RM

SINGLET SET

by PAUL NEWELL

single channel transmitter

super-regen receiver in relayless or relay versions

superhet receiver

RM BOOKLET SERIES

 30p

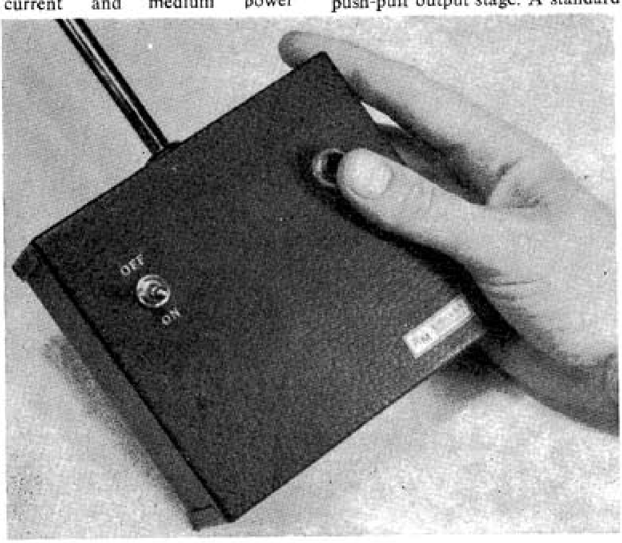
SINGLET

SINGLE CHANNEL TRANSMITTER

A simple, powerful s/c transmitter, presented in response to popular demand.

IN designing this transmitter, the aim has been to produce a unit which is simple to construct, has a high R.F. output, and takes advantage of the latest developments in high frequency transistor manufacturing techniques. The epoxy encapsulated transistors used are silicon planar types, with a 300mc/s cut-off and a high current and medium power capability. The main advantage of epoxy encapsulation is that the cost of manufacturing is considerably lower than for a hermetically sealed metal can, resulting in better transistors becoming available at a lower price.

The circuit employs a crystal controlled master oscillator, which is transformer-coupled into a push-pull output stage. A standard multivibrator is used to modulate the output at approximately 500c/s. The output from the multivibrator is applied to the base of VT4, causing it to switch the output stage at the tone frequency. When the transmitter is not keyed VT4 conducts, since a base current can flow via R4 and R5, thus giving a continuous carrier output.



Simple test equipment

An assembly sequence has been devised, with testing of each section as assembled. Thus, should a fault be present, its location is simplified, as only a small number of components will be involved at each stage. For testing, a multi-test meter is required and, since the current ranges only are essential, this does not need to be an elaborate or expensive type. It should be remembered, however, that if voltages are checked, a meter of at least 10,000 ohms.-per-volt should be used, since lower values could upset the circuit conditions.

For final alignment, a field strength meter is necessary. A suitable circuit can plug into a multi-meter. Another useful tool is a high impedence crystal earpiece, fitted with two crocodile clips. This is used for checking the tone generator, and also finds use in receiver tuning and testing.

Printed circuit board

Methods of making p.c. boards have been described in detail on many occasions, so it will not be repeated here.

All holes should be drilled with a No. 60 drill and certain holes opened out as follows:

4 off mounting holes: No. 42 drill (8BA clearance).
6 off coil former mounting holes: No. 42 drill (8 BA clearance).
2 off lead anchoring holes: No. 27 drill.
3 off coil core clearance holes: ¼in. drill.
1 off aerial socket mounting hole: ½in. drill.

If a plug-in crystal is to be used, the two holes on each copper land should be joined to form a slot for the tags of the crystal holder. A short length of fretsaw blade is useful for this purpose. The board should be trimmed down to the inside edge of the border.

Soldering to printed circuits

Before commencing construction, clean the copper conductors by lightly rubbing with fine steel wool, and rinse down under the cold water tap.

The use of the correct soldering iron is important. Use a low wattage iron, around 10-15 watts, with a 3/32in. diameter bit. A dampened piece of sponge rubber may be used to keep the bit cleaned during use. To solder a component in place, the tip of the bit should be placed *on the copper land,* without touching the component lead, and a brief period allowed for the copper to heat up. Resin cored, 22 swg. solder should then be touched on the copper and component lead simultaneously—not the iron—when the solder will flow around the pad and flux will spread on the component lead. As this happens, the bit should be touched against the component lead, when the solder will flow to make a sound joint. Practise on a scrap of board if you think this sounds tricky, and you will soon find how easy it really is to make neat, good quality, joints.

CONSTRUCTION SEQUENCE

At each stage of construction, check that components are fitted correctly and solder joints are sound. *Pay particular attention to the transistors,* referring, where necessary, to the p.c. board component layout and the diagrams of lead configurations for the two types of transistor.

Winding the coils

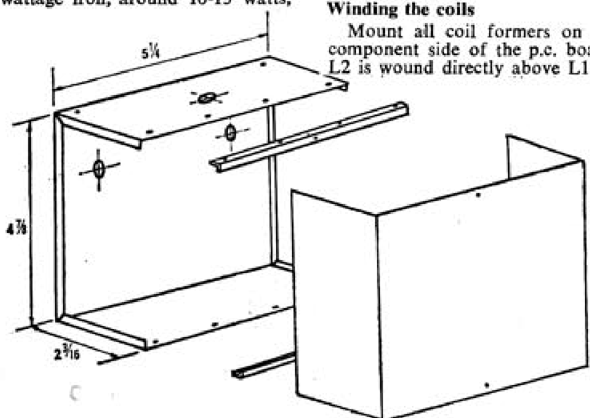
Mount all coil formers on the component side of the p.c. board. L2 is wound directly above L1 on the same former; similarly L4 is wound above L3. For each coil, *solder the start end into the hole marked "S"* and wind the appropriate number of turns in a clockwise direction, from the bottom of the former. The end is then brought off the former *to either the finish, "F" or tap, "T",* and soldered to the land. Tapped coils may be treated as two separate coils in series, the p.c. land carrying two holes at the tapped point for this purpose.

A light smear of Araldite should be applied around the top turn, to prevent the coils springing undone. *This is important since, if the coils tend to uncoil, the performance will be adversely affected.* A trace of Plasticine worked into the core threads will provide sufficient locking, whilst allowing adjustment.

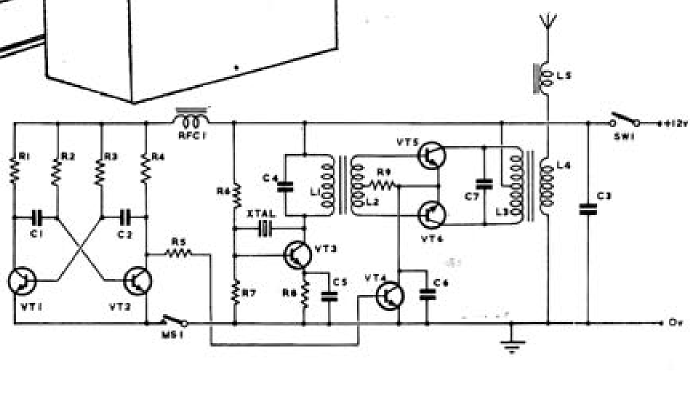
Continuity through the coils should be checked right through from the p.c. conductors, so that the soldered joints are included in the check.

