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45p

200W AMPLIFIER PROJECT

—FREE TANDY CATALOGUE—

MOST BRITISH SALES ONLY

PET HOME COMPUTER

WHITE LINE FOLLOWER

CASINGS SURVEY

200W AUDIO AMPLIFIER

NO LITTLE TIME AGO we published a project for a 100 W guitar amplifier. It has since proved to be our popular project *ever,* and shows no signs of lying down to die in a respectable manner.

The main complaint about this machine has been that it is not powerful *enough* — something which our burst eardrums have repeatedly failed to grasp. In an attempt to please all the people all the time (as usual) we decided to re-do a design completely, uprating the spec to 200W, and generally improving the quality as far as we could to make the amplifier suitable for high quality domestic usage.

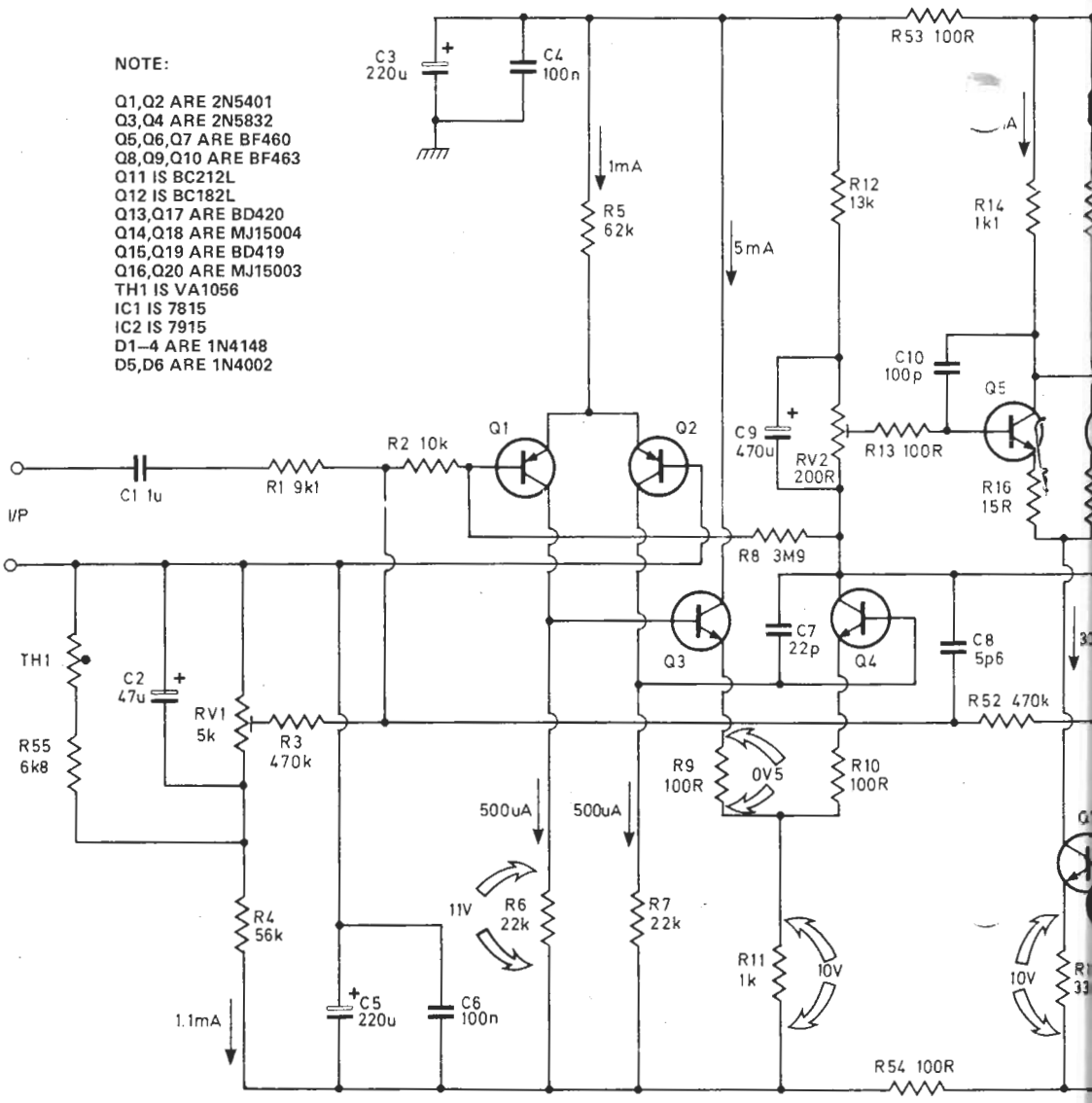
The subjective quality of the design is such that it will not be out of place in the highest of hi-fi set-ups, and its power enables it to drive the more inefficient monitors which seem to dominate such spheres.

SPECIFICATION

Output power		**200 W**
Input sensitivity (for rated output)		**.775 mV (0 dB)**
Distortion at		
200 W	**1 kHz**	**0.031%**
	10 kHz	**0.073%**
20 W	**1 kHz**	**0.025%**
	10 kHz	**0.060 %**
2 W	**1 kHz**	**0.027%**
	10 kHz	**0.042%**
Signal to noise ratio (CCIR weighted)		**—101 dB**
Frequency response (—3dB)		**10.2 Hz — 70.0 kHz**
Slewing rate		**20 V/u sec**

NOTE:

Q1,Q2 ARE 2N5401
Q3,Q4 ARE 2N5832
Q5,Q6,Q7 ARE BF460
Q8,Q9,Q10 ARE BF463
Q11 IS BC212L
Q12 IS BC182L
Q13,Q17 ARE BD420
Q14,Q18 ARE MJ15004
Q15,Q19 ARE BD419
Q16,Q20 ARE MJ15003
TH1 IS VA1056
IC1 IS 7815
IC2 IS 7915
D1–4 ARE 1N4148
D5,D6 ARE 1N4002



HOW IT WORK

USE OF DIFF. PAIRS

Extensive use is made in the design of the 'long-tailed' or differential pair. The basic voltage amplification stage is shown in Fig.2. The symmetrical operation of the long-tailed pairs run with equal current in each arm affords the stage low distortion. Differential operation also possesses high linearity, as any *non*-linearity in V_{in} for either transistors is compensated for by the other.

