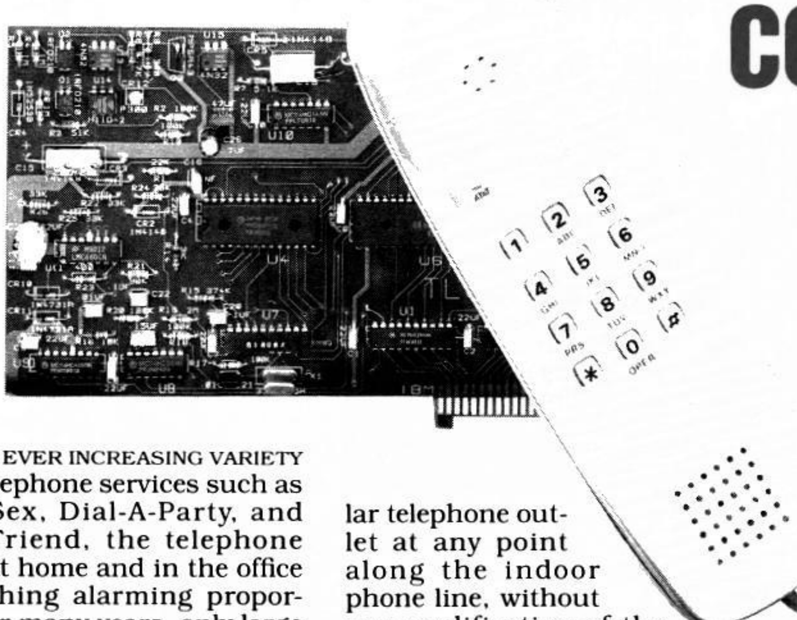
Build R-E's TELEPHONE-LINE CONTROLLER



Take full control of incoming and outgoing telephone calls.

MORDECHAI SAAD

WITH THE EVER INCREASING VARIETY of pay telephone services such as Dial-A-Sex, Dial-A-Party, and Dial-A-Friend, the telephone abuses at home and in the office are reaching alarming proportions. For many years, only large corporations were able to afford PBX (private branch extension) systems with facilities to restrict the use of certain numbers. However, now you can build an inexpensive, microprocessor-controlled, integrated telephone line controller that can selectively restrict outgoing calls, selectively restrict incoming calls, selectively dial an array of numbers for promotions, and record all activities on the telephone line, including the time, date, and duration of each call.

The controller uses an IBM PC or clone as a host. However, the card is almost a stand-alone device. It includes its own microprocessor and runs its own operating program. The computer is needed to load the operating program into the controller's static RAM, to initialize operations, and to let the user interact with the controller. The host computer may access the SRAM for reloading firmware, sending and retrieving data, and alternating modes and functions. An internal power supply allows the line controller to operate even when the host computer is turned off.

The line controller does not have to be installed on the phone line at the point of entry to restrict outgoing calls and screen unwanted incoming calls. The card can be plugged into a modular telephone outlet at any point along the indoor phone line, without any modification of the existing installation (see Fig. 1).

How it works

The controller is fully programmable and can perform a wide variety of functions. Using the software provided on the RE BBS, the controller can prevent a number from being dialed if the prefix matches a number on your "list to restrict" (see Fig. 2). If, for example, the list contains the number 9311, then dialing 931-1882 (or 931-1xxx) will be prevented. A list containing 0–9 will prevent all outside calls, and a list containing 0, 1, 20, 21, 30, 31, 40, 41...90, 91 will prevent the use of all area codes, operator, and international. The list can consist of up to 128 prefixes, up to 6 digits each.

The user may choose to have the controller automatically list all outgoing calls made on the computer screen. The list will consist of the destination telephone number, date, time, and duration of each call.

The user can screen incoming calls and limit them to as many as 32 relatives and friends. In that case, the card would have to be used in conjunction with a telephone answering machine. The answering machine would prompt the caller to enter his own number. Then, only the numbers that match one on the list will be allowed to go through. Any matching number, along with time and date, will be stored in memory for later use. The user can then make a list of the incoming calls appear on the screen.

The card can be used to automatically dial a number from the keyboard, a number selected from a menu, or a pre-selected range of numbers. The redial function is not limited to the last dialed number, as the user may select a number from a list of previously dialed numbers.

Circuitry

The line controller contains a microprocessor, memory to hold the software and data, interface circuitry for the host computer, a telephone line interface, and a wall transformer to maintain power when the host computer is off.

