DIRECT CONVERSION SHORT WAVE RECEIVER

by Chris Barlow

- ★ Receives Speech (SSB, DSB, AM) and Morse (CW)
- ★ Choice of Amateur band, 160 metre – 10 metre
- ★ Reduction drive 'Vernier' tuning
- ★ Tuned Active front end
- ★ Signal strength meter
- ★ Buffered RF Oscillator output
- ★ On-board Voltage regulator and Audio power amplifier

Specification of Prototype

RF Specifications (80 Metre version)

Tuning Range:	3.490MHz – 3.810MHz
Frequency Stability:	Less than 100Hz/hour drift after 30 minute warm-up
Sensitivity:	0.1µV for a readable signal 0.3µV or less for 10dB (S+N)/N
Oscillator Output:	450mV RMS off load 100mV RMS into 50Ω load

AF Specifications

Bandpass:	2.8kHz at –6dB (175Hz – 3kHz)
Dynamic range:	90dB
Signal to Noise:	40dB
Power Output into 8Ω:	1W RMS
Distortion:	1%
Tape Output:	100mV RMS into 47kΩ
Headphone Output:	8Ω – 32Ω Mono/Stereo

DC Specifications

Unregulated Power Input:	15 – 20V
Regulated Power Input:	10.5 – 14V
Quiescent Current at 12V:	147mA
Current at full Output:	295mA

Introduction

The receiver described in this article has been designed to have many of the features found on sophisticated ready-made short wave radios. The cost of such radio equipment is generally quite high and this can discourage newcomers to the hobby. However, good results can be achieved using relatively simple home-constructed receivers of the direct conversion design. This type of receiver has the advantage of simplicity of construction and ease of alignment, with the minimum of test gear.

The frequency range of the short wave bands start as low as 1.7MHz and extends up to 30MHz. To include all these bands on one receiver would present switching and tracking problems that would result in a compromise in its performance. For this reason it was decided that the receiver would cover only one band, but which one? Within the short wave spectrum there are segments allocated to amateur radio operators. These are people located all over the world pursuing the hobby of long distance communication using privately owned radio equipment.

There are six main amateur bands, with the addition of three new ones, and the choice of band is entirely up to you. However, the 80 metre band, admittedly not the best band for long distance reception will provide European stations after dark and British amateurs during daylight hours. When conditions are favourable and a suitable aerial is used, stations from further afield can be received, such as America, Africa and Australia. A popular higher frequency band is 20 metres, however this and even higher bands are affected by changes in world wide environmental conditions of the upper atmosphere. This tends to leave them inactive or 'dead' for much of the time and this fact should be taken into consideration when choosing the tuning pack associated with this project. A complete list of the HF amateur bands showing the relevant tuning pack you should use is shown in Table 1. DON'T FORGET TO ORDER THE TUNING PACK WHEN ORDERING YOUR RECEIVER KIT.

Direct Conversion

A direct conversion receiver achieves in one signal conversion operation what a superhet achieves in two or more. This is done by mixing the incoming RF signal in a non-linear device with a locally generated RF carrier close to the frequency of the incoming signal. One of the resulting products is the audio modulating frequency when receiving single sideband (SSB) or a beat frequency when receiving morse code (CW). This audio signal is then filtered out from the other unwanted mixer products and amplified, forming the audio output of the receiver.

Circuit Description

In addition to the circuit shown in Figure 2, a block diagram is detailed in Figure 1. This should assist you when following the circuit description or fault finding in the completed unit.

The receiver has two DC power inputs, regulated and unregulated. If using the regulated input, the voltage must be between 10.5 to 14V from an external DC regulated supply or batteries. When using the unregulated input, a mains adaptor such as the unregulated 1A (YM85G), set to its 12V output, will supply the necessary voltage to the regulator RG1. This will be in the order of 15 to 20V and RG1 will stabilise this voltage to 12V. It is most important that the DC supply be connected in the correct polarity, with the positive (+V) going to the centre pin of the DC connector SK1 or SK2.

When the power switch S1 is turned on the supply is connected to the main decoupling capacitor C3 and the front panel indicator LD1. LP1 is a wire-ended filament bulb mounted behind the signal strength meter to provide back illumination. The +12V supply then feeds a second voltage regulator, RG2, which is a variable output type and is set to produce +8V by the resistors R2, 4, 5 and RV1. The preset RV1 is a 22-turn cermet type, which is used when setting up the highly accurate +8V varicap tuning reference. R3, C6 and C7 provide yet more supply decoupling for the rest of the circuit. For the op-amps to function correctly a half supply reference must be generated, this is provided by one half of IC2. The voltage reference applied to the input of this op-amp is derived from the two resistors R6 and R7 which form a potential divider. The op-amp is merely used as a zero gain buffer to provide a low impedance half supply, its output being de-coupled by C80.

The aerial and earth from SK5 connects to pins P10,11 on the circuit board. To reduce the amount of 'out of band' signals reaching the RF amplifier, a series tuned circuit comprising of T1 and C10 is used. At its resonant frequency this circuit has a low impedance and will allow the RF to pass into the low impedance winding of T2. However, to all other frequencies this circuit appears as a high impedance, thus reducing the level of unwanted RF energy reaching T2. The output of T2 is a parallel tuned circuit, with C12, TC1 and the varicap diode VC1 controlling its resonant frequency. The RF signals across this circuit are then applied to the high impedance 'gate one' input of TR1. The other gate has a variable DC bias applied to it, derived from RV2, R19 and is de-coupled to RF by C14. As the bias voltage is increased,

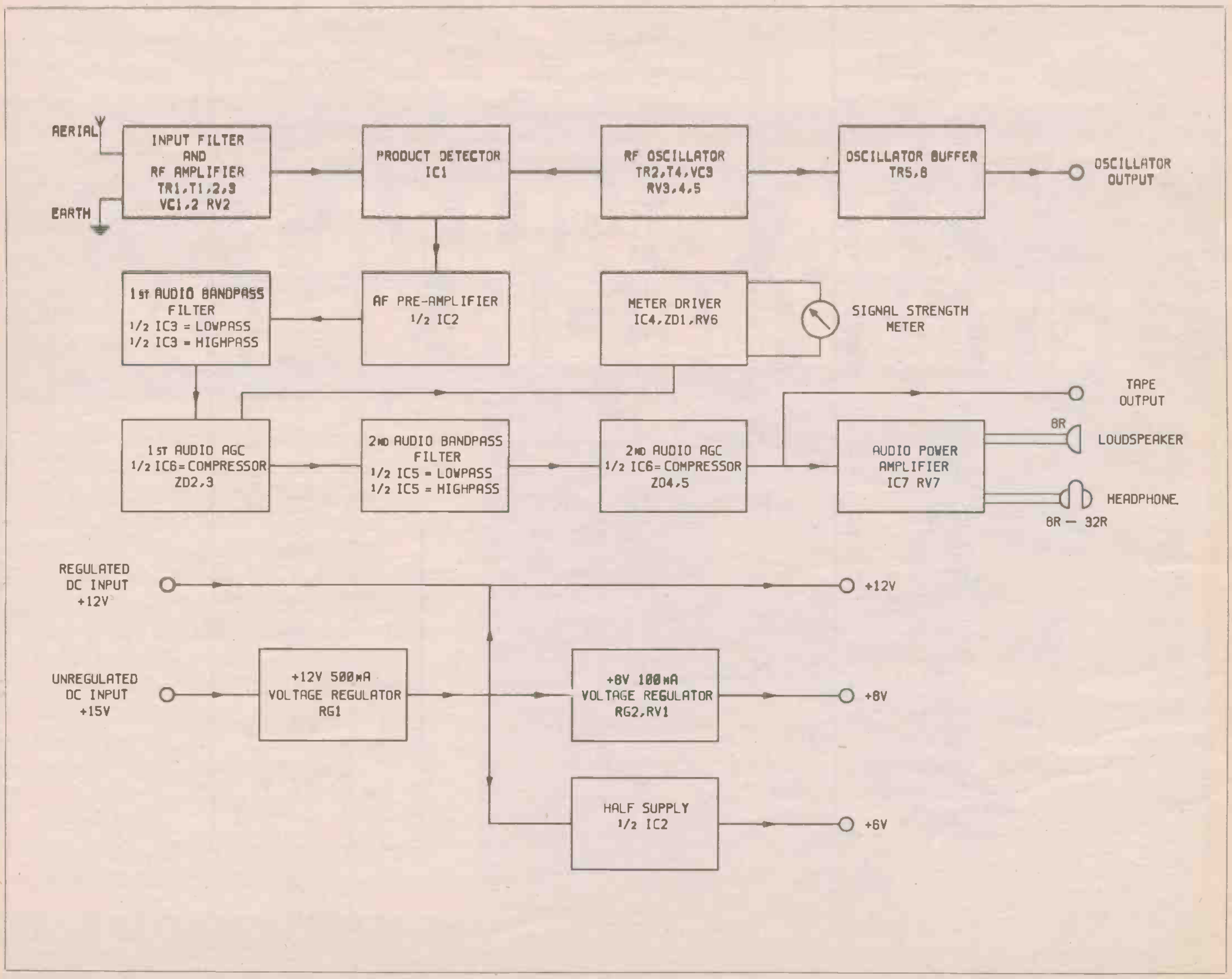

Figure 1. Block diagram.

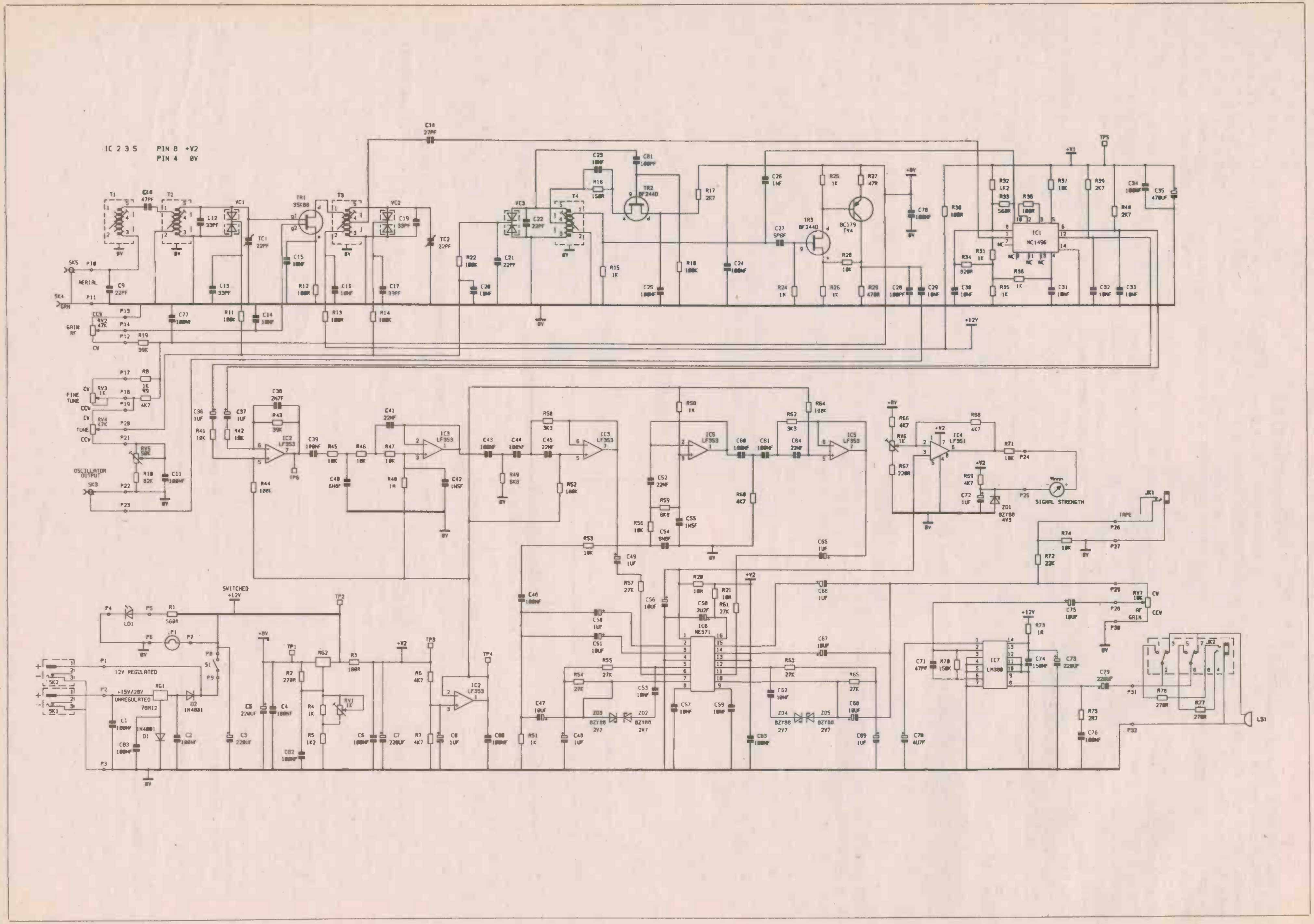

Figure 2. Circuit.

