Get the benefits of a second—or third—phone line at a fraction of the cost.

BUILD THIS DISTINCTIVE RING DECODER

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IN RECENT YEARS, MANY NEW FEAtures have been added to the telephone system. One of them, a distinctive ringing service, assigns more than one phone number to a single line. Each number generates a distinctive ringing pattern so that family members can answer only the calls that are intended for them. The monthly charge for distinctive ringing service is much less than for a separate line. Typically three additional numbers can be added for a low monthly fee of about $3 to $5.

Normally, if you subscribe to distinctive ringing, calls are identified by unique ringing patterns that are easy to distinguish, although all the phones in the house will ring. However, if you build the Distinctive Ringing Decoder (DRD) presented here, calls can be redirected to the intended phone without ringing all the other phones in the house. Calls for a fax machine or modem can be routed automatically. You might want to have a separate number for your home office, a separate phone number for the kid's room, and so on. Figure 1 is a block diagram of the system.

With a little imagination, you can find many uses for DRD. One of the best is for a home-based business. There are commercial devices available that will intercept a call and send it to a FAX, modem, or answering machine, but all of them must share the same phone number. With the DRD, each of these devices can be assigned a different phone number, thus providing convenience and the illusion of a larger company. Numbers can be assigned in categories so the phone can be answered differently for friends, co-workers, or bill collectors. The possibilities are endless.

Ringing theory

An AC ring signal is sent by the central office of the phone company to signal an incoming call. The ring signal varies from 40 to 130 volts and from 15.3 to 68 hertz. The Distinctive Ringing Decoder detects every cycle of the ring signal, and determines the frequency and cadence of that signal. However, only the pattern of the ring is important, so the device ignores

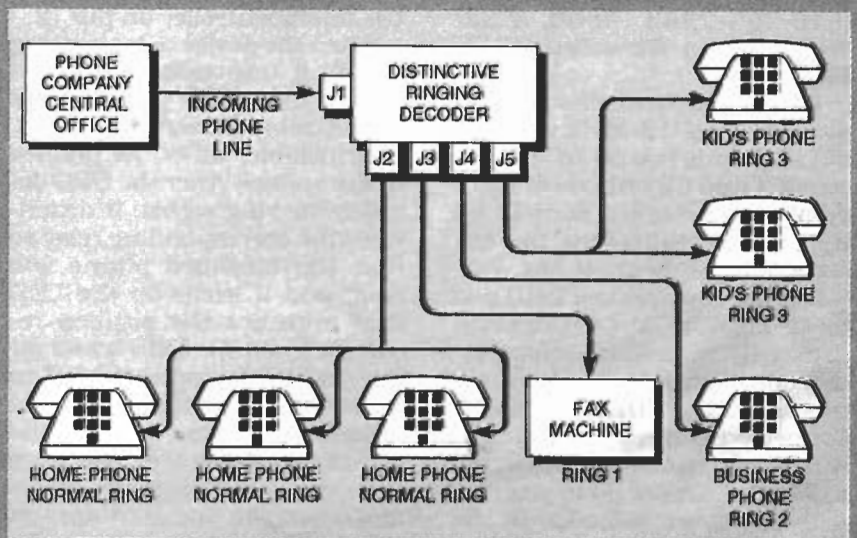


FIG. 1—BLOCK DIAGRAM OF THE DRD SYSTEM. Calls can be intercepted and redirected automatically, without ringing all the phones in the house. You can use a separate phone number for a FAX machine or modem, a separate number for your home office, a separate phone number for the kid's room, and so on.

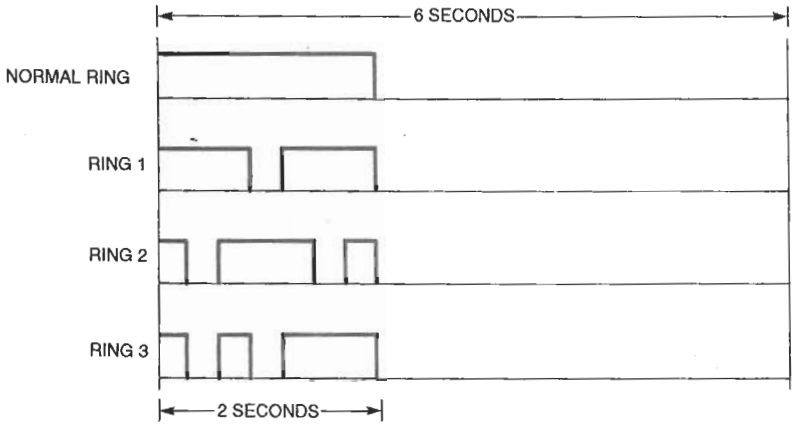


FIG. 2—FOUR DIFFERENT RING PATTERNS can be decoded with the Distinctive Ringing Decoder.

the frequency. The four different ring patterns are shown in Fig. 2.