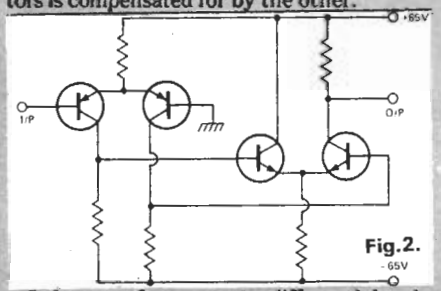


Fig.2.

It is normal to operate differential pairs with a constant-current source in the tail, i.e. Q8, D2 and R22-24 supply Q9 and Q10, and Q7, D1 and R18-20 supply Q5 and Q6. However, at the input of the amp (Q1 and Q2), only very small changes in tail current occur due to the small voltage swings, and a fairly 'large' value resistor, i.e. R5 will suffice. Similarly for R11 and Q3 and Q4. In the output driver stages very large voltage swings will be present and thus a current source is essential to correct operation.

OPERATION

For the purposes of operation the amplifier can be considered in four blocks: Two low gain, low distortion voltage amplification stages formed by Q1 and Q2 and by Q3 and Q4 output drivers Q5 and Q6 with Q9 and Q10 and finally the fully complementary output stages which consist of paralleled darlingtons. Discrete devices are employed for their better operating characteristics and speed 2MHZ. Q15 and Q16 are paralleled with Q19 and Q20 to form in effect a single output 'transistor'. Q13, Q14, Q17 and Q18 constitute

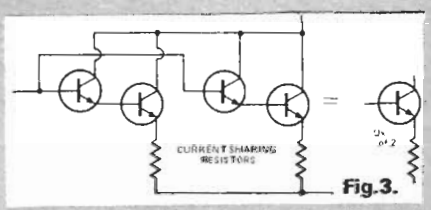


Fig.3.

an identical configuration for the other half of the cycle. Fig.3. shows how the four may be combined into 'Qx'.

OUTPUT TRANSISTORS

The output types themselves are 250 watt devices, since for reliability the load line of these transistors must lie within the "safe operating" area (Fig 4). This is simply achieved with a pure resistive load, but not with the reactive component of a loudspeaker added. For a 4R load instantaneous dissipation in this design has a max of 144W, but with a reactive load dissipation can rise to 288 W. For these reasons lower power

