

# Build this 100W VHF Linear Amplifier

*Cut through the noise on the 2-metre band!  
Put a really whopping signal out with this  
100W afterburner, the biggest kit amplifier  
currently available!*

by GREG SWAIN

Most VHF amateur band transceivers for mobile use feature power outputs of between 2W and 15W. That's fine for most situations, but how many times have you wished for more power to trigger a distant repeater or to put out a more readable signal?

If that's the case, then this new 100W 144MHz linear amplifier is the answer. It's available from Dick Smith Electronics as a complete kit of parts, boasts 120W continuous output power (15W input), and is easy to build and align.

In use, the amplifier is interposed between the transceiver and the antenna. There are just two front panel controls: a switch to select between FM and SSB/CW operating modes; and an operate/standby switch.

An on-air lamp and a relative output meter complete the front panel line-up. The back panel carries the input and output sockets.

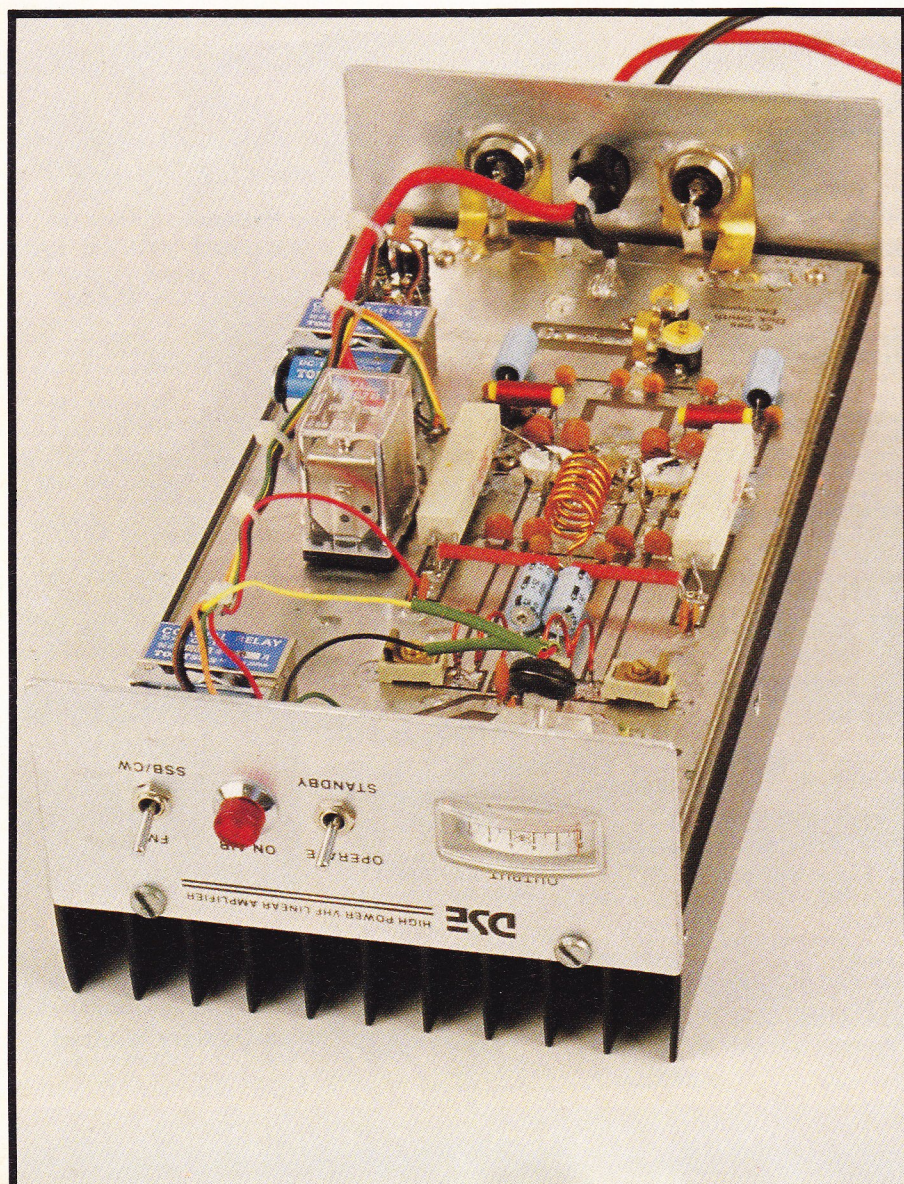
The operate/standby switch basically functions as an on/off switch. In the operate position, the amplifier is switched into circuit whenever the PTT button on the transceiver is pressed.

