Leaflet A30. 976.

RADFORD

Reference Standard Power Amplifiers

ZD50 ZD100 ZD200

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1. INTRODUCTION

Three stereo power amplifiers are described having nominal power output ratings of 50 watts, 100 watts and 200 watts average power per channel. All the amplifiers are of the same basic design.

ZD50 Stereo Power Amplifier

Suitable for driving any loudspeaker of nominal impedance 8 ohms regardless of impedance/phase v. frequency characteristic without distortion, and loudspeakers of nominal impedance 4 ohms with reasonable impedance/phase v. frequency characteristic. Intended primarily for home use to provide the highest quality of reproduction attainable. Suitable also for professional use where very high sound pressure level is not required. Average power available (true r.m.s. sine wave power into resistive load) is 70 watts into 8 ohms, 120 watts into 4 ohms and 130 watts into 3 ohms, per channel.

ZD100 Stereo Power Amplifier

Suitable for driving any loudspeaker of nominal impedance 8 ohms or 4 ohms. Designed for professional use but also suitable for home use where a higher sound pressure level or greater reserve power is required. The massive construction is designed to enable continuous 24-hour duty at output stage clipping level on rock type music without overheating, reduction of output power, or deterioration of quality of reproduction. Average power available is 90 watts into 8 ohms, 150 watts into 4 ohms and 200 watts into 2.8 ohms, per channel.

ZD200 Stereo Power Amplifier

As ZD100 amplifier but providing an average power of 150 watts into 8 ohms, 250 watts into 4 ohms and 350 watts into 2 ohms, per channel.

2. DESIGN PHILOSOPHY

The design philosophy of the amplifiers is based on obtaining the highest possible subjective performance from present day practical loudspeakers of all types, dynamic and electrostatic, and regardless of the load conditions presented to the amplifier by the loudspeaker in respect of impedance and phase with frequency.

Until recently it has been usual to specify only the static sine wave performance of an amplifier in terms of the power output versus distortion at the rated power into a pure resistance of 8 ohms at 1 kHz, without consideration of its dynamic performance at all frequencies when driven by transient signals into a complex load such as a loudspeaker.

The poor subjective performance of popular transistor amplifiers, particularly those in the lower and middle price range has been recognised for some time and some enthusiasts have even reverted to valve type amplifiers.

The design objective of the 'Reference Standard' series of amplifiers has been to reduce to virtually zero every type of distortion known or detectable with any practical loudspeaker and with any type of signal input under actual conditions of use. Furthermore, such a performance is to be maintained with continuous maximum input drive without overheating or reduction in power output.

3. PERFORMANCE CONSIDERATIONS

3.1 Power output

The amount of amplifier power output required depends on a number of factors such as the sound pressure level desired, size and characteristics of the room, loudspeaker efficiency, etc. The 'Reference Standard' range of amplifiers is intended to cover all the requirements of the enthusiast and professional user. The ZD50 will satisfy almost all domestic users as very few commercial loudspeakers intended for the home will handle more power than the amplifier is able to provide. The ZD100 or ZD200 will provide adequate power to drive loudspeakers to the highest tolerable sound pressure level required in recording studios.

3.2 Subjective/objective performance criteria

Almost all audio amplifiers are used for the reproduction of speech and music through loudspeakers. It is thus very difficult to specify objective tests which have some relevance to the end use. Arbitrary performance parameters have evolved which are obtained by standardised universal measurement techniques, which by familiarity have come to be accepted as valid criteria – for the want of something more meaningful.

Discriminating listeners, professional and others, have always been aware of the disparity between promotional specifications and practical performance of amplifiers. Subjective tests carried out by music societies, audio groups and hi-fi magazine teams reveal the surprisingly poor listening performance of popular present day conventional transistor amplifiers compared with valve amplifiers of 10 to 15 years ago, such as the Radford STA25 and STA100. (For example, see 'Hi Fi for Pleasure' magazine, December 1975, and subsequent correspondence.)

3.3 Loudspeaker load tolerance

A common weakness of the present day popular transistor amplifier is its inability to maintain it's rated output voltage into loads much below 8 ohms and supply current to a reactive load. Loudspeakers present a complex load to an amplifier and some nominal 8 ohms systems have an impedance of less than 4 ohms at some frequencies with a stressing phase characteristic. This combination produces listening fatigue and a sense of unease, due to transients produced by the switching operation of the protection circuits, and the crossover switching of quasi-symmetry output stages when driving practical dynamic loudspeakers at a sound level to be expected from the specified rated output power. Published tests have shown that some transistor power amplifiers rated at 100 watts output cannot provide as high an *effective* sound pressure level (i.e. without noticeable distortion) as a good valve amplifier rated at 25 watts output.

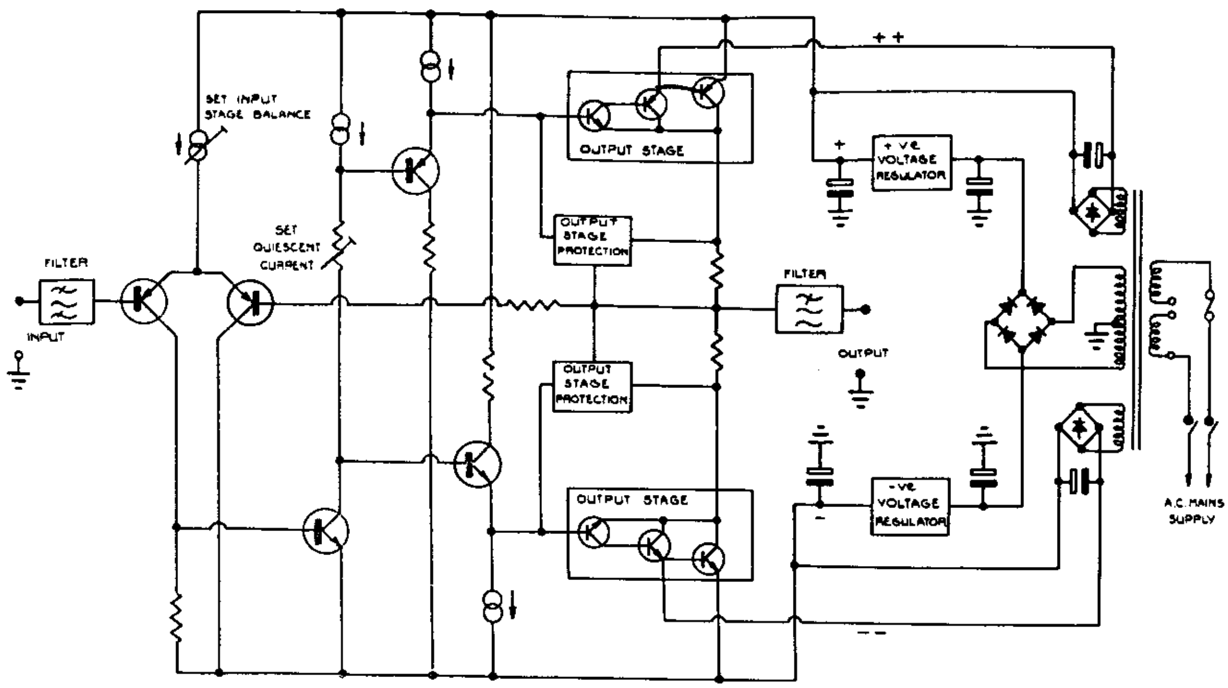
The present method of specifying the power output and distortion of an amplifier when loaded with 8 ohms resistance, without an output voltage/impedance curve and some information on reactive power capability, is not only of doubtful value but can be misleading when assessing practical performance.

The ZD50/100/200 amplifiers use true complementary symmetry output stages with additional circuitry to nullify to a considerable degree the transients developed at crossover by the output transistors at high current switching. High current rating transistors are used in the output stages which are designed to provide a constant voltage into low impedance loads and supply the wattless current required by practical loudspeakers without operating the protection circuits.

3.4 Listening fatigue and unease

Serious listeners have always been aware of an unease while listening to reproduced music when using certain transducers and amplifiers. This results in a premature desire to switch off, nervous tension, or mental fatigue. It is known that high order odd harmonics although of low energy value have a high irritation effect upon the nervous system. Transistor amplifiers using quasi-symmetrical output stages designed to give maximum power output into a pure resistance of 8 ohms, produce a significant amount of high order odd harmonics when driven into a practical loudspeaker. This, together with a similar distortion produced by protection circuit switching accounts for the 'gritty' sound referred to by investigators and listeners which can be apparent even at moderate listening levels.

Fig. 1. OVERALL COMPLETE SCHEMATIC DIAGRAM.



3.5 Performance acceptance values

Certain types of distortion are readily measurable but very difficult to quantify in terms of listening acceptance. A total harmonic distortion of 0.1% at 1 kHz at rated power is considered good in valve amplifiers but poor in a transistor amplifier due to the different harmonic structure.

Very low distortion is expensive both in development costs and possible circuit complexity. For the conventional domestically orientated hi-fi amplifier the designer is financially constrained to levels of distortion attainable with conventional circuits and a minimum of components. This necessitates a decision on relative acceptance limits of the known and measurable distortion factors, other than simple harmonic distortion, such as intermodulation (SMPTE and CCIF methods of testing), transient intermodulation (slew rate limiting), crossover transients, etc.

Outside the distortion acceptance specification, various other characteristics which profoundly affect the performance must be decided upon. Power output v. load resistance is an example. From a sales promotional point of view it is obviously wise to design the amplifier to give its maximum power into a pure resistance of 8 ohms, which is the standard nominal impedance for high fidelity loudspeakers. From a practical performance point of view this is undesirable as already pointed out.

For amplifiers intended for the highest possible performance all forms of distortion and malfunction, under practical operating conditions, must be reduced to the lowest attainable within the present day level of technology and at a selling price acceptable to the 'high end' consumer and the professional.

3.6 Unquantifiable factors – listening validation

It is a fact that amplifiers have been designed, tested in the laboratory and put into production without being connected to a loudspeaker. All specification parameters should be objective and the reluctance of engineers to place any value on subjective tests is understandable. It is convenient and comforting to believe that the performance of an amplifier can be precisely defined by its electrical specification alone. No doubt this would be true if all the relevant performance requirements were known and understood. New tests are continuously being devised to approach this ideal.

Listening validation demands a perceptive and experienced ear, and needs to be carried out over a period of time using all types of music on loudspeakers of different characteristics. Subjective testing is very time consuming, but significantly rewarding when extensive design effort and laboratory testing is finally validated in the finished products – such as the ZD50/100/200 series amplifiers.

3.7 Thermal characteristics

The thermal design of almost all consumer type hi-fi amplifiers is on the premise that the amplifier will be used only for short periods at a time and with such music as never to approach maximum dissipation conditions. This enables considerable savings in respect of material and circuitry as well as reduced size and weight. The practical performance disadvantages of such designs can be serious, however.

3.7.1 *Power output contraint*

Amplifiers which have a low mass in relation to the rated power output (where thermal design is sacrificed to cost, size, weight and styling) heat up rapidly. Precautions must therefore be taken to reduce the power dissipated to prevent serious overheating. Such protection can severely limit the effective power output – to possibly half the rated power.

