Build The Phone Pager

Here is a way to signal family members or co-workers that their presence is requested or that there is a phone call for them without putting a strain on you vocal cords

BY JIM COOKE

If your business or home has lots of telephone activity, the *Phone-Pager* project described in this article may be of interest you. The Phone-Pager has an adjustable beeper, a seven-segment display, an easy-to-customize graphics overlay, and connectors for access to the phone line. The unit also has its own DC power supply, so it does not have to draw power from the phone line.

Working in conjunction with standard touch-tone phones, the Phone-Pager allows you to non-verbally notify others of phone calls, dinner, business meetings, etc. You simply use your existing touch-tone phone as the sender, while the Phone-Pager listens for communications directed to it. The Phone Pager, which also works well with cordless phones, is a must for families with teenagers or for small businesses where rapid communication is needed.

In addition, its operation is simple. For example, let's say that you have two teenage children, and they each have an extension phone in their rooms; on top of that, there are extension phones in the kitchen and family room. Further, let's assume that each phone has a Phone-Pager connected to it.

In addition to being individually addressable, the Phone-Pager also has the ability to accept "wildcard" addressing as well as global addressing; *i.e.*, a unit can respond to more than one number. Now let's assume that child 1's unit is programmed to recognize numbers 1 and 2, and child 2's unit is set to recognize 4 and 5. Since both children use the family room, the Phone Pager there is set to recognize 1, 2, 4, or 5. Now, when a call comes in for child 1, you simply press the asterisk (*) key followed by 1 on your touch-tone phone. The purpose of the asterisk key is to inform all Phone-Pagers to "watch" for the next key press (number) to see if it matches what it's programmed for.

After pressing the asterisk key followed by the 1 key, the unit in child 1's room as well as the one in the family room is activated, causing them to sound a 2-second beeper as well as display the number (in this case 1) sent for 10 seconds. (Units not specifically addressed remain idle.) The number is used in our family room example to see exactly who the call is for.

With regard to global or wildcard addressing, in our example, child 1's unit was set to recognize numbers 1 or 2, so 1 could be a code meaning that there is a phone call for child 1; a 2 could mean come to dinner.

To make the Phone-Pager even more useful, pressing the asterisk key twice followed by the number is used to page all units, which then display the number entered. That basically overrides the specific address of the unit. That feature could be used if the person being paged has not answered the first page, or it could be used as a "calling-all-persons" message.

Theory of Operation. A complete schematic diagram of the Phone-Pager is shown in Fig. 1. The input to the circuit is fed through one of two telephone jacks (J1 or J2), which are parallel-connected to one another to allow the phone line to be daisy-chained between the wall jack and the telephone. Note the two jumpers (labeled JP1, JP2), which, if installed, would allow a single power supply to be shared between several units. By installing those jumpers, power is distributed between all connected units via pins 1 and 6 of J1 and J2. (To support two line-phone setups, pins 3 and 4 of J1 and J2 are tied together.)

The input signal is picked off pin 3 of the input jack and coupled to pin 2 of U3 (an SC11270 DTMF—*D*ual-*T*one *M*ulti*F*requency-decoder) through the C2/R2 combination. The other leg of the input (at pin 4) is coupled to ground via C3. Using two capacitors at the input provides AC coupling, while blocking any DC that might interfere with the operation of the circuit. Zener diode D1 clamps the input applied to pin 2 of U3 so that is does not exceed 5.1 volts, preventing very high ring voltages from reaching U3 and damaging the IC. Timing for U3 is provided by a 3.58 MHz crystal (XTAL1) that is connected through pins 7 and 8 to the units internal oscillator. Components C1 and R1 determine the response time of the chip.

