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Automatic FOUR-LINE TELEPHONE SELECTOR

Build this telephone ring selector circuit that will pick up on the first call received on multiple-line telephone installations.

A "BLACK BOX" THAT ALlows any standard single-line answering machine or telephone to answer up to four lines will make it easier to handle up to four phone lines in your home or office. Ring selector, the subject of this article, provides that service—without the need to modify any of your telephone lines.

As a bonus, the ring selector also works as a ringing-line router to allow a standard single-line telephone located in a remote location (such as a garage, basement, or workshop) to answer multiple lines. It can also route multiple lines to a cordless telephone so that no matter where you are, you can answer any line.

Figure 1 is the schematic for the ring selector. Its operation depends on board-mounted multipole and reed relays for switching the telephone line. The circuit consists of four identical switching circuits partitioned so that two switching circuits are on each of two separate boards for convenience in packaging. There is, however, only one line- sense relay and two 556 timer ICs that function as pulse stretchers for four circuits. The 556 is a dual 555, providing a 555 for each line.

How it works

Terminal strip TS1 mounted on the upper board accepts the wires from RJ-11 telephone jack J1 and RJ-45 telephone jack J2, as well as the positive and negative wires from the AC-to DC adapter. Assume that telephone line 1 rings. When the ringing pulse arrives, the ringing voltage and current are limited by diode D17 and resistor R29. The voltage at the anode of D17 falls to a level that energizes 5-volt reed relay RY13.

Because the ringing voltage is an an AC signal, the relay is energized and deenergizes very rapidly. While RY13 is energized, positive voltage is fed through it to transistor Q14, which turns on and momentarily grounds pin 6 of IC1. That triggers IC1's timing cycle. Output pin 5 goes high and remains high until the timing cycle ends. Positive voltage is then sent to Q9, which energizes SPST reed relay RY9. Transistor Q1 is also activated when RY13 is energized, and it sends a positive voltage to SCR1. With disable relay RY9, energized, SCR1 conducts and relay RY1 is energized.

Dual timer IC1 keeps the ringing line connected to telephone jack J1 by keeping RY9 energized, thus keeping the switching circuit based on SCR1 powered. The switching circuit is activated by SCR1 within the first half second of the ringing pulse.

With the switching circuit powered and the ringing line connected to J1, most of the ringing pulse is passed on to any equipment plugged into J1. As the pulse stretching function of IC1 ends and pin 5 goes low, the ringing pulse retriggers IC1, RY9 remains energized, and the switching circuit stays powered.

If the equipment connected to J1 goes off-hook, positive voltage flows from line-sense relay RY17 to transistor Q13, which also triggers IC1. Timer IC1 does not begin its timing cycle until after its INPUT pin 6 goes high again.

As long as power is applied to Q13, the output at pin 5 of IC1 will remain high, and the switching circuit will remain powered. Relay RY17 will remain energized as long as any equipment connected to J1 remains off-hook.

When that equipment goes on-hook, RY17 is deenergized and power no longer flows to Q13. When IC1 completes its timing cycle, RY9 will no longer conduct, and the switching circuit will be de-activated, line 1 will be disconnected from J1, and the ring selector will reset for the next telephone call. If the equipment on J1 does not go off-hook, the switching circuit will automatically shut down and reset after line ringing stops.

With the switching circuit powered, RY1 energizes. Relay RY1 has two main functions: to connect telephone line 1 to J1 (to which equipment is connected), and to disable the other switching circuits. Its ability to disable the other switching circuits is an important feature of the ring selector.

The disabling of the other switching circuits prevents other ringing from being connected to J1 at the same time. To disable the other switching circuits, one of the switching elements of RY1 sends a positive voltage to the disable relay of the other switching circuit on the board (but *not* to the disable relay of the same switching circuit). During a call on line 1, normally closed relay RY6 is energized, while the contacts of RY5 remain closed.

In effect, if the switching circuit for line 1 is powered, the switching circuit for line 2 is disabled. Similarly, if line 2 is powered, line 1 is disabled. The lines disable each other, but only one at a time because only one switching circuit at a time can be powered.