A schematic of the circuit is shown in Fig. 3. In the center of the diagram is the microprocessor (IC6, a 65SC02), which is an 8-bit CMOS version of the 6502 used in Apple, Atari, Commodor, and other computers. The static memory, IC4, is an 8K×8 SRAM. The host computer is used to write the program to IC4. The bi-directional tri-state buffer (IC5) is enabled by the pro-

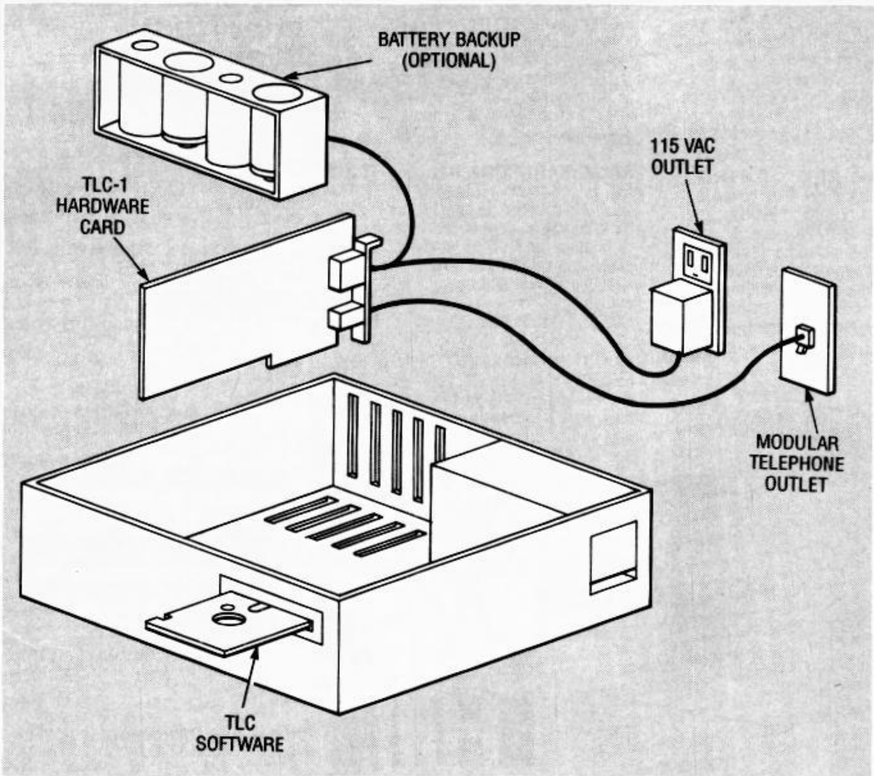


FIG. 1—THE ADD-ON-CARD can be plugged into a modular telephone outlet at any point along the indoor phone line, without any modification to the existing installation.

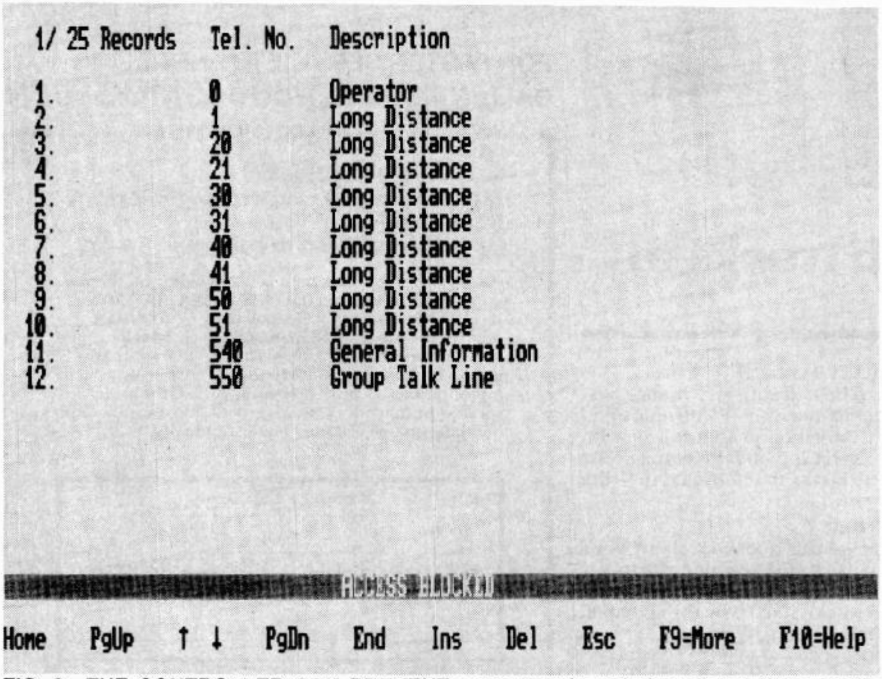


FIG. 2—THE CONTROLLER CAN PREVENT a number from being dialed if the prefix matches a number on your "list to restrict."

