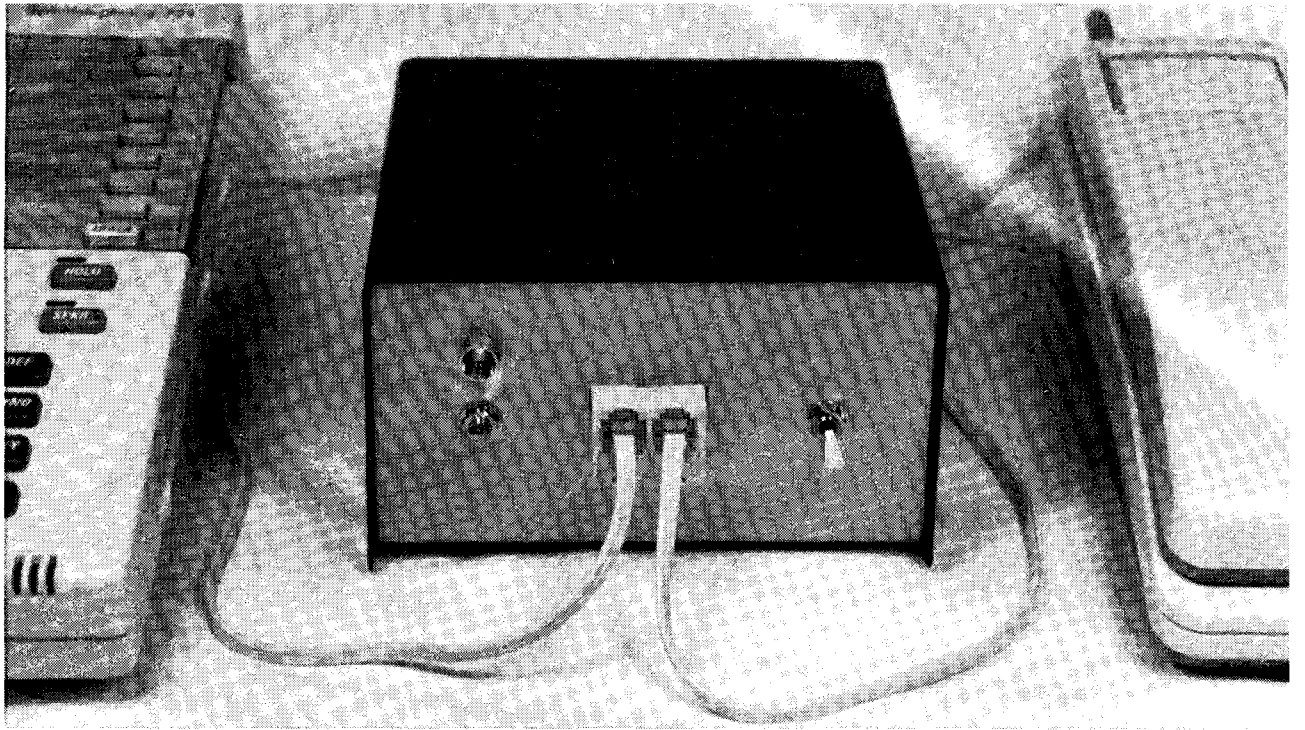
# TELCO IN A BOX

***Simulate a telephone line***
***with the Telephone Company in a Box.***



**YOU JUST BOUGHT A BRAND NEW ANswering machine and you want to test it out. You set it up, connect it to the telephone line, and then just sit there looking at it. You want to see and hear it work, so you drive to a pay telephone and call your home number-nothing happens. Then you rush back home, decide to read the user's manual to find the problem, and then rush back to the telephone booth to test it again.

Now suppose that instead of an answering machine, you have some old telephones lying around in your house that don't work any more. To test those telephones completely, they must be connected to your telephone line and then someone must call you. Perhaps you have a modem or a fax machine that you would like to test but don't want to pay your local copy shop $1 a page.