When a valid DTMF signal—which consists of a low tone and a high tone mixed together—is delivered to U3, the signal is fed to U3's internal dial-tone filter. The signal is then separated into high and low tones, which are, in turn, fed to digital-detection-algorithm and code-convert/latch circuits. Table 1 gives high and low frequencies and the decoded logic outputs of U3 associated with each key. Note that only four different low tones (labeled *f*low) and four different

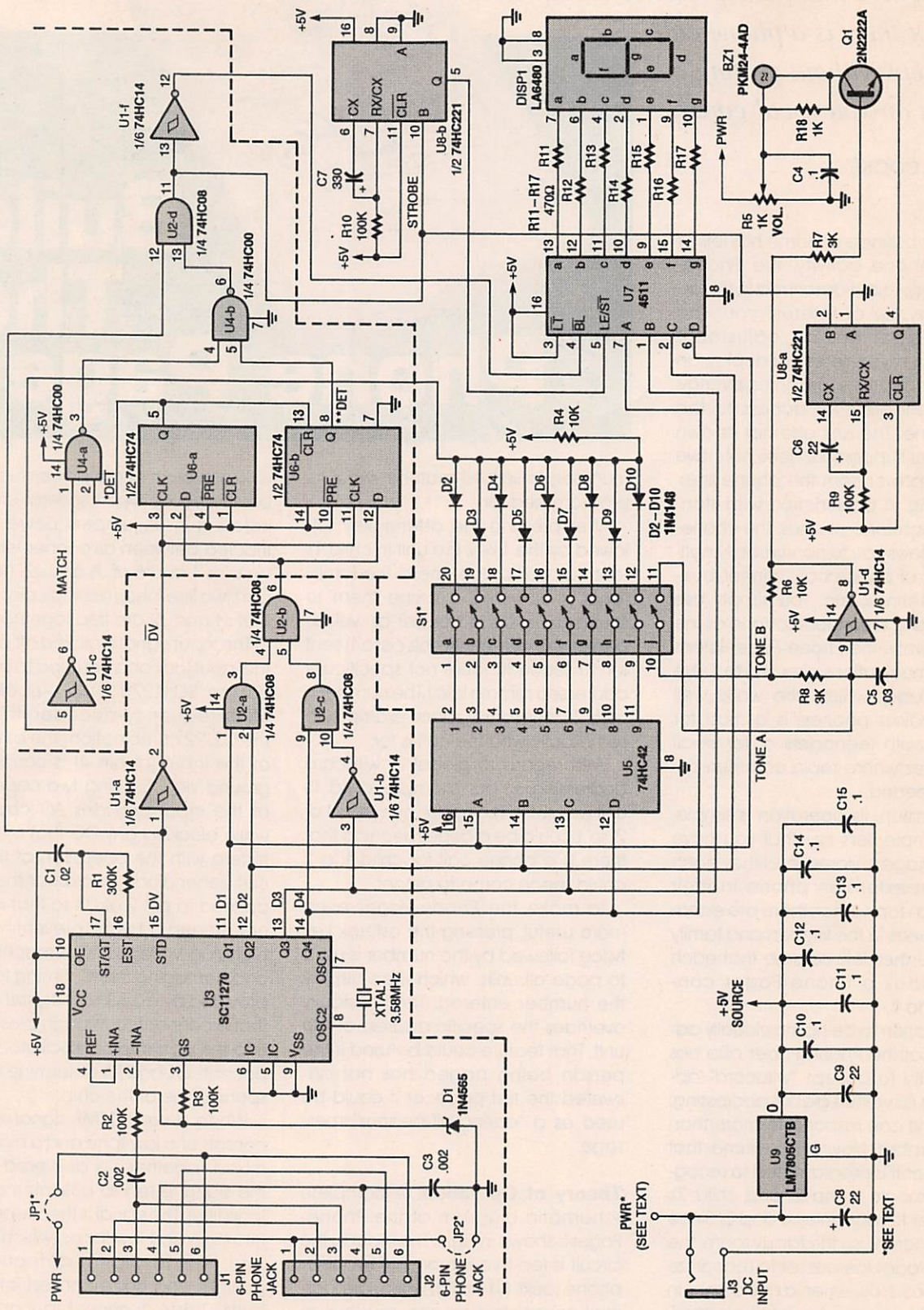

Fig. 1. The input to the Phone-Pager is fed through one of two telephone jacks (J1 or J2) to pin 2 of U3 (an SC11270 DTMF—Dual-Tone MultiFrequency decoder) through the C2/R2 combination.