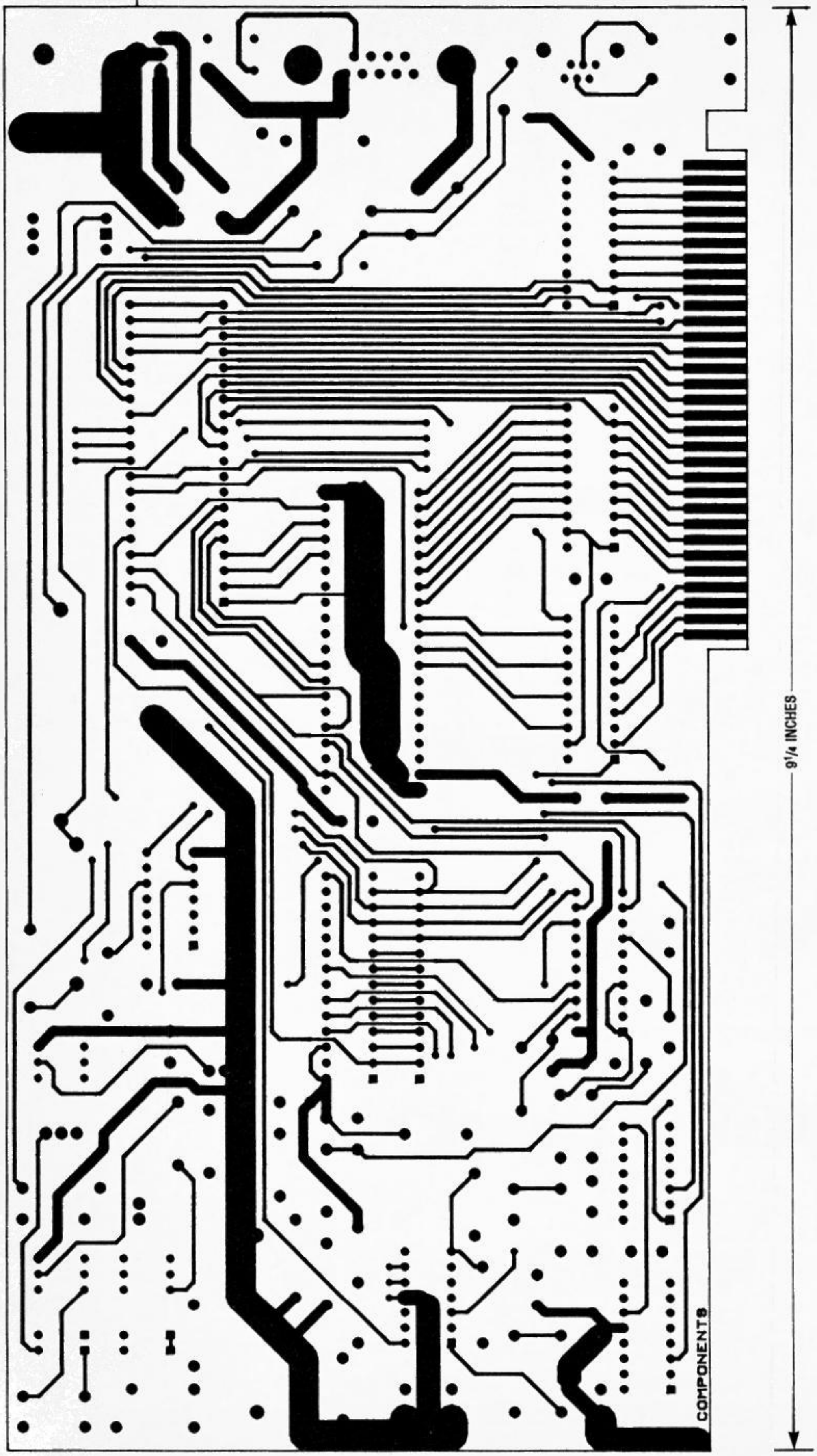
cessor on pin 1 (the direction pin) according to whether the host computer wants to read from or write to the SRAM. Components C16, R1, and D3 provide the processor with a power-on reset.

The peripheral interface adapter (PIA) IC3 is responsible for synchronizing the control of the buses between the host processor (80xx) and the controller's 6502. The DTMF (dual-tone multi-frequency) transceiver, IC7, is constantly monitoring the telephone line for DTMF activities, as well as for incoming calls. When dialing, the transceiver generates DTMF signals. Resistors R17 and R18 set the gain of IC7 to 1, C24 provides AC coupling for the incoming signals, and D10 and D11 are 4.3 volt-Zener diodes; when connected back to back they limit the voltage swing on the secondary of T1 to 5 volts (4.3 + 0.7), thereby protecting IC7 and IC11 from voltage transients. The transmitter output of the DTMF transceiver is buffered by IC11-b to drive the 600-ohm line transformer T1. IC11-b is configured as an inverting amplifier with a gain of 1. By connecting the non-inverting input to a reference voltage of 2.5 volts, the output swing can extend to both rails, centered around 2.5 volts.