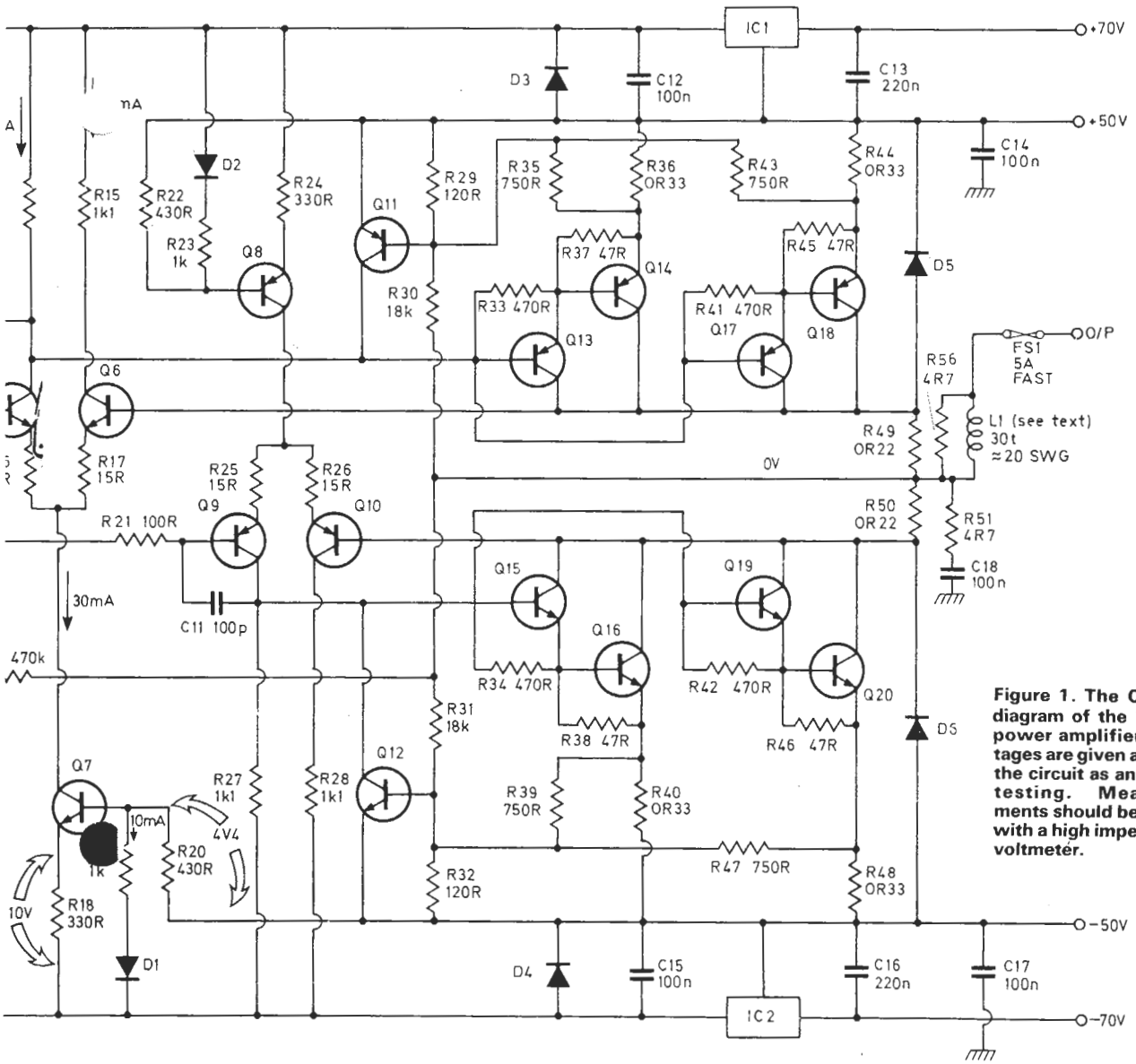


Figure 1. The Circuit diagram of the 200W power amplifier. Voltages are given around the circuit as an aid to testing. Measurements should be made with a high impedance voltmeter.

ORKS~Main Amp

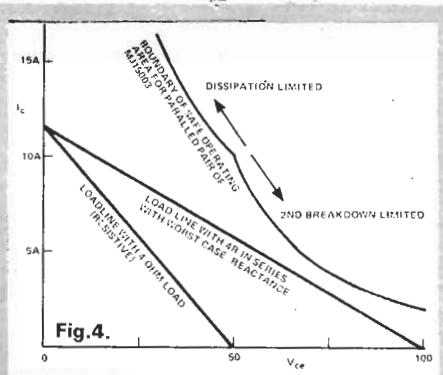


Fig.4.

devices are *not* recommended for use, unless more are paralleled to share the load.

Because the amp employs low overall feedback (14 dB) the bias current for Q1 is not obtained via the feedback resistor R52 since this would result in a large DC offset at the output. An independent supply is provided, consisting of RV1, R55 and R4. Temperature compensation is provided by TH1.

QUIESCENT CURRENT

With the employment of long-tailed pairs, setting of quiescent current in the output 'switches' QX is somewhat different to a 'normal' design. The function is affected by RV2, which varies the DC between Q5 and Q6 bases. Q5 base will follow the base of Q6 by differential pair action, and similarly Q9 and Q10 this means that the voltage across R49 and R50, which is proportional to Iq will be 'referred back' to RV2. Temperature effects can be removed by keeping Q5 and Q6 as well as Q9 and Q10 at the same temperature, and to ensure this pair is thermally connected to a (different) heat sink.

Regulators IC1 and IC2 are employed to stabilize the 50-volt rails with respect to the 65-volt rail for the constant current sources supplying driver stages Q5 and Q6 and Q9 and Q10.

Diodes D3 and D4 protect IC1 and IC2 from any reverse voltages that might be present at switch on.

OUTPUT PROTECTION

Conventional short circuit protection is employed, using load-line limiting, i.e., referring to Fig 5. The current through R31 will voltage limit the output, and the current through the parallel combination imposes a current limiting function. If either limit is exceeded, Q12 switches on and closes down the drive signal.

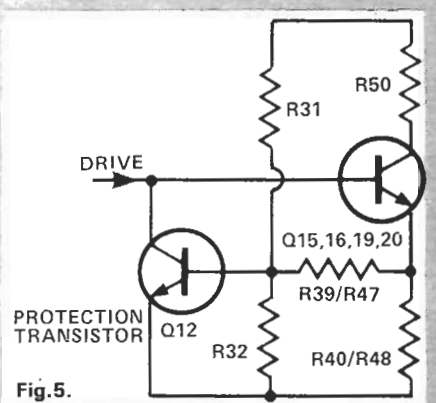


Fig.5.