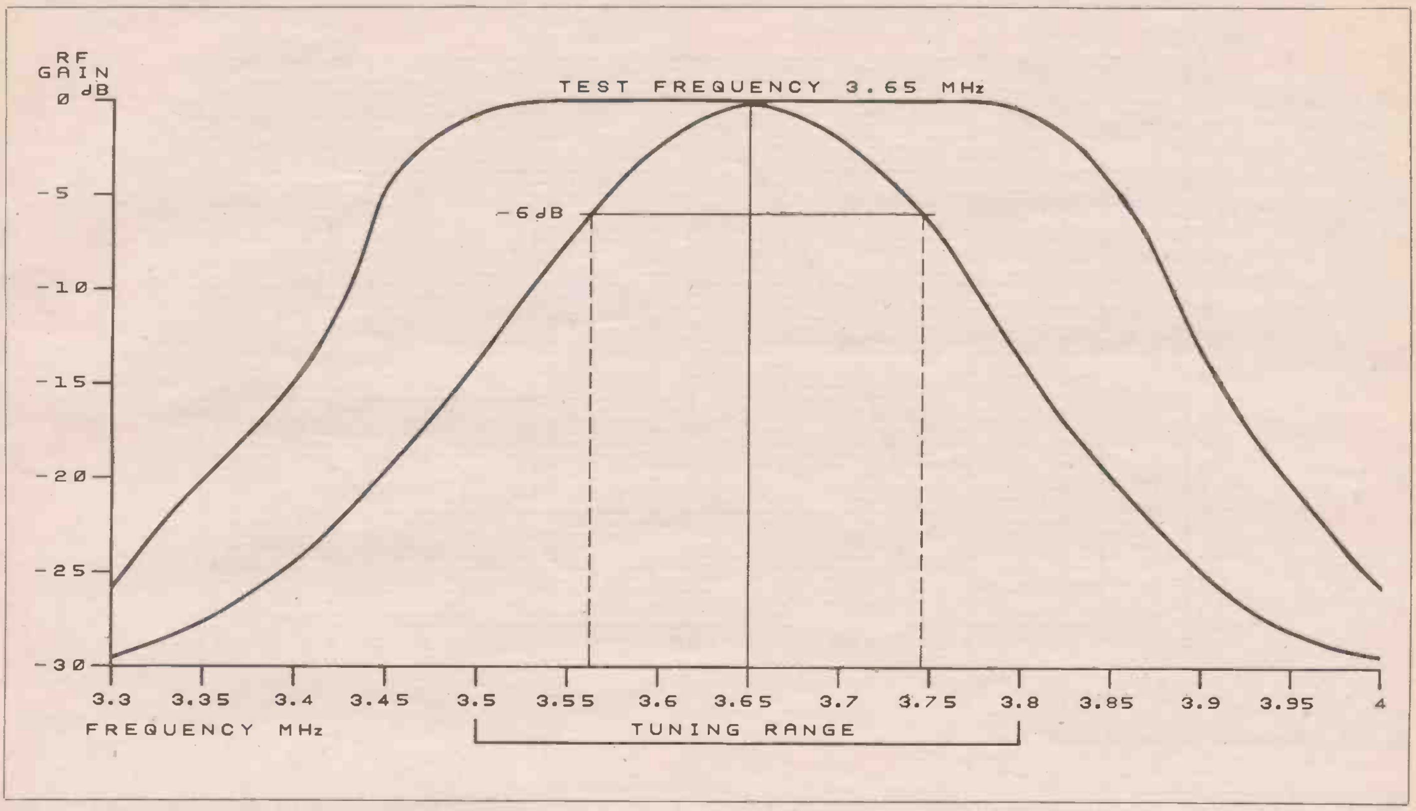

Figure 3. RF filter and amplifier response (80 metre version).

the gain of the amplifier will increase to provide almost 20dB of gain. The low impedance winding of T3 is placed in the drain of TR1 and its output is tuned by C19, TC2 and VC2. The RF signals are then taped off and fed via C18 to the product detector IC1. A graph showing the tuning and bandpass response of the prototype 80 metre front end is illustrated in Figure 3.

The RF oscillator consists of an FET transistor TR2 and T4 being tuned by C22, VC3, in the Hartley configuration. The output is taken from the low impedance winding of T4 and is fed to the product detector via C26. The output is also taken via C27 to a broad band buffer, comprising of TR3 and TR4. This provides a low impedance output for driving frequency counters or other devices. The DC bias used to tune the oscillator and RF amplifier is generated by a chain of resistors. The high end is set by the value of R8 and fine tuning is provided by RV3. RV4 is used for the main tune control, with the 22-turn preset RV5 and R10 setting the low frequency limit. A plot of the frequency stability of the prototype 80 metre oscillator is shown in Figure 4.

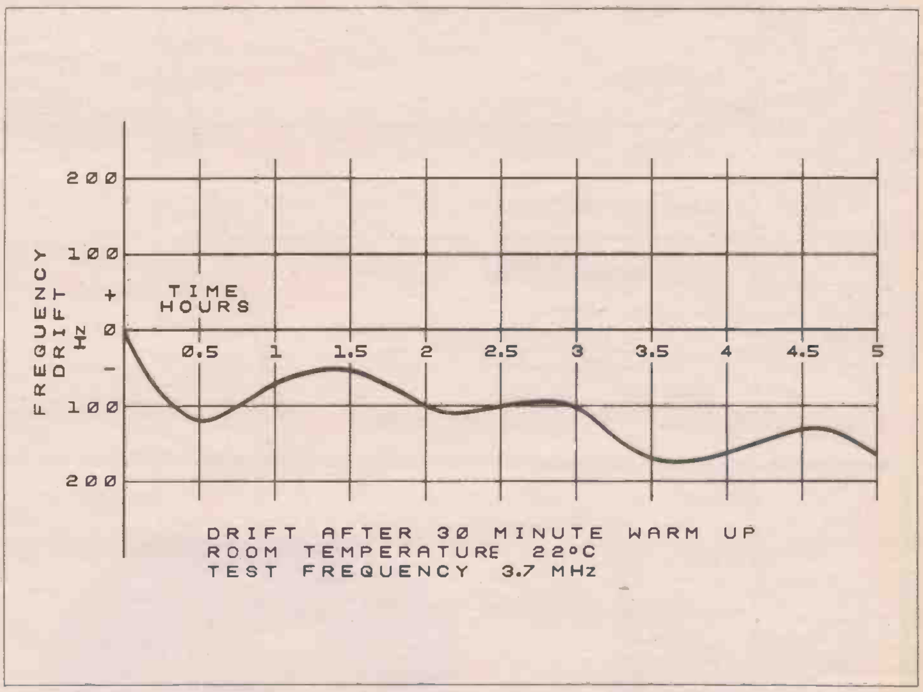

Figure 4. Frequency stability.

An MC1496 double balanced mixer IC1 is used to produce the sums and differences of the two frequencies applied to pins 1 and 10. The audio output we want is the difference frequency between the RF signals from the input amplifier and the output of the RF oscillator. IC1 produces two audio outputs which are in anti-phase to each other. These signals are fed via C36, C37 to the inverting and non-inverting inputs of IC2. This op-amp is used to produce a high level signal for the bandpass and compressor circuits.

The audio processor comprises of four stages, two bandpass filters and two compressor circuits. Each bandpass filter is made from a lowpass and highpass circuit using a dual op-amp, the first being IC3 and the second IC5. The combined effect of these filters can be seen in Figure 5. A compressor is used to provide an automatic gain control (AGC) to reduce the volume differences between strong and weak stations. The DC reference produced by the first AGC stage is used by the meter driver IC4 to indicate the strength of the signal. RV6 on pin 2 is used to set the meter zero point and as the voltage on pin 3 progressively increases from the AGC stage the meter will show a steadily rising value. The combined affect of the two compressors is shown in Figure 6 and the signal strength meter response in Figure 7.

The output from the second compressor feeds the final audio product to the tape output and the AF gain control RV7. The sound output stage IC7, the LM380, is capable of driving an 8Ω loudspeaker or 8 to 32Ω headphones. Stereo or mono phones can be used and when plugged into the quarter inch jack socket JK2 the speaker is automatically switched out.

PCB Assembly

The PCB is a double-sided, plated-through hole type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult with this kind of board so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly

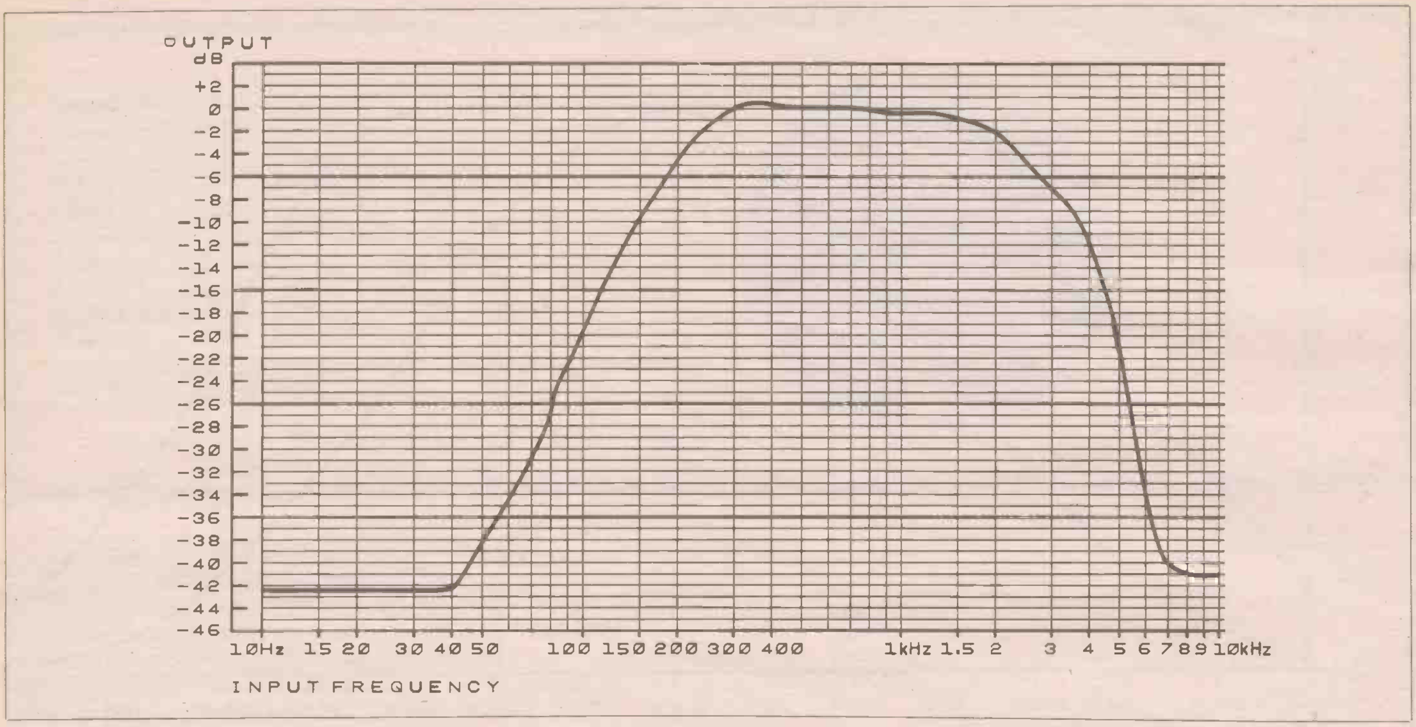

Figure 5. Audio bandpass filter response.