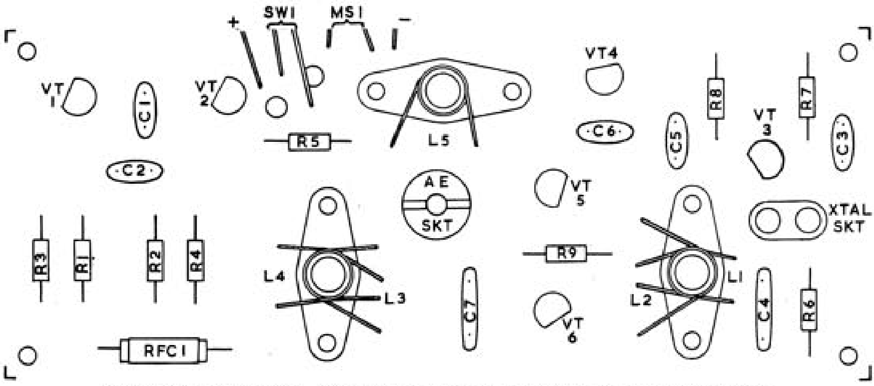
The oscillator

Fit the crystal oscillator components; R6, R7, R8, C3, C4, C5, VT3 and the crystal. Also wire in the on/off switch. Connect the positive and negative to 12v. supply, via a test meter on the 10 mA. range, or next higher. With the L1/L2 slug fully out, the current should be around 5 to 6mA., the exact value depending on the individual transistor characteristics. Now, slowly screw the slug in until the current rises to around 8 to 9 mA., indicating that the circuit is now oscillating. Screw the slug in one turn further (to ensure that the circuit is not operating too near the critical point at which oscillation starts), and leave it at this position. Disconnect the battery before continuing.



Minimum inside dimensions given; position holes as required for internal clearance of components and batteries.





COMPONENT PLACEMENT—When held up to the light, positioning on p.c. lands can be seen

Tone generator

The tone generator components should now be added, comprising: VT1, VT2, RFC1, R1, R2, R3, R4, R5, C1 and C2. Connect the battery and clip a crystal ear-piece to the battery negative and one side of R5. A tone should be heard when the key is pressed. Disconnect the battery before continuing construction.

The remaining components may now be fitted, including the aerial socket. Note that, if using the recommended case layout, the socket should be mounted so that the aerial projects from the copper side of the p.c. board.

Screw the aerial into its socket and connect the battery via a meter on the 100 mA. range. The current will be anywhere between 20 and 80 mA., and should vary as the L3/L4 slug is adjusted. With a field strength meter, check that some R.F. output is present.

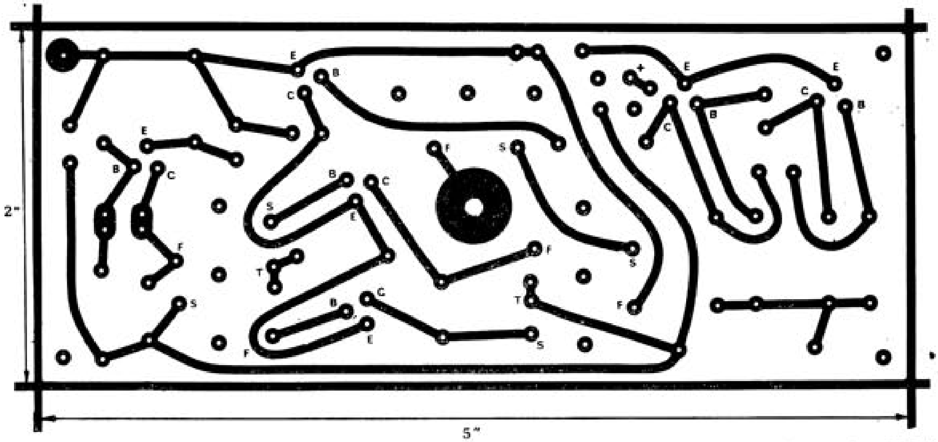
COMPONENT VALUES

VT1, VT2: 2N2926 or 2N3704 or 2N3705 or 2N3706
VT3, VT4, VT5, VT6: 2N3704 or 2N3705 or 2N3706
R1, R4, R5, R7: 4.7K (Yellow-mauve-red).
R2, R3: 33K (Orange-orange-orange).
R6: 22K (Red-red-orange).
R8: 220ohm (Red-red-brown).
R9: 560ohm (Green-blue-brown).
(All resissors Radiospares sub-min carbon).
C1, C2: .047mfd. 10v. disc ceramic
C3: .01mfd. 20v. disc ceramic
C4, C7: 47pf. silver mica
C5, C6: .001mfd. disc ceramic
RFC1: 1A Radiospares T.V. Choke
L1: 7¾ turns 28swg e.c.w. } ¼in. Radiospares former
L2: 2¾×2¾ T 28swg e.c.w.
L3: 3¾–3¾T 28swg e.c.w. } ¼in. Radiospares former
L4: 3¾T 28swg e.c.w.
L5: 16T 28swg e.c.w. ...¼in. Radiospares former
MS1: Pushbutton microswitch
SW1: On/Off toggle switch
2 Pairs press stud battery connectors
2 Off PP1 6v. dry batteries
48in. 10-section telescopic aerial with socket
Crystal: Wire-ended, or plug-in type with socket

Now key the transmitter and note that the meter reading falls to about half its previous value. Final adjustments of L3/L4 slug and the aerial loading coil, L5, are made with the unit installed in its case.

Case construction

To many home constructors, the case presents something of a problem but, with a little patience and some wooden blocks, this need not be so. The diagram shows a construction method which eliminates any bends that cannot be made in a 3in. vice. Mark out the inside dimensions of the front half, on a piece of 20 or 22 swg. aluminium and cut out with a hacksaw—the entire length of the cut being supported by wooden blocks. This prevents distortion of the aluminium during cutting. The flanges along each edge should be bent in one operation, using wooden blocks to extend the vice jaws, and remem-



bering that the panel is marked out on the *inside* of the bend. Notch the flanges so that the top and bottom may then be bent over. If the overall width of the case front is now measured, this will show how much the material thickness is adding to the marked out dimension. Mark out the rear panel accordingly, and cut and bend as before.

Lengths of ½in. aluminium, or brass angle, may now be screwed into the front half, to give added rigidity to the top and bottom, and to provide fixing for the rear panel. If these are recessed slightly, the rear half of the case will fit flush at the top and bottom. Holes for the p.c. mounting board, switches and aerial grommet, may now be drilled and opened out to size with a round file. The angle strip is tapped 8 BA for the rear cover fixing.

For final finish, the case may be either painted or rexine covered, most grades of the latter being completely fuel proof. If rexine is used, 8 BA countersunk screws may be Araldited in place before covering, so avoiding unsightly screw heads on the finished unit.

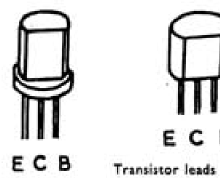
Mounting in the case

The printed circuit board is mounted in the top of the case, with the components facing downwards, half inch spacers being used to hold the board away from the metal panel. *Ensure that the copper land around one of the mounting holes connects properly to the case, for earthing.* Battery and switch leads should be looped through the two holes provided in the board.

Sponge rubber strips may be used to provide pressure for holding the batteries in place. If there is any danger of the battery connections shorting to the case, use thin paxolin or acetate sheet, glued in place, to prevent such an occurrence.