The other side of T1's secondary is connected to the output of IC11-a which is configured as a voltage follower to buffer the voltage reference of IC7, and is also used as a return for the line transformer T1. The on-chip clock oscillator of IC7 uses a 3.58-MHz crystal, and the output is coupled to the input of 4-bit binary counter IC8-a via C21. The first-stage output of the counter is the source of the 1.79-MHz clock for the processor. The fourth bit of IC8-a outputs 224 kHz, which IC8-b divides down to 14 kHz. The 14-state counter, IC9, divides the 14 kHz by 1024 down to 13.65 Hz, which is the real-time clock. The 13.65-Hz clock signal is used to tag events such as outgoing calls, incoming calls, and duration of calls, with a relative time and date. The host computer converts it to absolute time and date.

Varistors R27–R29 are used as surge suppressors, preventing the tip and ring terminals from exceeding a differential potential of 150 volts with respect to chassis ground and to each other. Bridge-rectifier BR2 is used to correctly polarize the telephone line on its way to the line-status and -control circuitry. The ring-detector circuitry is connected directly to tip and ring. It detects an AC signal greater than 100 volts p-p. Capacitor C18 blocks the 48-volts DC from opto-coupler IC15's LED, and R11 limits the LED's current.

When a ring signal is present, the opto-coupler's output transistor is on, which causes C26 to



YOU CAN MAKE YOUR OWN PC BOARD for the telephone line controller. This pattern is for the component side of the board.

discharge, pulling the input of IC10-d to ground. The processor reads the output of IC10-d (high when ringing) into data line DO by enabling IC1. Resistor R10 charges C26 at a rate where the brief pauses between rings will not reach the threshold of IC10-d, thereby maintaining IC10-d's output high.

Schmitt trigger IC10-e and IC14 allow the controller to "pick-up," or get on line. The processor sets the input of IC10-e. The output of IC10-e then drives the LED part of opto-coupler IC14 to ground via R7. The transistor part of IC14 then turns on, driving Q3. At this point, the following components are conducting the loop current in a clockwise order: R13, ¼ of BR2, Q3, LED1, R9, ¼ of BR2, and R12. LED1 is there only to indicate that the controller has "picked-up."

A circuit made up of transistors Q1 and Q2, IC13, and IC10-c continually monitors the telephone line. When any telephone on the line is picked up, the voltage between the tip and ring drops from 48- to 7-volts DC and, as a result, Q2 turns off. Transistor Q1 then turns on, turning on the transistor in the opto-coupler IC13, causing the output of IC10-c to go high. That tells the processor that somebody is on the line. The processor reads that signal on data line D1 via IC1. IC10-a and -b provide the internal microprocessor with a reset pulse on power up, and on bus-transfer command.

The card can get its power from the host computer via D2, at least while the host computer is in operation, and the external wall transformer is not connected. The existence of external power