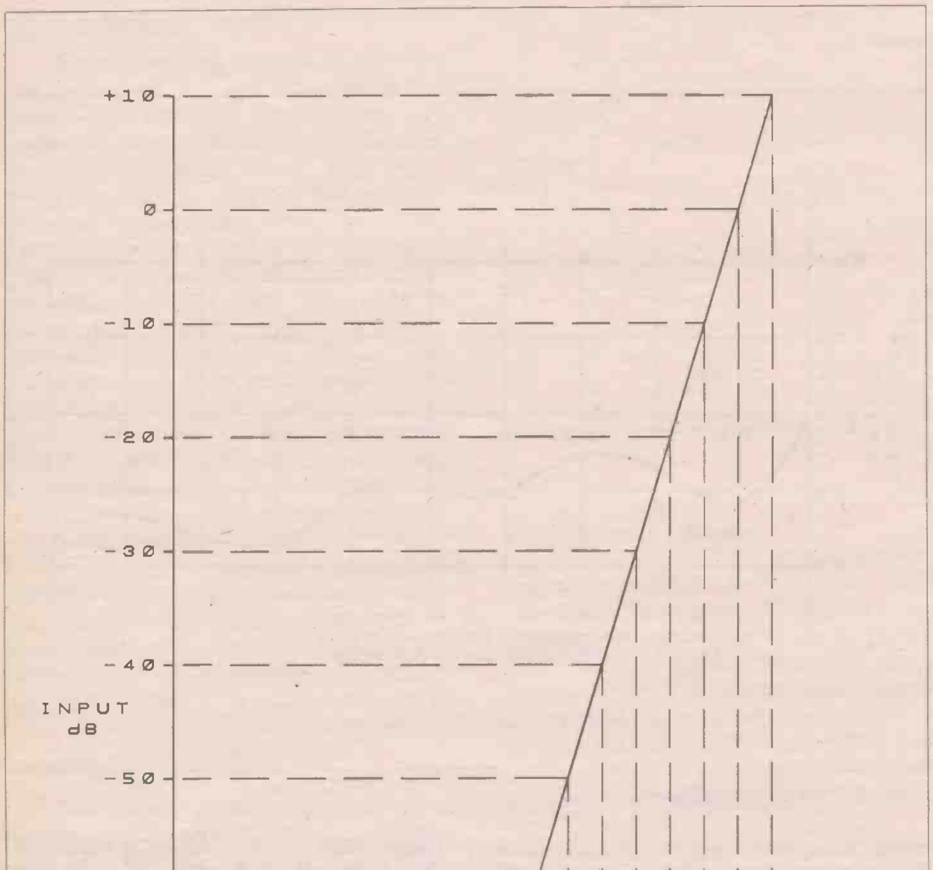

Figure 6. Input/output transfer characteristics.

positioning each item, see Figure 8. The majority of the components are supplied in the main kit (LM60Q), but some RF components have to be selected from the appropriate tuning pack for the desired band, see Table 1.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components, such as the resistors. Next mount the ceramic, polyester, polystyrene and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However on some capacitors the polarity is designated by a negative symbol (−), in which case the lead nearest this symbol goes away from the positive sign on the legend. All the silicon diodes have a band at one end. Be sure to position them according to the legend, where the appropriate markings are shown. The three varicaps VC1, VC2 and VC3 resemble transistors and you must carefully match the case to the outline shown on the legend. Next install all the transistors, matching each case to its outline. The dual gate MOSFET transistor TR1 is a surface mounting component and is shown in Figure 9. When fitting the IC sockets ensure that you install the appropriate one at each position, matching the notch with the block on the legend. Install IC1 to IC7 making certain that all the pins go into their sockets and the pin one marker is at the notched end. The RF transformers T1, 2, 3 and T4 will only fit one way, but make certain that they are pushed down firmly on to the surface of the PCB. Next install the three preset resistors RV1, 5, 6 and the two trimmer capacitors TC1, 2 and set them all to their half way positions. Install pins at the test points TP1 to TP6 ensuring that you push them fully into the board. When fitting the 'Minicon' connectors ensure that the locking tags are facing inwards, see Photo 1. Finally, mount the two voltage regulators, RG1 and RG2 in their correct positions on the board, ensuring

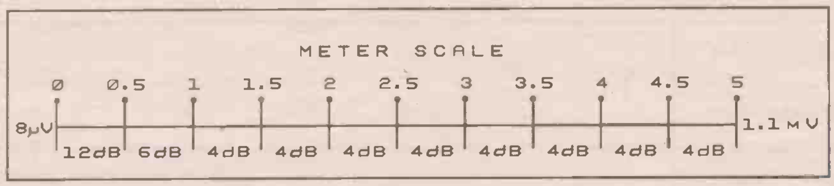

Figure 7. Signal strength meter response.

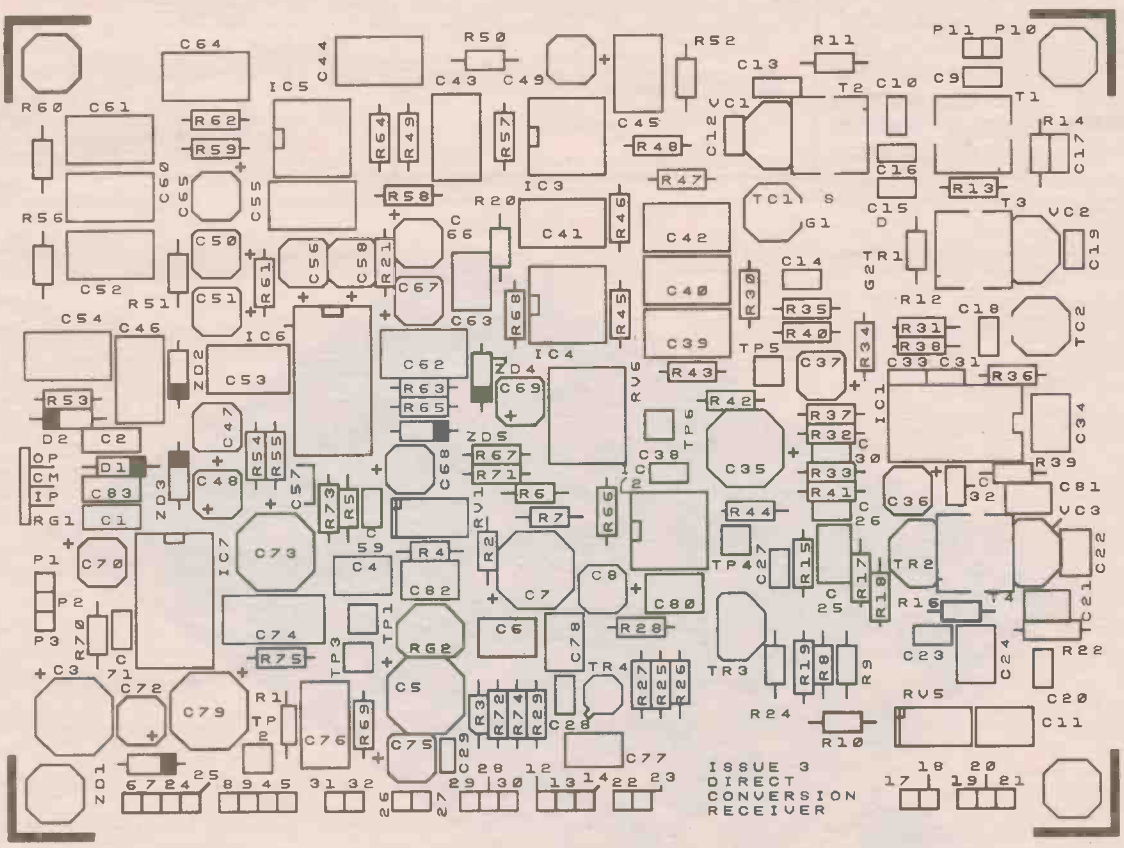

Figure 8. PCB layout.

that you fit RG1 as shown in Figure 15.

This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints are sound. It is also very important that the solder side of the circuit board does not have any trimmed component leads standing proud by more than 3mm, as this may result in a short circuit. Further information on soldering and assembly techniques can be found in the 'Constructors Guide' included in the kit. Photo 2 shows the completed PCB in clear detail.

Final Assembly

The unit is designed to fit in to a metal case type 2408/160 (Maplin code XJ33L) which is also available ready drilled (Maplin code YT05F). An internal chassis is also available for this box (XJ41U) and indeed this has been incorporated in the design, once again a ready drilled version is available (YT04E). However, if you wish to make up your own box, drilling details for the box and the chassis are given in Figure 10. Also shown in Figure 10 are details of the potentiometer mounting bracket should you wish to make your own, this item too is available ready made (JG47B). Custom made stick-on panels can be purchased to enhance the final look. When fitting ensure that the front and back metal panels of the box are clean then remove the protective backing from the self-adhesive decorative trims. Carefully position and firmly push down using a dry, clean cloth until the trims are securely in place. Photo 3 shows the rear trim.

Before fitting the headphone jack JK2 remove its forward facing locating tag. When installing the two jack sockets, position a pot washer between the steel chassis and the back of the front panel, see Figure 11. Next prepare the four rotary potentiometers by cutting the shafts to a length of 12mm. When mounting the AF, RF gain and fine tuning pots use two nuts as shown in Figure 12. Before mounting the main tuning control, rotate its shaft to its fully clockwise position. Then back it off a small amount to set the wiper onto the start of the active part of its carbon track. Set the vernier dial to read 100 and remove the small bolt at the rear of the dial. Do not remove

Amateur Band	Receiver Tuning Range	Tuning Pack	T1,2,3,4	1% 0.6W Metal Film			Ceramic Plate			Polystyrene
				R8	R9	R10	C10	C18	C12,13,17,19	C21,22
160M 1.810 – 2.000MHz	1.800 – 2.010MHz	1	KANK 3333R	22k	NOT FITTED	22k	180pF	100pF	120pF	100pF
80M 3.500 – 3.800MHz	3.490 – 3.810MHz			1k	4k7	82k	47pF	27pF	33pF	22pF
40M 7.000 – 7.100MHz	6.690 – 7.150MHz	2	KANK 3334R	10k	NOT FITTED	180k	180pF	27pF	120pF	100pF
10.100 – 10.150MHz	10.000 – 10.500MHz			1k	2k2	150k	47pF		47pF	33pF
20M 14.000 – 14.350MHz	13.990 – 14.400MHz	3	KANK 3335R	1k	4k7	180k	220pF	27pF	100pF	100pF
18.068 – 18.168MHz	18.000 – 18.500MHz				2k2	220k	180pF	15pF	68pF	68pF
15M 21.000 – 21.450MHz	20.990 – 21.500MHz					330k	100pF		47pF	47pF
24.890 – 24.990MHz	24.540 – 25.000MHz	4	KANK 3335R	1k	2k2	560k	56pF	15pF	22pF	22pF
10M 28.000 – 29.700MHz	A, 27.975 – 28.525MHz B, 28.475 – 29.025MHz C, 28.975 – 29.525MHz D, 29.475 – 30.025MHz						27pF		15pF	22pF

Table 1. Band Chart.

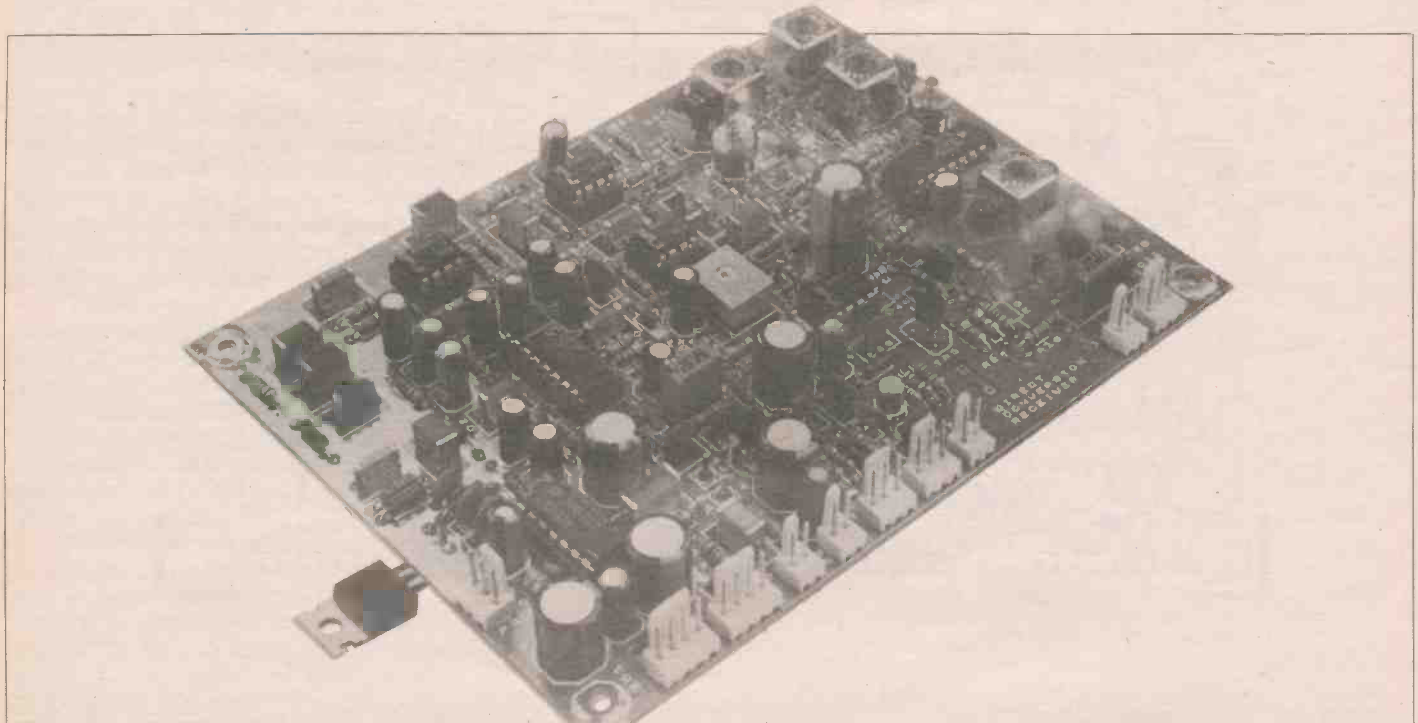

Photo 1. Note that the connector tabs face inboard.