Another of the elements of relay RY1 switches off the power to two switching circuits on the board. With this arrangement, all other switching circuits are disabled while one is powered.

TABLE 1
ELECTRICAL CHARACTERISTICS OF STOCK RELAYS*

Relay Number	Manuf. Number	Coil: Voltage (VDC)	Coil: Resistance (ohms)	Contacts: Type	Contacts: Rating (amps)	Contacts: Resistance (milliohms)
RY1-4	W78PCX-1	5.0	13K	4PDT	3.0	50
RY-5	W178REI-5DC	5.0	63	SPDT	5.0	100
RY9-13	W117SIP-1	5.0	500	1Form A SPDT N.O.	0.5	—

*Circuit board mounting, DC operation

This explains the presence of two switching circuits per board and two boards per ring selector.

Building the ring selector

The prototype ring selector was built on two stock 6¼ × 4½-inch perforated phenolic circuit boards with copper pads deposited around the 0.1-inch-spaced holes on one side for easier solder bonding. All wiring was point-to-point method. Twelve-position terminal strip TS1 with screw terminations accepts all 10 wires from the telephone jacks and the plus and minus 6-volt DC wires from the wall-outlet mounted AC-to-DC adapter.

All components but line-sense relay RY17 are standard items available from most mail-order distributors and electronics stores. Line-sense relay RY17 (see Fig. 2) is a small circuit-board mount loop-current detector with the safety and reliability features required for FCC Part 68 regulated telephone applications. When connected to the voice pair (tip and ring) of the telephone line, a 1 Form A relay closes in response to current above 20 milliamperes flowing through the wires.

This relay controls the ring selector circuitry for on-hook/off-hook operation. It is installed between telephone-related equipment and the telephone line. When plugged-in telephone equipment is off-hook, current flows through the two coils inside the relay and a contact closes.

Current must flow from the telephone line through the relay to the telephone equipment to energize the relay. Thus the relay is energized only when the connected telephone equipment is off-hook. When the relay is installed between a telephone and the telephone line, the relay will be energized only if that telephone is taken off hook; it will not be energized if other telephone units on the line are taken off-hook.

Caution: Take care when installing RY17. If it is connected incorrectly, current will not flow, and the relay will not be energized. Check and double-check the installation of this relay.

Relay RY17 is manufactured by Teltone Corp. 22121-20th Ave., SE, Bothell WA 98021, (800) 426-3926 as Part No. M-949-01.

Relays RY1 to RY4 are 4PDT 5-volt reed relays, relays RY5 to RY8 are SPDT 5-volt relays, and relays RY9 to RY16 are 1 Form A SPDT—N.O. reed relays that interface with logic-level signals. Table 1 lists the principal electrical characteristics of these standard relays.

Electronic assembly

There are no critical requirements for the placement of components on the circuit boards of the ring selector. However, parts placement diagram Fig. 3 is included to show how the components were placed on the two perforated boards of the prototype. With the components inserted as shown, there will be adequate spacing for the interconnecting wires.

There was adequate space in the enclosure selected to permit some of the resistors to be mounted vertically on the circuit boards. In the prototype, common ground buses were made by soldering lengths of solid No. 18 AWG wire along