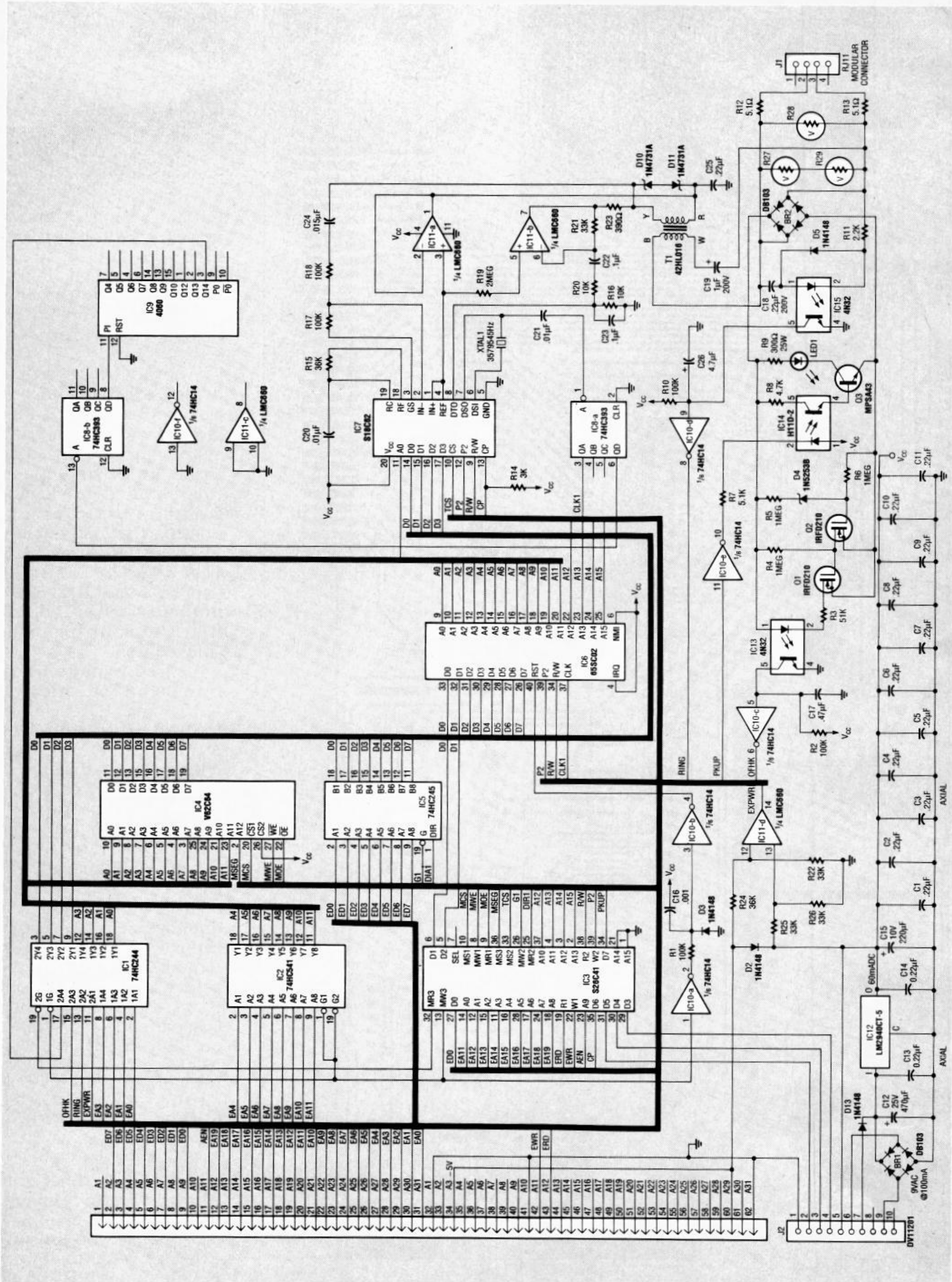


FIG. 3—SCHEMATIC OF THE LINE CONTROLLER. The 8-bit CMOS microprocessor (IC6) is used to coordinate everything.

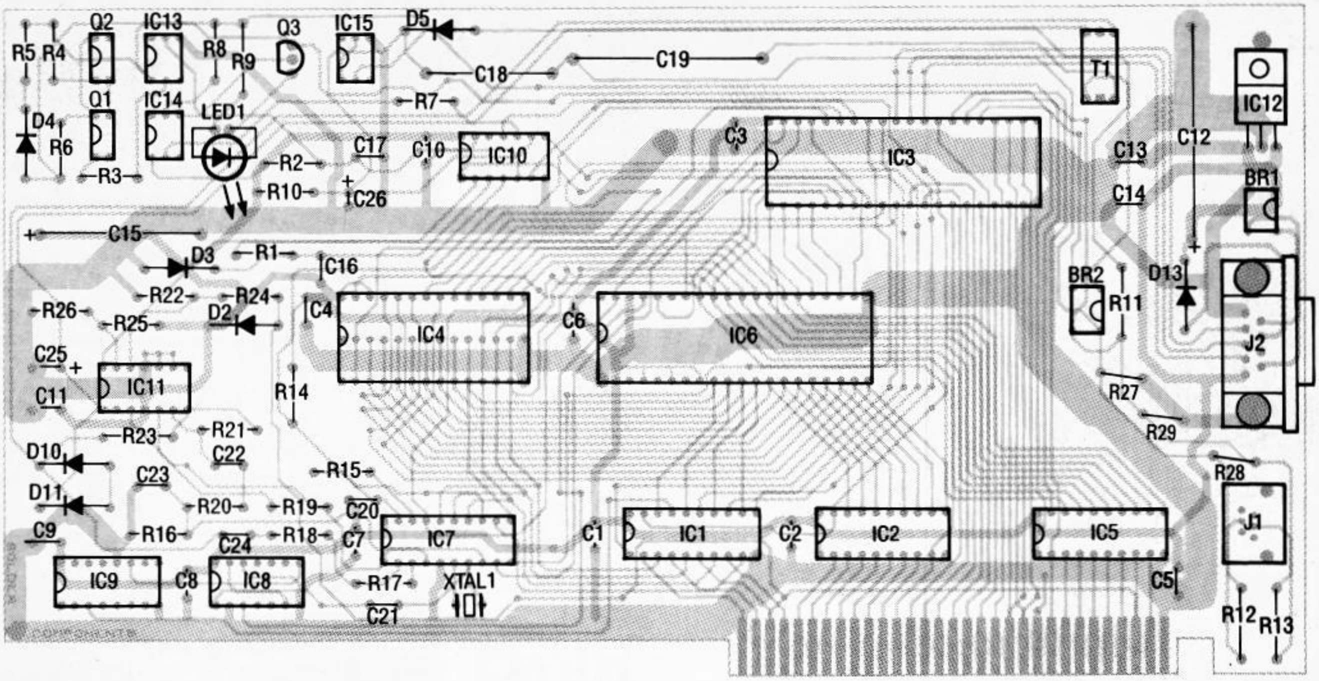


FIG. 4—PARTS-PLACEMENT DIAGRAM. The card is assembled on a double-sided PC board that fits in an expansion slot on your motherboard.