TABLE 1—DTMF DECODER OUTPUT

f_{low}	f_{high}	Key	Q4	Q3	Q2	Q1
697	1209	1	0	0	0	1
697	1336	2	0	0	1	0
697	1477	3	0	0	1	1
770	1209	4	0	1	0	0
770	1336	5	0	1	0	1
770	1477	6	0	1	1	0
852	1209	7	0	1	1	1
852	1336	8	1	0	0	0
852	1477	9	1	0	0	1
941	1336	0	1	0	1	0
941	1209	*	1	0	1	1
941	1477	#	1	1	0	0
697	1633	A	1	1	0	1**
770	1633	B	1	1	1	0**
852	1633	C	1	1	1	1**
941	1633	D	0	0	0	0**

**Not supported by normal phones

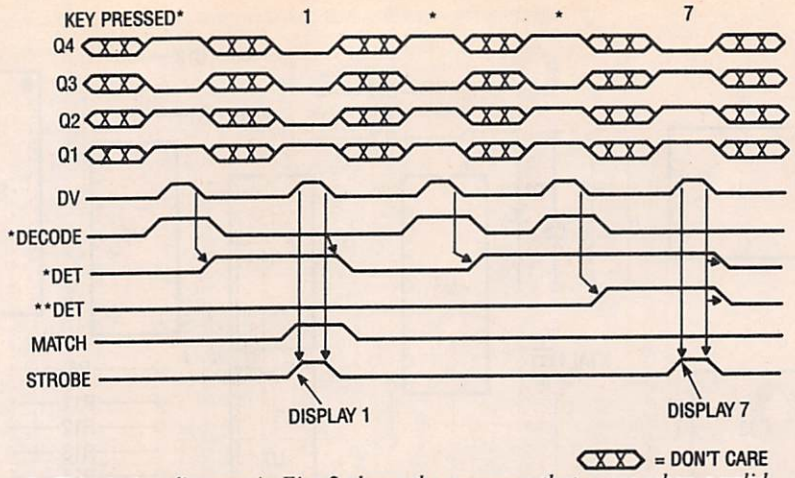

Fig. 2. This timing diagram in Fig. 2 shows the sequence that occur when a valid DTMF signal is detected.

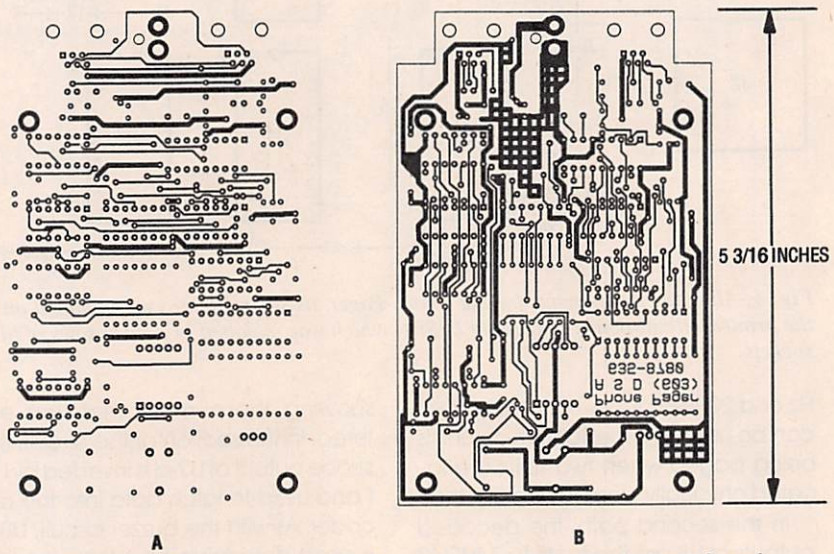

Fig. 3. The Phone-Pager was assembled on a double-sided printed-circuit board, measuring about 5 3/16 by 3 5/16 inches; templates for both sides of the board are shown here at half size (50%). The template in A is the component side of the board while B shows the foil side of the board.

high tones (labeled *f* high) combine to yield the 16 encoded outputs.

