REMOTE CONTROL

BY BOB YOUNG

Building a complete remote control system for models; Pt.3

This month, we describe the construction of the Mk.22 receiver board. The top of the board accommodates the coils, a ceramic resonator & crystal holder, while the underside is packed with surface mount components.

The receiver will be supplied as a full kit, as an assembled and tested PC board, or as a fully assembled receiver with decoder included. In all cases a PC board is supplied but for the those wishing to do their own PC boards, I have just one few tip which is "don't bother. After all, it took many refinements of the basic layout before I was completely happy."

However, a little background won't hurt. The Mk.22 is designed essentially as an AM receiver replacement for all brands of commercial R/C receivers. The decoder layout (to follow next month) allows the utmost in flexibility to overcome the problems of non standardisation of the servo plugs. The decoder also features heavy filtering to help minimise the problems of interference on long servo leads.

The physical layout is that used in all Silvertone receivers since 1969 and both the receiver and decoder PC boards may be used as direct replacements for earlier modules back to Mk.7. The Mk.22 is better in regard to mechanical robustness, receiver sensitivity and electric motor noise immunity. The physical layout provides the smallest frontal area, with the PC boards mounted at right angles to the direction of travel of the model. This minimises component damage in crashes. The case is very robust, being heavy gauge aluminium, and this also provides improved noise immunity.

The two-board arrangement also allows the receiver to be used separately, free of the clutter of an existing decoder. Note that the board is double sided, with the ground plane on the top. The holes are plated through, so there's no need to solder the through-hole components on both sides.

Construction

This is quite a delicate little PC board to make. Minimum track spacing is .016-inch, minimum track width

