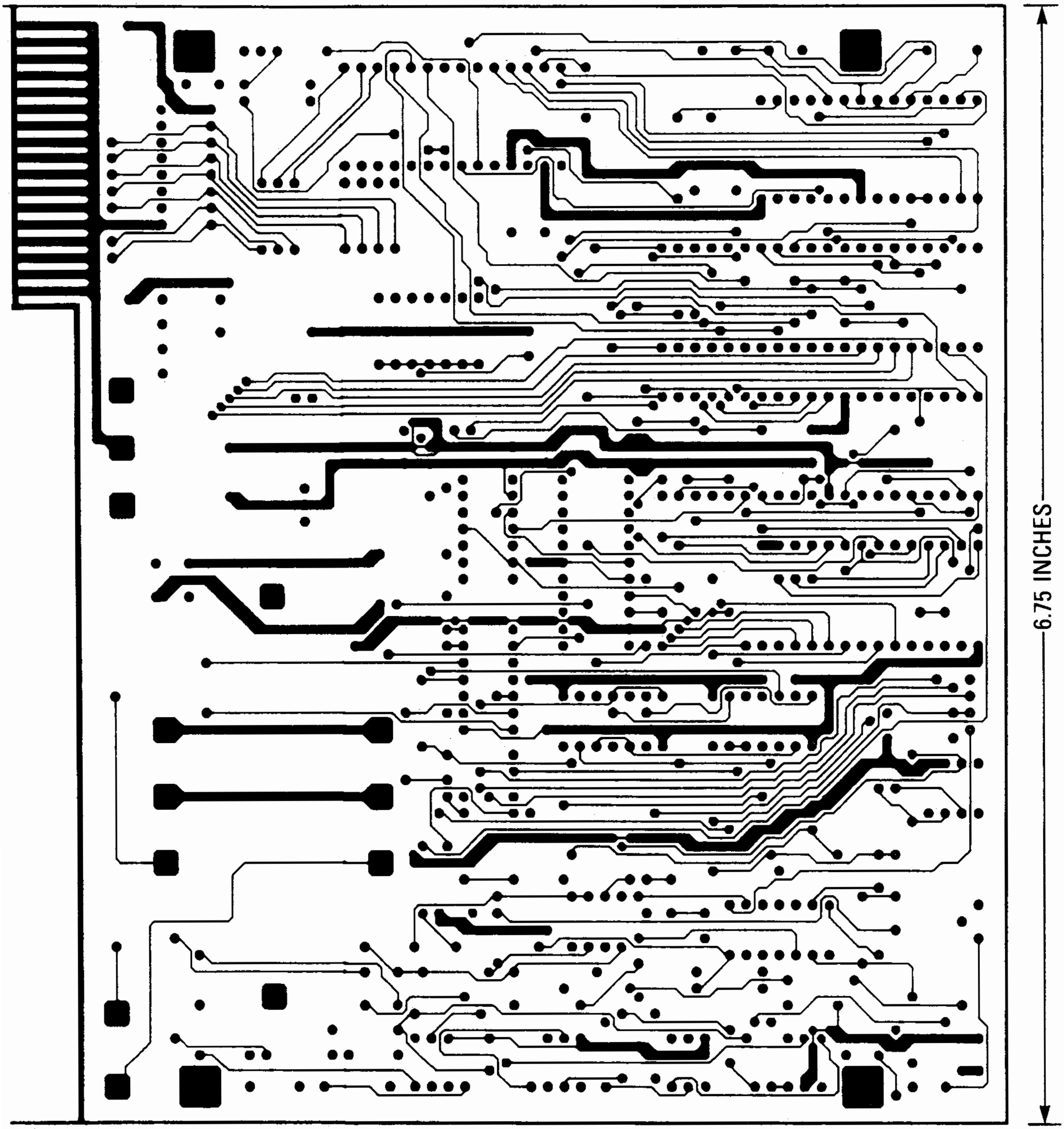
Construction aside, the type of circuit you'll need will depend on your inputs and outputs. Figure 9 shows ideas for several types of interfaces. Component values are not given for most of the circuits because those values can only be determined based on the voltage levels you'll be dealing with. But the circuits shown provide a good starting place.

Figure 9-*a* and Figure 9-*b* show two simple digital-output circuits. Neither can supply much current; the relay in Fig. 9-*b* should be a low-current type. The Fig. 9-*a* circuit is suitable for applications where isolation is unimportant; otherwise, use the Fig. 9-*b* circuit.

