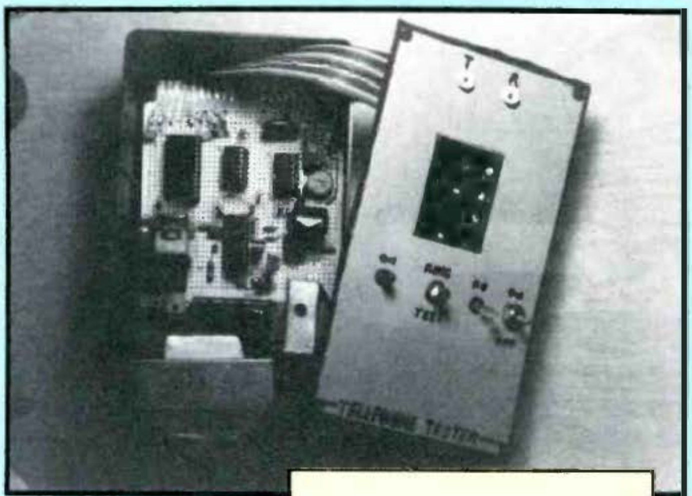
Build this telephone tester

By Joseph T. Szumowski, CET



You can build this telephone tester in a day at reasonable cost and use it to check tone-dial outputs and ringing voltage.

A most valuable piece of test equipment for servicing telephone units and systems is a device that can check all your Touch-Tone outputs and provide ringing voltage to test the ringer. This article describes how to build such a telephone tester. Thanks to recent developments – the high voltage MOSFET and the M-956 integrated circuit – cost will be reasonable and the circuit construction, straightforward. It can be completed in one afternoon.

There are basics that must be considered before proceeding to the circuit. Table 1 shows that each DTMF signal (1 through D) has a unique frequency pair. For example, the "#" signal is made up of two frequencies, 941MHz and 1477MHz.

Once the numbers and symbols have been encoded (put into tone pairs), some way of decoding (changing each tone pair into its binary equivalent) is necessary.

Until recently, this was quite complicated: Two ICs were required for each pair of frequencies for a total of no less than 24 separate ICs plus associated outboard components (resistors and coupling capacitors). A complete Touch-Tone decoder not only was involved, but required a considerable investment in parts and time.

The M-956 tone decoder receiver chip changed the whole picture. It now is possible to build a complete Touch-Tone decoder with just one IC, a resistor and an inexpensive 3.58MHz color crystal. In fact, when you purchase the M-956 from Teltone, you also receive the 22-pin socket and 3.58MHz crystal, as well as the 1MΩ resistor.

In Table 1, note the *HEX OUTPUT* column. The output of the M-956 is really four pins on the chip. As you examine the hex output, keep in mind that wherever you see a *1*, this means that the indicated pin (3, 2, 1 or 0) has an output of +5V, or a *high*. When you see a *zero* (0), you will read 0V, or ground potential, on a voltmeter connected to the pin. To be sure you understand, imagine that the input signal to the IC is the tone pair for the numeral *9* (frequencies 852MHz and 1477MHz). The four output pins would have outputs of 1001, or a high, low, low and high. As you examine the hex output column, note that each tone pair or signal has a unique hexadecimal output of ones and zeros, highs and lows.

To further understand the M-956, look at specific pins of the IC and determine how they apply to the test unit, see Figure 1.

- Pin 12 – This is the input. It requires a minimum of a 0.2Vpp to effect proper decoding.
- Pins 14, 15 – Connect the 3.58MHz crystal and its associated resistor to these pins.
- Pin 7 – Connect an LED to this pin to indicate when a tone-pair input is being decoded.
- Pin 5 – This is the pin that will determine if the M-956 will detect all 16 tone pairs or only the most common 12 pairs. When it is connected to +5V, it will detect only 12 tones. Connect it to ground and it will detect all 16 tone pairs.
- Pins 20, 21, 22, 1 – These are the data-output pins, see Table 2.

Pin 20 = 3, D3
Pin 21 = 2, D2
Pin 22 = 1, D1
Pin 1 = 0, D0

Other pins connect to ground or +5V as shown in the schematic, page 42.

