

Power amplifiers

(or -- what to do about the lousy efficiency when you need current.)

The problem

Suppose we need a 50 watt audio amplifier

→ 50 watts into 8 ohms

$$\text{That's } V = \sqrt{(50)(8)} = 20 \text{ Volts}$$

$$I = \sqrt{\frac{50}{8}} = 2.5 \text{ Amps}$$

↑
RMS.

Multiply by 1.41 to get peak

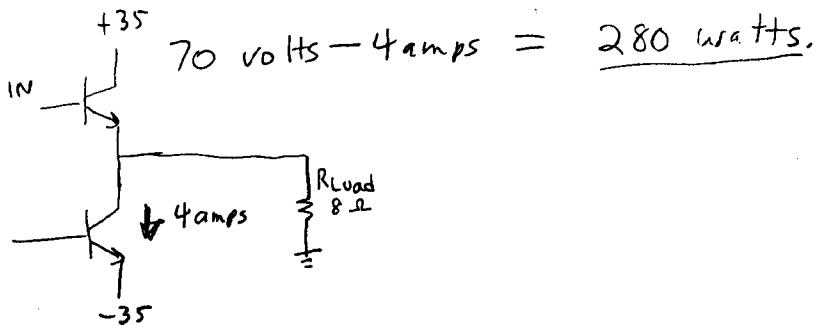
by 1.5 to have a little more -

$$V = 30 \text{ V. peak}$$

$$I = 3.75 \text{ amps}$$

So, we need a power supply a little more than ±30 Volts, try ±35

With an emitter follower and current mirror, need a current of a little more than 3.75 amps — try 4 amps.



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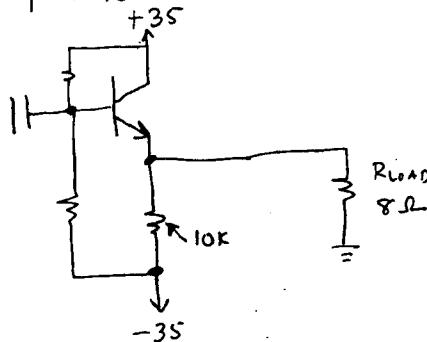
Idea ---

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→ Make our amplifier only amplify half of the signal

→ Use two of them — The other takes care of the other half of the signal.

Try this ---



Read chapter 10 (10.1-10.4)
Do exercises.

Look at 10.5, 10.6,
too —
we already did that.

Output looks like



It chops off the bottom half.

Positive current flows thru the transistor.

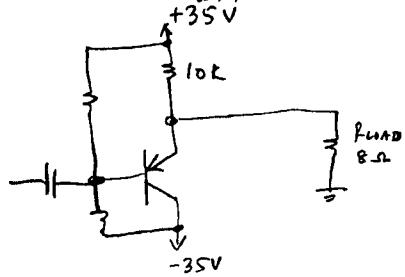
There is lots available.

Negative current flows thru the 10k resistor —

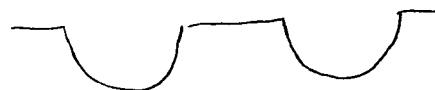
There is only a little available —
so it chops off the negative half.

But, the quiescent current is only 3.5 mA.
That's a quarter watt!

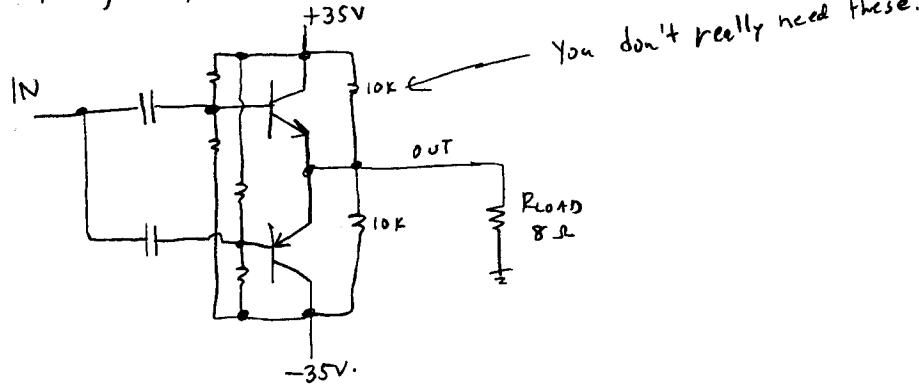
Make another with a PNP...



This one chops off the top half.



Now, put them in parallel:



Now, we have both halves, the whole signal—
with only a few millamps quiescent current.

This is a "class B amplifier"

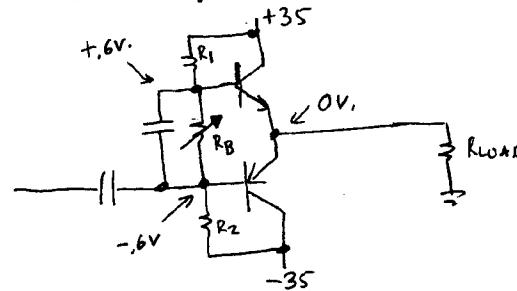
Problems—

There could be a glitch in the middle.
Bias is really critical.

