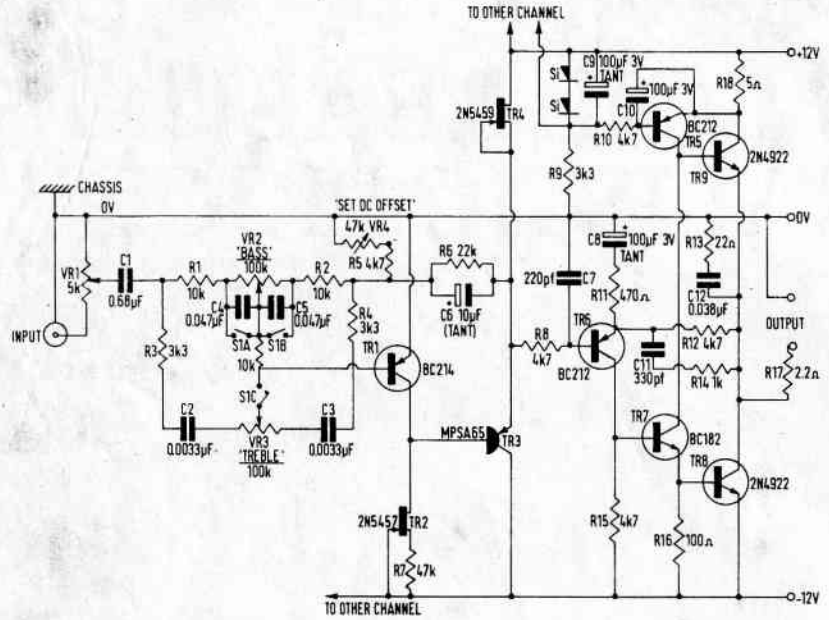
FIG. 2 HEADPHONE AMPLIFIER (LEFT-HAND CHANNEL SHOWN)



NOTE: Switch S1A, S1B, S1C is a tone control 'cancel' facility

single-ended, rather than 'push-pull' configuration. The use of Class-A completely eliminates the high odd-order harmonics which it is so difficult to remove fully and permanently from Class-B, and the avoidance of the conventional push-pull layout ensures both that such harmonics as do remain will be low order and 'even', and that the bends in the transfer characteristic are well away from the central 'small-signal' region. This, in turn, leads to a much more favourable distribution of the steady-state intermodulation products, with an associated transparency of tonal quality seldom otherwise attained.

In addition to this, the fundamental linearity of the Class-A system permits the use of much lower orders of negative feedback for a given THD level. While NFB is not, of itself, a bad thing, the use of it in large amounts does require a great deal of care in design—it is, in truth, the electronic engineer's tight-rope—and it does impose a number of restrictions in respect of the high frequency loop characteristics, which can only be solved as a compromise in one way or another. If one can get away with less, so much the better, and so much the easier to achieve a good, fast, clean, transient response without penalties in THD or reactive-load behaviour.

Finally, the use of Class-A, with the output stages allowed to draw a substantial, and largely constant amount of current permits, in the case of transistors, both rapid small-signal turn-on times (because the transistors are operating under conditions in which the HF performance is not impaired) and also fast turn-off response (because to turn off the signal does not necessitate turning off the transistor, with all the complications arising from hole storage and carrier recombination). This gives a characteristic aural response only obtained with some difficulty by other means.

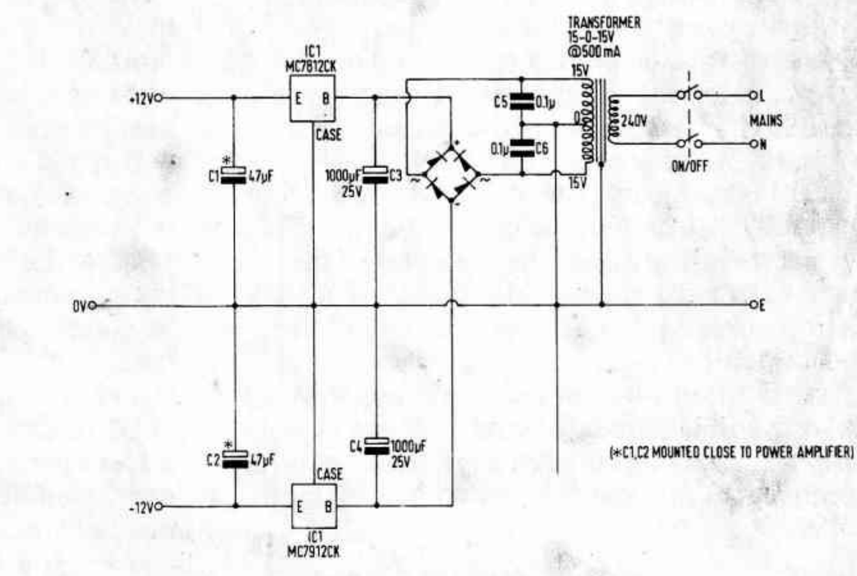
Circuit design

The circuit of the 'power' amplifier is shown in schematic form in fig. 1. This is basically a Class-A transistor amplifier stage (TR_2) driving an output emitter-follower (TR_4), which has an active emitter load (TR_3) also driven by TR_2. A constant-current source coupled to TR_4 serves both as a load for TR_2 and as a means of maintaining the output stage operating current at a constant mean value.

An input transistor amplifier (TR_1) serves to provide a somewhat larger loop gain and to restore the signal input level to near the '0 volt' line, since in this case it is intended to operate the amplifier in a direct-coupled form. Because all the transistors employed have high transition frequencies, and the loop stability—because of the very modest open-loop gain—is very high, no formal HF compensation, such as the ubiquitous and deplorable capacitor normally included between base and collector of the second amplifier stage (in this case TR_2) is necessary for stability. Consequently, neither slew-rate limiting of transients nor TID can occur. However, because it is neither necessary nor desirable that the amplifier should have a bandwidth extending into the MW radio band, an input CR integrating network is included in the amplifier, which gives a smooth roll-off in the HF response beyond 50 kHz. The closed-loop gain of the amplifier is also reduced from 10 (its low frequency value) to about 3 beyond this frequency by means of a step network connected across the feedback resistor. This is to minimise the risk of HF instability within the 'power' amplifier because of inadvertent proximity between output and input leads.

If all that is required is an amplifier having a 'flat' response, and an adequate power output to drive all normal headphones, the slider of the input gain control can be taken, via a suitable input capacitor-resistor network, directly to the input transistor (TR_6 in the complete circuit diagram). However, it was felt that some scope for tonal balance adjustment would increase the versatility of this design, and so a simple, but high quality, 'tone-control' circuit has been appended at the input. This is based on a Liniac arrangement, improved somewhat by the use of a *p-n-p* input transistor and a very high gain *p-n-p* Darlington emitter-follower with an

FIG. 3 CIRCUIT OF POWER SUPPLY FOR HEADPHONE AMPLIFIER



NOTE: IC1 and IC2 are TO3 type Integrated-circuit Voltage regulators mounted directly on chassis