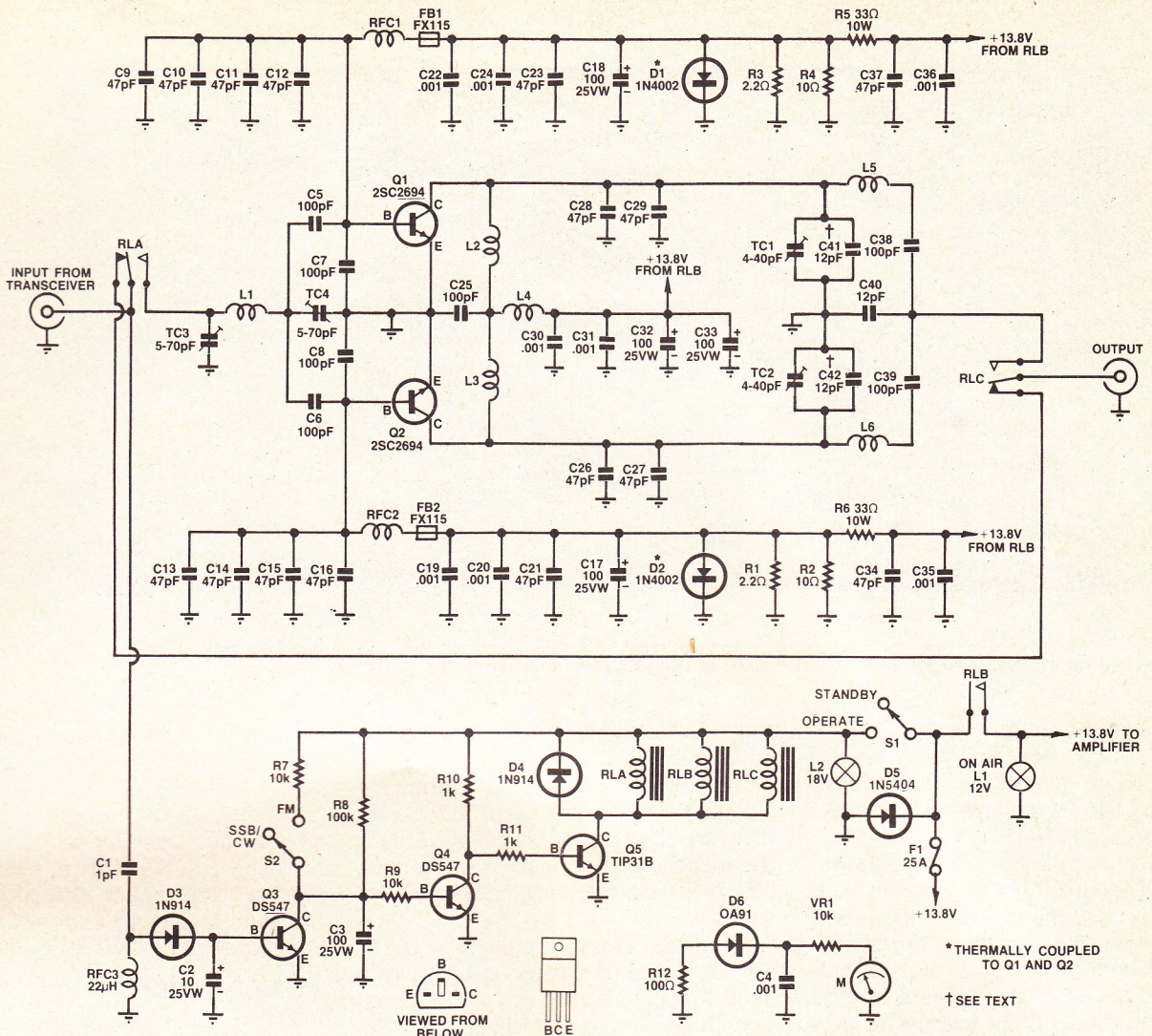
When the PTT button is released, the amplifier is switched out and the transceiver is connected to the antenna socket (on the back of the amplifier) via internal relay contacts.

In the standby position, the amplifier is switched off and the transceiver is connected, via the relays, to the antenna socket for both receive and transmit. This operating mode is handy for making local contacts, or in other situations where the high output power of the amplifier is not required.

Unlike some commercial units, this unit uses low-loss coaxial relays for RF switching. These keep the insertion loss in standby mode to just 0.6dB over the range 144-148 MHz.

By contrast, many commercial units exhibit an insertion loss of 1.5dB or





144MHz POWER AMPLIFIER

3/TR-

The circuit uses two parallel RF transistors, Q1 and Q2, operating in class B mode. Q3-Q5 provide relay switching.

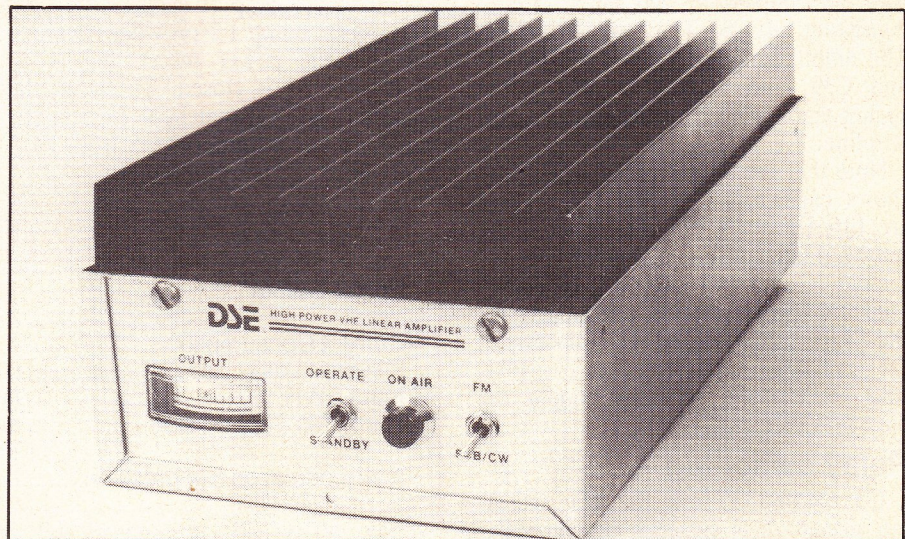
more due to the widespread use of cheap relays. This plays havoc with noise figures on receive and equates to about 7W out for 10W in when operating in standby mode.

### How it works

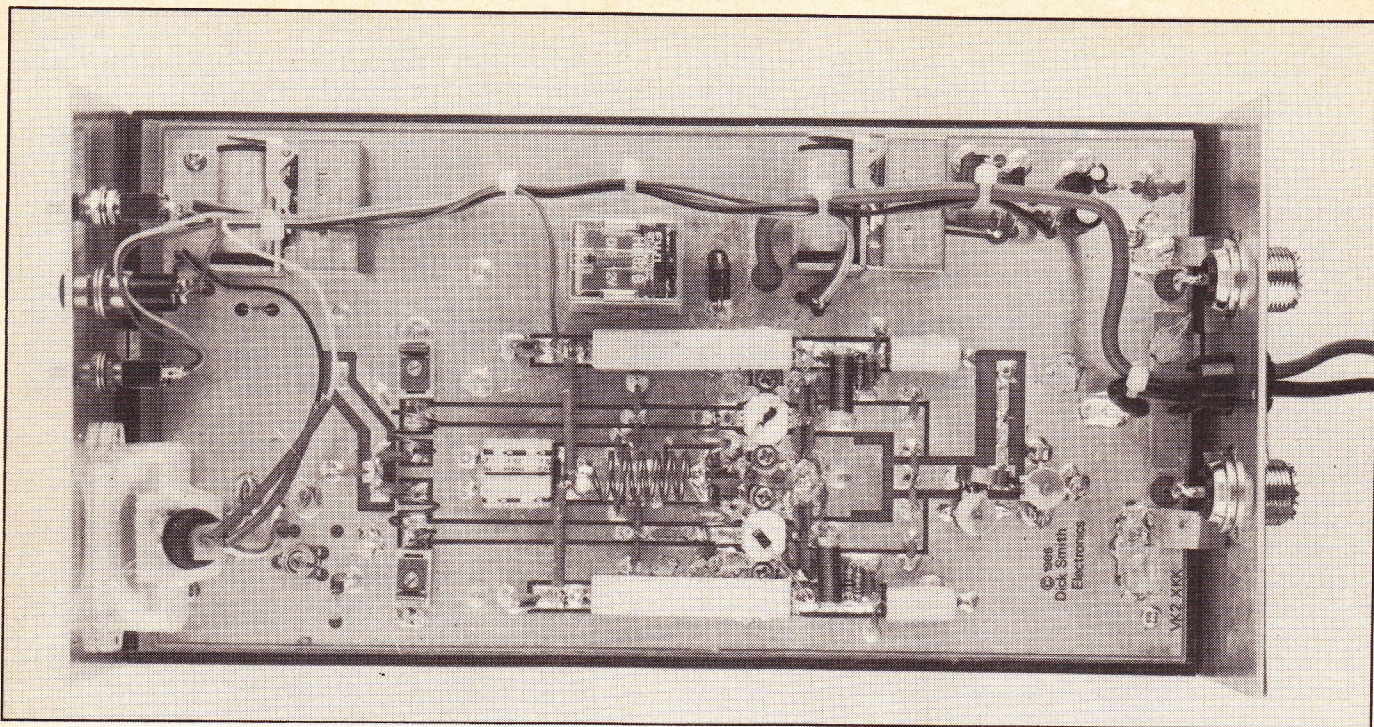
The circuit is quite straightforward and consists of two parallel RF power transistors, Q1 and Q2, operating in class B mode.

