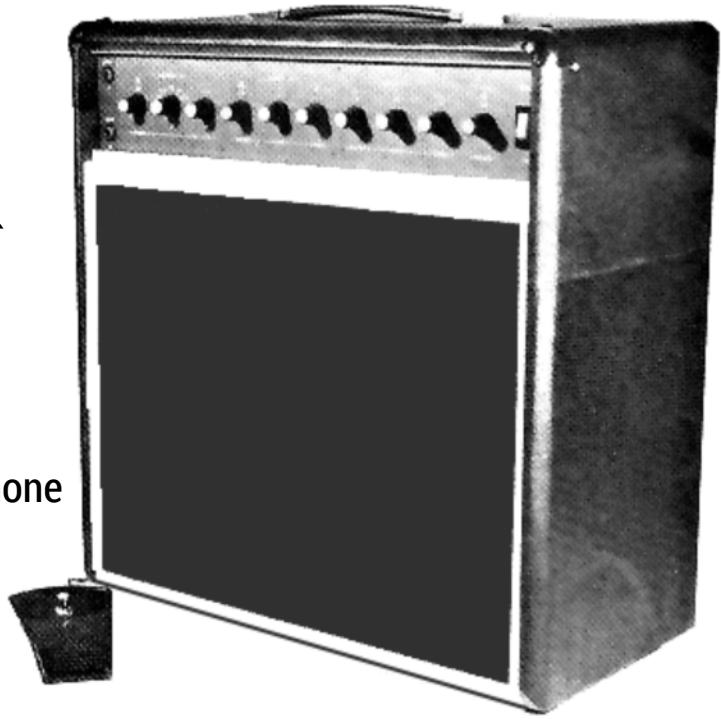
COMBO AMPLIFIER

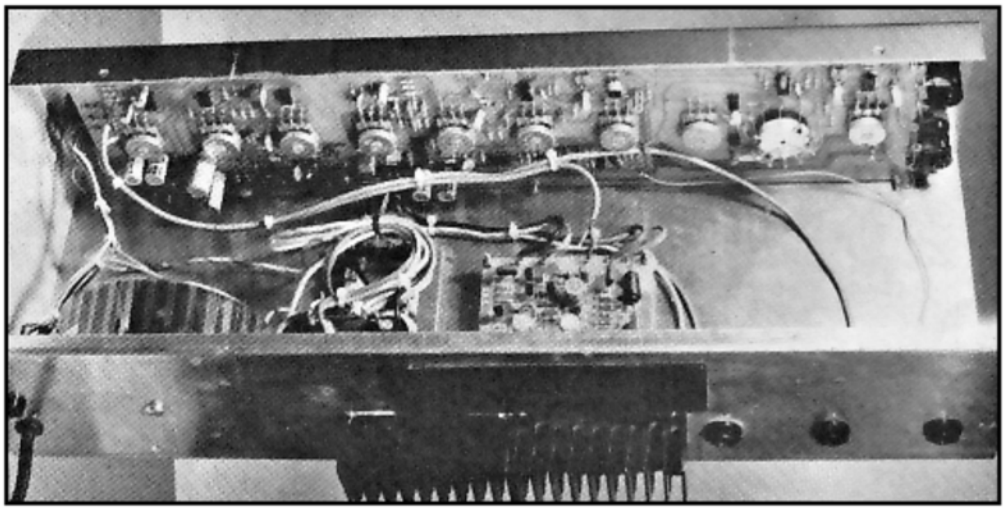
by Dave Goodman



- 120 watts of reliable MOSFET power
- Built-in flanger effect
- Two inputs for guitars, keyboards or microphone
- Five step equaliser on channel A
- Bass and treble controls on channel B
- Low noise BIFET pre-amplifier

This is an easy to build portable amplifier for all stage musicians requiring high power, reliability and versatility. A choice of equalisation methods is given on the two input channels, allowing a wide range of sounds in conjunction with the built in flanger.

Sockets are provided for feeding a slave, PA amplifier or tape recorder, and for using alternative speakers. The amplifier gives 75 watts into an 8 ohm speaker, or 120 watts into a 4 ohm speaker or combination of speakers.



Inside view of the amplifier chassis.

Input Circuitry

IC1 forms the input stage of channel A. RV1, R2 and R3 adjust stage gain from below unity up to X20, and C2 removes any HF noise and unwanted RF signals. Input levels of 10 mV up to 10 volts can be accommodated into 47k input impedance. Amplified signals from the volume control RV2 are processed by the filtering stages of IC2a and b. Selective feedback paths, determined by SW1a and b and C6 to C15 produce up to 10 dB boost and cut at the centre frequencies 150 Hz, 250 Hz, 500 Hz, 1.5 kHz, 2.5 kHz under the control of RV3.

Processed signals from IC2b are routed through bi-lateral switch IC3 and R26 to output mixer IC6b. IC3 can be viewed as an. electronic switch, being 'on' when the control gates (pins 5, 6, 12, 13) are high, and off when the control gates are low.

TR1 is normally biased off by R12, connecting IC3 pin 12 to the +7.5 volt supply through R11 and holding the switch 'on'. IC3 pin 13 will also be positive, connecting IC3 pins 5 and 6 down to the -7.5 volt rail. The two switches comprising IC3 pins 3/4 and 8/9 will therefore be open circuit.

Turning on TR1 by connecting pins 5 and 6 with the foot switch will reverse the quiescent condition of IC3. IC3 pins 10/11 will be open, pins 1/2 will be open, pins 3/4 and 8/9 will be closed. IC2b output will then be routed to the flanger effects circuitry and back to the output mixer IC6 via IC3 pin 8/9 and R27.

Channel B input IC4 is the same as channel A input stage. Signal processing, from volume control RV5 is achieved using a conventional Baxandall active tone control circuit. RV6 determines boost and cut of bass frequencies up to + 12 dB at 100 Hz, and RV7 gives boost and cut of treble up to + 12 dB at 10 kHz. C22 and C26 remove any instability at extreme boost settings and channel output is direct to the final mixer via R25.

RV8 is the master volume control supplying the power amp stage from IC6b output. IC6a is a unity gain buffer stage, supplying the slave output at a low impedance, and is not affected by the master volume control.

Flanger Circuit

The flanging effect can be switched in or out of circuit silently with the use of an external foot switch, as previously described. Flanging is similar to phasing, and here, the heart of the system is a TCA 350Z 'bucket brigade' device. Signals are applied to a low pass filter, IC7a and IC7d. All frequencies are reduced in amplitude at -24 dB per octave above 4 kHz. This is necessary to ensure that mixing of input and clock signals does not produce a distortion effect known as "aliasing". The TCA 350Z (IC12) delays input signals; the delay period is not fixed, but sweeps up and down at a rate set by triangle waveform oscillator IC9 and IC10.

IC9 is a Schmitt trigger and IC10 is an integrator. RV10 determines the rate of oscillation which is variable from zero to 10 Hz. IC11 is a CMOS oscillator, current controlled from D4 and D5, and its range of oscillation is variable from 15 kHz up to 0.75 MHz.