A valid DTMF signal causes the chip to generate two types of signals: a four-bit BCD output, Q1–Q4 at pins 11–14, respectively (which are internally latched to retain the last valid DTMF signal) and a DV (*D*ata *V*alid) output at pin 15 (which acts as a sort of enable signal for U2-d). The DV signal is also inverted by U1-a (providing a negative-going trigger signal) and fed to U6-a and U6-b (the two halves of a 74HC74 dual D-type flip-flop) at pins 3 and 11, respectively, to clock those devices. The DV output at pin 15 of U3 is normally low, and goes high when a valid signal is delivered to U3's input.

The BCD outputs of U3 are fed along three paths. In the first path, U3's outputs are fed to a pair of AND gates (Q1 and Q2 to U2-a and Q3 and Q4 to U2-c) whose outputs are then AND'ed together via U2-b, the output of which is fed to the D-inputs of flip-flops U6-a and U6-b, which are both clocked by the negative edge of the inverted Data Valid (DV) signal (pin 15 of U3). Flip-flop (U6-a) simply remembers if the previous keystoke was an asterisk. The timing diagram in Fig. 2 shows that in more detail. Flip-flop U6-b is used to detect the occurrence of a two-asterisk keystroke. That flip-flop is held reset (by feeding the output of U6-a to U6-b's clear input at pin 13) until a second asterisk keystroke is detected; once a second asterisk is detected, the flip-flop is set and remains set until a non-asterisk key is depressed. The output of U6-b is then fed to pin 5 of U4-b.

The output of U6-a is also fed to one leg of U4-a (pin 2) and acts as an enable signal for that gate. The output of U4-a is then fed to U4-b, where it is inverted and AND'ed with the output of U6-b. The output of U4-b is then fed to pin 12 of U2-d, where it is AND'ed with the DV output (pin 15) of U3. The output of U2-d the serves as a strobe signal for other subcircuits in the assembly. The strobe signal provided by U2-d at pin 11—which pulses high after a valid address has been decoded, or after double-asterisk keystrokes are followed by any number key—is fed to both halves of U8 (a 74HC221 dual monostable multivibrator).

Normally, when U8-a has not been triggered, the emitter of Q1 (which is tied to the output of U8-a) is held high, preventing it from turning on regardless of its base input signal. When monostable U8-a is triggered by the strobe signal, it brings ⊠ low for 2 seconds. The low output of U8-a pulls the emitter of Q1 low, thereby enabling it. That allows BZ1 to be activated by the output of U1-d (⅙ of a 74HC14 hex inverting Schmitt trigger), which is configured as a free-running oscillator, and has a frequency of about 2000 Hz. The length of time that BZ1 sounds is determined by the value of C6, which can be increased if a longer tone is desired. Potentiometer R5 (the VOL control) determines how much power is delivered to BZ1.

Switch S1-j is used to optionally add or remove the 3k resistor (R8) from the feedback of the oscillator. That allows the output of BZ1 to be set as a 2500-

