

# SOLID-STATE 6-WATT AMPLIFIER FOR 10 BUCKS

*All-purpose push-pull audio amplifier operates on wide range of input voltage and output impedance without bias adjustments*

**I**F YOU would like to have a quality, low-cost amplifier for a hi-fi or public address system—one you can use at home or in your car, and can convert into a speech amplifier, modulator, or high-power intercom—then try your hand at this transistorized “Six-Watter.” You can build it in less than two hours, at a cost of about \$10.00. All components can be mounted on a printed circuit board, and construction is easy.

Several novel circuit features make it possible to use few parts, eliminate transformers, and achieve high efficiency. A unique d.c. bias stabilizing network eliminates the bias adjustments normally found on this type of amplifier and permits operation with a wide range of supply voltages without modification.

The excellent low-frequency response of the Six-Watter is due in part to the absence of transformers and the use of high-value coupling capacitors as well as direct coupling. High-efficiency Class B operation makes it ideal for use wherever battery life is an important consideration. Power consumption from a 12-volt battery under no-signal conditions is less than  $\frac{1}{2}$  watt.

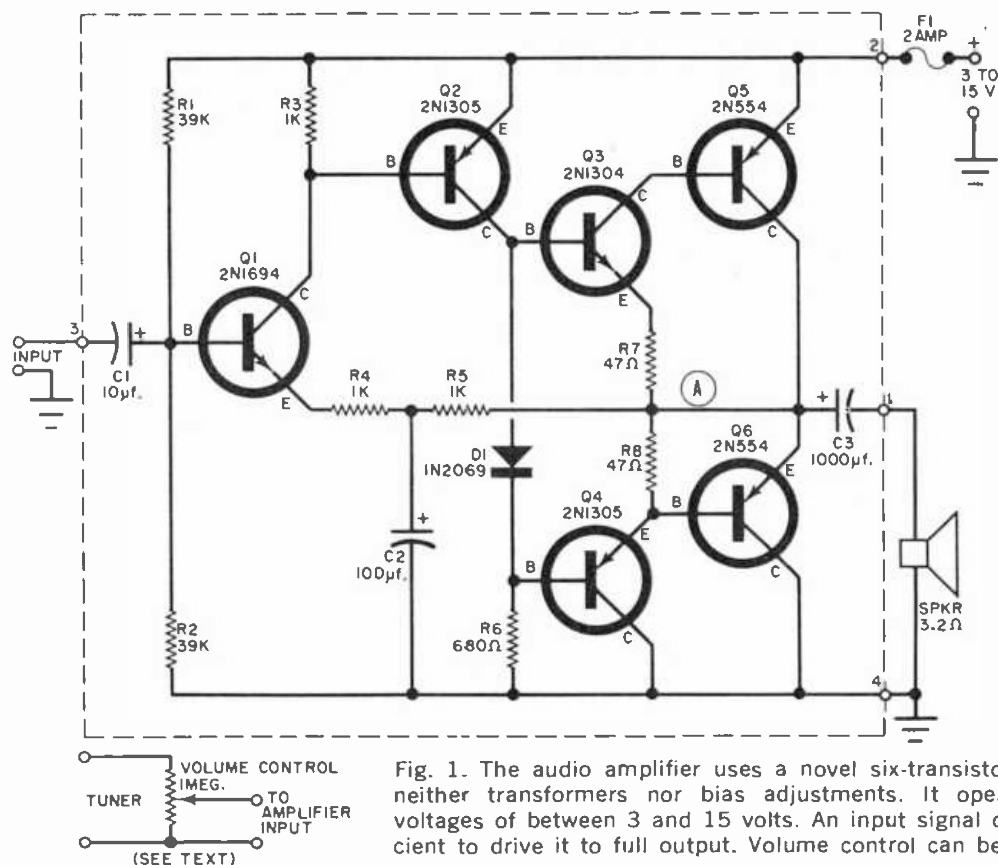
While the amplifier can work on any

supply voltage ranging from 3 to 15 volts, the higher the voltage source, the greater the audio power output you can get. An input signal of less than 0.2 volt is sufficient to drive the Six-Watter to full output. This is more than adequate gain for most tuners, and crystal or ceramic phono cartridges.

**How It Works.** Audio input is coupled to the base of transistor  $Q1$  through capacitor  $C1$ . The amplified signal at  $Q1$ 's collector is direct-coupled to the base of  $Q2$ . Here again, the signal is amplified and directly coupled to  $Q3$  and  $Q4$ . Transistors  $Q3$  and  $Q4$  work in opposite directions; while one is conducting more, the other is conducting less—their output signals are  $180^\circ$  out of phase with each other. This type of circuit makes it possible to drive a push-pull output stage without the aid of a transformer.