Any pin not used is not needed for this application. The data sheet for the M-956 provides a complete list of pin function and purpose.

When the device decodes the tones and provides a binary output at pins 1, 22, 21 and 20, this is fed into a 74154 Data Selector. The combination of highs and lows on the four input pins of the 74154 will cause only one of its output pins to go to ground potential, or a low. All that is necessary is to connect an LED to this output. The illuminated LED indicates that a specific hex combination is present at the input. The truth table (Table 3) for the 74154 illustrates input and output pattern for that device. Figure 2 is the complete schematic diagram of the telephone tester.

To complete the theory of operation, look at the final part of the tester: the ring-voltage generator. The circuit is made possible by the use of the high-voltage, logic-level, compatible-power MOSFET. The circuit diagram reveals that the heart of the circuit is a low-frequency, gated-output oscillator:

Table 1. DTMF to Binary Decoding

SIGNAL	LOW-FREQUENCY COMPONENT (Hz)	HIGH-FREQUENCY COMPONENT (Hz)	HEX OUTPUT FORMAT 3 2 1 0	2-OF-8 OUTPUT FORMAT 3 2 1 0
1	697	1209	0 0 0 1	0 0 0 0
2	697	1336	0 0 1 0	0 0 0 1
3	697	1477	0 0 1 1	0 0 1 0
4	770	1209	0 1 0 0	0 1 0 0
5	770	1336	0 1 0 1	0 1 0 1
6	770	1477	0 1 1 0	0 1 1 0
7	852	1209	0 1 1 1	1 0 0 0
8	852	1336	1 0 0 0	1 0 0 1
9	852	1477	1 0 0 1	1 0 1 0
0	941	1336	1 0 1 0	1 1 0 1
*	941	1209	1 0 1 1	1 1 0 0
#	941	1477	1 1 0 0	1 1 1 0
A	697	1633	1 1 0 1	0 0 1 1
B	770	1633	1 1 1 0	0 1 1 1
C	852	1633	1 1 1 1	1 0 1 1
D	941	1633	0 0 0 0	1 1 1 1

Note: The M-956 detects signals A through D only when the $12\sqrt{15}$ input is at logic "I."

TABLE 1.

Table 1. When a button on the tone-dial telephone is pressed, the telephone generates a pair of tones (for example, pressing the 7 button creates a pair of tones – one at 852Hz and one at 1209Hz). The M-956 converts this pair of tones into a binary (HEX) output.