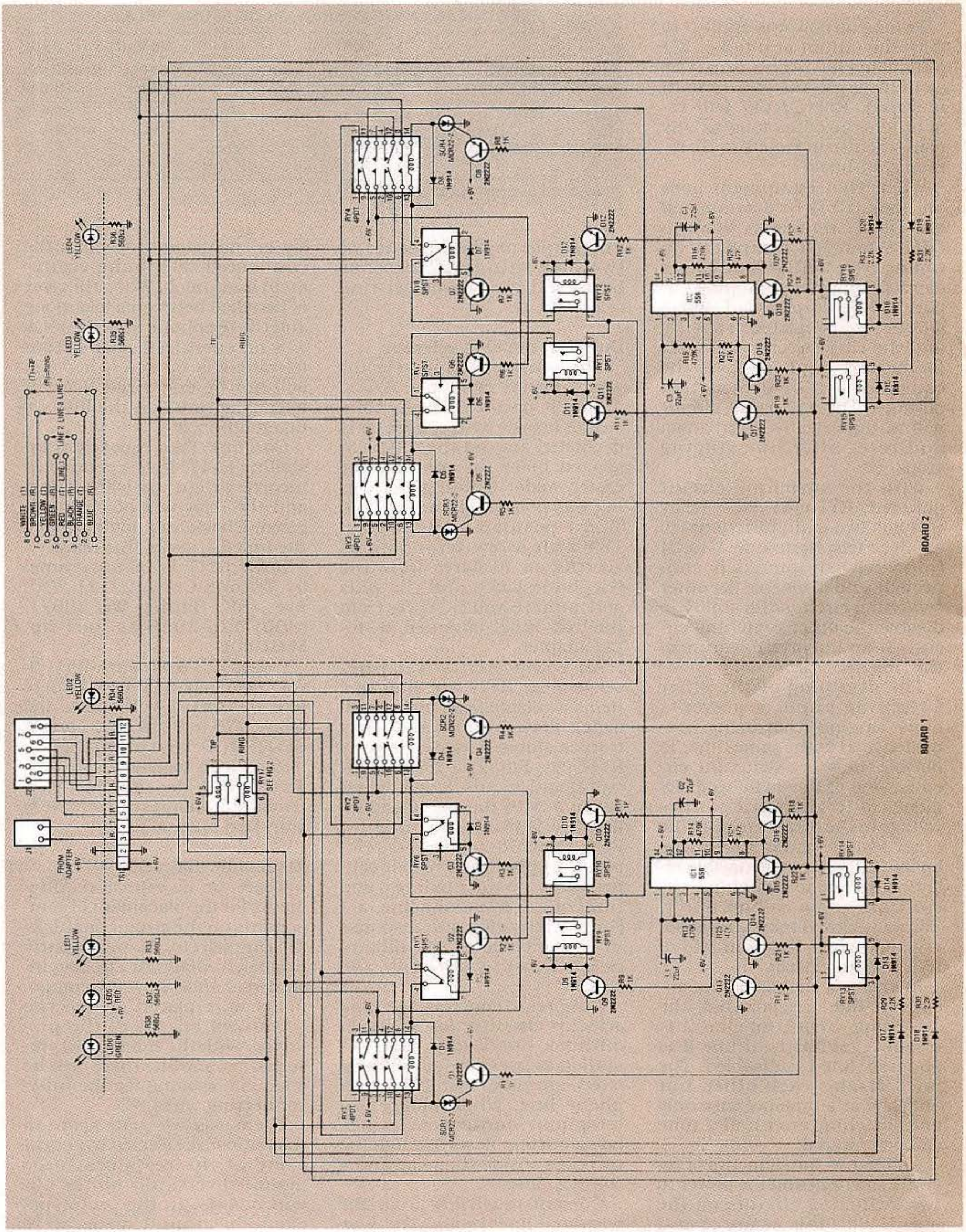

FIG. 1—SCHEMATIC FOR TELEPHONE RING SELECTOR: The complete circuit is partitioned into two switching circuits on each of two circuit boards.

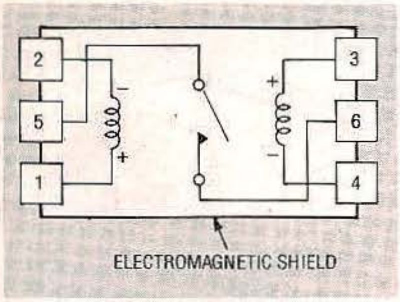

FIG. 2—ELECTRICAL SCHEMATIC for line sense relay M-949-01 made by Teltone.

both long sides of the boards near the edges on the copper-pad side of the boards. The two 556 IC's, IC1 and IC2, were mounted in sockets.

