5W INTEGRATED TRANSISTOR AMPLIFIER

FULL DETAILS ARE GIVEN HERE OF THE POWER AMPLIFIER SECTION

Six transistors are employed in the power amplifier, the circuit of which is shown in Fig. 6. The first transistor, TR5, is connected as an emitter follower, the collector being grounded to a.c. by the 32μF capacitor C15. This mode of operation gives high current gain and zero phase shift between input and output, a good match therefore exists for practically any type of input. Stabilisation is achieved by C14 across the bias network.

The output from the emitter of the first stage is directly coupled to the high gain stage TR6. C17 assists in reducing the high frequency rising characteristic of this stage. The collector of this stage is directly coupled to the base of the phase reversing *npn* transistor TR8 and via D1 to the base of TR7.

TR7 and TR8 operate in the class B Darlington mode to increase current gain. This again has the advantage of push pull emitter follower operation. It will be noted that each stage is directly coupled throughout the amplifier; there is therefore no phase shift or frequency losses due to capacitive coupling.

SPECIFICATION

Frequency response
Substantially flat from 20c/s to 25kc/s

Sensitivity
An input of 50mV is required for full drive

Overall feedback
17dB

Output Impedance
Less than 1 ohm

H.T. Supply
28V normal, 32V maximum
50mA quiescent. 500mA for full sine wave output

Battery Operation
When powered by a 9V battery, an output of 300mW is obtainable

FORWARD BIAS

The output transistors TR9 and TR10 have a small forward bias to minimise crossover distortion. This bias is set by the voltage drop across the 1 kilohm resistors R26, R27 which are in parallel with their input. Capacitors C18, C19 are connected across these resistors and stabilise the circuit reducing the drive some 70 per cent at 30kc/s.

Transistors TR7 and TR8 are biased for the same reason by the voltage drop across the OA10 diode D1.

FUNCTION OF THE DIODE

A 70 ohm resistor could be used in place of the diode D1 to serve the same function; a resistor would not, however, give any temperature compensation and the bias would be disturbed accordingly. True thermistors could be used to compensate for the

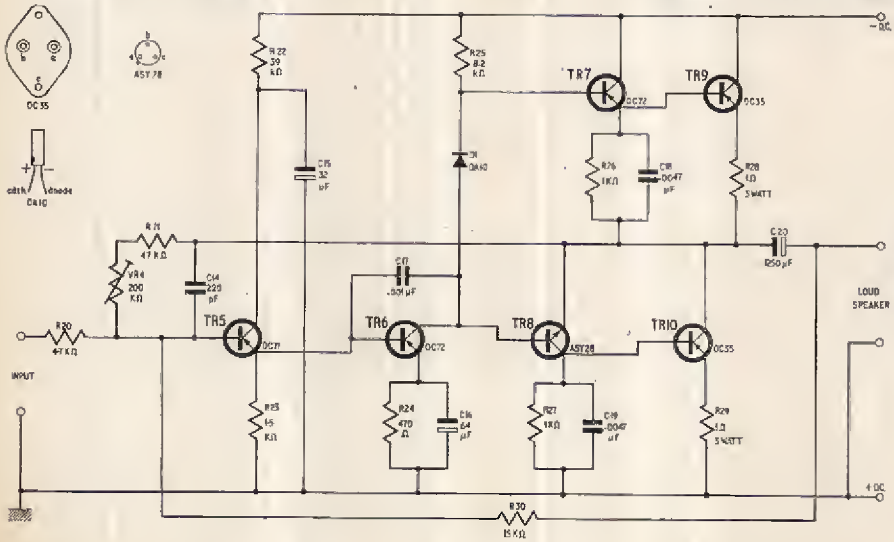


Fig. 6. Circuit diagram of the power amplifier with base details of transistors shown in the top left-hand corner of the drawing

temperature variation of the emitter base resistance, but their performance is not comparable with the OA10 diode which has characteristics similar to the germanium transistor.