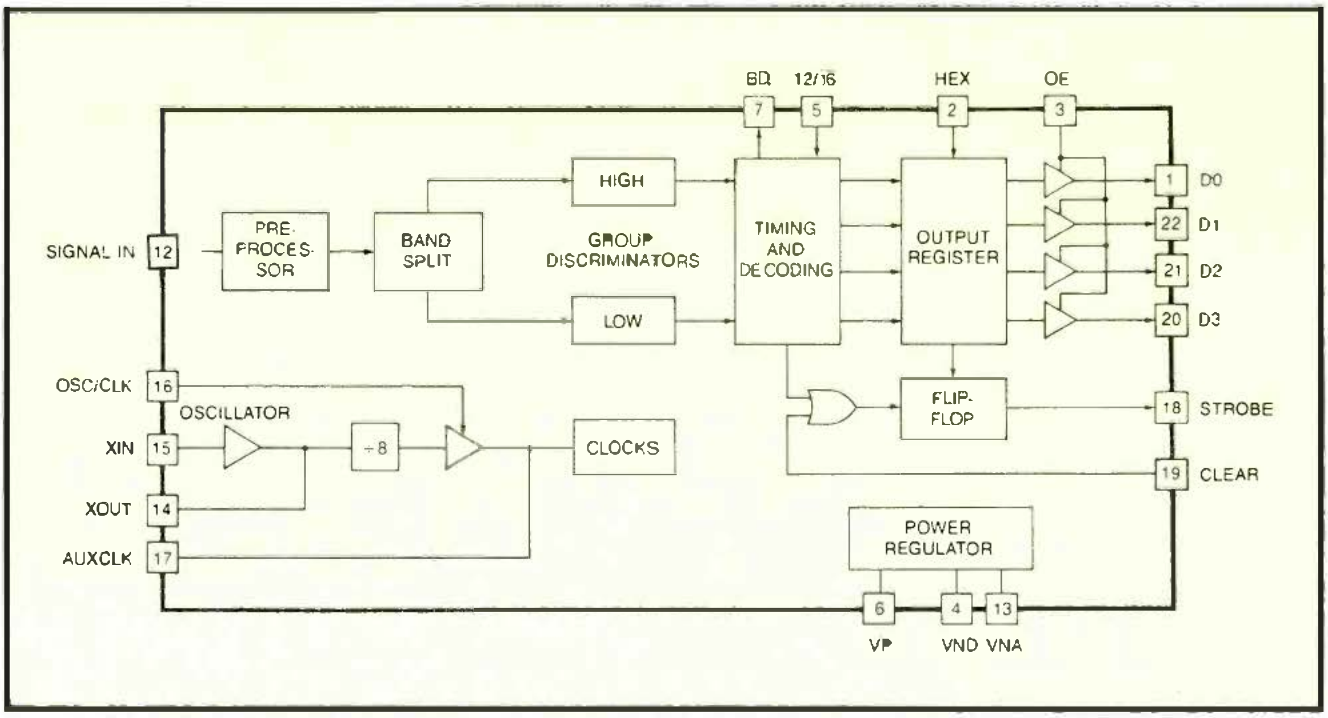


Figure 1. DTMF receiver (M-956) converts a dual-tone multifrequency input, pin 12, into a 4-bit binary output, pins 20, 21, 22, 1.

TABLE 2. PIN FUNCTIONS

PIN	FUNCTION	FUNCTION DESCRIPTION
12	SIGNAL IN	DTMF input. Internally biased so that the input signal may be ac-coupled. Signal in also permits dc-coupling as long as the input voltage does not exceed the positive supply. See Table 1 for the frequency pairs associated with each DTMF signal.
5	12√16	DTMF signal detection control. When 12√16 is at logic *1*, the M-956 detects the 12 most commonly used DTMF signals (1 through #). When 12√16 is at logic *0*, the M-956 detects all 16 DTMF signals (1 through D).
20, 21 22, 1	D3, D2 D1, D0	Data outputs. When enabled by the OE input, the data outputs provide the code corresponding to the detected digit in the format programmed by the HEX pin. See Table 1. The data outputs become valid after a tone pair has been detected and are cleared when a valid pause is timed.
3	OE	Output enable. When OE is at logic *1*, the data outputs are in the CMOS *push/pull* state and represent the contents of the output register. When OE is driven to logic *0*, the data outputs are forced to the high impedance or *third* state.
2	HEX	Binary output format control. When HEX is at logic *1*, the output of the M-956 is full, 4-bit binary. When HEX is at logic *0*, the output is binary coded 2-of-8. Table 1 shows the output codes.
18	STROBE	Valid data indication. STROBE goes to logic *1* after a valid tone pair is sensed and decoded at the data outputs. STROBE remains at logic *1* until a valid pause occurs or the CLEAR input is driven to logic *1*, whichever is earlier.
19	CLEAR	STROBE control. Driving CLEAR to logic *1* forces the STROBE output to logic *0*. When CLEAR is at logic *0*, STROBE is forced to logic *0* only when a valid pause is detected.
7	BD	Early signal presence output. BD indicates that a possible signal has been detected and is being validated.
14, 15	XOUT, XIN	Crystal connections. When an auxiliary clock is used, XIN should be tied to logic *1*.
16	OSC√CLK	Time base control. When OSC√CLK is at logic *1*, the output of the M-957's internal oscillator is selected as the time base. When OSC√CLK is at logic *0* and XIN is at logic *1*, the AUXCLK input is selected as the time base.
17	AUXCLK	Auxiliary clock input. When OSC√CLK and XIN are at logic *0*, the AUXCLK input is selected as the M-956's time base. The auxiliary input must be 3.58MHz divided by 8 for the M-956 to operate to specifications. If unused, AUXCLK should be left open.
4, 13	VND, VNA	Negative analog and digital power supply connections. Separated on the chip for greater system flexibility, VNA and VND should be at equal potential.
6	VP	Positive power supply connection.
8, 9, 10, 11	N/C	Not connected. These pins have no internal connection and may be left floating.