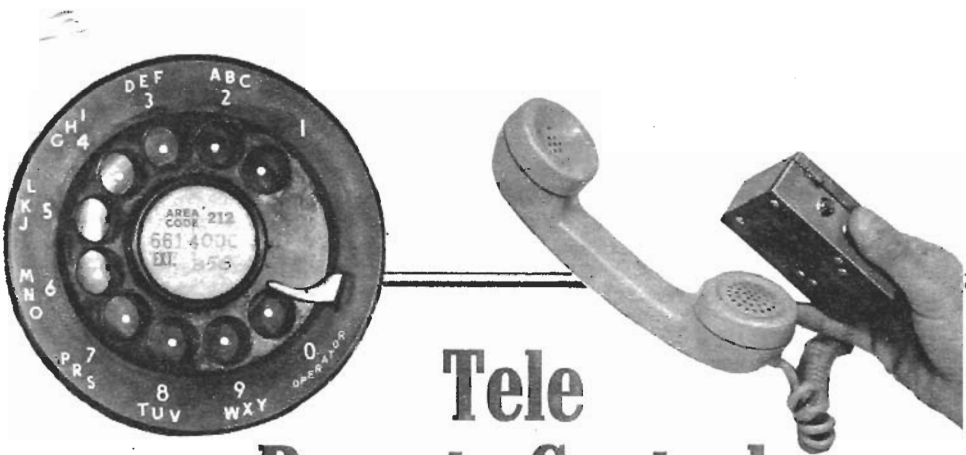
Figure 9-*c* and Figure 9-*d* show two simple analog-input circuits. As with Fig. 9-*a* and Fig. 9-*b*, the Fig. 9-*c* circuit is suitable for applications where isolation is unimportant; otherwise, use the Fig. 9-*d* circuit.

Last are circuits for transmitting digital data over the telephone lines. As shown in Fig. 9-*e*, the remote voltage of interest should be processed by a VCO (*V*oltage-*C*ontrolled *O*scillator) so that a tone suitable for phone-line bandwidth (3000 Hz) will be generated. The signal applied to either of the converter's self-canceling inputs should be in the range of 50–100 mV p-p. As shown in Fig. 9-*f*, the tone can be recovered at the receiving end after suitable isolation and buffering by a voltage-to-frequency converter or a PLL (*P*hase-*L*ocked *L*oop). **R-E**


6.75 INCHES



THE SOLDER SIDE of the Phonlink PC board is shown here.



Tele Remote Control

Dial your home, transmit a tone and you can switch on almost anything.

By VINCE DANIELS YOU stroll out of an air-conditioned theater and find the temperature has soared to 100 degrees and the humidity has risen to 98 per cent. Do you stand and groan with the rest of the crowd? Not at all! You hop into the nearest phone booth, pay a dime, dial your home, and then feed a tone into the phone with a small black box. At the other end of the line your Tele Remote Control turns on your air conditioner. When you arrive home you walk into heaven.

Or, you might want to turn on the coffee to have it steaming hot as you walk through the door. You even can work your CB gear through the phone. Use one tone and the CB transceiver—which is connected to the phone line through a patch—turns itself on and feeds the received signals into the phone. Press another button and the transceiver flips to transmit so you can transmit whatever you speak into the telephone.

The control's operation depends on different-frequency tones. The receiver (which is connected to a standard Western Electric phone you've bought and plugged into your extension phone's outlet) automatically answers the phone and feeds the incoming signal to the built-in amplifier. This drives a resonant-reed relay, a special type of relay which has five independent circuits, each of which can be activated by a different tone. If your tone generator can produce five different tones you can control up to five different circuits or appliances.

The number of circuits you can control is up to you. For example, the tone generator shown provides two tones. We show more than one circuit (Rx, Sx) so you know how to add additional tones. The receiver we show here has a single controlled circuit, but there's plenty of room on the front panel for additional relays for extra circuits.

The receiver does not directly control the appliance. Instead it provides a single pulse of 117 VAC, which actuates an external 117-VAC latching relay (such as Potter & Brum-

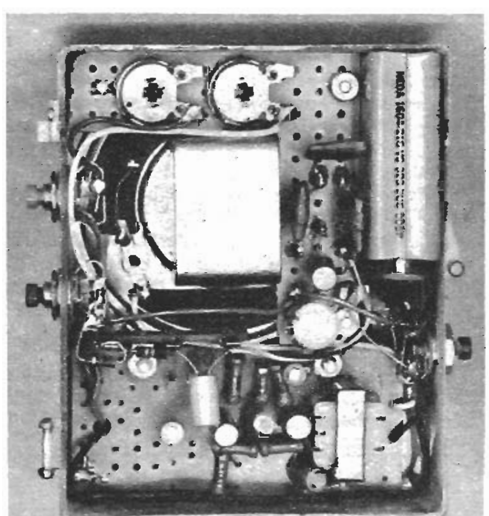
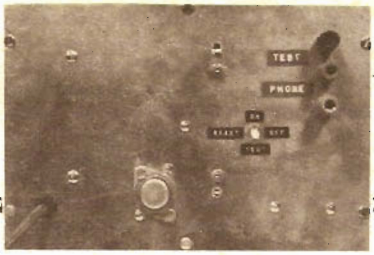
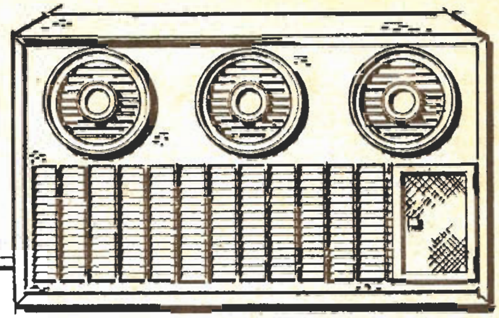


Fig. 1—Tone generator. Oscillator circuit is on L-shaped perforated board at top and right of speaker. Modified ready-made amplifier is at bottom.





field PC11A. This way, both on and off operation is possible. For example: The power to your air conditioner is controlled by a latching relay which is connected to power socket SO1. A single tone burst causes a short 117-V burst to appear at SO1 which causes the latching relay to flip to the *on* position. Even after power is removed from the latching relay it remains in the *on* position.