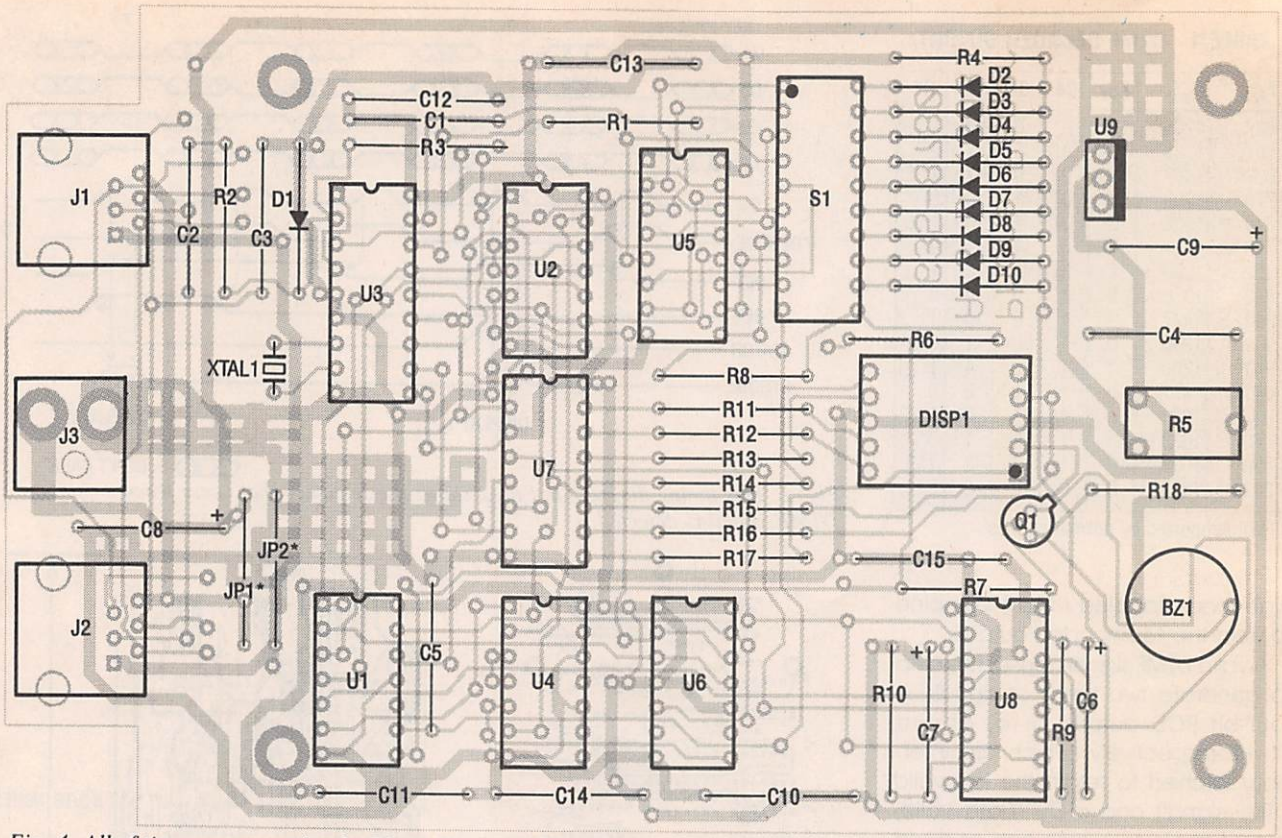

Fig. 4. All of the components for the Phone-Pager, as shown here, were mounted on the printed-circuit board, including DISP1, which was mounted in double rows of SIP sockets.

Hz or a 2000-Hz tone—an option that can be used to ascertain which unit is being paged when two units are located physically close to one another.

In the second path, the decoded outputs of U3 are fed to U5 (a 74HC42 BCD-to-decimal decoder), which in combination with diodes D2 through D10 and DIP switch positions S1-a–S1-i allows us to provide a match on any combination of the decoded numbers one through nine. The diodes constitute a "wired-OR" output that allows the user to configure the Phone-Pager to answer to only one address or all addresses. The DIP switch can be omitted, and the circuit can be programmed by simply soldering a jumper across the appropriate switch position. The OR'ed decimal output of U5 is inverted by U1-c and fed to the second leg of U4-a, and on to U4-b (as mentioned earlier in connection with the strobe signal output by U2-d).

In the third path, the decoded outputs of U3 are fed to U7 (a 74HC4511 BCD-to-7 segment decoder/display driver), which is connected to seven-segment display DISP1 through seven 470-ohm resistors, causing the appropriate segments of DISP1 to light, showing the number that was entered. In this section of the circuit, the strobe output of U2-d is inverted by U1-f and used to latch data into the decoder. As with the buzzer circuit, U8-b is used determine how long the display remains active. In this case, U8-b and its associated components keep DISP1 lit for about 10 seconds. By increasing the value of C7, the display's on-time can be increased.

Construction. The Phone-Pager was assembled on a double-sided printed-circuit board, measuring about 5 3/16 by 3 5/16 inches; full-size templates for both sides of the board are shown in Fig. 3; the template in A is the component side of the board while B shows the foil side of the board. Those unable to produce their own double-sided boards or to find U3 (the DTMF decoder), can purchase a complete kit of parts or fully assembled units from the supplier listed in the Parts List.

All of the components for the Phone-Pager are mounted on the printed-circuit board, including DISP1, which was mounted in double rows of SIP sockets. That was done to raise the height of the display, placing it very close to the graphics overlay. A parts-placement diagram for the unit's printed-circuit board is shown in Fig. 4.

