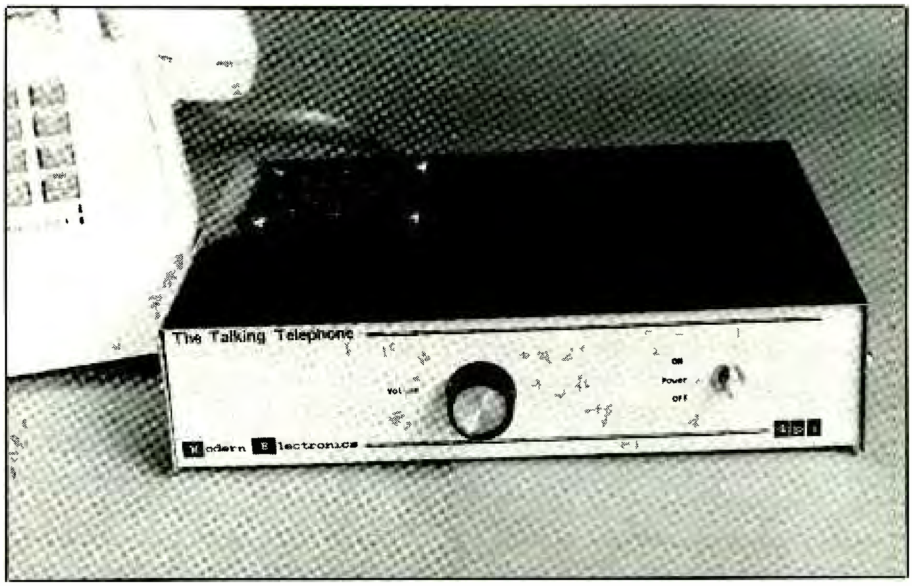
A Talking Telephone

Vocalizes each number digit as you "dial" it on a Touch Tone-type keypad

By Steve Sokolowski



The circuit presented here will actually "speak" the number you dial as you key it in on a telephone Touch Tone-type keypad. It accomplishes this with the aid of the Digitalk Speech Synthesizer made by National Semiconductor.

Aside from its novelty, this project has its practical side. It is an excellent means for eliminating mis-dialed telephone numbers because it serves as a form of "error correction" as you "dial" the digits of a telephone number. As you listen, you can tell if you touched a wrong key and, if so, terminate the operation before the misdialed number gets through your telephone office and you are charged for a wrong number. This feature is particularly handy for the visually handicapped, who can also vocally verify that they have dialed correctly.

About the Circuit

Before getting into how the Talking Telephone works, it is important that you know something of how a standard telephone instrument works. Though there are two main types of telephone instruments—rotary-dial (or pulse) and Touch Tone-types—the latter are far more commonly found in the modern home and office. Because of its widespread use, the Talking Telephone was designed around the Touch Tone system.

Touch Tone dialing was developed by Bell Telephone some 20 years ago. It uses pairs of eight specially selected audio tones that are further divided into groups of four low and four high tones. Because tone pairs are used for each digit in the telephone number, the system of dialing used is technically known as "Dual Tone Multi Frequency" (DTMF) dialing. A genuine DTMF tone is the algebraic sum of one tone from each of the low- and high-frequency groups.

How these tones are used can be visualized by referring to Fig. 1. In (A) is shown the waveform of an 825-Hz sinusoid that is generated by simultaneously pressing Row 3 buttons 7, 8 and 9 on the Touch Tone-compatible keypad. The 1,336-Hz sinusoid waveform generated by the tone dialer if Column 2 buttons 2, 5, 8 and 0 are pressed simultaneously is illustrated in (B). Now, if only button 8 on the keypad is pressed, internal circuitry sums these two tones to produce the waveform illustrated in (D).

The conventional tone-type keypad has only 12 buttons for the numerals 0 through, * and #. However a complete DTMF keypad can have 16 buttons in all—the usual 12 plus four more labeled A through D (see Fig. 2). These last four buttons are used for communication with special equipment and, as a result, are rarely included on standard home and office telephone instruments.

By using a special DTMF receiver integrated circuit, the dialing tones of the telephone instrument can be converted into binary codes that can subsequently be fed into the Data input of the Digitalker IC. These binary codes are converted by the Digitalker chip into words that are vocalized through a speaker.

The specialty integrated circuit that accomplishes the above is the G8870 DTMF Receiver chip manufactured by California Micro Devices. It is quite sophisticated, as demonstrated by the block diagram of its internal circuitry shown in Fig.

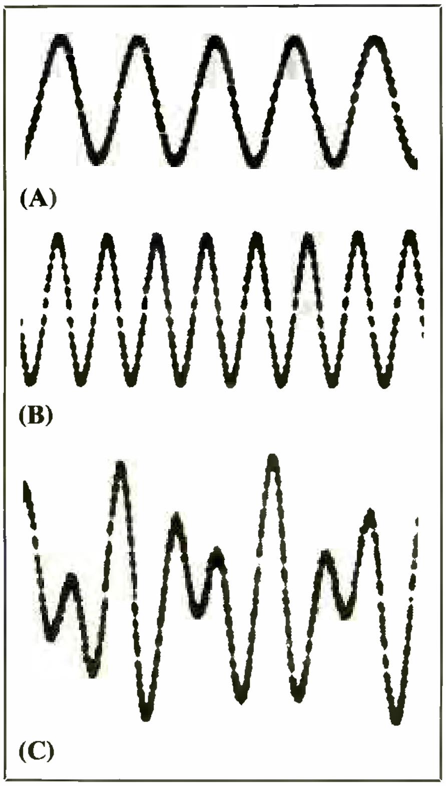


Fig. 1. Examples of DTMF tones generated when (A) a Row 3 button is pressed on the dialing keypad (582 Hz); (B) a Column 2 button is pressed (1,336 Hz); and (C) the "8" button is pressed (algebraic sum of Row 3 and Column 2 signals).