Table 2. Pin functions for DTMF receiver IC.

the 4001 IC, designed to oscillate at about 20Hz. Its frequency is controlled by R_{17}. The output, on pin 4, is 10Vpp. To simulate the *on* and *off* times of ringing voltage, the 4001 oscillator is gated (turned *on* and *off*) by the timer IC (555). The duration of this gating pulse is controlled by R_{14}. Finally, this gated 20Hz signal is applied to the gate of a power MOSFET, the RFP10N15. To check on the operation of the oscillator, connect an LED to the gate. When this LED goes *on* it indicates that a ringing frequency is applied.

The indicator in the drain lead provides the load for the simplified ringing voltage. There should be about 105V, 20Hz of square wave developed at the output.

Circuit construction

Using a board already laid out for ICs – such as a Radio Shack 40-pin circuit board – makes it easy to mount the ICs and hardwire the remaining components, see photo of tone-decoder board, page 42.

The power supply transformer and other related components were wired separately in the minibox. The front panel was wired to the output pins on the circuit board. There is no critical wiring, but it is necessary to observe good wiring practice and to keep the wires short.

In due time – but not until after you carefully checked your work – the M-956 should be socketed. This is no problem because the manufacturer will supply you with the necessary 22-pin socket. Remember that this is a CMOS IC. Handle with care.

Final testing

When you complete the wiring, give your work a complete visual check. Examine carefully for any solder bridges. Especially check the IC socket pins to be sure that no pins are touching.

Do not insert the M-956 in its socket until you have completed the following determinations:

- Make a few resistance checks.
- Be sure all groundsare common.
- Check the 5V supply pins for any shorts to ground.
- Check the 105V supply for any continuity to ground.

Once you are satisfied that all is well, turn on the power. Test for proper output on both the +5V and +105V supplies.

Now, shut off the power and insert the M-956. When you turn on the power again, scope pin 17 of the M-956. If all is in order with the M-956, you should see a waveform with a frequency of 440kHz on this pin.

Connect a Touch-Tone telephone to the proper input pins and depress any key (holding it in). Scope the output of the 741 (pin 6) and adjust R_4 for about 200mV at pin 6. Note that D1 will light, and when you adjust $R_4$for more than 200mV, D1 will go out. Either too-much or too-little signal will cause the M-956 not to decode.

Also at this time, you should see the proper output LED light. If you do not see this, test for proper inputs to the 74154: pins 20 to 23. Once you are satisfied the decoder section is working, test the ringer output subsection. Caution: you have 105V at the output test jacks. Be careful! It can bite.