Starting at the input, the RF signal is fed via the contacts of relay RLA to an input matching network consisting of L1 and trimmer capacitors TC3 and TC4. From there, it is capacitively coupled to the bases of Q1 and Q2 which are Mitsubishi 2SC2694 devices rated at 75W each.

Resistors R5 and R6 and diodes D1 and D2 provide bias for the transistor stages. This bias, which is simply the



View of the completed prototype. The large finned heatsink allows the amplifier to be operated continuously at full output.



Construction follows standard RF practice with most of the parts soldered to the top of the PC board.

forward voltage drop of each diode, is applied to the transistor bases via RF chokes RFC1 and RFC2. The resulting quiescent current through each device is of the order of 150-200mA.

In practice, diodes D1 and D2 are thermally coupled to the power transistors to prevent thermal runaway. Here's how the scheme works: As the transistors get hotter, the diodes also get hotter. As a result, the forward voltage across the diodes drops and this reduces the bias on the transistors.

Thus, the transistors are automatically throttled back as they become hotter.

The collector outputs of the transistors are coupled to two tuned circuits consisting of L5, TC1 and L6, TC2. The amplified signal is then fed to C38 and C39, and applied to the output socket via coaxial relay RLC and a 50Ω stripline.

Note that the output tuned circuit also shows capacitors C41 and C42. These are fitted initially but may have to be removed later during alignment.

Coils L2, L3 and L4 and their associated capacitors provide decoupling for the 13.8V supply rail to the collectors of Q1 and Q2. Similarly, C9-C24, FB1, FB2, RFC1 and RFC2 decouple the base bias voltages.

### Relay switching

Q3, Q4 and Q5 form the relay switching circuit. This switches the amplifier into circuit between the transceiver output and the antenna socket on transmit,

and switches the amplifier out of circuit during receive.

The circuit works like this: During receive, Q3 is off and Q4 is on. Thus, relay driver transistor Q5 is also off and the transceiver is connected to the output socket via relay contacts RLA and RLC.

When the transmit button is pressed, part of the signal passes via C1, is rectified by D3 and charges C2. This provides base bias to Q3 which turns on, turning Q4 off and Q5 on. Q5, in turn, drives relays RLA and RLC to switch the amplifier into circuit.

At the same time, power is supplied to the on-air lamp (L1) via relay contacts RLB. Lamp L2 provides illumination for the power meter and is on while ever S1 is closed. S1 allows the amplifier to be switched to standby mode while D4 protects Q5 from back EMF when the relays turn off.

When the transmit button is released, the relays remain on for a short time until C3 charges sufficiently to turn Q4 on. Switch S2 considerably extends the relay dropout time for SSB and CW by switching out R7. This is necessary to prevent relay chatter since there is no carrier in SSB mode and only an intermittent carrier in CW mode.

### Power meter

The relative power meter circuit monitors the RF energy in the output tank circuit. Here's how it works:

Part of the energy in the tank circuit is coupled into the anode circuit of D6 via two parallel tracks on the underside of the PC board. This signal is then rectified by germanium diode D6, filtered by C4 and applied to the meter movement via calibration trimpot VR1.

Note that D6 must be germanium type to ensure low forward voltage.

## SPECIFICATIONS

Power Output .....	120W (max.) CW for 15W input at 146MHz (see Table 1)
Current Consumption .....	15A (see Table 1)
Insertion Loss .....	0.6dB from 144-148MHz
Input SWR .....	less than 1.2:1 from 144-148MHz
Harmonic Suppression .....	second: -55dB (same as exciter); third: -65dB (same as exciter)
Intermodulation Suppression .....	better than -35dB at 200W PEP on SSB two tone signal (500Hz & 2400Hz); exciter -38dB (ie, 3dB degradation)