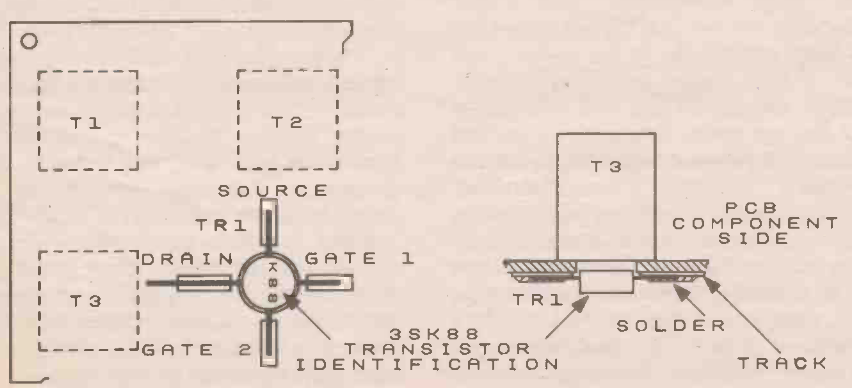

Figure 9. Mounting the dual gate mosfet.

the pot shaft retaining bolt, merely slacken it off enough to allow the shaft to enter the dial. Using M3 hardware, mount the bracket assembly and vernier dial to the front panel, as shown in Figure 13. Next, install the rest of the front panel components and secure the three knobs so that the pointers are at zero when the controls are set fully-anticlockwise.

The EARTH terminal is mounted directly onto the back panel, with the insulating bushes, solder tag and one 4mm washer being discarded, see Figure 14. Fit the two RF connectors; SK3 is the BNC and SK5 is the SO239, ensuring that both are tightly secured. The two 2.5mm power sockets are held in place using M2 bolts and do not require fixing nuts as the mounting holes are threaded.

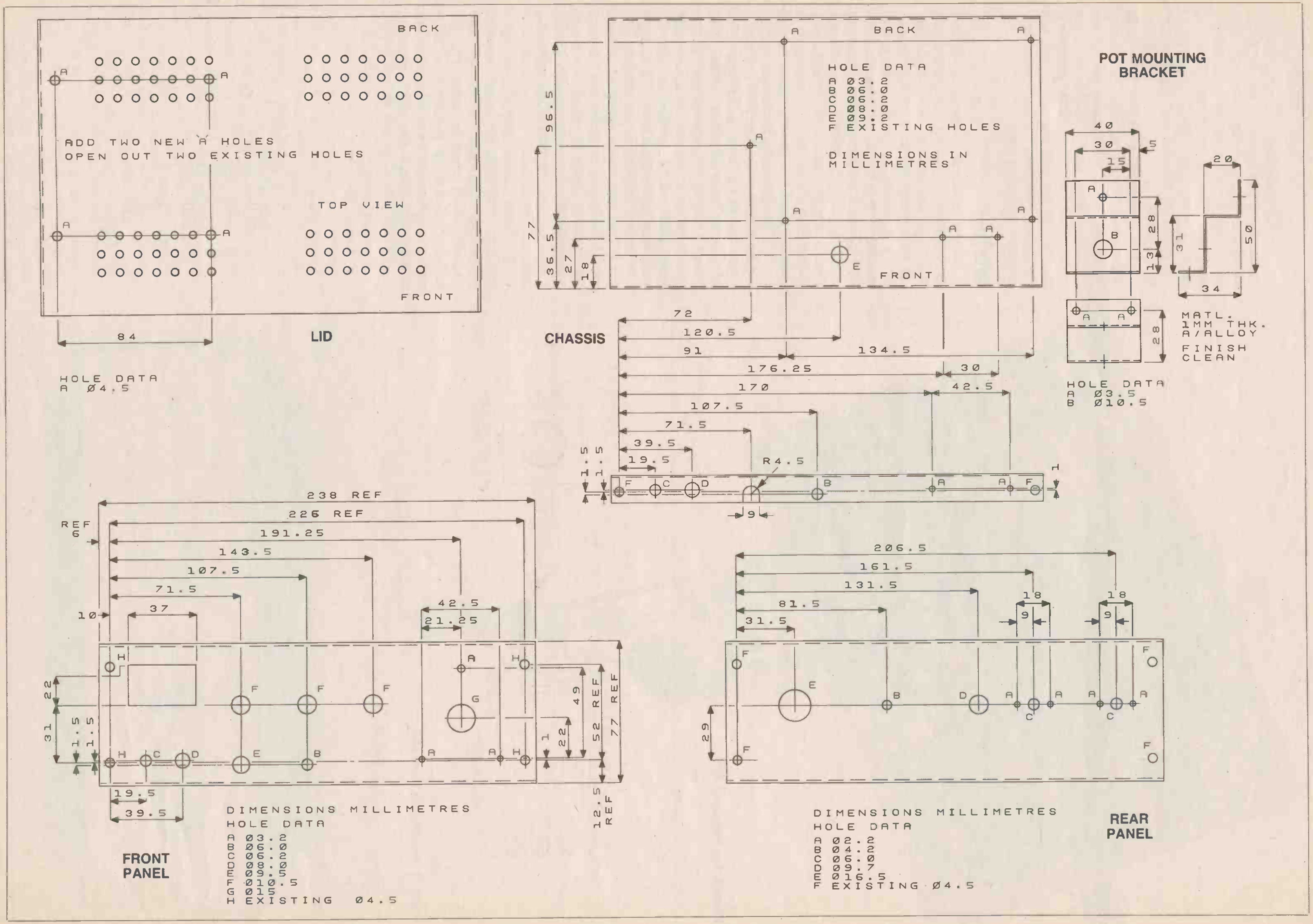

Figure 10. Mounting bracket and box drilling details.

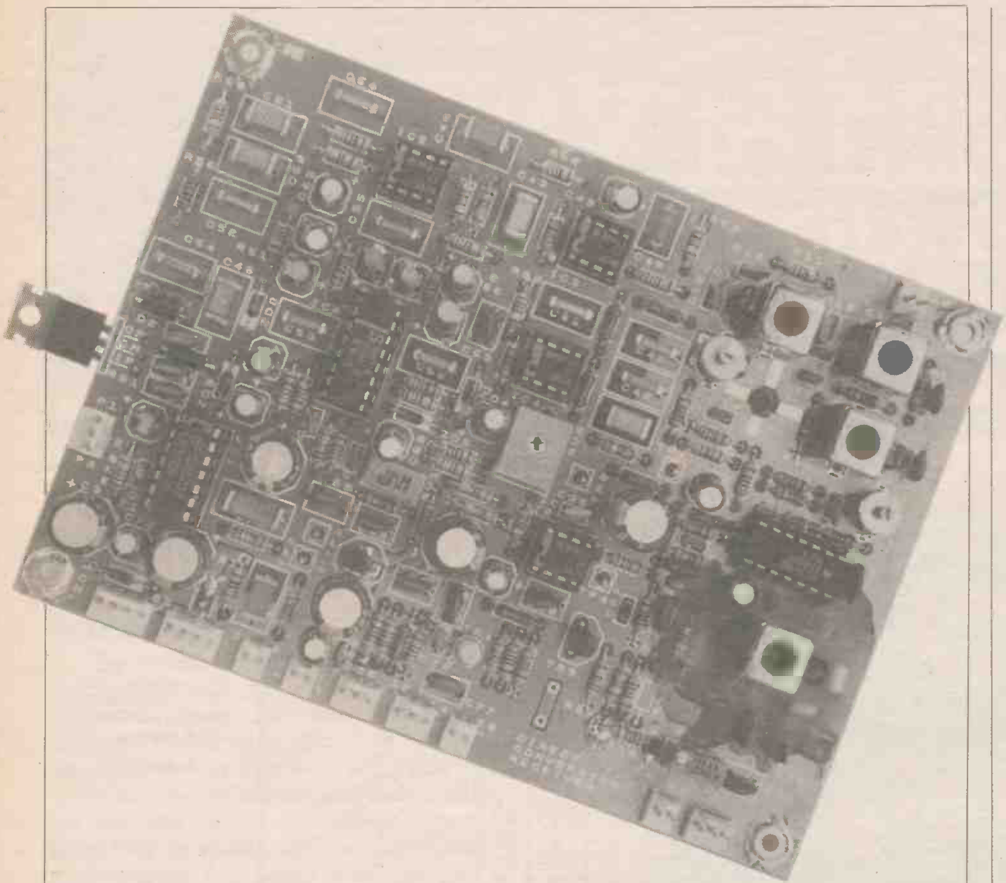

Photo 2. The completed PCB.

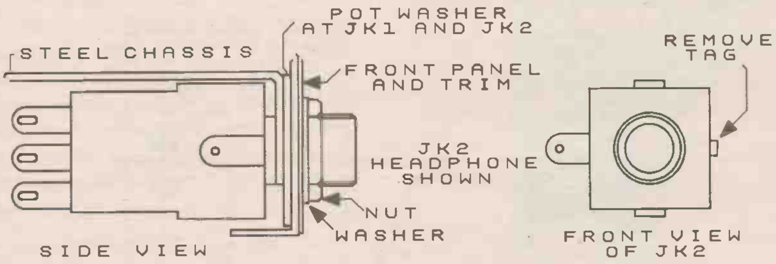

Figure 11. Mounting JK1 and JK2.

Photo 3. Rear view.

The PCB assembly is secured to the steel chassis using 6BA hardware, see Figure 15. When mounting the voltage regulator RG1 ensure that the mica washer and insulating bush are correctly positioned. It is not essential to use heat transfer compound on this device as it is run well within its safe working limits.

The loudspeaker is mounted to the top lid of the case using M4 hardware, as shown in Figure 16. The nut between the speaker and the case is used as a spacer to assist the sound output. This completes the mechanical assembly of the unit and you should now check your work very carefully before proceeding to the wiring stage.

Wiring

If you purchase a complete kit from Maplin it should contain six, one metre lengths of coloured hook-up wire. No specific colour has been designated for each wire connection, it is entirely up to you. The use of coloured wire is to simplify matters, thus making it easier to trace separate connections to off-board components, just in case there is a fault in any given part of the circuit. A wiring diagram showing all the interconnections is given in Figure 17. The wire connections to the PCB are made using 'Minicon' connectors and the method of installing them is shown in Figure 18. All the wires to the front panel components below the internal chassis pass through a small PVC grommet, see Photo 4. The connections to the headphone jack socket JK2 and the loudspeaker LS1 are made using 'figure 8' zip cable. Do not forget to fit the two link wires or the resistors, R76 and R77 on JK2. When wiring the filament bulb LP1 follow the assembly and mounting instructions in Figure 19 which shows construction details for a cardboard shroud which is used to mount the bulb on the rear of the meter, see Photo 5.

The cable used on SK3 and SK5 has a semi-conducting polythene sheath between the braided screen and the inner insulated conductor. It is most important that the semi-conducting sheath should not be able to come into contact with the centre conductor or anything connected to the centre conductor,

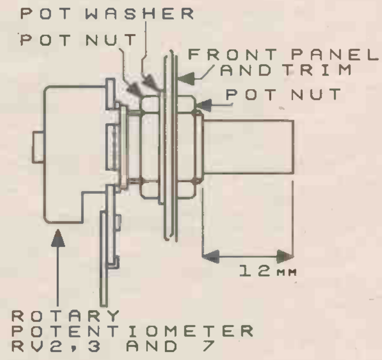

Figure 12. Mounting the AF/RF gain and Fine Tuning pots.