**JAMES E. CICON**

These hypothetical examples are some of reasons why you will want to build a Telephone Company in a Box, or TCB for short, the subject of this article. It will solve all of the problems posed in these scenarios, cheaply and quickly All of the components needed to build this project are readily available. You will not need a PC! board, nor will you be required to program a microprocessor or microcontroller.

## The telephone company

**To** understand how the TCB works, it is helpful to know what happens on your telephone line when an outgoing call is made or an incoming call is received. When a telephone handset is on-hook, the telephone line voltage is about 50 volts DC. When a handset is off-hook, the telephone line is loaded and the voltage drops to about 7 volts DC; this voltage is detected by the telephone company's central office equipment as an off-hook condition. The central office then provides a dial tone and the equipment waits for you to start dialing. When you dial a telephone number, the central-office equipment halts the dial tone, waits to receive a valid dialed number, and then makes a connection between your telephone and the number you dialed.

When the telephone company's central office equipment has a call for you, it rings your telephone by pulsing the 50-volt DC line voltage on and off at about 20 Hz for a short period of time, then it pauses, pulses again, pauses again, and so on. This produces the ring-ring-ring effect that informs you that there is an incoming call. When

you pick up the handset, the telephone line voltage drops back down to about 7-volts DC. The central office equipment detects the drop in line voltage, stops ringing the telephone, and connects your telephone to the calling party

How **does TCB work?**

**Two** telephones can be plugged into the TCB, which will then simulate all telephone-line functions. When both telephones are on-hook, the TCB supplies 24-volt DC line voltage to both telephones. Although the telephone company supplies 50 volts, the 24 volts will work well because the resistors in series with the telephones have lower values than those used by the telephone company Moreover, 24 volts DC is both safer to work with and easier to generate.

When one telephone handset is taken off-hook, its line voltage drops to 7 volts DC. The TCB senses this and, if the other telephone handset is on-hook, it emits a ring signal. The ring signal is a 60-Hz sinewave at about 37-volts peak-to-peak. It is applied to the line for one second and halted for one second, repeatedly, until the other handset is picked up. Although the telephone company's ring signal is a 20-Hz squarewave at 50-volts peak-to-peak, the lower ringing voltage is used for two reasons. One is for safety, and the other is because it's easier to pick the ring voltage directly from the secondary of an AC transformer than to generate it with additional circuitry.

When both handsets are off-hook, both lines are loaded to l0-volts DC. The TCB senses the condition, halts the ring signal, and connects both telephones together. Note that when the TCB is ringing the on-hook telephone, it is also sending the ring signal to the off-hook telephone. Depending on the design of the off-hook telephone, it might or might not ring. You