Having explained the reason why the diode is used and its function in the amplifier circuit, it would be well to describe a precaution that must be observed in placing it in the circuit when constructing the amplifier.

The OA10 is a high current, low voltage germanium junction diode. It is important that no alternative diode is used in the amplifier and great care should be taken during construction that it is connected the correct way round in the circuit. The function of D1 is to assist in temperature stabilisation of the circuit and to couple the complementary pair TR9, TR10 in a correct push pull mode.

It is important that the base inputs to the driver transistors are never open circuit with respect to one another at any time. An equivalent condition arises should the OA10 diode be inadvertently reversed. If this happens the base of the driver transistor TR7 becomes more negative while the base of TR8 becomes more positive, moving towards the earth rail. The resulting large bias increase will cause the collector/junction resistance to become extremely low and the output transistors will then draw excessive current through the base in a matter of seconds resulting in collector to emitter short and the ruining of expensive transistors. (This is of course no different from connecting the grid of a thermionic valve to a 400V line.)

To enable the amplifier to be used with low-level sine wave testing, 1 ohm resistors are inserted in the emitter circuits of the output transistors, giving reverse bias and further aid to linearity.

The quiescent current is some 50mA rising to 500mA for full sine wave output.

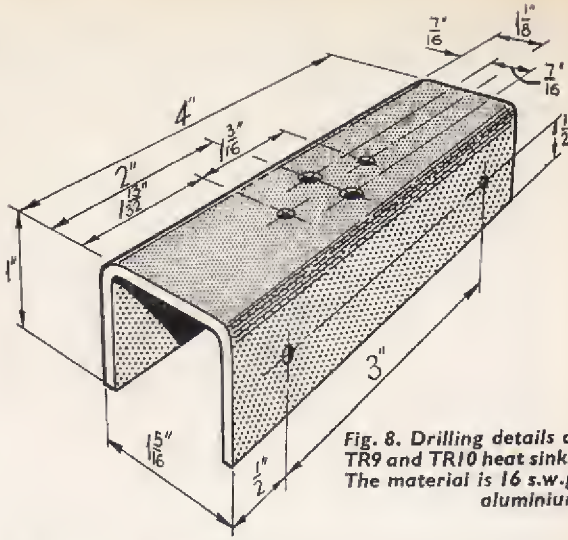


Fig. 8. Drilling details of TR9 and TR10 heat sinks. The material is 16 s.w.g. aluminium