Something comes up and you can't get home early, so why run up the electric bill? You call your home again and once more transmit a tone. The second 117-V burst at SO1 causes the latching relay to flip to the *off* position, thereby turning off the air conditioner. Of course, you can utilize control relay RY5 in any way you want. You can wire it to be self latching, control DC, start a recorder, etc.

Getting The Parts. To avoid the problems associated with obtaining special or obscure parts, the system has been designed to use components readily available from mail-order parts distributors. However, in some places the circuitry is special and will work only with the components specified. Unless specifically permitted, do not substitute for components in the Parts List.

Relay RY4 has two reeds which can't be used in this application. The relay we specify for RY4 will, therefore, provide for only three control circuits. If you can get one, a resonant-reed relay with a 2,000-ohm impedance coil (at 400 cycles) and reed frequencies between 500 and 1,000 cycles should be substituted for five-circuit operation. The tone generator, whose tones are designed around the reed relay, has a top frequency of slightly under 400 cycles. It can be modified for a 500 to 1,000 cps. range by substituting .01-μf capacitors for C1, C2 and C3.

Construction. Since the tone generator is needed to check out the receiver, build it first. Ours, which will fit into a jacket pocket, produces a maximum of two tones and is assembled in a 3⅞ x 3⅛ x 1⅛ in. plastic box. If you are not experienced in tight wiring or you need more than two tones, use a larger cabinet.

Mount all components in the tone generator box with No. 4 hardware. Assemble the unit in the order given. Do not mount any components until all cabinet holes have been drilled. Since the plastic cabinet is easily shattered, back it with a block of wood when drilling and use a very sharp bit and a slow-

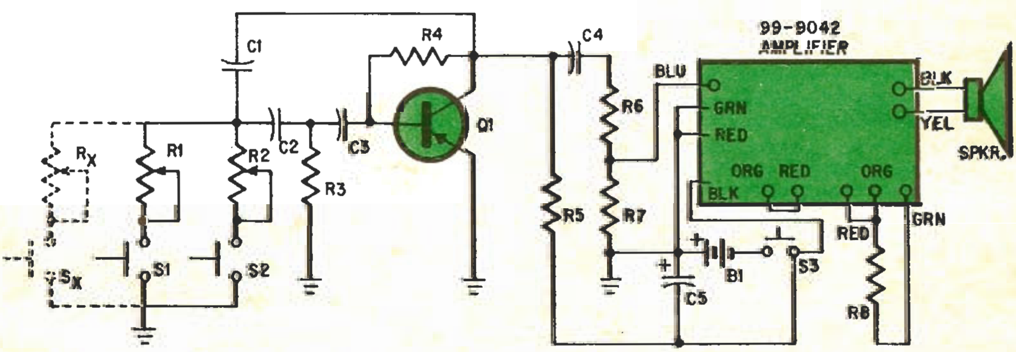


Fig. 2—Tone generator schematic. Add Rx and Sx for each extra tone. S3, under amplifier, turns on power.

