diodes D_1 and D_2 and adding one resistor, but the advantages gained from this are negligible.

Circuit description

The function of Tr_1, Tr_2, and Tr_3 is to convert an error voltage—the difference between the input and feedback voltage—into a proportional output current. Now to produce the required mutual conductance of this stage (1A/V) without sacrificing either noise performance or linearity, the design in Fig. 1 was used. Starting at the input transistor Tr_1, this p-n-p type is used mainly as a level shifter. If we assume that the current gain of Tr_2 was extremely large (> 500), then this input stage would have a maximum voltage gain of about five—not very much! If voltage gain was increased to the theoretical maximum of 30 (by decreasing the value of R_2 and R_4) problems would arise with the voltage offset at the speaker output due to increased emitter current flowing through R_3 and base current flowing through R_1.

Assuming for the moment that this first stage gain is a reasonable compromise, it now becomes obvious that the noise and distortion performance is dictated by the next stage. This stage (Tr_2, R_8) is a straightforward class A amplifier with very high gain (typically 400) and low distortion due to the limited modulation index of the collector current (0.04 max). The peak 2nd harmonic voltage generated is about 10μV and, assuming this is referred to the input of the first stage, it represents less than 0.001% 2nd harmonic distortion with feedback. Thus this second stage is the work horse of the input section, the third device Tr_3 being used both as a buffer to reduce the loading of R_{10} on R_8, and to convert the voltage changes across R_8 into an output current to drive the emitters of the signal splitter.

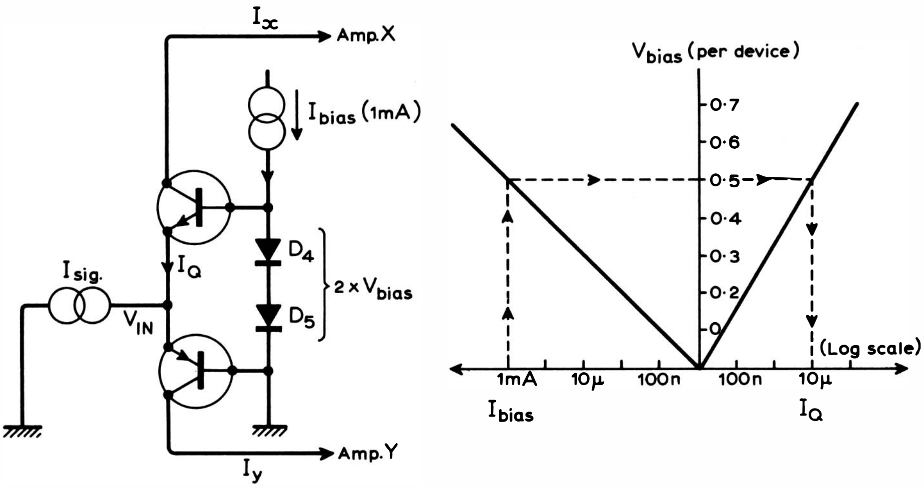
Resistor R_{10} performs two functions in this last stage of the input section. It defines the conversion constant *Engmen* for the stage, and it governs the maximum current which can be driven out of the collector of Tr_3. (This maximum current is defined by using the conducting voltages of D_3 and Tr_2 and the value of R_{10}.) Therefore this input section seems to have excellent performance during normal operation, but what can happen during an overload?

If the input transient was negative all would be well due to Tr_2 entering saturation. But if the transient was positive Tr_1 would turn off completely, the potential across R_{10} rising toward that at the end of R_8. (Tr_2 would also be completely cut off.) This would cause excess currents to flow in Tr_3, upsetting the bias chain R_7, D_4, D_5, R_8. After the excessive input signal is removed some time would elapse before recovery would take place, hence diode D_3 clamps the voltage and maintains Tr_2 in full conduction to reduce recovery time and improve amplifier stability.