3 (its case configuration and pin assignments are shown in Fig. 4). Considering the internal complexity of this chip, its retail price of about $10 provides a very cost-effective way to go for designing and building inexpensive telephone-related projects.

A tone-dial telephone instrument produces a dual-tone (two-tone) output whose unique frequencies are rigidly determined by the Row and Column of the switching matrix for each particular button in the keypad. When it was first introduced in the 1960s, the Touch Tone dialer was made from a comparatively large number of inductors and capacitors that produced pure sine-wave output signals. In contrast, modern DTMF keypads use crystal-controlled integrated circuits that generate the synthesized stair-step waveform illustrated in Fig. 5.

Though the step waveform produced by modern tone-type keypads may only crudely approximate the sine waveform, DTMF receiving equipment like the G8870 can receive and decode every tone into its corresponding binary output (see Table 1). It is this output code that is converted by another integrated circuit—a preprogrammed 74188 PROM that has been programmed with the appropriate data)—into the required digital code that is then delivered to the input of the Digitalker.

Refer now to the schematic diagram of the of the basic Talking Telephone circuitry shown in parts (A) and (B) of Fig. 6. The G8870 DTMF Receiver chip and programmed 74188 PROM are shown as *IC1* and *IC2*, respectively, in part (A). It is the eight-bit output of *IC2* at pins 1 through 7 that is fed to the inputs at pins 15 through 9, respectively, of MM54104 Digitalker chip *IC3* in part (B). Each eight-bit input that is delivered to *IC3* (burnt into *IC2*) selects the word—or in the case of our Talking Telephone the number—*IC3* is to vocalize when a key on the telephone instrument's keypad is pressed.

Actual vocalization of any given digit is the responsibility of the Digitalker chip. This chip, *IC3* in Fig. 6(B), stores complete words in its two support SSR1 and SSR2 chips. (The three-chip set is available for about $25 from Jameco Electronics.) The MM54104 specified for *IC3* is the heart of the Digitalker set. This 40-pin DIP device has eight data lines on which the binary code of the word (or

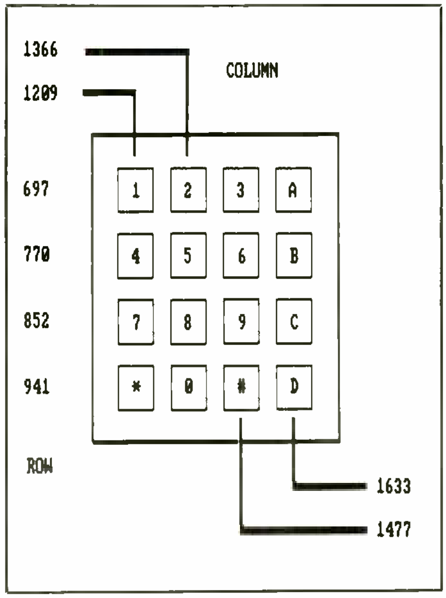


Fig. 2. A tone-type DTMF dialing keypad can have a total of 16 keys, though all but the ones labeled "A" through "D" are normally found on current home and business telephone instruments.

Table 1. Tone Keypad Frequencies and Binary Codes

Button	Low Frequency Component (Hz.)	High Frequency Component (Hz.)	HEX Output Format 3	2	1	0
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0
A	697	1633	1	1	0	1
B	770	1633	1	1	1	0
C	852	1633	1	1	1	1
D	941	1633	0	0	0	0

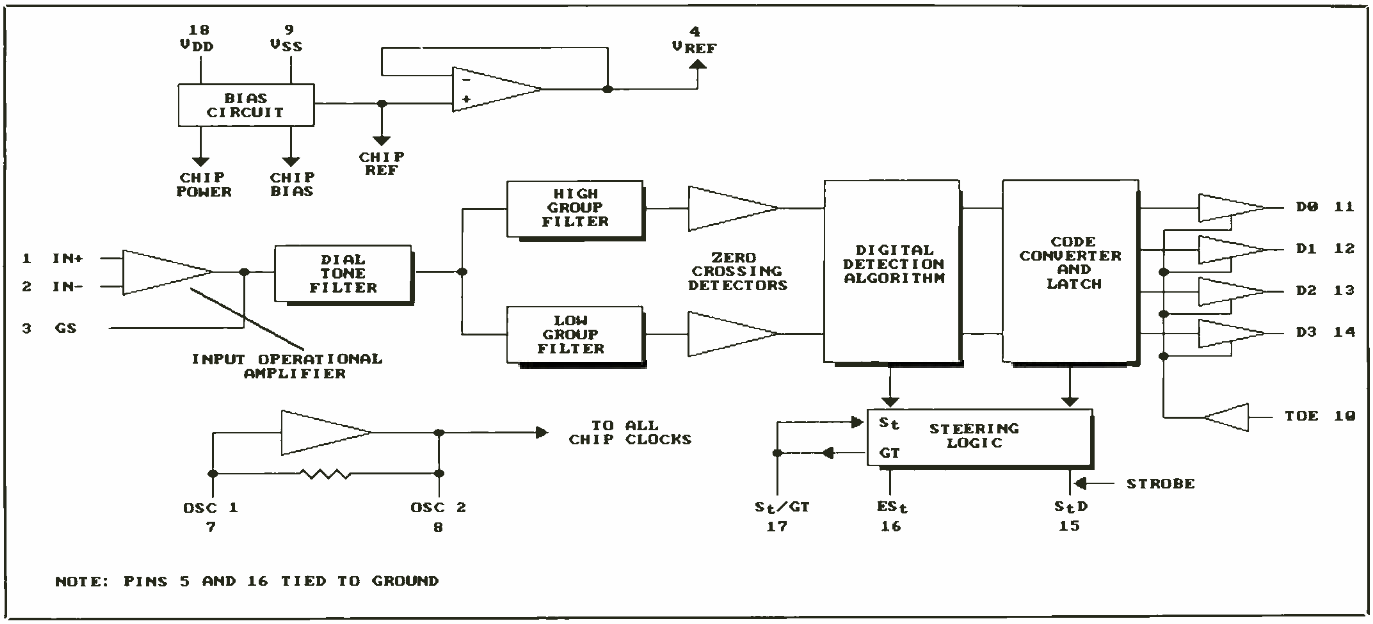


Fig. 3. Block diagram of circuitry inside the G8870 DTMF Receiver chip.

number) you wish to be vocalized through a speaker is placed.

