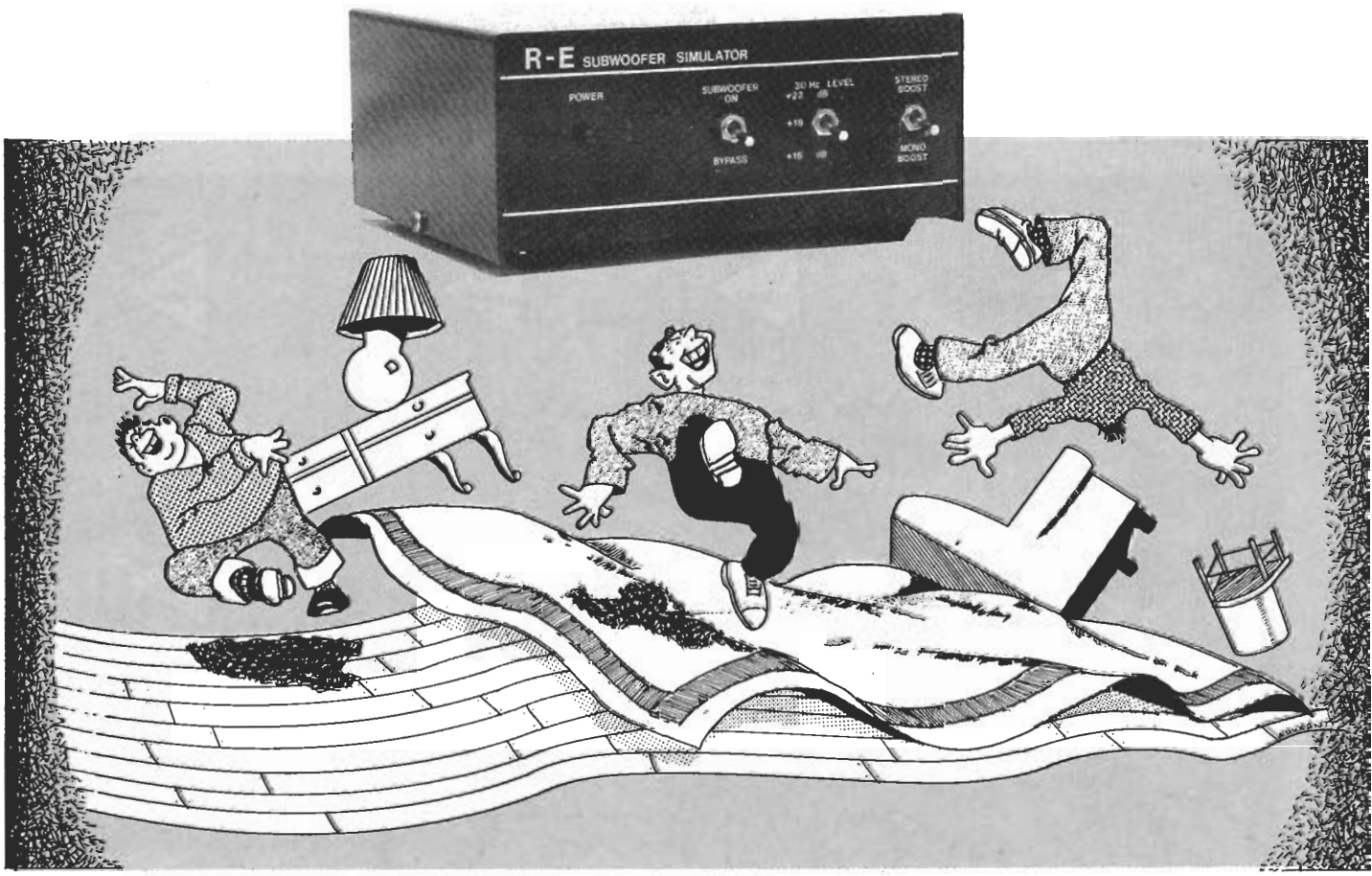
BUILD THIS

SUBWOOFER SIMULATOR

NORM HILL



Build a subwoofer simulator and fill your living room with movie-theater sound you can actually feel.