The signals from  $Q3$  and  $Q4$  are directly coupled to  $Q5$  and  $Q6$  respectively. Transistors  $Q5$  and  $Q6$  operate as Class B power amplifiers. Balanced operation requires that the product of the current gain of  $Q3$  and  $Q5$  be equal to that of  $Q4$  and  $Q6$ .

The filter network,  $C2$  and  $R4$ , prevents audio voltage variations at point



### PARTS LIST

C1—10- $\mu$ f., 15-volt electrolytic capacitor  
 C2—100- $\mu$ f., 15-volt electrolytic capacitor  
 C3—1000- $\mu$ f., 15-volt electrolytic capacitor  
 D1—1N2069 diode  
 F1—2-ampere fuse  
 Q1—2N1694 transistor  
 Q2, Q4—2N1305 transistor  
 Q3—2N1304 transistor  
 Q5, Q6—2N554 or 2N2148 transistor  
 R1, R2—39,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R3, R4, R5—1000-ohm,  $\frac{1}{2}$ -watt resistor  
 R6—680-ohm,  $\frac{1}{2}$ -watt resistor  
 R7, R8—47-ohm,  $\frac{1}{2}$ -watt resistor  
 1—Printed circuit board, available from Hazleton Scientific Co., Box 163, Hazel Park, Mich. 48030 for \$2.85 postpaid with all holes drilled and for \$1.95 postpaid undrilled  
 2—1 $\frac{1}{2}$ " x 2 $\frac{1}{2}$ " x  $\frac{1}{16}$ " heat sinks, copper or aluminum

A in Fig. 1 from reaching Q1's emitter. This results in a high degree of d.c. stability without affecting the a.c. gain of the amplifier.

Any speaker impedance ranging from 1.6 to 16 ohms can be used. Because power output is a function of speaker impedance, and source voltage, stick to a 3.2-ohm speaker and a 12-volt source, if possible.

**Construction.** You can make your own circuit board, or purchase one for \$2.85

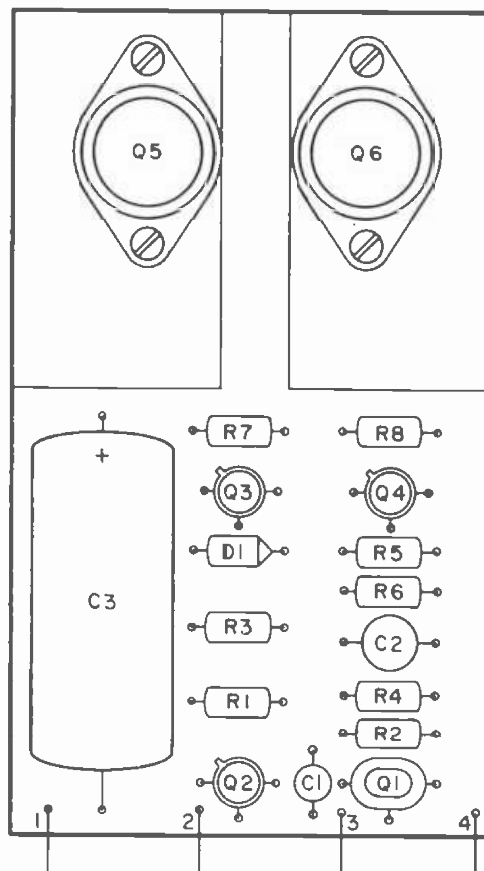


Fig. 2. Carefully locate and solder all of the components onto the printed circuit board as shown.