Table 2 lists the 11 binary codes you need for this project. These are all contained inside the SSR1 RAM that comes as a basic element in the Digitalker kit. Since the SSR2 RAM is not needed in this project, store it away in a safe place. You may want to use it at some future time for another talking circuit.

So far, we have discussed the device that converts the DTMF signal of a tone dialer into a binary code and the Digitalker that accepts this code as input and transforms it into the word that is to be vocalized. How this is accomplished is as follows.

Pins 1 and 2 of *IC1* in Fig. 6(A) connect directly across the telephone line through the *C1/R1* and *C2/R2* networks, respectively. This input allows the DTMF signal that is generated by pressing one of the keys on the tone dialer to be passed to the complex filtering and switching electronics inside *IC1*. The binary code that corresponds to the key pressed, listed in Table 1, is made available at pins 11 through 14 of *IC1*.

Compare Tables 1 and 2 for a moment. The whole idea of this project

Table 2. Digitalker Vocabulary List

Word	Address SW8	SW1	Word	Address SW8	SW1	Word	Address SW8	SW1
This is Digitalker	0000	0000	Q	0011	0000	IS	0110	0000
ONE	0000	0001	R	0011	0001	IT	0110	0001
TWO	0000	0010	S	0011	0010	KILO	0110	0010
THREE	0000	0011	T	0011	0011	LEFT	0110	0011
FOUR	0000	0100	U	0011	0100	LESS	0110	0100
FIVE	0000	0101	V	0011	0101	LESSER	0110	0101
SIX	0000	0110	W	0011	0110	LIMIT	0110	0110
SEVEN	0000	0111	X	0011	0111	LOW	0110	0111
EIGHT	0000	1000	Y	0011	1000	LOWER	0110	1000
NINE	0000	1001	Z	0011	1001	MARK	0110	1001
TEN	0000	1010	AGAIN	0011	1010	METER	0110	1010
ELEVEN	0000	1011	AMPERE	0011	1011	MILE	0110	1011
TWELVE	0000	1100	AND	0011	1100	MILLI	0110	1100
THIRTEEN	0000	1101	AT	0011	1101	MINUS	0110	1101
FOURTEEN	0000	1110	CANCEL	0011	1110	MINUTE	0110	1110
FIFTEEN	0000	1111	CASE	0011	1111	NEAR	0110	1111
SIXTEEN	0001	0000	CENT	0100	0000	NUMBER	0111	0000
SEVENTEEN	0001	0001	400HZ TONE	0100	0001	OF	0111	0001
EIGHTEEN	0001	0010	80HZ TONE	0100	0010	OFF	0111	0010
NINETEEN	0001	0011	20MS SILENCE	0100	0011	ON	0111	0011
TWENTY	0001	0100	40MS SILENCE	0100	0100	OUT	0111	0100
THIRTY	0001	0101	80MS SILENCE	0100	0101	OVER	0111	0101
FORTY	0001	0110	160MS SILENCE	0100	0110	PARENTHESIS	0111	0110
FIFTY	0001	0111	320MS SILENCE	0100	0111	PRECENT	0111	0111
SIXTY	0001	1000	CENTI	0100	1000	PLEASE	0111	1000
SEVENTY	0001	1001	CHECK	0100	1001	PLUS	0111	1001
EIGHTY	0001	1010	COMMA	0100	1010	POINT	0111	1010
NINETY	0001	1011	CONTROL	0100	1011	POUND	0111	1011
HUNDRED	0001	1100	DANGER	0100	1100	PULSES	0111	1100
THOUSAND	0001	1101	DEGREE	0100	1101	RATE	0111	1101
MILLION	0001	1110	DOLLAR	0100	1110	RE	0111	1110
ZERO	0001	1111	DOWN	0100	1111	READY	0111	1111
A	0010	0000	EQUAL	0101	0000	RIGHT	1000	0000
B	0010	0001	ERROR	0101	0001	SS (Note 1)	1000	0001
C	0010	0010	FEET	0101	0010	SECOND	1000	0010
D	0010	0011	FLOW	0101	0011	SET	1000	0011
E	0010	0100	FUEL	0101	0100	SPACE	1000	0100
F	0010	0101	GALLON	0101	0101	SPEED	1000	0101
G	0010	0110	GO	0101	0110	STAR	1000	0110
H	0010	0111	GRAM	0101	0111	START	1000	0111
I	0010	1000	GREAT	0101	1000	STOP	1000	1000
J	0010	1001	GREATER	0101	1001	THAN	1000	1001
K	0010	1010	HAVE	0101	1010	THE	1000	1010
L	0010	1011	HIGH	0101	1011	TIME	1000	1011
M	0010	1100	HIGHER	0101	1100	TRY	1000	1100
N	0010	1101	HOUR	0101	1101	UP	1000	1101
O	0010	1110	IN	0101	1110	VOLT	1000	1110
P	00101	111	INCHES	0101	1111	WEIGHT	1000	1111

NOTE 1: "SS" makes any single word plural
NOTE 2: Address 143 (WEIGHT) is the last legal address in this particular word list.
Exceeding address 143 will produce pieces of unintelligible invalid speech data.

is to have the Digitalker vocalize a predefined word when a specific binary code is placed on its Data Input bus, shown as SW8 through SW1 at pins 8 through 15 in Fig. 6(B). For illustrative purposes, let us assume that the "1" button on the dialer keypad is pressed. Table 1 indicates that this would generate a binary code of 0001. Table 2 indicates that a binary code of 00000001 is placed on the Data Bus of *IC3*, causing the Digitalker to vocalize the word "one."

