to the emitter so that Q2 continues conducting during all portions of the cycle.

The design of the bootstrap circuit is quite simple. Since R_{B2} and R_{Y2} are essentially across the load through C2, they should be made as large as possible consistent with the current requirements of the base circuit of Q2. Both resistors are usually specified as equal to each other.

Under quiescent conditions $E_{CC}/2$ appears across the series circuit formed by R_{B2} and R_{Y2} as well as across the circuit formed by R_{B2} and C2. As $R_{B2} = R_{Y2}$, the voltage across C2 is one half of $E_{CC}/2$ or is equal to $E_{CC}/4$. Charged to this voltage, C2 maintains a constant current through R_{Y2} and Q2's base-emitter junction. C2 must be large enough to maintain its charge even when low frequencies are being reproduced.

An alternate bootstrap circuit designed to eliminate the need of capacitor C2 and resistors R_{B2} and R_{Y2} is shown in Fig. 3. Instead of these components, a resistor is connected from the junction of C_L and R_L to the base of Q2. C_L doubles as the bootstrap capacitor besides coupling the signal to the output load resistor or speaker. R_L is connected to $+E_{CC}$, an ac ground. The major drawback of this circuit is that the dc base current for the drivers will flow through load R_L. If this current is very small, it should not affect the operation of the loudspeaker usually used as R_L.

A constant-current source at the bases of the complementary drivers can eliminate the need for the bootstrap capacitor. This circuit is in Fig. 4. A constant current is supplied to the drivers while a high impedance is presented to voltage amplifier stage Q1. The voltage drop between the base of Q6 and $+E_{CC}$ should be as small as practical so as not to limit the output voltage swing. Hence low forward-voltage dropping silicon diodes should be used in the constant-current circuit, rather than the higher voltage Zener diodes. The main advantages of this circuit include the improved distortion at low frequencies and more symmetrical clipping of the peaks in both halves of the signal.

Direct coupled load

In all quasi-complementary circuits discussed thus far, the load was coupled to the output transistors through a large electrolytic capacitor, C_L. Although frequently used, the capacitor has several drawbacks, not the least of which is the inherent nonlinearity of electrolytic coupling devices. Other reasons for eliminating C_L are the low frequency roll-off due to the R_L-C_L "high pass filter", and the corner frequency created by this roll-off which can contribute to instability when feedback is applied around the circuit. Finally, and perhaps the most important drawback, is that this capacitor must be charged through the output transistors. If, in the process, the transistor handles more energy (power X time) than it can dissipate, it will destroy itself.

In Fig. 2, one end of R_L is connected to ground. When idling, the other end of R_L must be at the same ground potential if there is to be no dc flowing through the resistor (or loudspeaker) load. This is easily accomplished when a coupling capacitor is used. In the absence of C_L, the junction of Q4 and Q5 must be placed at a zero potential with respect to ground while the circuit is idling.

To accomplish this, a positive voltage with respect to ground, $+E_{CC}$, is placed at Q4's collector while an identical negative voltage, $-E_{CC}$, is placed at the emitter of Q5, or more exactly at the lower end of resistor R_{E5}. If both transistors, Q4 and Q5, conduct idential amounts of current during the idling period, there is zero voltage at the junction of the two devices to which the load is connected (or at the junction of the collector of Q5 and the lower end of R_{E4}). With signal applied, the positive going portion swings the voltage across R_L from zero towards $+E_{CC}$ while the negative portion of the signal swings it from zero and towards $-E_{CC}$.

All would be great if the quiescent current can be maintained constant at all times, so that the voltage across R_L will not shift from zero volts. Unfortunately, Q1 will drift with temperature changes. But any change in the collector current through Q1 will upset the balance at the output more than will drifts in transistors further up the chain. Drift due to the drivers and outputs is minimized by maintaining the upper and corresponding lower devices at equal temperatures on heat sinks or in free air. In this manner, drift in one half of the driver and output circuit is

