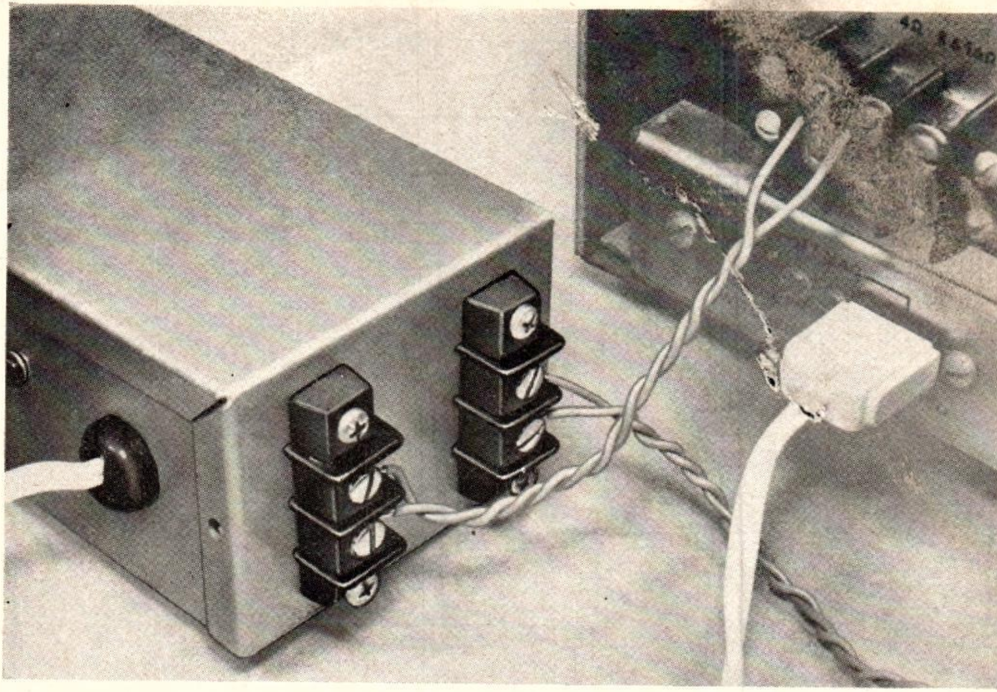


# Build a WOOFER GUARD

## SAFETY FIRST FOR SPEAKER CONES

**BY PHIL ARTHUR**

MANY DIRECT-COUPLED solid-state output amplifiers produce a loud "thump" every time you turn them on or off. Worse still, if their output circuits fail, the full supply voltage (on the order of 37.5-42 volts d.c.) could be delivered to your speaker systems, causing serious damage if not detected in time.

The turn-on/turn-off thump is a result of the supply voltage's being suddenly applied or removed from the output stages of the amplifier. If of sufficient amplitude, these voltage transients can "pop" speaker cones, irreparably damaging your speaker systems. The way to eliminate the thump is to delay the output signal (and, consequently, the transient) until the output voltage is at a safe level for the speakers—especially the woofers which are most prone to damage by the low frequency of the transient.

The other big hazard connected with direct-coupled outputs—short-circuit failures that deliver full supply voltage to the speakers—can be dealt with by the same delay circuit. Since such a delay circuit is voltage sensitive, it would actuate long before the voltage available at the output could attain a damaging level.

The "Woofer Guard" was designed to allow hi-fi buffs to operate their systems with complete safety. Placed between the output terminals of any direct-coupled power amplifier and the speaker systems, it quite literally "guards" the speakers from damage.

**About The Circuit.** The Woofer Guard is composed of two circuits: a timer which prevents turn-on and turn-off transients from reaching the speakers, and a voltage sensing circuit that "samples" the output voltage of the amplifier to determine whether or not to complete the circuit to the speakers. Resistor *R8,* potentiometer *R9,* and capacitor *C2* in Fig. 1 form an *RC* timing circuit.