A MOVIE THEATER CREATES REALISM BY projecting a large picture, using surround sound, and by extending the sound's low-frequency response with subwoofers so that the viewer can actually feel the special-effects. When a movie contains explosions, jet rumble, thunder, galloping horses, or other heavy-duty action, the subwoofer adds realism by literally shaking the floor.

Although it is generally accepted that a healthy ear can hear a frequency range of 20 Hz to 20 kHz, in fact, some of that range is not so much heard, but sensed. For example, many people cannot hear frequencies higher than 15 kHz, although they can sense that they exist. It's the same thing for frequencies in the deep-bass range of 20–50 Hz; many persons cannot hear frequencies within that range, although they can feel and sense them as vibrations.

In a theater, special effects are often exploited by enhancing the deep-bass frequencies, so that when the jets rumble, they rumble so powerfully that you can actually feel the runway vibrating under your feet. (And a flat frequency response ceases to be desirable once your feet become the listening transducers.) Below 20 Hz, sound is neither felt nor heard; at best there is a strange sensation of changing air pressure.

But although most people can perceive sounds in the 20–50 Hz range, because conventional woofers, even 12-inch and larger, roll off below 50 Hz, deep bass sounds are rarely heard unless some kind of deep-bass compensation is provided. The usual solution to providing deep bass in both theaters and the home is to add a monaural subwoofer that is driven off the front channels by an active filter and a separate amplifier.

Not that perfect

Unfortunately, there are some drawbacks to using a monaural subwoofer. It is commonly assumed that deep-bass information has such a long wavelength that it will be summed by the room to a mono signal, and that therefore a single transducer can be

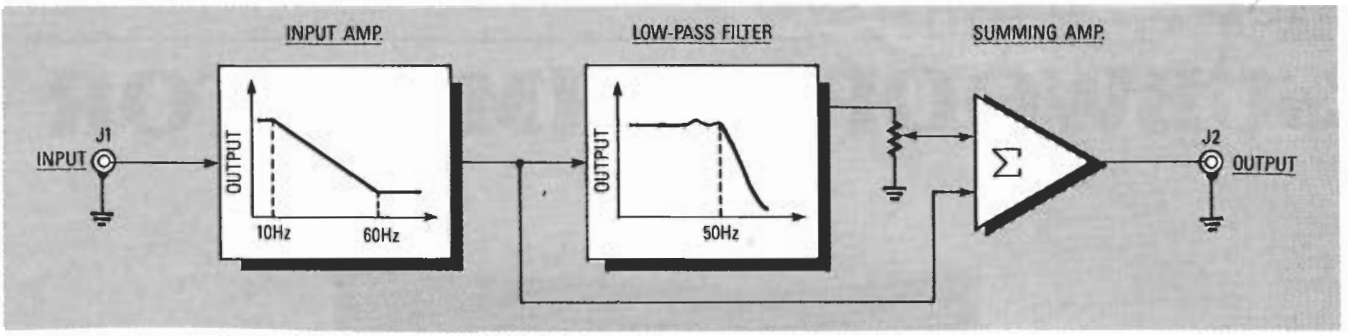


FIG. 1—TO ENSURE THAT ONLY THE DEEP-BASS FREQUENCIES are enhanced, the simulator's first stage amplifies the frequencies below 60 Hz before the low-pass filter attenuates all signals above 50 Hz.