PARTS LIST

All resistors are ⅛-watt, 2%, unless otherwise indicated.

R1, R2, R10, R17, R18—100,000 ohms
R3—51,000 ohms
R4–R6—1 megohm
R7—5100 ohms
R8—4700 ohms
R9—300 ohms, ½-watt
R11—2200 ohms
R12, R13—5100 ohms
R14—3000 ohms
R15, R24—36,000 ohms
R16, R20—10,000 ohms
R19—2 megohms
R21, R22, R25, R26—33,000 ohms
R23—390 ohms
R27–R29—P7056 125-volt surge suppressor

Capacitors

C1–C11, C13, C14, C25—0.22 µF, 50 volts, ceramic
C12—470 µF, 25 volts, electrolytic
C15—220 µF, 10 volts, electrolytic
C16—1000 pF, 100 volts, ceramic
C17—0.47 µF, 50 volts, ceramic
C18—0.22 µF, 250 volts
C19—1 µF, 250 volts
C20, C21—0.01 µF, 100 volts, ceramic
C22, C23—0.1 µF, 50 volts, ceramic
C24—0.015 µF, 100 volts, ceramic
C26—4.7 µF, 25 volts, electrolytic

Semiconductors

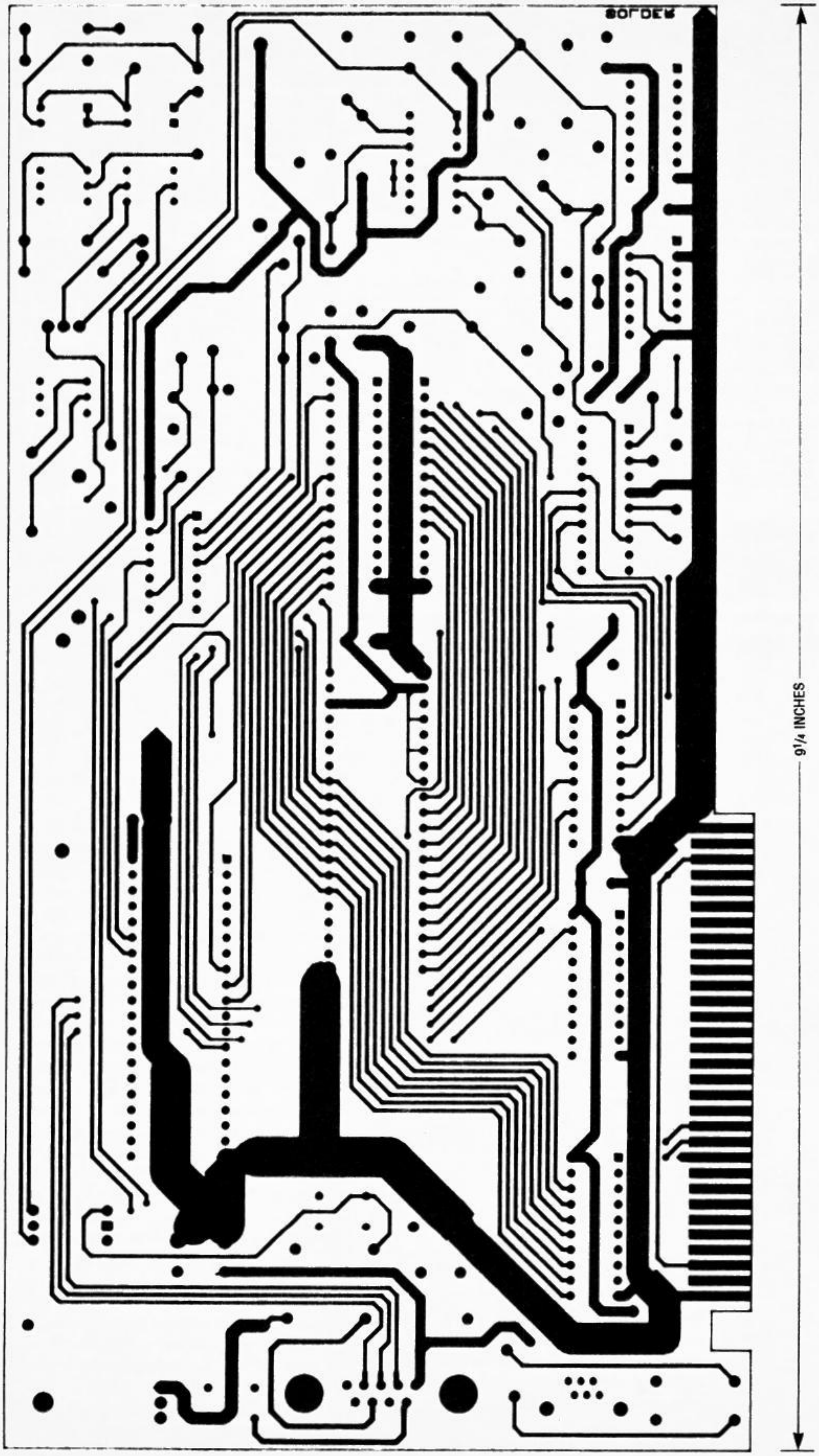
IC1—74HC244 octal tri-state buffer
IC2—74HC541 octal tri-state buffer
IC3—S26C41 interface adapter
IC4—V62C64 8K × 8 SRAM
IC5—74HC245 octal transceiver
IC6—65SC02 8-bit microprocessor
IC7—S18C62 DTMF processor
IC8—74HC393 dual 4-stage counter
IC9—74HC4060 14-state counter
IC10—74HC14 hex Schmitt trigger
IC11—LMC660 quad op-amp
IC12—LM2940CT-5 +5-volt regulator
IC13, IC15—4N32 optoisolator
IC14—H11D-2 optoisolator
BR1, BR2—DB103 bridge rectifier
D2, D3, D5, D13—1N4148 switching diode
D4—1N5253B 25-volt Zener diode
D1, D6–D9, D12—not used
D10, D11—1N4731A 4.3-volt Zener diode
LED1—P300 light-emitting diode (any color)
Q1, Q2—IRFD210 N-channel hex DIP
Q3—MPSA43 H.V. NPN transistor