Tele Remote Control

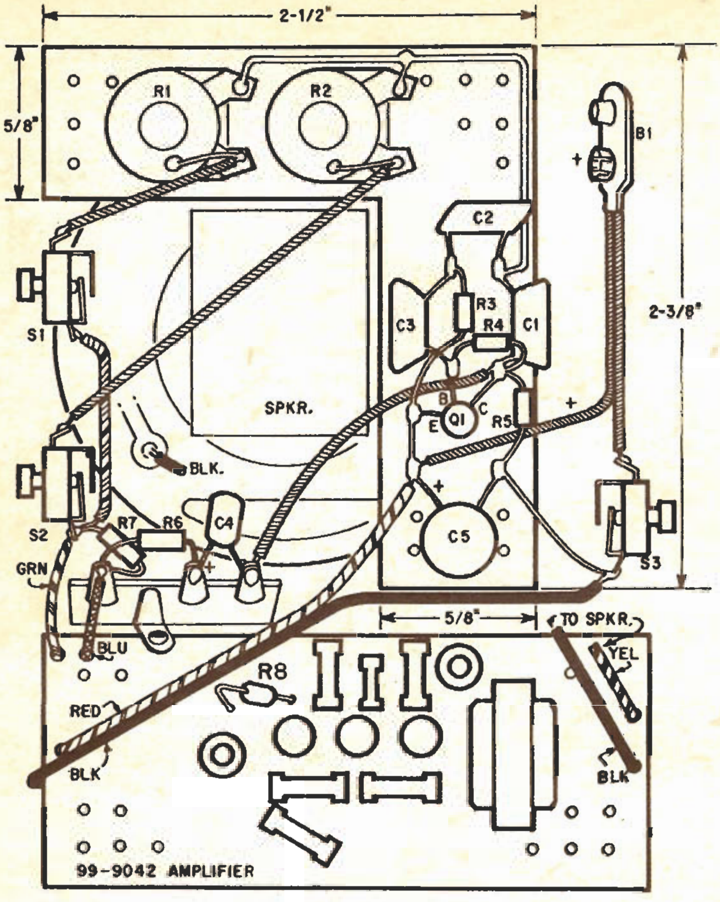
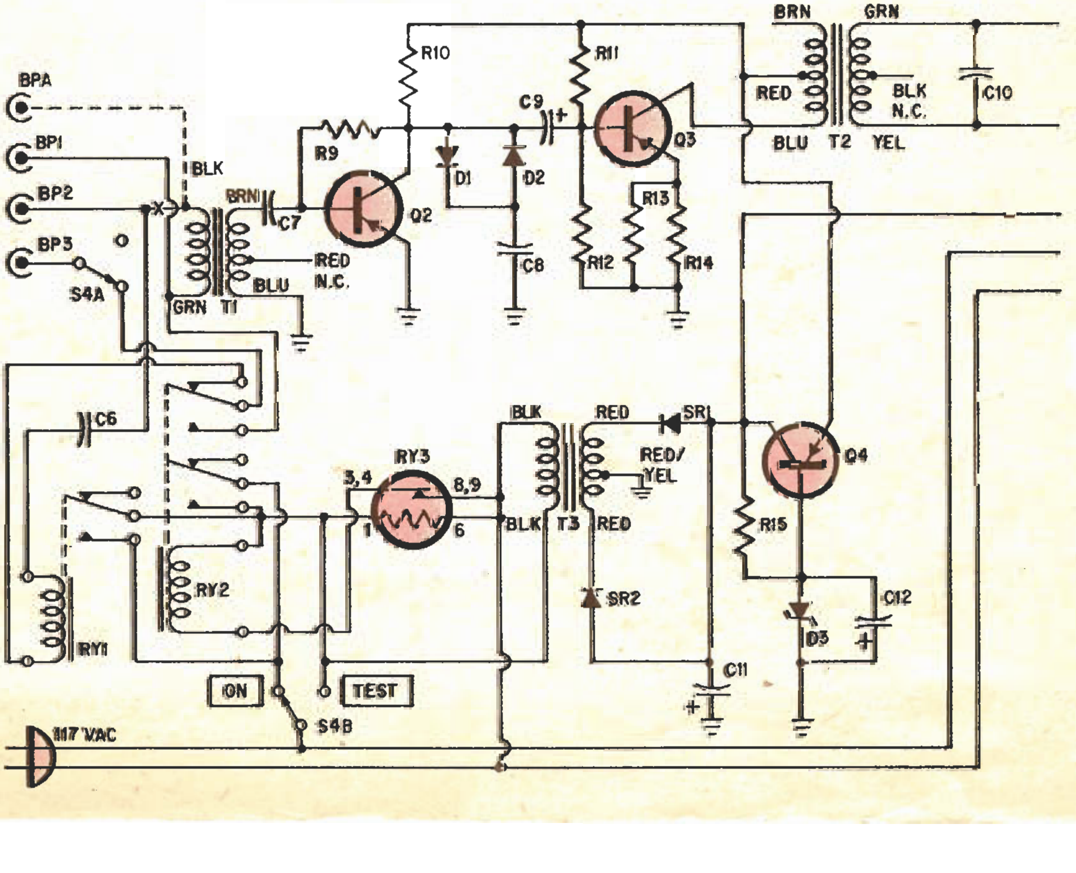


Fig. 3—Tone generator. Oscillator should be built on L-shaped perforated board (2½ x 2⅜ x ⅝ in.) before installing board in plastic box. Switches S1,S2 and S3 mount in left and right side of box. Note where ¼-watt resistor R8 is installed on amplifier. Note on trimmer pots R1 and R2 that you must solder a wire from the bottom lug to the case of the pot. In our model R3, R4 and R5 are installed under the board.