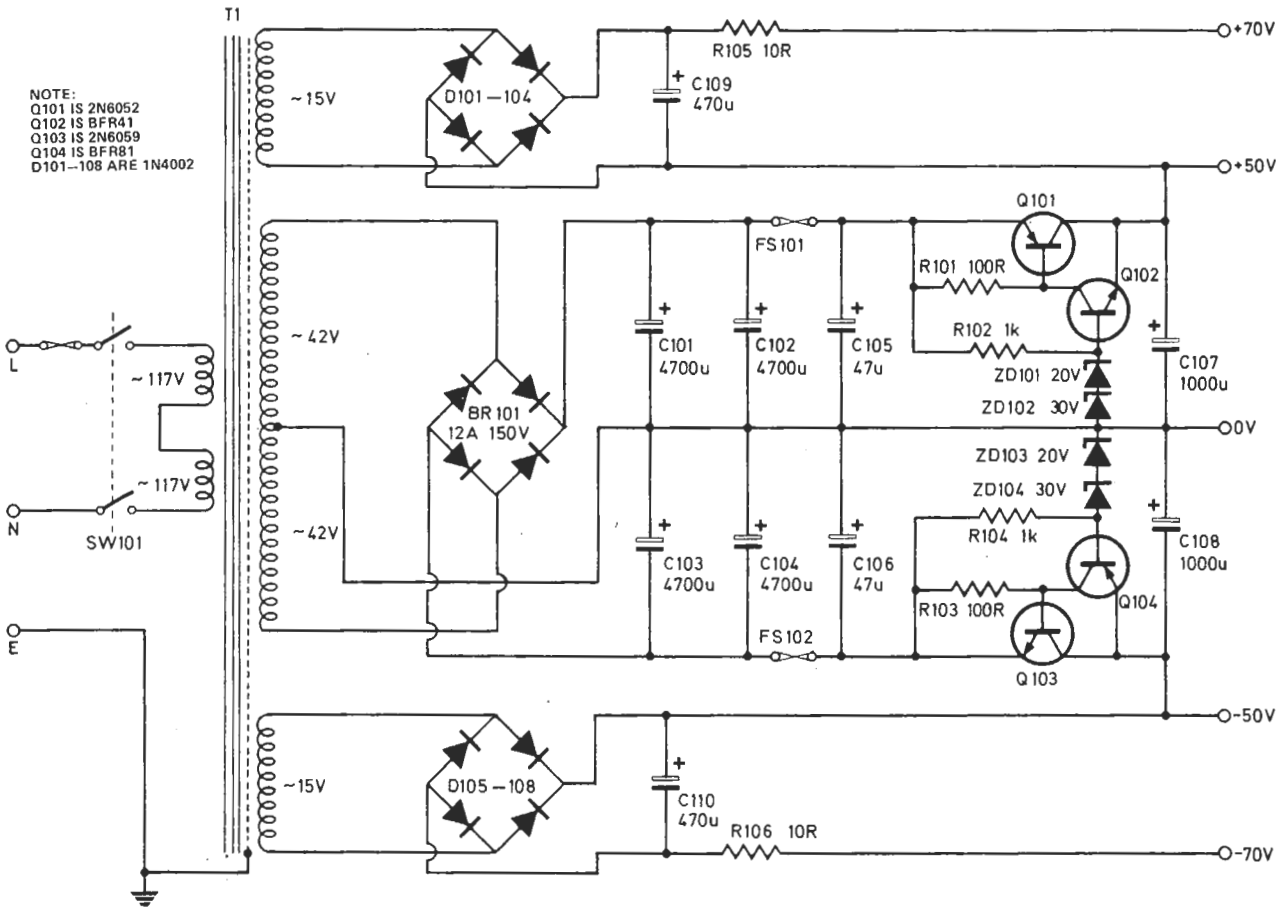
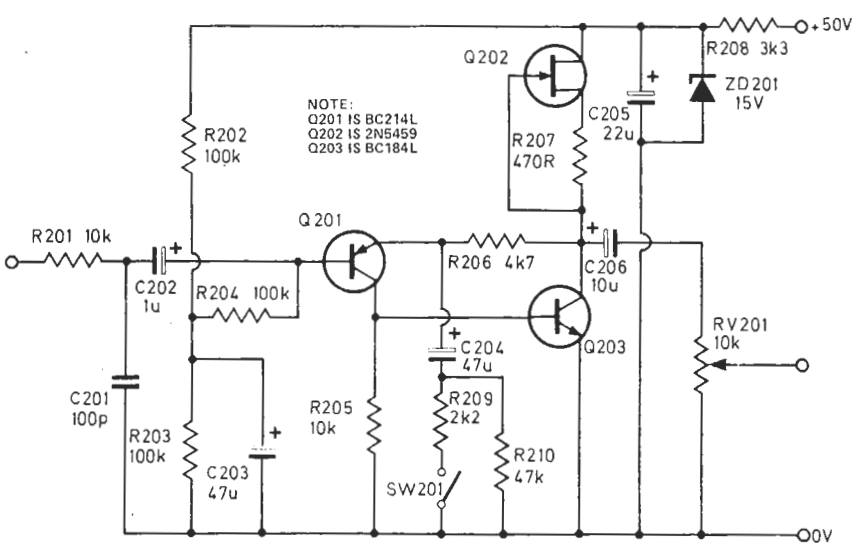


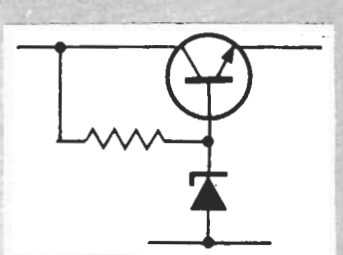
Figure 6. (Above) Circuit diagram for the PSU. Note that the transformer is a special unit wound for the 200W amplifier by Powertran Electronics. Figure 7. (Below) The circuit diagram for the buffer to increase the input impedance of the unit, and provide variable input sensitivity if required.



HOW IT WORKS -Buffer & PSU

THE power supply is a conventional series pass circuit. The basic circuit elements are shown below. The circuit is essentially an emitter follower, the voltage at the base of the transistor being some 0V6 below that set by the zener in the base. The final circuit shown in Fig. 6 shows that Q101 forms the pass element in the +50v rail while Q103 forms the complementary device in the negative rail. Q102 and Q104 provide increased drive to the pass elements.