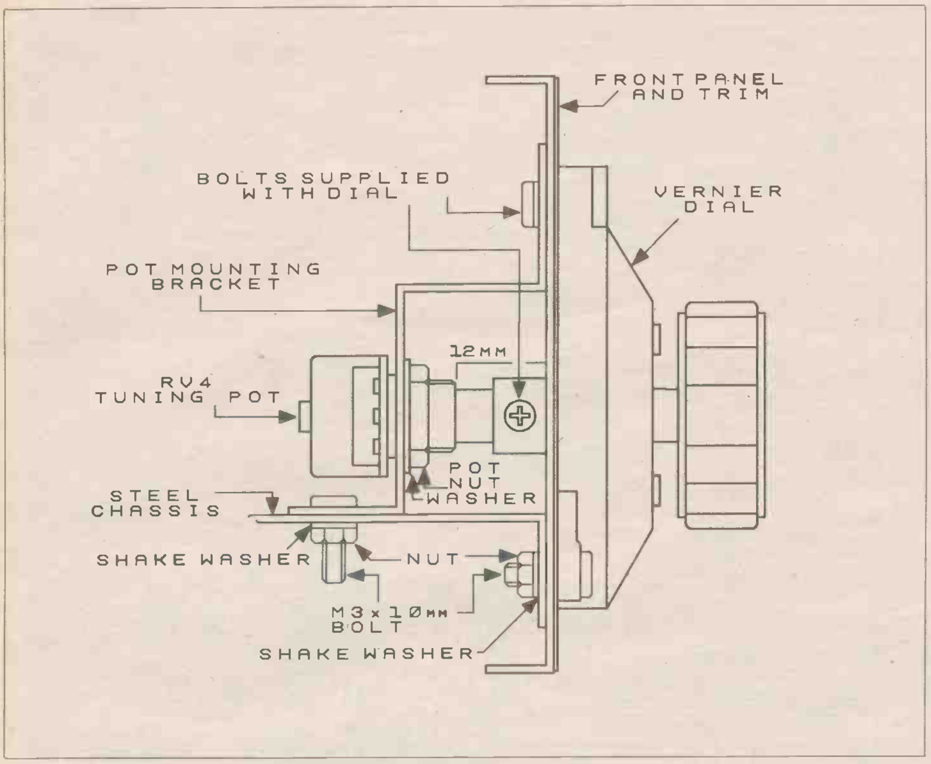

Figure 13. Mounting the Tuning pot.

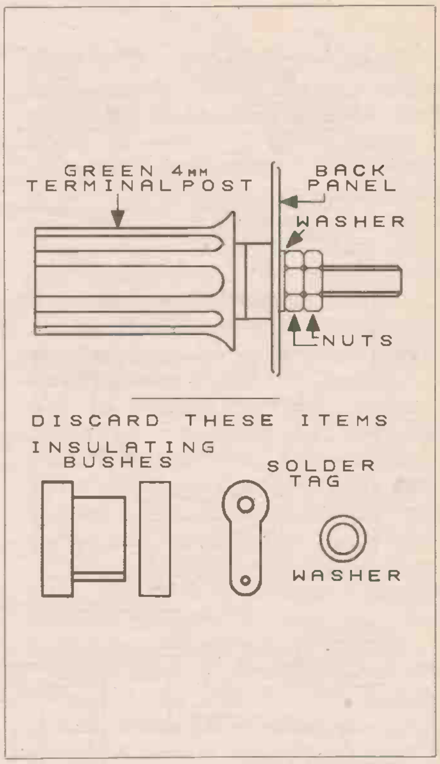

Figure 14. Fixing the earth terminal.

but that it should be stripped back to the braiding. Photo 6 shows the connections to SK3 and SK5.

This completes the wiring of the receiver and you should now check your work very carefully making sure that all the solder joints are sound.

Testing and Alignment

Before you commence testing the unit set the PCB presets and the front panel controls to the following positions:

On the PCB

RV1, RV5 and RV6 should be set to their half way positions. RV1 and RV5 are 22-turn cermet presets with a slipping clutch which should make an audible clicking sound at each end of their travel. To set them half way, simply rotate the adjustment screw until the clicking sound is heard, then reverse the direction for 11 turns.

On the Front Panel

Set the AF and RF gain controls at zero with the fine tuning set half way to its zero mark. Set the vernier to read 100 on its dial and ensure that the power switch is in the OFF position.

The power supply used during the test procedure was an unregulated 1A mains adaptor type (Maplin code YM85G) and it was set to its 12V output. The polarity switch must be set for positive (+) on the tip of the plug, otherwise damage may be caused to the receiver and power supply when connected. If you intend to use other power supplies, such as rechargeable lead-acid or nickel cadmium batteries, it is STRONGLY recommended that an in-line 1 amp fuse be placed in the positive power line. DO NOT connect the power supply until it is called for during the test procedure.

The aerial used was a 30 metre end fed long wire at approximately 10 metres above the ground. However, the aerial you use will be determined by the available space and the amateur band you have chosen. The theoretical and practical design of shortwave aerials is an involved topic which can not be covered by this article. However, a list of some of the many books available on this subject is given at the end. DO NOT connect the aerial to the receiver until it is called for.

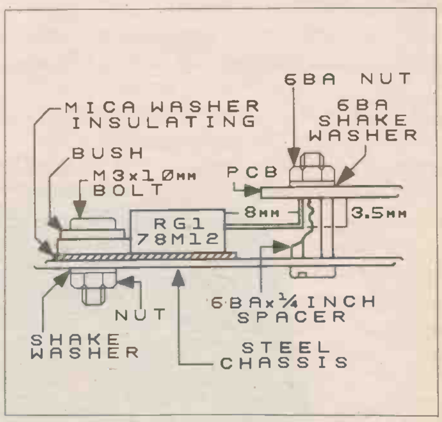

Figure 15. Mounting the PCB and Regulator.

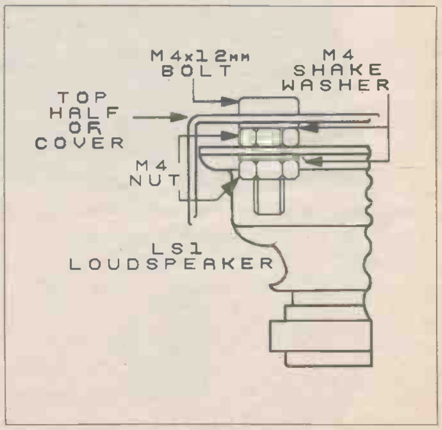

Figure 16. Loudspeaker fixing.

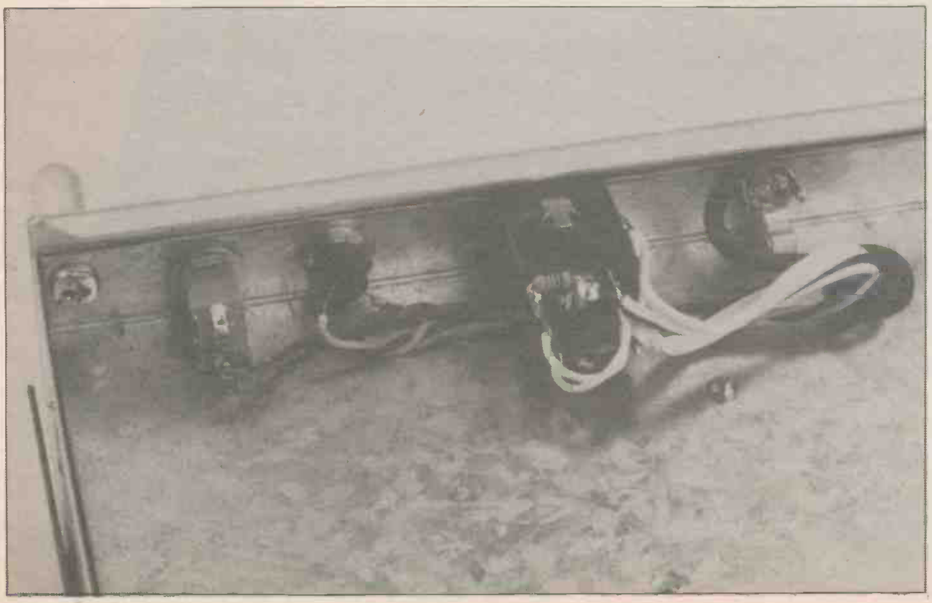

Photo 4. Under the chassis.

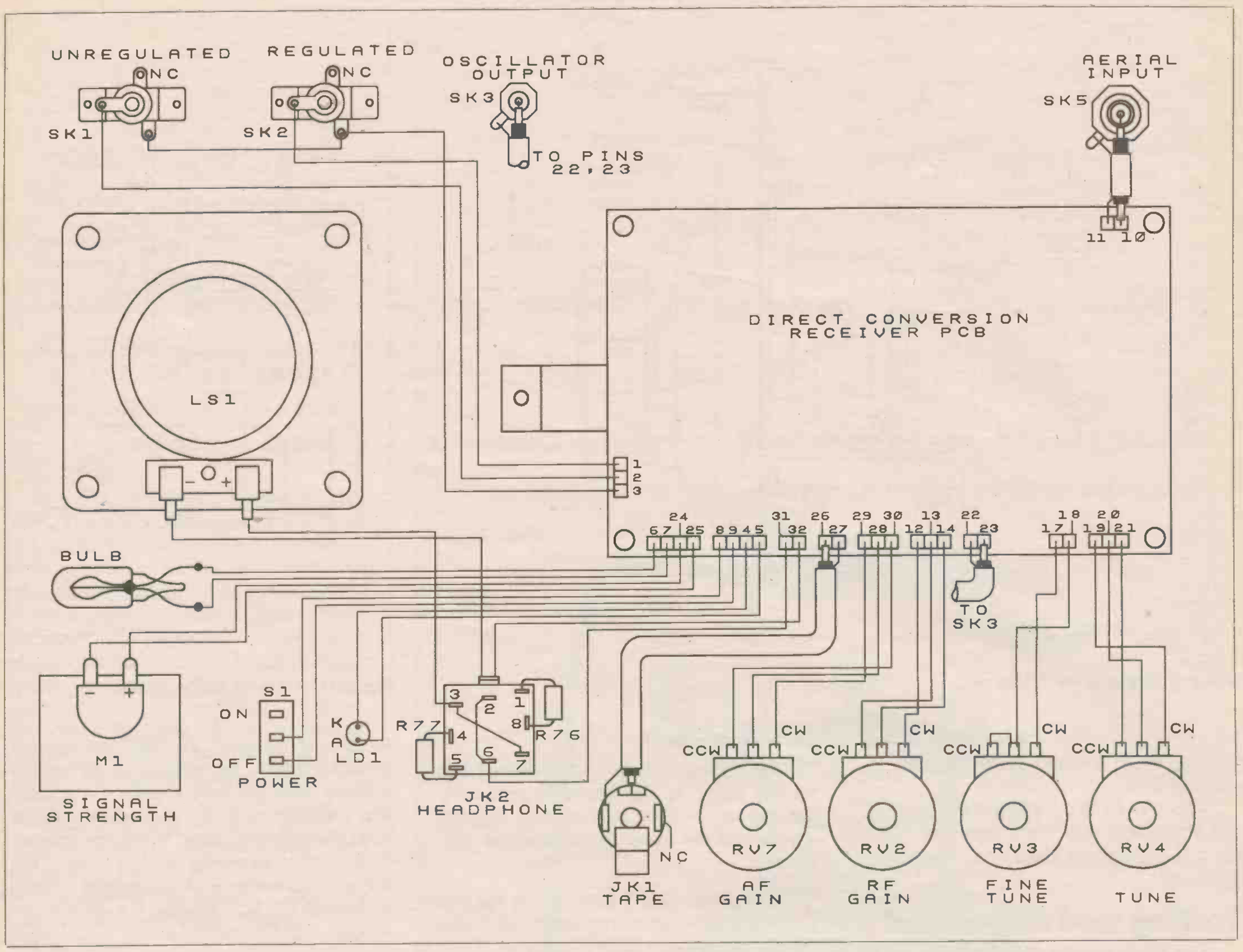

Figure 17. Wiring.