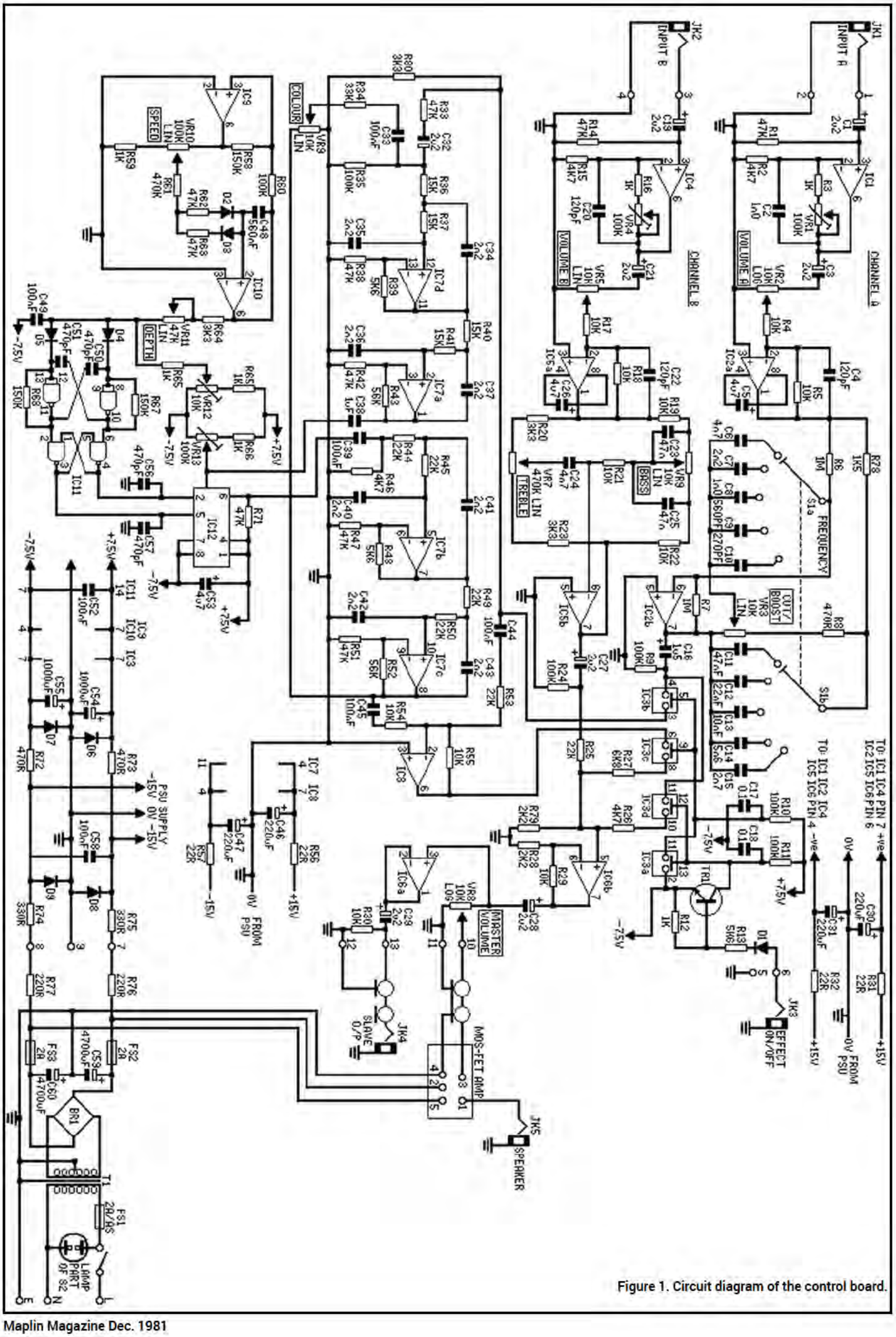


Figure 1. Circuit diagram of the control board.

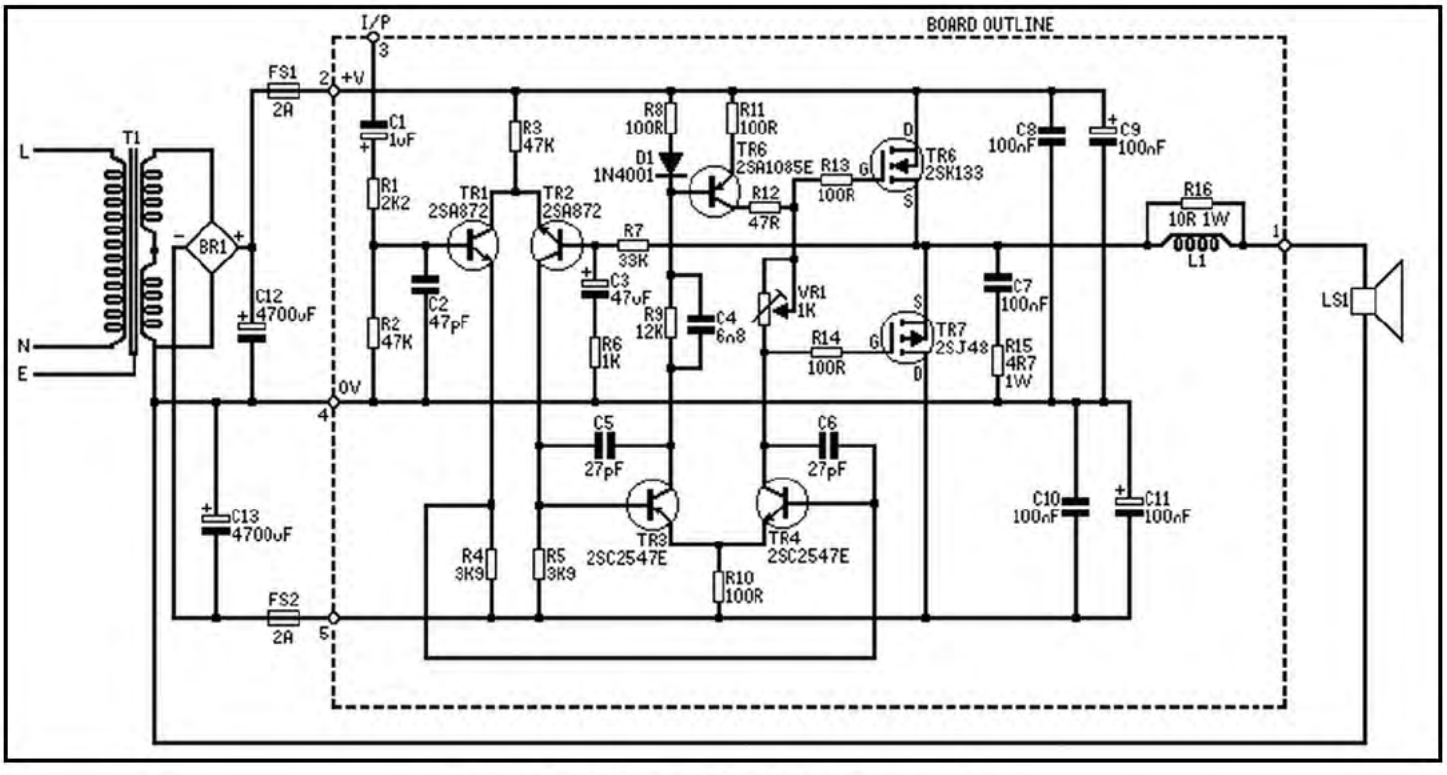


Figure 2. Circuit diagram of the MOSFET power amplifier.

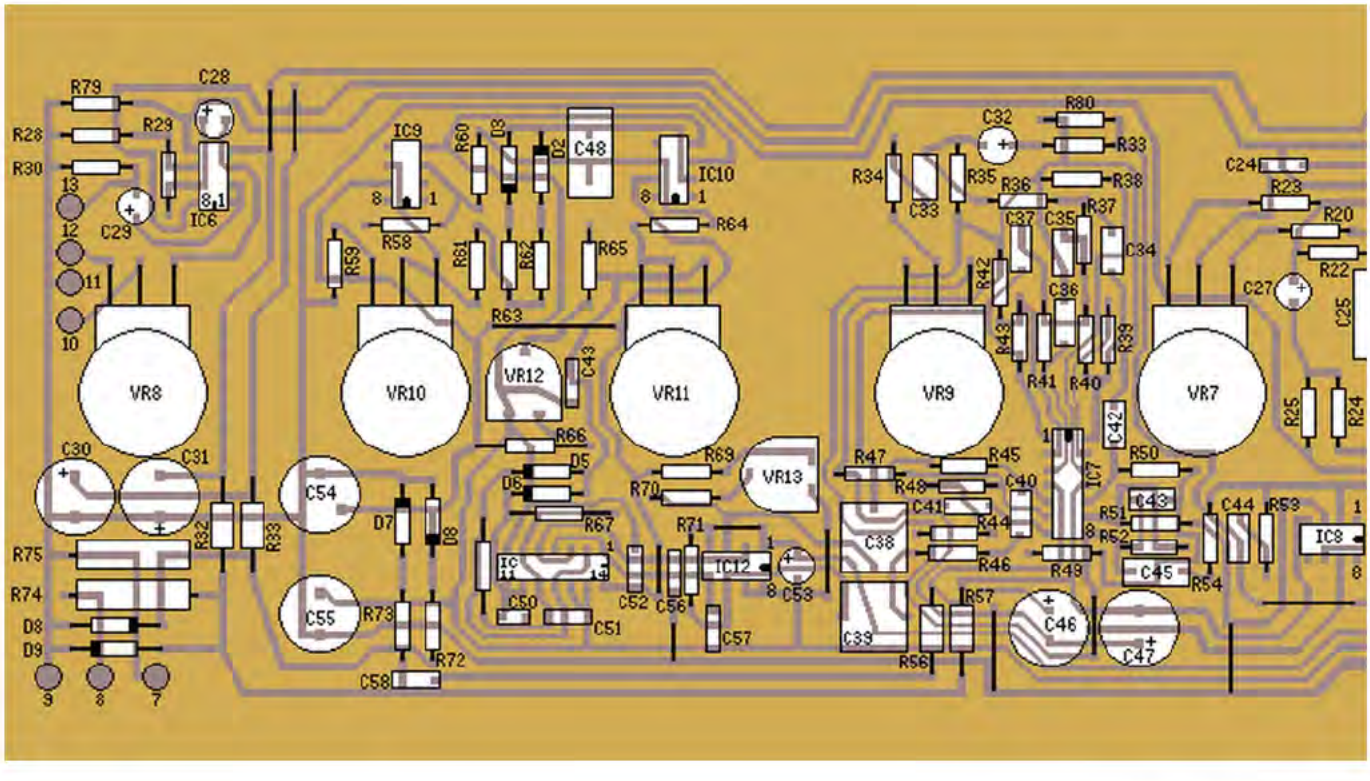
The slow running triangle wave ramps the fast running square wave oscillator up and down depending on the depth control RV11. The minimum fast running oscillator frequency is preset by RV12. Antiphase square wave signals are applied to the two clock inputs, pins 2 and 5 of IC12.