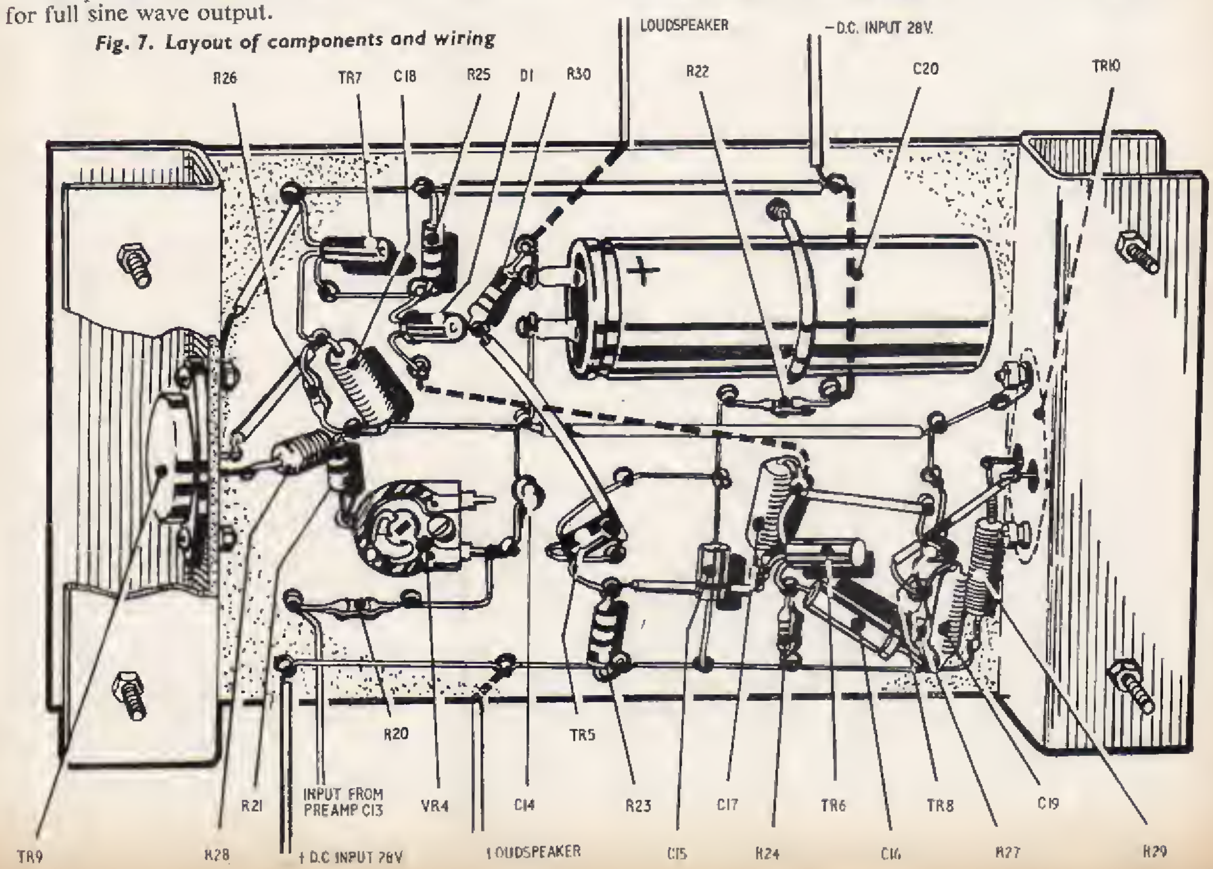
The h.t. is normally 28 volts with 32 volts maximum. The amplifier will perform quite satisfactorily at a reduced output of 300mW when supplied by a 9V battery.

Overall feedback of some 17dB is applied via the 15 kilohm resistor R30 from the amplifier output to the base of TR5.

CONSTRUCTION

Construction is straightforward and follows similar lines to that of the pre-amplifier, as described in last month's article. If larger components than those shown in the layout diagram (Fig. 7) are used, the

Fig. 7. Layout of components and wiring



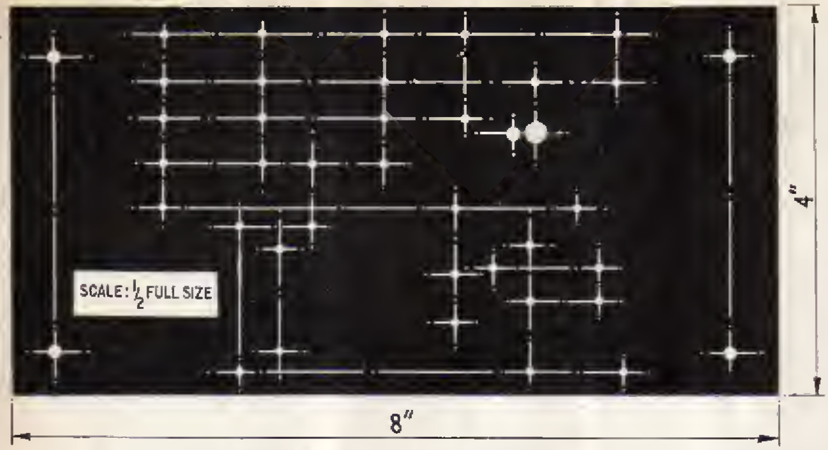


Fig. 9. Drilling details of the plastics board

circuit board (Fig. 9) may have to be enlarged accordingly, but providing the general layout arrangement is adhered to no difficulties should arise on this account.