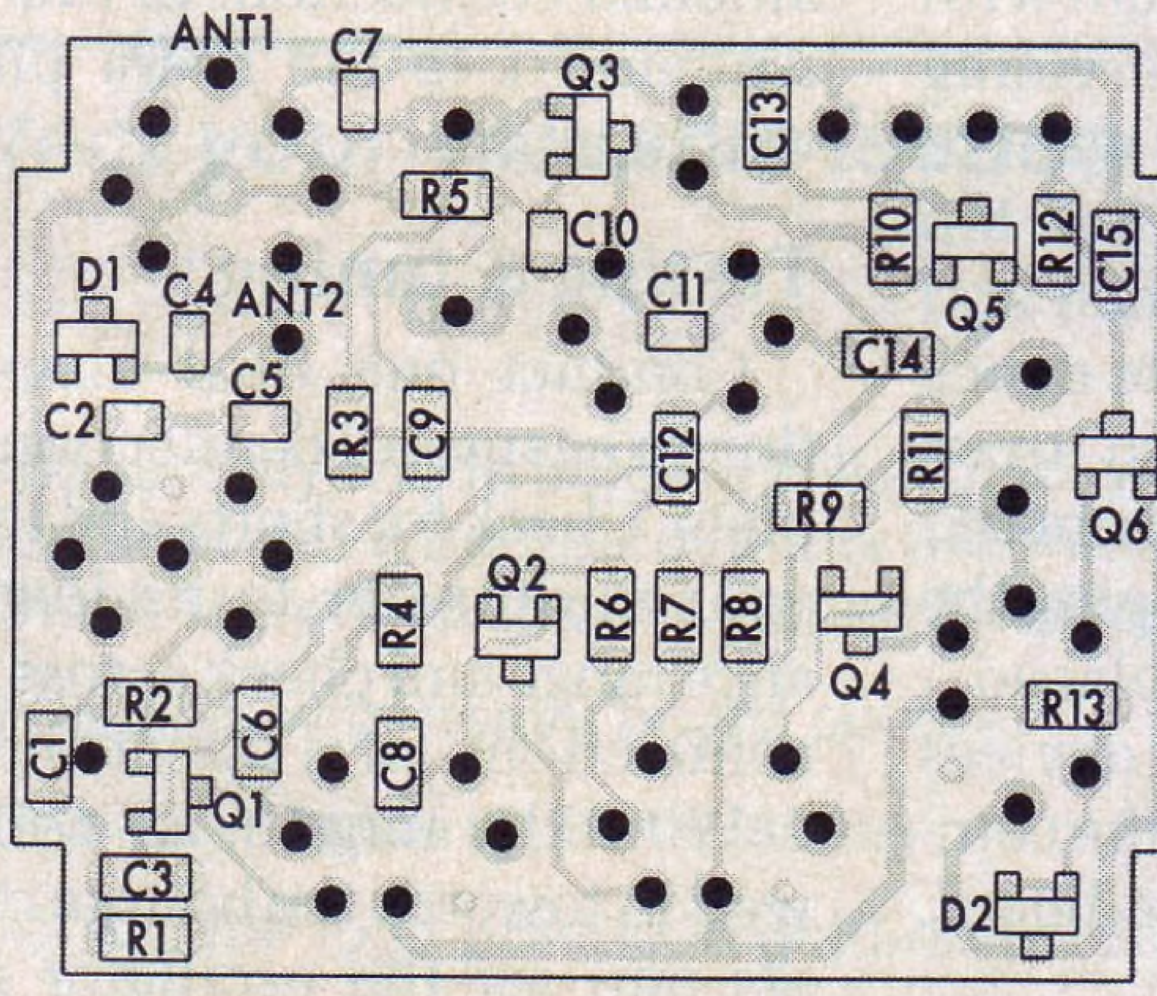


Fig.1: the layout of the surface mount components, shown 50% larger than actual size. Note that the components are numbered to match those on the circuit published in last month's issue.