Final alignment

With the batteries in place and aerial extended, adjust the L3/L4 slug for maximum reading on your field strength meter. The aerial loading coil, L5, is similarly adjusted, with the case held firmly. Check that the L1/L2 slug is not set near the critical point. This is done by unscrewing it until the R.F. output falls off, then screwing it back in 1½ turns. Now make final adjustments to L3/L4 and 15, with the case held firmly as before. ■



TROUBLE SHOOTING CHART

If a circuit fails to operate, re-check the assembly, including soldered connections, and ensure that no short circuits are occurring between conductors. Check especially that transistor lead connections are correct. If the fault persists, the table below will provide guidance.

CIRCUIT FAULT	SYMPTOM	POSSIBLE CAUSE
Crystal oscillator does not operate.	Current low.	Damaged transistor or open circuit resistor.
	Current high.	As above or damaged C5.
	Current correct but oscillation will not start.	Faulty crystal, damaged capacitors or coil turns shorting.
Tone generator does not operate.	Current same as for local oscillator.	Microswitch incorrectly connected.
	Faults other than above.	Damaged components.
No output from power amplifier indicated on F/S meter.	Current as for oscillator plus tone generator.	VT4 or C6 damaged, R9 open-circuit.
	Current increased compared with above.	C7 damaged.
Output present but does not modulate.	F/S meter reading does not fall when Tx keyed although tone generator operating.	Damaged VT4 or C6.

RM SINGLET

SINGLE CHANNEL RECEIVER

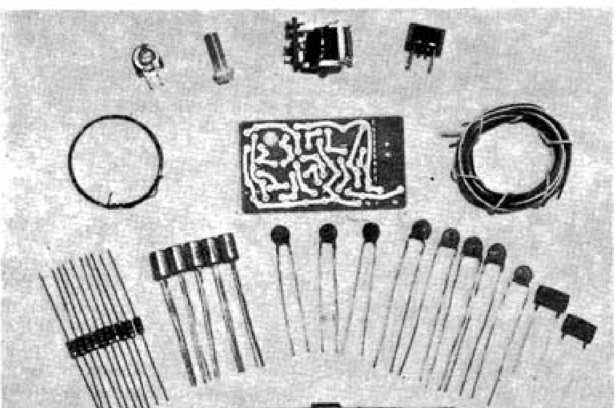
This super-regen receiver may be built in relayless or relay versions.

ALTHOUGH this super regenerative receiver has been designed particularly for use with the R.M. "Singlet" transmitter, it will work equally well with other single channel tone transmitters. It is, however, preferable to employ continuous carrier between signals, since this assists in suppressing any spurious noise arising in the super-regen hiss. Electric motor noise rejection is typical of super-regen circuits but, for maximum safety, it is recommended that a relay be incorporated when the receiver is used with motorised actuators.

Relay or relayless versions

With this in mind, the receiver is presented here in both relayless and relay versions. The circuit is, in fact, the same in both cases, the only difference being that the p.c. board is slightly longer for accommodating a relay. For a relayless version, the overall size may be reduced by cutting along the dotted line.

Whilst the unit is small and the components closely spaced, no difficulty should be experienced in construction provided reasonable care is taken. As with the transmitter, the technique of testing each section of the circuit as it is assembled has been adopted, a high impedance crystal earpiece, fitted with crocodile clips, being the only test-equipment required, although a multi testmeter could also be helpful.



The circuit is fairly conventional, the super-regen R.F. detector being capacitively coupled into a two-stage audio amplifier. The output from the second audio amplifier is transformer coupled into a switching circuit, for driving either a 10 ohms. actuator or 50 ohms. relay. Since super-regen circuits are somewhat dependent upon individual transistor characteristics, a variable resistor has been included in the base bias circuit so that adjustment to optimum operating conditions may be easily carried out.

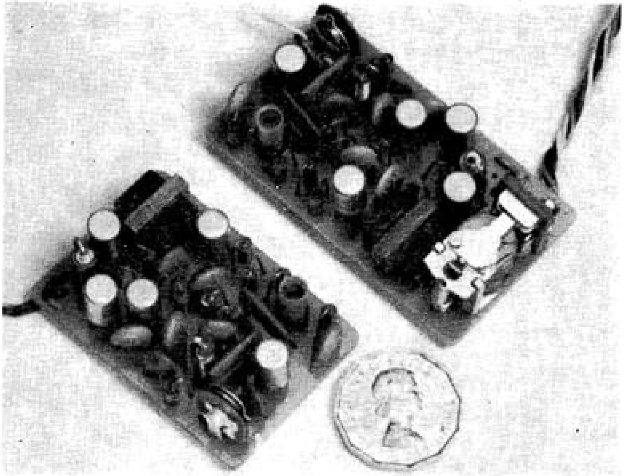
Printed circuit board

Methods of making p.c. boards have been described in detail on many occasions, so will not be repeated here.

All holes should be drilled with a No. 60 drill and the larger ones opened out as follows:—

1 off coil former hole: No. 12 drill.

1 off anchoring hole (battery and actuator connections) and 1 off anchoring hole (relay contacts



Quite a number of "Singlet" prototypes are already in regular use. Relay and relayless shown here together.

and armature connections): No. 48 drill.
1 off relay mounting screw hole: No. 48 drill.
1 off relay mounting pin hole: No. 50 drill.

If a relayless receiver is to be made, the p.c. board may be trimmed down in length by cutting along the dotted line, ignoring the two conductors which are severed in the process. Before commencing construction, clean the copper lands by lightly rubbing with steel wool and rinse down in running water.

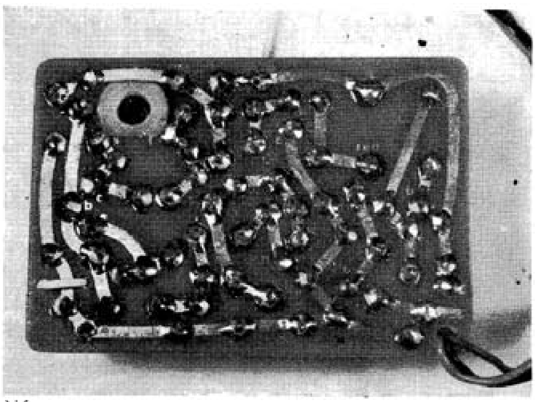
CONSTRUCTION SEQUENCE

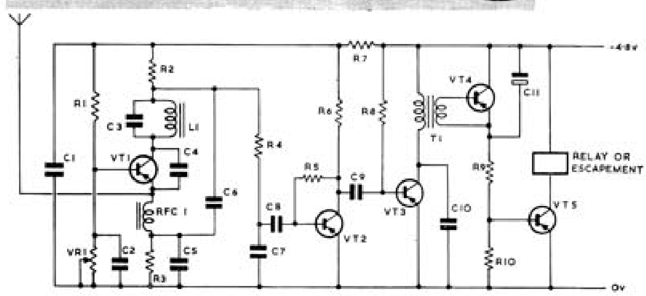
Throughout construction, care must be taken to ensure that all components are correctly fitted, particular attention being paid to the transistors and transformer. When mounting components upright, it is a good idea to bend all the top leads around a dowel before starting assembly. Check the polarity of the electrolytic capacitor when doing this; the lead exiting from the can through some insulation is the positive connection.

Resistors and capacitors should be pushed down as close as possible to the board, provided the leads are not strained. Transistors, however, should have a small gap, about ⅛ in. left between the case and the p.c. board. Avoid excessive heat when soldering the components in place.