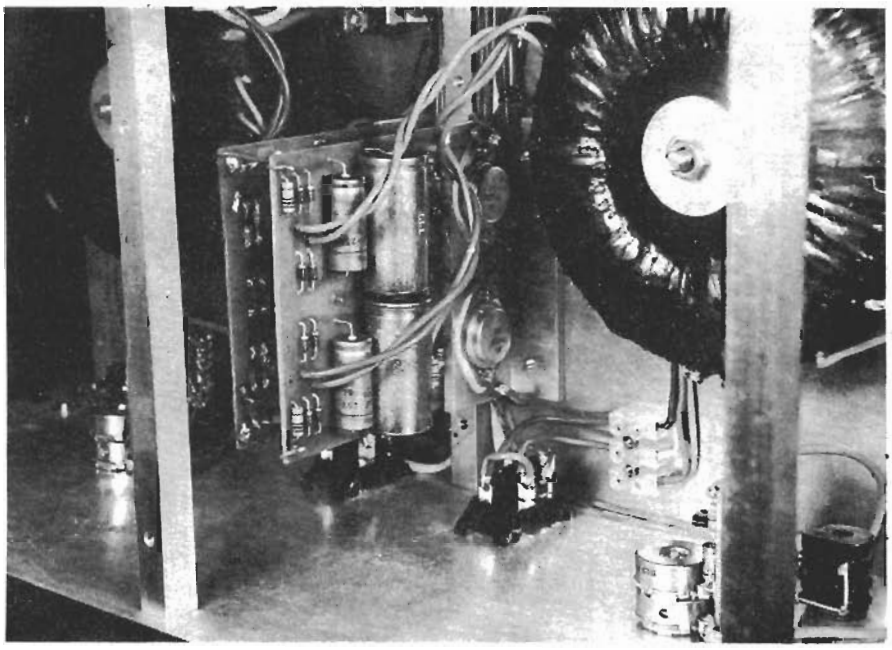
The ±70V rails are dreived from a simple bridge rectifier circuits.



THE BUFFER

The buffer is a straightforward circuit formed by Q201-203. The buffer provides an high input impedance and allows for two gains, with RV201 at maximum, +0dB with SW201 open and +10dB with R209 in circuit. Changing the value of R209 to 470R will give a 20dB boost when SW1 is operated.

The buffer is powered from the +50V rail with ZD201 included to provide a 15V rail.



The PSU can be seen above. The layout of all the major components can be seen with the buffer (in close up below) just appearing at bottom right.

In addition the bodies of diodes D1 and D2 should be in contact with the heat sink of the appropriate group transistors.

The coil L1 is formed by winding thirty turns of self-fluxing polyurethane covered wire (about 26 SWG) around resistor R56 (4R7), soldering the wire to the leadouts at either end of the resistor.

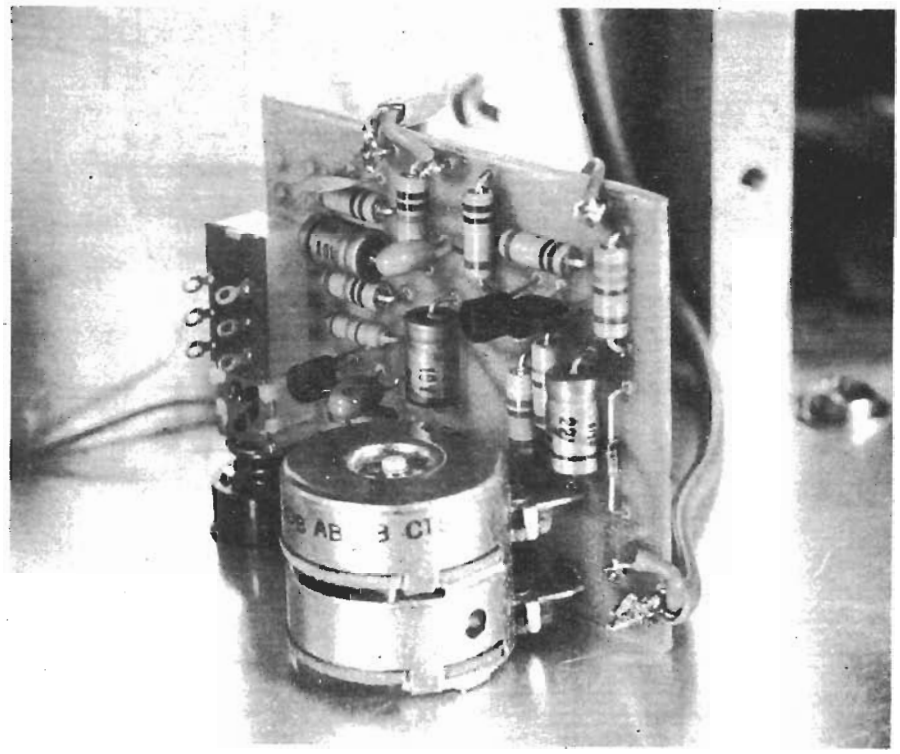
The interwiring of the various completed units should be undertaken by referring to the overlays and the various views of the amplifier chassis designed to show the layout that should be adopted in te completed unit.

Testing

Test of the amplifier should commence with satisfying yourself that the power supply is operating correctly before connecting it to the main amplifier. The voltages shown in Table 1 should be present upon switching on the mains.

TABLE 1

C102+ to 0 V	**62 V**
C103— to 0 V	**—62 V**
C109— to C109+	**22 V**
C110— to C110+	**22 V**



If all is well switch off and — please — discharge the four hefty capacitors via a resistor before doing anything further or else you will be in danger of having a lot of energy make its way to earth via you.

Next connect a 1k5 1W resistor between Q101c and 0V and a similar resistor between Q103c and 0V. Switch on and hopefully the voltages will be shown in Table 2.