Now let us assume that the "5" button on the dialer keypad is pressed, which causes *IC1* in Fig. 6(A) to output the binary code 0101, as indicated in Table 1. Table 2 shows that this code will cause the Digitalker to vocalize the word "five." Let us take this a bit further by assuming that the "0" key is pressed, causing the binary code 1010 to be generated, according to Table 1. Referring to Table 2, the binary code 1010 will cause the word "ten" to be vocalized. Obviously, this is not what is wanted. One of the tasks assigned to *IC2* is to correct for this situation for our particular application.

ROM *IC2* can be programmed to deliver the 0001 1111 binary output of the word "zero" every time its input code is the 1010 binary code for decimal 10. This programming can also be taken a step further. Suppose you press the "*" or "#" key on the dialer keypad. Table 2 indicates that if you press either key, the Talking Telephone would ordinarily vocalize the words "eleven" and "twelve," respectively. By programming *IC2* to deliver the binary code for a 400-Hz tone burst (0100 0001) every time either of these keys is pressed, you eliminate mis-spoken words.

The second task of *IC2* is to correct a problem associated with the G8870 chip used for *IC1*. If you compare the pinouts of the G8870 given in Fig. 4(A) with those of the 74188 or 8223 used for *IC2* in Fig. 4(B), you will see that the Data Output lines of the former are in reverse of those of the latter. Normally, pin 10 of the 74188 or 8223 is reserved for a Data 0 input. At this physical location, *IC1* delivers a Data 3 output. This dilemma can be corrected by programming *IC2* to output a binary code that is the reverse of the original.

To resume our explanation where we left off, pins 1 and 7 of *IC2* deliver the appropriate binary code to the Data Input bus of *IC3* at pins 8 through 15. To allow the Digitalker to output a signal that will vocalize the selected word, a logic-1 pulse must be applied to the pin 4 Write Strobe input of *IC3* in Fig. 6(B). Returning to Fig. 6(A), the pin 10 Strobe Output of *IC1* produces the

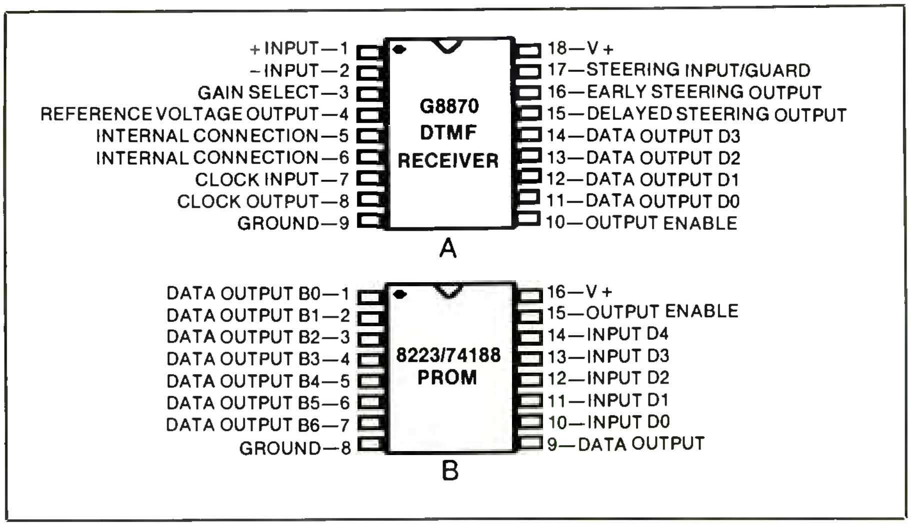


Fig. 4. Package configurations and pinouts for (A) G8870 DTMF Receiver and (B) 8223 or 74188 PROM.