Winding the coil

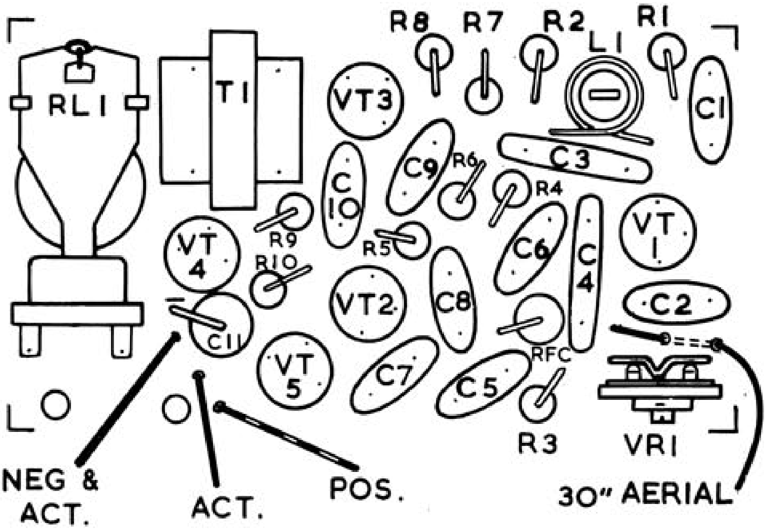
Construction is commenced with coil L1, which is wound on a 4 mm. (core) diameter former. Plasticine worked into the core threads will stop this working loose during use, and will prevent a stuck core occurring at a later date. Fit the coil former by pushing it through from the copper side of the p.c.





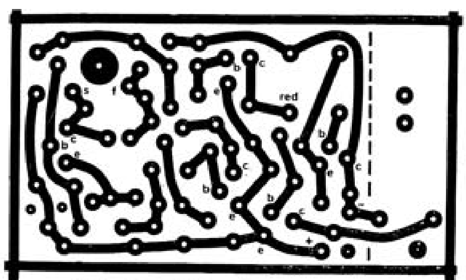
COMPONENTS LIST

VT1: GM1213B
VT2, VT3: NKT274.
VT4: NKT271.
VT5: NKT218.
R1, R2: 22K (Red-red-organge).
R3: 3.3K (Orange-organge-red).
R4, R6: 10K (Brown-black-orange).
R5, R8: 470K (Yellow-mauve-yellow).
R7: 1K (Brown-black-red).
R9: 180ohm (Brown-grey-brown).
R10: 560ohm (Green-blue-brown).
(All resistors Radiospares sub-min carbon).
C1, C7, C8, C9: .047mfd. 10v. disc ceramic.
C2, C5, C6: .001-mfd. disc ceramic.
C3: 47pF silver mica.
C4: 10pF silver mica.
C10: .01mfd. 20v. disc ceramic.
C11: 10mfd. 16v. Mullard electrolytic.
RFC1: 1A Radiospares TV Choke.
VR1: 5K Egen Preset.
L1: 10 turns 28swg e.c.w. 4mm (core) former.
T1: "MacPack" type or Remcon.
RL1: O.S. 50ohm relay.
Aerial: 30in. flex.
P.C. board.

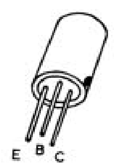


COMPONENT PLACEMENT—
When held up to the light, the positions of components on lands can be seen

board, and Araldite it in place. Excess projection on the underside of the p.c. board may be trimmed off. Clean one end of a length of 28 swg. enamelled wire and solder it into the hole marked "S." Closely wind on 10 turns in a clockwise direction, looking from the top of the former, and take the finish out to the hole marked "F." Ensure that the enamel is completely cleaned off the wire before soldering. A smear of Araldite around the top turn will prevent the coil springing unwound. Do not neglect this, as a poorly wound coil can be a source of trouble.



P.C. BOARD—ACTUAL SIZE



TRANSISTOR LEADS—
collector is marked by red spot

R.F. detector

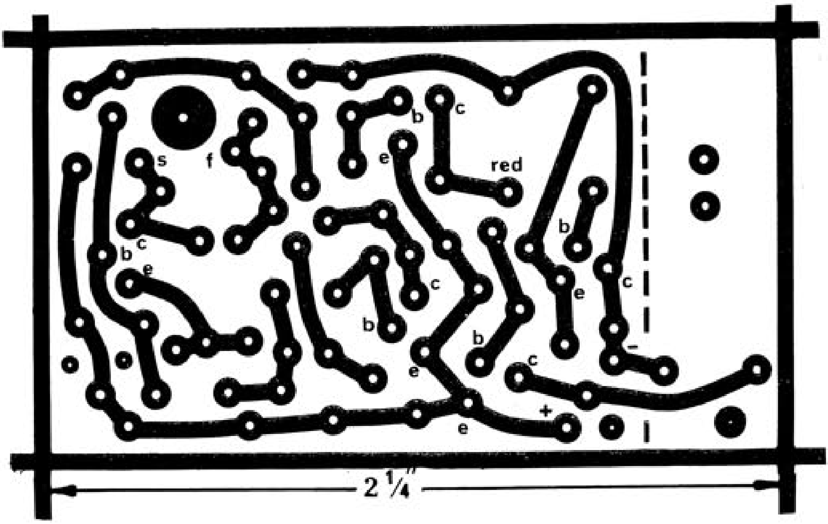
The components for the R.F. detector section may now be added; VT1, C1, C2, C3, C4, C5, C6, R1, R2, R3, VR1, RFC1, 30in. aerial and also R7. With VR1 set fully anti-clockwise, looking from the edge of the p.c., a 4.5v. battery or 4.8v. Deac may be connected to the conductors marked with positive and negative signs. Connect a crystal earpiece between battery positive and the finish, top end, of the coil. Listen in the earpiece and slowly turn VR1 clockwise until a hissing noise is heard to commence. Switch on the carrier of the transmitter and adjust the coil slug until the hissing stops. Switch off the transmitter and the hissing should start again. If not, readjust VR1 and repeat the above procedure.

The adjustment may be checked by keying the tone, which should be clearly audible in the earpiece. When satisfactory operation is obtained, check that the tone can still be heard with the Tx placed about 20ft. away from the receiver, with its aerial retracted. The adjustment of the coil slug may be altered so that the tone is peaked up. Disconnect the power supply before proceeding.

Amplifier stages

Add the components of the first amplifier stage; R4, R5, R6, C7, C8, VT2. If the earpiece is now connected between battery positive and VT2 collector, the tone should now be noticeably louder, with the Rx switched on and the transmitter keyed.

Components for the second amplifier stage may now be fitted; C9, C10, R8, VT3, T1. Take care to ensure that the transformer is correctly connected.



Satisfactory operation may be checked as for the first amplifier stage, but with the earpiece connected between battery positive and the collector of VT3.

The remaining components should now be fitted. If a relayless receiver is being constructed, an actuator should now be wired to the receiver so as to check the operation. This should be connected between battery negative and the collector of VT5. Note that if the actuator is of the type that employs p.c. wipers behind the pawl, these do not always pull in unless tensioned by the (rubber) actuator motor. If fitting a relay, short lengths of wire will be required to connect the coil tags to the p.c.

On switching on the receiver, the relay or actuator should now operate when the transmitter is keyed. (If not, refer to trouble shooting chart).