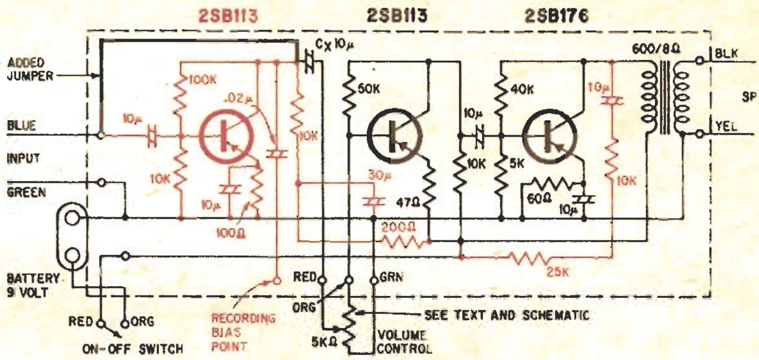


Fig. 4—Schematic supplied with Lafayette modular amplifier. Components and wiring in color must be removed. Add a jumper from the input point to an existing 10-µf electrolytic capacitor. Remove the leads for the volume control and solder one lead of R8 in the hole from which you removed GRN lead. See text for other changes.

drill speed. A high-speed drill will melt the plastic and gum up the bit.

Position the cabinet as shown in Fig. 1. fit the speaker flush against the corner and drill the four mounting holes. Using the four holes as the corners of a square, scribe horizontal and vertical lines on ½-in. centers. Drill through the cabinet with a ¼-in. drill at the intersection of each horizontal and vertical line to make a speaker grill.

The tone generator's amplifier is a ready-made amplifier that you must modify. Position the amplifier's two mounting holes so they are close to the speaker and mark and drill two mounting holes. (It may be necessary to cut away part of the speaker's two mounting flanges to provide clearance for the amplifier's mounting screws.)

Before proceeding, modify the amplifier by eliminating the first stage and its associated components as shown in Fig. 4. Using wire cutters, clip out the components indicated in color. Next, solder a jumper from Cx (10 µf) to the printed-circuit terminal to which the blue input lead is soldered. Eliminate the wires for a volume control—red, orange and blue. Solder one end of a 4,700 ohm ¼-watt resistor (R8, Fig. 1) to the red and orange wire holes and solder the other end of the resistor to the green-wire hole.

Temporarily install the speaker and the amplifier using a ¼-in. standoff or stack of

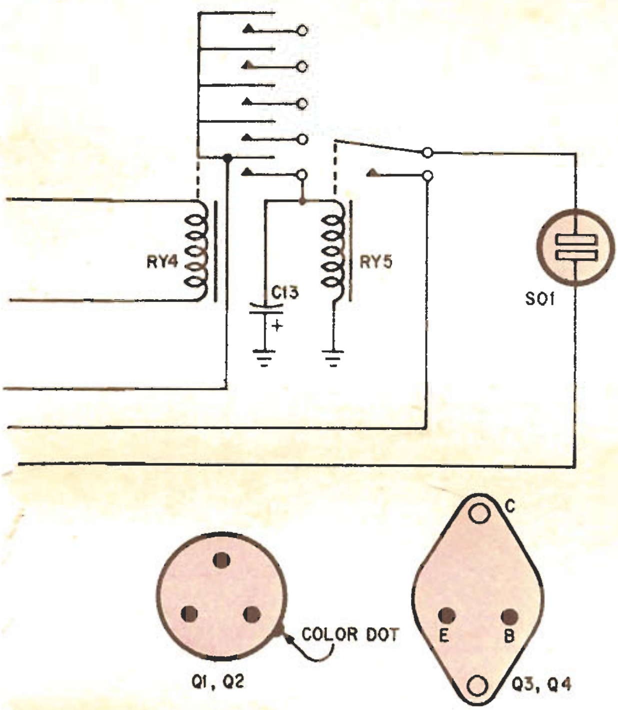


Fig. 5—Receiver. To test unit, connect speaker to BP1,BP2 and set S4 to test. To operate, set S4 to on. Connect two two-wire phone to BP2,BP3. If three-wire line, connect T1's black lead to BPA; connect BPA,BP3 to talking pair, BP2 to ringing wire.

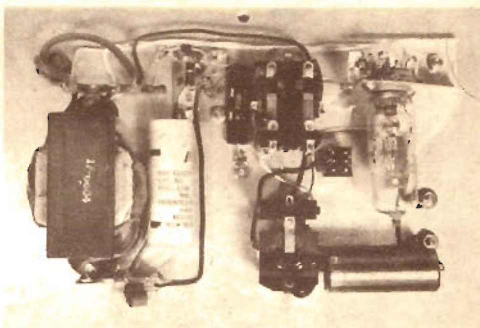


Fig. 6—Power-supply panel. Time delay relay RY3 is the tube at the upper right. Its socket is mounted on a small L-bracket made of scrap aluminum.