3.7.2 *Distortion*

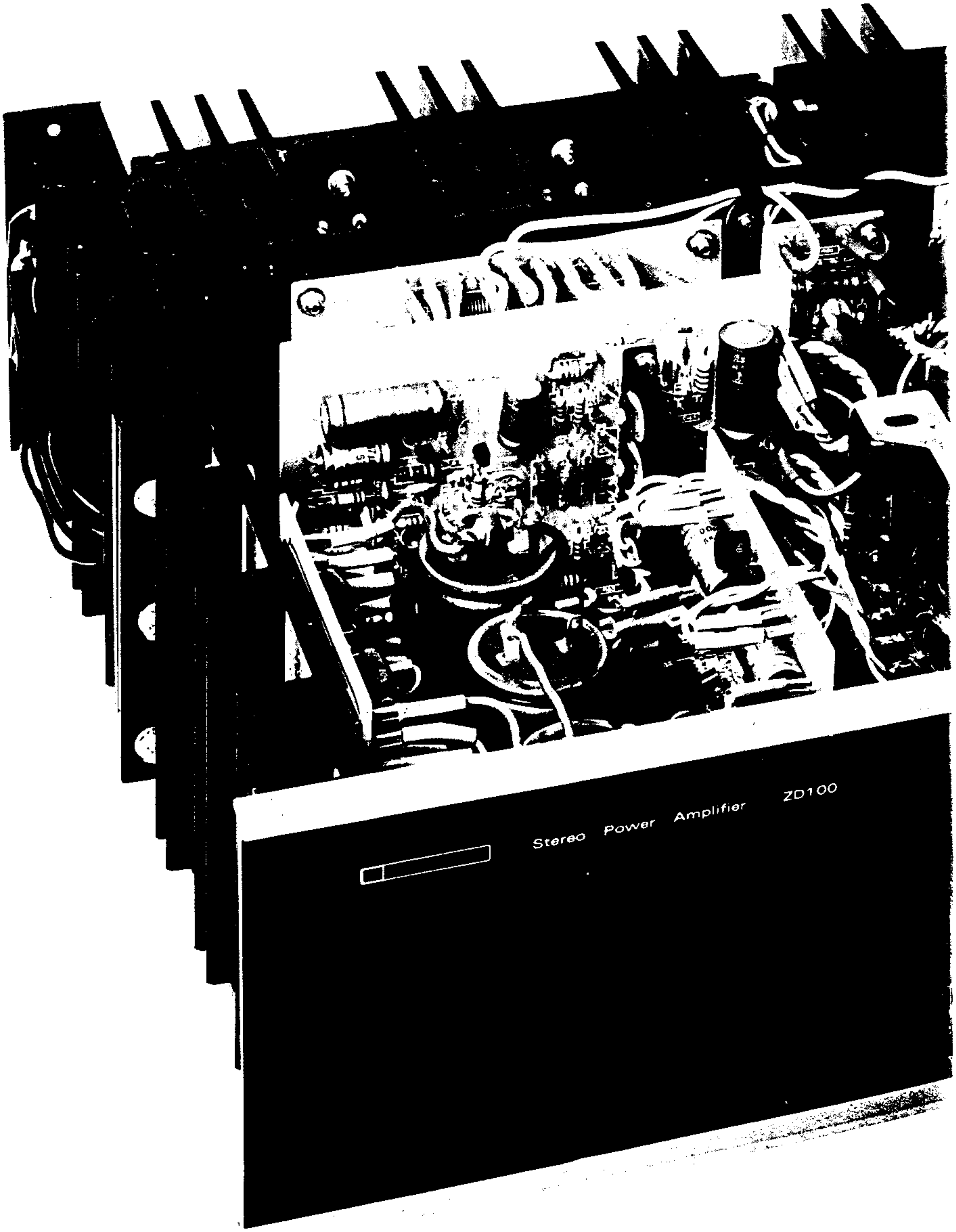
Minimum crossover distortion is obtained by optimum adjustment of the output stage quiescent current. As the transistor parameters change with case temperature, some method of compensation is necessary to maintain a constant quiescent current.

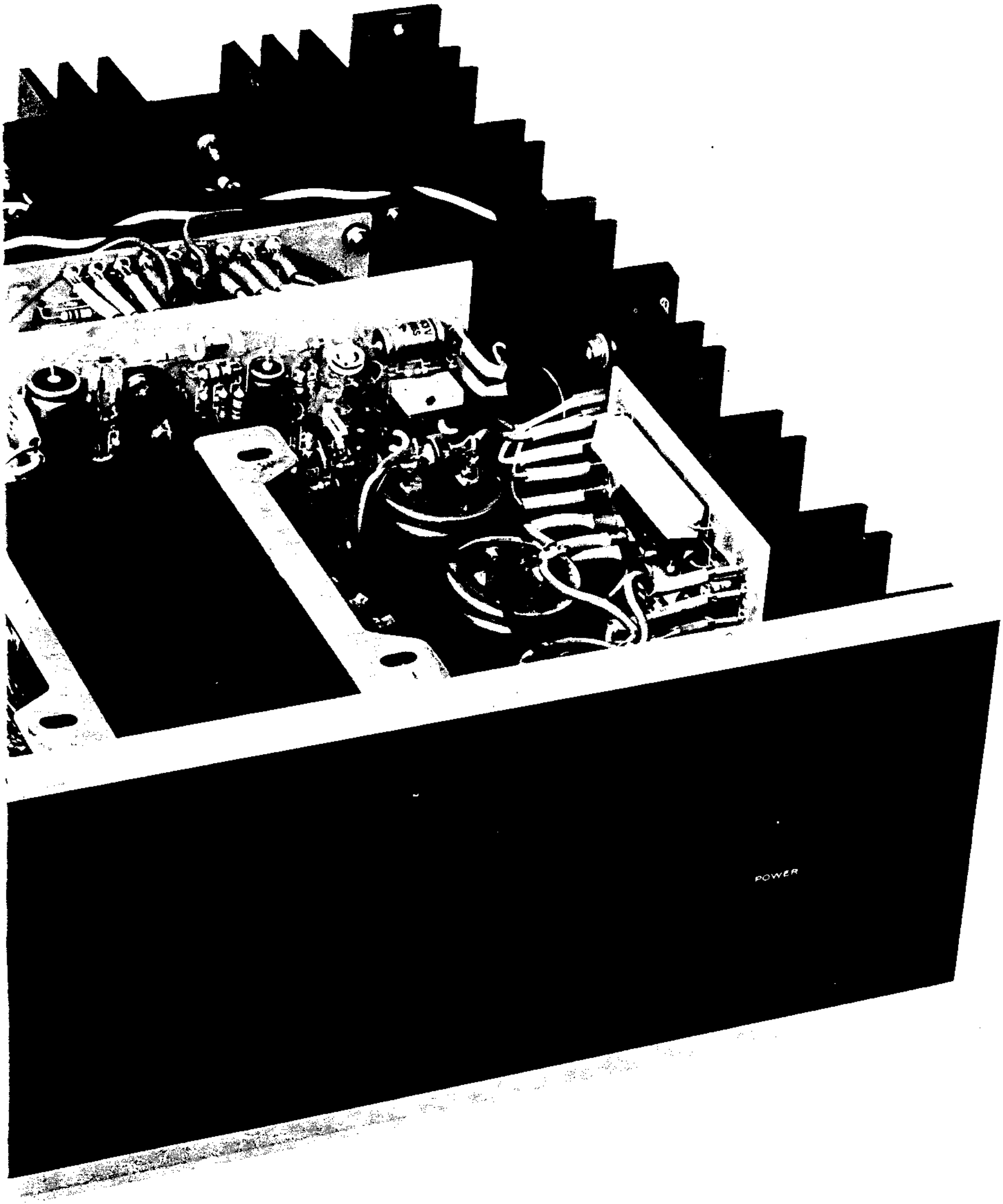
3.7.3 *Stability*

A point frequently overlooked is the change in the stability characteristics of the amplifier with temperature. The change in the operating parameters of output devices particularly can affect the overall phase margin and induce instability on transient peaks near clipping level.

3.7.4 *Overheating*

Adequate protection against catastrophic failure due to overheating is a necessity. Some amplifiers rely solely upon blowing the mains fuse by excessive current drawn by the amplifier when a short circuit is applied to an unregulated power supply by a thermal sensor. This can be expensive by damage to the components, is a potential fire hazard, and is considered unsatisfactory. Alternatively, power output may be reduced by V-I limiting as a function of the heat sink temperature.


Stereo Power Amplifier
ZD100


POWER

4. CIRCUIT DESIGN OF REFERENCE STANDARD AMPLIFIERS

4.1 Input circuit

In order to prevent the amplification of unwanted frequencies a filter is used at the input of the amplifier. The low frequency filter prevents d.c. shifts and inaudible low frequencies from input transducers causing intermodulation of signal frequencies in the amplifier, *but particularly in the loudspeaker.* The high frequency filter reduces the rate-of-change of a signal arriving at the input to within the capacity of the amplifier. If the amplifier proper cannot follow an input transient wave form, the steady state conditions are disturbed and transient intermodulation distortion (t.i.m.) may be introduced. The time taken for an amplifier to recover from a transient impulse depends on the reactive characteristics of the load. A simulated test of the amplifier's ability to deal with transients is to measure the time it takes to recover (settling time) when driven by a 10 kHz square wave and terminated with a capacity reactive load.

The low frequency input filter has a slope of 12 dB/oct with the —3 dB point at 8 Hz and the high frequency filter rolls off at 6 dB/oct from —3 dB at 50 kHz. The filter is terminated by a differential input stage.

4.2 Voltage Amplifier

A cascode configuration is used for the second voltage gain stage which combines good high frequency performance with excellent linearity. Non linear collector-base capacitance, usually the main contributor of high frequency distortion, has been reduced by two or three times. The high output and large bandwidth of the stage enables a value of only 4.7 pf compensating capacitance which ensures that slew rate limiting (t.i.m. distortion) cannot occur within the bandwidth set by the input filter.

4.3 Penultimate stage

True complementary symmetry emitter-followers are used to drive the output stage which also provides the crossover bias instead of the conventional diode chain. The advantages of this circuit are:

(a) The optimum bias condition is maintained by close thermal tracking between bias source and output stage, thus ensuring minimum distortion regardless of drive level and temperature.

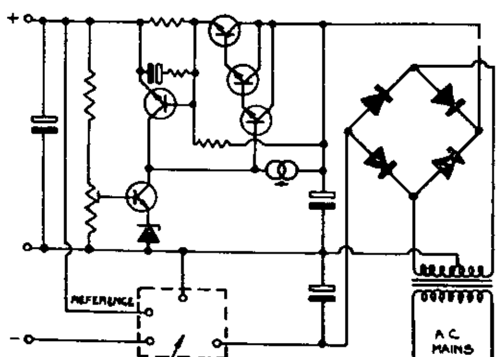
(b) The voltage amplifier is completely isolated from the output stage, making the amplifier loop gain independent of the output load and ensuring minimum distortion regardless of the loudspeaker characteristics.

(c) The low output source resistance of the emitter followers enables good high frequency response and linearity in the output stage itself, thus ensuring minimum distortion.

4.4 Output stage

The output stage operates in a true complementary symmetry configuration (n.p.n.–p.n.p.) to reduce the unsymmetrical crossover residual products. Each symmetrical half comprises three transistors in cascade with heavy feedback. For the purpose of description the transistors within the feedback loop are defined as pre-driver, driver, and power output. In the ZD50 one power output device is used in each complementary half, whereas the ZD100 uses two in parallel, and the ZD200 three in parallel.

Fig. 3 POWER SUPPLY SCHEMATIC



-VE REGULATOR SIMILAR TO POSITIVE HALF

An unusual feature of the output stage is the provision of auxilliary power supplies of ± 10 V to the driver transistors to ensure that the output transistors are controlled from a voltage source throughout the whole of the signal cycle. This prevents the generation of switching transients at the crossover point. (The crossover switching transients generated by a true complementary output stage are already small compared with those produced by a quasi-symmetrical arrangement as used in almost all popular hi-fi amplifiers.)

4.5 Power supplies

It is conventional to use unregulated power supplies which comprise a full wave silicon rectifier and reservoir capacity. There are considerable advantages however in using a regulated supply, not only from the performance point of view, but in the protection it provides.

With an unregulated supply the voltage applied to the amplifier changes with operating level and so changing the amplifier dynamic operating conditions. Whilst it can be shown by static measurements that an unregulated supply is satisfactory it is considered inadequate for a high performance amplifier under practical dynamic conditions of use.

The protection security provided by a correctly designed voltage regulated power supply is considerable. The ZD50/100/200 power supplies are designed with a 'foldback' characteristic such that should a fault develop in the amplifier proper causing a current drain in excess of that required for full power output, the supply voltage is reduced to zero. This electronic switch in the power supply is also triggered by a heat sensor to protect the amplifier against overheating (should the normal ventilation be obstructed) and a differential d.c. output offset voltage sensor to protect the loudspeaker. The regulated supply also protects the expensive complementary symmetry output transistors against overvoltage surges in the mains supply. With a regulated supply the performance of the amplifier is independent of the mains supply voltage over a considerable range.

The power supply for each type of the amplifier is basically the same but different in respect of power capacity.

4.6 Loudspeaker protection

In a direct coupled amplifier it is possible that the failure of a transistor or other component may cause an offset voltage to appear at the loudspeaker terminals and so burn out the voice coils of the loudspeaker bass drivers. Although such a possibility is remote in the ZD50/100/200 amplifiers, an electronic trip is incorporated which senses the d.c. offset level and triggers a thyristor which operates the 'foldback' circuits in the power supply before a damaging current is passed through the voice coils. A further back-up is provided in that should the power supply regulator fail to reduce the supply voltage the heavy duty thyristor will pass sufficient current to blow the equipment mains fuse.