Final tuning

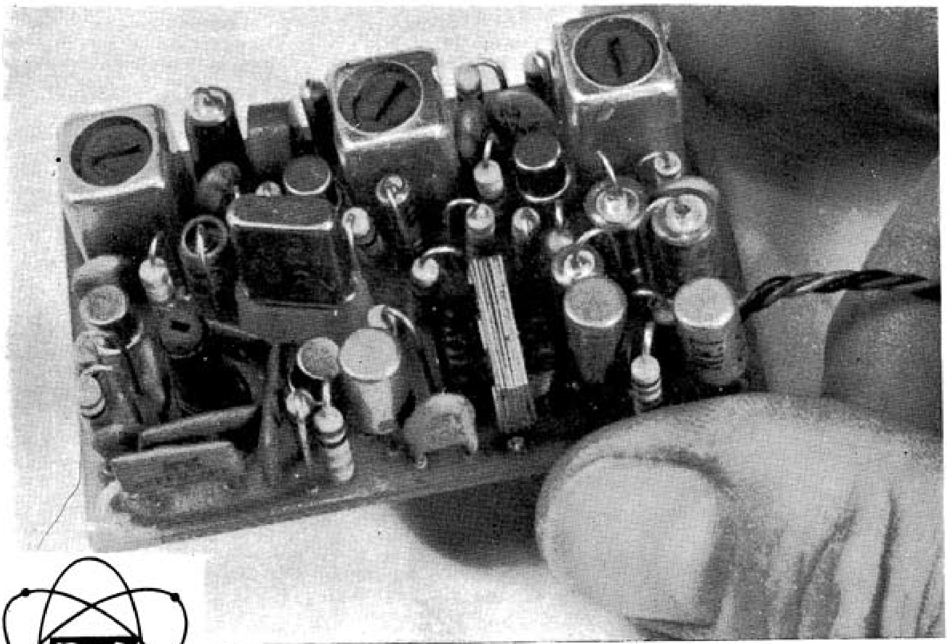
Final tuning should now be carried out with the crystal earpiece connected between battery positive and the collector of VT3. With the transmitter at a considerable distance, the tuning is adjusted in the same manner as when testing the R.F. section. Ensure that VR1 is not set too close to the critical point at which the super-regen action (hissing) starts, otherwise operation may stop as the batteries run down. Finally, carry out an extreme range check before installing the receiver in a model. Unless subjected to violent shock, the receiver should not need adjustment except on very rare occasions.

It is recommended that the receiver be housed in a box, to provide a reasonable degree of protection. One constructed of 1/16in. ply has been found satisfactory, particularly if wrapped around with nylon, doped on. Alternatively, the case may be covered in black rexine, as recommended for the transmitter, resulting in a most presentable finish. ■

TROUBLE SHOOTING CHART

If a fault is apparent, a thorough check on the assembly should be made, including all soldered joints. If this does not reveal the source of the trouble, the table below will provide guidance.

CIRCUIT FAULT	SYMPTOM	POSSIBLE CAUSE
R.F. stage inoperative	No super-regen hiss at any position of L1 slug or VR1 setting. Super-regen hiss not stopped by Tx carrier when L1 and VR1 adjusted.	L1 turns shorting. Damaged component or open circuit pot. wiper. C3 damaged or L1 turns shorting.
Amplifiers not functioning	No (or very weak) tone on collector of VT2 or VT3.	Damaged component in stage following last stage at which signal present.
Switching circuit not functioning correctly	Relay/escapement does not pull in.	T1 incorrectly inserted. Open circuit resistor, or damaged transistor or capacitor.
	Relay/escapement holds in when Tx carrier present and super-regen hiss suppressed. Relay / escapement chatters when no carrier present. Unsatisfactory range.	If noise present in earpiece at VT3, VR1 is incorrectly set. VR1 incorrectly set. Retune L1 if VR1 adjusted. Battery below 4v. on load (escapement held in on signal). Tuning adjustment adjustment L1 and VR1 not correctly set.



"SINGLET"-SUPERHET

a thoroughly tried and tested superhet receiver specially for the home-constructor. No special equipment is required for setting up, other than a multi-test meter.

FOLLOWING the popular reception given to the RM Singlet transmitter and super-regenerative receiver, we present the Singlet **Superhet** for home construction. Due to the greater complexity of a superhet circuit, we hasten to say that this is **not** recommended as a first try at a constructional project, since a fault can be extremely difficult to locate if the circuit operation is not understood thoroughly.

No originality is claimed for the circuit, well proven techniques have been employed, with careful attention not to push any given stage to its limit. Good quality components, which are both electronically and mechanically suitable for the application are employed, so that the completed receiver should prove extremely reliable in use. The sensitivity is such that, with any modern powerful single channel tone transmitter, range is far in excess of that required for all normal applications. The circuit is reasonably tolerant of electrical noise from servo motors, provided they are properly suppressed, but it is recommended that motorised actuators should be operated from a separate battery pack via a relay. In all cases the aerial should be kept well away from the servo-motors and leads.

Before we get down to the constructional details, a little of the theory behind the circuit will be described, so that you will have some idea of how this receiver works—and how the use of superhets allows more than one model to be operated independently at the same time.

Circuit description

Any type of receiver employs a circuit tuned to the signal frequency; in this case L1 and C3 perform this function. A maximum signal-voltage is introduced in this circuit when it is tuned to the incoming signal. Incoming signals close to, but not exactly matched to the tuned frequency, also induce voltage oscillations, and these may be sufficient to cause the following receiver stages to operate. This is why a super-regenerative circuit will respond to any transmitter in the R/C band. We require somehow to make the receiver select only the induced voltage caused by the correct transmitter signal. To achieve this, we build into the receiver, a crystal controlled oscillator, known as the local oscillator, which produces another signal of a slightly different frequency from that of the transmitter. The signals in the tuned circuit are mixed with the local oscillator output, in this case by VT1, and the resultant output is a range of frequencies, one of which is the difference between the transmitter and the local oscillator frequencies. Consider, for example, a transmitter frequency of 26.995 MHz, and a local oscillator frequency of 26.525 MHz, the difference frequencyis 470 KHz. A transmitter on the next spot frequency, 27.045 MHz, will produce a difference frequency of 520 KHz. Clearly it is easier to discriminate between two frequencies 50 KHz apart when they are in the order of 500 KHz instead of 27 MHz. (1 MHz = 1000 KHz).

The primary of the intermediate frequency transformer (I.F.T.) is tuned to 470 KHz and so a maximum signal develops across it at this frequency. 520 KHz and signals from other transmitters are at much lower signal levels.

The secondary of I.F.T. 1 couples the signal at 470 KHz into the first I.F. amplifier (VT 3) and I.F.T. 2 selects our wanted 470 KHz signal and passes it to the second I.F. amplifier (VT 4). At each of the tuned stages, the ratio of the signal voltage at 470 KHz, to the unwanted voltages at other frequencies, is being increased. The output from the second I.F. amplifier is passed to the detector stage by I.F.T. 3.

Until now we have only considered the 470 KHz signal. This is an a.c. signal, the peak amplitude of which varies in accordance with the modulation impressed upon the transmitter carrier. The diode allows only the positive half-cycle of oscillation to be passed, and if this is of steady amplitude (i.e. no tone superimposed), the half-cycle "pulses" are smoothed out by C 13 and R 14. The junction point of D1, R14, and C13 takes a steady voltage value dependent upon the amplitude of the 470 KHz signal, which is, in turn, dependent upon the strength of the transmitter signal, assuming the local oscillator output is constant.