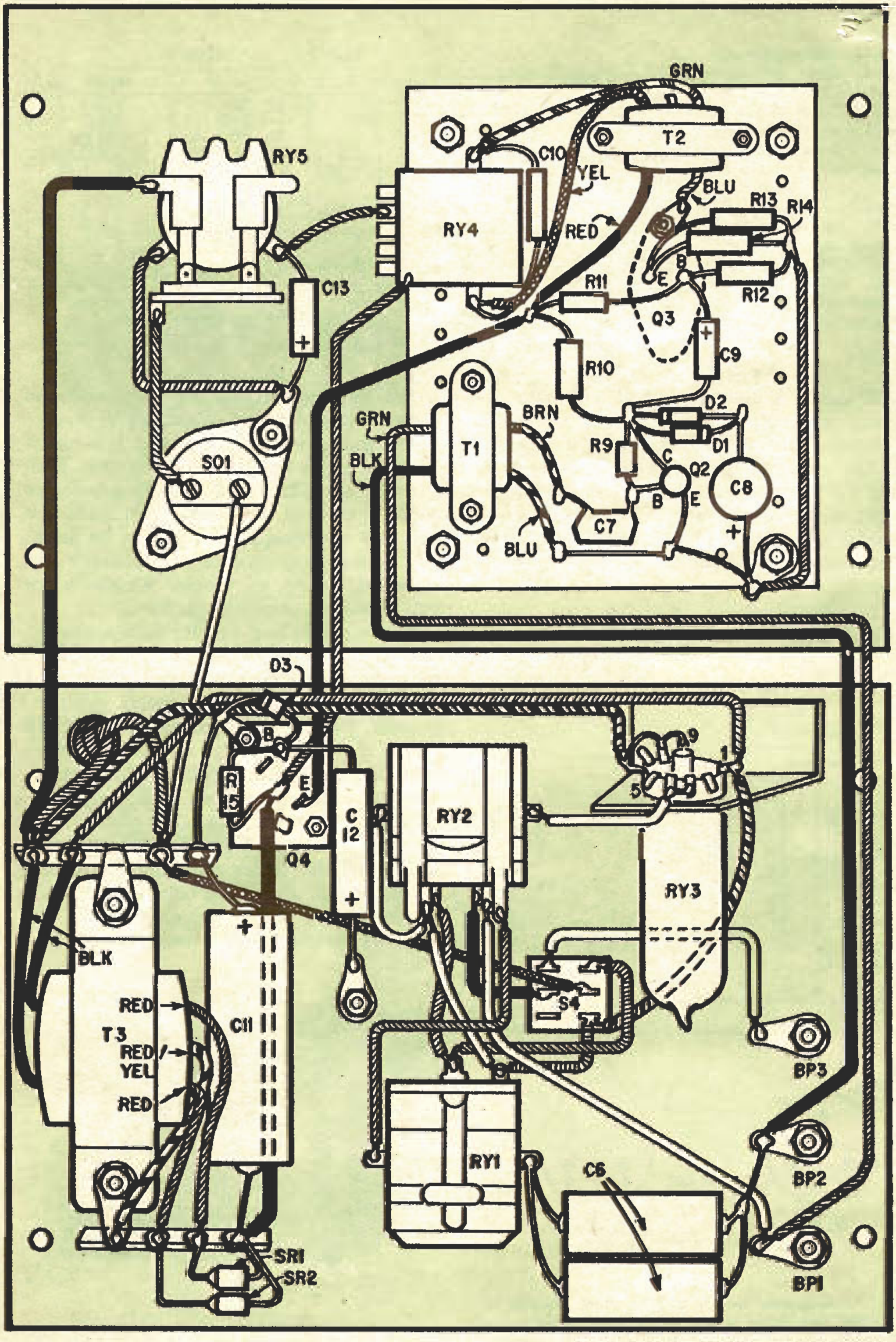


Fig. 7—Amplifier panel, top and power-supply panel, bottom. Note on amplifier circuit board that Q3 is mounted on underside of board and wires are soldered directly to its leads. Make sure Q3's case (collector) doesn't touch aluminum panel. Transistor Q4 is installed on panel with a special mounting kit.

Tele Remote Control

washers under the amplifier's mounting holes. Slide a 9-V battery into the upper right corner. Mark off the holes for the tone pushbutton switches and power switch S3.

Note that the schematic shows three pushbutton switches, Sx, S1 and S2. Switches S1 and S2 are required for each tone. If you use a single tone, position S1 opposite the speaker magnet. If you want two tones position S2 between the first switch and the amplifier. Additional tones would be produced by Rx and Sx shown in the schematic as dotted lines.

With the speaker, amplifier and battery in position, cut an L-section of perforated board, with the dimensions shown in Fig. 3. Drill three mounting holes to line up with the speaker's mounting screws. Remove the board and assemble the oscillator.

Wire most of the oscillator, Q1, R1, R2, R3, R4, C1, C2 and C3. The lugs of pot R1 will fit the spacing between two holes. Drill the holes for the mounting tabs with a No. 4 bit. Note that R1 has only two terminals—the body is the wiper contact. Make certain you solder a jumper between the body and one terminal, as shown.

Mount the speaker with ⅝ in. long screws. Then, run down a second set of nuts on three of the screws until they're ¼ in. from the top. Install the amplifier on its standoffs and then mount the oscillator on the speaker's mounting screws. Only two nuts are used to hold the oscillator board; do not use a nut at the upper left corner as it may jam R1. Mount a miniature terminal strip on the left amplifier mounting screw. Finish the tone-generator wiring.