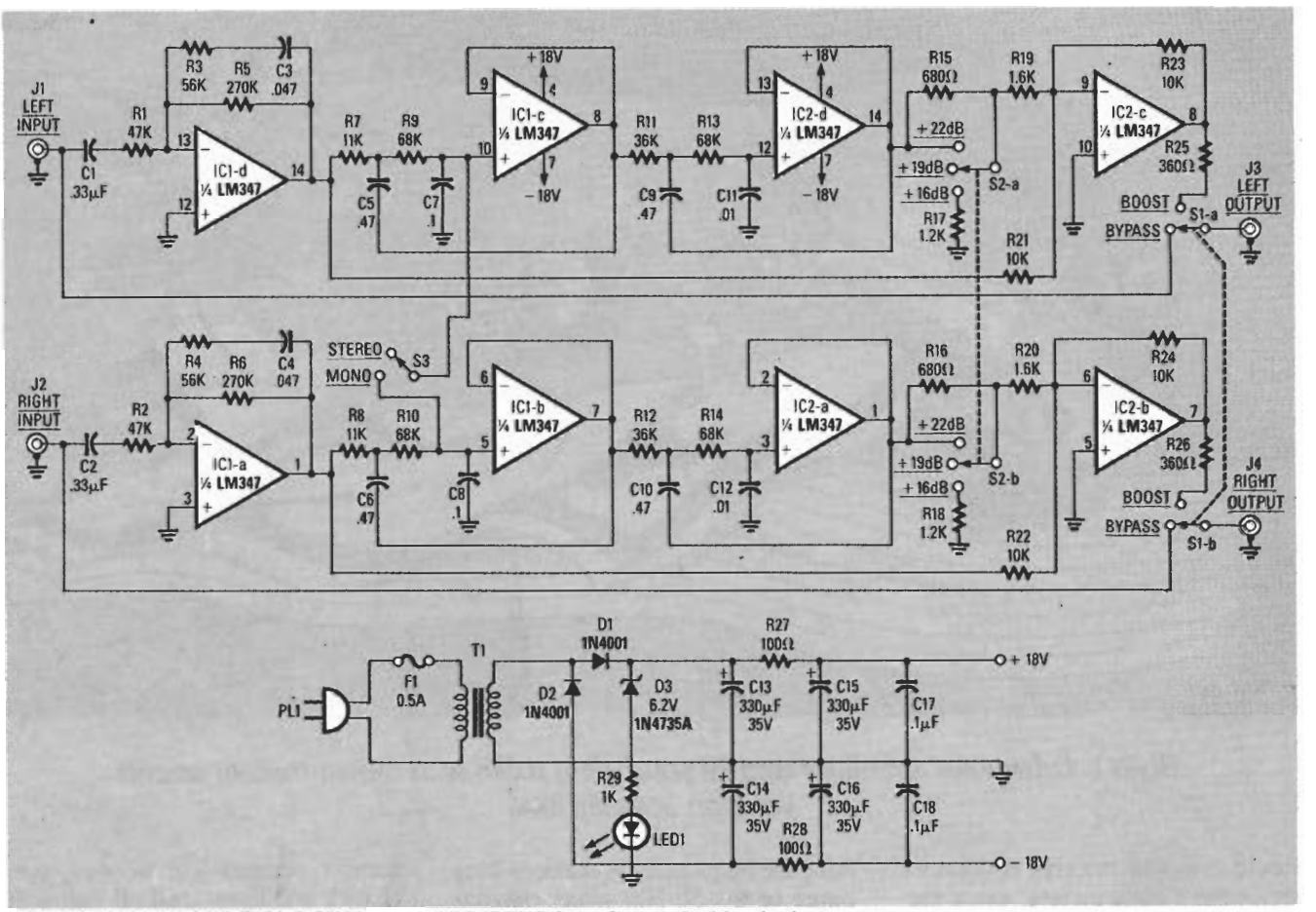


FIG. 2—THE LEFT AND RIGHT CHANNELS ARE IDENTICAL. Switch S3 blends the two channels when only mono deep-bass sounds are wanted. Switch S2 provides three levels of deep-bass amplification.

used. A simple comparison of mono and stereo bass-boosting calls that into question. Jet rumble, such as in the movie *Top Gun*, takes on a flatter, quieter, less spacious sound when boosted monaurally instead of stereophonically. A quick check of the low-frequency information (measured using a dual-trace scope and active 50-Hz stereo filters) shows that the two channels have little in common during jet rumble or numerous other situations. Only in music are the two channels similar.