If a tone is superimposed upon the 470 KHz signal, the voltage at the D1, R14 and C13 junction varies with the tone signal, since R14 and C13 are chosen so as not to smooth frequencies in the audio range. This variation in the voltage level is our recovered tone or audio signal.

Before we take this through any further, let us have another look at the first I.F. amplifier. The transfilter, F1, decouples the emitter of VT3 to a.c. signals at, or very close to, 470 KHz, so increasing the selectivity of the stage. A capacitor would have a similar effect but over a much wider frequency range. Notice also that R8 in the base circuit is not taken to the Ov. line, but to a point where a voltage dependent upon signal strength is developed. As the signal strength increases, the bias on VT3 changes reducing the stage gain, so avoiding signal overloading in the I.F. amplifiers. C9 smooths this control voltage so that it does not vary with the tone frequency. This is the automatic gain control (A.G.C.) employed in the receiver.

Returning now to our audio signal at the detector, this is capacitively coupled to the audio amplifier (VT5), the output of which is transformer coupled into the switching circuit (VT6 and VT7). The emitter of VT5 does not have a decoupling capacitor so that low-level signals and noise are not amplified sufficiently to actuate the switching circuit.

Pre-publication evaluation

The circuit has been designed to be tolerant of component variations within the manufacturer's specifications, **but if you start substituting components, then you are "on your own", as we cannot deal with queries arising from the use of components not as specified.**

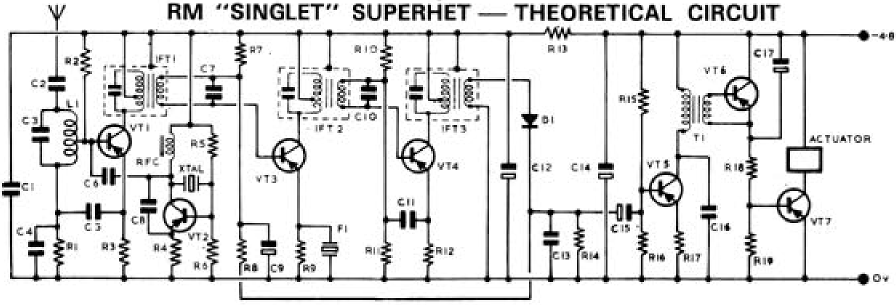
To prove the circuit and constructional instructions, several of these receivers have been built by modellers with no specific knowledge of electronics and only one has given slight trouble. This was quickly traced to solder bridging two conductors. The P.C. board has since been modified to give more clearance in the offending area, hence you may spot some very minor differences in conductor placement in the photographs.

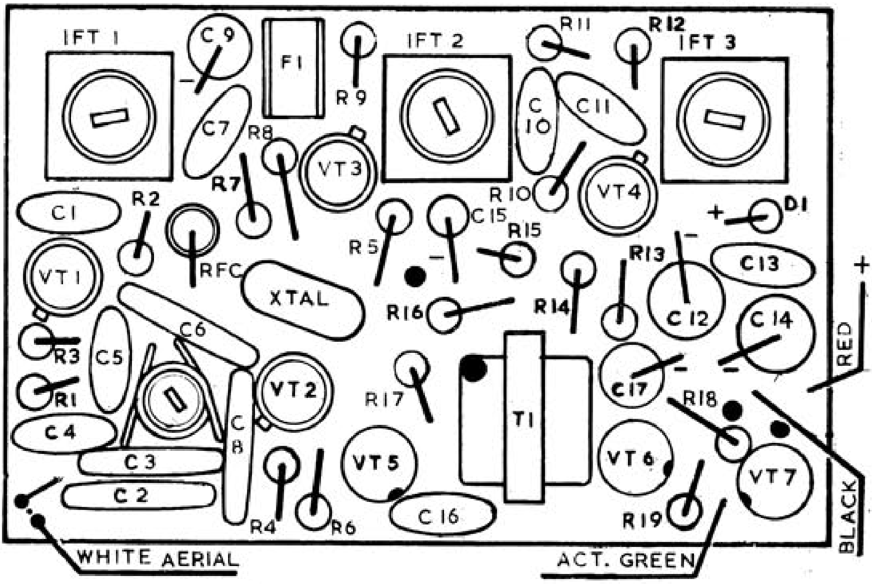
One constructor was unable to get the I.F. strip to align, but on returning the receiver to the designer everything was found to be alright. The "fault" was that he had been using a meter of only 2,000 ohms per volt sensitivity, instead of the recommended 5,000, and the needle deflection was practically indescernible. Thus, if your soldering is reliable, you should not expect to encounter any problems in getting the receiver to function correctly. The lining-up procedure for the I.F.T.s has been streamlined to requiring nothing more than an operating transmitter, two resistors, **and a test meter of at least 5,000 ohms-per-volt sensitivity.** Take care with the latter, since some of the cheaper meters available do not meet this specification.

Transmitter requirements

Many modellers are under the erroneous impression that there is something special required of

RM "SINGLET" SUPERHET — THEORETICAL CIRCUIT





COMPONENT PLACEMENT DRAWING

— when held up to the light, positions on p.c. lands may be seen.

COMPONENT LIST

D1	1GP5	Radio Spares or Mullard OA91
VT1	GM1213B	Texas
VT2	GM1213B	Texas
VT3	GM1213B	Texas
VT4	GM1213B	Texas
VT5	NKT274	Newmarket
VT6	NKT271	Newmarket
VT7	NKT281	Newmarket

R1	10K	Brown	Black	Orange
R2	47K	Yellow	Mauve	Orange
R3	1K	Brown	Black	Red
R4	1K	Brown	Black	Red
R5	100K	Brown	Black	Yellow
R6	10K	Brown	Black	Orange
R7	47K	Yellow	Mauve	Orange
R8	10K	Brown	Black	Orange
R9	1K	Brown	Black	Red
R10	47K	Yellow	Mauve	Orange
R11	10K	Brown	Black	Orange
R12	1K	Brown	Black	Red
R13	470ohm	Yellow	Mauve	Brown
R14	4.7K	Yellow	Mauve	Red
R15	47K	Yellow	Mauve	Orange
R16	10K	Brown	Black	Orange
R17	390ohm	Orange	White	Brown
R18	180ohm	Brown	Grey	Brown
R19	560ohm	Green	Blue	Brown

All resistors 10% sub miniature.

