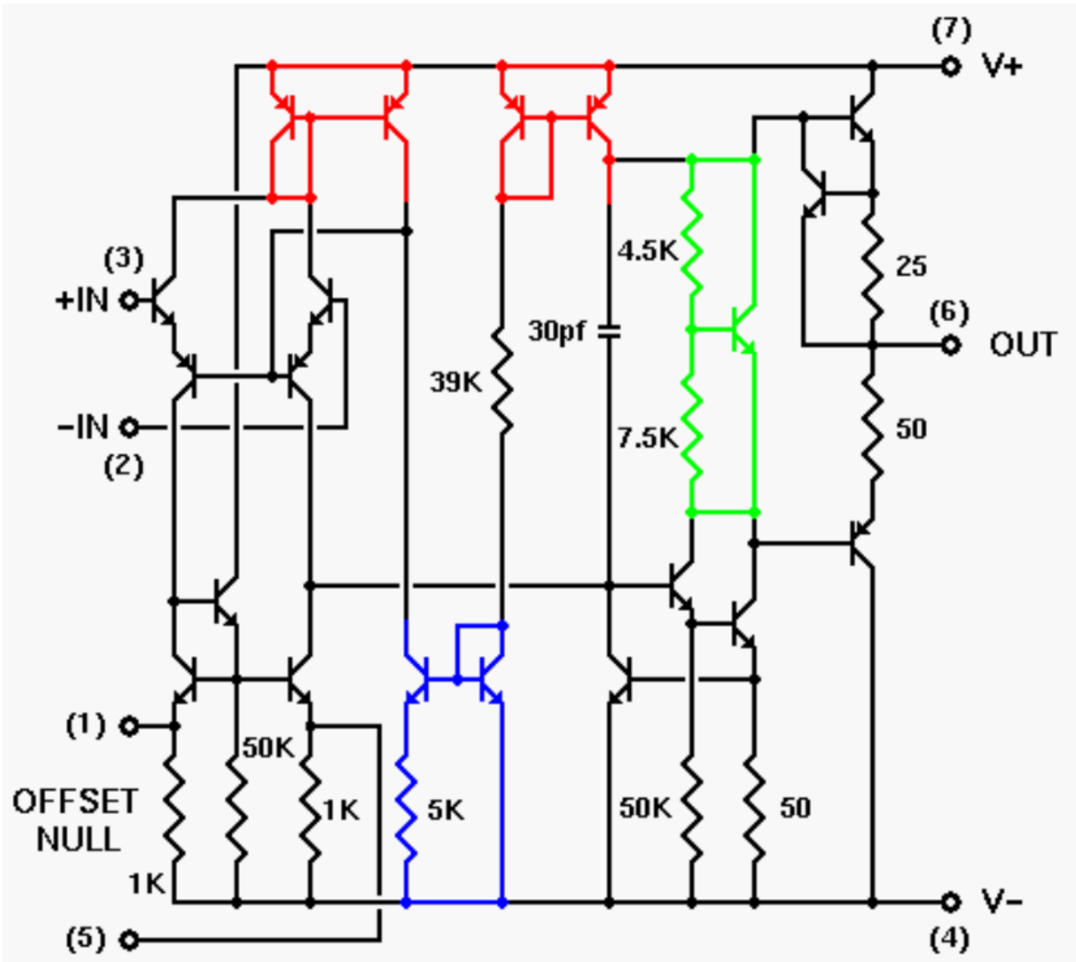
Inside the 741 Op-Amp (from http://www.play-hookey.com/analog/inside_741.html)

The type 741 operational amplifier is the basic model for a wide range of commercial devices. Many different manufacturers produce similar or equivalent devices and they all have variations in their designations, but the digits "741" are part of the designation in most cases. We'll use the Signetics device, designated the µA741, as our example here.



The internal circuitry of the 741 op amp.

The numbers in parentheses at the external connections for the above schematic diagram refer to the terminal pinouts for the 8-pin IC package. The pin numbers are the same for both the 8-pin mini-DIP package and the 8-pin round Type-T metal can. In both cases, pin 8 has no connection.