4.7 Thermal characteristics

The mechanical assembly of the ZD50/100/200 series amplifiers is designed as a thermal instrument in itself to provide the maximum convection and radiation of heat with an optimum temperature differential over the complete amplifier chassis, and the component parts. Due to the large mass and appropriate thermal design the amplifiers are able to operate on a continuous duty basis under full drive, as required for studio monitoring.

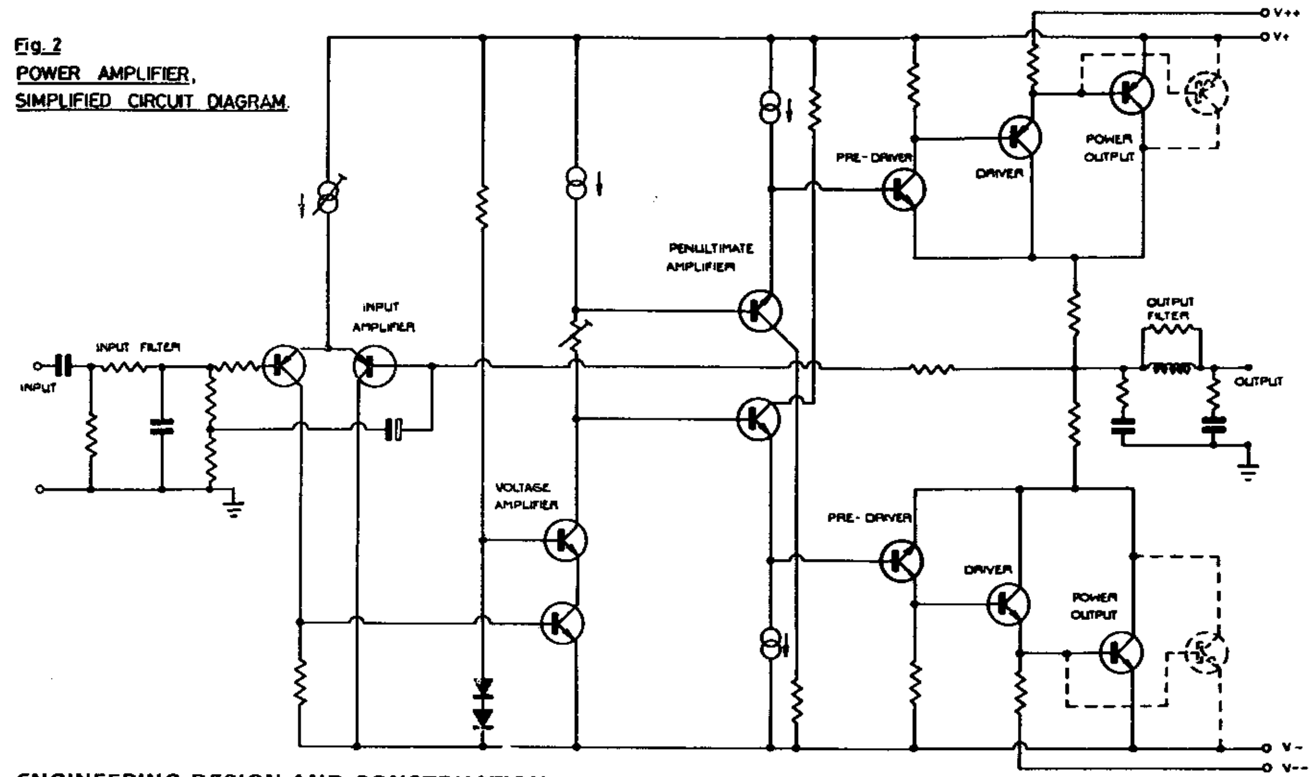
Bias voltage for the output stage is obtained from a temperature compensated constant current source and transferred to the output stage via the thermally tracked emitter follower penultimate amplifier and predriver, thus retaining optimum dynamic operating conditions for minimum distortion.

The amplifier is completely stable even under conditions of severe clipping with transients, and a practical reactive load, when operating at maximum temperature rise.

Under normal operating conditions where ventilation is not restricted it is not possible to overheat the amplifier and the amplifier maintains its full power output without any change in its performance parameters.

Should any conditions of use prevent the disposal of heat, the amplifier is protected against overheating. A voltage sensitive resistor (Moxie) is thermally connected at the junction of the output stage heat sinks, and when the temperature exceeds 90 °C the voltage foldback mechanism of the power supply is operated.

Fig. 2
POWER AMPLIFIER,
SIMPLIFIED CIRCUIT DIAGRAM.



5. ENGINEERING DESIGN AND CONSTRUCTION

The chassis of the amplifiers is of all aluminium construction. The ZD100 and ZD200 amplifiers are identical in mechanical design; the difference being only in the chassis height. The chassis is of simple box construction comprising four sides and a baseplate. The rear and sides are constructed from finned extrusions which form the heat sinks for the power output and power supply voltage regulating transistors. The chassis is completed by the front facia extrusion with trim panel. Screens are fitted to the power output heatsinks to provide convection cooling and keep heat out of the amplifier compartment, which is also convection cooled by slots in the base and cover. The cover is located in the front by a channel in the extrusion and secured by screws in the rear side panels and baseplate.

The ZD50 is of similar construction to the ZD100/200 except that the side panels are fabricated from aluminium sheet. The power supply regulator and output heat sinks together with the input and output termination panels form the rear panel. The front facia extrusion of the ZD50 and ZD100 are 4¾" high and the ZD200 is 7" high.

The mains power fuse is accessible only by removing the cover. The mains power switch and a pilot lamp is fitted to the front chassis panel.

6. FINISH

The heat sink extrusions are black anodised and machined at the transistor mounting faces. The baseplate and cover are primed with a 'two pack' stoving etch and finished with matt black spotted ORGANOSOL paint. The facia extrusion is natural anodised to which is fitted a matt black anodised trim panel. Printing characters are chemically engraved through the black surface into the base aluminium.

7. QUALITY OF MATERIALS

Design consideration has been given to the quality of materials and component parts used for reliability and safety. The mains power components have been approved by world standards authorities and are fitted in such a way as to meet the safety requirements of these authorities for complete equipments.

Where country-to-country standards are at variance, the equipment is manufactured to meet the requirements of the end use country. For example, mains power cables for North America and Europe are different and the appropriate cable is fitted at the factory.

7.1 Mains Power Transformer

The mains transformer is of a generous size and is designed for tropical working. Winding wire is vinyl-acetal covered. The wound coil is impregnated with a thermo-bond varnish and cured by baking at 120 °C for approximately ten hours. A safety copper screen is fitted between primary and secondary windings. High grade paper is used between winding layers and polyester film between windings. The complete transformer, after assembly of the laminations and securing frames, is finished with a tropical varnish making it virtually failure proof and capable of withstanding considerable overloads for long periods.

7.2 Circuit boards

The circuit boards are manufactured from first grade glass epoxy material $\frac{1}{16}$" thick. Circuit component references are screen printed on the board face enabling immediate identification of components with the circuit and parts list. Connections to other parts of the amplifier from circuit boards are made by wires with individual clip on 'AMP' type solderless connectors. Wires are colour coded to simplify reconnection. The colour of the connecting lead is printed adjacent to the connection on the circuit board. Circuit boards are flow soldered using an active flux and completed by an extensive cleaning process. The possibility of dry or imperfect soldered joints is remote.

8. RELIABILTY

Every effort has been made to make the amplifiers as reliable as possible by quality control and testing at all stages of manufacture. All components are conservatively rated and capable of continuous use in tropical climates, providing adequate ventilation is arranged.

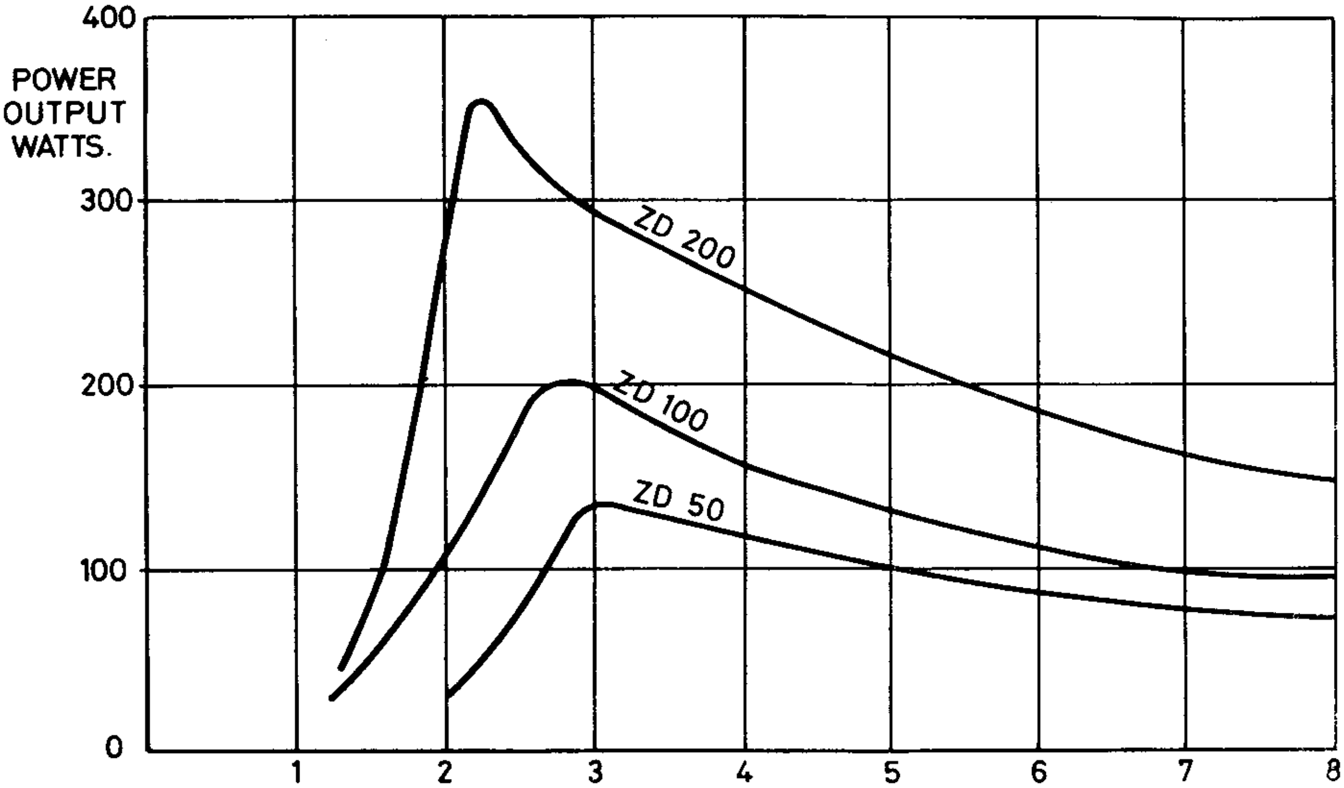
Complete performance tests are also carried out before and after a 24-hour soak testing period.

The engineering construction is such that should maintenance be required any component is accessible within a few minutes.

9. MAINTENANCE

As a back-up to the considerable effort in design and manufacture for reliability, the engineering construction has been arranged for easy fault finding and speedy replacement of a component part or module. A Technical Instruction leaflet B/C30 is supplied with each equipment covering installation and maintenance.

Fig. 4 Power output v. load resistance characteristics



SPECIFICATION CHARACTERISTICS

Power output per channel into resistive load (watts true r.m.s. both channels driven)

	ZD50	ZD100	ZD200
8 ohms load	70	90	150
4 ohms load	110	150	250
Max. power (V-I limited)	130	200	350
	(3 ohms)	(2.8 ohms)	(2.2 ohms)

Suitable output load. Resistive or reactive transducers of phase characteristics normally encountered in practice. Specifically a loudspeaker or combination of loudspeakers, of rated nominal impedance not less than 4 ohms total.

Reactive power capability

	ZD50	ZD100	ZD200
8 ohms nominal impedance loudspeaker	Very good	Excellent	Excellent
4 ohms nominal impedance loudspeaker	Good	Very good	Excellent

Frequency response (Determined by low and high frequency intermodulation input filter):
Low: —3 dB @ 8 Hz Maximally flat 12 dB/Oct rolloff.
High: —3 dB @ 50 kHz 6 dB/Oct rolloff.

Input sensitivity: 1V for rated output.

Input Impedance: 47 k ohms.