After all wiring was complete on both boards, the wires between the two boards were bundled with plastic cable clamps attached to the boards with screws to form a loose cable between boards. Be sure that this interboard wiring is long enough to permit the removal of the upper board from the lower board for ease in testing and maintenance.

Mechanical assembly

A stock two-part aluminum case was selected for packaging the prototype ring selector. The case measures 8×6×3 inches, and the lower section was equipped with four rubber foot pads.

Drill four holes in the base section for the four mounting screws that support the stacked boards, as shown in Fig. 4. Determine the spacing from the holes in the circuit boards. Displace the position of these holes toward one corner of the base in order to provide enough room for wiring 12-position terminal strip TS1.

Drill six holes in a horizontal row in the vertical wall of the case as shown in Fig. 4 with diameters that will accept snap-in sockets for T-1¾ LED's LED1 to LED6. Snap the six sockets into the drilled holes.

Form a rectangular hole in the vertical wall of the case, as shown in Fig. 4, just large enough to permit mating plugs to access jacks J1 and J2. Cement the standard four-conductor RJ-11 jack J1 and the standard eight-conductor RJ-45 jack J2 together with epoxy or other suitable adhesive. Then cement both jacks to the inside vertical wall of the case behind the cutout. Jack J2 can accept four telephone lines so it takes up less space than four RJ-11 jacks.

The power supply is a wall-outlet mounted AC-to-DC adapter rated for 6-volts, 200 milliampere DC output. *Caution:* input voltage greater than 6 volts could damage some of the relays. Remove the plug from the DC line cord of the adapter and strip the insulation back from the ends of the wires. Drill a hole for the cord and grommet in the case large enough to admit a grommet as shown in Fig. 4; install the grommet and insert the cord ends. Tie a knot in the cord about 3 inches back from the ends.

Assemble the wired boards to the four vertical screws mounted on the bottom plate of the case with nuts and spacers as shown in Fig. 4. With the boards mounted securely in position, connect the positive and negative wires from the adapter to terminal strip TS1 as shown in Figs. 1 and 4.