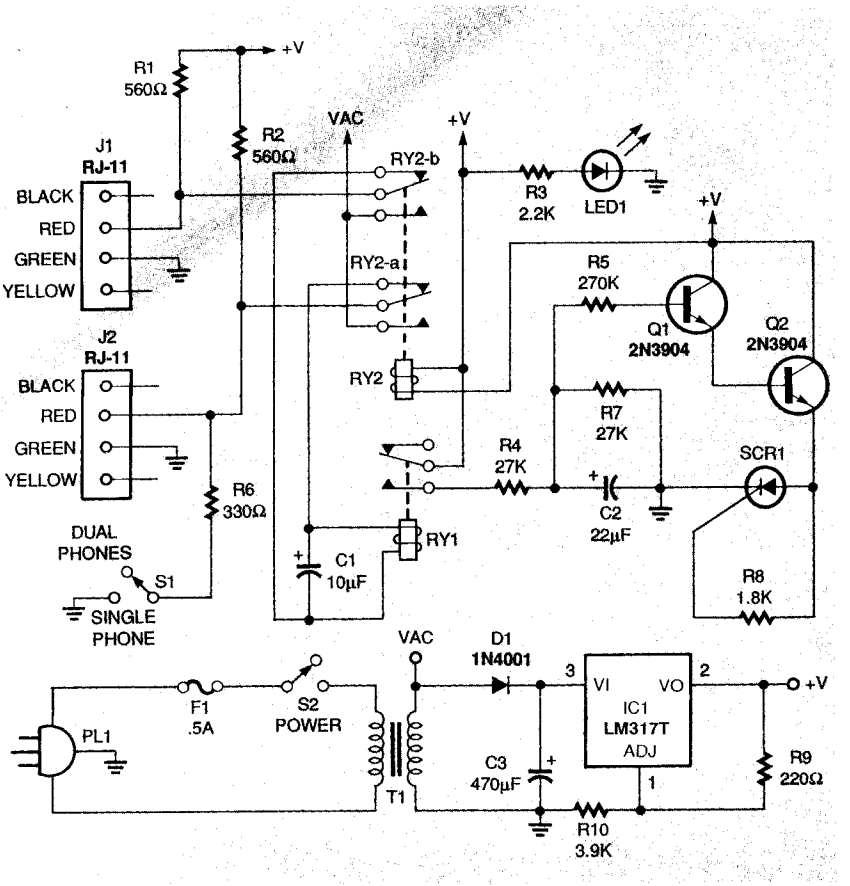



FIG. 1—TCB SCHEMATIC. When telephones plugged into J1 and J2 are both off-hook, they transmit and receive their own audio.

might also hear the ringing from the speaker of the handset as a loud buzzing. This is not a problem-just a distraction. Telephones are designed to accept a ring signal even when they are off-hook.

## Circuit description

Figure 1 is the schematic for the TCB circuit. When both handsets are on-hook, resistors Rl and R2 supply power to them, and the rest of the circuit can be ignored. When both telephones are off-hook, they transmit and receive their own audio, so all that the TCB does is supply power to them through Rl and R2. If switch Sl is closed, resistor R6 simulates a telephone being plugged into J2, permitting the testing of only one telephone. The rest of the circuit can be ignored in this example.

Now consider the situation where one handset is on-hook and one is off-hook. That causes

## PARTS LIST

All **resistors are ½-watt, 5%.**
R1, R2-560 ohms
R10-3900 ohms
R3-2200 ohms
R4, R7-27,000 ohms
R5-270,000 ohms
R6-330 ohms
R8-1800 ohms
R9-220 ohms

**Capacitors**
C1-10 µF, **35** volts, electrolytic
C2-22 µF, 35 volts, electrolytic
C3-470 µF, 35 volts, electrolytic

**Semiconductors**
D1-1N4001 diode
Q1, Q2-2N3904 NPN transistor
LED1-light-emitting diode, any color
IC1-LM317 3-terminal adjustable positive voltage regulator
SCR1--200-volt, 6 ampere silicon controlled rectifier (Radio Shack No. 276-1067)

**Other components**
F1-½ ampere fuse
J1, J2--RJ-11 telephone jack (see text)
PL1-AC plug and linecord
RY1-SPST reed relay (12 VDC, 11 mA coil; l-ampere, 125 VAC contacts)
RY2-DPDT miniature relay (12 VDC, 43 mA coil; l-ampere, 125 VAC contacts)
S1, S2-SPST switch
T1-120/25.2 VAC transformer, 450 mA
**Miscellaneous:** perforated construction board, fuse holder, project case, wire, solder

the on-hook line to go to 24 volts DC and the off-hook line to go to 7 volts DC. The coil of relay RYl is connected across the two telephone lines, and the voltage difference between the two lines energizes it. When the contacts of RYl are closed, C2 charges through R4: it takes about 1 second for C2 to charge to 12 volts DC. The 12-volts DC across C2 causes a voltage-controlled switch consisting of R5, Q1, Q2, SCRl, and R8 to close, thus energizing RY2.