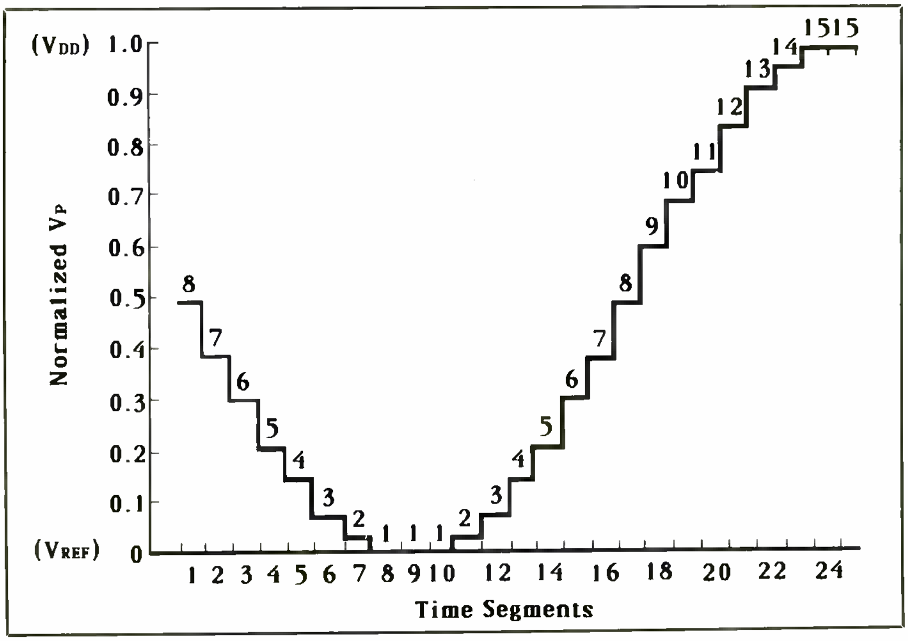
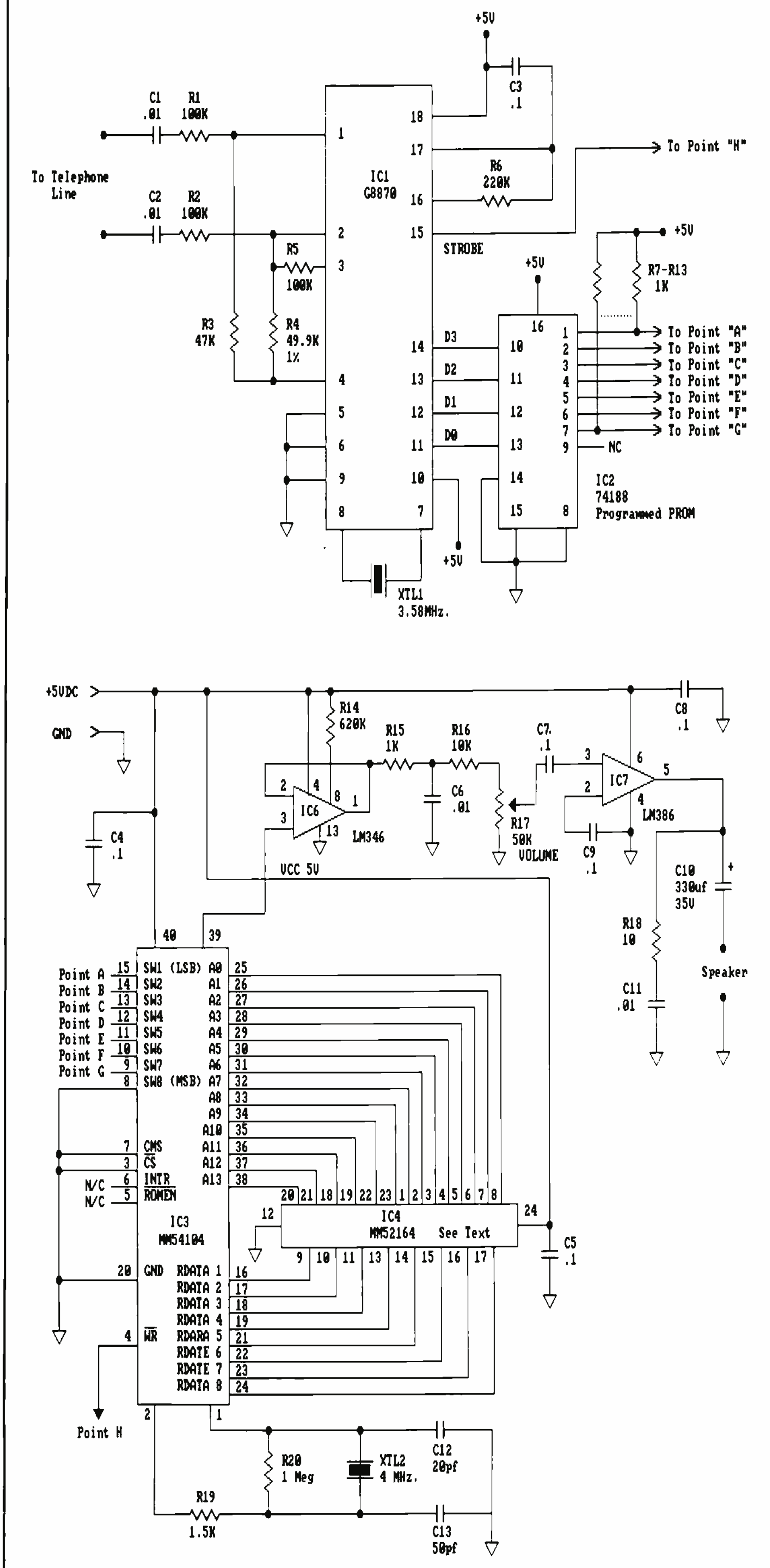


Fig. 5. Modern DTMF keypads use crystal-controlled ICs that generate a synthesized stair step wave that is a crude approximation of the pure sinusoid wave produced by original DTMF dialers.



required positive-going pulse every time a valid tone is detected at the input of this IC.

The positive-going pulse is coupled directly to pin 4 of *IC3* in Fig. 6(B). When any key on the dialer keypad is pressed, two actions occur. The first is placement of the appropriate binary code on the Data Input lines of *IC3*. The second is that the needed positive-going pulse is generated by the DTMF Receiver and is available at pin 10 of *IC1* in Fig. 6(B).

The MM52164 shown in Fig. 6(B) as *IC4* is the SSR1 ROM that is programmed with the vocabulary data listed in Table 2.

Resistors *R15* and *R16* and capacitor *C6* in the *IC6* circuit make up a filter, while *IC7* is a low-voltage power amplifier whose output level is adjustable by VOLUME control *R17*. Vocalization is accomplished by capacitively coupling the output at pin 5 of *IC7* through *C10* to a small speaker as shown.

Power for the Talking Telephone is provided by a common 9-volt, 500-milliampere dc plug-in wall power supply, as shown in Fig. 7. The raw dc output from this power supply is filtered by *C4* and regulated to 5 volts by regulator chip *IC5*. It is then delivered to the circuitry shown in Fig. 6.

Construction

There is nothing critical about component layout or conductor routing when assembling this project. Therefore, you can use either printed-circuit wiring or point-to-point wiring on perforated board that has holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware. Whichever approach you choose, it is a good idea to use sockets for all DIP integrated circuits.

If you wish, you can fabricate your

Fig. 6. Schematic diagram of basic Talking Telephone circuitry shown in two parts.