Hum and noise (below rated power output):
IEC/DIN 'A' weighted 115 dB
DIN 'AUDIO BAND' 110 dB

Distortion at rated power output:
Total harmonic: **1 kHz** 8 ohms and 4 ohms less than 0.004%
typically 0.0015%
10 kHz 8 ohms less than 0.004%
4 ohms less than 0.008%
Intermodulation: less than 0.01% (SMPTE Method)
Transient intermodulation: non-existent (t.i.m.)

Equipment protection:
Output: V-I limiting
Power supply: Overload foldback characteristic
Loudspeaker: D.C. offset electronic trip
Thermal: Temperature sensing device (Moxie) operating power supply foldback
Mains: Anti-surge fuse

Size (overall):

ZD50	ZD100	ZD200
44×13×30 cm	44×13×36 cm	44×19×36 cm

Weight:

ZD50	ZD100	ZD200
11 kg (24 lb.)	13 kg (28 lb.)	16 kg (35 lb.)

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RADFORD

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TECHNICAL INSTRUCTIONS

INSTALLATION AND ADVANCED MAINTENANCE FOR

POWER AMPLIFIERS ZD50 ZD100

1. INTRODUCTION

This manual is concerned with the installation and maintenance of amplifiers ZD50 and ZD100. Its purpose is to enable the owner to obtain maximum performance from the amplifier by correct installation and maintenace. The inclusion of technical information is for dealer use only. The information contained herein is sufficient for a qualified audio electronics technician anywhere to ensure that the amplifier meets the original specification characteristics. It is in the owners interest to retain the manual in a safe place. Should an occasion arise for service checking, the manual should be delivered with the equipment to the dealer.

Amplifiers ZD50 and ZD100 are basically the same and derive from the same circuit principle. They are different in respect of power output, construction and size. The techniques of performance testing and maintenance are common to both amplifiers. Significant information concerning the design of the amplifiers is outlined in the sales leaflet A30 which should be understood before attempting to carry out tests and maintenance.

2. MAINS INPUT SELECTION

The amplifiers are designed to operate from A.C. Mains of 100V – 120V and 200V – 240V, 40 – 60Hz. To change the voltage setting remove the cover and adjust the connections on the transformer tags as indicated in Fig. 12 and Table 1. **DISCONNECT THE SUPPLY BEFORE ANY ADJUSTMENT IS MADE** by removing the cable plug from the supply socket.

3. VENTILATION

It is essential that adequate ventilation is provided, particularly if the amplifier is used for heavy duty continuous service such as in discotheques. If amplifiers are fitted in enclosures, a free air passage should be arranged to ensure convection. Rubber feet are fitted to the chassis base to permit air access through the chassis.

4. MAGNETIC RADIATION

Although the amplifier is fitted with a mains transformer which has low magnetic radiation, it is advisable to take advantage of its extremely high signal-to-noise ratio by locating it as far as possible from magnetic pick-ups, tape heads or other input transducers.

5. TERMINATIONS

5.1 Input: Standard Models

The standard model has unbalanced 47k ohm inputs terminated by phono sockets. Signal connections should be made with single screened cables terminated by standard phono plugs. In order to maintain the extremely low hum performance it is important to keep the area enclosed between a stereo pair of leads to a minimum.

5.2 Input: Professional Models

The professional version of the amplifier includes balanced input transformers and preset level controls. The input terminations are Canon XLR-3 sockets at the rear of the amplifier. Preset input level controls are mounted behind the front extrusion and are accessible by removing the cover plate.

5.3 Output

The output of amplifier channels is connected to press-type terminals.

6. LOUDSPEAKER IMPEDANCE MATCHING

6.1 ZD50 Amplifier

The ZD50 amplifier is intended for use with loudspeakers of a nominal impedance of 8 ohms. The amplifier will deliver a maximum power output of 130 watts into a resistance load of 3 ohms and may therefore be used with loudspeakers of nominal impedance 4 ohms providing that the impedance does not fall much below the nominal value over the frequency band and that the phase angle is less than 30° above 100Hz. Should the impedance/phase angle of the loudspeaker cause an excessive load at some frequencies the voltage/current protection circuit will operate to restrict the power to within safe dissipation limits of the output transistors. In such circumstances it may be found that a higher *effective* sound pressure level (without audible distortion) is obtained from a nominal 8 ohm loudspeaker.

6.2 ZD100 Amplifier

Two transistors are used in parallel in the ZD100 and the amplifier has double the reactive current capability of the ZD50 amplifier. It is intended for use with loudspeaker loads of nominal impedance of 8 ohms or 4 ohms. Basically, the same considerations in respect of the use of 4 ohm loudspeakers apply to the ZD100 as to the ZD50, but in practice other considerations will apply. Due to the considerable power output of the ZD100 (200 watts per channel into 3 ohms) any known commercially available 4 ohm loudspeaker will be destroyed if driven to the point where distortion is audible for more than a short period.

Experience with the ZD100 installed in discotheques shows that with a load on each channel of two loudspeakers of 8 ohms each in parallel, the mid-range drive units (operating range 500 Hz – 5kHz) are destroyed after a few months operation, despite the use of aluminium former voice coils.

These considerations do not apply in the home where the power output is used only to provide undistorted transients as the voice coils cannot become overheated.

7. MAINTENACE

7.1 ZD50 Amplifier

The general assembly layout of the amplifier is shown in Fig. 1. The component parts of the amplifier are readily accessible after removal of the aluminium cover, secured by six retaining screws, four in the chassis baseplate and two in the rear chassis panels. To obtain access to the components associated with the amplifier output stages, the loudspeaker protection circuit, and the power supply regulator output sections, the whole rear heatsink assembly may be removed by taking out the four 4BA screws through the rear chassis panels. Disconnect the 'Amp' connectors from circuit board M3388 to free the wiring. The amplifier circuit boards M3380B and M3382 are removed by two screws in the chassis baseplate, and disconnection of the 'Amp' type connectors. All interconnections are numbered and colour coded to ensure correct lead re-connection after board replacement.

7.2 ZD100 Amplifier

The general assembly layout of the amplifier is shown in Fig. 2. The rear heat sink assembly which includes the output amplifier modules M3381 may be removed by taking out four 2BA screws (two on each side) from the rear side extrusions. These screws locate into hank bushes in the heat sink assembly. Disconnect the wiring by removing terminal tags from module M3381 and unsoldering the MOXIE resistor.

The power transistors in the power supply regulator fitted to the front side extrusions are accessible after the removal of circuit board modules M3383A and M3383B.

8. TEST EQUIPMENT

8.1 Essential Equipment

The minimum amount of test equipment required to service the ZD50 and ZD100 amplifier is:

Accurate multimeter (e.g. Model 8 Avo meter or similar) with 20,000 ohms/volt sensitivity or greater.
Audio oscillator.
Audio millivoltmeter.
Oscilloscope.
Two 150 watt 4 ohm non-inductive wirewound resistors. (Two in parallel for 2 ohms).

8.2 Equipment required for Performance Testing

Radford Series 3 Low Distortion Oscillator
Radford Series 3 Distortion Measuring Set.
Radford Audio Noisemeter ANM1 or ANM2.
Dual Beam Oscilloscope
Sensitive Digital Multimeter
Transistor Tester.

9. TEST PROCEDURE

Should an amplifier fail in operation basic information can be obtained by checking the static and dynamic voltages at suitable positions in the circuit. Correct voltages are shown for these points on the circuit diagrams and any differences should be investigated. Once the amplifier appears to be working correctly the test procedure outlined in Table 1 should be followed where possible.

10. PERFORMANCE MEASUREMENT

Conventional measuring equipment is incapable of measuring the very low total harmonic distortion and noise levels of the ZD50 and ZD100 amplifiers. RADFORD instruments as detailed above are therefore desirable for ultimate performance analysis.

Great care is necessary when assembling and interconnecting measuring equipment for testing an amplifier. It is essential that no earth loops are formed by cable screens in the measuring set-up. It is also important that distortion and noise measuring equipment is connected directly across output terminals of the channel being measured such that the 'earth' is derived from the respective channel's earthy terminal.

TABLE 1
MAINS VOLTAGE INPUT ADJUSTMENT ZD50 AND ZD100

Mains Voltage	Input Tags	Links
100	A, B	A–D B–E
120	A, C	A–D C–F
200	A, E	B–D
220	A, E	C–D
240	A, F	C–D

12. MODIFICATIONS

The following technical modifications have been introduced since production began. These concern factory production only, and no action is necessary in respect of existing unmodified amplifiers.

12.1 Modifications to M3380A and B

Boards designated M3380A/1 and M3380B/1 incorporate a modification to the output stage V-1 protection circuit in order to increase the output voltage available into low impedance reactive loads. The modification and changes to resistor values are as follows:

R56 and R57 are added and appear between the base and emitter of TS10 and TS11 respectively. They are 200R ⅛W 5% carbon film types.
R25 and R28-110R (was 100R)
R31–3k3 (was 3k9)

12.2 Modification to M3384

Boards designated M3384/1 incorporate a modification in order that the 'Moxie' resistor triggers the thyristor directly, instead of operating the foldback protection in the regulator control board M3382. This eliminates the possibility of overheating causing severe distortion as the output current capability of the power supply is reduced. The modification is as follows:

D36 (a 33 volt ½ watt zener diode) is added, the cathode connected to earth, the anode to one side of the moxie resistor. The moxie is connected between D36 anode and the thyristor gate via two 'Amp' connectors.

13. MODULE REPAIR OR REPLACEMENT

Complete information on p.c.b. modules is given in this manual to enable the technician to replace an individual faulty component. Should difficulty arise however, replacement modules are available from Radford Audio or its agent in the country of the owner if the equipment was purchased in that country.