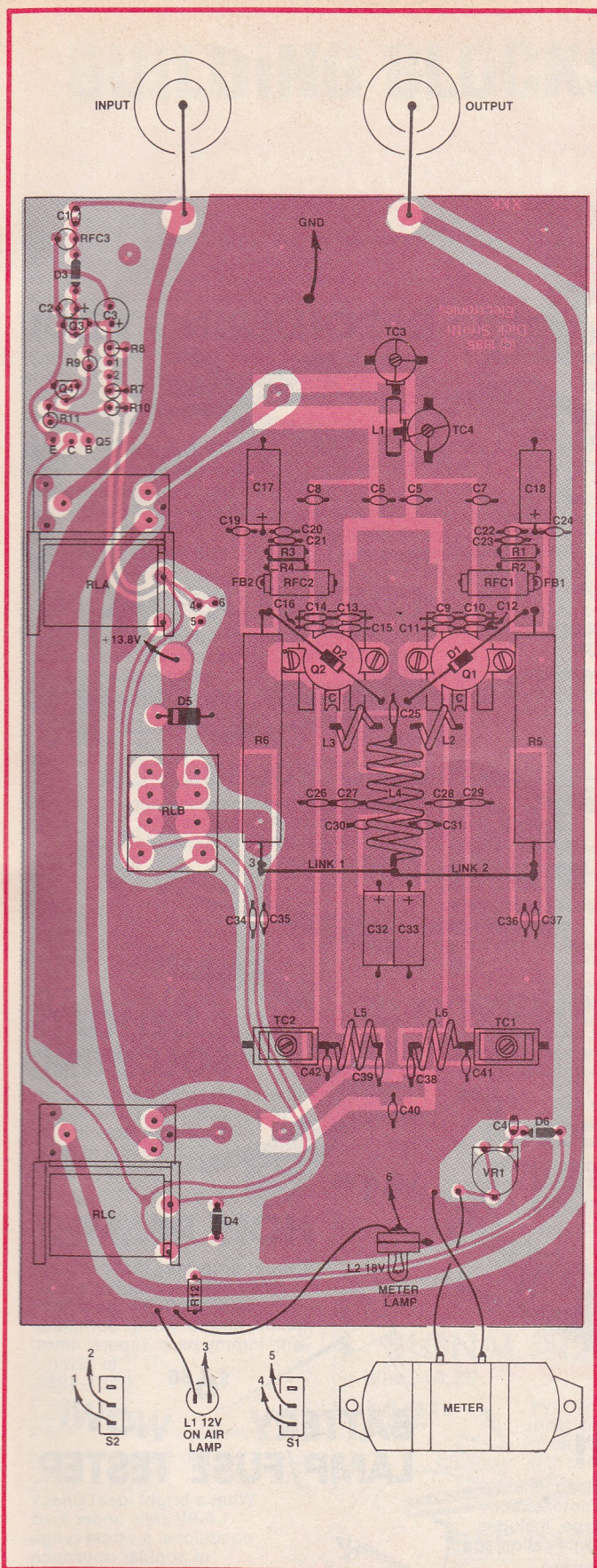


Fig. 1: parts layout and wiring diagram. Follow this diagram exactly when installing the parts and keep all leads as short as possible.

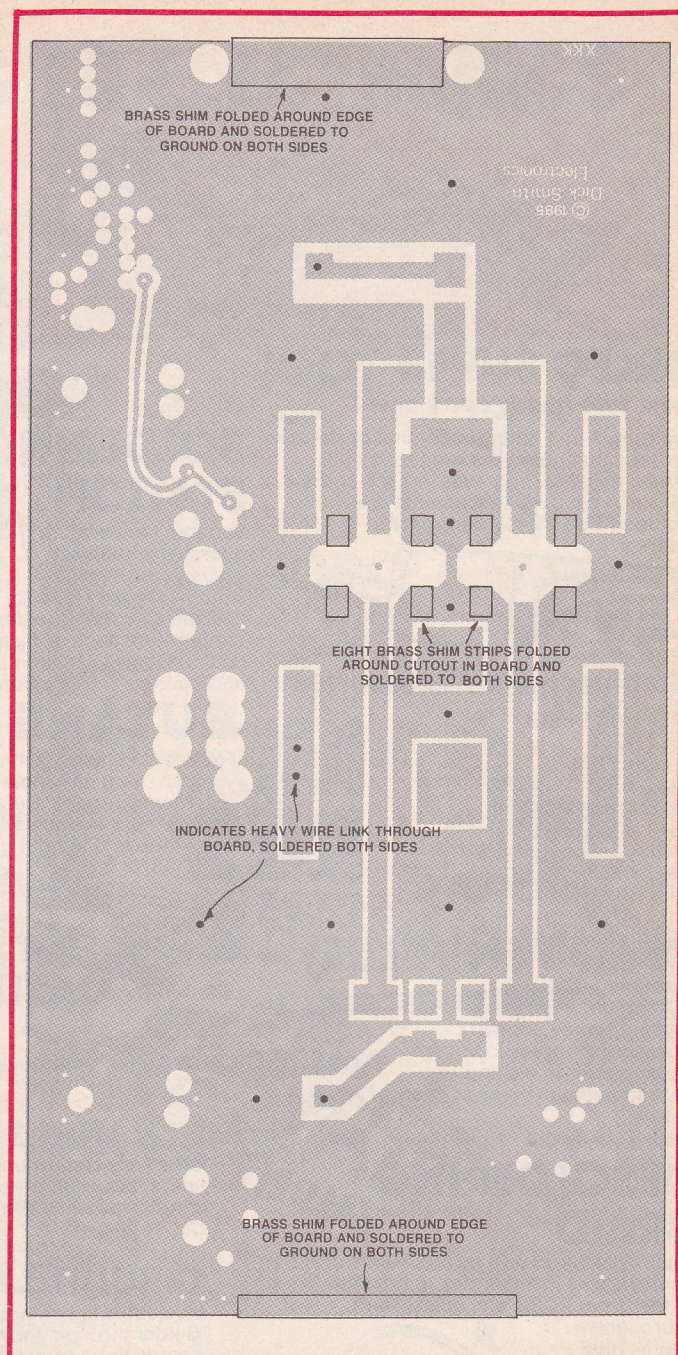


Fig. 2: this diagram shows the locations of the through-board links and brass shims (see text).

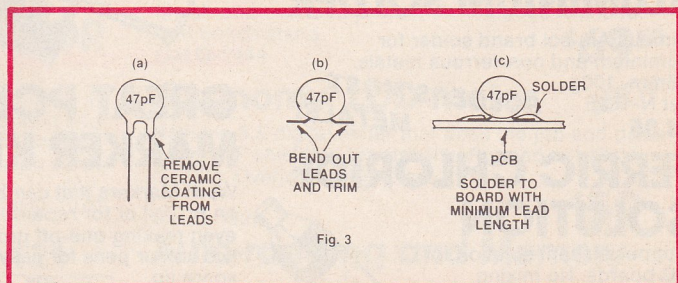


Fig. 3: the ceramic capacitors are all soldered to the top of the board, except for C1 which is mounted in the conventional manner. Trim the leads as shown in the diagram.