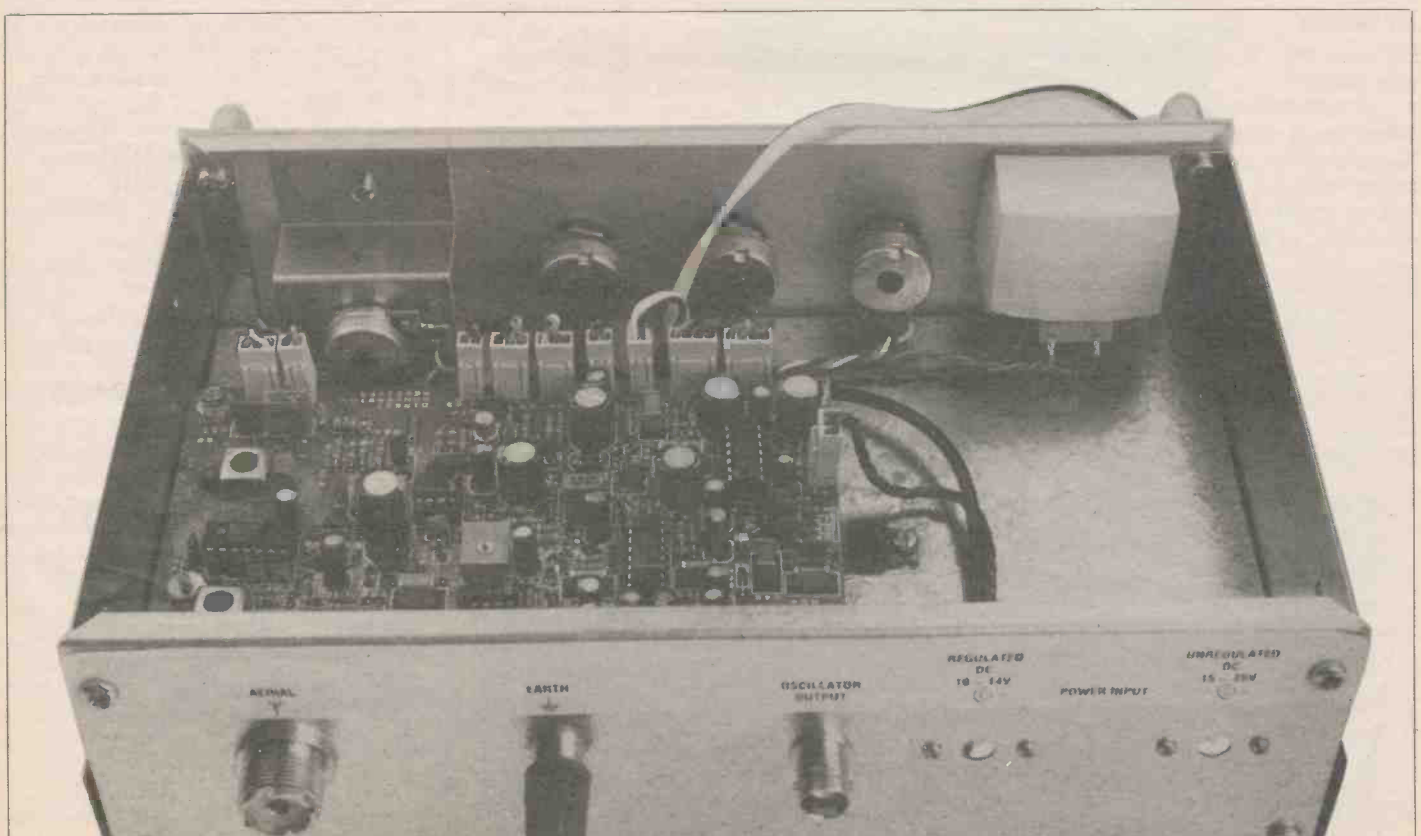

Photo 5. Inside of the front panel.

To measure the DC voltage, current and resistance you will need a digital, or electronic analogue, multimeter with an input impedance of not less than 10MΩ. Other multimeters can be used but some of the readings obtained may vary slightly.

The first test is to measure the resistance at SK1 and SK2. With the meter leads either way round on the centre pin of the unregulated power input socket SK1, a reading of greater than 100kΩ should be present with respect to the chassis. This reading should drop by a small amount when the power on/off switch S1 is activated. Repeat this test on the regulated input SK2, where you should observe the following readings. With the power switch in its OFF position and the test meter leads either way round on the centre pin, an infinite resistance 'open circuit' should be present with respect to the chassis. However, when switched ON this reading should fall to approximately 17Ω. This is mainly due to the low resistance of the filament bulb LP1 and if the Minicon connector in front of ZD1 is temporarily disconnected this reading should rise to greater than 1kΩ if the positive probe is on the centre pin of SK2.

Select a suitable range on your meter that will accommodate a 500mA DC current reading and place it in the positive power line from SK1. Connect the mains adaptor and switch on. The signal strength meter and power indicator LD1 should light up, with a current reading of approximately 147mA being observed. Switch off the receiver, then remove the test meter and reconnect the positive line to SK1.

Now set your multimeter to read DC volts. All voltages are positive with respect to ground, so connect your negative lead to a convenient ground point on the chassis. When the receiver is switched back on, voltages present on the PCB test points should approximately match the following:

TP1 = 8.67V
TP2 = 12.03V
TP3 = 10.19V
TP4 = 5.09V
TP5 = 11.36V
TP6 = 5.08V

The voltage at TP1 must now be set to exactly 8.000V by adjusting RV1. Whilst observing the signal strength meter, set RV6 so that the needle is just on the beginning of the zero marker. This completes the DC testing and alignment of the receiver, which must now be left running for a minimum of one hour before commencing the RF adjustments.

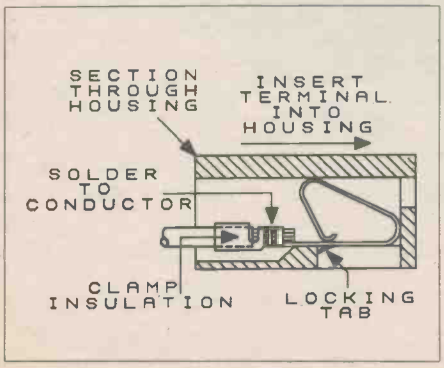

Figure 18. Terminating the wires.

There are three basic methods of RF alignment:

1. The high accuracy approach using an RF signal generator and frequency counter.
2. Medium accuracy using another receiver and aerial on the same band.
3. The 'poke and hope' method using only an aerial.

Method 1

When using a frequency counter to set the tuning range, connect its input to the oscillator output on the back of the receiver and use as short a lead as possible to prevent stray RF pick up. Ensure that the main tuning vernier dial is set to 100 and the fine tune is at the half way zero point. Using a non-metallic trimming tool, carefully adjust the iron dust core of T4 until the top end (high frequency) is set. Then position the main dial to read 0 and adjust RV5 for the low end of the band. Repeat this procedure until both limits have been set for the required band, as shown in Table 1.

When using an RF signal generator to align the front end, its output is connected to SK5 the aerial input of the receiver. The level of RF injection should be set to produce a half scale deflection on the signal strength meter when the carrier is tuned in. If the AF gain is turned up, an audio tone should be heard whose frequency will change as the receiver is tuned across the incoming signal. At the low end of the band the dust cores of T2 and T3 should be adjusted to give a peak in signal strength. The top end of the tuning range is then peaked using the trimmer capacitors TC1 and TC2. Next set the tuning dial to 50 and adjust the input filter coil T1 for maximum signal reading. Repeat this procedure until no

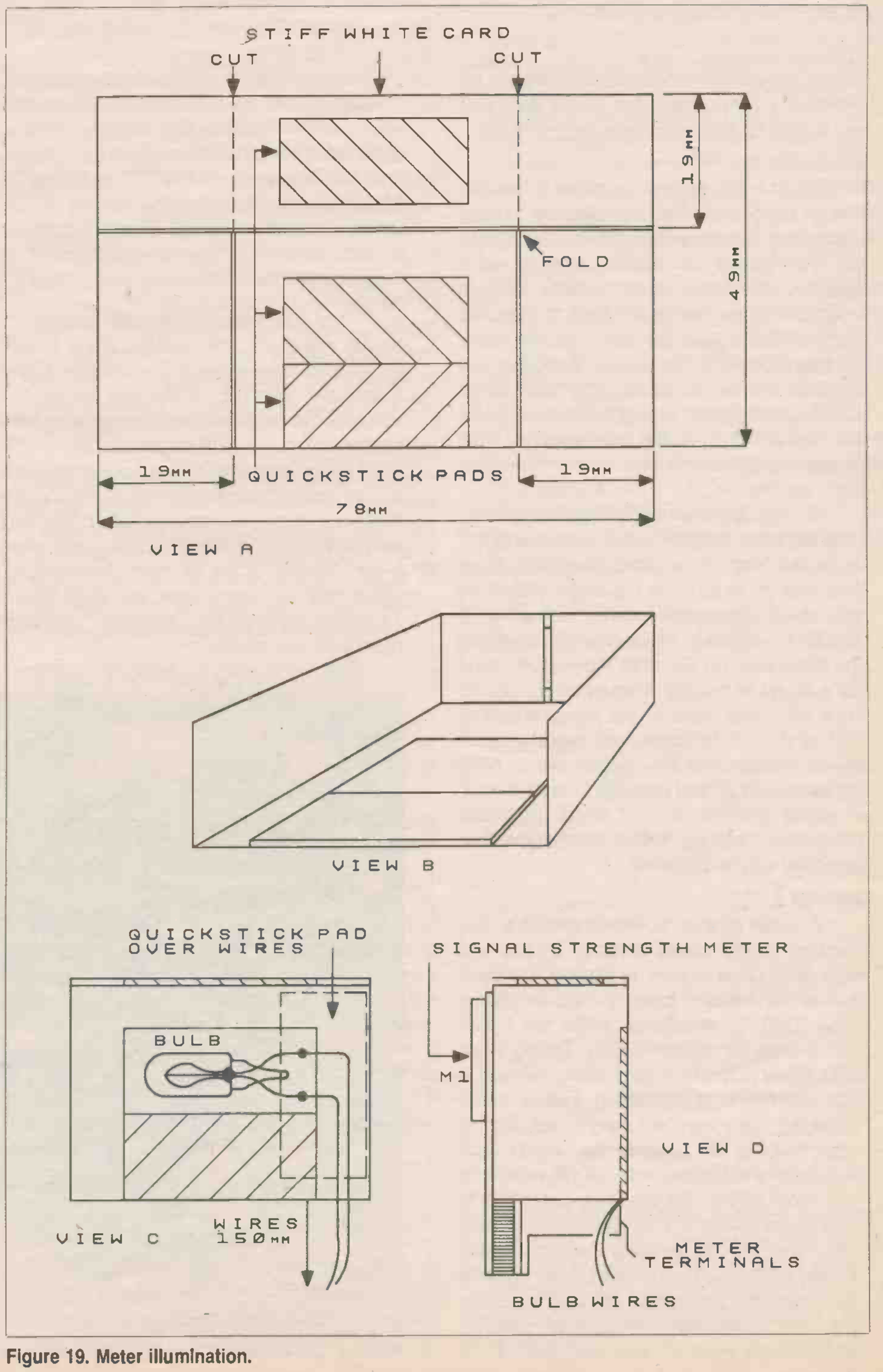

Figure 19. Meter illumination.

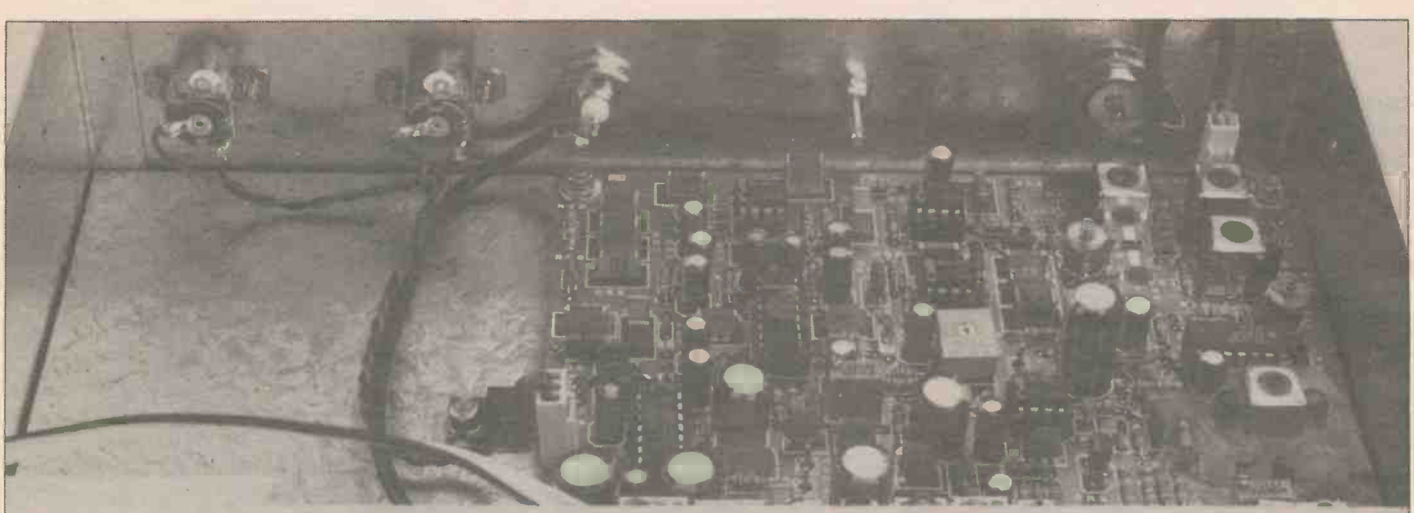

Photo 6. Inside of the rear panel.

further improvement in signal strength can be detected. Finally, check that the RF gain and fine tuning controls are functioning correctly.