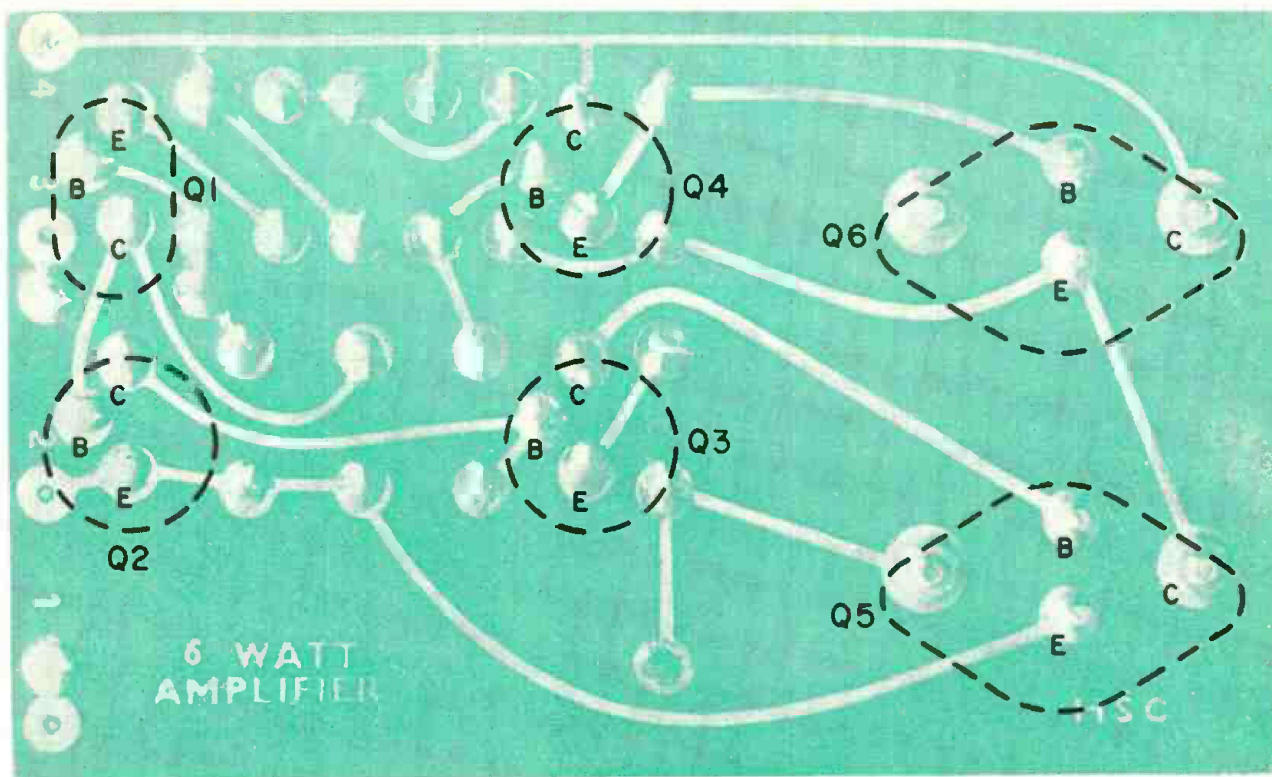


Fig. 3. Use this full-size guide in making your printed circuit board. Space the transistors about  $\frac{1}{2}$ " above the board and hold transistor leads on top side of board with a pair of long-nose pliers when soldering.

(see Parts List), or you can mount and wire the components on a small (approximately 4" x 6") conventional type chassis. If you use the board, locate and solder the parts in place as shown in Fig. 2. Space the transistors about  $\frac{1}{2}$ " above the board and hold the transistor lead on the top side of the board with a pair of long-nose pliers while soldering.

Heat sinks for Q5 and Q6 can be cut from a  $\frac{1}{16}$ " copper or aluminum sheet,

and should measure  $1\frac{3}{8}$ " x  $2\frac{1}{2}$ ". Drill holes as shown in Fig. 3. Two holes are used to mount each heat sink on the board, and two are used for the transistor pins. Paint the heat sinks black to increase thermal dissipation. If you plan to use the amplifier continuously at high power levels and high ambient temperatures, increase the size of the heat sinks.

**Final Check.** After completing construction, feed a 6- to 12-volt d.c. source to terminals 2 and 4 (positive voltage to terminal 2) and measure the d.c. voltage between point A and terminal 4.

It should be one-half the supply voltage. If it is not, R1 and R2 may not be matched closely enough. In this case, temporarily replace R1 with a 100,000-ohm potentiometer and adjust the pot until the voltage at point A measures one-half the supply voltage. Then measure the resistance of the potentiometer and replace it with a fixed resistor of that value.

**Modifications.** You can add a volume control to the amplifier by connecting a potentiometer to the circuit between the  
(Continued on page 111)

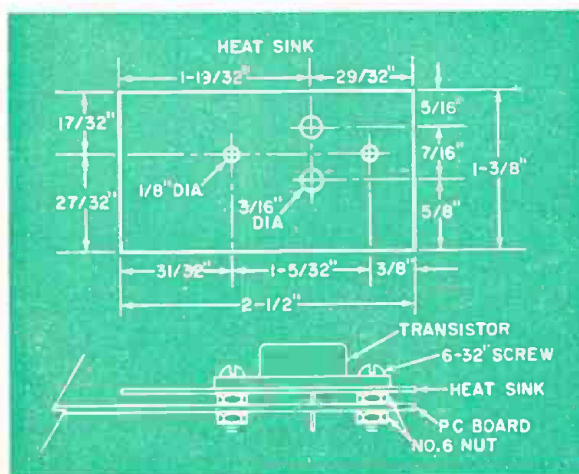


Fig. 4. Use thin copper or aluminum stock to make heat sinks and mount with the transistor as shown.

nected to its input terminals, as shown in Fig. 10.