## PARTS LIST

### Semiconductors

Q1, Q2 — 2SC2694 RF power transistor  
Q3, Q4 — BC547 NPN transistor  
Q5 — TIP31B NPN power transistor  
D1, D2 — 1N4002 diode  
D3, D4 — 1N914 diode  
D5 — 1N5404 diode  
D6 — OA91 germanium diode

### Capacitors

C1 — 1pF 50V ceramic  
C2 — 10 $\mu$ F 25V PC electrolytic  
C3 — 100 $\mu$ F 25V PC electrolytic  
C4, C19, C20, C22, C24, C30, C31, C35, C36 — 0.001 $\mu$ F 50V ceramic  
C5-C8 — 100pF 50V ceramic  
C9-C16, C21, C23, C26-C29, C34, C37 — 47pF 500V ceramic  
C17, C18, C32, C33 — 100 $\mu$ F 25V axial electrolytic  
C25, C38, C39 — 100pF 500V silver mica  
C40-C42 — 12pF 500V silver mica  
TC1, TC2 — 4-40pF trimmer  
TC3, TC4 — 5-70pF trimmer

### Resistors (0.25W, 5% unless noted)

R1, R3 — 2.2 $\Omega$   
R2, R4 — 10 $\Omega$   
R5, R6 — 33 $\Omega$ , 10W  
R7, R9 — 10k $\Omega$   
R10, R11 — 1k $\Omega$   
R12 — 100 $\Omega$   
VR1 — 10k $\Omega$  horizontal trimpot

### Other parts

S1, S2 — SPST toggle switch  
L1 — 12V lamp bezel (red)  
L2 — 18V meter  
M — edge level meter  
RFC3 — 22 $\mu$ H RF choke  
RLA, RLC — coaxial relay  
RLB — Fuji HH62B relay  
FB1, FB2 — FX115 ferrite bead

### Miscellaneous

PC board, metal work and heat-sink, SO-239 sockets, elephant-tide insulation, 0.1mm brass shim, in-line cable clamp, red and black heavy-duty power cables, 25A in-line fuse, cable ties, rubber grommet, nylon washers, machine screws and nuts, self-tapping screws, enameled copper wire (0.5, 1, 1.3, 1.6mm dia.).

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## Construction

Construction is straightforward with most of the parts mounted on a double-sided PC board coded ZA-1661 and measuring 128 x 250mm. This is mounted on a large finned heatsink which forms the top of the case and provides heatsinking for the two RF power transistors.

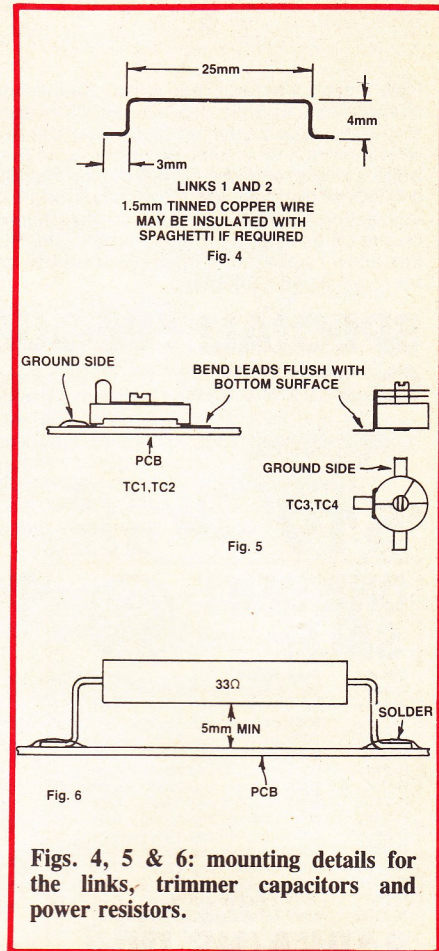
A black anodised base and two end panels complete the case.

To make construction really easy, Dick Smith Electronics will be supplying the metalwork and heatsink predrilled. In addition, the front panel features white screened lettering on a black background to give the unit a really professional appearance.

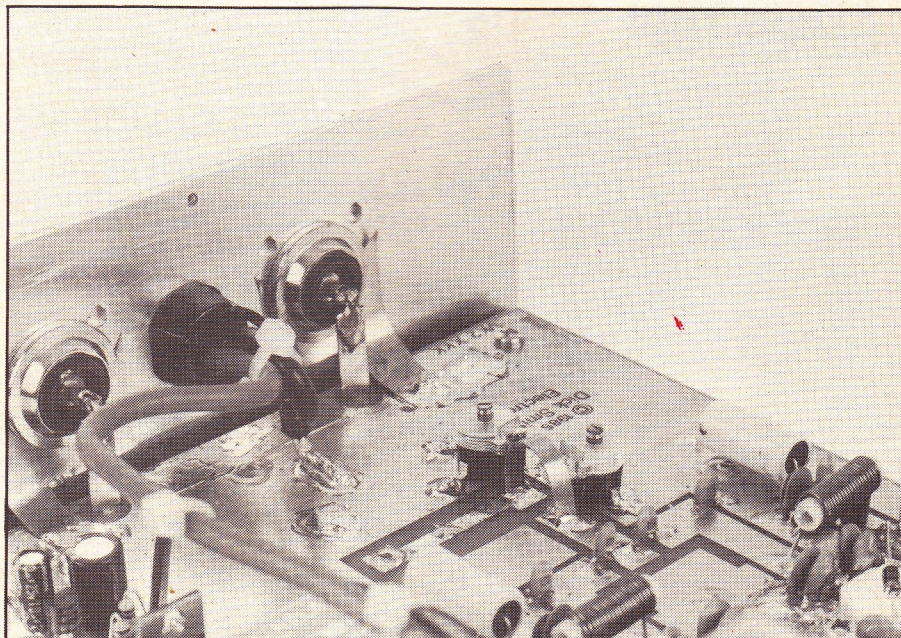
Begin construction by fitting the through-board links to the board as shown in Fig.2. There are 19 through-board links in all and these should be installed using 1.6mm diameter tinned copper wire.

With the links installed, the next step is to fit the brass shims in the positions indicated. These will have to be cut from the 100 x 100mm sheet provided.

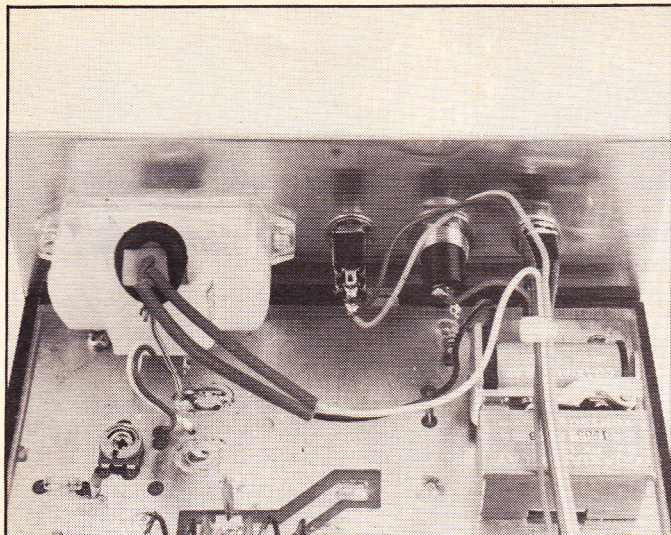
Begin by cutting eight 4 x 12mm strips, one 10 x 53mm strip and one 20 x 40mm strip. This done, fold each strip in half and fit them to the PC board as shown in Fig.2. Note that the shims



Figs. 4, 5 & 6: mounting details for the links, trimmer capacitors and power resistors.