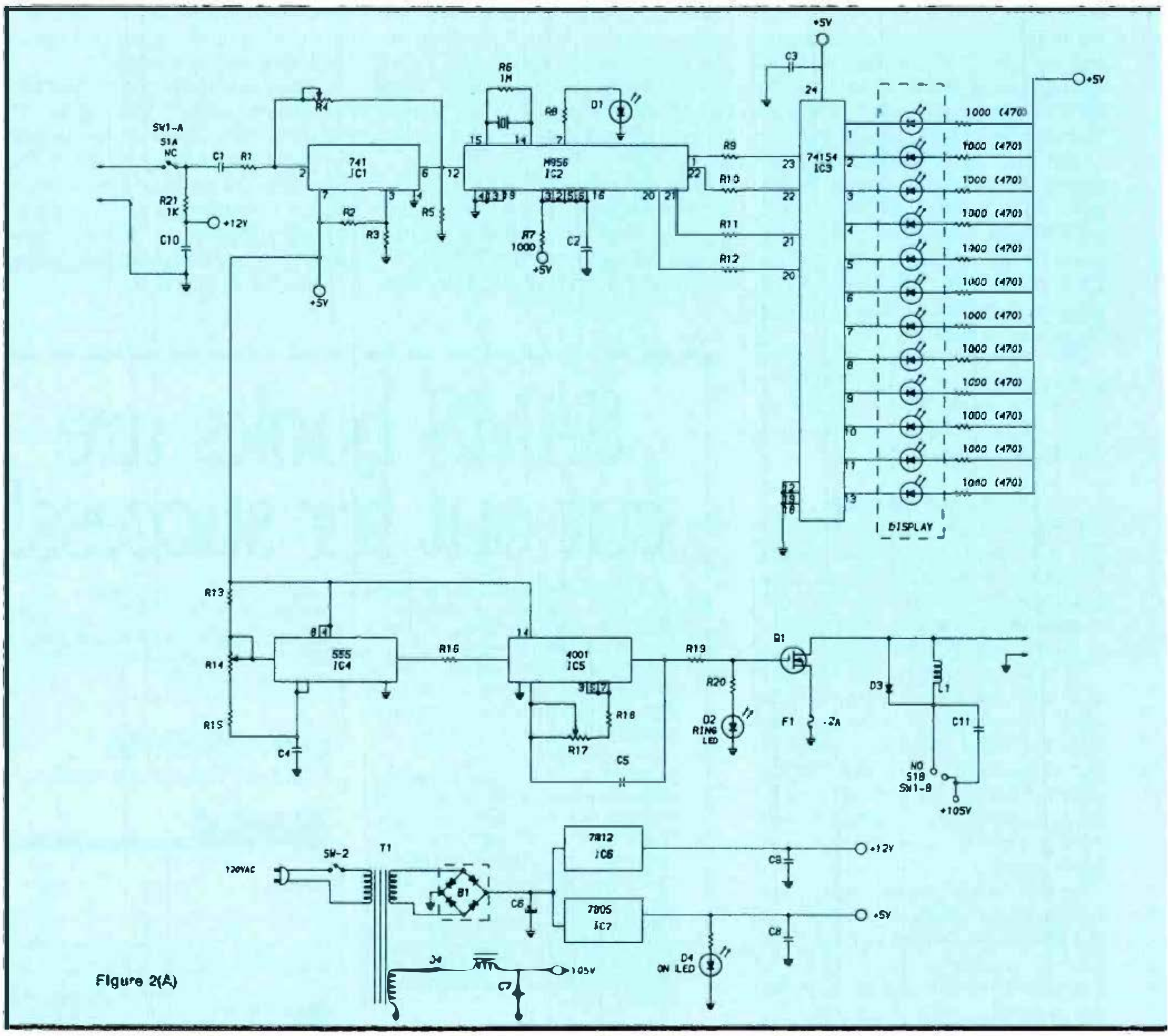


Figure 2(A)

TRUTH TABLE FOR 74154

INPUTS D C B A (PIN→ 20 21 22 23)	OUTPUTS PIN LOW*
0 0 0 0	1
0 0 0 1	2
0 0 1 0	3
0 0 1 1	4
0 1 0 0	5
0 1 0 1	6
0 1 1 0	7
0 1 1 1	8
1 0 0 0	9
1 0 0 1	10
1 0 1 0	11
1 0 1 1	13
1 1 0 0	
1 1 0 1	
1 1 1 0	
1 1 1 1	

NOTE
only the pin indicated here is low. All other pins are *high.*

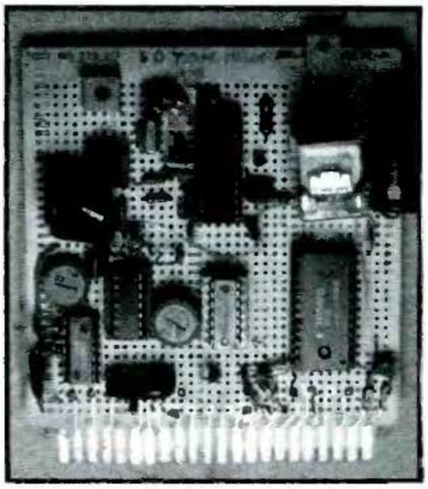
Example
When a *binary five* Is inputed,
0101 = only pin 6 is low,
LHLH all others high.