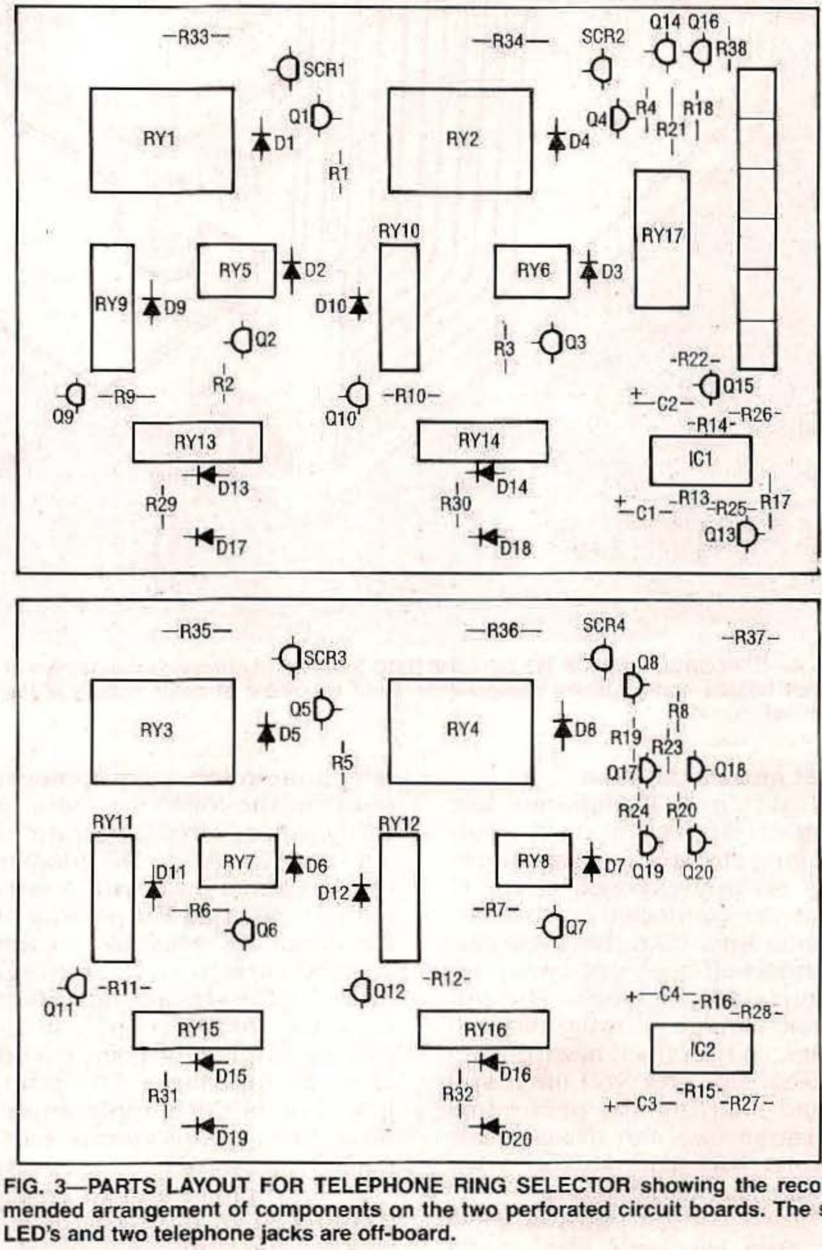

FIG. 3—PARTS LAYOUT FOR TELEPHONE RING SELECTOR showing the recommended arrangement of components on the two perforated circuit boards. The six LED's and two telephone jacks are off-board.