Checking The Tone Generator. Connect the battery and press both S1 and S3. Press S3 with your thumb and S1 with your third finger. Using a small screwdriver adjust R1. If you hear the tone when the switches close, adjusting R1 should change the frequency. If there is no tone when the switches are closed, adjusting R1 should start the oscillator. If the oscillator doesn't start, check for a wiring error in the oscillator or in the connection to the amplifier.

Finally, drill six or more 3/16-in. holes in the cabinet cover directly behind the exposed part of the speaker cone. This is necessary because closing the cover loads the speaker and slightly alters the output tone.

PARTS LIST

B1—9-V battery (Burgess 2U6 or equiv.)
BPA,BP1,BP2,BP3—Five-way binding post
Capacitors:
C1,C2,C3—.05 µf, 30 V or higher ceramic disc
C4—10 µf, 6 V electrolytic
C5—100 µf, 12 V electrolytic
C6—4 µf, 100 V electrolytic (see text)
C7—.25 µf, 30 V or higher ceramic disc
C8,C12—100 µf, 12 V electrolytic
C9—1 µf, 12 V electrolytic
C10—.5 µf, 30 V or higher ceramic disc
C11—500 µf, 25 V electrolytic
C13—160 µf, 25 V electrolytic
D1,D2—1N34A diode
D3—9.1 V zener diode (Motorola HEP-104)
Q1,Q2—2N2613 transistor (RCA)
Q3—2N301 transistor (RCA)
Q4—Power transistor (Lafayette 19 T 4205)
Resistors: 10% unless otherwise indicated (R3 through R8, ¼ watt. Others ½ watt)
R1,R2,Rx—3,000 ohm, linear-taper trimmer potentiometer (Mallory MTC-4 Minitrol, Lafayette 33 T 1674, or equiv.)
R3,R8,R10—4,700 ohms R4,R9—470,000 ohms
R5,R12—3,300 ohms R6—22,000 ohms
R7—150 ohms R11—33,000 ohms
R13,R14—10 ohms R15—560 ohms
RY1—SPDT relay; 115 VAC, 1,500-ohm coil (Allied 41 B 4652 or equiv.)
RY2—DPDT relay; 115 VAC, 1,500-ohm coil (Allied 41 B 4657)
RY3—20-second miniature time-delay relay; normally-closed contacts, 115-V heater (Amperite 115C20T, Allied 41 B 5296 C-115C20T)
RY4—Five-channel resonant-reed relay (Lafayette 42 T 6101)
RY5—DPDT relay, 12-VDC coil (Potter & Brumfield KT11D-12 VDC, Lafayette 30 T 8696 or equiv.)
S1,S2,S3,Sx—Miniature pushbutton switch
S4—DPDT switch (center off)
SP1—10 ohm, 2½-in. speaker
SR1,SR2—Silicon rectifier; 750 ma, 50 PIV
T1—Transistor driver transformer; primary: 1,000 ohms, secondary 100 ohms. (Lafayette 33 T 8549)
T2—Transistor interstage transformer; primary, secondary: 500 ohms (Allied 54 B 4174)
T3—Filament transformer; secondary 24 V center tapped @ 1 A (Allied 54 B 4710)
Misc.—Three-transistor miniature audio amplifier (Lafayette 99 T 9039. Modified, see text)

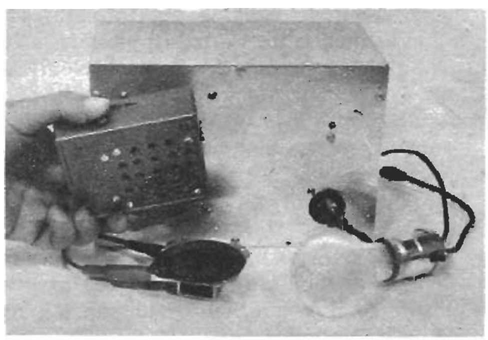


Fig. 8—To test receiver, plug a small lamp in SO1 and connect speaker to BO1,BP2. Press S1 and S3 on tone generator and light should come on.

Building The Receiver. The receiver is built on the front and rear panels of a 6 x 9 x 5-in. aluminum utility cabinet. One rear panel contains the regulated power supply and telephone-answering relays and the other panel contains the amplifier-limiter, resonant-reed relay, the control relay and the power outlet.

For two-wire phone lines, that is, where two wires are used for both the talking and ringing, install three binding posts—BP1, BP2 and BP3. If yours is a party line, where the ringing and talking pair are separate, install binding post BPA, break the connection to transformer T1 as shown, and install the connection to BPA as indicated by the dotted line. BPA and BP3 will then be connected to the talking pair and BP2 is connected to the ringing wire.

Build the power supply first, close to the right edge of the panel. Regulator transistor Q4 uses the panel as a heat sink, but it must be electrically insulated from the panel. Use a mounting kit (Lafayette 19 T 1531) which includes a thin mica insulator to fit between the transistor and the panel.

While Q4 may be any inexpensive PNP power transistor, such as a 2N301, do not substitute for the specified D5—a Motorola HEP-104 zener diode. Relay RY5's contact arrangement depends on how you use the control; we show only a single set of contacts used to switch 117 VAC for the latching relay.