This close up view shows how link L1 and its adjacent trimmer capacitors are mounted. The power cables are secured using a cord-grip grommet.



View of the front panel. Note mounting details for the meter lamp bezel.

must be soldered to both sides of the PC board.

The real job of installing the parts on the PC board can now be tackled. Note that because the circuit works at VHF, all leads must be kept as short as possible. For this reason, most of the components are soldered to the top of the PC board.

This means that the layout diagrams must be followed carefully when installing the parts. In most cases, there are no holes to guide the constructor.

Some parts are, however, mounted conventionally. Where possible, their leads must be soldered on both sides of the board.

Fig.1 shows the parts layout on the

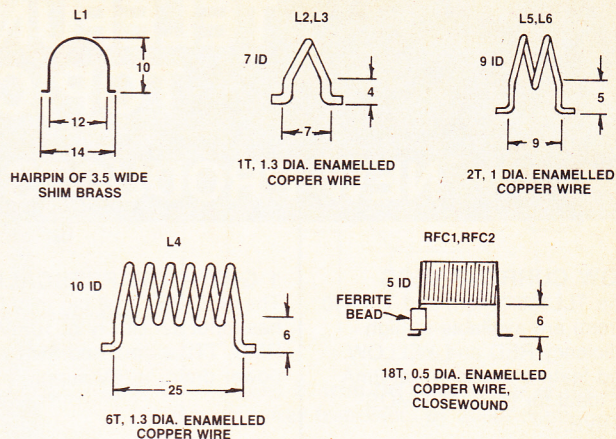
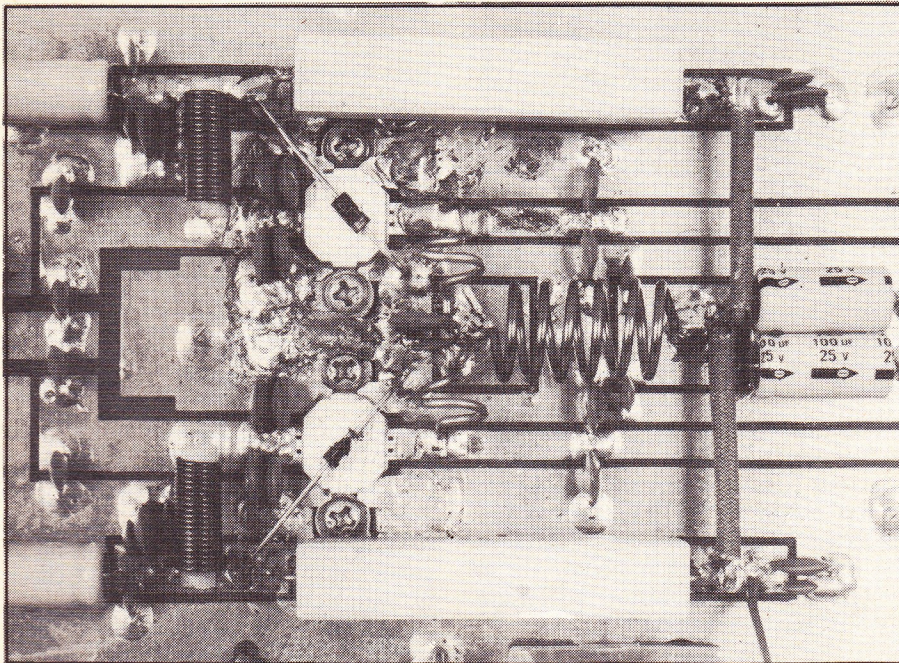


Fig. 7 DIMENSIONS IN MILLIMETRES

Fig. 7: coil winding details. The coils are all air-wound using metric drill bits as the coil formers.

PC board. No particular order need be followed when assembling the board but we suggest that the resistors, capacitors (but not C9-C16), links and diodes (but not D1 and D2) be installed first. Fig.3 shows how the ceramic capacitors are mounted (except for C1 which is mounted in the conventional manner), while Fig.4 shows the details for Link 1

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The two RF transistors are bolted directly to the heatsink and their leads soldered to the brass shims. Note mounting details for D1 and D2.

and Link 2.

Note that resistors R5 and R6 become quite warm during operation and should be stood off the board by about 5mm (see Fig.6). Capacitors C9-C13 are installed after the two RF power transistors are installed and should be left out of circuit for the time being.

The trimmer capacitors can be installed next. These must be correctly oriented, otherwise the adjusting screws will have high RF voltages on them. Fig.5 shows the mounting details for the two different types of trimmer capacitors.

Installation of transistors Q3-Q5 is straightforward but Q1 and Q2 should be left off the board for the time being. We'll come to those later. Push the transistors down onto the board as far as they will comfortably go before soldering the leads.

Note that the emitter leads of Q3-Q5 must be soldered on both sides of the board. Install Q5 so that its metal tab faces relay RLA.

## Coil winding

The coils for the 144MHz Power Amplifier require only a few minutes work. With the exception of L1, they are all wound using various grades of copper wire. A set of metric drill bits can be used as the coil formers.

Fig.7 shows the winding details. Be sure to use the correct grade of wire for each coil and don't forget to install a ferrite bead on one leg of both RFC1 and RFC2. Solder each coil to the PC board as it is wound and secure the windings of RFC1 and RFC2 using epoxy adhesive.

Note: on the prototype, short lengths of spaghetti sleeving were covered with adhesive and pushed into the RFC1 and RFC2 windings.

## RF transistors

Installing the RF transistors requires a number of steps involving assembly and disassembly of the PC board onto the heatsink. Here's what to do:

(1) Position the sheet of "elephantide" insulation supplied with the kit on

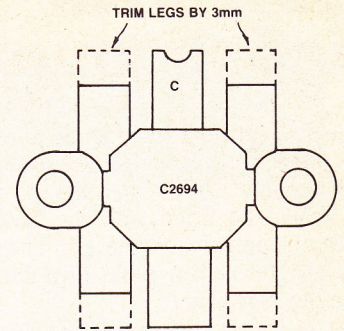


Fig. 8

Fig. 8: trim the outside legs of the RF power transistors by about 3mm.

the mounting surface of the heatsink and temporarily secure the board using machine screws and nylon washers. The latter (three per screw) are used as standoffs between the PC board and the heatsink.