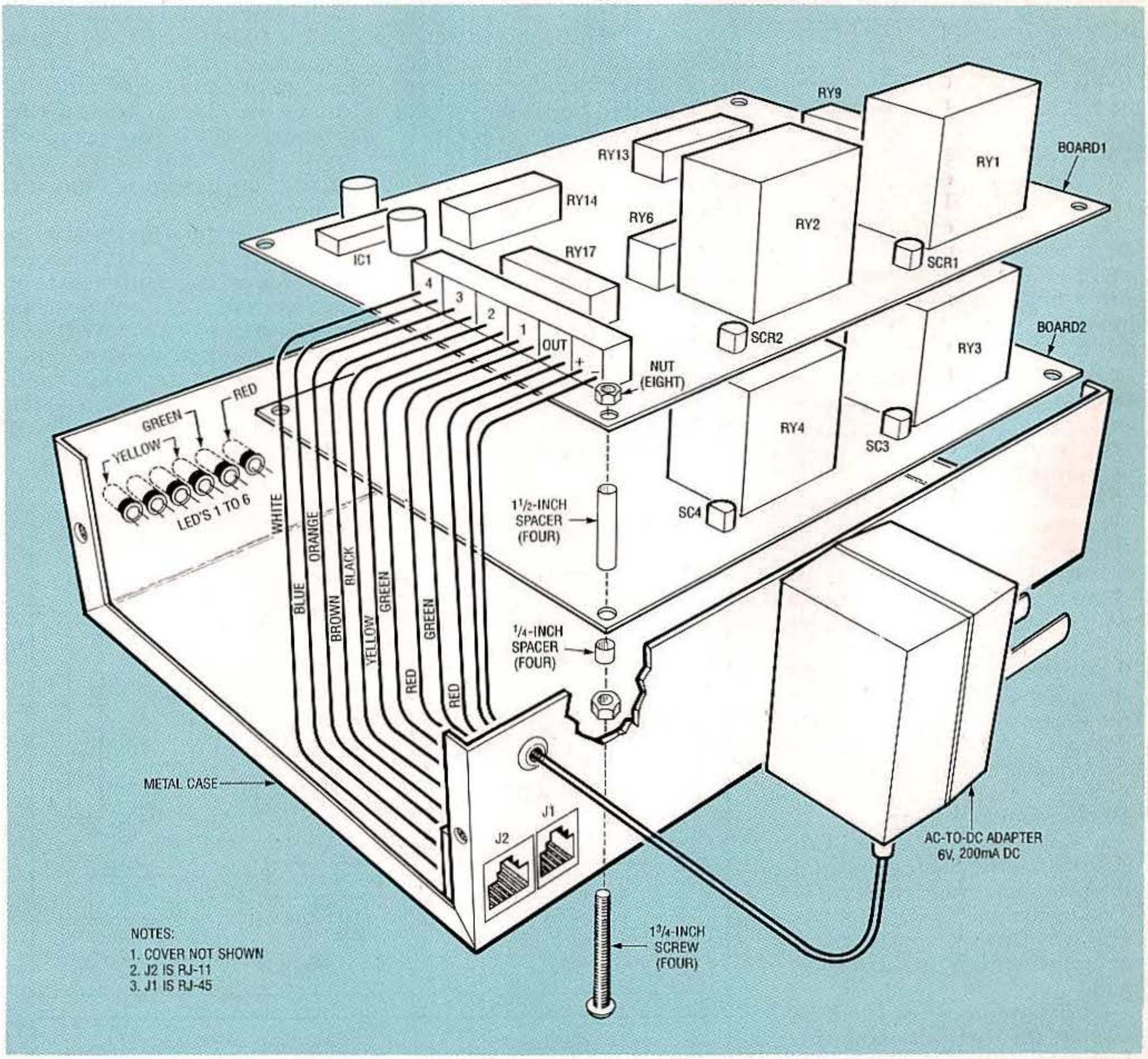

FIG. 4—EXPLODED VIEW OF TELEPHONE RING SELECTOR showing arrangement of circuit boards and off-board components. Note the order of color coding at the terminal strip.

Test and installation

Caution: the telephone line has an approximate 50-volt ringing circuit. If you are working on any exposed contacts that are connected to the telephone line, take the telephone handset off-hook until you have completed the work. The off-hook voltage is only about 6 volts, so the shock hazard is reduced. However, you must still avoid shorting the phone line because this can damage the phone line and disable your phone service.

Before connecting ring selector to a telephone line or any telephone-related equipment, perform the following tests to verify proper circuit operation:

1. Plug the AC-to-DC adapter into an outlet and, with a voltmeter, verify that the polarity of the 6-volt DC available on the board is correct. Light-emitting diode LED5 should light. If it does not, the DC polarity is incorrect. Unplug the adapter and check for the source of the problem. The power supply might have been inadvertently connected backwards.

2. Short pins 1 and 7 of relay RY13 together to bypass the relay's coil and simulate an incoming ring. If all wiring is correct, the switching circuit for that line should be powered and LED1 should be illuminated. However, after a few seconds the circuit should automatically shut itself off. Then perform this test in sequence on relays RY14, RY15 and RY16.

3. Repeat test 2 again after you have actuated relays RY13, RY14, RY15, and RY16, and shorted pins 5 and 6 of relay RY17. Shorting relay RY17 simulates an answering machine. If the switching circuit under test is working properly, one of the corresponding line indicator

LED's (for example, LED1 will light for Line 1, LED2 for line 2, etc.) will stay illuminated until the jumper on relay RY17 is removed.

After removing the jumper from RY17, ring selector should reset and LED1 (or LED2, LED3, LED4, depending on which relay is under test) will extinguish. If the switching circuit being tested shuts off while this test is being performed, it indicates a fault, probably with the connections from RY17. Recheck the wiring, and make any necessary changes before proceeding with further testing of the unit.

4. Repeat test 2 to verify the proper operation of the disable relay functions. Immediately after shorting relay RY13, momentarily ground pin 5 of RY5. When pin 5 of these relays is grounded, the switching circuit should shut off immediately. Then test relay RY14 with RY6 grounded, RY15 with RY7 grounded, and RY16 with RY8 grounded.

5. Connect the leads of a continuity checker to positions 3 and 4 on terminal strip TS1 that terminate the red (ring) wire and the green (tip) wire, respectively. There should be no continuity. If there is, recheck the wiring and correct the fault before proceeding with any further testing.