PARTS LIST

Semiconductors
IC1—G8870 DTMF receiver (see text)
IC2—74188 or 8223 programmed PROM (see text)
IC3—MM54104 Digitalker (see text)
IC4—MM52164 SSR1 RAM (part of Digitalker IC kit; SSR2 chip is not used—see text. Available from Jameco—see text)
IC5—7805K fixed +5-volt regulator in TO-3 case
IC6—LM346 operational amplifier
IC6—LM386 audio power amplifier

Capacitors
C1,C2,C6,C11—0.01-μF ceramic disc
C3,C5,C7,C8,C9—0.1-μF ceramic disc
C4—220-μF, 35-volt radial-lead electrolytic
C10—330-μF, 35-volt axial-lead electrolytic
C12—20-pF ceramic disc
C13—50-pF ceramic disc

Resistors (¼-watt, 5% tolerance)
R1,R2,R5—100,000 ohms
R3—49,000 ohms
R4—49,900 ohms (1% tolerance)
R6—220,000 ohms
R7 thru R13,R15—1,000 ohms
R14—620,000 ohms
R16—10,000 ohms
R18—10 ohms
R19—1,500 ohms
R20—1 megohm
R17—50,000-ohm, audio-taper panel-mount potentiometer

Miscellaneous
T1—9-volt, 500-mA dc plug-in power supply
XTL1—3.58-MHz colorburst crystal
XTL2—4-MHz crystal
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for all DIP ICs; suitable enclosure; telephone line cord; small rubber grommets (see text); heat sink and insulator kit for voltage regulator (see text); spacers; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Steve Sokolowski, P.O. Box 8535, Spring Hill, FL 34606: Ready-to-wire double-sided pc board with plated-through holes, $21.50; G8870 DTMF Receiver chip, $10.50; programmed 74188 PROM, $5.75; 3.58-MHz crystal, $1.75; telephone T adapter, $2.25. Include $2.75 P&H per order. Florida residents, please add state sales tax.

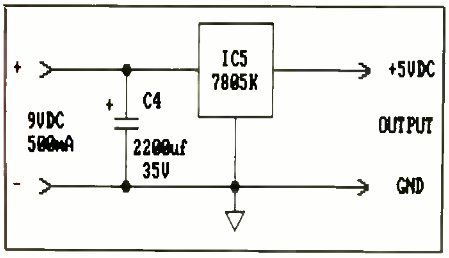


Fig. 7. Schematic diagram of power-supply circuitry for Talking Telephone.

own printed-circuit board for the project using the actual-size etching-and-drilling guides shown in Fig. 8. Note here that this is a double-sided board. You can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List. This board has plated-through holes, which allows you to complete all soldering on the solder side of the board.

If you home fabricate your pc board, bear in mind that it will *not* have plated-through holes. Thus, you *must* solder all component leads and pins to the copper pads on *both* sides of the board. Also, without plated-through holes, you cannot use conventional IC sockets that do not provide soldering access on the top side of the board. Therefore, use Molex Soldercon® socket strips in place of conventional sockets.

Orient the pc board on your work surface as shown in Fig. 9 (make certain that its component side is facing up) and begin wiring it by installing and soldering into place the IC sockets. Do *not* install the ICs in the sockets until after you have conducted voltage checks and are certain that your wiring is correct. (Note: Use Fig. 9 as a rough guide to component layout if you wire the project on perforated board, but refer back to Fig. 6 and Fig. 7 for wiring details.)

With the sockets in place, install and solder into place the resistors, noting that all but one of them above *IC3* mount on-end. Note also that one lead of *R7* through *R13* just above *IC3* pass through holes in the board and solder into place. The remaining resistor leads tie together to form a single-conductor "bus" that plugs into the hole to left of the resistor network and solders into place. The method of accomplishing this is shown in the detail drawing at the lower-right in Fig. 9.

Next, install voltage regulator *IC5* in the location shown. This IC is in a TO-3 case and must mount on a heat sink using an insulator and heat-transfer compound. If you are using a pc board that has plated-through holes, mount the regulator on its heat sink to the board using 4-40 × ¼-inch machine screws, nuts and lockwashers.

If you are using a board that does not have plated-through holes, loosely mount the regulator to the heat sink using 4-40 × ½-inch machine screws, lockwashers and nuts. Crimp and solder a 1-inch length of bare solid hookup wire or cut-off resistor lead to each pin of the regulator. Mount the regulator in place, using ¼-inch metal spacers and the machine hardware already loosely securing the it to the heat sink. Feed the screws through the holes in the "corners" of the regulator and then into holes in the board.

Make sure that the wires on the regulator pins go into the two holes in the board provided for the regulator pins and that a lockwasher is placed between the trace on the bottom of the board and nuts that fasten down the screws. Then solder the pins of the regulator to the pads on the bottom of the board that has plated-through holes or the wires to the pads on both sides of the board if you are