FIG. 1 GENERAL ASSEMBLY LAYOUT. ZD50

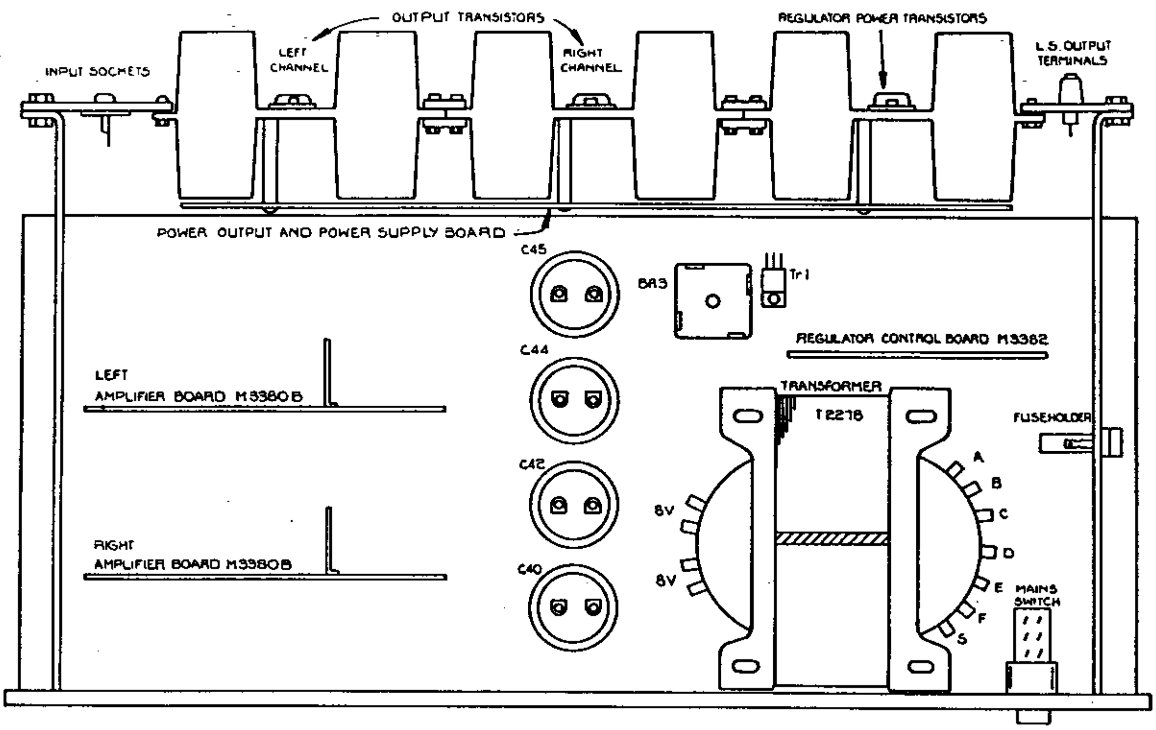


FIG. 2 GENERAL ASSEMBLY LAYOUT. ZD100

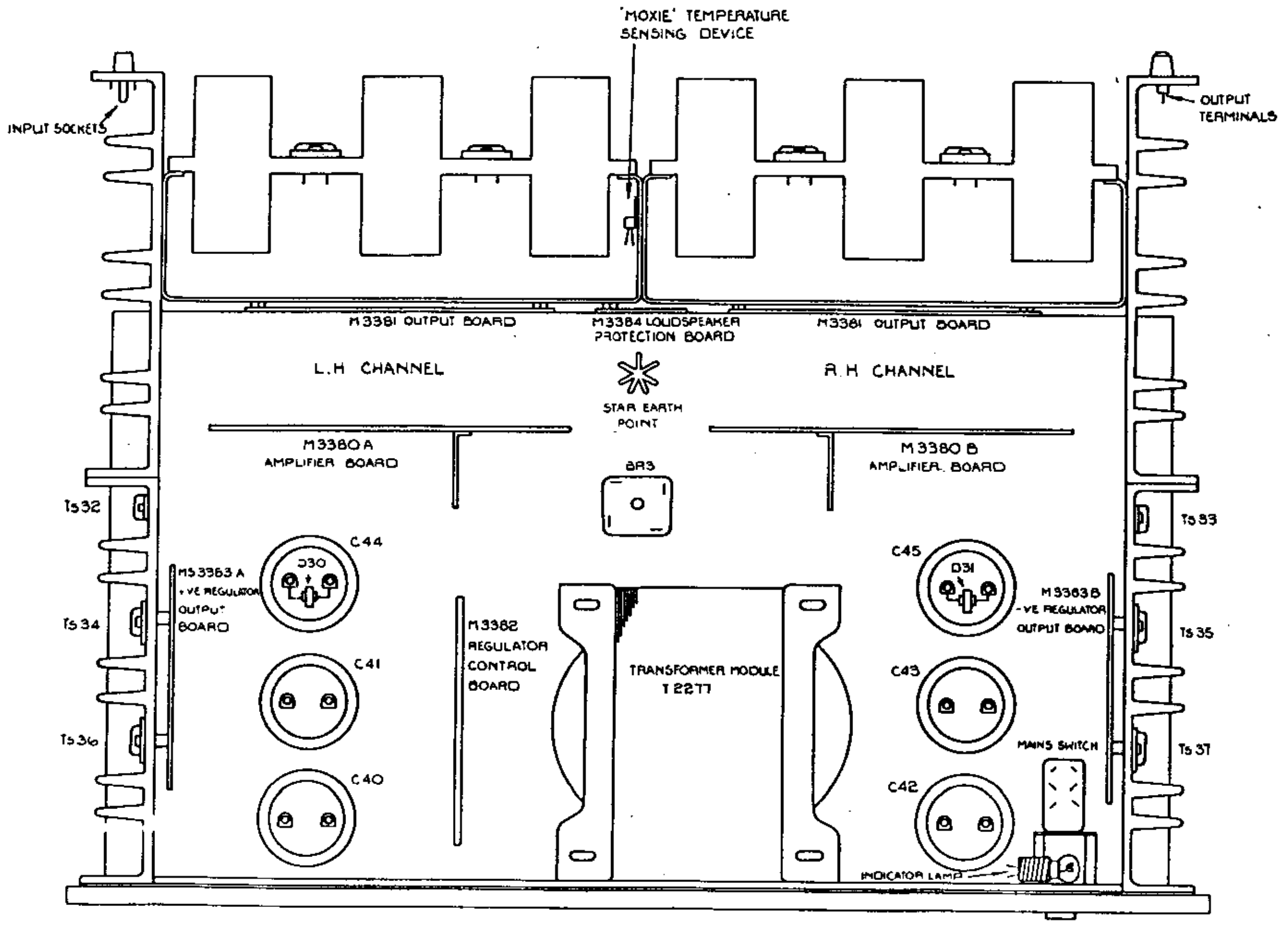


FIG. 3 AMPLIFIER MODULE M3380A. ZD100 ONLY

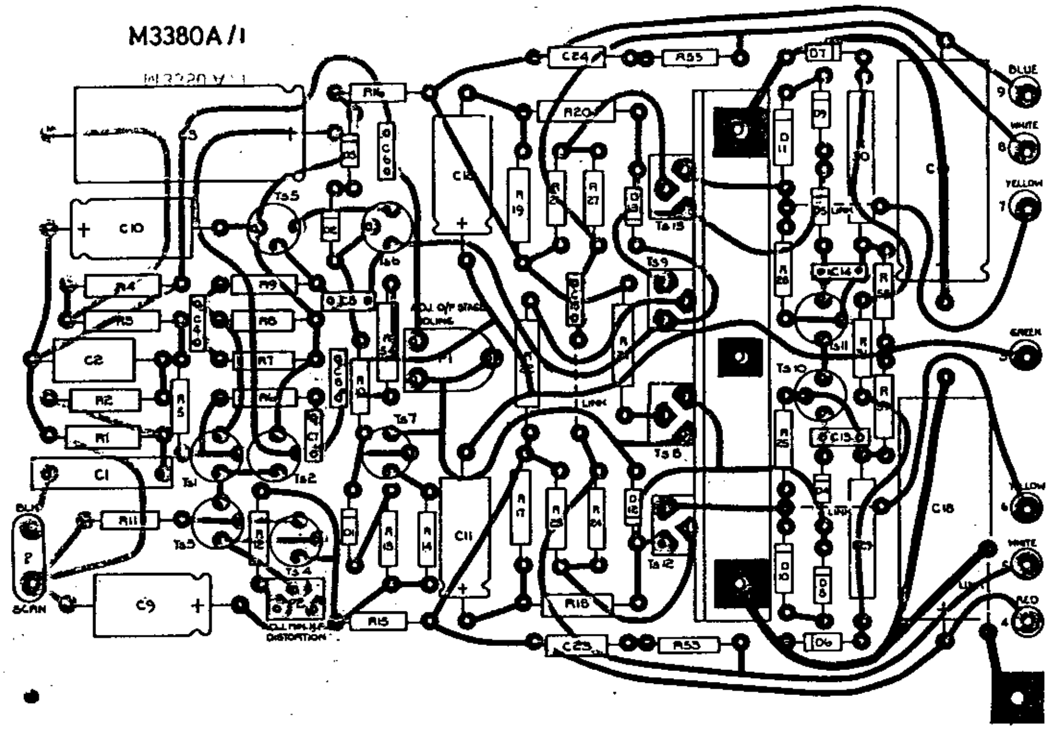


FIG. 4 AMPLIFIER MODULE M3380B. ZD50 AND ZD100

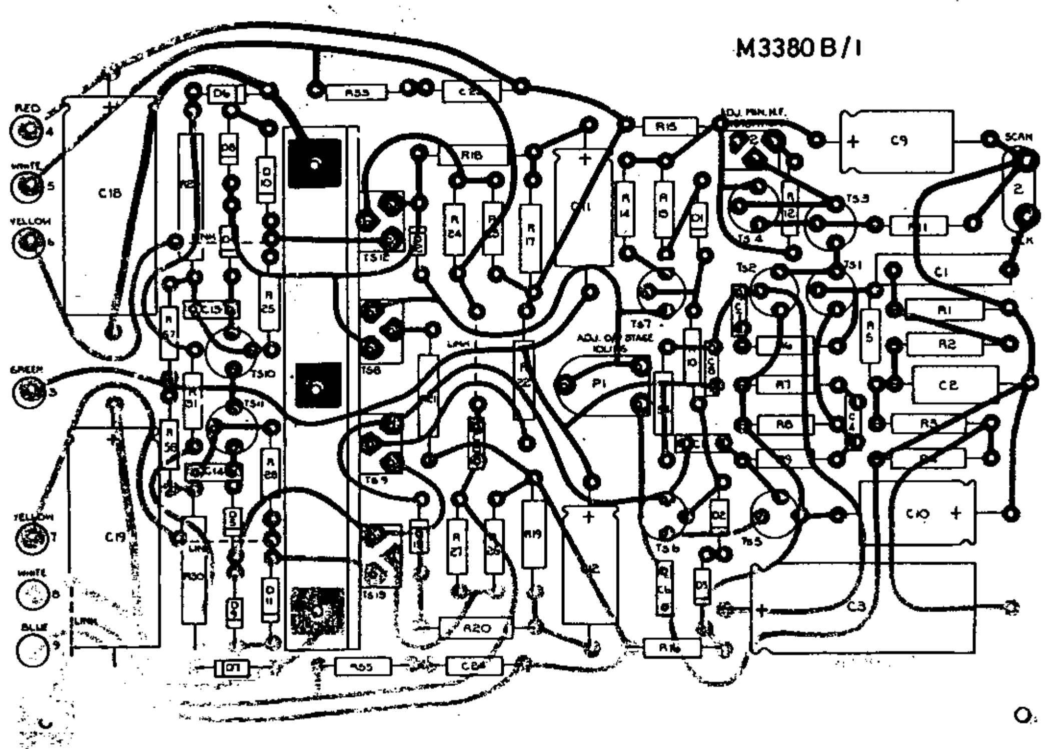


FIG. 5 AMPLIFIER MODULE M3380A & B CIRCUIT DIAGRAM

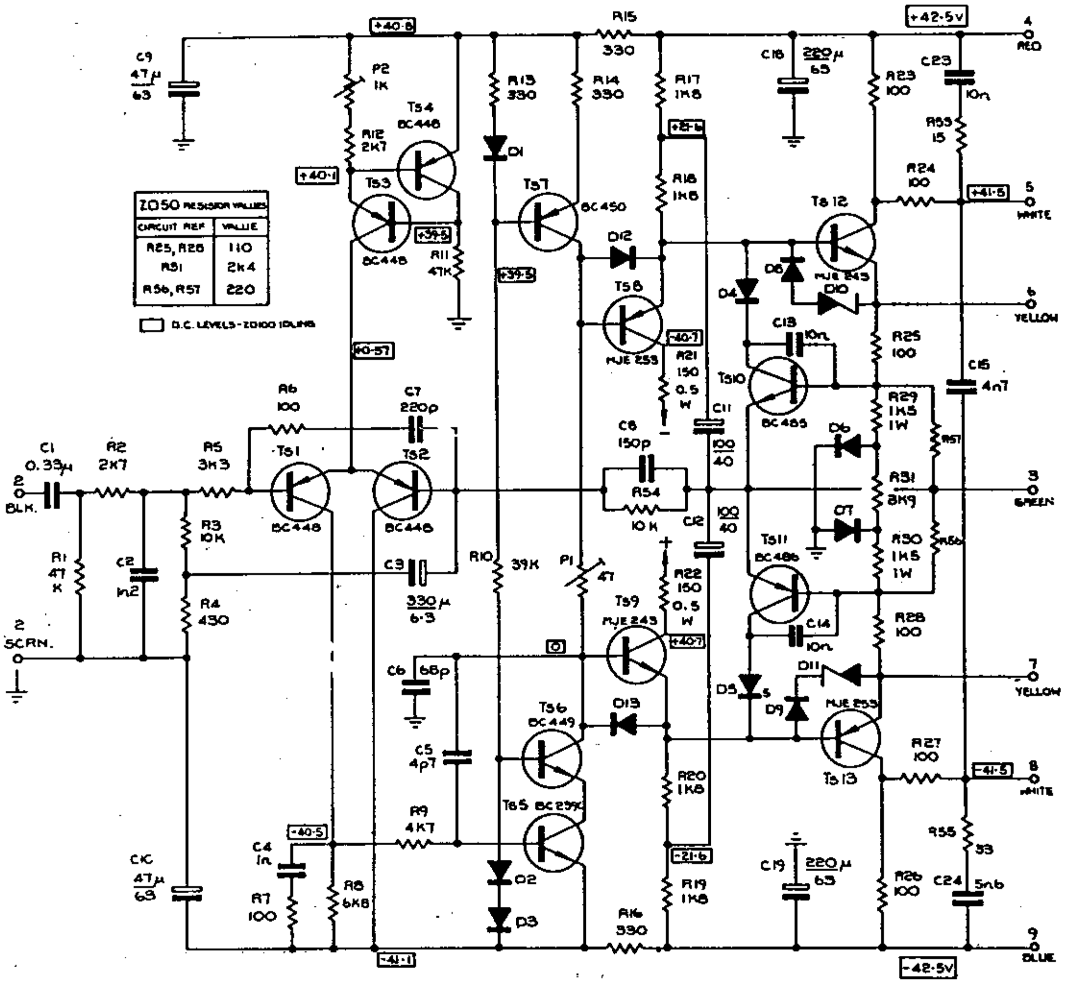


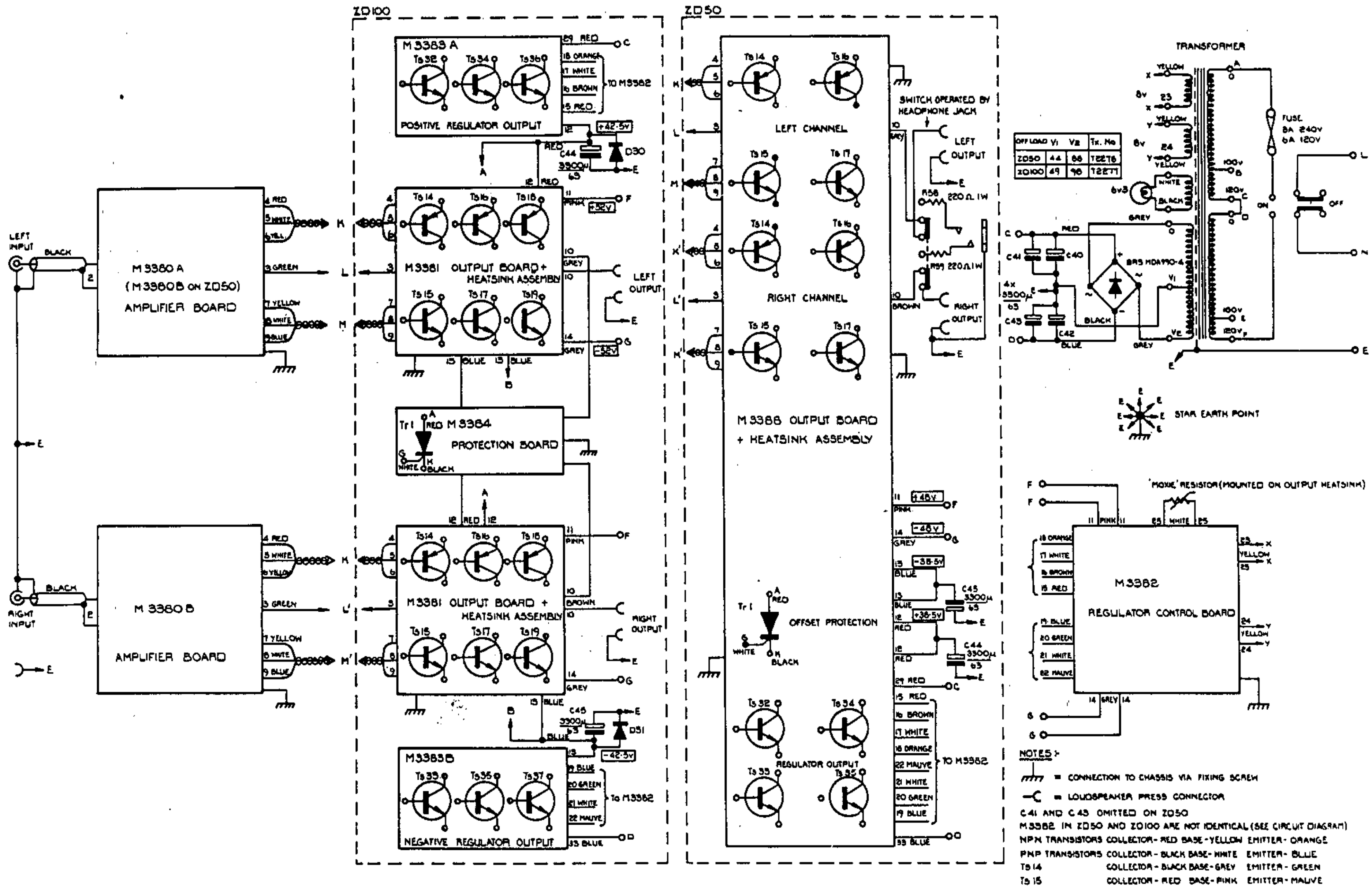
FIG. 6 AMPLIFIER MODULE M3380A & B PARTS LIST

R1	MO	0.5W	47k	2%
R2	MO	0.5W	2k7	2%
R3	MO	0.5W	10k	2%
R4	MO	0.5W	430R	2%
R5	CF	0.25W	3k3	5%
R6	CF	0.25W	100R	5%
R7	CF	0.25W	100R	5%
R8	MO	0.5W	6k8	2%
R9	CF	0.25W	4k7	5%
R10	CF	0.25W	39k	5%
R11	CF	0.25W	47k	5%
R12	CF	0.25W	2k7	5%
R13	CF	0.25W	330R	5%
R14	CF	0.25W	330R	5%
R15	CF	0.25W	330R	5%
R16	CF	0.25W	330R	5%
R17	CF	0.5W	1k8	5%
R18	CF	0.5W	1k8	5%
R19	CF	0.5W	1k8	5%
R20	CF	0.5W	1k8	5%
R21	CF	0.5W	150R	5%
R22	CF	0.5W	150R	5%
R23	CF	0.25W	100R	5%
R24	CF	0.25W	100R	5%
R25	CF	0.25W	SEE TEXT 12.1.1	
R26	CF	0.25W	100R	5%
R27	CF	0.25W	100R	5%
R28	CF	0.25W	SEE TEXT 12.1.1	
R29	CF	1W	1k5	5%
R30	CF	1W	1k5	5%
R31	CF	0.25W	SEE TEXT 12.1.1	

R53	CF	0.25W	15R	5%
R54	MO	0.5W	10k	2%