0 = Low (Ground)
1 = High (+5V)

PIN
12 = Ground
24 = +5V

*Be sure pins 18 and 19 are grounded.

Table 3. The data selector circuit, a 74154 IC, converts a 4-bit binary input signal at its input pins; 20, 21, 22, 23, into a single-pin output signal. This is the truth table for that circuit.



The telephone tester circuit was constructed on a Radio Shack 40-pin circuit board.

PARTS LIST

R1	10k ½ W	C1	0.47μFd 16wV
R2	68k ½ W	C2	0.01μFd 16wV
R3	68k ½ W	C3	0.01μFd 16wV
R4	50k Trimpot	C4	25μFd 16wV
R5	1k ½ W	C5	1μFd 16wV
R6	1M ½ W	C6	1000μFd 25wV
R7	1k ½ W	C7	200μFd 350wV
R8	1k ½ W	C8	0.1μFd 16wV
R9	1k ½ W	C9	0.1μFd 16wV
R10	1k ½ W	C10	1μFd 16wV
R11	1k ½ W	C11	0.1μFd 350V
R12	1k ½ W	B1	Bridge rectifier
R13	1k ½ W	IC-1	741 op-amp 276-007
R14	50k Trimpot	IC-2	M956
R15	100k ½ W	IC-3	74154 available in
R16	4.7k ½ W		ECG or RCA SK type
R17	100k Trimpot	IC-4	555 276-1723
R18	10k ½ W	IC-5	4001 276-2401
R19	1k ½ W	IC-6	7812 276-1771
R20	10k ½ W	IC-7	7805 276-1770

Q_1 = RCA type RFP1ON15 MOSFET

Switches

SW1-A > Single momentary
SW2-B contact toggle switch. Wire SW1-A as a normally closed (NC) and SW-B as a normally open (NO).

SW-2 = SPST 125V@ 1A

Miscellaneous

T1 = Power transformer: 90V out @ 100mA, 12.6V out @ 1A.

L1 = Inductor coil (not critical: for example, a 7H @ 150mA).

D1, D2, D4 = 5V LEDs

D3 = Any 1A 500 PIV silicon diode. For example: Radio Shack 276-1104.

Minibox - 270-227, Radio Shack.

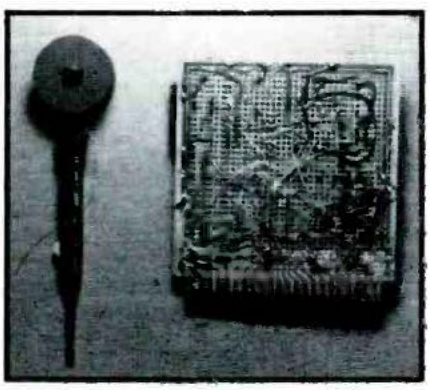
NOTE:
All *276* part numbers are Radio Shack type.

Figure 2(B)

Figure 2. (A) Complete circuit diagram of test unit shows both sections: the tone decoder and the ring tester. (B) Parts list.

The ringer operates at about a 20Hz frequency. If your oscillator (IC5) is not properly adjusted, the ringer will not ring.

Connect a scope to the gate of the MOSFET. There should be about 10Vpp. Adjust R_{17} for a 20Hz square wave: Note that LED D2 should be blinking. Now adjust R_{14} for the duration of the *time-on, time-off* interval. Observe the ring LED and judge its intensity (this is not critical). Finally, check at the drain of *Q* for 105V, 20Hz square wave. Be sure you depress the *ring* test button.



The interconnections at the back of the circuit board were made with a manual wire-wrap tool.

Ringer-only procedure

If there is no interest in the *on, off* feature but only in whether or not the ringer works, eliminate IC4 (555). However, be sure you connect pin 1 or IC5 to −5V. Do not leave it floating or disconnected.

Also, be sure the telephone is *on-hook* before you test the ringer. When the receiver is off-hook, the ringer is not connected to the input lines of the telephone. If the receiver is on-hook and the breaker trips, this indicates a short somewhere in the ringer circuitry.

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