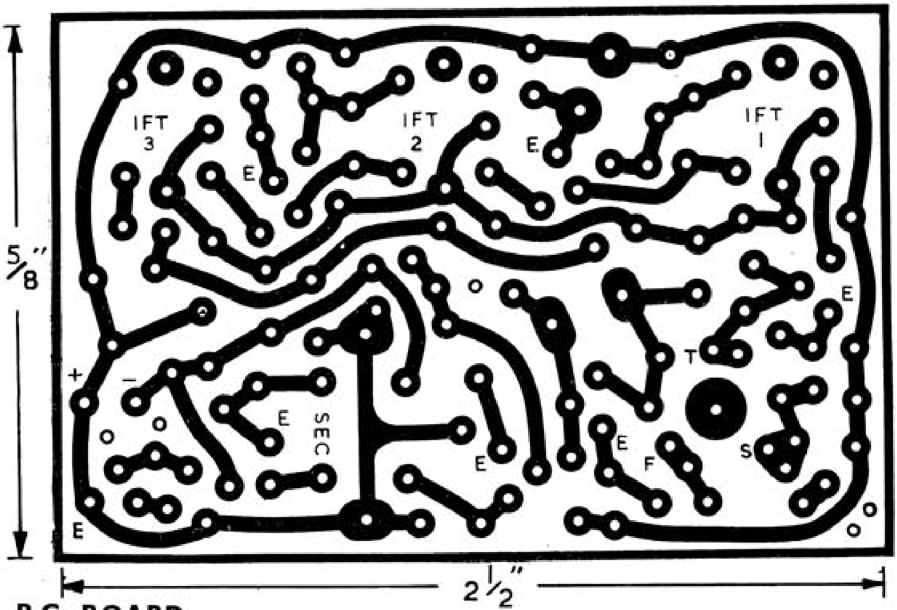
C1	.01mfd. Disc Ceramic
C2	47pf. Silver Mica
C3	20.pf. Sjlver Mica
C4	470pf. Disc Ceramic
C5	.047mfd. Disc Ceramic
C6	5pf Silver Mica
C7	.001mfd. Disc Ceramic
C8	10 pf. Silver Mica
C9	10mfd. 16v Electrolytic
G10	.001mfd. Disc Ceramic
C11	.047mfd. Disc Ceramic
C12	40mfd. or 50mfd. 6.4v Electrolytic
C13	.047mfd. Disc Ceramic
C14	40mfd or 50mfd. 6.4v Electrolytic
C15	2mfd. 10v Elecrolytic or 2.5 mfd 16v
C16	.01mfd Disc Ceramic
C17	10mfd. 16v Electrolytic

All disc ceramic, sub minature type, Radio Spares or Eric.
All electrolytics, Mullard
All Silver micas, Radio Spares or Lemco.

T1 MacPack 5:1 interstage type.
F1 Transfilter type TF01D Brush Clevite.
IFT 1 Red Brown FP50 245/C E.I.H. Electronics Ltd.
IFT 2 Mauve White FP50 247/IC E.I.H. Electronics Ltd.
IFT 3 Black FP50 225/C E.I.H. Electronics Ltd.
Coil former & slug 4 m.m. type.
R.F.C. 1A T V Choke. Radio Spares.
9 in. Red Black, Green Flex.
36 in. Flex to crystal colour code for aerial.
24 in. 28 SWG E.C.W.
Crystals: 470 KHz spacing. 1 pair.
Metal Case.
P.C. Board—Fibre Glass.
Insulation .020 in. "Plasticard" or acetate sheet.
Self tapping screw.
2 Grommets.

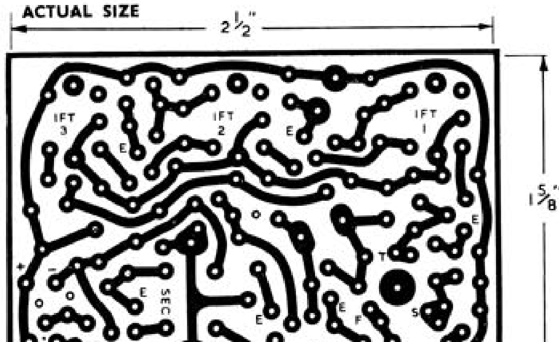
a transmitter with a superhet. The only requirement is that the transmitter should operate on the correct frequency, and this is achieved by employing a matched pair of crystals of the chosen "colour" or spot frequency. The difference between the two crystals of the pair is dictated by the receiver, in this case 470 KHz, and the lower frequency crystal is used in the receiver.

The design of the amplifying stage and switching circuit requires the transmitter tone to be in the range 400 Hz to IKHz. Higher tones such as intended for tuned filter receivers are not suitable. The tone is required to modulate the transmitter carrier to 100 per cent—i.e. completely switch the carrier on and off in every cycle of the tone frequency. To the best of our knowledge, all commercial transmitters, and published designs, meet this require-



P.C. BOARD

ACTUAL SIZE



ment. The shape of the tone waveform, i.e. sine or square wave, is not important with this receiver.

In common with all superhet receivers, it is not recommended that this receiver be operated by a low power transmitter since, apart from reduced range, (superhets are generally less sensitive than super-regenerative types), trouble could be experienced when operating in close proximity to other transmitters. As a general rule, if the transmitter only uses a small layer battery (P.P.3 type) then it will probably not have sufficient output for use with a superhet. The RM "Singlet" transmiter is, of course, ideal for use with this receiver.

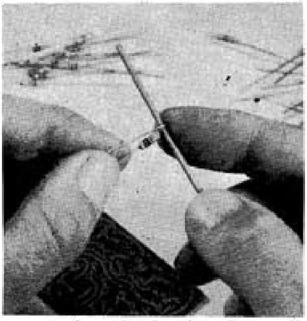
Preparation of components

1. Take the crystal socket and cut off the centre spigot, flush with the nylon moulding. (If, in fact, a plug-in crystal is to be used—this is optional.)

2. Wrap the I.F. cans around with P.V.C. tape or "Sellotape" so that there will be no danger of component leads shorting on the metal cases. Take care not to cover the colour codings (otherwise your chances of identifying the transformers correctly is 1 in 6!). The crystal may be similarly treated if it does not have a plastic sheath. (The Rx crystal is the lower frequency of the matched pair).

3. Select all the resistors and straighten their leads. Using a $\frac{3}{32}$ in. dowel or a piece of 12 swg wire as a former, bend back the lead at one end of each resistor, so that it is parallel to the resistor body. It is recommended that the tolerance band (silver or gold) be kept at the unbent end. The diode is similarly treated, the bend being made at the end marked with a band or red dot.

4. The electrolytic capacitors are prepared in the same manner,



except that the bend radius will be dependent upon the capacitor size. All bends are made at the negative end, i.e. the end NOT insulated from the metal case.

5. The leads on the remaining components, except the R.F.C. which is treated as above, should be straightened so that they will fit easily into the P.C. board.

P.C. board

Methods of making printed circuit boards have been described in detail on many occasions (for instance p. 116 of April 1966, and p.192 June 1967 issues). However, due to the complexity of the conductor pattern, and the accuracy of the hole-positioning required for the I.F. cans, it is strongly recommended that a photographically produced board be obtained. Paper laminate P.C. board material is *not* suitable for this receiver, it being too prone to damage. **Fibreglass or similar is therefore essential.**

Trim the P.C. board to the inside edge of the border line and drill all holes with a No. 60 drill. Certain holes are opened up as follows:--

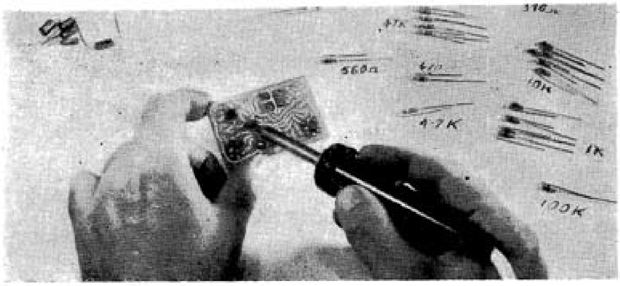
1 hole No. 12 drill for coil former.

2 holes No. 48 drill for battery leads.

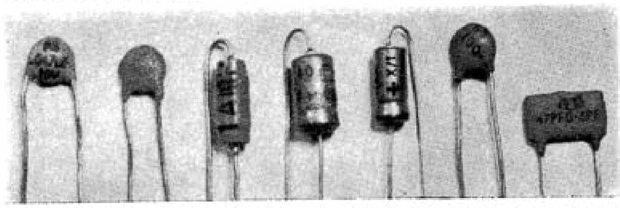
1 hole No. 50 drill for self-tapping screw mounting.