We now have our low pass filtered audio signal being delayed by IC12 for time periods between 300µS and 6 mS. The delay line output stages must be biased into class A operation, and preset RV13 should be adjusted for a symmetrical signal at pin 6 of IC12 - equivalent to 8 volts between pins 3 and 7 of IC12. Obviously, an asymmetrical output will give a distorted sound, so ensure accurate adjustment of RV13.

IC7b and c are, again, low pass filters and they serve to restore the 'stepped' waveform from IC12 by removing the clock signal and amplifying the delayed audio signal. The delayed signal is mixed at IC8 with a percentage of the original unaltered signal. The flanging effect is enhanced by introducing feedback from IC7c output via RV9, R34 and C33 back into the input filters. IC8 output is connected via IC3 pins 8/9 and R27 to the output mixer, IC6b.

R31, R32, C30 and C31 decouple the ±15 volt supply to IC7 and IC8. R72, R73, C54, R55, D6 and D7 connect ±7.5 volts to IC9, IC10, IC11 and IC12. C58 removes any RF present at the supply input, and R74, R75, D8, D9 regulate the +50 volts from the power amp supply. This degree of supply rail isolation and de-coupling is necessary to maintain a low noise level throughout the pre-amp circuitry.

The power amplifier stage is the MOSFET amplifier published in Electronics & Music Maker, June 1981. The details are reprinted here for convenience.



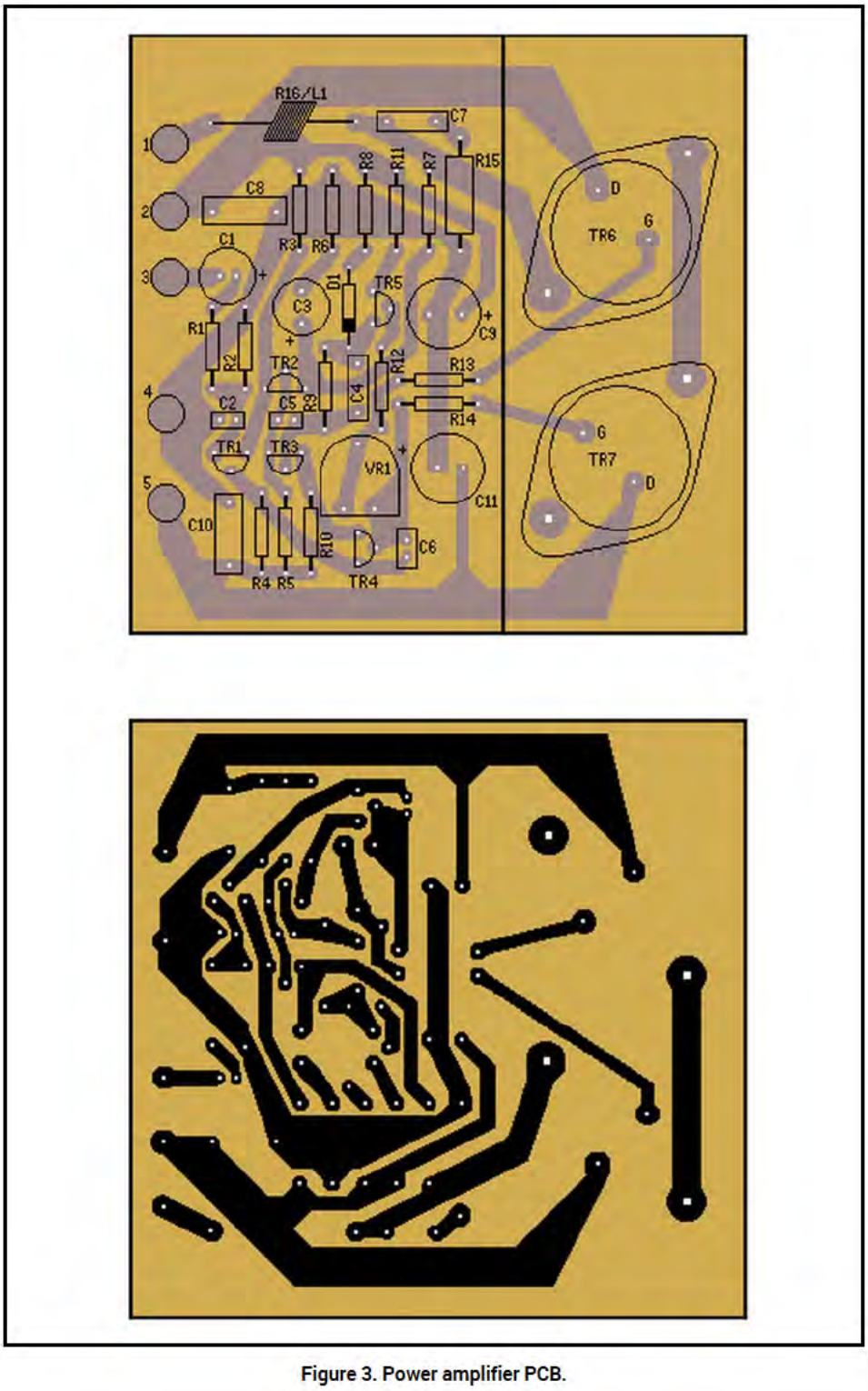


Figure 3. Power amplifier PCB.

Circuit Description

TR1 and TR2 form a stable, differential input buffer amplifier, the bias current for each transistor being set to 0.5 mA. The 2SA872 transistor is used because it has a very low noise output but can handle high voltages. TR3 and TR4 form a 'current mirror' to give a high open-loop voltage gain. TR5 acts as a constant-current load and this low-noise, high-gain, class A amplifier stage is all that is required to drive the power MOSFETs TR6 and TR7. The transistors in the driver stage need to have a high voltage durability, high FT and low Cob. They also have to supply sufficient power to charge and discharge the gate-to-source capacitance of the power MOSFETs. In this case a bias current of around 50 mA is sufficient to ensure adequate power is available at all frequencies and power levels.

The input impedance of the amplifier is set by R2 to 47k, and C2 bypasses any RF signals present at the input. The amplifier has a gain of 33, and this is set by R7 and R6, via decoupling capacitor C3. R13 and R14 improve the stability at high frequencies by reducing the effective gate load capacitance. C7 and R15 are a Zobel network which, in conjunction with R16 and L1, ensures excellent stability into reactive loads at high frequencies.