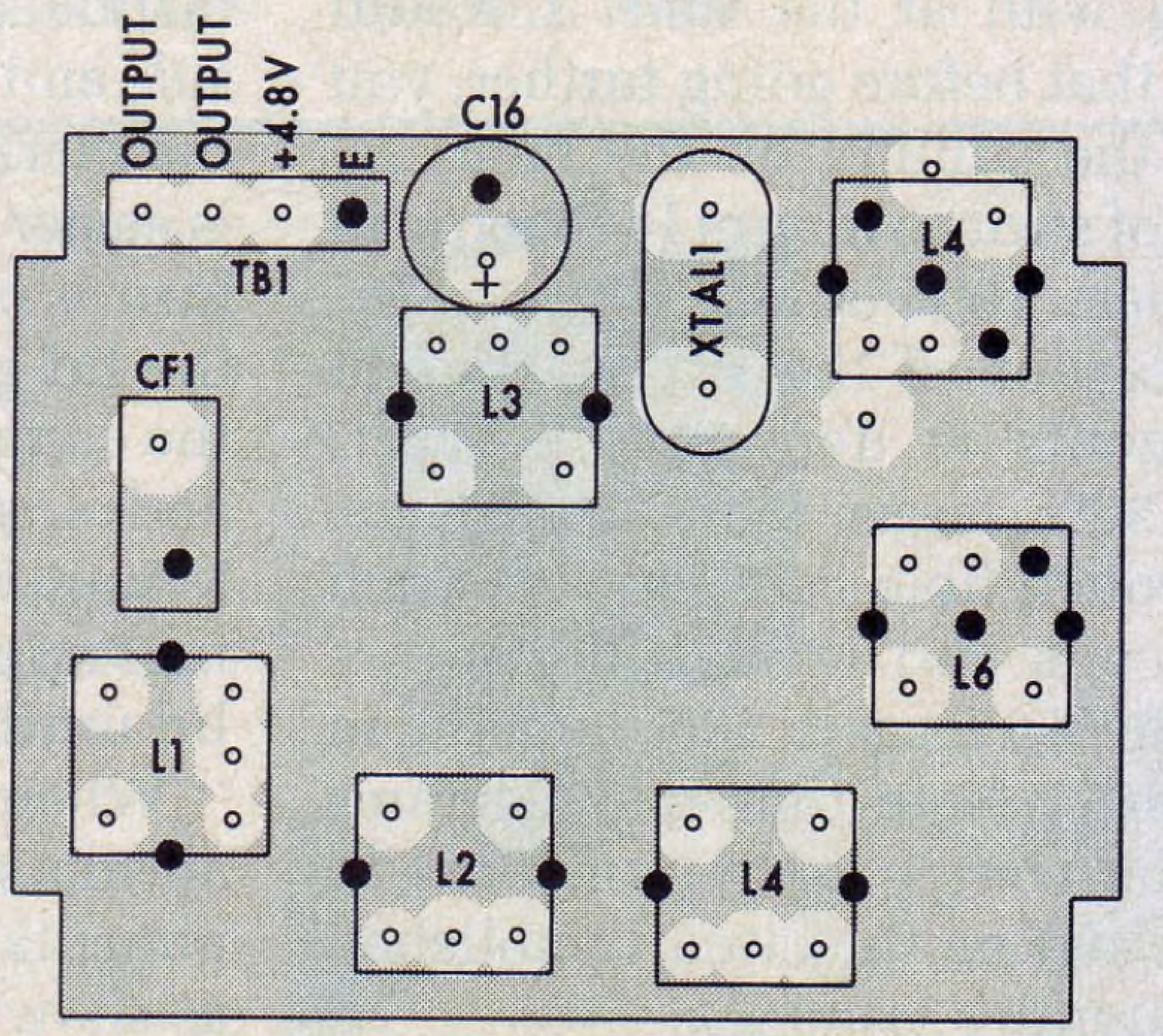


Fig.2: the through-hole components, such as the coils and crystal holder, shown 50% larger than actual size. Note that the coils are numbered to match those on the circuit published in last month's issue.