6. With the continuity checker still attached to the terminal strip as in step 5, trigger relays RY13, RY14, RY15 and RY16 (as described in step 2). As relays RY13 to RY16 are actuated, observe or listen to the continuity checker to be sure there are no shorts. If there is a short, recheck the wiring, looking for an error, and correct that error before proceeding.

7. With the continuity checker still attached as in step 6, connect a jumper across the terminals for line 1 (positions 5 and 6) on terminal strip TS1 to short them together. Actuate RY13 and observe or listen to the continuity checker. There should be an indication of a short to indicate that line 1 is wired properly. Repeat this test on the other lines, being sure to move the shorting wire to each line you are testing. After completing this test, remove the jumper.

8. After completing the tests, remove the continuity checker and wire both telephone jacks J1 and J2 to the terminal strip. After this is completed, plug a telephone into J1, then connect connect a telephone line to line 1 on the terminal strip (positions 5 and 6).

If the switching circuit for line 1 engages, disconnect the telephone line and reverse the wires to the terminal strip (positions 5 and 6) to correct the polarity. Repeat the test for line 1. The switching circuit should not engage.

With the telephone line attached, ask another person to dial the telephone number for the line attached to Ring Selector. When the phone rings, the switching circuit should engage immediately. Take the handset off the cradle of the telephone plugged into J1; LED6 should light and the circuit should remain functional. Speak into the handset to be sure that the circuit is working properly. Hang up the telephone plugged into J1, and the switching circuit should disconnect after a few seconds. Repeat this test for all of the other telephone lines.

9. The ring selector should now be completely tested and fully operational.

Reassemble the circuit boards on the four screws. Then close the cover and fasten it. If the "immediate engage" problem discussed in step 8 should recur, it is possible that the telephone cord has reversed wires that cause the problem. If this happens, all you have to do is reverse the connection as discussed in step 8. Ω

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise specified.

R1–R12, R17—R24—1000 ohms
R13–R16—470,000 ohms
R25–R28—47,000 ohms
R29–R32—2.200 ohms
R33–R36—560 ohms

Capacitors

C1-C4—22µF, 16 volts, aluminum electrolytic

Semiconductors

Q1–Q20—2N2222 NPN switching transistor
SCR1–SCR4—silicon-controlled rectifier, 1.5 ampere, Motorola MCR22-2 or equivalent
IC1, IC2—556 dual timer, Motorola MC3456 or equivalent
D1–D20—1N914 silicon switching diode
LED1–LED4—yellow light-emitting diode, T-1 3/4 package
LED5—red light-emitting diode, T-1 3/4 package
LED6—green light-emitting diode, T-1 3/4 package

Relays

RY1, RY2, RY3, RY4—4PDT Relay, 5-volt DC coil, Magnecraft W78PCX—1 or equivalent.
RY5, RY6, RY7, RY8—SPDT Relay, 5-volt DC coil, Magnecraft W178RE1-5DC or equivalent
RY9, RY10, RY11, RY12, RY13, RY14, RY15, RY16—SPST Reed Relay, 5-volt DC coil Magnecraft W117SIP-1 or equivalent.
RY17—Line-sense relay, Teltone Corp., No. M-949-01. (see text)

Other components

J1—RJ-11 telephone jack
J2—RJ-45 telephone jack
TS1—12-position, PCB terminal strip with screw connections

Miscellaneous: Two 0.10-inch perforated phenolic circuit boards with copper pads (see text), two 14-pin IC sockets, aluminum two-part case (see text), AC-to-DC adapter with 6-volt, 200 mA DC output, six snap-in sockets for T-1¾ LED's, two plastic cable clamps, No. 18 AWG insulated hookup wire, screws, nuts, spacers, solder, plastic adhesive.

Note: The following parts are available from Christopher Zguris, 521 West 26th Street, New York, NY 10001

• Complete kit of components including perforated boards, relays, IC's, transistors, resistors, diodes, LED's, phone jacks and terminal strip.—$58.00

• Line sense relay—$5.00

Add $4.00 for shipping and handling. New York State residents add appropriate sales tax for county of residence.