Resistor *R8* and potentiometer *R9* allow capacitor *C2* to charge up to about 1.2 volts when voltage is applied to the

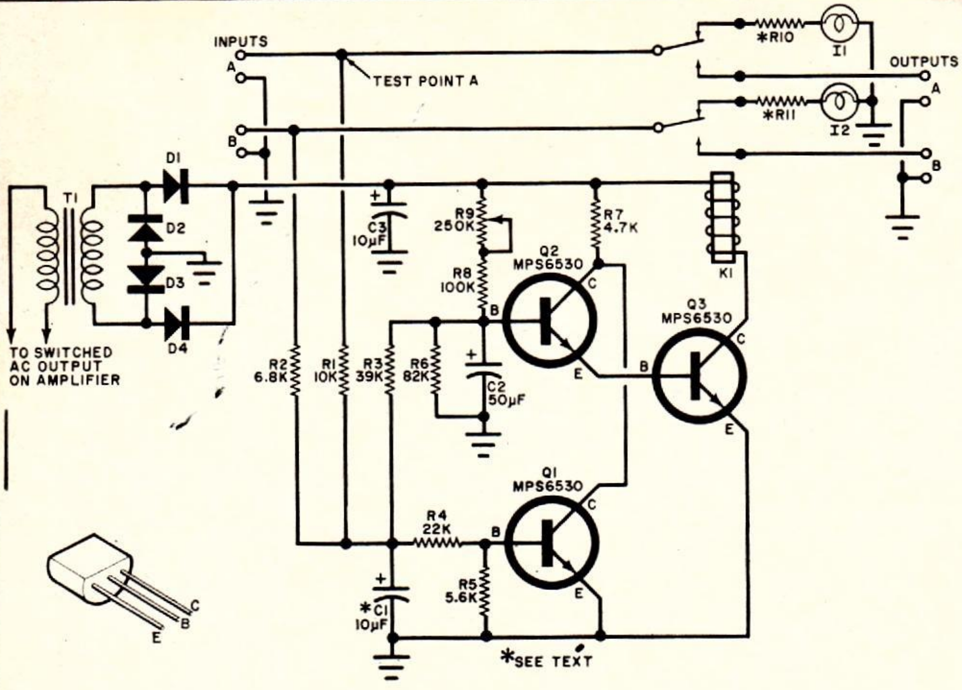



**Fig. 1. Any high-level audio signal or constant d.c. voltage detected by amplifier circuit Q1-Q3 causes relay K1 to be deenergized.**

## PARTS LIST

*C1—10-µF, 50-volt electrolytic capacitor (see text)*
*C2—50-µF, 15-volt electrolytic capacitor*
*C3—10-µF, 50-volt electrolytic capacitor*
*D1-D4—100-volt, 0.5-ampere diode*
*I1,I2—Optional indicator lamp (see text)*
*K1—D.p.d.t. 24-volt, 600-ohm relay (Allied Electronics No. 41D4659 or similar)*
*Q1-Q3—Bipolar transistors (Motorola MPS6530, HEP 721, or similar)*
*R1—10,000-ohm*
*R2—6800-ohm*
*R3—39,000-ohm*
*R4—22,000-ohm*
*R5—5600-ohm*
*R6—82,000-ohm*
*R7—4700-ohm*
*R8—100,000-ohm*
(*All resistors ½-watt*)
*R9—250,000-ohm, linear-taper potentiometer*
*R10, R11—Optional dropping resistors for I1 and I2 (see text)*
*T1—24-volt, 0.5-ampere filament transformer*
*Misc.—Aluminum utility box; rubber grommets for I1 and I2; a.c. line cord with plug; screw-type barrier blocks; hookup wire; solder; hardware; etc.*

circuit. Since transistors *Q2* and *Q3* are arranged in a Darlington-pair configuration, the transistors are cut off until the charge across *C2* exceeds the sum of *Q2*'s and *Q3*'s emitter-to-base junction voltage (approximately 0.6 for each transistor, or a total of about 1.2 volts). As soon as 1.2 volts is exceeded, *Q2* and *Q3* will immediately go into conduction and cause *K1,* the relay, to be energized which completes the circuit between the amplifier and speaker systems. Now, if a component in the amplifier fails and the amplifier applies a positive or negative voltage, with respect to ground, to the output, the sensing circuit goes into action and reverses the process just outlined, disconnecting the speakers from the amplifier output circuits.