Construction

Fit the five Veropins, labelled 1 to 5, to the PCB and solder. Fit and solder diode D1 taking care that it is the right way round. Fit and solder all the resistors except R16, and all the capacitors, taking care with the polarity of the electrolytic ones, C1, C3, C9 and C11 (refer to Figure 3). Scrape or burn the enamel off one end of the piece of enamelled copper wire and solder it to one lead of R16, close to the body of the resistor. Now wind the wire tightly around the resistor ten times to form L1, as shown in Figure 4. Do not cut the wire, but hold it tightly and scrape off the enamel where it will touch the other lead-out wire of the resistor, then wrap it around the lead and

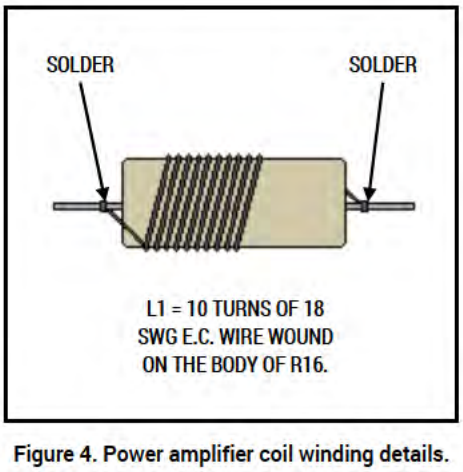


Figure 4. Power amplifier coil winding details.

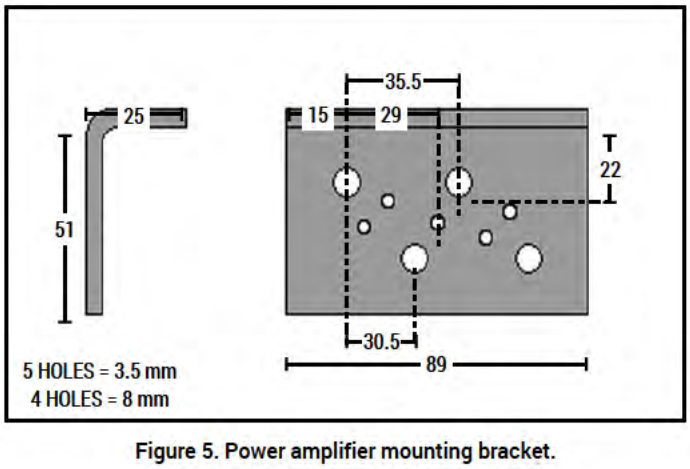


Figure 5. Power amplifier mounting bracket.

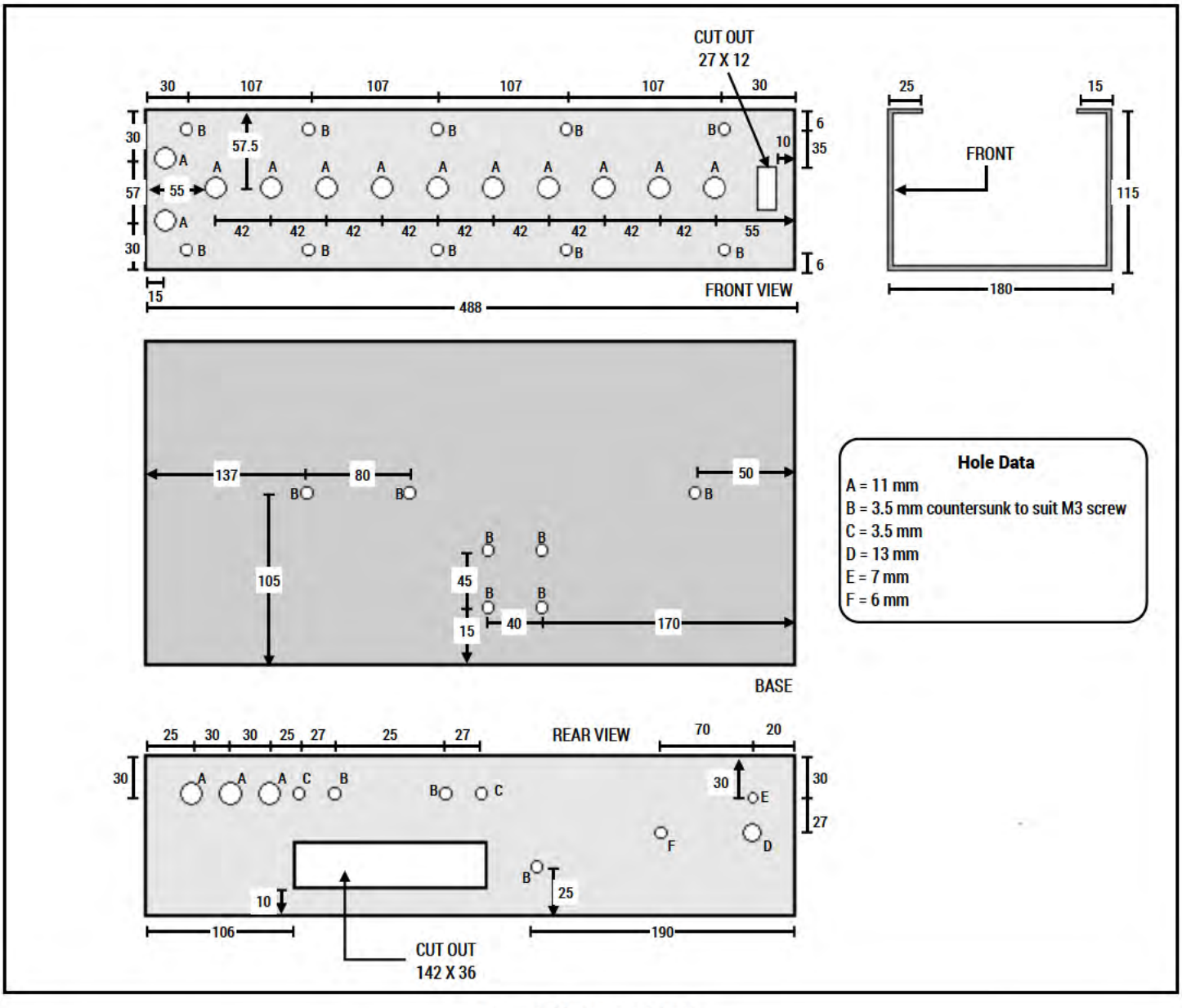
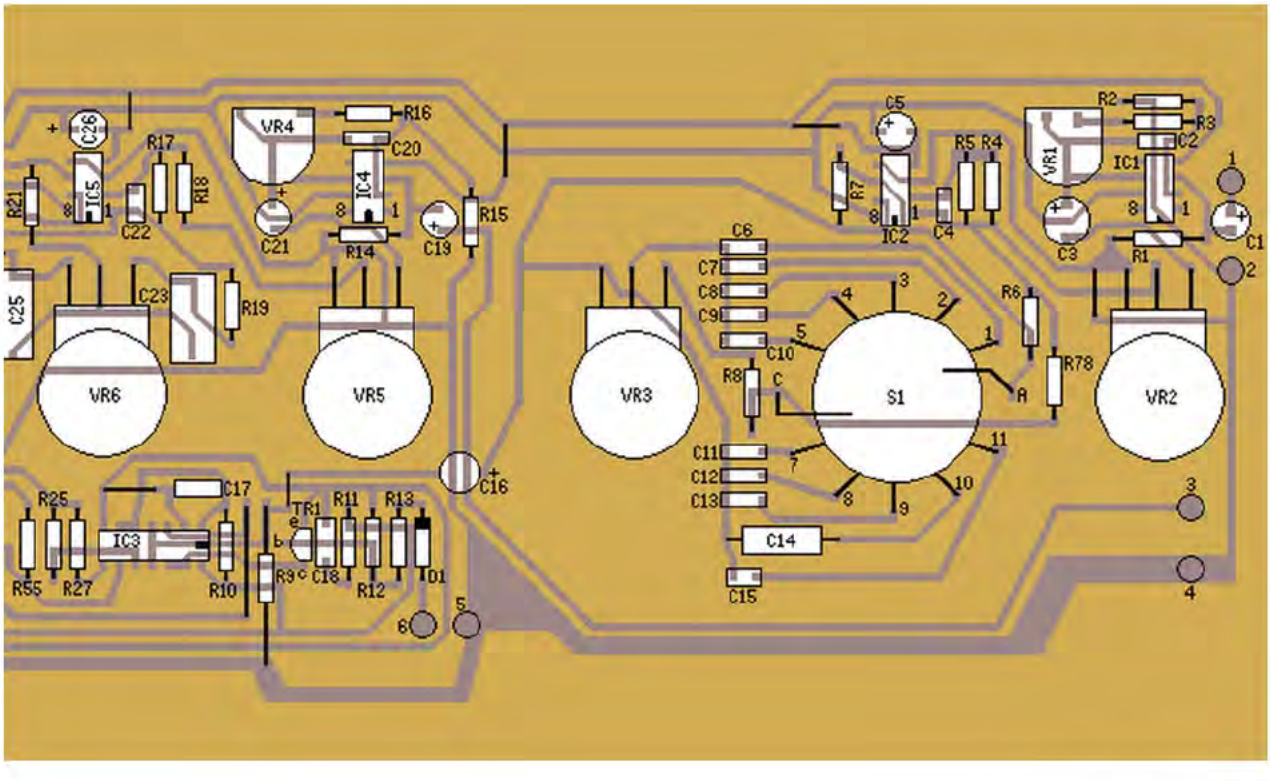


Figure 8. Metalwork details.