Other components

J1—H9032 modular connector
J2—8926 747844-1 female D-subminiature connector
T1—42HL016 600/600-ohm transformer
XTAL1—3.579545-MHz crystal

Miscellaneous: PC board, 9-volt 200-mA AC wall adapter, E09P male D-subminiature connector, battery holder, PC bracket, hardware, solder, etc.

Note: The following items are available from AC&C, 717 E. Jericho Tpk., Suite 101, Huntington Station, N.Y. 11746: A PC board (TLC-1) and OGC Restrainer software (on 5¼-inch floppy disk), $55.00; A wall transformer, modular phone cord, three connectors, and a metal PC mounting bracket $36.00; all the above mentioned items, and all components including semiconductors, resistors, capacitors, and optoelectronics devices; $198.00. Be sure to add $5.50 to any order for shipping and handling. For technical information, write to AC&C, and please include a self-addressed stamped envelope. AC&C is constantly adding software functions for the entire product line, and for those with unique applications, AC&C is ready to work on your custom software requirements.



THIS IS THE FOIL PATTERN for the solder side of the telephone line controller PC board.

(AC line transformer, and or battery backup) is detected by IC11-d, in order to alert the user before shutting off power on the host computer. Resistors R24 and R22 are set to provide the non-inverting input of IC11-d with 2.39 volts.

When external power exists, the cathode of D2 is at 5 volts. When external power does not exist, the voltage drops to 4.3 volts; resistors R25 and R26 divide the voltage by 2, to 2.5 and 2.15 respectively, to drive the inverting input of IC11-d. The output, therefore, will go high when the external power does not exist and vice-versa. The 5-volt regulator IC12 provides the circuits with power as long as it is supplied with at least 6.5-volts DC or 7 volts AC RMS.

A provision has been made for future interface with external hardware on a three-line serial communication; see pins 2–4 of connector J2. Also, ground and V_{CC} is brought to pins 1 and 5 respectively. The connection of a battery to pin 7 is optional; when used, it ensures proper operation during power interruptions.

Construction

Construction of the card is straightforward. Figure 4 shows a parts-placement diagram. The PC board can be made from the foil patterns provided, or you can purchase one from the source mentioned in the parts list. When building the board, just be sure to install the IC's last, as they are more susceptible to damage than the other components. The only other thing that needs explaining is the bracket that holds the card down in the computer. You must take a "blank" IBM-

(Continued on page 82)

TELEPHONE LINE

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PC type bracket, and cut openings for J1 and J2.

Installation

With the modified bracket installed on the card, it is very simple to install in an IBM PC or clone. All you have to do is locate an unused slot in your computer's expansion bus. Make sure the computer is off during the installation. Remove the blank mounting bracket from the back of the computer (if one exists), and insert the new card into the slot. Install the mounting screw, and then plug in the phone line and the AC adapter and battery backup if used, and you're ready to roll.

Software

The software is menu driven and, in most cases, a single key stroke is all it takes to change mode or to perform an operation. Screen colors are used for highlights, and for separation of fields. The only thing you have to remember is to type TLC and hit return (from the DOS prompt). All programming, functions, and mode selections thereafter are done using menus. (See sources box for custom software.)