The circuit

Figure 3 is a complete schematic of the DRD circuit. An Intel 8031 microcontroller simplifies the design. It contains a full-duplex serial port, 2 timers, and 128 bytes of RAM. Two lines on port 3 are used for input; port 1 is used for output. The software for the DRD is contained in a 2764 EPROM. Alternatively, a single-chip microcontroller with built-in EPROM (an Intel 8751) can be substituted in the design. (Note that software for the DRD is available from the source mentioned in the Parts List and from the *Electronics Now BBS* (516-293-2283, 9600, V.32/V.42bis) as a file called RINGER.ZIP.

The microcontroller's clock source is a 12-MHz crystal (XTAL1) with two 30-pF capacitors (C1 and C2). At power up, a small reset circuit, formed by R3 and C3, initializes the microcontroller. Because the software that controls the DRD can be in an EPROM or contained internally in a single-chip microcontroller, the EXTERNAL ADDRESSING (EA) line must be connected correctly. If the software is contained in an external EPROM, EA must go to ground; if the software is loaded in the single-chip microcontroller, EA must go to +5 volts.

It is less expensive to build the DRD with the 8031 microprocessor and an external EPROM. However, it is easier to build it with an 8751 microcontroller (basically an 8031 with built-in EPROM) because the external EPROM and 74HC573 latch are not required. Therefore, wiring is simplified. The choice is up to you—the software is identical for either method.

The tip and ring lines from the phone company are connected to a metal-oxide varistor (MOV1). If a surge enters the device from the phone line, the MOV will absorb it. The ringing signal is monitored by R6, C4, and optocoupler IC7, whose output goes low for each cycle of the ring signal. The output of IC7 is normally pulled high through R7, and is connected to the microcontroller on pin 12.

When the device detects a ring signal, it responds by energizing all the relays through the 2813A relay-driver chip (IC5). That disables all of the phones in the system. After the DRD decodes the ring signal, it deactivates the corresponding relay so that the intended phone will ring, and it turns on the LED that matches the pattern received. Then the DRD waits for the ringing to stop or the call to be answered. If the call is not answered, the unit resets. If the line is picked up, it is held until the extension hangs up. To detect when the line is in use, its voltage is monitored; when the phone is on-hook, the voltage on the phone line is about 48 volts DC, and when it goes off-hook, the voltage drops to about 6 volts. A bridge rectifier (BR1) eliminates any phone-line polarity problems.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R2, R4, R5, R10—220 ohms
R3—10,000 ohms
R6—22,000 ohms
R7—15,000 ohms
R8—10 megohms
R9—1 megohm
Capacitors
C1, C2—30 pF, mica
C3—10 µF, 16 volts, tantalum
C4—0.47 µF, 250 volts, mylar
C5—4.7 µF, 16 volts, electrolytic
C6—0.0047 µF, mica
C7—10 µF, 16 volts, electrolytic
Semiconductors
IC1—8031 microcontroller (Intel)
IC2—4093 quad NAND gate
IC3—27C64 EPROM
IC4—74HC573 latch
IC5—ULN2813A relay driver
IC6—7805 5-volt regulator
IC7—H11AA1 optocoupler
BR1—200-volt, 1-ampere bridge rectifier
MOV1—300-volt metal-oxide varistor
LED1–LED4—red light-emitting diode
LED5—green light-emitting diode
Other components
XTAL1—12 MHz crystal
J1–J5—4 pin RJ-11 modular phone jack
J6—Coaxial power connector
RY1–RY4—DPDT 5-volt DIP relay
Miscellaneous: 9-volt DC 500 mA wall transformer, project case, bezel, solder, etc.