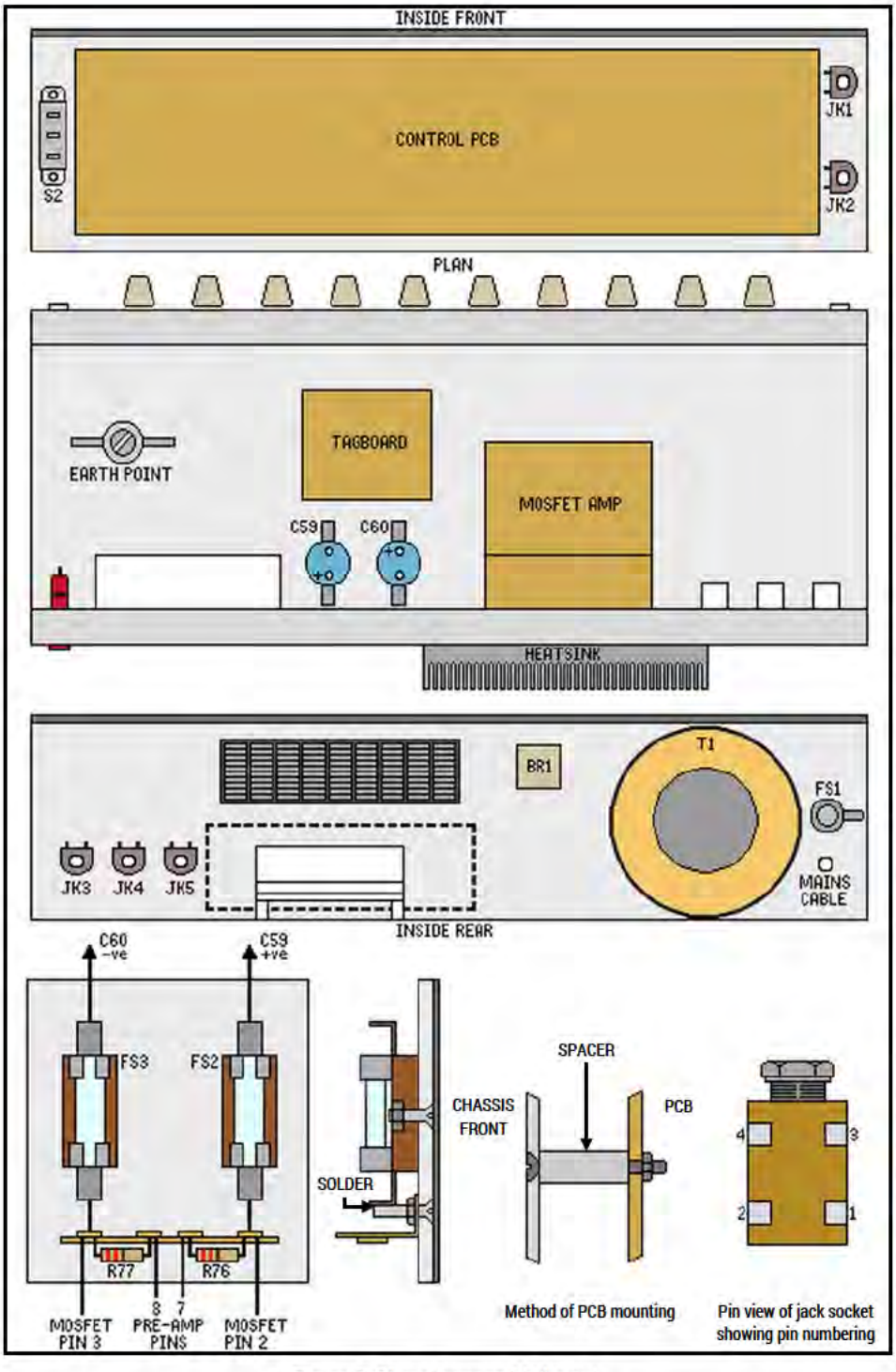


Figure 9. Chassis assembly layout.

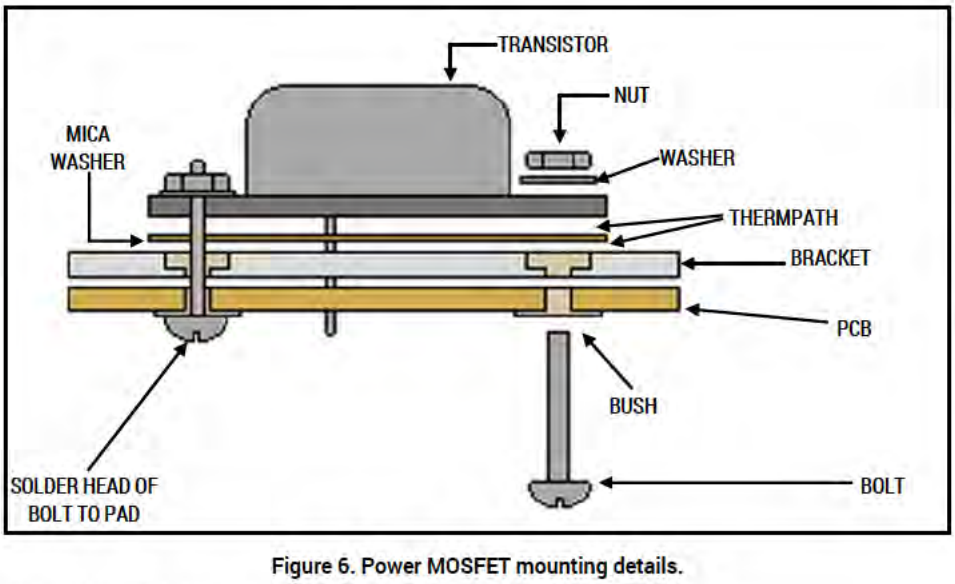
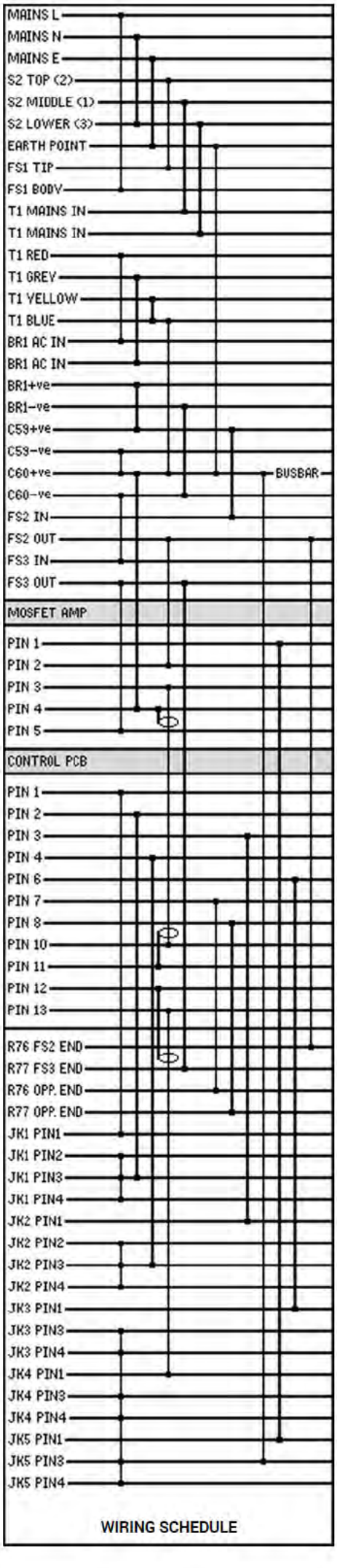


Figure 6. Power MOSFET mounting details.