R55	CF	0.25W	33R	5%
R56	CF	0.25W	SEE TEXT 12.1.1	
R57	CF	0.25W	SEE TEXT 12.1.1	
P1	HORIZONTAL SKELETON PRESET		47R	
P2	VERTICAL SKELETON PRESET		1k	
C1	PR	0.33µF	100V	
C2	PR	1200pF	100V	
C3	E	330µF	6.3V	
C4	CR	1000pF	63V	
C5	CR	4.7pF	400V	
C6	CR	68pF	63V	
C7	CR	220pF	63V	
C8	CR	150pF	63V	
C9	E	47µF	63V	
C10	E	47µF	63V	
C11	E	100µF	40V	
C12	E	100µF	40V	
C13	PR	0.01µF	100V	
C14	PR	0.01µF	100V	
C15	PR	4700pF	100V	
C16	NOT USED			
C17	NOT USED			
C18	E	220µF	63V	
C19	E	220µF	63V	
C23	PR	0.01µF	100V	
C24	PR	4700pF	100V	

TS1	BC448
TS2	BC448
TS3	BC448
TS4	BC448
TS5	BC239C
TS6	BC449
TS7	BC450
TS8	MJE253
TS9	MJE243
TS10	BC485
TS11	BC486
TS12	MJE243
TS13	MJE253
D1	BAX16
D2	BAX16
D3	BAX16
D4	BAX16
D5	BAX16
D6	BAX16
D7	BAX16
D8	BAX12
D9	BAX12
D10	1N4732A
D11	1N4732A
D12	BAX16
D13	BAX16

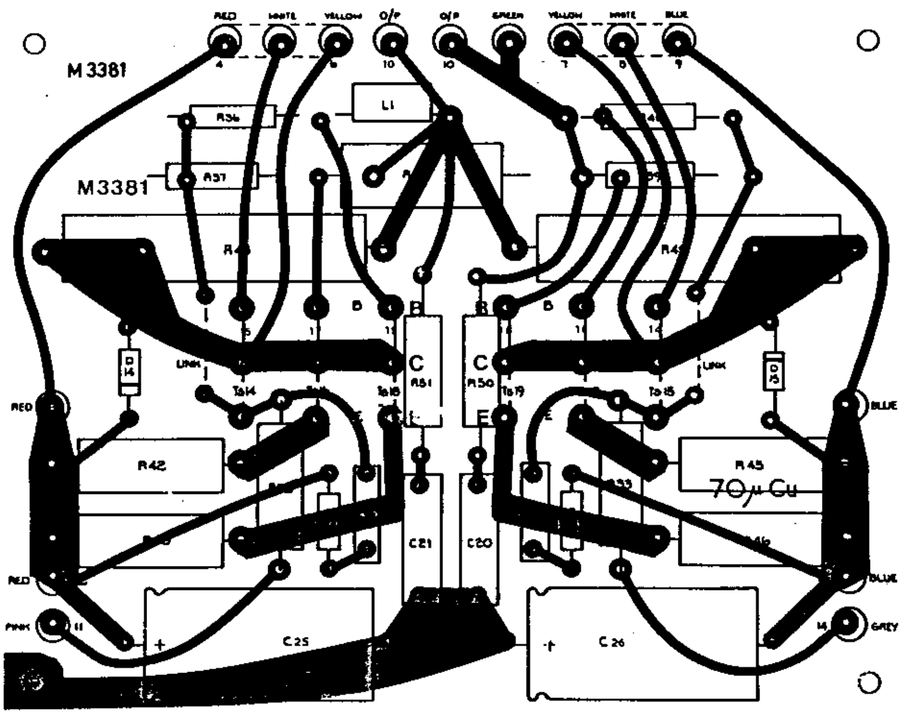
NOTE: Transistor pairs TS8 and TS13, and TS9 and TS12, must be selected for equal V_{BE} drop to within 2mV, at I_{EBS}=10mA.

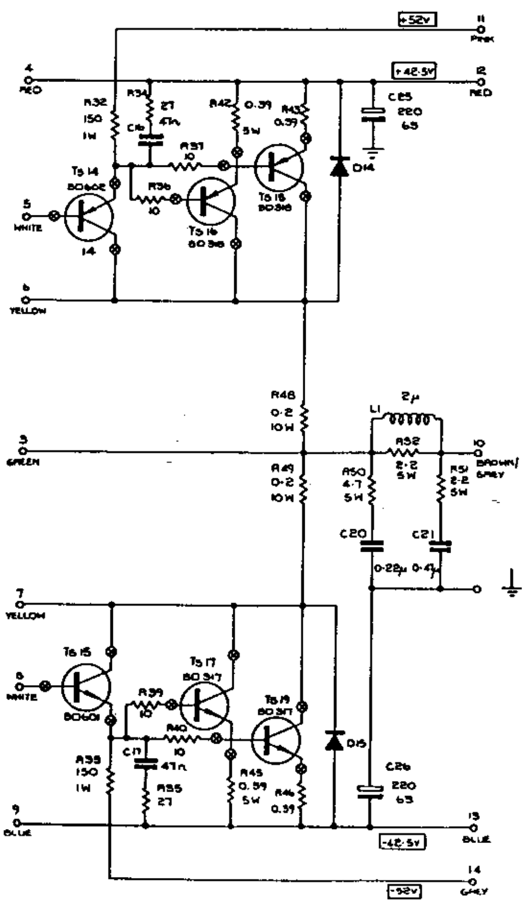


OFF LOAD	V1	V2	Tx. No
ZD50	44	88	T2276
ZD100	49	98	T2277

FIG. 7 . SCHEMATIC DIAGRAM. ZD50 AND ZD100

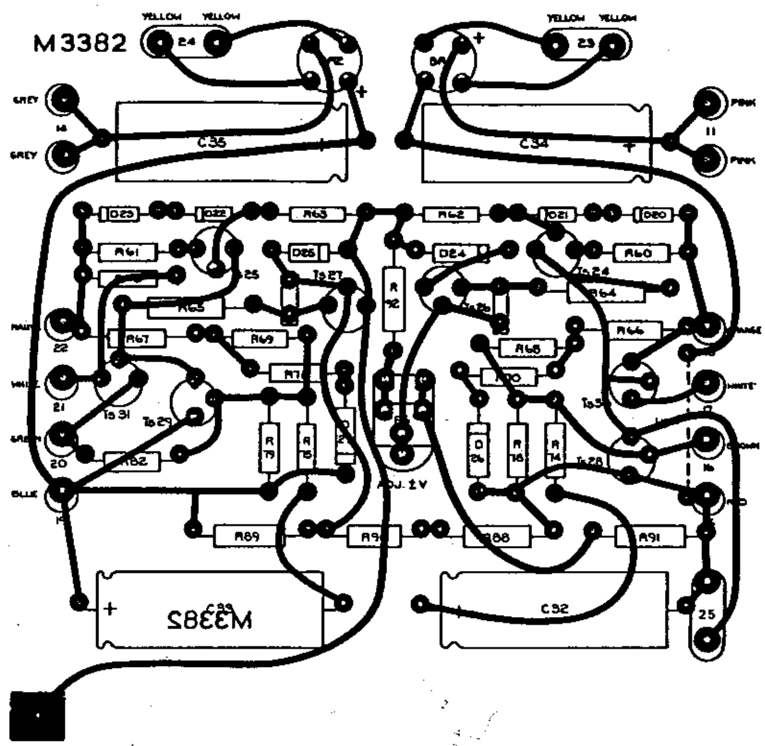
FIG. 8 OUTPUT STAGE MODULE M3381. ZD100 ONLY