Another concern is the type of filter used to feed the subwoofer. All filters have substantial phase shift at the roll-off frequencies. It can easily turn out that the high-band and low-band speaker cones will end up out of phase during the transition region, causing a loss of response over, say 60–90 Hz, which will produce a peculiar bass quality. It is likely that many subwoofer systems suffer that problem, especially those using simple passive crossovers for which 180° is a common roll-off phase angle.

Price is another objection to a mono-subwoofer system that includes a filter and separate amplifier: You'll have to spend a lot before your floor starts to shake, rattle, and roll.

A cheaper way

A less expensive way to simulate the "feelie" effect of the movie theater's deep-bass system is to simply boost the bass signal delivered to your existing front speakers. (Most home-stereo systems are overbuilt, at least when listening to a video movie at the

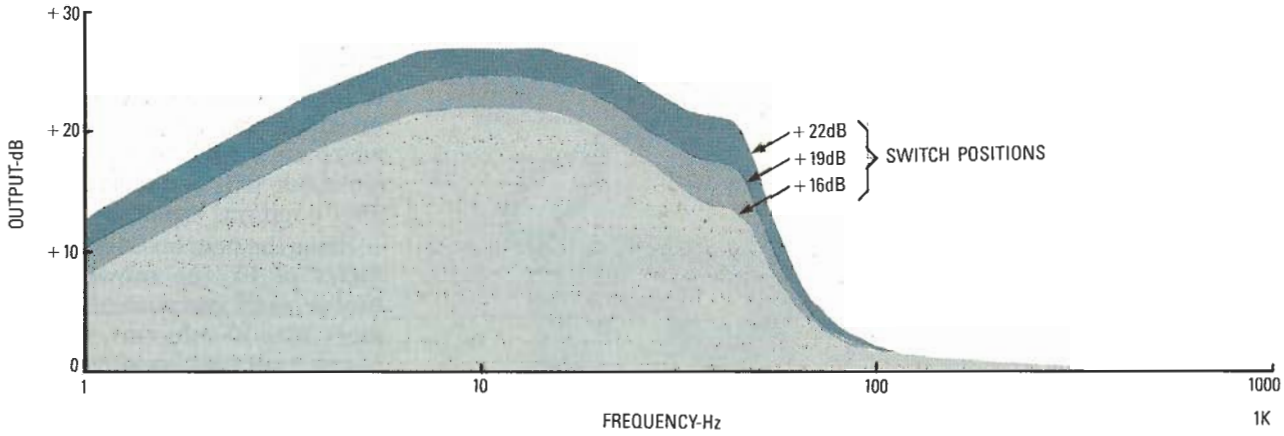


FIG. 3—MAXIMUM DEEP-BASS BOOST IS ATTAINED AT approximately 12 Hz. Note that the curves shown are unattainable with conventional tone controls.