The values of tuned circuit  $L1$  and  $C1$  are chosen to resonate at the desired control frequency. A general-purpose diode (1N34A) and an npn transistor (2N169) can be used. Adjust the *Sensitivity* control until the relay just closes in the absence of the radio signal. An incoming radio signal will open the relay.

Bench tests with the remote control circuit were made using a standard AM broadcast-band ferrite-core antenna coil (Superex "Vari-Loopstick") for  $L1$  and a 270-pf. ceramic capacitor for  $C1$ . With a relatively short antenna, positive relay operation was obtained when a strong local broadcast station was tuned in.

Photocells of all types can be used with *Super-Sens* to make it respond to variations in illumination and color. Invisible infrared rays can be used as intruder alarms. Smoke detectors and industrial counting devices can also be made. Regardless of the intended application, whether specific or general, the only limit to *Super-Sens* is your imagination and skill.

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## 6-WATT AMPLIFIER

(Continued from page 75)

signal source and amplifier input as shown in Fig. 1. Although a 1-megohm pot is shown, values of 100,000 or 500,000 ohms can be used.

If plans call for the amplifier to be employed with a low-impedance input device, say about 1000 ohms, reduce the value of  $R4$ —or even eliminate it. This will give you a substantial increase in gain. There's no point in reducing the value of  $R4$  for a high-impedance input, as no appreciable gain will be realized. A 150-ohm resistor placed in series with  $C2$  introduces negative feedback, and lowers the output impedance still more, and reduces distortion, but sacrifices gain. The higher the resistance, the greater the feedback and the lower the gain.

The amplifier's high-frequency response can be substantially improved by substituting 2N2148 transistors for the 2N554's in the output stage. They cost

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## BIAS NETWORK

A closer look at the biasing arrangement of the various transistors in the Six-Watter is needed for a better understanding of how the circuit operates and how balanced operation can be achieved even if the d.c. current gain of the transistors differs.

Resistors  $R1$  and  $R2$  maintain the bias voltage at the base of  $Q1$  at approximately one-half the supply voltage. If the voltage at point  $A$  in Fig. 1 drops, the potential difference across  $Q1$ 's base-emitter junction increases and causes  $Q1$  to conduct more heavily. The greater current flow through  $R3$  increases the voltage drop across  $R3$ , and increases the forward bias of  $Q2$ . This makes  $Q2$  conduct more heavily and increases the forward bias on  $Q3$  and  $Q5$ , at the same time decreasing the forward bias on  $Q4$  and  $Q6$ .

Transistors  $Q5$  and  $Q6$  act like a voltage divider across the power supply, and the biasing action just described reduces the dynamic resistance of  $Q5$ , and increases the dynamic resistance of  $Q6$ . This raises the voltage at point  $A$  and tends to restore it to its former value.

If, on the other hand, the voltage at point  $A$  rises above normal, the forward bias on  $Q2$  decreases, reducing the bias on  $Q3$  and  $Q5$ , increasing the bias on  $Q4$  and  $Q6$ , increasing the dynamic resistance of  $Q5$ , decreasing the dynamic resistance of  $Q4$ , and, finally, decreasing the voltage at point  $A$  to its normal value.

Diode  $D1$  also affects the bias of  $Q3$  and  $Q4$ . The voltage drop across  $D1$  places a small forward bias on  $Q3$  and  $Q4$ , which in turn places a small forward bias on  $Q5$  and  $Q6$ . This forward bias reduces crossover distortion and serves to thermally stabilize the amplifier. Changes in voltage drop across the diode due to changes in temperature tend to compensate for similar temperature changes in the base-to-emitter voltages of the transistors. The voltage drop across  $D1$  is essentially independent of supply voltage and therefore is able to maintain the same bias over a relatively wide range of supply voltage.

about \$1 more each; the 2N554's were used because of their low cost. Should you decide to substitute "bargain" transistors for  $Q5$  and  $Q6$ , you may run into higher than normal leakage currents. To overcome this situation, you can connect a 100-ohm, 1/2-watt resistor between the base and emitter of  $Q5$  on the bottom side of the board.

If you plan to use the Six-Watter as a narrow-band speech amplifier, reduce the value of  $C2$  and place a small capacitor in parallel with  $R5$  to cut the amplifier's response at both the high and low ends.

The amplifier can also be used as a modulator for small transmitters. An ordinary output transformer connected backwards makes a reasonably good match as a modulation transformer. Use an output transformer which can match the impedance of the final stage of your transmitter to the amplifier's nominal 3.2-ohm load.

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