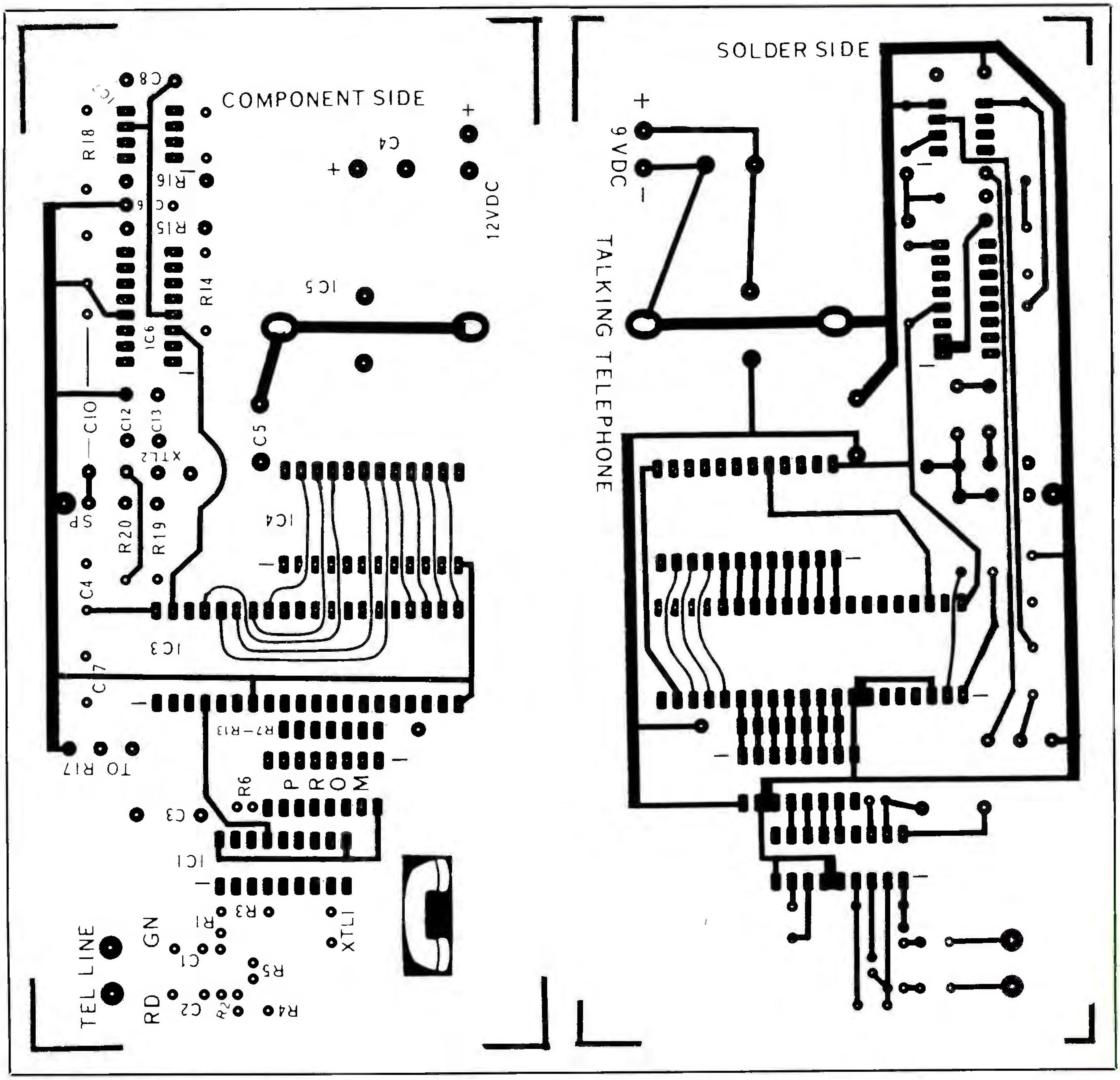


Fig. 8. Actual-size etching-and-drilling guides for top (left) and bottom (right) of double-sided printed-circuit board required for wiring together the project.

using a board that does not have plated-through holes.

Continue wiring the circuit-board assembly by installing and soldering into place the capacitors. Make sure the electrolytics are properly oriented before soldering their leads to the pads on the bottom of the board. Then install the crystals.

Strip ¼ inch of insulation from both ends of five 5-inch-long hookup wires. If you are using stranded hookup wire, tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder. Plug one end of the wires into the holes for the speaker and VOLUME control and solder into place. Temporarily set aside the circuit board.

Now prepare the enclosure that will house the project. You can use any type of enclosure that will accommodate the circuit-board assembly and provides mounting space for the speaker and VOLUME control. Machine the enclosure as needed. That is, drill four mounting holes for

(Continued on page 70)

the circuit-board assembly in the floor of the enclosure. Then drill a mounting hole for the control and entry holes for the plug-in wall power supply's cord and the incoming telephone line cord in the back panel. Finally, drill a series of small holes in the top panel to permit the sound from the speaker to escape. If you are using a metal enclosure or drilled holes through a metal panel, deburr them to remove sharp edges.

Secure the speaker in place, centered over the small holes you drilled for the sound to escape, with a thick bead of silicone adhesive. Allow the adhesive to set undisturbed for several hours and preferably overnight before proceeding.

Meanwhile, mount the VOLUME control in its hole and route the free ends of the plug-in power supply and telephone line cords through their entry holes. If there is a connector on the end of the either or both cords, clip it off and discard it before routing the free ends into the enclosure. Also, if you drilled the entry holes through a metal panel, line them with small rubber grommets. Tie a strain-relieving knot in each cord.

Prepare the free end of the power-supply cable by separating the two conductors a distance of about 1½ inch. Strip ¼ inch of insulation from the ends of both conductors, tightly twist together the fine wires exposed in each conductor and sparingly tin with solder. Use a dc voltmeter or a multimeter set to the dc-volts function to ascertain the polarity of the conductors with the power supply plugged into an ac outlet.

Making certain to observe correct polarity, plug the conductors of the unpowered power supply into the holes provided for them in the circuit-board assembly and solder into place. Then mount the circuit-board assembly into place with ½-inch metal spacers, 4-40 × ¾-inch machine screws, lockwashers and nuts. Locate the three wires for the VOLUME control and crimp and solder them to the lugs of the panel-mounted control as shown.

Carefully remove 1½-inch of outer plastic jacket from the free end of the telephone line cable. You need only the red- and green-insulated conductors of this cable. Strip ¼ inch of insulation from the ends of the red- and green-insulated conductors (clip away any other conductors you might have exposed when you removed the outer plastic jacket).