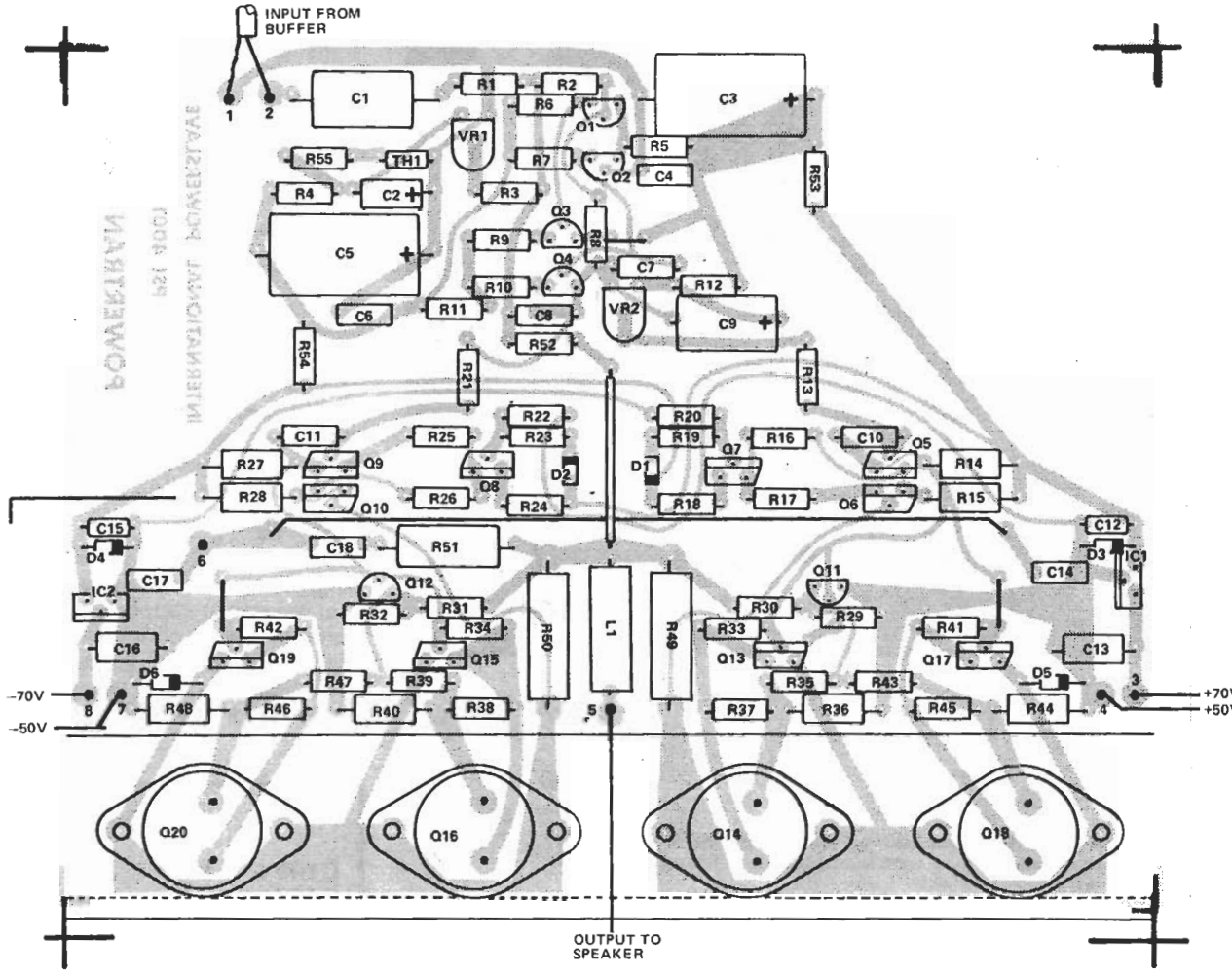
TABLE 2

Q101c to 0 V	**+50 V**
Q103c to 0 V	**—50 V**
PSU pin 101 to 0 V	**+72 V**
PSU pin 106 to 0 V	**—72 V**

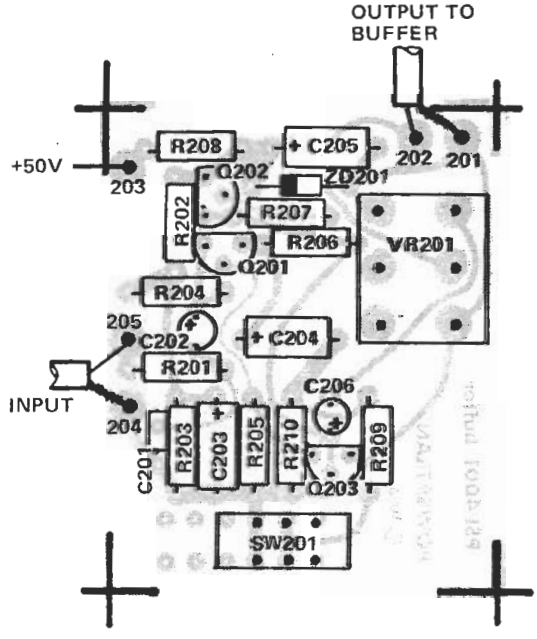
Again if OK, switch off and discharge those Cs.

