Now, we can divide v_{out} by v_{in} to get:

$$A_V = \frac{v_{\text{out}}}{v_{\text{in}}} = \frac{i_c r_c}{i_e(r_e + r'_e)} = \frac{v_c}{v_b}$$

Since $i_c \approx i_e$, we can simplify the equation to get:

$$A_V = \frac{r_c}{r_e + r'_e} \tag{10-6}$$

When r_e is much greater than r'_e, the foregoing equation simplifies to:

$$A_V = \frac{r_c}{r_e} \tag{10-7}$$

This says that the voltage gain equals the ac collector resistance divided by the feedback resistance. Since r'_e no longer appears in the equation for voltage gain, it no longer has an effect on the voltage gain.

The foregoing is an example of **swamping,** making one quantity much larger than a second quantity to eliminate changes in the second. In Eq. (10-6), a large value of r_e swamps out the variations in r'_e. The result is a stable voltage gain, one that does not change with temperature variation or transistor replacement.

Input Impedance of the Base

The negative feedback not only stabilizes the voltage gain, it also increases the input impedance of the base. In Fig. 10-7*b*, the input impedance of the base is:

$$z_{\text{in(base)}} = \frac{v_{\text{in}}}{i_b}$$

Applying Ohm's law to the emitter diode of Fig. 10-7*b*, we can write:

$$v_{\text{in}} = i_e(r_e + r'_e)$$

Substitute this equation into the preceding one to get:

$$z_{\text{in(base)}} = \frac{v_{\text{in}}}{i_b} = \frac{i_e(r_e + r'_e)}{i_b}$$

Since $i_e \approx i_c$, the foregoing equation becomes:

$$z_{\text{in(base)}} = \beta(r_e + r'_e) \tag{10-8}$$

In a **swamped amplifier,** this simplifies to:

$$z_{\text{in(base)}} = \beta r_e \tag{10-9}$$

This says that the input impedance of the base equals the current gain times the feedback resistance.

Less Distortion with Large Signals

The nonlinearity of the emitter-diode curve is the source of large-signal distortion. By swamping the emitter diode, we reduce the effect it has on voltage gain. In turn, this reduces the distortion that occurs for large-signal operation.

Put it this way: Without the feedback resistor, the voltage gain is:

$$A_V = \frac{r_c}{r'_e}$$

Since r'_e is current-sensitive, its value changes when a large signal is present. This means that the voltage gain changes during the cycle of a large signal. In other words, changes in r'_e are the cause of distortion with large signals.

With the feedback resistor, however, the swamped voltage gain is:

$$A_V = \frac{r_c}{r_e}$$

Since r'_e is no longer present, the distortion of large signals has been eliminated. A swamped amplifier therefore has three advantages: It stabilizes voltage gain, increases the input impedance of the base, and reduces the distortion of large signals.

Example 10-6

MultiSim

What is the output voltage across the load resistor of MultiSim Fig. 10-8 if $\beta = 200$? Ignore r'_e in the calculations.

MultiSim **Figure 10-8** Single-stage example.