The software consists of two programs: the operating program and the resident program (which are available on the RE-BBS—516-293-2283). The operating program runs on the host computer and provides the interface with the controller's hardware. The resident program is what the operating program loads into the on-board SRAM. The resident program is the actual program that determines what the controller will perform. But it is the operating program that is used to select, configure, and load the resident program.

User registration cards

Although the software is not copy protected, we strongly recommend users to register their copies; doing so will automatically put you on AC&C's mailing list. AC&C will inform users of new applications software, functions, and updates. **R-E**

The Sound of Audio: An AES conference report

LARRY KLEIN

Last month I wrote about an audiophile High End Hi-Fi Show. This column is about an altogether different kind of "show" sponsored by the Audio Engineering Society (AES). Properly billed as a conference, rather than a show, "The Sound of Audio" was a wide-ranging exploration of the latest findings on the perception, measurement, recording, and reproduction of sound. A variety of papers were presented along with a special session on the reviewing of audio products featuring reviewers from both "slick" and "underground" publications. Given my 20 years in charge of product reviewing for *Stereo Review*, I heard nothing new—although the session gave me a chance to say hello to a lot of old friends. However, the pertinent and intelligent questions from the audience led me to make a mental note to discuss the somewhat controversial topic of equipment reviews in a future *Audio Update* column. Now, on with the conference.

Pyschoacoustics

Because of my ongoing interest in psychoacoustics, I found the several sessions devoted to audio perception both interesting and enlightening. As you may know, psychoacoustics deals with subjective sonic perceptions, as contrasted to objective sonic measurements. A simple example: For a sound to be heard subjectively as twice as loud, its objective increase in sound-pressure level must be approximately 10 dB.

The three presenters were all university researchers, and their talks included some of their own original research in addition to the very latest findings in the field. Rather than attempting to synthesize three lengthy, and sometimes complex, papers, I'll extract (and paraphrase when necessary) some of the opinions and findings that caught my ear.

- Despite hundreds of years of investigation into human hearing, many mysteries and confusions remain. One author discussing the difficulties of operating in the area of qualitative judgments (Is it twice as loud or 1½ times as loud?) urged that because we are trying to measure the behavior of a very complex biological system that we be skeptical of the derived numbers—they might not mean what we think they do. I got a strong feeling that there is an enormous amount of research that remains to be done, and that digital manipulation of the testing signals is an important new facilitating tool.
- There is more to hearing loss than a simple reduction of sensitivity to various frequency areas. Unfortunately, at the frequencies where there is a hearing loss there are also additional changes that affect perception. Thus, we generally cannot restore normal perception by simply restoring normal sensitivity with a hearing aid or by using equalizers or tone controls in a hi-fi system. The study of the perceptual consequences of hearing loss is an important and very active research area of psychoacoustics and audiology.
- The ear has an incredible absolute sensitivity: At 3 kHz, where the ear is most sensitive, a sound at the threshold of hearing produces a displacement of the eardrum that is about 1/100 of the diameter of a hydrogen molecule! The threshold of pain (ranging from 140 dB at 20 Hz to about 120 dB at 2 kHz) is generally given as the upper intensity limit of hearing. Unlike the eye, whose iris visibly adjusts itself to the ambient illumination, the ear maintains its approximately 120-dB dynamic range by dividing different intensity levels among separate groups of nerve fibers. Each of the fiber groups can handle a range of only 30–40 dB. At levels about 40 dB or so, only about 15–20% of the ear's 30,000 nerve fibers are handling the incoming sounds.
- It is almost always incorrect to refer to the *loudness* of a sound as, say, 90 dB SPL. Sound pressure level is a physical measurement and only indirectly related to loudness, which is a subjective evaluation. A sound measuring 90 dB could be, depending on its frequency spectrum, loud or quite soft.
- There's a new interest in sound-localization research. Some recent findings include: Complex, broadband sounds are localized best, high frequencies must be present for accurate judgment of a sound source's apparent height, and localization is most precise for signals in front and at ear level.

WHO IS AES?
The AES is an international organization whose membership includes more than 10,000 persons involved on a professional, semiprofessional, and amateur level in all aspects of audio. For further information on The Sound of Audio conference, on how to become a member of the AES, and/or a catalog of available publications and technical papers, write to: Audio Engineering Society, 60 East 42nd Street, New York, NY 10165-0075.

It has been generally accepted that our brain localizes sound sources by using the intensity and timing difference between the sounds reaching each of our ears. Although research has shown that the specific convolutions of our external ears (pinnae) cause reflective cancellations and reinforcements of signals before they reach our ear canals, only recently has it been understood that this direction-dependent spectral filtering plays an important role in our ability to localize sound sources.

Another recent experiment on directional perception sought to determine the relative importance of interaural arrival-time versus sound-intensity differences in determining localization. By digitally manipulating the signal, the experimenters were