When RY2 is energized, RYl is removed from the circuit and a 60-Hz, 37-volt peak-to-peak sinewave is placed on the telephone lines causing the telephones to ring. Because RYl is removed from the circuit, capacitor C2 starts discharging through R7. It takes about 1 second for the capacitor to discharge to about 2.4 volts DC. That lower voltage level causes the voltage-controlled switch to disable RY2, removing the ring voltage from the telephone lines and putting relay RYl back in the circuit. If one telephone is still off-hook and one is on-hook, the cycle is repeated.

The voltage-controlled switch works as follows: Transistors Ql and Q2 gre connected as a Darlington pair, which couples the voltage across C2 to SCRl. Resistor R8 supplies gate current to the SCR, which is organized so that C2 must charge to 12 volts DC before the SCR will turn on. When SCRl turns on, the switch is essentially closed, and relay RY2 is energized. When the voltage across C2 drops to about 2.4 volts, Ql and Q2 force SCRl to turn off, thus turning the electronic switch off. Resistor R3 and LED1 provide a power-on indication for the user.

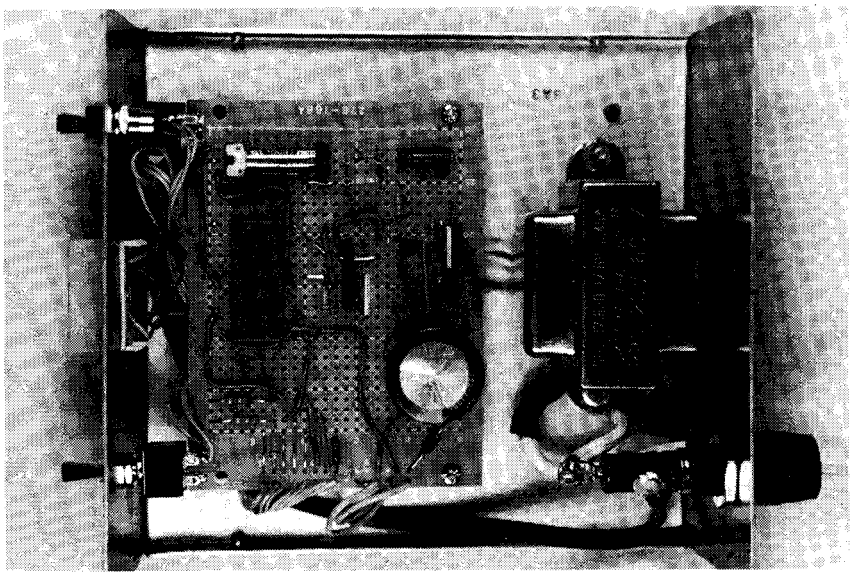


**FIG. 2-THE FINISHED BOARD can be mounted in a metal case. Jacks J1 and J2, switches S1 and S2, and LED1 are mounted on the front panel.**

## Construction

The circuit is so simple that a PC board is not necessary. Use point-to-point wiring. The power cord and AC plug PLl were obtained from a 6 foot extension cord that usually sells for less than $1. The female end was cut off, making it a line-cord. Jacks J1 and J2 were two parts of a duplex telephone jack adapter that was cut apart. Snap off the male end and solder the wires directly to the exposed leads. However, any RJ-11 jacks will work well. Mount the finished board in a metal case. Any standard project case will do. Mount jacks J1 and J2, switches Sl and S2, and power indicator LED1 on the front panel of the case. Figure 2 shows the inside of the author's prototype unit.

## How to use TCB

The TCB is easy to use. Plug a telephone into each of the two telephone jacks and turn the unit on. If you pick up the handset of one of the telephones, the other telephone will ring. When the handset of the other telephone is picked up the ringing stops, and you can talk normally between the telephones, as if a connection had been made by your local telephone company.

If you are testing an answering machine, plug it into one jack, and plug a standard telephone into the other jack. Pick up the handset on the standard telephone, and the answering machine will start ringing and should pick up the line. You will then hear the answering machine's outgoing message in the handset you are holding. The same procedure applies to the testing of modems, fax machines, or virtually any other telephone device whose operation you want to verify.