Resistors *R1* and *R2* serve to isolate the Woofer Guard, preventing it from interfering with the normal operation of the amplifier. Capacitor *C1* prevents the sensing circuit from going into action on loud music (high-voltage) passages.

If a positive voltage with a sufficient time duration appears at the output of the amplifier, a portion of this voltage will bias *Q1* into conduction and cause the collector voltage of *Q2* to decrease. This decrease, in turn, cuts off *Q3* and causes *K1* to deenergize and disable the circuits between amplifier and speaker systems.

If a negative voltage is applied to the input of the Speaker Guard circuit, a portion of this voltage would be fed, through *R3*, to the base of *Q2*, biasing both *Q2* and *Q3* into cutoff. Again, with these two transistors cut off, *K1* will be deenergized.

The power supply for the Speaker Guard consists of a simple bridge rectifier and a small-value filter capacitor (*D1-D4* and *C3*). Capacitor *C3* prevents *K1* from "chattering" prior to being fully energized.

The *I1/R10* and *I2/R11* circuits are optional features that provide a visual indication of which output circuit is defective in the event of an amplifier failure. The operation of these circuits is as follows: If channel A malfunctions and supplies the full supply (42 volts) to the Woofer Guard, the voltage-sensing circuit deenergizes *K1* as described above, disconnecting the speaker systems. The relay contacts are now in the positions shown, applying the supply voltage to *I1* through *R10*, indicating that Channel A is malfunctioning.

The values of resistors *R10* and *R11* must be calculated for your given amplifier. Since power supply voltages differ from amplifier to amplifier, you will have to use Ohm's Law to compute the values: $R = E/I$, where E is the amplifier's supply voltage minus the voltage rating of the lamp, and I is the current rating of the lamp.

To show how the values of *R10* and *R11* are computed, assume that E is 42 volts and the lamp is rated at 6 volts at 40 mA. Plugging these figures into the Ohm's Law equation, we get: $R = E/I = (42 - 6)/0.04 = 900$ ohms. Then, to obtain the power rating of the resistor, use the power formula: $P = E^2/R = 36^2/900 = 1.44$ watts. Hence, we would use a 900-ohm, 2-watt resistor for the lamp voltage dropper in each channel.

**Construction.** Due to the simplicity of the circuit, all components (except *T1* and *K1*) can be easily mounted on a small piece of perforated phenolic board as shown in Fig. 2. The board is held in place with #6 hardware and ½" spacers.

Notice that input and output connections are made to separate screw-type barrier blocks. Make sure that, when wiring the blocks up, you do the job correctly. (Note: If your amplifier has one channel that can be switched to reverse the phase, check to make sure that the grounds in each channel are common to each other. If they are not, run separate ground wires for each channel through the Woofer Guard, and do NOT GROUND either of these wires to the chassis of the Woofer Guard or operating the phase reversal switch can damage your amplifier.)