(2) Mark out the transistor mounting positions, then remove the board and make two square cutouts in the insulation material so that the RF transistor cases can make direct contact with the heatsink.

(3) Re-install the PC board on the heatsink.

(4) Carefully trim the four outside legs of the RF transistors by about 3mm (see Fig.8). This done, bolt the transistors to the heatsink and solder their legs to the PC tracks and brass shims. Fig.9 shows the details.

Note that an earth lug must be fitted under each of the four mounting screws. Solder these to the ground plane on the PC board.

(5) Install capacitors C9-C16 and remove the PC board from the heatsink.

## Final assembly

Now for the final assembly. This mainly involves installing the remaining hardware and wiring up the front and rear panels (see Fig.1). Secure the meter to the front panel using epoxy adhesive.

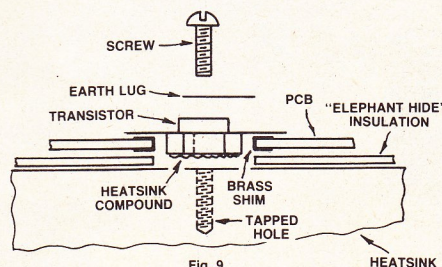


Fig. 9

Fig. 9: mounting details for the RF transistors.

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The two power supply leads must be run using the heavy-gauge insulated cable supplied. Note that the positive lead should be fitted with the 25A in-line fuse supplied with the kit. The two leads exit through a cable restraint fitted to the rear panel.

The remainder of the wiring can be run using light-duty hookup wire. This should be bound into a wiring loom using cable ties as shown in the photographs. Note that one of the leads to S1 must be soldered on both sides of the PC board.

With the wiring completed, smear heatsink compound on the underside of the RF transistors and re-install the PC board on the heatsink. The two end panels can now be secured to the heatsink using the large self-tapping screws supplied and the meter lamp mounted in position.

The accompanying photograph shows how the meter lamp is mounted. It is pushed into a rubber grommet and supported by a short length of tinned copper wire which is soldered to the PC board. The lamp is positioned over the meter by bending the copper wire.

Connections between the PC board and the rear panel sockets should be made using the brass shim and short lengths of tinned copper wire.

The input and output connections

each use a piece of brass shim measuring 4 x 15mm, with an extension lug to go through the PC board for soldering. The other ends are connected to the socket terminals with a short piece of 1.5mm tinned copper wire, as shown in the photograph.

The two earth straps are made from brass shim. The straps should be cut so as to clear the input and output connections. They are secured to the panel by the socket flanges, while the other ends of the straps should be soldered to the PC board.

Construction can now be completed by installing diodes D1 and D2. Apply a generous coating of heatsink compound to the tops of the RF transistors before soldering the diodes into circuit. Arrange the diodes so that their bodies are in contact with the transistors to ensure good thermal conduction.

## Alignment

This is quite a straightforward process but you do need access to some test equipment: (1) a multimeter, (2) a 100W dummy load (eg, DSE Cat. No. D-7030); (3) an SWR meter; (4) a 0.5-1W VHF transceiver; and (5) an RF power meter (optional).

Before commencing the alignment, there are a few precautions that must be observed. First, always use an insulated

alignment tool when making adjustments. Second, keep your fingers away from the coils and the PC pattern to prevent RF burns. And third, do not initially apply full drive to the amplifier, or damage may occur.

The step-by-step alignment procedure is as follows:

(1) Connect the output of the amplifier to the dummy load.

(2) Connect the amplifier to a 13.8V 15A power supply (eg, the VK Powermaster, EA, March 1984 or a car battery).

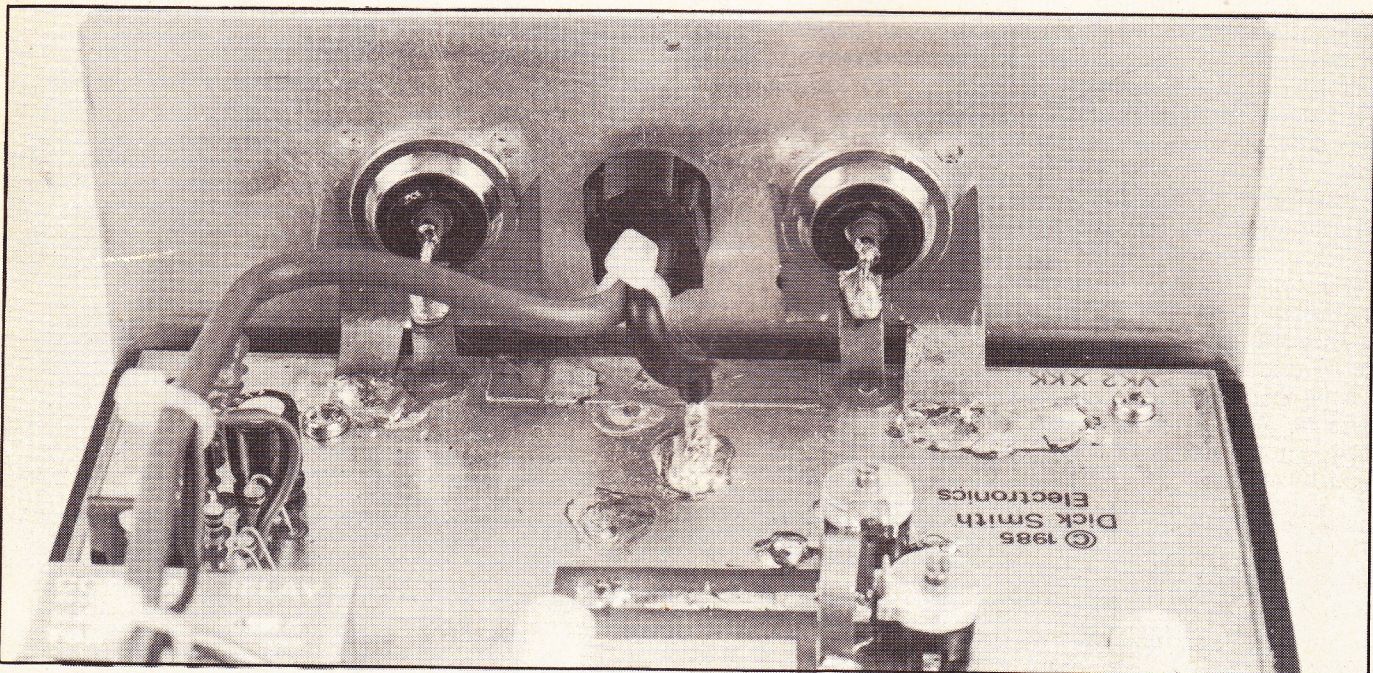
(3) Switch the amplifier to operate mode and FM. The relays should turn on and then drop out. Check that the current consumption is about 50mA at this point (due mainly to the meter lamp).