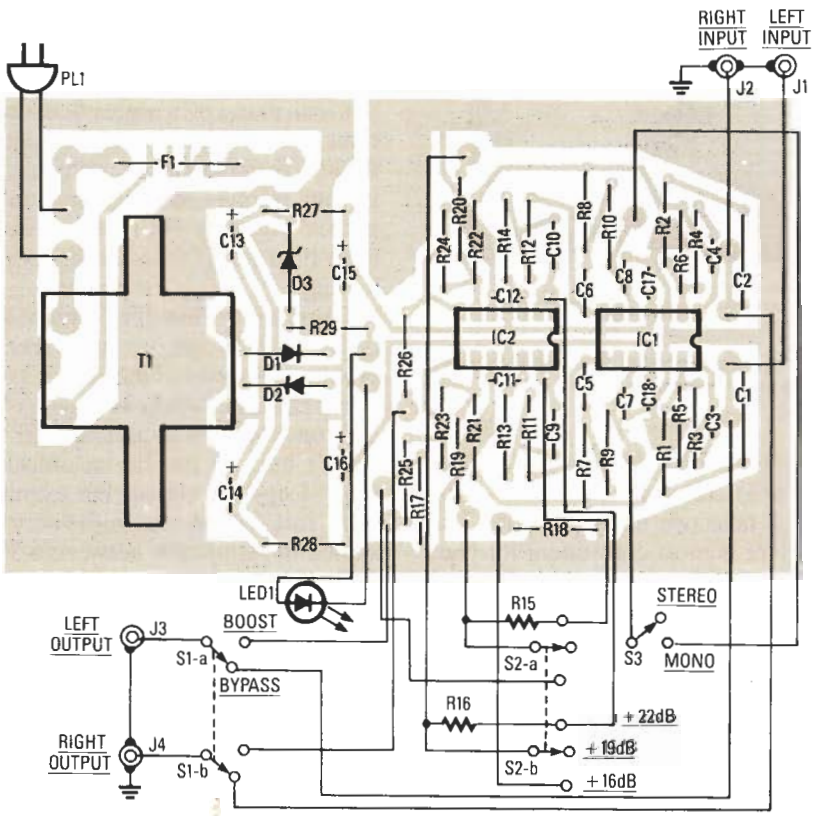


FIG. 4—THIS IS THE PARTS LAYOUT for the printed-circuit board. Take note that resistors R15 and R16 are mounted on switch S2, not on the board.

usual living-room volume level.) Although home-speaker systems having a 10- or 12-inch woofer may be rolling off between 20–50-Hz, that doesn't mean that they can't radiate energy in that range. We merely need to provide compensation so that they get more power in the deep-bass frequency range. An analogy is hitting the loudness switch or turning up the bass, except that the boost must be more selective to create the illusion of a subwoofer's sound & feel.

Figure 1 shows the block diagram of a subwoofer simulator that can be used for either the left or right channel. The first stage is a buffer-amplifier that provides gain below 60 Hz to compensate for the fact that most speakers roll off in that range. The buffer is followed by an active low-pass filter that removes everything except the deep-bass frequencies. The output from the filter is summed with its input so that the total bandwidth is at a substantially higher level than it

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R2—47,000 ohms
R3, R4—56,000 ohms
R5, R6—270,000 ohms
R7, R8—11,000 ohms
R9, R10, R13, R14—68,000 ohms
R11, R12—36,000 ohms
R15, R16—680 ohms
R17, R18—1200 ohms
R19, R20—1600 ohms
R21–R24—10,000 ohms
R26, R26—360 ohms
R27, R28—100 ohms
R29—1000 ohms

Capacitors
C1, C2—0.33 µF, 100 volts
C3, C4—0.047 µF, 50 volts
C5, C6, C9, C10—0.47 µF, 50 volts
C7, C8, C17, C18—0.1 µF, 50 volts
C11, C12—0.01 µF, 50 volts
C13–C16—330 µF, 35 volts, electrolytic

Semiconductors
IC1, IC2—LF347N, Quad JFET op-amp
D1, D2—1N4001 rectifier diode
D3—1N4735A, Zener diode, 6.2 volts,
LED1—Light-emitting diode

Other components
F1—½-amp slo-blo fuse
J1–J4—Phono jack
S1—Switch, DPDT
S2—Switch, DPDT, center off
S3—Switch, SPST
T1—Power transformer, 117 volt primary; 12.6-volt, 300-mA secondary.

Miscellaneous: PC-board materials, fuse clips, wire, linecord, solder, enclosure, etc.

An etched and drilled PC board is available for $10.25 postpaid from Fen-Tek, P.O. Box 5012, Babylon, NY 11702-0012. NY residents must add appropriate sales tax.