When soldering to the diodes and transistors, exercise caution to prevent heat

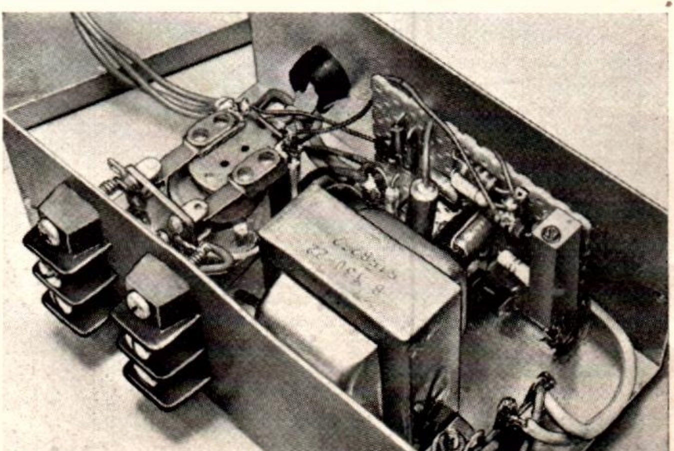
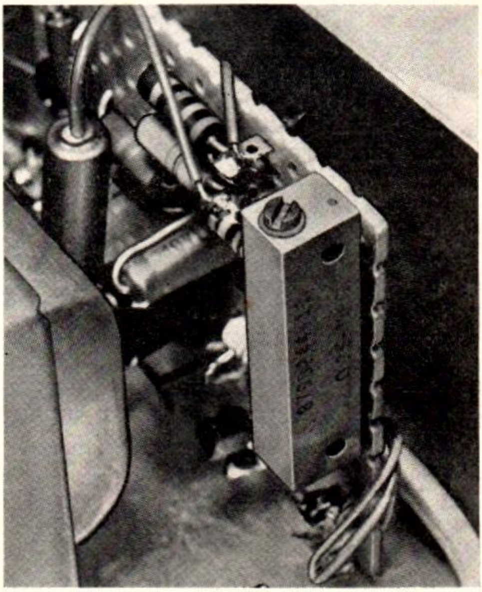


Fig. 2. Except for relay, jacks, and transformer, all components mount on small piece of perforated phenolic board; use small L brackets for board mounting.

damage to these components. Use a low-wattage soldering iron, and apply the heat only long enough to get the solder to flow, while protecting the component lead with a heat sink. Also, make sure that electrolytic capacitors, diodes, and transistors are installed in the proper lead orientation.

**Test and Adjustment.** Without the speakers and amplifier connected to the Woofer Guard, plug in the guard's line cord and adjust the setting of *R9* to obtain approximately a 2-second delay before the relay contacts close. Time the delay from the instant the power cord is connected until the contacts close.

To test the voltage-sensing circuit, momentarily touch the positive contact of a 9-volt transistor battery to test point A in the Woofer Guard circuit; the negative contact goes to the COMMON input terminal. The relay should immediately deenergize. Then, by momentarily touching the battery contacts to the same points in the Woofer Guard circuit in the opposite direction, the relay should again almost immediately deenergize.



Long block shown in foreground is special trimmer potentiometer. You can substitute commonly available printed circuit type pot of appropriate value.

Now, assemble the Woofer Guard's case and connect it to your amplifier outputs and speaker systems. In use, you might notice that the Woofer Guard disconnects your speaker systems on high-level, low-frequency notes (about 70 watts r.m.s./channel below 20 Hz). If you find this annoying, you can replace *C1* with a 20-μF capacitor. —30—

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## Project Evaluation

Tested on the laboratory workbench, it was found that the relay in the Woofer Guard dropped out with as low as ±3 volts d.c. applied to the inputs. It seemed a little sluggish at this low voltage (perhaps 0.5-second operating time), but at 5 volts or more, it operates in about 0.1 second. The release time after dropping out is on the order of 2 seconds.

Low-frequency audio signals were tried to determine what would trip the Woofer Guard. A sine wave of 10 volts r.m.s. at 5-6 Hz was capable of tripping the circuit, but a 9-volt peak-to-peak square wave of *any* frequency up to 50 kHz would also trip it. This is consistent with the static operation (d.c.) of the device, since it operates on both polarities; the square wave appears to the Woofer Guard as a d.c. input of about 4.5 volts.

The Woofer Guard was then connected between an Acoustic Research receiver and a pair of 8-ohm speakers. It trips on the muting "thump" if the volume setting on the amplifier is somewhat above the normal listening level, or if any great amount of bass boost is used. The only way the Woofer Guard was made to trip when fed with program material was to play the amplifier at very high levels, preferably with bass boost.

The Woofer Guard protects only the woofer in a speaker system, but the tweeter in many cases is more vulnerable. Even though few amplifiers have direct-coupled outputs, there is always the chance that the blocking capacitor will break down and place half of the supply voltage in the amplifier across the speaker system. The Woofer Guard should take care of such a situation nicely.