While discussing the problem of recovery from overload, the charge across the compensation capacitor C_4 has also to be taken into account. The time for the accumulated charge to decay is a function of the amount of charge and the rate of decay. If the rate of decay is constant, the only way to reduce the recovery time is to limit the accumulated charge (in terms of voltage). Diode D_3 performs this function as well as clamping the voltage across R_{10} at 1V thus limiting drive current into the signal splitter.

The second section is the signal splitter, unique to this approach, and consists of transistors Tr_4 and Tr_5 plus a current source transistor Tr_6. The signal current into the emitter of Tr_4 or Tr_5 is derived by subtraction of two current levels, one constant and set by the voltage across R_9, and the other the output current of the input section. This signal current either appears at the collector of Tr_5—causing a voltage change across R_{20}—or at the collector of Tr_4—causing a voltage change across R_{21}. These voltage changes are converted into positive and negative output currents in the output section, which are then added together to give the final waveform. The current gain of the output sections which are conventional triples are governed by the ratio of R_{20} to R_{17} and R_{21} to R_{18}, and in this case the gain of 1000 seemed reasonable.

To keep the output triples above the minimum conduction level a bias current is provided by R_{11}. The procedure adopted for setting the standing current is to first set R_{20} and R_{21} to minimum (diode end).



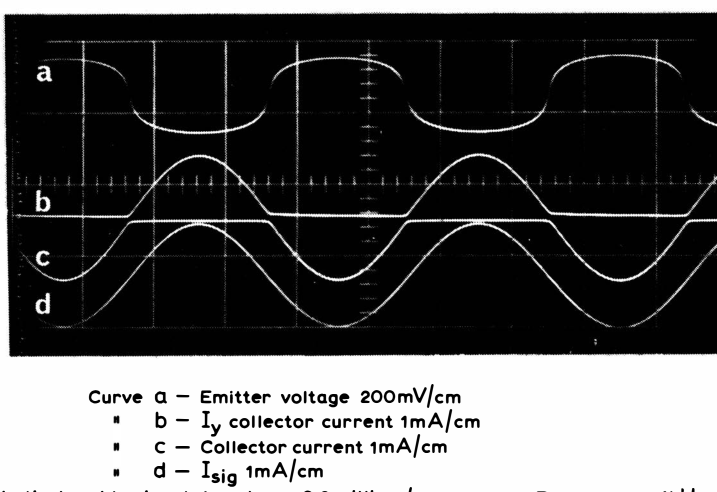


Fig. 2. Input amplifier converts signal voltage to a proportional current to feed transistor signal splitter. Bias diodes reduce voltage excursion from 1.2V to 300mV pk-pk. Bottom trace is current signal input to splitter.

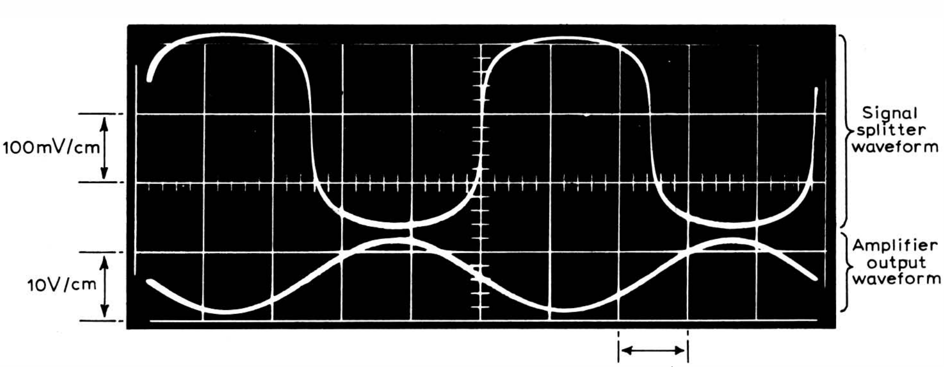


Fig. 3. Voltage excursion at signal splitter input with corresponding sinusoidal amplifier output current (R_L=15Ω).