(4) Temporarily connect the +13.8V supply rail to the cathode of D3 (base of Q3). Check that the relays all operate and that the current consumption rises to about 1.2A. If the current is greater than 2A, switch off and check for wiring errors.

(5) Remove the power supply connection to D3 and set trimmer TC4 to half mesh.

(6) Connect the 0.5-1W 2-metre transceiver to the amplifier input with the SWR meter in series. Note: do not use a transceiver with a larger output at this stage.

(7) Set the transceiver to 146MHz (ie, to the centre of the band), operate the PTT switch and adjust TC3 for lowest reflected power (SWR). This done, adjust TC4 for lowest SWR and check the



The rear panel sockets are "wired" using the brass shim material and short lengths of 1.5mm tinned copper wire.



SWR at the band edges.

Repeat the adjustments until the SWR is less than 1.2:1 over the entire band.

(8) Remove the SWR meter and connect the transceiver directly to the amplifier unit. Where available, connect an RF power meter to the output. Note: keep the dummy load if the meter is not a terminating type.

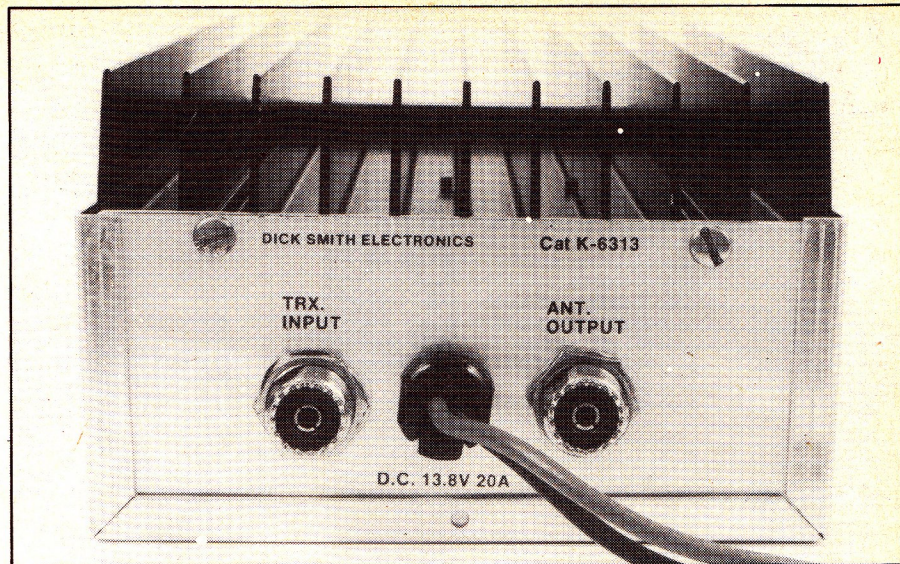
(9) Screw the adjusting screws of TC1 and TC2 down until they are finger-tight.

(10) Operate the transceiver PTT switch and alternatively back off TC1 and TC2 a fraction of a turn each for maximum reading on the power meter. The idea here is to get the two output tank circuits to resonate with TC1 and TC2 set to about the same value.

Initially, C41 and C42 should be in-circuit. Remove them if TC1 and TC2 cannot be conveniently adjusted to bring the tank circuits to resonance (ie, if the adjusting screws become loose).

(11) If no RF power meter is available, use the output meter built into the amplifier. Use VR1 to adjust the meter sensitivity if the reading is initially too low to register.

(12) Connect a 5W 2-metre transceiver to the input, operate the PTT switch and re-adjust TC3 and TC4 for maximum output. This done, re-adjust TC1 and TC2 but make sure that their



The rear panel accommodates the two SO-239 sockets and the cord-grip grommet. Use good-quality 50Ω coax for all input and output connections.

values are kept as equal as possible.

Note: a 10-15W transceiver can be used for this step, provided that you proceed with caution. Operate the PTT switch for short periods of time only (a few seconds) when making adjustments to prevent damage to the amplifier.

(13) Remove the drive and check that the current consumption drops to around 50mA when the relays drop out.

(14) Switch the amplifier to SSB and apply drive (ie, a carrier) until the relays pull in. Remove the drive and

check that the current consumption drops to around 1.2A before the relays drop out, then to about 50mA.

(15) Connect a 10-15W transceiver and repeat step 12 to ensure maximum output. Adjust trimpot VR1 so that the amplifier meter reads full scale at maximum drive. That completes the alignment.

## Operation

The amplifier can be driven by any 2-metre transceiver with an output power of up to 15W. Do not apply more than 15W of drive, otherwise the RF power transistors will be over-driven and may burn out.

Similarly, the RF transistors may also burn out if the amplifier is driven into mismatched loads (SWR greater than 2:1). Check the antenna SWR before connecting up the amplifier and always use good-quality 50Ω coaxial cable for the input and output connections.

Finally, it is normal for the output power of the amplifier to drop by about 10% after a few minutes of continuous operation due to the action of the compensation diodes (D1 and D2).

## Where to buy the kit

This project was developed by the Research and Development Department at Dick Smith Electronics Pty Ltd. It is being marketed as a complete kit of parts and can be obtained by mail order or from your nearest Dick Smith store.

The kit comes complete and includes anodised and screen-printed metalwork (supplied pre-drilled), a fibreglass PC board, and a detailed construction manual. The cost is \$249 plus postage and packing charges where applicable.

Mail orders should be sent to: Dick Smith Electronics Pty Ltd, PO Box 321, North Ryde, NSW 2113. Phone (02) 888 2105.

Note: all PC artworks copyright Dick Smith Electronics Pty Ltd.

### Table 1

Input power (watts CW)	Power output (watts CW)	Current consumption (A)
2W	43W	9A
3W	55W	10A
4W	66W	11A
6W	85W	12A
7W	90W	12.5
8W	98W	13A
9W	100W	13.2A
10W	110W	14A
15W	120W	15A

### Table 2

Frequency (MHz)	Power output (watts CW)	Current consumption
144	110	14.0A
145	110	14.0A
146	110	14.0A
147	110	13.5A
148	110	13.5A

Note: all readings in Table 1 and Table 2 taken with 13.8V supply.