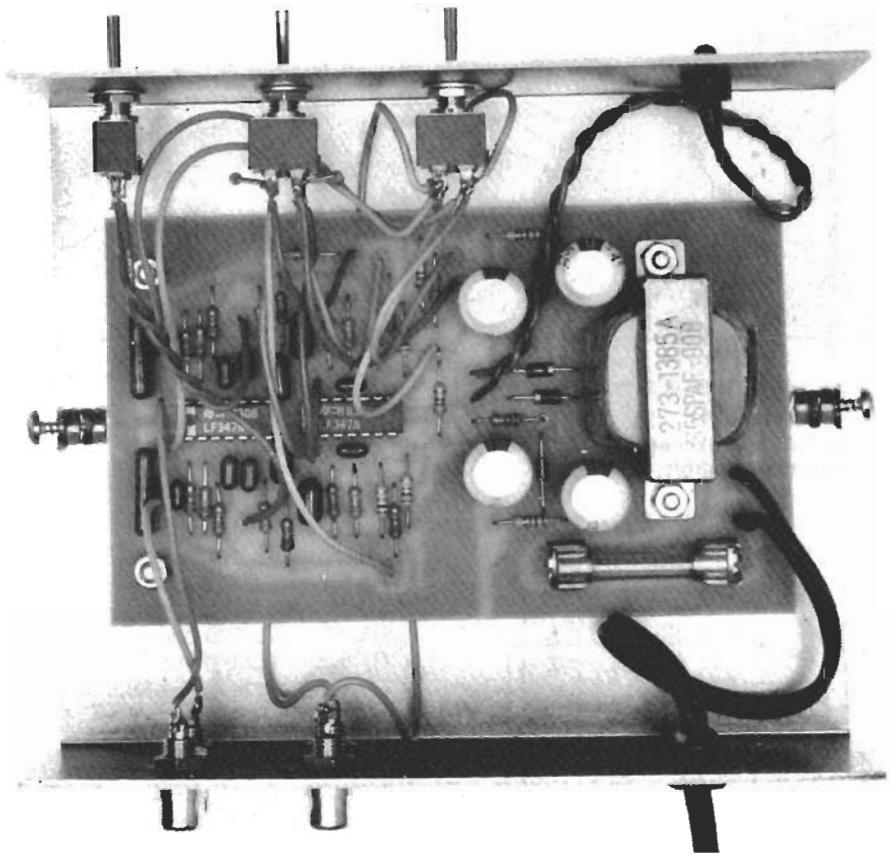


FIG. 5—TO AVOID NOISE PICKUP the simulator should be enclosed in a metal cabinet. Cabinets that are partially metal and partially plastic aren't suitable.

would be if only the deep-bass frequencies were filtered.

Figure 2 shows how the block diagram becomes the schematic for our stereo-subwoofer simulator.

How it works

Both channels are identical. Buffer amplifier IC1-a has unity gain above 60 Hz, and a rising gain characteristic below 60 Hz to compensate for the speaker's deficiency in the deep-bass range. Active low-pass filters, IC1-b and IC2-a, pass the frequency components below 50 Hz. Amplifier IC2-b sums the input and output signals of the filters. Switch S2-a provides three levels of bass summation—a fancy way of saying "bass boost." The subwoofer simulator's frequency-response curves for the three switch positions are shown in Fig. 3.

Construction

The project should use printed-circuit assembly to avoid introducing noise. A foil template for the PC board is provided in PC Service. You'll find that the template has holes to accommodate either a pigtail-lead fuse (F1), or individual fuse clips (which take two holes per clip) Use whatever is most convenient for you.

The parts layout for the PC-board and the connections for the panel-mounted components are shown in Fig. 4. For simplicity, an on/off power switch was not included so that the unit would be switched on and off by the master power switch for the entire system. If you want separate power control for the subwoofer simulator, simply install a SPST switch in series with one leg of the power cord.

Although the circuit will accept conventional part tolerances for the resistors and capacitors, for best results we suggest you use 5% capacitors for the active-filter components. As shown in Fig. 5, the prototype is mounted in a metal enclosure; do not use a cabinet that is part metal and part plastic.