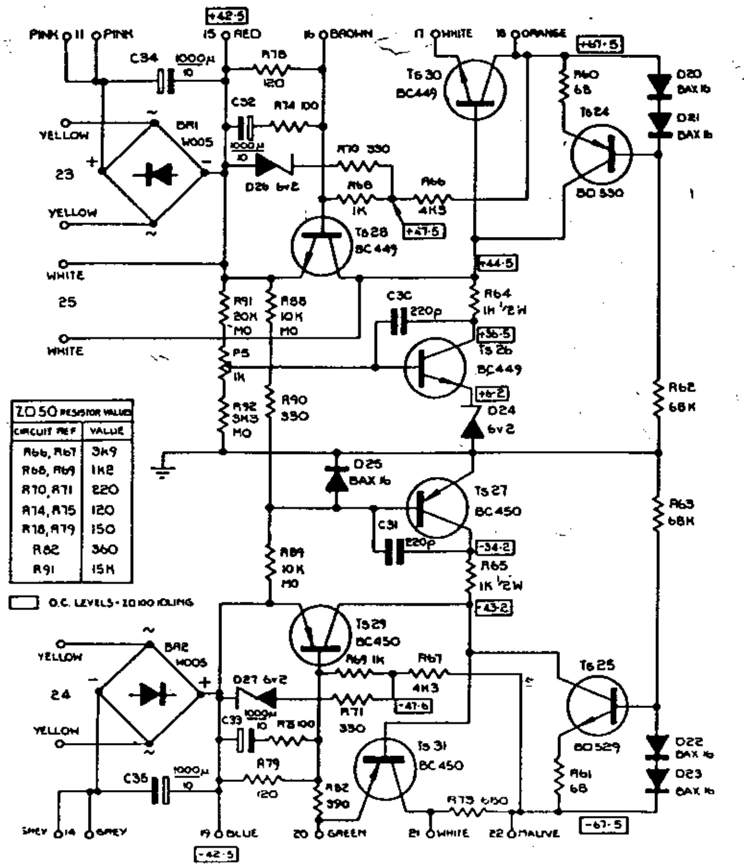




R32	CF	1W	150R	5%
R33	CF	1W	150R	5%
R34	CF	0.25W	27R	5%
R35	CF	0.25W	27R	5%
R36	CF	0.5W	10R	5%
R37	CF	0.5W	10R	5%
R38	NOT USED			
R39	CF	0.5W	10R	5%
R40	CF	0.5W	10R	5%
R41	NOT USED			
R42	WW	5W	0.39R	5%
R43	WW	5W	0.39R	5%
R44	NOT USED			
R45	WW	5W	0.39R	5%
R46	WW	5W	0.39R	5%
R47	NOT USED			
R48	WWS	10W	0.2R	2%
R49	WWS	10W	0.2R	2%
R50	WW	5W	4R7	5%
R51	WW	5W	2R4	5%
R52	WW	5W	2R2	5%
C16	PR	0.047μF	100V	
C17	PR	0.047μF	100V	
C20	PR	0.22μF	100V	
C21	PR	0.47μF	100V	
C25	E	220μF	63V	
C26	E	220μF	63V	
L1	INDUCTOR 1-2μH			
D14	MR812			
D15	MR812			

FIG. 9 POWER SUPPLY MODULE M3382. ZD50 AND ZD100



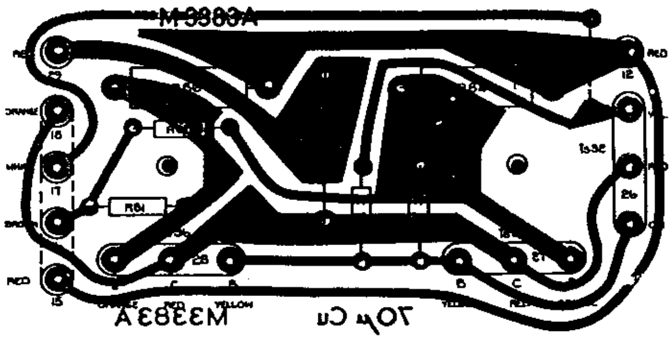


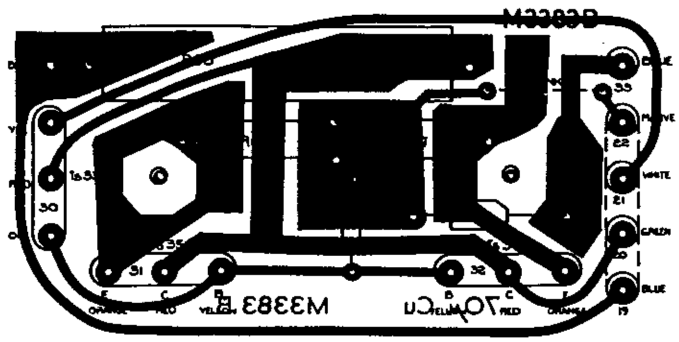
ZD50 RESISTOR VALUES	
CIRCUIT REF	VALUE
R66, R67	3K9
R68, R69	1K2
R70, R71	220
R74, R75	120
R78, R79	150
R82	360
R91	15K

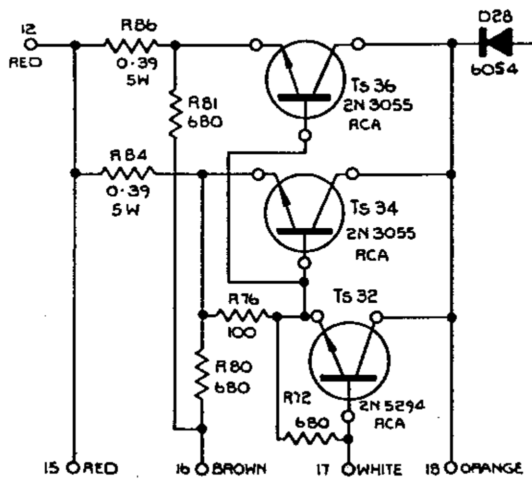
R60	CF	0.25W	68R	5%
R61	CF	0.25W	68R	5%
R62	CF	0.25W	68k	5%
R63	CF	0.25W	68k	5%
R64	CF	0.5W	1k	5%
R65	CF	0.5W	1k	5%
R66	MO	0.5W	See circuit diagram	
R67	MO	0.5W	See circuit diagram	
R68	CF	0.25W	See circuit diagram	
R69	CF	0.25W	See circuit diagram	
R70	CF	0.25W	See circuit diagram	
R71	CF	0.25W	See circuit diagram	
R73	CF	0.25W	680R	5%
R74	CF	0.25W	See circuit diagram	
R75	CF	0.25W	See circuit diagram	
R78	CF	0.25W	See circuit diagram	
R79	CF	0.25W	See circuit diagram	
R82	CF	0.25W	390R	5%
R88	MO	0.5W	10k	2%
R89	MO	0.5W	10k	2%
R90	CF	0.25W	330R	5%
R91	MO	0.5W	20k	2%
R92	MO	0.5W	3k3	2%
P5	VERTICAL SKELETON PRESET			1k
C30	CR	220pF	63V	5%
C31	CR	220pF	63V	5%
C32	E	1000µF	10V	
C33	E	1000µF	10V	
C34	E	1000µF	10V	
C35	E	1000µF	10V	

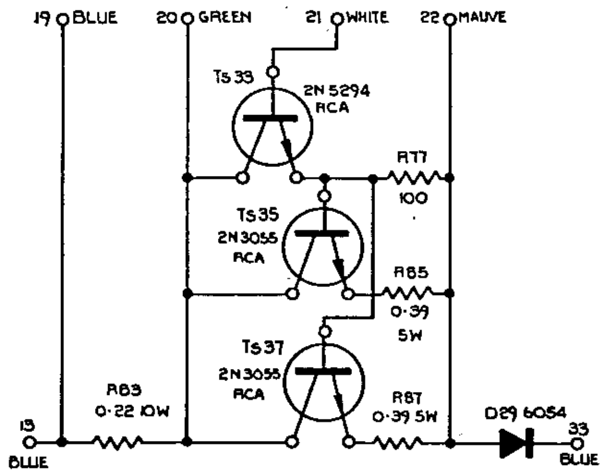
		D20	BAX16
TS24	BD530	D21	BAX16
TS25	BD529	D22	BAX16
TS26	BC449	D23	BAX16
TS27	BC450	D24	BZY88 C6V3
TS28	BC449	D25	BAX16
TS29	BC450	D26	BXY88 C6V3
TS30	BC449	D27	BZY88 C6V3
TS31	BC450	BR1	WO6
		BR2	WO6

FIG. 10 POWER SUPPLY REGULATOR MODULES M3383A & B. ZD100 ONLY





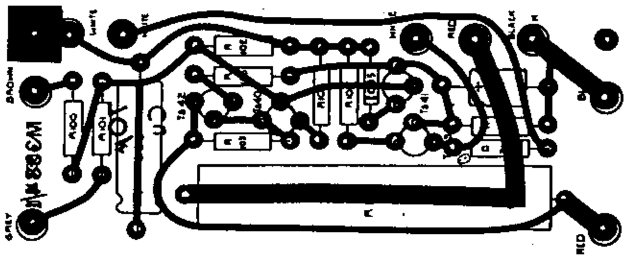


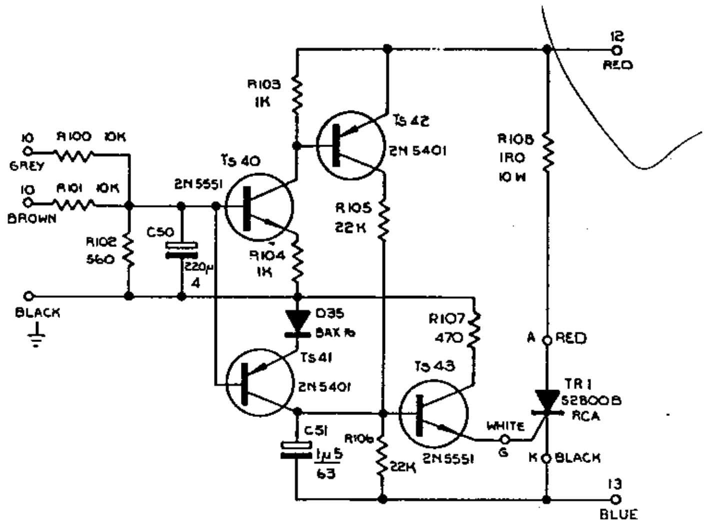


R72	CF	0.25W	680R	5%
R76	CF	0.25W	100R	5%
R80	CF	0.25W	680R	5%
R81	CF	0.25W	680R	5%
R84	WW	5W	0.39R	5%
R86	WW	5W	0.39R	5%
D28	60S4 or MR752			

R77	CF	0.25W	100R	5%
R83	WW	10W	0.22R	5%
R85	WW	5W	0.39R	5%
R87	WW	5W	0.39R	5%
D29	60S4 or MR752			

FIG. 11 D.C. OFFSET PROTECTION MODULE M3384. ZD100 ONLY





R100	CF	0.25W	10k	5%
R101	CF	0.25W	10k	5%
R102	CF	0.25W	560R	5%
R103	CF	0.25W	1k	5%
R104	CF	0.25W	1k	5%
R105	CF	0.25W	22k	5%
R106	CF	0.25W	22k	5%
R107	CF	0.25W	470R	5%
R108	WW	10W	1R0	10%
C50	E	220μF	4V	
C51	E	1.5μF	63V	
TS40	2N5551			
TS41	2N5401			
TS42	2N5401			
TS43	2N5551			
D35	BAX16			
D36	BZY88 C33			