Note: The following items are available from Audio Visual Imagery, P.O. Box 332, Randolph, MA 02368:
- **PC board—$30.00**
- **Pre-Programmed 2764 EPROM—$10.00**
- **Pre-Programmed 8751 microcontroller—$35.00**

(If you're using the 8751, you do not need the 74HC573 or EPROM, just remember to move the EA jumper on pin 31 of the microcontroller to +5 volts)

Please add $3.00 shipping and handling to any order. MA residents must add 5% sales tax to all orders.

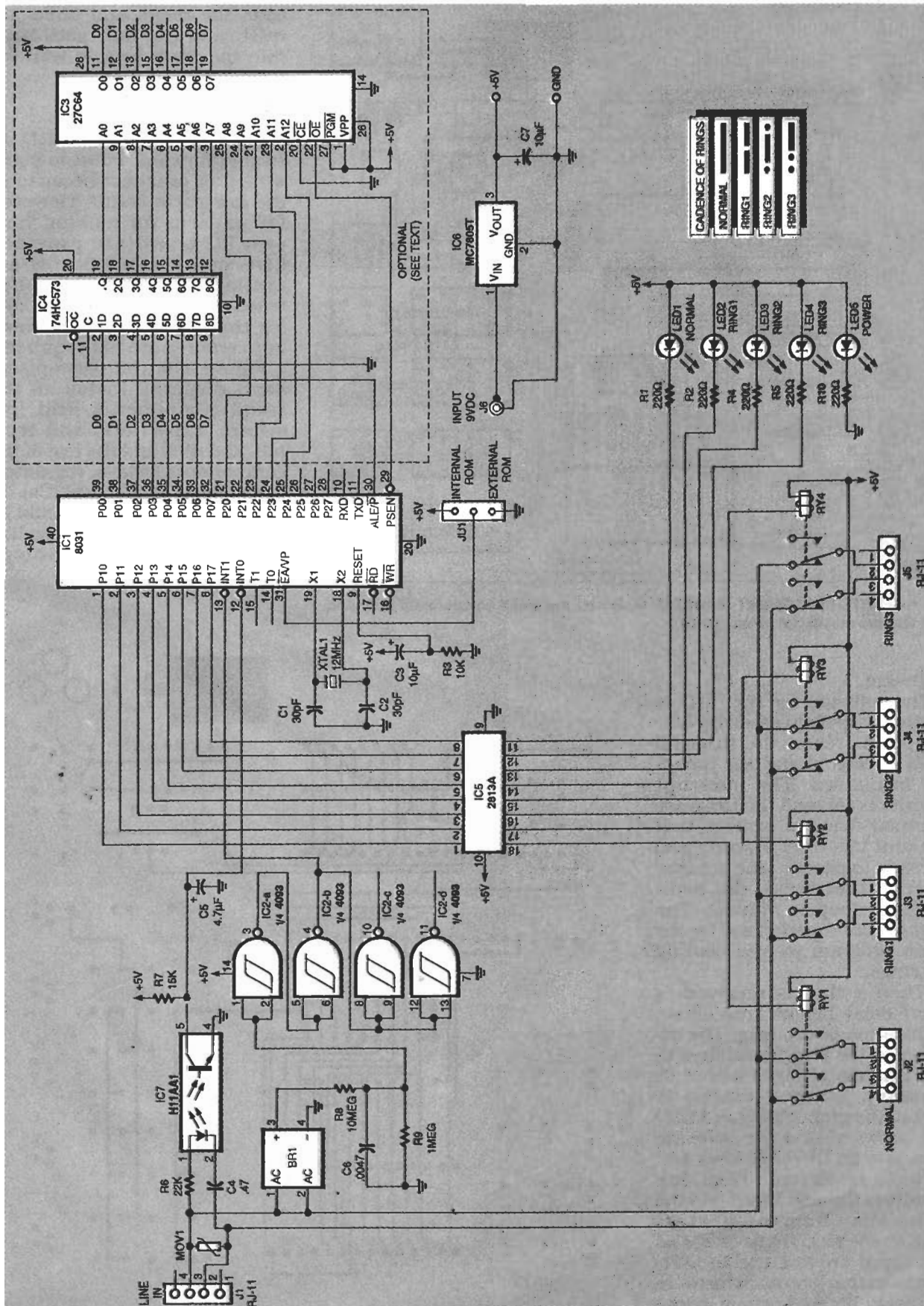


FIG. 3—COMPLETE SCHEMATIC OF THE DRD CIRCUIT. An Intel 8031 microcontroller consists of a full-duplex serial port, 2 timers, and 128 bytes of RAM.