There are a number of interesting points about this circuit. First, the input transistors are connected as npn emitter followers, feeding their outputs directly to a pair of pnp transistors configured as common-base amplifiers. This configuration isolates the inputs, preventing signal feedback that might otherwise have some harmful frequency-dependent effects.

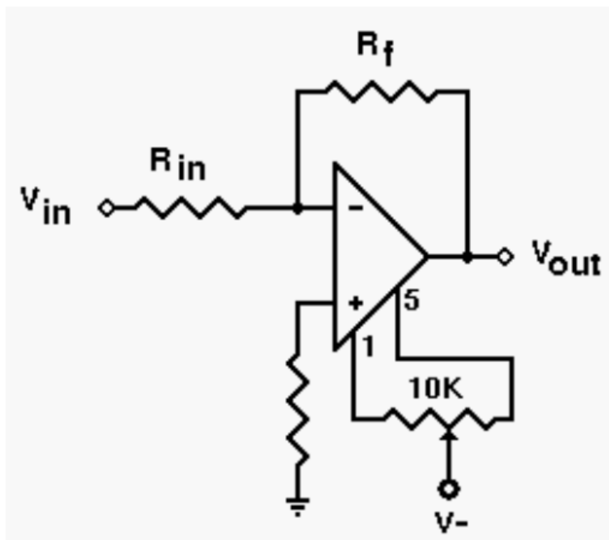
Note the two pairs of transistors shown in red. One transistor in each pair has its collector connected to its base, as well as to the base of the other transistor. In addition, the transistor emitters are connected together, in this case to the V+ power source. In some diagrams, the transistor with the collector and base shorted together is rendered as a diode, which shows bias for the other transistor, but doesn't show the full value of this configuration.

This arrangement is known as a *current mirror*. The two transistors are manufactured side by side on the same silicon die, at the same time. Thus, they have essentially identical characteristics. The controlling transistor (on the left in each pair) will necessarily set its emitter-base voltage to exactly that value that will sustain the collector current it is carrying, even down to fractions of a millivolt. In so doing, it also sets the emitter-base voltage of the second transistor to the same value. Since the transistors are essentially identical, the second transistor will carry exactly the same current as the first, even to an independent circuit.

The use of a current mirror on the input circuit allows the inputs to accommodate large common-mode voltage swings without exceeding the active range of any transistor in the circuit. The second current mirror in red provides a constant-current active load for the output circuitry, again without regard for the actual output voltage.

A third current mirror, shown in blue, is a bit different. That 5K resistor in series with the emitter of the mirrored transistor limits its collector current to virtually nothing. Thus, it serves as a high-impedance connection to the negative power supply, providing a reference without loading the input circuit. This particular circuit is therefore able to provide the slight base bias current needed for the PNP transistors in the differential input circuit, while allowing those transistors to operate correctly over a wide common-mode input voltage range.

The final odd circuit within the op amp is shown in green. Here, the two resistors bias the transistor in what would seem to be an unusual way, since there is no apparent signal input to the base of the transistor. To understand its purpose, assume zero base current for a moment, and a V_{BE} of 0.625 volt. Ohm's Law then requires a current of 0.625 ÷ 7.5K = 0.0833mA through the 7.5K resistor. The same current must also flow through the 4.5K resistor, which will therefore exhibit a voltage drop of 0.0833mA × 4.5K = 0.375V. The total voltage across the two resistors, then, and therefore across the transistor, is 0.625V + 0.375V = 1.0V. This, then, is a simple voltage reference, providing an internal 1-volt difference without a connection to either power supply, nor to ground. This circuit floats internally, and provides its 1-volt bias regardless of the actual dc output voltage of the overall circuit.



The offset null connections (pins 1 and 5) provide a simple way to balance out the internal variations and zero out the output offset which might be apparent with zero input voltage. It is used simply by connecting a trimmer potentiometer between pins 1 and 5, as shown to the right. The slider on the potentiometer is connected to the negative power supply. To adjust for zero offset, ground the input resistor and use the offset null potentiometer to set the output voltage precisely to zero.

The offset null terminals are not available in packages such as the 5558 and 1458, which put two independent op amps in a single 8-pin mini-DIP package.