FIG. 12 MAINS POWER TRANSFORMER CONNECTIONS. ZD50 AND ZD100

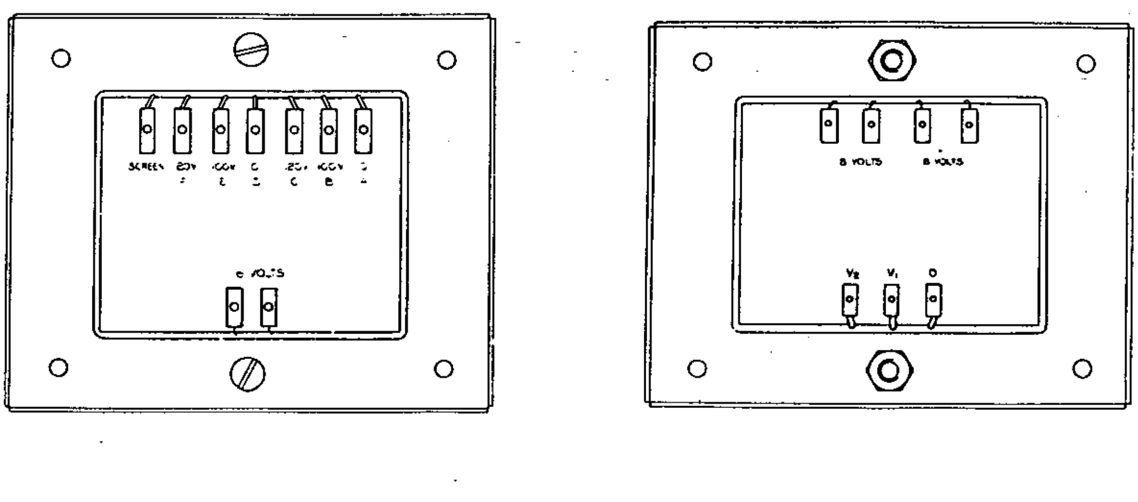
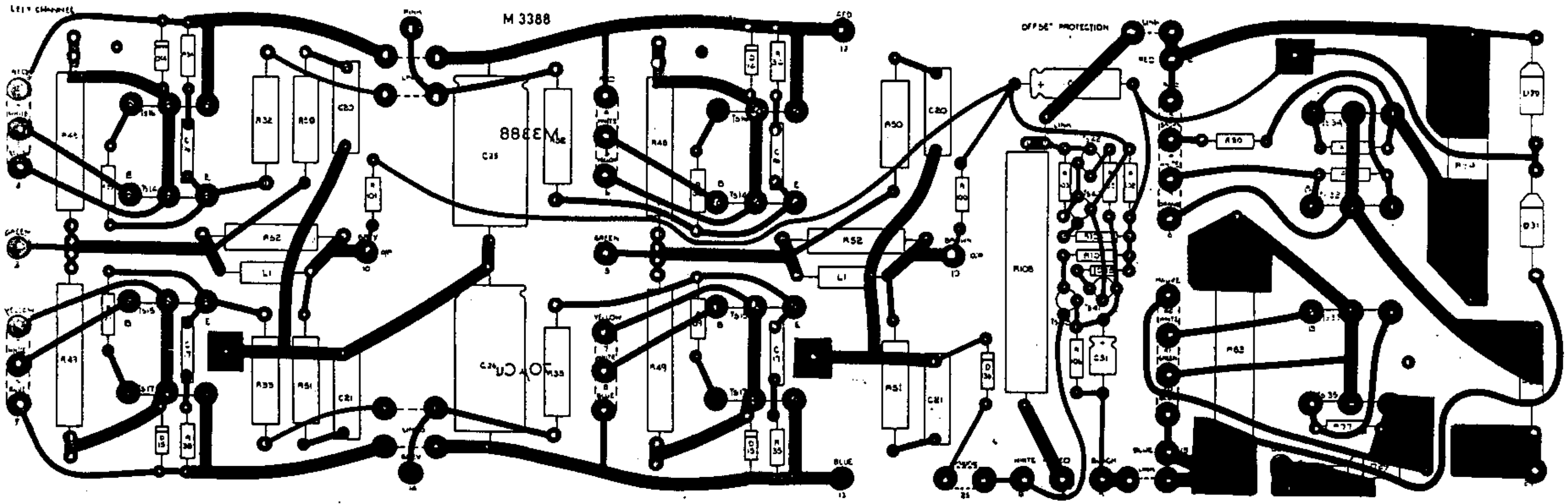
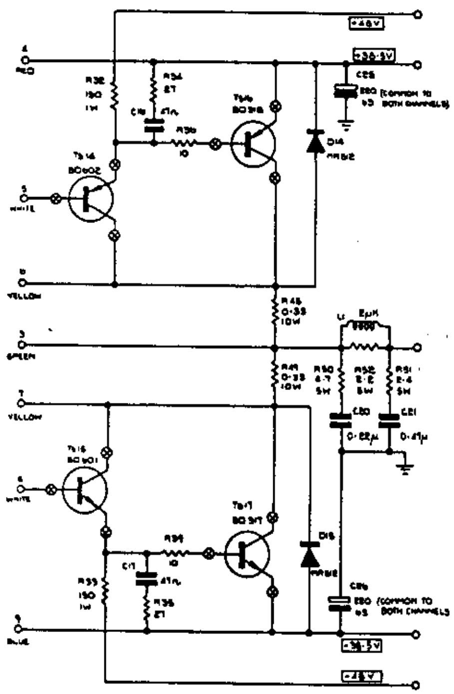


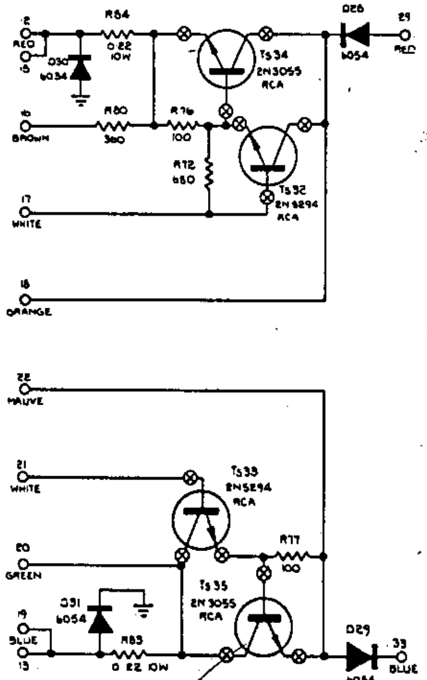
FIG. 13 OUTPUT STAGE, POWER SUPPLY REGULATOR AND D.C. OFFSET PROTECTION MODULE M3388. ZD50 ONLY



NOTES: 1. Above board actual size 314 x 95mm reduced to 248 x 75mm in this diagram.
2. D.C. offset protection circuitry is as Fig. 11.



OUTPUT STAGE (ONE CHANNEL ONLY)



POWER SUPPLY REGULATOR

R32	CF	1W	150R	5%
R33	CF	1W	150R	5%
R34	CF	0.25W	27R	5%
R35	CF	0.25W	27R	5%
R36	CF	0.5W	10R	5%
R39	CF	0.5W	10R	5%
R48	WWS	10W	0.33R	2%
R49	WWS	10W	0.33R	2%
R50	WW	5W	4R7	5%
R51	WW	5W	2R4	5%
R52	WW	5W	2R2	5%
R72	CF	0.25W	680R	5%
R76	CF	0.25W	100R	5%
R77	CF	0.25W	100R	5%
R80	CF	0.25W	360R	5%
R83	WW	10W	0.22R	5%
R84	WW	10W	0.22R	5%
R100	CF	0.25W	10k	5%
R101	CF	0.25W	10k	5%
R102	CF	0.25W	560R	5%
R103	CF	0.25W	1k	5%
R104	CF	0.25W	1k	5%
R105	CF	0.25W	22k	5%
R106	CF	0.25W	22k	5%
R107	CF	0.25W	470R	5%
R108	WW	10W	1R0	5%

C16	PR	0.047μF	100V
C17	PR	0.047μF	100V
C20	PR	0.22μF	100V
C21	PR	0.47μF	100V
C25	E	220μF	63V
C26	E	220μF	63V
C50	E	220μF	4V
C51	E	1.5μF	63V
L1	INDUCTOR	1·2μH	
TS40	2N5551		
TS41	2N5401		
TS42	2N5401		
TS43	2N5551		
D14	MR812		
D15	MR812		
D28	60S4 or MR752		
D29	60S4 or MR752		
D30	60S4 or MR752		
D31	60S4 or MR752		
D35	BAX16		
D36	BZY88 C33		

TABLE 2 TEST PROCEDURE – ZD100 & ZD50

TEST PROCEDURE – ZD100

It is strongly advised that, following the replacement of semi-conductor devices, the amplifier be restarted using a variable transformer on the mains input. This procedure is included below.

Step	Test	Frequency	Input Level	Adjustment Action or Observation
1.	Restart Procedure (Power supply)			Disconnect power supply connections 12 and 13 from boards M3383 A and B and connections 11 and 14 from M3382. Slowly increase mains input and check for voltage steadily increasing to —42.5 Volts (approx) on tage 13 of M33[illegible]B. Check for ± 52 Volts on tags 11 and 14 of M3382.
2.	Restart Procedure (Amplifier)	1kHz	1 volt rms	Reconnect power supply to amplifier after allowing voltage to fall, starting with connectors 11 and 14 on M3382, followed by those on M3383 A and B. Slowly increase mains voltage and observe symmetrical formation of sine wave of both channel outputs.
3.	Supply Voltage			Adjust P5 on M3382 for not less than 42.5V on either +ve or —ve rail. If imbalance is greater than 1 volt adjust value of R90 on M3382. Increase the value to decrease —ve rail relative to +ve rail and vice versa.
4.	Power output and current limiting	1kHz	1 volt rms	Connect 4 ohm load to both channels. Adjust input level to both channels until clipping begins. Check that output is at least 24.5 volts rms. Apply 2 ohm load to each channel in turn. Check for approximately symmetrical current limiting.
5.	Distortion	1kHz	1 volt rms	Connect 4 ohm load to left channel. Connect DMS across load and check for less than 0.003% distortion. Repeat for right channel.
6.	Distortion	20kHz	0.9 volts rms	With no load connected measure distortion and adjust P2 for minimum on both channel amplifier boards M3380A and B
7.	Distortion	10kHz	0.1 volt rms	Connect 4 ohms to both channels. Adjust P1 on M3380A and B for minimum crossover distortion.
8.	Distortion	10kHz	1 volt rms	Connect 4 ohm load to L.H. channel. Check for less than 0.01% distortion. Power supply wiring dress around boards M3381 may need adjustment. Repeat for RH channel.
9.	Loudspeaker Protection			Connect voltmeter across power supply rails to measure 85 volts approx. Disconnect from the LH channel output the grey load between M3381 and M3384 and touch the tag briefly on the —ve 'power supply rail – observe power supply voltage fold back to less than 2.5 volts. Repeat with brown lead on RH M3381 touching +ve rail after switching set off for 5 seconds to reset.
10.	Over temperature protection			Observe 85 volt supply rail as above. Touch 'moxie' resistor with soldering iron – wait a few seconds for supply to fold back rapidly to less than 2.5 volts.
11.	Noise		Short circuit both inputs	Connect Microvoltmeter to output terminals. Measure in 20Hz – 20kHz bandwidth and adjust green leads – between M3380 and M3381 for minimum hum. Total output should be 70µV (—83dBv) or less.

TEST PROCEDURE ZD50 (Where different from above)

Step	Test	Frequency	Input Level	Adjustment Action or Observation
1.	Restart Procedure (Power supply)			Disconnect power supply connections 12 and 13 to the left of the offset protection circuit on M3388, and connections 11 and 14 from M3382. Slowly increase mains input and check for voltage steadily increasing to —38.5 volts (approx) on tag 13 of M3388. Check for ±48 volts on tags 11 and 14 of M3382.
2.	Restart Procedure (Amplifier)	1kHz	1 volt rms	As ZD100 except read M3388 for M3383A and B
3.	Supply Voltage			As ZD100 except read 38.5V for 42.5V
4.	Power Output and current limiting	1kHz	1 volt rms	As ZD100 except read 21 volts for 24.5 volts
5, 6, 7, 8				As ZD100 noting that ZD50 employs 2 off M3380B and output board is designated M3388.
9.	Loudspeaker protection			Connect voltmeter across power supply rails to measure 77 volts approx. Connect the positive side of C50 (at the top of the offset protection section of M3388) via a 10k ohm resistor to the positive rail and observe the power supply voltage fold back to less than 2.5 volts. Repeat with negative rail after switching set off to reset.
10.	Over temperature protection			As ZD100 except read 77 volts for 85 volts.
11.				As ZD100