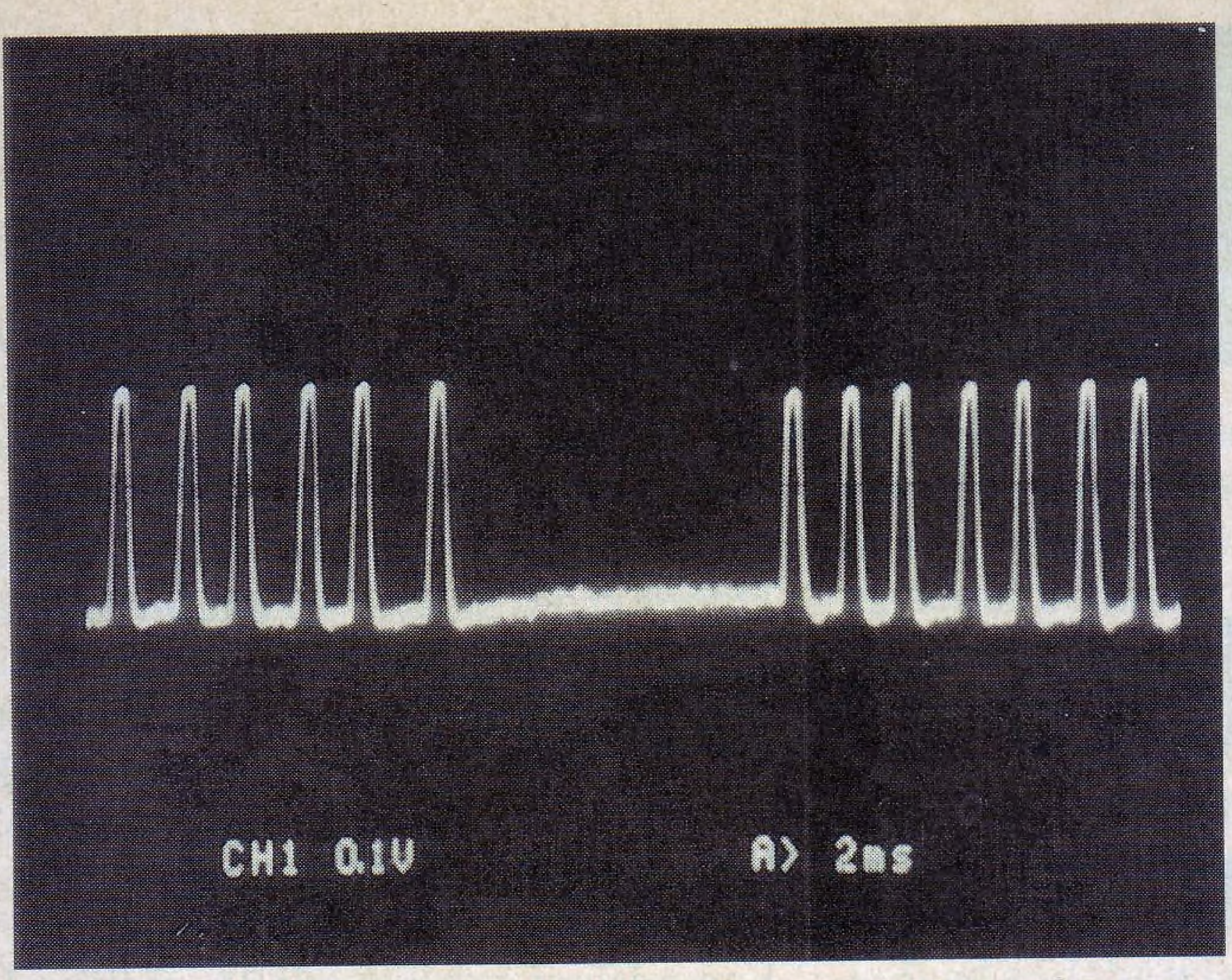
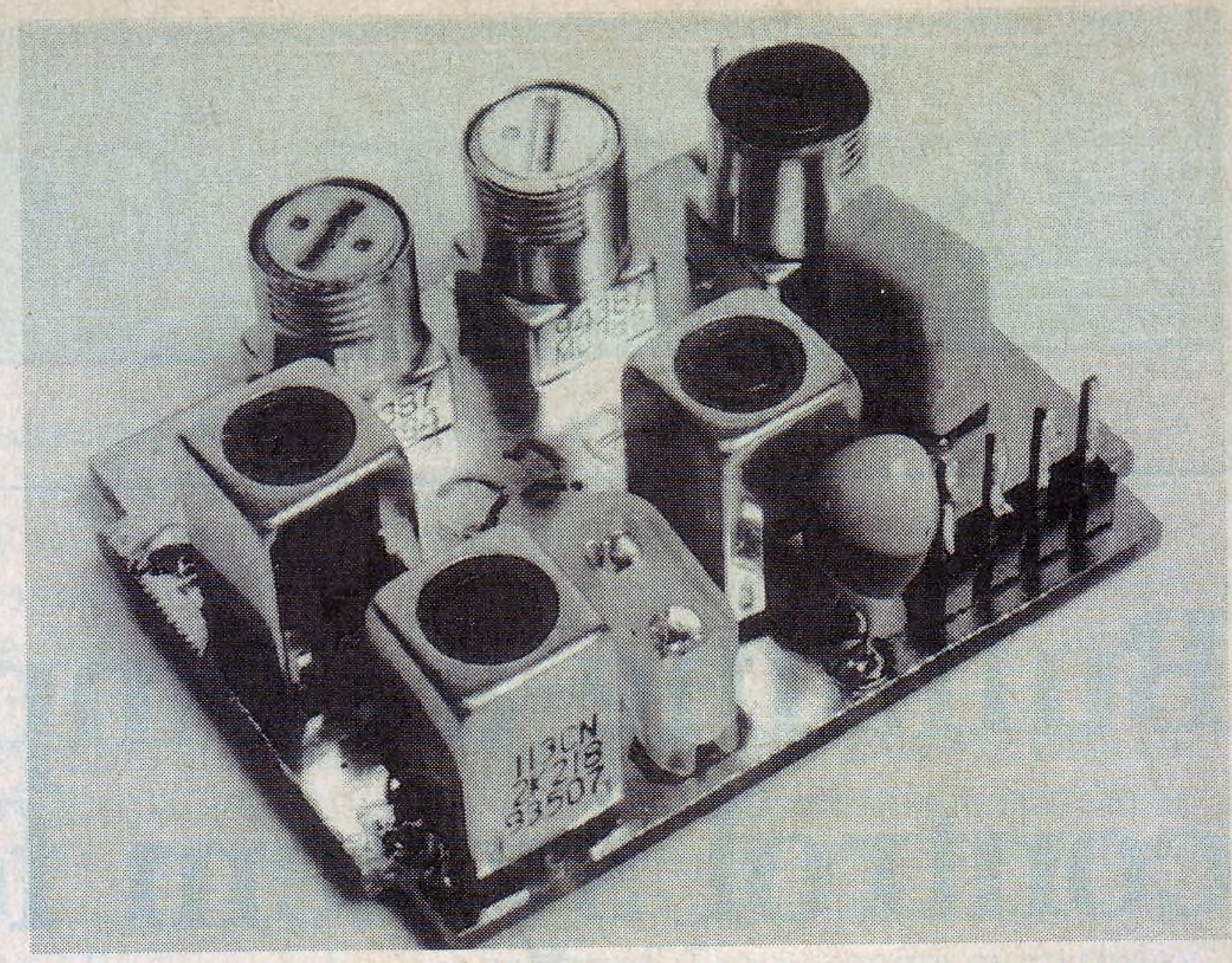