Method 2

When using another receiver to set the tuning range of the oscillator no direct connection is made between them. To pick up the RF output, a short piece of wire approximately 200mm (8 inches) long is inserted into the centre terminal of the BNC socket. With a suitable aerial on the other receiver, tune it to the end of the band and listen for the carrier coming from your direct conversion receiver. To adjust this, use T4 for the high and RV5 for the low frequency limit, repeat this procedure until both ends of the band are set.

To align the front end using this method, tune the other receiver into a readable signal at the low end of the band. Swap the aerial over and try to tune for the same station on your direct conversion receiver, adjusting T2 and T3 for a peak in signal strength. Next, put the aerial back on the other receiver and tune for a signal at the high frequency end. Swap back the aerial, tune in the signal adjusting TC1 and TC2 for maximum reading. In a similar manner, set the vernier dial to read approximately 50 and using T1 tune for a peak in signal strength. Repeat these alignment procedures until no further improvement in reception can be obtained.

Method 3

If no test gear or receiver is available, you must set the frequency coverage by trial and error using off air signals. In general, the lower part of the amateur band is used for morse code (CW) transmissions, whilst the upper part is used for speech (SSB). Tuning in an SSB signal properly is quite tricky, but with a little practice it is something that is easily mastered. Very careful tuning is required in order to bring the audio to the correct pitch and the fine tuning control RV3 will make this task much easier. Set the main tuning dial to read 0 and adjust T4 until you start to receive CW transmissions, peaking the signal using T2 and T3. As you tune progressively higher in frequency you should find the SSB transmissions and at the extreme end of the dial TC1 and TC2 are used to peak the signal. If the SSB stations appear to extend past this point, retune T4 until no more amateur transmissions can be received, then reset the low end of the band using RV5. Next, tune for a station near to the centre of the dial (50) and using T1 adjust for maximum reading on the signal strength meter. Repeat these alignment procedures until no further improvement in reception can be obtained.

Once you have successfully completed the RF alignment, the oscillator stage should be covered in candle wax, see Photo 7. Using a lighted household candle drip the molten wax over the oscillator components being very careful not to get any inside the top of T4. Build up the wax a layer at a time and allow it to cool between applications until the components are completely encapsulated. The wax will cause a shift in oscillator tuning and when it has cooled down to room temperature, which may take some time, you must retune T4 using one of the alignment methods previously described.

Using the Receiver

A good aerial and earth system are essential if the receiver is to be expected to perform at its best, and you should allow it to 'warm up' for at least 30 minutes to obtain frequency stability. The skill of the operator will also play a large part in weeding out the more exotic long distance (DX) stations from the interference (QRM/QRN) on today's crowded bands.

There are two main types of radio signal used by amateurs, morse code (CW) and speech (SSB). When tuning in a CW transmission, the pitch of the dots and dashes start high, then as the receiver is tuned closer to the same RF frequency, the audio pitch will fall. At the dead centre there will be no audio tone as the signal is at the zero beat point. But, if the receiver tuning is continued the pitch of the tone will increase until it goes outside the frequency range of the audio bandpass filter. The final pitch setting will be a matter of personal taste, however 500Hz to

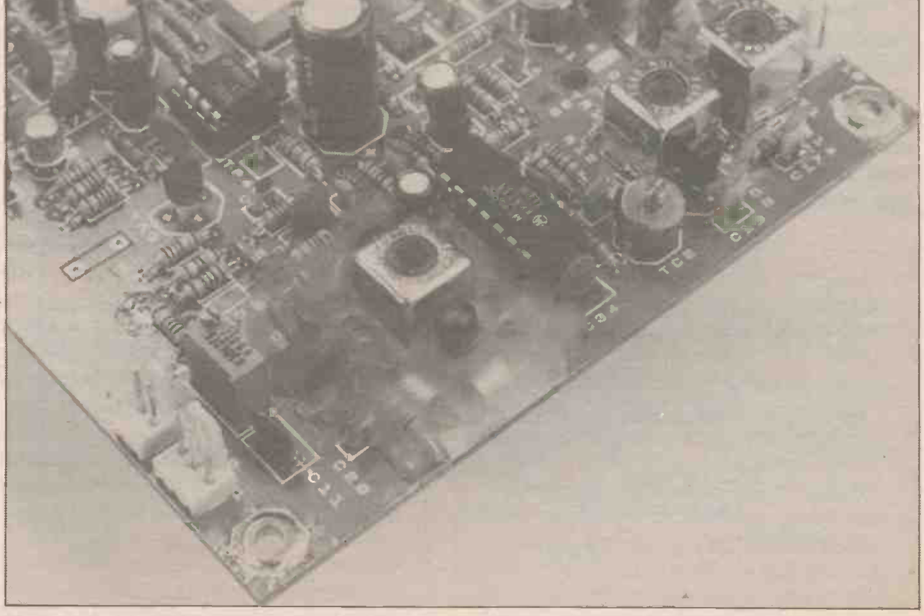

Photo 7. Oscillator section encapsulated in wax.

1kHz is a commonly used range.

The use of single sideband (SSB) for the transmission of speech is preferred by most radio amateurs because of its higher efficiency over ordinary amplitude modulation (AM). In an AM radio signal the level of the RF carrier is modulated by the audio produced by the user. With that type of receiver a small tuning error will probably give no more than a slight loss of audio quality and could even go completely unnoticed. This is not the case when receiving SSB, where the tuning has to be spot on if the station is to be fully resolved. A product of an AM signal is the generation of two sideband signals, lower sideband (LSB) and upper sideband (USB). The sidebands contain the same audio information as the modulated carrier but in a different form. This means that to transmit the information only one of the sidebands needs to be sent and the carrier with the other sideband can be suppressed. However, to resolve the signal the carrier must be re-injected by the product detector in the receiver, which is why the tuning is so critical. The direct conversion receiver principle will permit double sideband signals (DSB) to be received. However, these are not commonly found on the amateur bands where LSB is used up to 40 metres and USB is used on all frequencies above 10MHz. When an SSB station is tuned in on a DSB receiver you will get two places where the signal will be received, but only one sideband will be resolvable. This is the one that matches the original transmitted signal and the overall tone of the audio is set by fine tuning the receiver.

A useful addition to the receiver is a digital frequency counter used to provide an accurate tuning display. The counter should be capable of resolving down to the nearest 100Hz when set to its 0.1 of a second gate time. To prevent the pick up of stray RF signals it should be connected to the oscillator output of the receiver using the shortest possible length of cable. If a frequency counter is not permanently available then a tuning chart can be generated using graph paper, see Figure 20. This will help to provide a reasonable tuning accuracy from the vernier dial when the counter is not available.

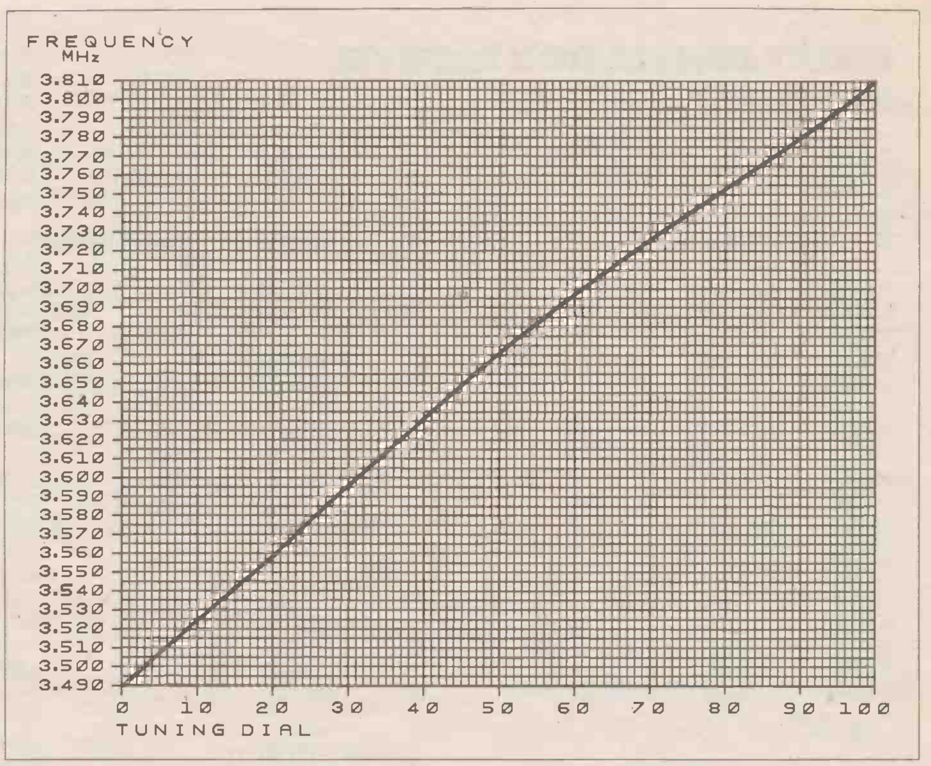

Figure 20. Receiver tuning range (80 metre version).

If the station being received is excessively strong it may start to distort the audio output. This can usually be cured by reducing the RF gain until the reading on the signal strength meter is just below the 5 on the scale.

That wraps it up for this project, I hope you spend many happy hours building your receiver (finished unit shown in Photo 8) and that you find it a pleasure to use once you're on the air.

Useful Reading

HF Antennas by L.A.Moxon, G6XN. Published by the Radio Society of Great Britain.

Wires and Waves. Published by Practical Wireless.

Radio Wave Propagation (HF Bands) by F.C. Judd.

25 Simple Indoor and Window Aerials by E.M. Noll.

An Introduction to Radio DXing by R.A. Penfold.

Beginner's Guide to Amateur Radio by F.G. Rayer.

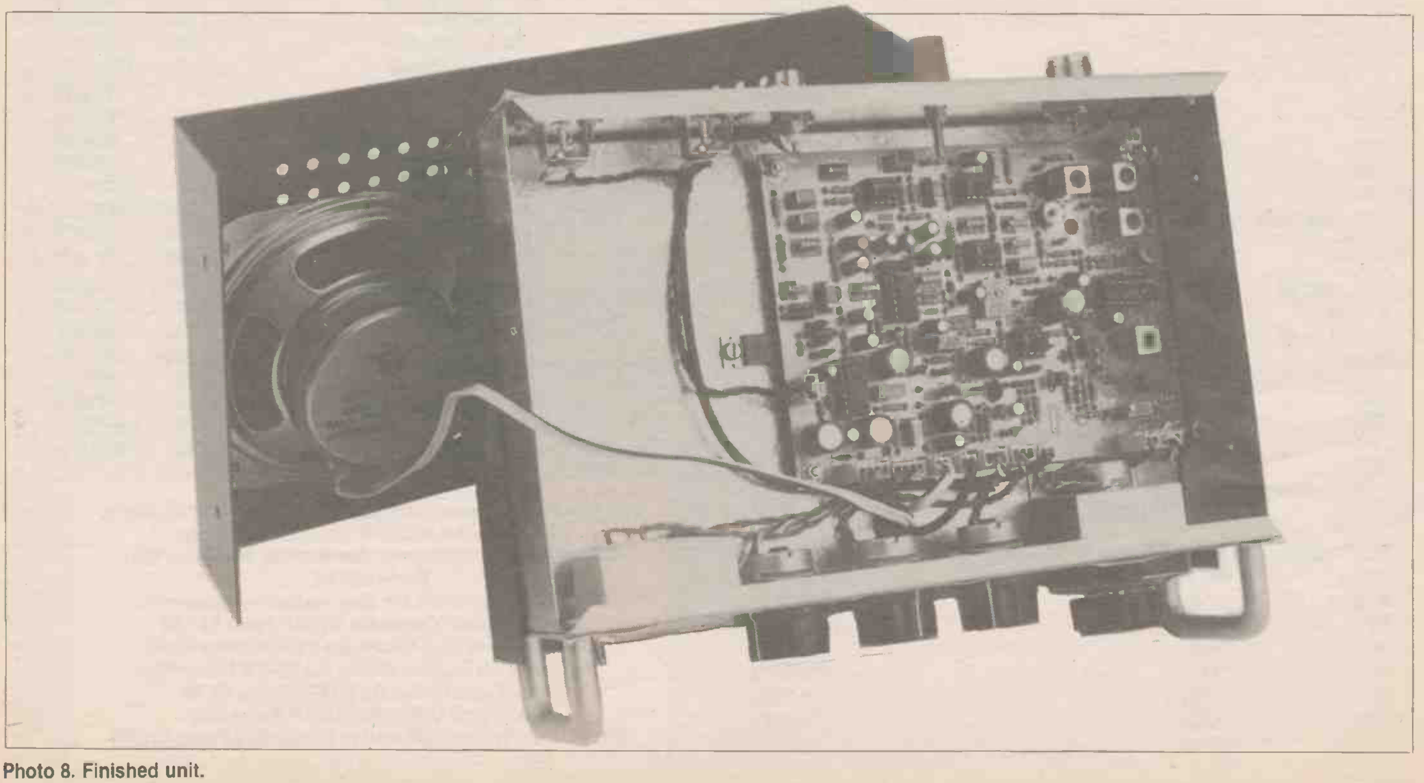

Photo 8. Finished unit.