Hookup

If your sound system has a separate pre-amp and power-amp, the subwoofer simulator connects immediately before your front power amplifier—after any surround-sound decoder. If you have a receiver, your only option is to connect the simulator before the receiver's AUX input, or within the tape-monitor loop—which isn't quite ideal because the simulator will be receiving a line-level 1-volt rms signal

Since the bass boost can exceed a factor of 10, the subwoofer simulator may occasionally output more than 10-volts rms, so to avoid blowing out your speakers, be careful when first trying the subwoofer simulator.

Increase the amplifier's gain slowly. Back off the amplifier's output power if you hear distortion. The author developed the circuit using a 200-watt-per-channel amplifier and speakers rated for 250 watts. If your system is more modestly powered, you may not want to use S2's higher boost positions. Also, if your amplifier is rated for less than 60 watts per channel, or if your woofers are smaller than 10-inches, you may not attain sufficient deep-bass output to create the sense of feeling.

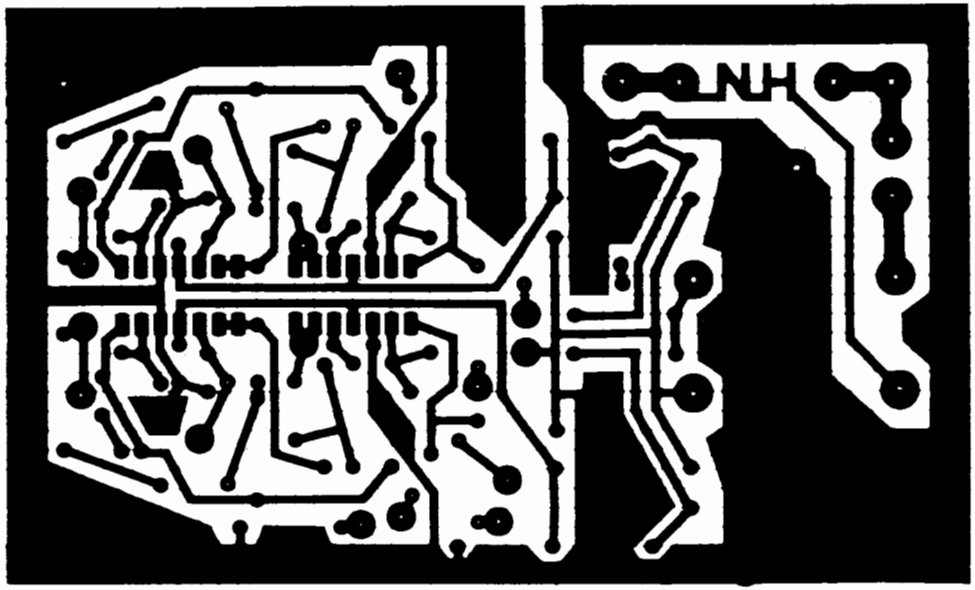
Clipping within the simulator is possible, although we have seen no problems because of the device's relatively high DC supply voltage. A bigger concern is an audio amplifier that wasn't built to handle an unusually large deep-bass signal. For example, one time we absent-mindedly installed the simulator between a VCR and a *Trinitron* monitor, which has an audio switching function. It took quite a while to figure out that the sound's distortion was caused by the *Trinitron* monitor's inability to handle more than a few volts of input. Moving the simulator so that it was installed after the monitor, between the TV and preamplifier, completely resolved the problem.

The payoff

Once your system is wired for surround sound you'll discover that some movies have effects that you can literally feel, while others don't. There is a wide variation in the quality of the effects, usually from one studio to the next, not from one movie to the next. Some outfits put in plenty of enjoyable, surround-sound and "feelie"effects, while others put in few sound effects. Unfortunately, the only way to find which is which is through trial and error. **R-E**

PC SERVICE

Here are the PC patterns for the construction projects in this month's issue. All patterns are right reading and full sized, unless otherwise noted.



5 INCHES

BUILD THE SUBWOOFER SIMULATOR using this board.