Fig.3: repeated from last month, this scope photo shows a typical output waveform at the collector of transistor Q6. Note that the number of spikes will depend on the control settings of the transmitter.



This larger-than-life size photo shows the completed receiver assembly. Note the socket for the plug-in crystal. The resistors, capacitors & transistors are surface-mounted on the other side of the board.

is .012-inch and minimum component spacing is .020-inch. I have tried to keep the number of components to a minimum and the spacing as wide as possible but on a board this size spacing will always be tight. Check the etched PC board for shorts, particularly where two tracks go under one component.

Now set the PC board groundplane down on a clean sheet of white paper and commence to place the surface mount components. The paper is for contrast when you drop a component. You will not find it on a dirty bench. Do not leave discarded components lying around on the bench where you are working, especially unmarked capacitors. You have been warned. Keep that sheet of paper clear of all items except the component value you are working with at the time. I would suggest that before going further, you re-read the column on the hand assembly of surface mount PC boards in the January 1995 issue.

The layout of the surface mount components is depicted in Fig.1, shown 50% larger than actual size. The through-hole components, such as the coils and crystal holder, are shown in Fig.2, again 50% larger than actual size. Note that the diagrams show the components numbered to match those on the circuit published in last month's issue.

Begin by aligning the PC board with the single SOT23 pad for D2 closest to your soldering hand. Proceed to tin one pad only in each component set. The best pad to tin is that closest to your soldering hand. Once one pad in every component set is tinned, you may commence component placement. To mount each component, simply pick it up with the tweezers, heat the tinned pad and slide it into position, taking care to obtain correct alignment on the centre of the pads. Now, while the component is still warm, solder the other leg(s).

There is no set order of assembly but it is a good idea to place all of one value at a time. I usually start with the semiconductors. One good tip is keep your components in a little plastic tray. The lid of a small pill bottle is ideal, but make sure it is white. Tip all of the components (one type only) into the lid.

Most components, if they are marked at all, are only labelled on one side and you should mount them with the marking visible, so that servicing is easier later. Now when you want to turn a component over you just tap the lid gently on the workbench and the components will do a little dance and some of them will turn over. Mount those that present the markings up and then just keep tapping the lid until all components are placed.

When all the surface mount devices are mounted, begin mounting the components on the topside of the board, as shown in Fig.2.

Finally, solder one metre of hookup wire to Antenna 2 (ANT 2). Plug in the receiver crystal and you now have a finished receiver. It takes me approximately an hour to assemble a receiver with conventional components or 45 minutes for the surface mount version. A surface mount assembly machine will do the same job in approximately one minute!

There is one point to note in regard to TB1, the 4-pin header. This may be mounted or left out completely. In the latter case simply insert the wires from the decoder directly into the holes. You may wonder why there are two pins connected together. The spare pin can be very useful for tuning the receiver. Even if the header pins are not mounted, solder a short piece of wire into the spare hole as a tuning point to hook oscilloscope and meter leads onto.