DIRECT CONVERSION RECEIVER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,33	560Ω	2	(M560R)
R2,76,77	270Ω	3	(M270R)
R3,12,13,30, 36	100Ω	5	(M100R)
R4,15,25,26,31,35, 38,51	1k	8	(M1K)
R5,32	1k2	2	(M1K2)
R6,7,60,66, 68,69	4k7	6	(M4K7)
R17,39,40	2k7	3	(M2K7)
R11,14,18,22, 44,52,64	100k	7	(M100K)
R16	150Ω	1	(M150R)
R19,43	39k	2	(M39K)
R20,21	10M	2	(M10M)
R24,48,58	1M	3	(M1M)
R27	47Ω	1	(M47R)
R28,37,41,42,45, 46,47,53,56,74	10k	10	(M10K)
R29	470Ω	1	(M470R)
R34	820Ω	1	(M820R)
R49,59	6k8	2	(M6K8)
R50,62	3k3	2	(M3K3)
R54,55,57,61, 63,65	27k	6	(M27K)
R67	220Ω	1	(M220R)
R70	150k	1	(M150K)
R71	18k	1	(M18K)
R72	22k	1	(M22K)
R73	1Ω	1	(M1R)
R75	2Ω7	1	(M2R7)
RV1	1k Cermet 22T	1	(UH23A)
RV2,4	47k Pot Lin	2	(FW04E)
RV3	1k Pot Lin	1	(FW00A)
RV5	50k Cermet 22T	1	(UH26D)
RV6	1k Hor Preset	1	(UH00A)
RV7	10k Pot Log	1	(FW22Y)

CAPACITORS

C1,2,4,6,11,24,25, 34,63,77,78,80, 82,83	100nF Minidisc	14	(YR75S)
C3,5,7,73,79	220µF 16V PC Electrolytic	5	(FF13P)
C8,36,37,48,49,50, 65,66,69,72	1µF 100V PC Electrolytic	10	(FF01B)
C9	22pF Ceramic	1	(WX48C)
C71	47pF Ceramic	1	(WX52G)
C14,15,16,20,23, 29,30,31,32,33, 57,59	10nF Ceramic	12	(WX77J)
C26	1nF Ceramic	1	(WX68Y)
C27	5p6F Ceramic	1	(WX41U)
C28	100pF Ceramic	1	(WX56L)
C35	470µF 16V PC Electrolytic	1	(FF15R)
C38	2n7F Ceramic	1	(WX73Q)
C39,43,44,46,60, 61,76	100nF Polylayer	7	(WW41U)
C40,54	6n8F Polylayer	2	(WW27E)
C41,45,52,64	22nF Polylayer	4	(WW33L)
C42,55	1n5F Polylayer	2	(WW23A)
C47,51,56,67, 68,75	10µF 50V PC Electrolytic	6	(FF04E)
C53,62	10nF Polylayer	2	(WW29G)
C58	2µ2F 100V PC Electrolytic	1	(FF02C)
C70	4µ7F 63V PC Electrolytic	1	(FF03D)
C74	150nF Polylayer	1	(WW43W)
C81	100pF Polystyrene	1	(BX28F)
TC1,2	22pF Trimmer	2	(WL70M)

SEMICONDUCTORS

IC1	MC1496	1	(QH47B)
IC2,3,5	LF353	3	(WQ31J)
IC4	LF351	1	(WQ30H)
IC6	NE571	1	(YY87U)
IC7	LM380	1	(QH40T)
D1,2	1N4001	2	(QL73Q)
TR1	3SK88	1	(UH63T)
TR2,3	BF244	2	(QF16S)
TR4	BC179	1	(QB54J)
VC1,2,3	BB212 Varicap	3	(YH83E)
RG1	78M12UC	1	(QL29G)
RG2	LM317LZ	1	(RA87U)
ZD1	BZY88C4V3	1	(QH05F)
ZD2,3,4,5	BZY88C2V7	4	(QH00A)
LD1	LED Red	1	(QY48C)

MISCELLANEOUS

S1	Sub-min Toggle A	1	(FH00A)
M1	Signal Strength Meter	1	(LB80B)
LS1	4in. Spkr 8Ω	1	(YJ16S)
	Pin 2145	1 Pkt	(FL24B)
	P.C. Board	1	(GD78K)
LP1	Wire Bulb 12V	1	(WQ13P)
SK1,2	Power Socket 2.5mm	2	(HH86T)
SK3	BNC Socket 50Ω	1	(HH18U)
SK4	Terminal Post Green 4mm	1	(HF05F)
SK5	Socket SO239	1	(BW84F)
JK1	Jack Socket 3.5mm	1	(HF82D)
JK2	Switched Jack Socket ¼in.	1	(BW80B)
	Vernier Dial Ratio 7·5:1	1	(RX40T)
	DIL Socket 8-pin	4	(BL17T)
	DIL Socket 14-pin	2	(BL18U)
	DIL Socket 16-pin	1	(BL19V)
	Minicon Latch Plug 2W	5	(RK65V)
	Minicon Latch Plug 3W	4	(BX96E)
	Minicon Latch Plug 4W	2	(YW11M)
	Minicon Latch Housing 2W	5	(HB59P)
	Minicon Latch Housing 3W	4	(BX97F)
	Minicon Latch Housing 4W	2	(HB58N)
	Minicon Terminal	3 Pkts	(YW25C)
	Kit P Plas	1	(WR23A)
	Knob K7B	3	(YX02C)
	Hook-up Wire Black	1 Pkt	(BL00A)
	Hook-up Wire Blue	1 Pkt	(BL01B)
	Hook-up Wire Green	1 Pkt	(BL04E)
	Hook-up Wire Red	1 Pkt	(BL07H)
	Hook-up Wire White	1 Pkt	(BL09K)
	Hook-up Wire Yellow	1 Pkt	(BL10L)
	Zip Wire	1 Mtr	(XR39N)
	Low Noise Screened Cable	1 Mtr	(XR18U)
	Quickstick Pads	1 Stp	(HB22Y)
	Constructor's Guide	1	(XH79L)

OPTIONAL

	Power Supply Unregulated	1	(YM85G)
	Power Plug 2.5mm	2	(HH63T)
	Fuse Holder In-line	1	(RX51F)
	Fuse 1.25in. 1A	1	(WR11M)
	Trim Tool Set	1	(BK34M)
	Preset Trim Tool	1	(BK49D)
	Pot Nut M10	1 Pkt	(FP06G)
	Pot Washer M10	1 Pkt	(FP07H)
	Grommet Small	1	(FW59P)
	Box Pre-drilled	1	(YT05F)
	Chassis Pre-drilled	1	(YT04E)
	Pot Mounting Bracket	1	(JG47B)
	Front Panel Stick-on	1	(JG48C)
	Back Panel Stick-on	1	(JG49D)
	Spacer Tapped 6BA x ¼in.	1 Pkt	(FD10L)
	Bolt 6BA x ½in.	1 Pkt	(BF06G)
	Nut 6BA	1 Pkt	(BF18U)
	Shake Washer 6BA	1 Pkt	(BF26D)
	Isobolt M2 x 6mm	1 Pkt	(JD11M)
	Isobolt M3 x 10mm	1 Pkt	(HY30H)
	Isonut M3	1 Pkt	(BF58N)
	Isoshake M3	1 Pkt	(BF44X)
	Isobolt M4 x 12mm	1 Pkt	(BF49D)
	Isonut M4	1 Pkt	(BF57M)
	Isoshake M4	1 Pkt	(BF43W)

The parts listed above, excluding Optional, are available as a kit, but is not shown in our 1988 catalogue:
Order As LM60Q (Direct Conversion Receiver Kit) Price £69.95
The following items are also available separately:
Box Pre-drilled **Order As YT05F Price £17.95**
Chassis Pre-drilled **Order As YT04E Price £3.95**
Pot Mounting Bracket **Order As JG47B Price 78p**
Front Panel **Order As JG48C Price £1.98**
Rear Panel **Order As JG49D Price 60p**
Direct Convrsn Rec PCB **Order As GD78K Price £11.95**

PARTS LIST TUNING KIT 1

RESISTORS: All 0.6W 1% Metal Film			
	1k	1	(M1K)
	4k7	1	(M4K7)
	22k	2	(M22K)
	82k	1	(M82K)
CAPACITORS			
	27pF Ceramic	1	(WX49D)
	33pF Ceramic	4	(WX50E)
	47pF Ceramic	1	(WX52G)
	100pF Ceramic	1	(WX56L)
	120pF Ceramic	4	(WX57M)
	180pF Ceramic	1	(WX59P)
	22pF Polystyrene	2	(BX24B)
	100pF Polystyrene	2	(BX28F)
MISCELLANEOUS			
	RF Transformer KANK 3333R	4	(FD02C)

PARTS LIST TUNING KIT 2

RESISTORS: All 0.6W 1% Metal Film			
	1k	1	(M1K)
	2k2	1	(M2K2)
	10k	1	(M10K)
	150k	1	(M150K)
	180k	1	(M180K)
CAPACITORS			
	27pF Ceramic	1	(WX49D)
	47pF Ceramic	5	(WX52G)
	120pF Ceramic	4	(WX57M)
	180pF Ceramic	1	(WX59P)
	33pF Polystyrene	2	(BX25C)
	100pF Polystyrene	2	(BX28F)
MISCELLANEOUS			
	RF Transformer KANK 3334R	4	(FD03D)

PARTS LIST TUNING KIT 3

RESISTORS: All 0.6W 1% Metal Film			
	1k	1	(M1K)
	2k2	1	(M2K2)
	4k7	1	(M4K7)
	180k	1	(M180K)
	220k	1	(M220K)
	330k	1	(M330K)
CAPACITORS			
	15pF Ceramic	1	(WX46A)
	27pF Ceramic	1	(WX49D)
	47pF Ceramic	4	(WX52G)
	68pF Ceramic	4	(WX54J)
	100pF Ceramic	4	(WX56L)
	180pF Ceramic	1	(WX59P)
	220pF Ceramic	1	(WX60Q)
	47pF Polystyrene	2	(BX26D)
	68pF Polystyrene	2	(BX27E)
	100pF Polystyrene	2	(BX28F)
MISCELLANEOUS			
	RF Transformer KANK 3335R	4	(FD04E)

PARTS LIST TUNING KIT 4

RESISTORS: All 0.6W 1% Metal Film			
	1k	1	(M1K)
	2k2	1	(M2K2)
	560k	1	(M560K)
CAPACITORS			
	15pF Ceramic	5	(WX46A)
	22pF Ceramic	4	(WX48C)
	27pF Ceramic	1	(WX49D)
	56pF Ceramic	1	(WX53H)
	22pF Polystyrene	2	(BX24B)
MISCELLANEOUS			
	RF Transformer KANK 3335R	4	(FD04E)

All 4 Tuning Kits are available, but are not shown in our 1988 catalogue:
Order As LM61R (Tuning Kit 1) Price £2.95
Order As LM62S (Tuning Kit 2) Price £2.95
Order As LM63T (Tuning Kit 3) Price £2.95
Order As LM64U (Tuning Kit 4) Price £2.95

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