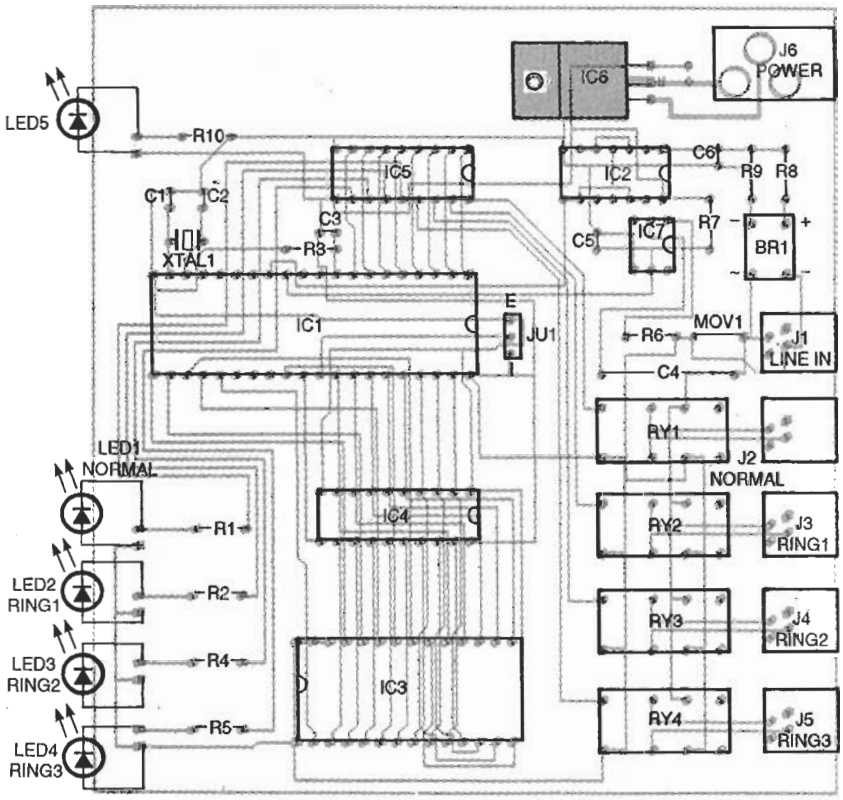


FIG. 4—PARTS-PLACEMENT DIAGRAM. Install all the small components first, and then add the rest of the components.

Software

The software for the DRD is written entirely in assembly language. At reset, the internal RAM is cleared and the timers are initialized. The interrupt priority is set, and the LEDs are scanned twice to confirm that the unit has reset properly and is ready to decode ring signals. After initialization, the main program loop is started. The only function performed by the main program loop is waiting for rings.