WIRING SCHEDULE

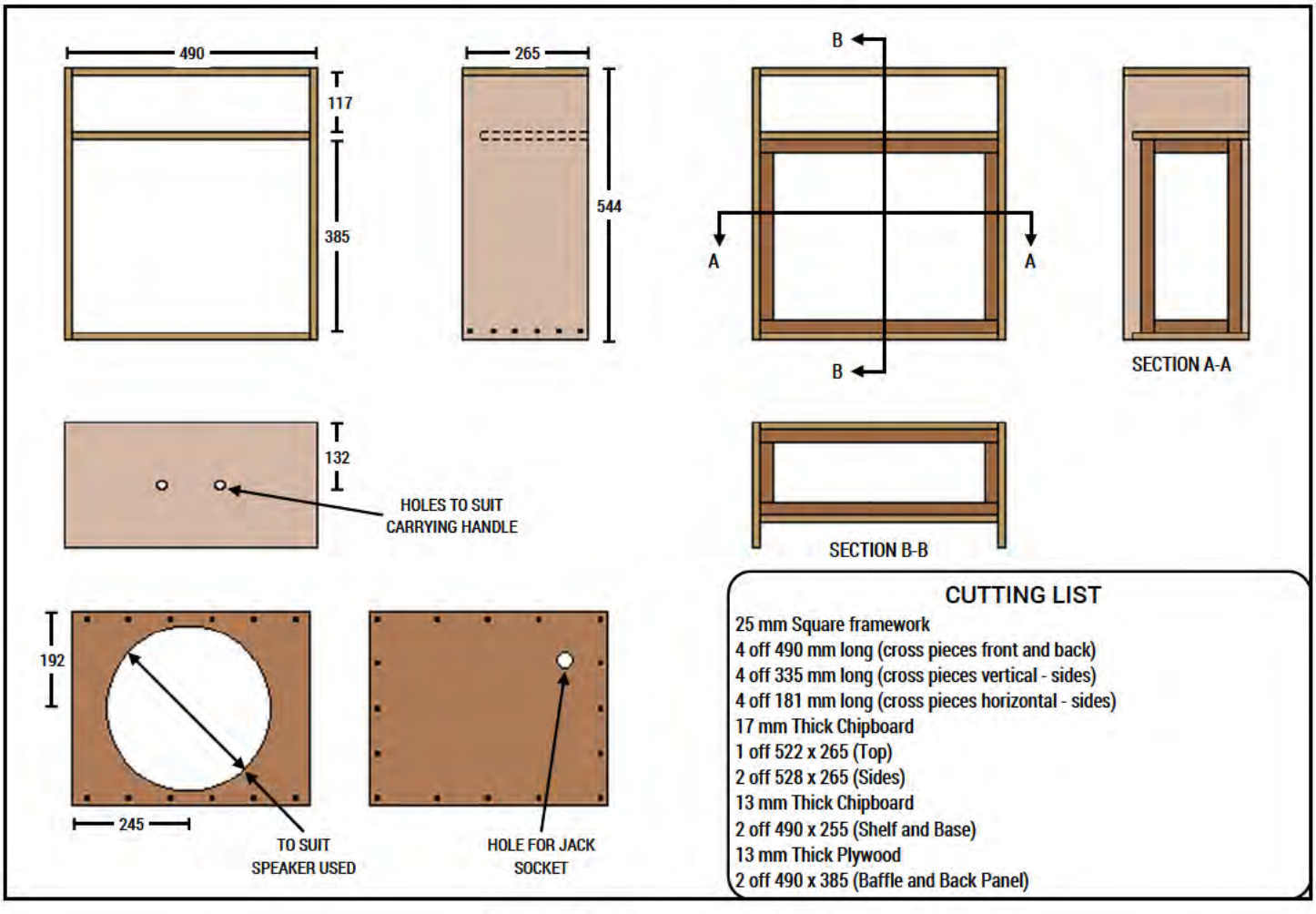


Figure 10. Cabinet construction details.

solder. Fit this composite component to the PCB and solder. Fit and solder the preset to the PCB, then the transistors (TR1-5).

Make the heatsink bracket shown in Figure 5. The mounting bracket fits to the component side of the PCB as shown in the photograph. Align it with the holes in the PCB and put one bolt through the centre hole from underneath using a 6BA nut, bolt and shakeproof washer. Referring to Figure 6, place a nylon bush in each of the four large holes in the bracket, smear both faces of both mica washers with Thermpath silicone grease and place these in position. Mount the two power MOSFETs, ensuring that TR6 (2SK133) is fitted closest to the coil L1. Put in the 6BA bolts to hold the transistors from underneath and secure them using nuts and shake-proof washers. Solder the bolt heads to the track on the PCB. Finally solder the drain and gate pins to the PCB and recheck all component positions, polarisations and solder joints.

Setting Up

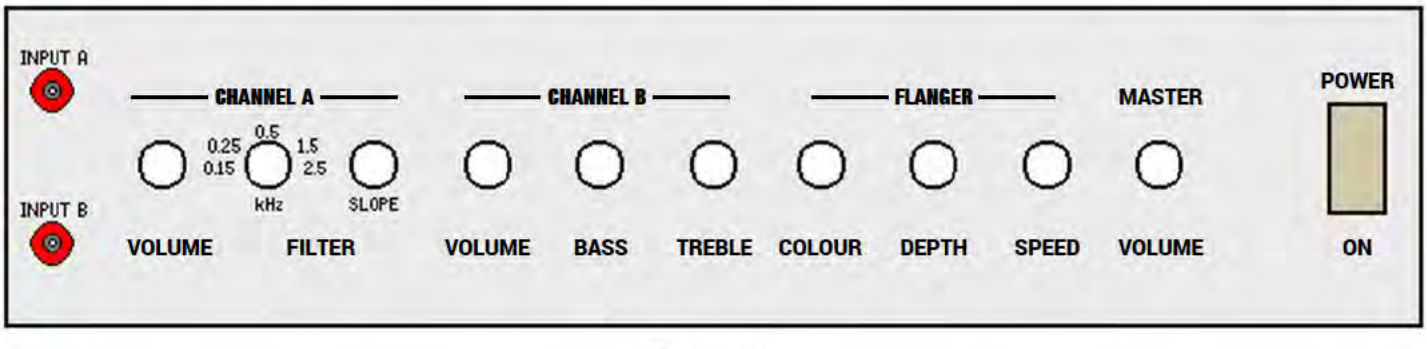
With no speaker connected and fuses not inserted, check that the voltage across C12 is approximately 48 volts (+5 volts) and that the voltage across C13 is the same. Switch off and short C12 and C13 in turn with a resistor (e.g. one of the test resistors). Now connect FS2 and FS3, via 100 ohm 5 watt resistors, to pins 2 and 5 respectively. Connect 0 volts to pin 4. Check with a multimeter set to the highest resistance range, that there is no connection between the MOSFET cases and the mounting bracket. Turn RV1 fully clockwise.

Insert 500 mA fuses for test purposes as FS2 and FS3 and switch on again. If either fuse blows or any component gets excessively hot switch off immediately. If all is well, connect a DC voltmeter between pin 1 and pin 4. The meter should read about 0 volt (not more than ±100 mV). Switch off and remove the two 100 ohm resistors. Connect FS3 directly to pin 5 and connect a multimeter switched to about 100 mA DC between FS2 and pin 2 (+ve lead to fuse and -ve lead to pin 2). Switch on again and rotate RV1 slowly until the meter reads 50 mA. Leave for 10 minutes and re-adjust.

Switch off, disconnect the meter and connect FS2 direct to pin 2. Replace FS2 and FS3 with 2 amp types.

Control PCB Assembly

Fit all links first, and then the resistors and capacitors. Electrolytic and tantalum capacitors are polarised, and attention



Front panel.