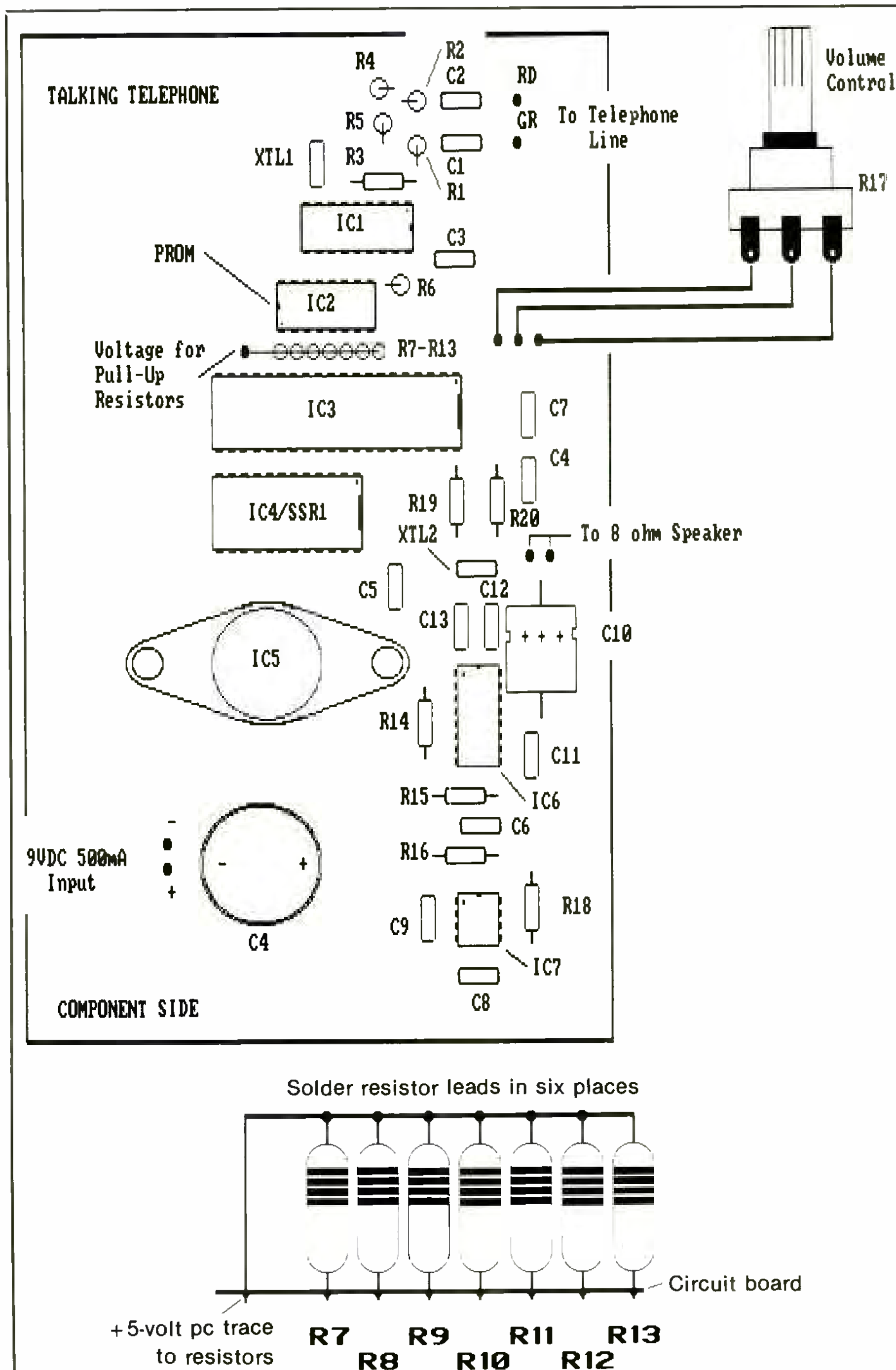


Fig. 9. Wiring diagram for printed-circuit board, with detail for mounting resistors on-end.

Tightly twist together the fine wires in each conductor and sparingly tin with solder.

As you did for the power-supply cord, plug the ends of the conductors in the telephone line cable into the holes provided for them in the board. Observe proper color coding before soldering these conductors into place.

Checkout & Installation

With only voltage regulator *IC5* installed on the circuit-board assembly, clip the common lead of a dc voltmeter (or multimeter set to the dc-volts function) to a convenient circuit-ground point in the project. Plug the power supply into a convenient ac outlet. Then touch the "hot" probe of the meter to pin 18 of the *IC1* socket, pin 16 of the *IC2* socket, pin 40 of the *IC3* socket, pin 24 of the *IC4* socket, pin 4 of the *IC6* socket and pin 6 of the *IC7* socket. In all cases, you should obtain a reading of +5 volts.

If you do not obtain the correct reading at all points, touch the "hot" probe to the OUTPUT pin of regulator *IC5*. Once again, the reading obtained should be +5 volts. If not, touch the "hot" probe to the INPUT pin of the regulator and note if you obtain a reading of approximately +9 volts. If not (or if a negative reading is obtained), power down the project and double check the polarity of the input voltage from the plug-in power supply. Correct the problem before proceeding.

Once you are certain that you have properly wired your Talking Telephone, unplug it from the ac line. Allow a minute or so for the charges to bleed off the electrolytic capacitors. Install the ICs in their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

At least two of the ICs in this project—*IC3* and *IC4*—are delicate MOS devices that require special anti-static handling procedures. Make sure you ground the project and yourself before attempting to remove these devices from their carriers and installing them in their sockets.

When the silicone adhesive has set enough to prevent the speaker from moving around, place the top half of the enclosure alongside the bottom half. Crimp and solder the free ends of the remaining two wires to the lugs of the speaker.

Without connecting the Talking Telephone to a phone line, just plugging its power supply into an ac outlet will cause the Digitalker to automatically announce: "This is Digitalker" in a female voice. This indicates that a majority of the circuitry is operational.

To further test the circuit, plug the telephone line cord into a standard telephone jack and set the VOLUME control to about halfway. If you do not have a free telephone jack into which to plug the project, use an adapter that will let you plug two devices into a single jack.

Lift the receiver of a nearby tone-dial telephone instrument that is connected to the same line to which the project is connected. Press each button and listen for the appropriate vocalization of the corresponding word from the Talking Telephone. Test all 10 buttons on the dialing keypad. Be sure to hang up between groups of three numbers so that you do not complete an unwanted call.

When you have ascertained that the project is operating properly for all 10 numeral buttons on the keypad, press the "*" and "#" buttons. You should hear a tone burst from the speaker as you press each of these two buttons.

When the project is not in use, the Talking Telephone should be turned off. You can accomplish this in either of two ways—unplugging the power supply from the ac outlet or installing a toggle or slide switch in series with the +9-volt line from the power supply to the project. ME