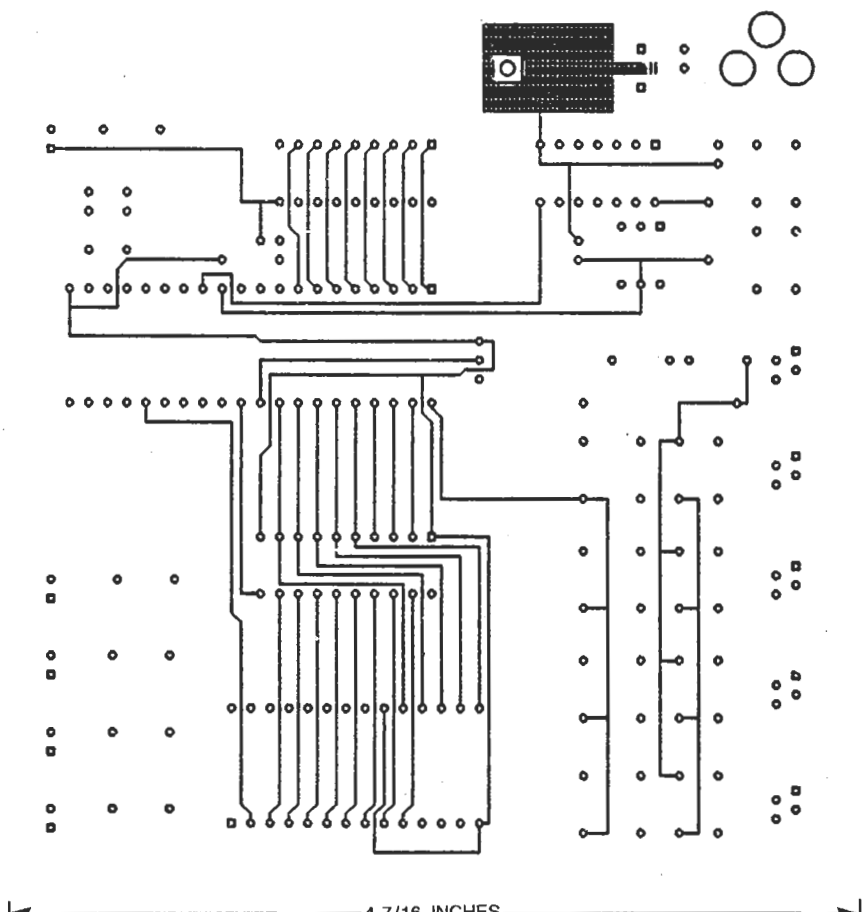
When a ring is received, a short delay begins that allows verification of the ring. The cadence of the ring is matched to the ringing patterns stored in memory. When a match is found, the proper relay and LED are activated and the software goes into an IN—USE loop, and a timer is started. This loop monitors the RING input and the IN-USE input from the 4093. As long as the RING input or the IN-USE input are low, the DRD remains in this loop and the timer is reset. When both of those lines go high, the timer times down. When the timer reaches zero, the relays and LEDs are reset. and the unit goes back into the main loop to wait for rings.

Construction

Assembly of the DRD is straightforward. Point-to-point wiring is practical because of the low parts count. However, foil patterns for making your own PC board are provided here, and finished boards are available from the supplier listed in the Parts List. Sockets for the ICs are recommended but certainly are not required.

Figure 3 is the parts-placement diagram. Install all the small components first (resistors, capacitors, and crystal), and then add the rest of the components (relays, regulator, connectors, MOV1, and ICs).

The finished board should be mounted in a suitable case like the wire-wrapped prototype shown in Fig. 4.



COMPONENT SIDE FOIL PATTERN.

Operation

Note that you must first subscribe to a distinctive-ringing service for the DRD to work. For the most flexible installation, the DRD should be connected to the phone line at the point where it enters the house. This will allow all calls to be redirected to their correct locations.

Plug the extension phones into the device and apply 9-volts DC to the unit with a wall-outlet mounted adapter. The DRD will respond by energizing, and then de-energizing the relays. The LEDs will scan back and forth twice, and the unit is then ready to receive and decode incoming calls.

If the unit doesn't respond, first make sure that all cables are installed correctly. Check for 9 volts DC at the input to the regulator, and 5 volts DC at its output. If no voltage is present, check for the proper polarity of the wall adapter.