If you do not plan to use DIP switch S1, you need to give some thought to the address(es) you want to set the unit for. By referring to Fig. 1, you will see that the address decoding is very straightforward. Diodes D2 through D10 are used to decode number keys 1 through 9 respectively. If the DIP switch is not installed, you must wire a jumper across the switch for the numbers that you wish to decode. Once all components are soldered in place, check your work for the usual construction errors.

Once you are satisfied that the circuit contains no defects, plug the wall-mount power supply into the Pager and apply power to the unit. Initially, the beeper will sound for 2 second and the display will light for about 10 seconds. If that does not happen, check the output of voltage-regulator U9 for +5 volts. If the voltage is okay, check the board for other defects of the sort mentioned above. Also remember that since the circuit

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PARTS LIST FOR THE PHONE-PAGER

SEMICONDUCTORS

U1—74HC14 hex Schmitt trigger, integrated circuit
U2—74HC08 quad two-input AND gate, integrated circuit
U3—SC11270 DTMF decoder (Sierra), integrated circuit
U4—74HC00 quad two-input NAND gate, integrated circuit
U5—74HC42 BCD-to-decimal decoder, integrated circuit
U6—74HC74 dual D-type flip-flop with preset and clear, integrated circuit
U7—74HC4511 BCD-to-7 segment latch/decoder/driver, integrated circuit
U8—74HC221 dual monostable multivibrator with Schmitt-trigger input and clear, integrated circuit
U9—LM7805CTB positive 5-volt, 1-amp voltage regulator, integrated circuit
Q1—2N2222A general-purpose NPN silicon transistor
D1—1N4565 5.1-volt Zener diode
D2–D10—1N4148 general-purpose small-signal silicon diode
DISP1—LA6480 (ROHM) seven-segment LED display (or HP HDPS-5803)

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—300,000-ohm
R2, R3, R9, R10—100,000-ohm
R4, R6—10,000-ohm
R5—1000-ohm potentiometer
R7, R8—3000-ohm
R11–R17—470-ohm
R18—1000-ohm

CAPACITORS

C1—0.02-μF, ceramic-disc
C2, C3—0.002-μF, 200-WVDC, ceramic-disc
C4, C10–C15—0.1-μF, 10- to 100-WVDC, ceramic-disc
C5—0.03-μF, ceramic-disc
C6, C8, C9—22-μF, 16-WVDC, electrolytic
C7—330-μF, 10-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

BZ1—Murata PKM24-4A0 buzzer
J1, J2—4-pin telephone jack (MT6G)
J3—Powerjack (Mouser 16JP031 or similar)
S1—10-position DIP switch (optional, see text)
XTAL1—3.58 MHz crystal (HC-49 case)
Printed-circuit materials, enclosure, 12-volt, 200-mA DC, wall adapter, wire, solder, hardware, etc.

Note: The following are available from Jim Cooke (PO Box 834 Pelham, NH 03076; Tel. 603-635-8780): A complete kits with all the components, including the case, and the power supply, $49.00 each in single-unit quantities; two kits for $45.00 each; and $39.00 for three or more. Assembled units are available for $59.00 each in single-unit quantities; $55.00 each for 2; and $49.00 each for three or more. Add 5% to total for shipping and handling. MC and Visa accepted. New Hampshire residents please add appropriate sales tax.

has an adjustable volume control, there is a possibility that the volume is turned all the way down.

Final Checkout. Once you have completed the initial checkout, you can proceed to plug the Phone-Pager into the telephone line. For a quick test, simply lift the receiver of a nearby phone and dial 1. That will clear the dial tone from the line. Then press the asterisk (*) key followed by the number that the Phone-Pager has been set to respond to. That should cause the Phone-Pager to beep and display the number entered. You can repeat that last step to verify any additional numbers if the unit has been configured to decode more then one number. Once you've verified the units operation, you can place the printed-circuit board into its enclosure, anchor it in place with screws, and attach the enclosure's cover. The enclosure provided with the kit offered in the Parts List has a graphic overlay that has space so that you can write the meanings assigned to the various numbers. If wall mounting is desired, that can easily be done using Velcro (which is available at most hardware stores). That's all there is to it. ■