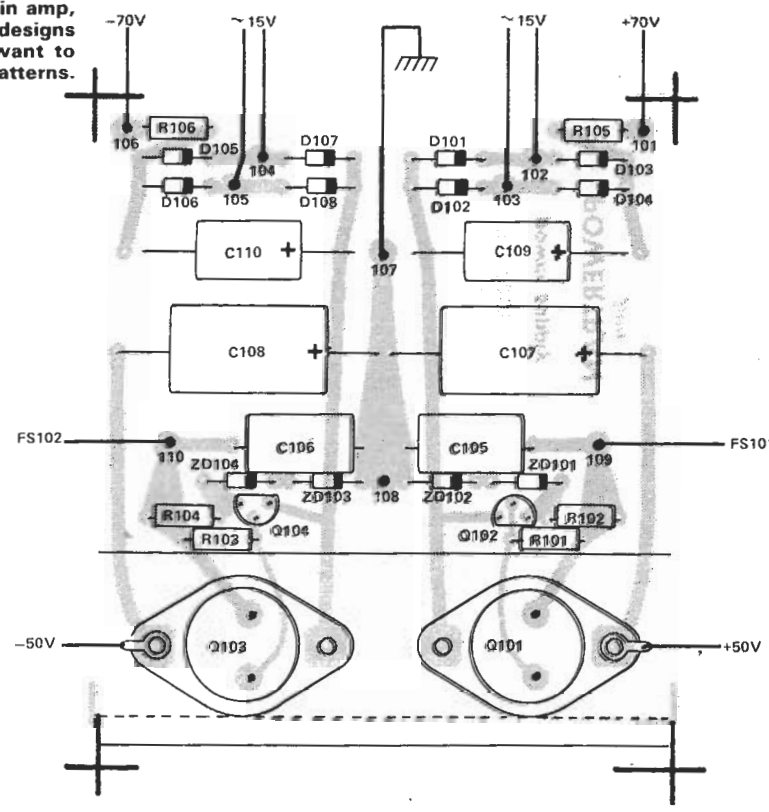
Next replace the 5A PSu fuses with a 12V 2W4 light bulb in series with a 47R ½W resistor. This

▶



On this page are gathered together overlays for the main amp, the power supply and the buffer. Please note the board designs are copyright Powertran but for those of you who want to produce your own an SAE to us will secure you the foil patterns.





PARTS LIST - Buffer & PSU

POWER SUPPLY PARTS LIST

RESISTORS (allows 2% metal oxide unless stated).

R101, 103	100R
R102, 104	1k
R105, 106	10R

CAPACITORS

C101, 102, 103 104	4700u 63 V electrolytic
C105, 106	47u 63 V electrolytic
C107, 108	1000u 63 V electrolytic
C109, 110	470u 25 V electrolytic

SEMICONDUCTORS

Q101	2N6052
Q102	BFR 41
Q103	2N 6059
Q104	BFR 81
D101-108	1N4002
BR1	12A 150 V bridge
ZD 101, 103	20 V 400 mW
ZD 102, 104	30 V 400 mW

TRANSFORMER

T1	see text

MISCELLANEOUS
PCB as pattern, fuses.

BUFFER

RESISTORS (All 2% OW5 metal oxide unless stated).

R201, 205	10k
R202, 203, 204	100k
R206	4k7
R207	470 R
R208	3k3
R209	2k2
R210	47k

POTENTIOMETERS

RV20 1	10k

CAPACITORS

C201	100p polystrene
C202	1u 16 V tantalum
C203, 204	47u 10 V electrolytic
C205	22u 25 V electrolytic
C206	10u 16 V tantalum

SEMICONDUCTORS

Q201	BC214L
Q202	2N5459
Q203	BC184L
ZD1	15 V 400 mW

MISCELLANEOUS
PCB as pattern.

PARTS LIST - Main Amp.

200 W AMP PARTS LIST

RESISTORS (all 2% OW5 Metal Oxide unless stated)

R1	9k1
R2	10k
R3, 52	470k
R4	56k
R5	62k
R6, 7	22k
R8	3M9
R9, 10, 13, 21, 53, 54	100R
R11, 19, 23	1k
R12	13k
R14, 15, 27, 28	1k1 1W Carbon Film
R16, 17	15R
R18, 24	330R
R20, 22	430R
R25, 26	15R
R29, 32	120R
R30, 31	18k
R33, 34, 41, 42	470R
R35, 39, 43, 47	750R
R36, 40, 44, 48	OR33 2W5 Wire Wound
R37, 38, 45, 46	47R
R49, 50	OR22 5W Wire Wound
R51,	4R7
R55	6k8
R56	4R7 2WG Wire Wound

POTENTIOMETERS

RV1	5k Cermet
RV2	200R Cermet

THERMISTOR

TH1	VA1056

CAPACITORS

C1	1u polyester
C2	47u 10 V electrolytic
C3, 5	220 63 V electrolytic
C4, 6, 12, 14, 15, 17, 18	100n polyester
C7	22p 160 V polystrene
C8	5p6 63 V polystrene
C9	470u 6V3 electrolytic
C10, 11	100p 160 V polystrene
C13, 16	220n poltester

SEMICONDUCTORS

Q1, 2	2N5401
Q3, 4	2N5382
Q5, 6, 7	BF460
Q8, 9, 10	BF463
Q11	BC212L
Q12	BC182L
Q13, 17	BD420
Q14, 18	MJ15004
Q15, 19	BD419
Q16, 20	MJ15003
IC1	7815
IC2	7915
D1-4	1N4148
D5, 6	1N4002

INDUCTOR

L1	see text

MISCELLANEOUS
PCB as pattern, thermal fuse, mica washers, connecting wire, etc.

Construction

With a project of this type, while attempting to keep construction as straightforward as possible, the sheer physical size of many of the components precludes mounting them on a PCB. This inevitably leads to more constructional work and hence to a greater scope for error. Care taken during assembly and careful checking at each stage can save time and (plenty of) money later on. With this in mind please read this section thoroughly and study the photographs of the finished unit before starting constructional work.

The first stage in building up the amplifier is to mount all the passive components and links on the three PCBs according to the appropriate overlay. Needless to say all soldering must be or the highest standard and checks should be made to ensure that there are no solder bridges present.