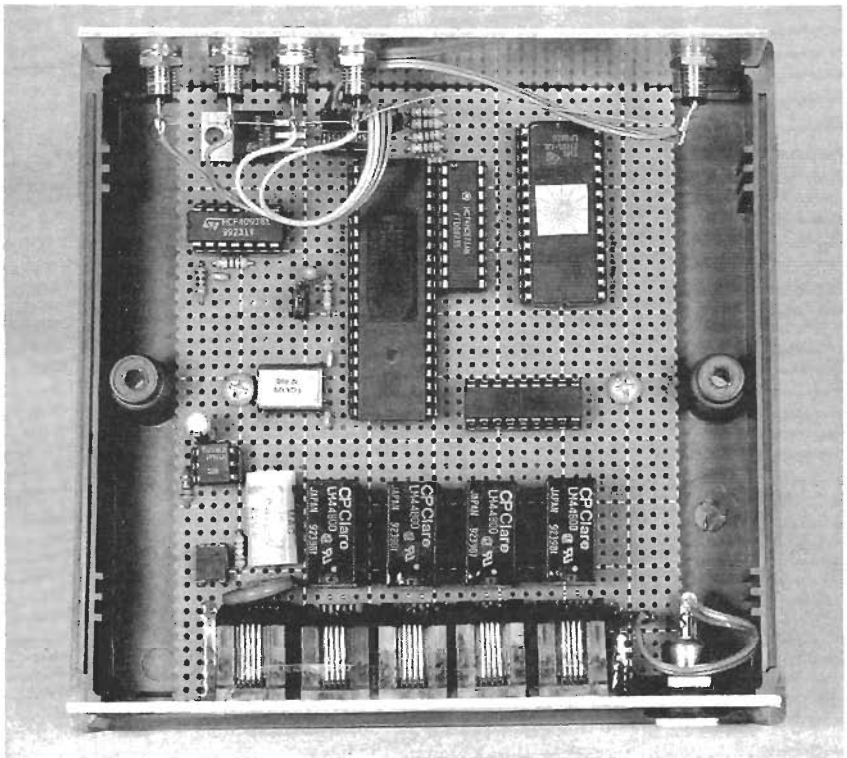
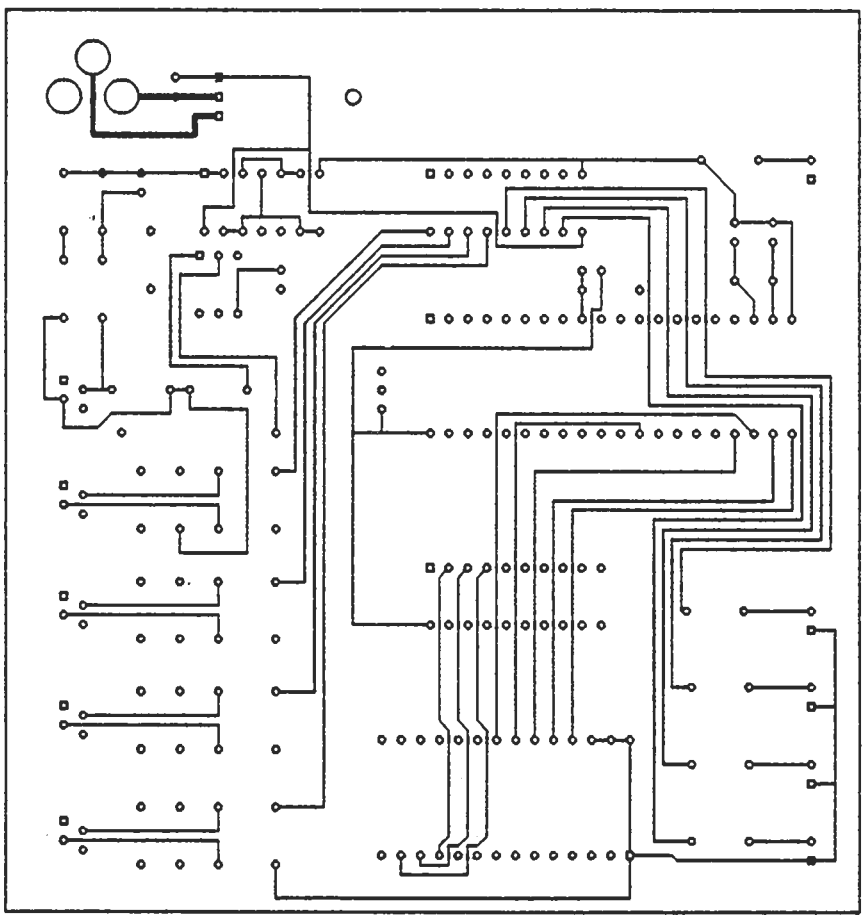


FIG. 5—COMPLETED PROTOTYPE. This one was made using point-to-point wiring.



4 7/16 INCHES

SOLDER SIDE FOIL PATTERN.

If you use an EPROM and latch chip, make sure the EA line of the microcontroller is jumpered to ground. If you use the single-chip microcontroller, make sure the microcontroller is connected to 5 volts. Also place a scope probe on pin 18 or 19 of the microcontroller and measure to be sure the oscillator is running. Check pin 30 of the microcontroller for a signal that is approximately one-sixth that of the oscillator frequency.

If all the signals are present but the LEDs don't scan back and forth, check the wiring of the LEDs, the 2813A chip, and the reset circuit (C3 and R3). If the unit resets but won't respond to the ringing signal, check the positioning of IC7. When the phone is ringing, the output of the optocoupler should pull low for each cycle of the ring. If the optocoupler's output does not do that, check R6, R7, and C4. If the unit decodes the rings correctly but will not reset the relays at the end of a call, verifyt that pin 4 of the 4093 goes low when an extension phone goes off-hook. Ω