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Biasing the class-B amplifier.

It is simpler to use a single voltage divider—



Since β is about the same for both,
make $R_1 = R_2$.

Adjust R_B for proper bias.

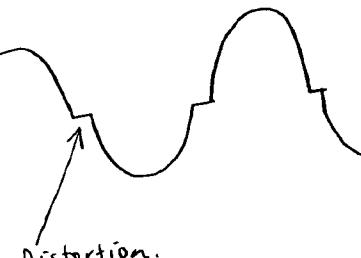
What is proper bias ???

Usually, apply a signal, and tune it
to minimize the distortion.

Too low: ($I_Q=0$)

Output looks like →

This is "crossover distortion".



Real waveform is smoother --

because cutoff is
not sharp —
it's a diode.



Too high --

There is an overlap + . . .

Both transistors drive the load
for a small piece in the middle-

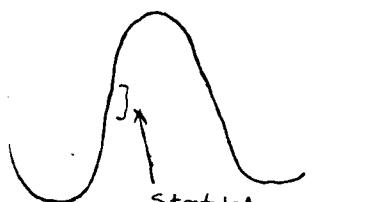
Output is stretched at the crossing.

But only a little--

Big problem with too high --

Excess power dissipation.

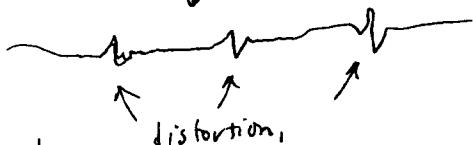
So, set the bias for
minimum crossover distortion,
using a distortion analyzer.



Stretched region -
You probably won't
notice.
 $G_{av} = .95$ here
.90 elsewhere.
(example)

→ A distortion analyzer will show you the
signal with the fundamental removed.

You see something like →



You can get it close with only
a scope.

This bias is extremely critical.

It is usually set with a pot for
each unit.

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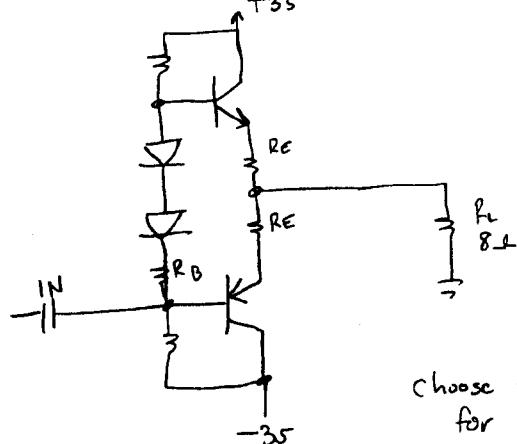
Problem: Thermal runaway --

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As temperature goes up, V_{BE} goes down --

Solution --

- ① Track it with diodes.
- ② Add emitter resistors to stabilize it.



Choose the value of R_E, R_B
for proper bias.
Usual value $\approx 1 \Omega$ for R_E .

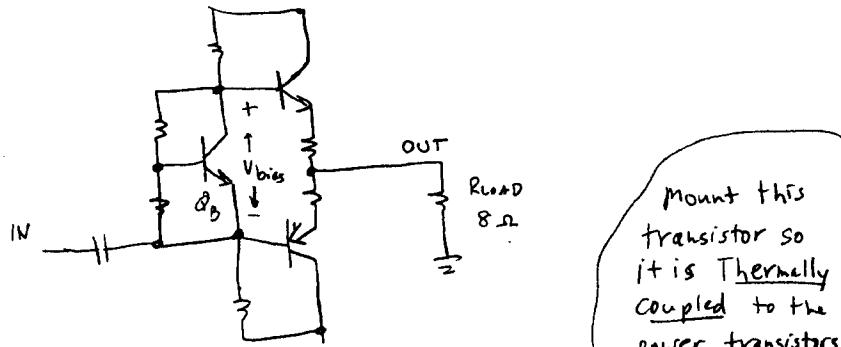
Still too critical.

A better bias circuit!

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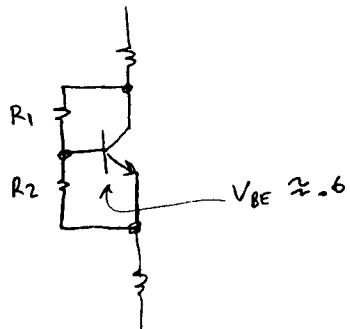
A transistor --

" V_{BE} multiplier"



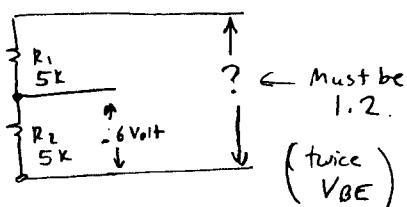
What is V_{bias} ?

Assume β of Q_B is infinite --



V_{CE} is determined by

$R_1, R_2 \dots$



$$\frac{V_{CE}}{V_{BE}} = \frac{R_1 + R_2}{R_2}$$

Make R₁ adjustable
to tune it in.

