Ultra-low quiescent current AF power amplifier

This is an audio power amplifier, similar to what is common in transistor radios and other portable audio equipment. This circuit however, has an ultra-low quiescent current of about 250uA, due to a unique bias circuit. I don't even know of a chip that does that. This circuit also has much higher open-loop gain, due to the bootstrap effect that the circuit provides as a by-product of its operation.

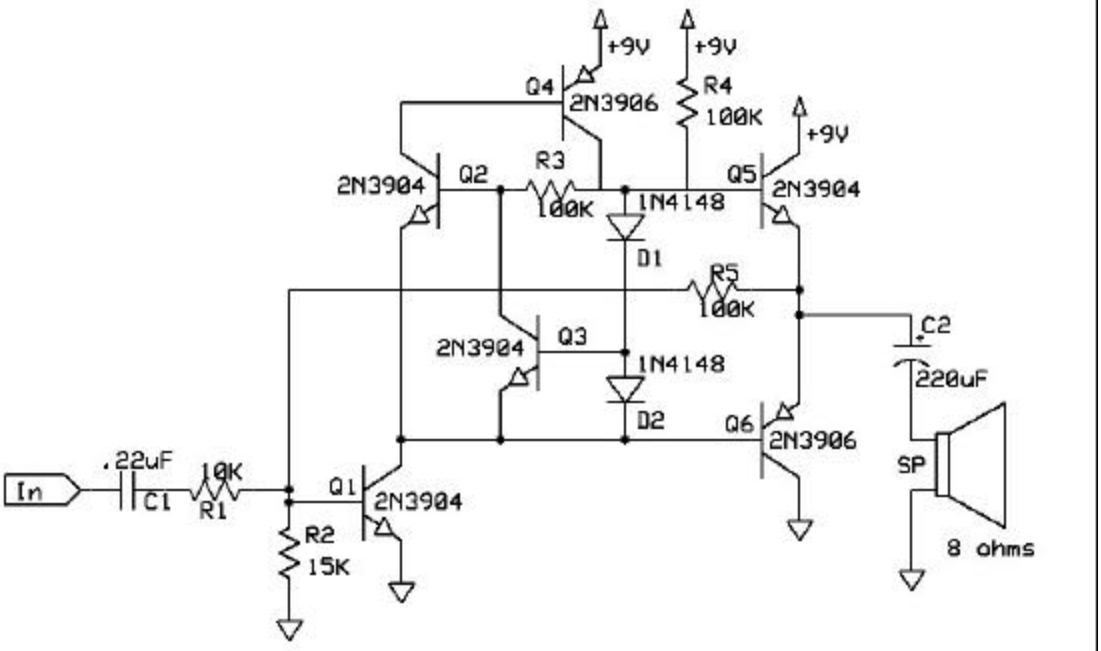
Diodes D1 and D2 perform the usual task of closing the gap between the point where Q5 or Q6 stops conducting and where the other transistor starts conducting. This gap causes an effect known as "crossover distortion". To prevent crossover distortion, Q5 and Q6 would normally be slightly in simultaneous conduction when no signal is present, wasting precious battery power. Because precise control of the quiescent current is extremely difficult, it is always adjusted such that significant power is wasted. This circuit uses an extremely tight control loop to maintain the proper voltage across D1 and D2 eliminating crossover distortion with almost no simultaneous conduction of Q5 and Q6.

Q2 and Q4 form a regenerative (infinite gain) amplifier, similar to an SCR. It would indeed latch up like an SCR without negative feedback from Q3, which senses the voltage across D2. D1, having essentially the same current, will have essentially the same voltage across it. R4 provides the start-up current for Q2, which causes Q4 to conduct. This in turn, causes Q2 to conduct more, causing the previously mentioned regenerative effect.

The voltage across D2 will keep Q3 just barely in conduction. Since the diodes and transistors are all silicon, the voltage across D1 and D2 will also be just exactly the voltage necessary to keep Q5 and Q6 just barely in conduction. No wasted power. Note that D1, D2, Q3, Q5 and Q6 must be in the same temperature environment. For larger amplifiers, they should be on the same heat sink. In really big amplifiers, D1 and D2 should be replaced with 1N400x types. The quiescent current will be proportionately larger.

If you want more quiescent current, or need emitter current limiting resistors, you will have to add a resistor in series with D1 to get the added voltage. The drop across the resistor will be constant because the diode current will be constant. Due to the infinite gain of the Q2 and Q4 combination, quiescent current is essentially unaffected by battery voltage. Note that the circuit works poorly if the diodes are replaced with resistors. The circuit works because the non-linearity of the diodes matches that of the transistors' E-B junctions.

An interesting by-product of this process is the bootstrap effect it causes in the amplifier. When Q1 conducts less, the current through D2 conducts less as well. The control circuit increases the current through D2, but feeds Q5 as well. On the positive half-cycle of the audio, the load impedance on the collector of Q1 is extremely high, raising its gain considerably.



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