Power And Its Place

The four power transistors associated with the amplifier and the two required for the power supply are mounted on cooling brackets as shown in our photographs. Care should be taken to ensure that there are no burrs around the holes in the heat sink that might damage the mica washers that must be fitted to all six transistors. In order to aid heat flow from the transistors silicon grease should be smeared on both sides of these mica washers.

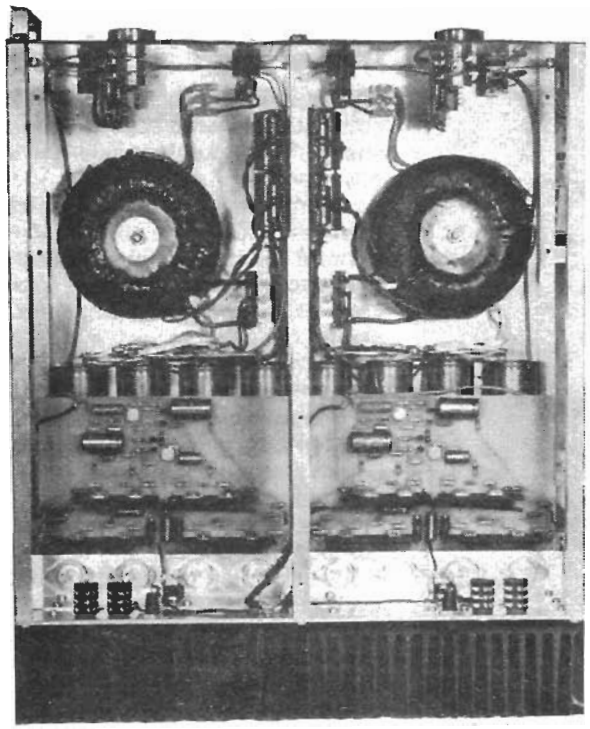
Note that solder tags are required to connect to the cases of the two PSV transistors but not on the main amp's devices where connection is made via the PCB.

Bracketed Cooling

The thermal cutout is also fitted to the cooling bracket on which the amplifier's output devices are mounted.

As can be seen in the photos of the amplifier board the following groups of transistors are thermally connected

Q5 Q6 and Q7
Q8, Q9 and Q10
Q13 and Q17
Q15 and Q19 ▶



The photograph above shows a version of the amplifier built with power level meters. The circuitry required to provide this facility is shown below.

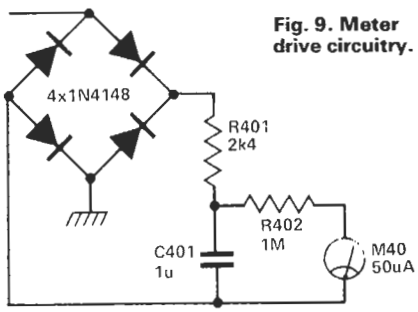
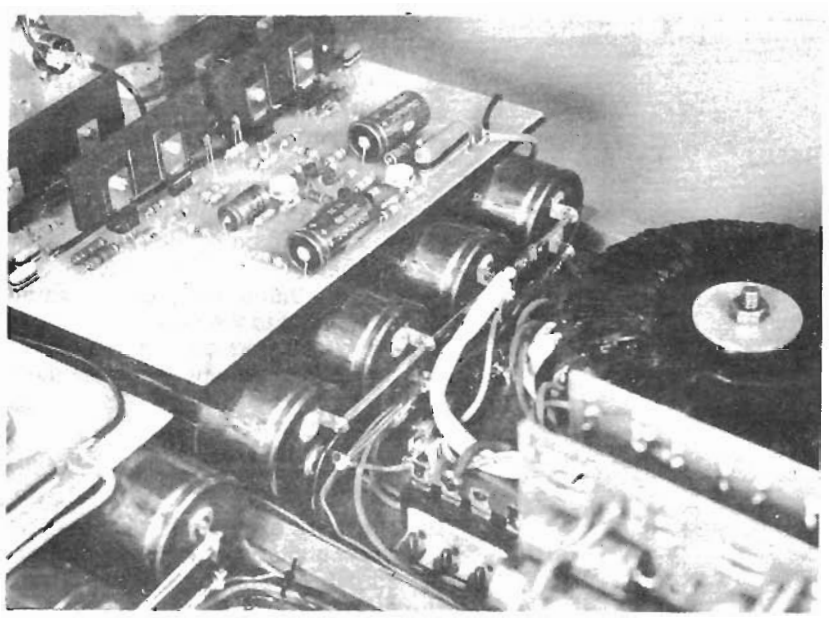


Fig. 9. Meter drive circuitry.

Below can be seen the main circuitry. The heatsinking arrangements of the various output devices can be seen as well as the mounting of C101-C104. Above — an overall view of the amplifier.



provides a convenient method of monitoring and limiting the current drawn by the amplifier. Note that if the main amplifier is working correctly you will see an initial surge of light from the bulb which should then die away.

Before connecting power to the amplifier set RV1 to its centre position RV2 fully clockwise and RV201 fully anti-clockwise.

Switch on and check that the voltage between 0V and the R56 and R51 junction is near zero. RV1 should be adjusted until this voltage is exactly zero.

Next RV2 should be rotated until the lamps in the power supply lines start to brighten.

If everything is still going according to plan, replace the power supply fuses and adjust RV2 until the voltage between Q14c and Q16c is 20mV. Resetting the output to zero volts with RV1 completes setting up.

Leave the amp on for about half an hour and recheck all voltages, making any necessary adjustments connect a speaker to the output and 'test drive' the amp for about an hour. A final check of all voltages and your amplifier is ready to go into service.

ETI

BUYLINES

Powertran are to provide a complete kit of parts for this project. For prices and further details see their advert on the inside front cover.