Alternatively, if a remote antenna is used, these two pins may be separated and the spare pin used as an antenna connection. In this case, join Antenna 1 to the spare pin on TB1 with a jumper.

Testing & tuning

Conduct one final visual inspection to ensure all connections are complete. Check for shorts and then switch your multimeter to its lowest resistance range and check across the power connections for a direct short.

Wind the slugs in RF coils L5 & L6 well in towards the bottom of the formers and set the oscillator slug flush with the top of the coil. You must use a plastic alignment tool for this job; don't use a small screwdriver as it is too easy to damage the slugs.

Begin with the routine DC checks. Hook up a 4.8V nicad pack to the appropriate pins on TB1. If the header pins have been installed, then the pin layout is directly compatible with a J.R or Futaba battery pack connector and the battery pack may be plugged directly into this connector. Check to ensure that the DC conditions are correct on each stage. The decoupled power rail after Q5 will be about +4.1V when supplied directly from the battery and approximately 0.2V lower when supplied from the decoder which has its own decoupling.

The oscillator coil tuning is not critical and the oscillator should be running with the slug in the coil flush with the top of the coil former. If an oscilloscope and frequency counter are at hand, then check the waveform and frequency of the oscillator. The waveform should be near sinusoidal, approximately 1.5V volts peak-peak in amplitude and if Showa crystals are used, almost on frequency. The tolerance on these crystals is ±0.005% and thus a variation of ±1.5kHz is acceptable. C7 and C10 may be adjusted to trim the frequency if other brands of crystals are used and they are not close enough to the designated frequency.

If all is well at this point, hook up a meter to ground (Black) and pin 4 on TB1 (red lead). It is a good idea to put a 4.7kΩ resistor in each meter lead to provide isolation for the receiver. Hook the scope to the meter side of these leads. Apply power and the meter should read approximately 3.9V and steady. The scope trace should be a straight line. You are now ready to tune the RF and IF stages. This will be achieved by tuning for the maximum dip in the collector voltage of Q6.

The finished receiver & decoder are shoe-horned into a very compact folded aluminium case. This easily comes apart for good access to the two boards inside.

Turn on the transmitter or signal generator and set the output to maximum or fully extend the transmitter antenna. A dip should be noticeable on the meter with the RF signal present. You may have to almost touch the transmitter and receiver antennas. These may be touched together as long as the Rx antenna is insulated. Beginning with coil L5, tune the slug for maximum dip (minimum volts) at the collector of Q6. Move then to L6, L4, L2 and L1. By this time the voltage at Q6 should be almost zero.

Now reduce the signal level, move the transmitter away or collapse the antenna and retune with the smallest comfortably detectable signal (about 0.5V). From here on, all tuning must be done with the lowest level of signal possible, otherwise the AGC action will affect the tuning on the IF coils. Continue to cycle through the coils, reducing signal and retuning until no further gains are to be had. At this point the receiver is tuned.

A word of warning: do not run commercial transmitters for too long with the antenna collapsed as this may damage the output transistors.

If you have a scope, check the output waveshape at Q6 and compare it with the photo of Fig.3. All being well, it should be comparable. You now have a going receiver ready for connection to a decoder.

Troubleshooting

Provided you have used the components supplied in the kit, most of your problems will be assembly faults. Check for dry joints and shorts or missing or unsoldered components.

A scope is very handy at this point. Begin by checking the rail voltages and then move on to the oscillator and check the DC voltages at the transistor. If the oscillator is running, the base voltage will be lower than the emitter voltage.

Next, check the voltages around transistors Q1, Q2 and Q4. The base voltage will be approximately 0.6V higher than the emitter voltage (eg, base +1.1V, emitter +0.35V). The collectors will sit at the decoupled supply voltage, +4.1V. The base of Q6 will be +0.6V and the collector with no signal approximately +3.9V.

If all of the DC conditions are OK, from here on it is routine RF servicing, using a signal generator (Tx) and oscilloscope and stage by stage debugging. If all else fails, send it back to father (yours truly) and he will either repair it or replace the module at a nominal fee. Details of kit availability and prices will be given in next month's issue. **SC**