COMBO AMPLIFIER PARTS LIST

Resistors - all ¼ watt 5% carbon unless specified

R1, R14, R33, R38, R42, R47, R51, R62, R63, R71	47K	10 off	Yellow Violet Orange
R2, R15, R26, R46	4K7	4 off	Yellow Violet Red
R3, R12, R16, R59, R65, R66, R69	1K	7 off	Brown Black Red
R4, R5, R17, R18, R19, R21 R22, R29, R30, R54, R55	10K	11 off	Brown Black Orange
R6, R7	1M	2 off	Brown Black Green
R8, R72, R73	470R	3 off	Yellow Violet Brown
R9, R10, R11, R24, R35 R60, R70	100K	7 off	Brown Black Yellow
R13, R39, R48	5K6	3 off	
R20, R23, R64, R80	3K3	4 off	Orange Orange Red
R25, R44, R45, R49, R50, R53	22K	6 off	Red Red Orange
R27	6K8		Blue Grey Red
R28, R79	2K2	2 off	Red Red Red
R31, R32, R56, R57	22R	4 off	Red Red Brown
R34	33K		Orange Orange Orange
R36, R37, R40, R41	15K	4 off	Brown Green Orange
R43, R52	56K	2 off	Blue Green Orange
R58, R67, R68	150K	3 off	Brown Green Yellow
R61	470K		Yellow Violet Yellow
R74, R75	330R	2 off	3W wirewound
R76, R77	220R	2 off	3W wirewound
R78	1K5		Brown Green Red

Potentiometers

VR1, VR4, VR13	100K	3 off	Horizontal preset
VR2, VR5, VR8	10K	3 off	Log. potentiometer
VR3, VR9	10K	2 off	Lin. potentiometer
VR6, VR10	100K	2 off	Lin. potentiometer
VR7	470K		Lin. potentiometer
VR11	47K		Lin. potentiometer
VR12	10K		Horizontal preset

Capacitors

C1, C3, C19, C21 C27, C28, C29, C32	2µ2 63V PC electrolytic	8 off
C2, C8	1n0 ceramic plate	2 off
C4, C20, C22	120pF ceramic plate	3 off
C5, C26, C53	4µ7 35V tantalum	3 off
C6	4n7 monolithic ceramic	
C7	2n2 monolithic ceramic	
C9	560pF ceramic plate	
C10	270pF ceramic plate	
C11	47nF monolithic ceramic	
C12	22nf monolithic ceramic	
C13	10nF monolithic ceramic	
C14	5n6 polystyrene	
C15	2n7 ceramic plate	
C16	1µ5 35V tantalum	
C17, C18, C33, C34 C45, C49, C52, C58	100nF disc ceramic	8 off
C23, C25	47nF polycarbonate	2 off
C24	4n7 polycarbonate	
C30, C31, C46, C47 C34, C35, C36, C37	220µF 16V PC electrolytic	4 off
C40, C41, C42, C43	2n2 polycarbonate	8 off
C38	1µ0 polycarbonate	
C39	100µF polyester	
C48	560nF polycarbonate	
C50, C51, C56, C57	470pF ceramic plate	4 off
C54, C55	1000µF 16V PC electrolytic	2 off
C59, C60	4700µF 63V can electrolytic	2 off

Semiconductors

IC1, IC4, IC8	LF351	3 off
IC2, IC5, IC6	LF353	3 off
IC3	4016BE	
IC7	LF347	
IC9, IC10	µA741C	2 off
IC11	4011BE	
IC12	TCA350Z	
TR1	BC548	
D1, D2, D3, D4, D5	1N4148	5 off
D6, D7	BZY88C7V5	2 off
D8, D9	BZX61C15V	2 off
BR1	PW06	

Miscellaneous

	MOSFET amplifier kit	
S1	2-pole 6-way rotary switch make before break	
T1	35-0-35V 160VA toroidal transformer	
	Chassis fuseholders	2 off
	Panel fuseholder	
FS1	2A 20 mm antisurge fuse	
FS2, FS3	2A 20 mm fuse	2 off
S2	SPST rocker with neon	
JK1, JK2	Chrome bezel jack socket	2 off
JK3, JK4, JK5, JK6	¼ inch jack socket	4 off
	L knobs	10 off
	Red knob caps	3 off
	White knob caps	7 off
	2E heatsinks (see text)	2 off
	Jack plugs	3 off
	Footswitch	
LS1	Loudspeaker 12 inch	
	Handle	
	Ventilation grille	
	4-way tag strip	
	Grommet	
	6BA x 1 inch c/s bolts	10 off
	6BA ½ inch c/s bolts	11 off
	6BA nuts	27 off
	6BA washers	27 off
	6BA x ½ inch spacers	8 off
	Jack socket mounting plate	
	Cabinet cloth	1 m
	Speaker fabric	½ m
	Connecting wire	
	Screened cable	1 m
	Mains cable	
	Aluminium chassis (see Fig. 8)	

should be paid to their plus signs. Fit diodes, transistors and ICs using IC holders if preferred. Lastly, fit the rotary pots and SW1. The rotary switch fits into a locating hole which lines up the switch tags to their appropriate holes on the PCB. Connect pins 1 to 5 and pins 7 to 11 to the PCB; pins 6 and 12 are not used. The switch is a 6 way type and can be adjusted for 5 way with the lug washer on the spindle; the lug should go into the slot marked with a '5' moulded into the switch body. Wire pins A and C to the PCB. The 9 potentiometers are wired to the holes adjacent, either direct or by using Vero pins (1 mm type). After soldering and cutting all component wires, scrub the PCB with paint thinners and sponge, to clean off flux, and check for shorts etc. Double check all components. A ±15 volt supply can be attached for testing the pre-amp circuitry before assembly in the chassis.

Chassis Assembly

C1 and C2 come with their own mounting clips which are fixed with 4 x ½ inch 6BA countersunk bolts, nuts and washers. BR1 is also mounted with a ½ inch 6BA countersunk bolt, nut and washer. T1 is supplied with mounting pads, nuts and bolts. The 2 fuse holders FS2 and FS3 are fitted to a paxolin panel (for insulation) using ¼ inch 6BA bolts, and the 4 way tag strip is soldered to the holders.

Resistors R1 and R2 are mounted to the tag strip - see Figure 9 - and then wired to the Combo pre-amp PCB + and - inputs.

The MOSFET amplifier bracket is smeared with Thermpath and bolted to the back panel with 6BA bolts. The front of the PCB is supported using 1 inch countersunk bolts and ½ inch 6BA spacers.

If it is intended to use less than 8 ohm loads on the power amp, heatsinks are advisable. Two extra holes are shown for mounting 2 x 2E heatsinks.

Additional cooling is catered for by cutting a slot in the back panel, above the power amp. A Cool Grille can be accommodated in the dimensions shown in the chassis diagram.

Control PCB Mounting

The chassis front panel has 6 countersunk holes. Fit 6 x 1 inch bolts and

MOSFET AMPLIFIER PARTS LIST

Resistors - all ¼ watt 1% metal film unless specified

R1	2K2	Red Red Red
R2	47K	Yellow Violet Orange
R3	47K	Yellow Violet Orange
R4	3K9	Orange White Red
R5	3K9	Orange White Red
R6	1K	Brown Black Red
R7	33K	Orange Orange Orange
R8	100R	Brown Black Brown
R9	12K 1W Carbon Film	
R10	100R	Brown Black Brown
R11	100R	Brown Black Brown
R12	47R	Yellow Violet Black
R13	100R	Brown Black Brown
R14	100R	Brown Black Brown
R15	4R7 3W Wirewound	

Potentiometers

VR1	1K	Horizontal preset

Capacitors

C1	10µF 35V axial electrolytic
C2	47pF Ceramic
C3	47µF 50V SMPS
C4	6n8F Polylayer
C5	27pF Ceramic
C6	27pF Ceramic
C7	100nF Polylayer
C8	100nF Polyester
C9	220µF 63V PC Electrolytic
C10	100nF Polyester
C11	220µF 63V PC Electrolytic

Semiconductors

D1	1N4001
TR1	2SA872A
TR2	2SA872A
TR3	2SD765
TR4	2SD765
TR5	2SB716
TR6	2SK135
TR7	2SJ50

Miscellaneous

	Insulator TO3	2
	MOSFET Amp Bracket	1
	Veropins type 2141	1 packet
	Bolt 6BA x ½ inch long	1 packet
	Nut 6BA	1 packet
	Washer (Shakeproof)	1 packet
L1	EC Wire 0.9 mm (see text)	

tighten with 6 x 6BA nuts. Place 6 x ½ inch 6BA spacers over the bolts and fit the Combo PCB over the bolts and spacers. Use 6 x 6BA nuts and washers to hold it down (note orientation of the PCB).