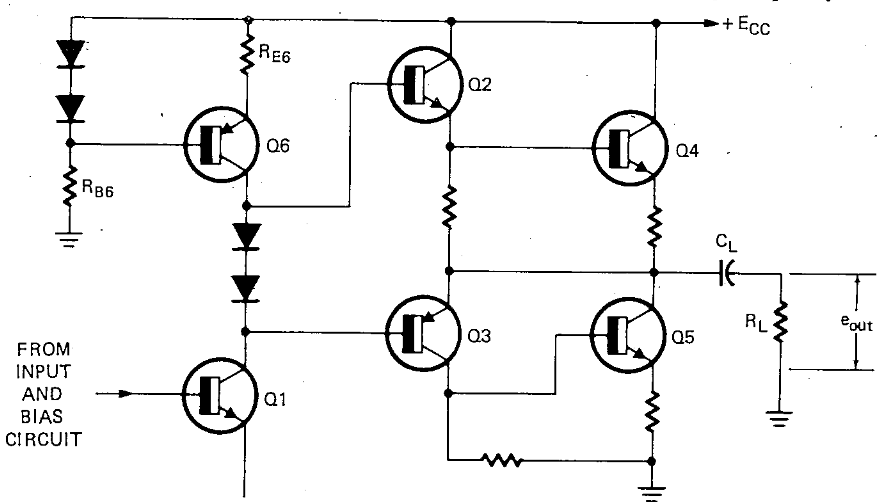

FIG. 4—CONSTANT-CURRENT SOURCE, Q6 for bases of the complementary drivers eliminates the need for boodstrap capacitor and reduces low-frequency distortion.

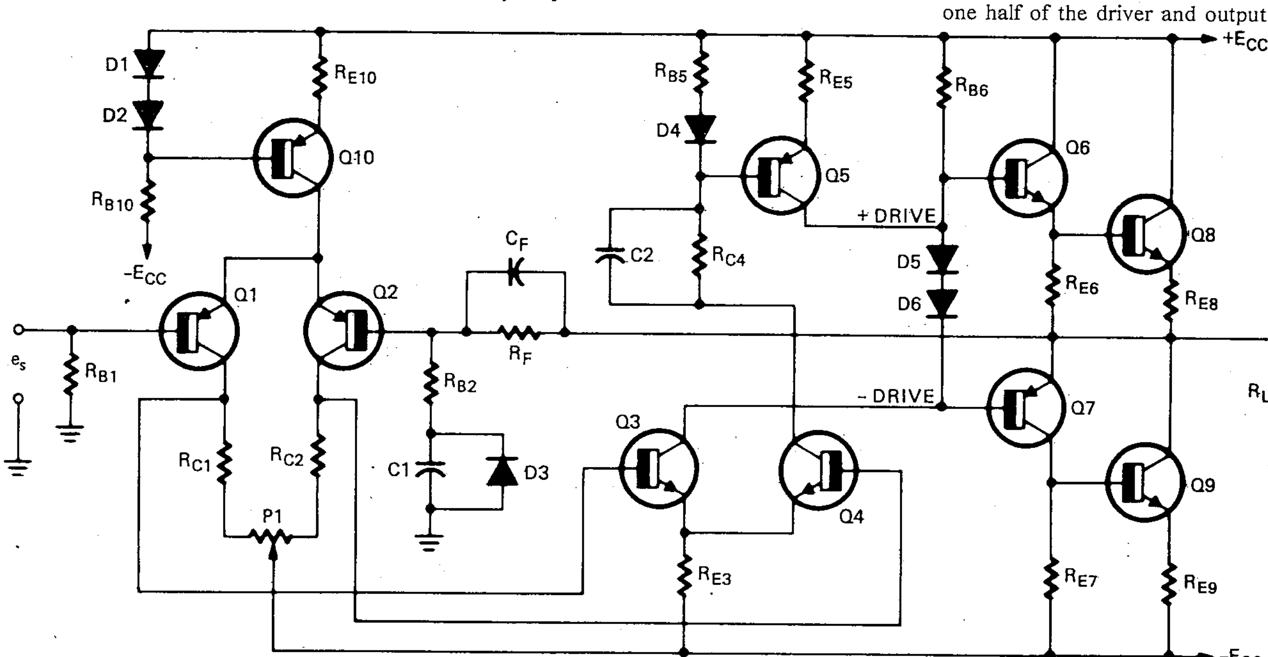

FIG. 5—DIFFERENTIAL AMPLIFIER replaces input transistor Q1 in the earlier circuits and thus minimizes changes in quiescent output current due to temperature changes.