Relay RY3 is an Amperite time-delay relay (it looks like a tube) which disconnects the receiver from the line, to permit additional incoming calls to get through. The RY3 specified in the Parts List provides a 20-second delay before disconnect—plenty of time to get your tones through. If you need more time use a relay with a longer on-time—up to several minutes is available. Additional types are listed in Allied's catalog. Just make certain you get one with normally-closed contacts.

Switch S4 is a DPDT with a center-off position. A standard DPDT switch may be substituted if you're willing to pull the AC plug each time the receiver is reset from the test position.

When the power supply panel is completed check it out as follows: Connect the positive lead of a VOM (10-VDC range) to the panel and connect the negative lead to Q4's collector terminal. Plug in the AC plug and, using an insulated screwdriver, press down RY2's armature. If RY2 fails to lock-in there is a wiring error at RY2's contacts. As soon as RY2 closes the meter should indicate from 9.1 to 9.6 V. If you fail to get an indication set the meter to measure 25 VAC and connect it across T3's secondary. If the meter indicates 24 VAC check for a wiring error in the power supply. If there is no voltage across T3's secondary, check that the line voltage is being fed into and through RY3.

After 20 seconds, or whatever time RY3 is rated for, RY3 should open and release RY2. After about 15 seconds RY3 will close, allowing the power supply to be re-cycled.

The amplifier is assembled on a 3 x 4¼ in. piece of perforated board. As with the tone generator, flea clips or Vector T28 terminals can be used for tie points. Since the frame of reed relay RY4 is also a contact, it must be mounted on the amplifier board to avoid a short to the chassis. Relay RY4's frame is drilled for 6-32 mounting screws. While T1 can be any 100 to 1,000-ohm transformer, T2 *must* be the type specified in the Parts List.

Transistor Q3 is mounted on the underside of the board, with its terminals protruding through the board to the top, or wiring, side. Connection is made directly to Q3's emitter and base leads.

Use spacers to raise the board away from the front panel. To prevent Q3's case, which is the collector, from touching the panel, place several layers of tape on the panel directly under Q3.

Capacitor C13 is not used to reduce RY5's kick-back voltage; don't replace it with a diode. Since the voltage fed to RY5 has a low average value, C13 is used to charge to the full 12 V necessary to close RY5. While capacitor C10 is specified as 0.5 μf, it may be cheaper to use two parallel-connected 0.25 μf capacitors.

Capacitor C10 resonates T2 and RY4's coil to the operating frequencies. If you substitute a different reed relay, it will be necessary to determine the new value for C10. Connect an AC voltmeter across RY4's coil, feed in a .01-V signal to the amplifier at about the center frequency of the reeds, and

[*Continued on page* 111]

Tele Remote Control

Continued from page 44

determine which capacitor value gives the highest voltage across C10.

Note that C13, RY5 and S01 are connected to a single reed-relay terminal. Additional control circuits, identical to C13, RY5 and S01 may be connected to the other reeds.

Checkout and Operation. Connect a 117-VAC lamp to S01 and any small speaker to test terminals BP1 and BP2. Temporarily connect a jumper across RY3's No. 3 and No. 8 terminals. Plug the unit in and set S4 to the *test* position—RY2 should close. Hold the tone generator directly over the speaker and press S1 and S3. Using a small screwdriver, adjust R1 until the correct reed vibrates, as indicated by the test lamp coming on. Move the tone generator as far as possible from the test speaker and readjust R1—the object is to set R1 so the reed relay vibrates with the minimum possible input signal from the tone generator.

Disconnect the temporary jumper across RY3's lugs and connect the unit to the phone lines. Set S4 to *on*. Make certain if you have a three wire circuit that BPA and BP3 are connected to the talking pair.

Have your friend or neighbor call you. At or before you hear the first ring, RY1 will close, the ringing signal will stop and RY2 will close. Relay RY1 will release and remain open. After about 20 seconds RY3 should release RY2, readying the unit for the next call.

Keying The Remote. We recommend that each time you plan to use the control that you check out the control unit through the test binding posts (BP1, BP2). Hard knocks may jar the settings of R1.

We suggest R1 be adjusted at about 70° room temperature as an increase in the ambient temperature will cause the output frequency to rise very slightly.

When operating the tone generator, always press S3 first, then S1 (it may be done almost simultaneously) and move the control within ½ to ¼ in. of the telephone mouthpiece. Make one single tone burst of approximately one second as soon as you hear the ringing signal stop. Then make certain you release S3 before S1. Hold S1 down for about 1 second after you release S3. When releasing, S3 opens the connection from the battery, C5 discharges, taking about ½ second to discharge. The decreasing voltage from C5 causes the control tone to glide down slightly, and it is the glide tone that compensates for changes in the control unit's basic frequency.

If you release S1 before S3, there will be no glide-tone, and if the control has drifted off-frequency the receiver will fail to operate. Therefore, the rule is: activate S3 first, and release it first.