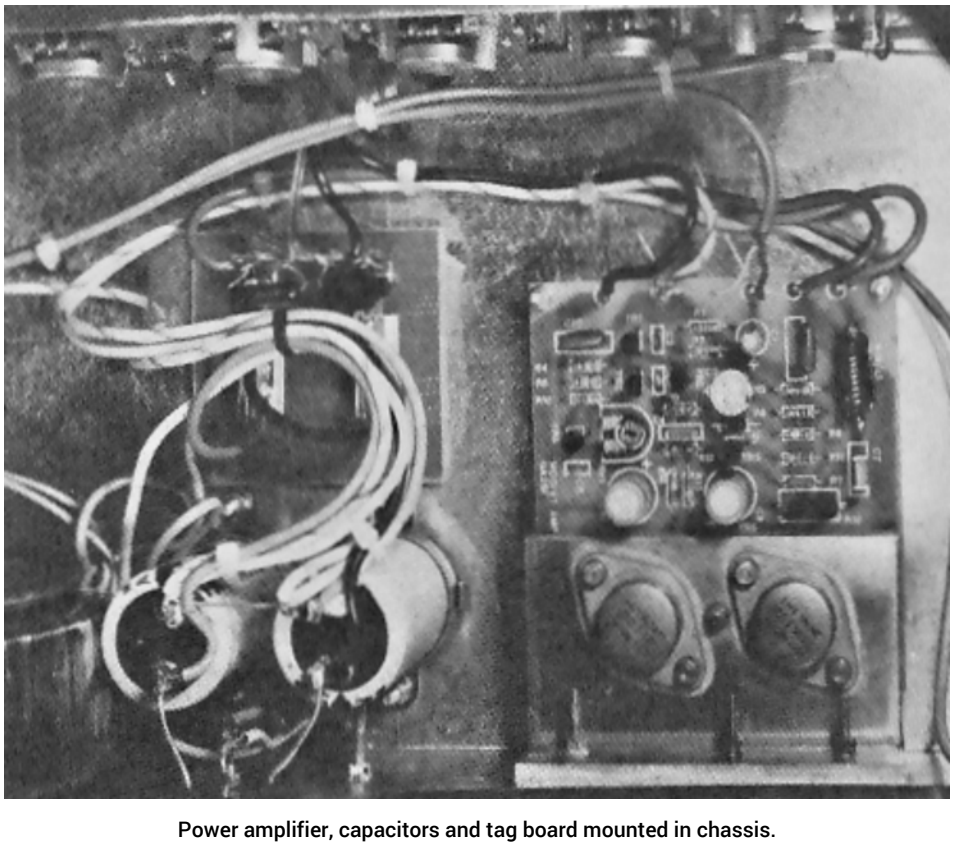
Fit the chrome bezel jack sockets to the front panel, and the mains neon switch.

Cut the rotary control spindles to size and fit the knobs; use red caps for the volume controls, white caps for the others.

The control PCB Output, pin 10, is connected to the power amp input using screened cable. Connect the cable screen to the power amp 0 volt pin and the control PCB 0 volt pin. The C1/C2 0 volt bus bar is wired to the power amp 0 volt and this also supplies the control PCB 0 volt. Do not connect pin 9 to the 0 volt rail separately or earth loop hum will result.

The slave output pin should be wired with screened wire to the slave jack socket. Do not connect the screen at the jack socket end. Combo pin 6 (effect switch) is wired to the footswitch jack socket using hook-up wire. The bus bar supplies the 0 volt on all three jack sockets as in the chassis layout diagram.

The front panel input sockets are wired directly to the inputs and 0 volt pins on the control PCB. Screened wire is not necessary as the run is only about 1" long.



Power amplifier, capacitors and tag board mounted in chassis.

Cabinet Construction

16 mm (⅝ inch) and 12 mm (½ inch) chipboard and 12 mm (½ inch) plywood is used in the construction of the cabinet. Material thicknesses vary and it is important to keep to the cabinet inside measurements when marking out.

Cut out the five basic cabinet sections. Drill the top panel to accommodate a suitable carrying strap. The panel inside face will need the holes countersunk so that the nuts lie flush.

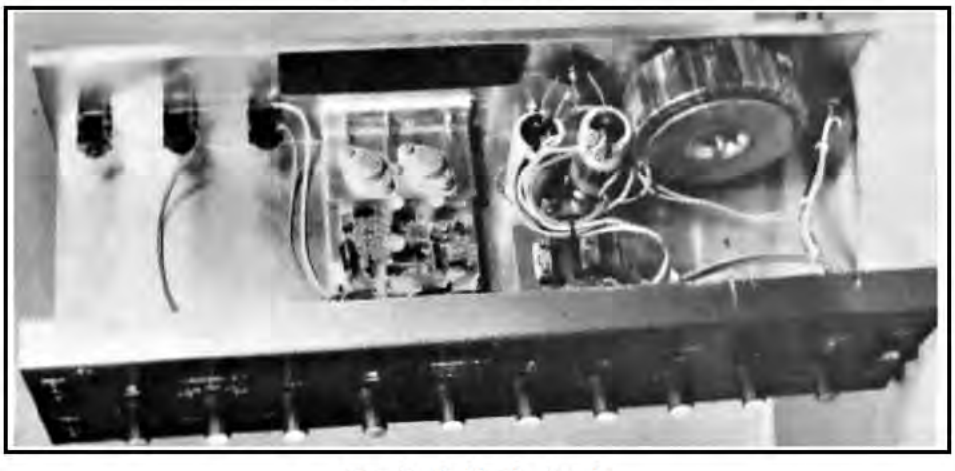
Use a good wood glue on the joints, and pin them (or use clamps) ready for drilling and screwing down. Use 1¼ inch No. 8 screws and countersink the outside of all holes. Note that the shelf and base panels fit flush with the back edges, while the front edges are set back by 10 mm.

Before fully tightening all screws, fit the front baffle board, after cutting a hole to suit the loudspeaker to be used. A 292 mm (11½ inch) hole is required for a 12 inch loudspeaker. Mark off the speaker mounting holes, drill and counter drill the holes to counter sink the mounting bolts. 1 inch x 2BA bolts usually suffice for this job.

Screw into the baffle board edges, through the cabinet sides. Ensure that the board is flush with the shelf front edge and base front edge. Tighten down all cabinet screws, and leave the assembly for the glue to dry.

Cut the 25 mm (1 inch) square wood to make a framework fitting inside the cabinet. Again, 1 inch prepared wood can vary considerably in thickness, so take this into account before cutting to size. Twelve pieces will be needed for the frame. Glue and screw the frame along the baffle edge (inside), but ensure the outer edge (back) framework is set back enough to accommodate the back panel 12 mm.

Completed MOSFET Amplifier.



Completed wiring in chassis.

Radius the front edges of the cabinet, and smooth all surfaces with a Surform and glass paper. The cabinet can then be covered using a suitable impact adhesive and cloth backed PVC material. About 2 metres of 0.5 metre wide material will be required. Cover the cabinet top with impact adhesive and lay the cloth centrally on to the glued surface. Smooth the cloth over the top completely. Remove the cloth and leave for two minutes - no more. Re-lay the cloth and stretch it gently, smoothing out any creases. Repeat this action for the sides; trim the corners and glue the cloth over the edges and into the cabinet about 25 mm.

The baffle can be covered with a suitable speaker material, glued (very conservatively) and laid over. Cut the edges with a sharp scalpel type blade.

The shelf and base front edges can be covered with aluminium angle trim. The two sides of the baffle board can be fitted with our mixer trim channel.

Fit four plastic feet (or castors) to the base. Drill a hole in the back panel and cut out to accommodate a jack socket mounting plate. Wire the socket to the loudspeaker and screw the back panel into place. Fit the carrying strap to the top panel, and ensure the nuts are fully recessed.

If our chassis is to be used, slide it into the shelf area, up to the angle trim (if used) or to within 25 mm of the shelf front edge. Cut two pieces of channel trim to fit horizontally along the chassis front, top and bottom. This serves to cover the PCB mounting screw heads. Glue the channel to the cabinet top and shelf. Finally, screw in two small wood blocks behind the chassis to keep it in position.