There is no hum level to worry about and the whole unit is extremely stable.

The construction of the heat sinks is quite simple if the following procedure is adopted. Obtain a piece of hard wood 1¼in square and 4in in length. From a sheet of 16 s.w.g. aluminium cut two pieces each measuring 4½in × 4in. Hold each piece in a vice and bend it round the mandrel to form a C channel heat sink. See Fig. 8.

In the centre section of each heat sink drill the holes for the power transistor fixing screws and the feed-through holes for the base and emitter connections. In the corners of each heat sink drill four holes for fixing the assembly boards into their final positions.

Special care must be observed when connecting the ASY28 *npn* transistor TR8. The collector looks towards the positive rail and the emitter towards the negative side of the output electrolytic C20. This is, of course, opposite to the connection of the OC72 *pnp* transistor TR7.

SETTING UP

When the power amplifier panel has been completed, check the connections carefully. A loudspeaker must be connected to the output terminals before power is applied to the amplifier. The output impedance of the amplifier is less than 1 ohm and ensures good loudspeaker damping. Any speaker having an impedance of from 3 to 15 ohms can be used.

If you have any doubts regarding the speaker impedance you propose using, remember a very easy way of finding the impedance is to measure the d.c. resistance and multiply this by $\sqrt{2}$. The power supply can be derived from either a battery or from a mains power unit giving a d.c. output of 32V.

The improved loudspeaker damping and absence of an output transformer (which is both costly and inefficient) are quite definite steps in the direction of true quality reproduction. Class B amplification has the advantage of low quiescent current and high efficiency at full output, the average current consumption on music being about one-third of that on maximum sine wave output.

BIAS ADJUSTMENT

In principle, the two output transistors should be biased to cut off; however, strict adherence to this condition results in crossover distortion which is most unpleasant to the listener. This serious disadvantage which takes the form of a thin reedy kind of noise, which at low input gives the impression of a displaced loudspeaker cone, can be overcome by applying a small forward bias to each transistor, as stated in the earlier description of the transistor functions stage by stage.

Any slight distortion discernable can be eliminated by careful adjustment of the variable voltage level control VR4 between the base of TR5 and emitter collector junction rail to TR9, TR10. The ease of this adjustment is only apparent when final setting up is taking place at a low volume of a piano recording of, say, Beethoven's "Moonlight Sonata". Once the correct position is set, no further adjustment is necessary.

CAUTIONARY NOTE

Do not attempt to use the amplifier at any time without a speaker or equivalent d.c. resistive load connected between the output capacitor C20 and earth. Always remove the d.c. supply before disconnecting the speaker: very large transient currents are built up in the large electrolytic capacitor and, if undamped by the low resistance of the speaker, will surge through the output transistors and damage them.

COMPONENTS . . .

Resistors

R20	4·7kΩ	R25	8·2kΩ
R21	47kΩ	R26	1kΩ
R22	39kΩ	R27	1kΩ
R23	1·5kΩ	R28	1Ω 3W
R24	470Ω	R29	1Ω 3W
		R30	15kΩ

All ⅛W, cracked carbon, high stability 5%, unless otherwise indicated

Potentiometers

VR4 200kΩ carbon preset (skeleton type)

Capacitors

C14	220pF ceramic	C17	1,000pF polyester
C15	32μF 10V	C18	4,700pF polyester
C16	64μF 10V	C19	4,700pF polyester
		C20	1,250μF 25V

All electrolytics, unless otherwise indicated

Transistors

TR5	OC71	TR8	ASY28
TR6	OC72	TR9	OC35
TR7	OC72	TR10	OC35

Diode

D1 OA10

The next and concluding article will describe a simple mains power supply unit giving 28V from a standard battery-charger transformer. This article will also include some advice on the stereophonic arrangements for those who are interested in stereo reproduction and do not mind the cost of duplicating the amplifier and pre-amplifier