2 holes No. 54 drill for aerial anchoring.

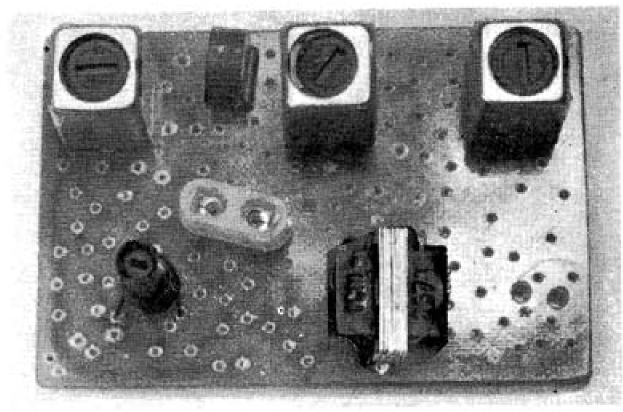
Some components have flat lugs and the holes for these should be slotted using a fretsaw, or fretsaw-blade gripped in a pair of pliers. **Do not** drill these holes out to clear the lugs. 6 holes for the cans of the I.F.T.s and 2 holes for the transfilter require this treatment. Also, if a crystal socket is employed, slots will be required for its lugs. If the crystal is to be soldered in, the holes may require opening out to suit the thickness of the pins.



Above: pre-sorting the resistors, marking the groups with their values, helps a lot in ease and speed of assembly.



Above—capacitors—note crimped positive ends of electrolytics.



STAGES 1-6 showing coil, crystal socket (optional), transfilter, the three I.F. transformers and interstage transformer.

Take care when handling the I.F.T.s at this stage. Do not force them into the board if the pin alignment is not correct; carefully open up the offending holes. **Mishandling can cause irrepairable internal damage.**

Soldering

Usually, at this stage, it is pertinent to make some comments on soldering. However, before attempting a project of this complexity, the constructor should already have become proficient with a soldering iron. We will, however, stress the importance of using an iron of not more than 15 watts rating, and of keeping the bits clean and well tinned.

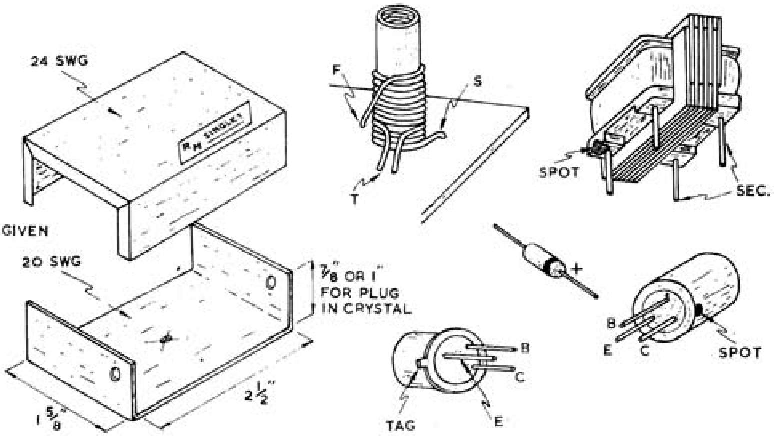
Assembly sequence

1. If the P.C. board is not of the pre-fluxed type, clean down the copper side with fine steel wool and rinse down under running water.

2. Fit the coil former into the P.C. and "Araldite" in place taking care not to cover any of

DETAIL SKETCHES

—at right are shown case construction, coil windings, interstage transformer and component lead identification.



the copper conductors. When set trim off any projection on the copper side of the board, to less than 1/32 in. with a fine file or emery paper.

3. Scrape the enamel from one end of a length of 28 s.w.g. enamelled copper wire and solder into the "start" hole (marked S) of the P.C. board. From the bottom of the former, tightly wind on 3¼ turns in a clockwise direction and bring the wire out to the tapping point marked T, and lead it through the hole nearest to the point where it leaves the former. Push the turns tightly on to the former, pulling on the wire to prevent them springing open again. Maintain the tension whilst the wire is bared when it emerges through the hole on the copper side of the board, and solder in place. Check that the turns are tight before clipping the wire off. A further 9¼ turns are now wound on in the same direction, up the former, directly above the first set of windings, as shown in the drawing. The start of these 9¼ turns is in the other hole on the tapping point "T", and the finish in the hole marked "F". The result of this complete operation should be a coil of total 12½ turns, wound clockwise up the former, starting at "S" and finishing at "F". At 3¼ turns up from "S" a tapping is present, brought out to conductor marked "T" on the P.C. board. If you are not satisfied with this coil, strip it off and start again; a badly wound coil will be a constant source of trouble at later stages.

A light smear of "Araldite" around the top turn will prevent any tendency for the coil to come unwound.

4. Take the interstage transformer and identify its primary and secondary connections from the sketch. Insert it into its holes in the P.C. board, ensuring that the secondary connections are on the correct side of the laminations and solder in place.

5. If a crystal socket is to be employed, this should now be fitted, seating it as close to the P.C. board as possible.

...**6.** Identify each of the I.F. transformers by means of their colour coding and fit them into the P.C. board, ensuring that they are seated correctly before soldering. The transfilter F1 may also be fitted at this stage, again ensuring that it is seated correctly.

Continuity checks

A few continuity checks are advisable at this stage to ensure that no windings have been damaged in handling. These may conveniently be made with the Ohms range of a test meter. For the tuning coil, continuity should exist betwen all three connections, S, T and F. For the interstage transformer, continuity should exist between the two primary connections and between the two secondary connections, but not between the primary and secondary. For each of the I.F. transformers, continuity should exist between all the primary connections (the three pins) and also between the secondary connections (the two pins), but not between the primary and secondary windings. If any troubles show up check for any dry joints, and if this does not show the trouble, then you have damaged the offending component. If all is well proceed with the next stage:—

7. Fit resistors. If you are not too certain of the colour code, lay the resistors out in sequence according to their circuit references. In any case, take care not to confuse colours as, under certain lighting conditions, red and orange can appear very similar! Working through in sequence, solder each resistor into position, seating it close onto the p.c. board. The *diode* should also be fitted at this stage taking care with its polarity. Check through to ensure that the resistors are all in the correct position.

8. Select the silver mica and disc capacitors and identify the different types. Take care not to confuse decade values, i.e. 4.7pF 470pF, .047μF, the latter may be marked 47K and similarly .01μF may be marked 10K.

9. The electrolytic capacitors and RF choke should now be fitted.

Solder each in place in circuit reference sequence, seating as close to the board as possible without straining the leads. When this operation is complete, again check everything through against the component placement drawing.

10. Take the transistors and spread the leads to fit into the P.C. holes. Push each transistor into its appropriate location ensuring that the leads go into the correct holes, and with the transistor spaced 1/16 in. off the board, solder in place.

11. Bare ¼ in. of the ends of the battery and output leads and tin these with solder. Insert these into the appropriate holes from the component side and solder. Loop the leads through the two anchoring holes and twist together.

A 36 in. length of flex is similarly fitted as an aerial and looped through the two holes at the corner of the P.C. near the tuning coil.

12. Fit the crystal, and the p.c. board assembly is complete.

Check your work

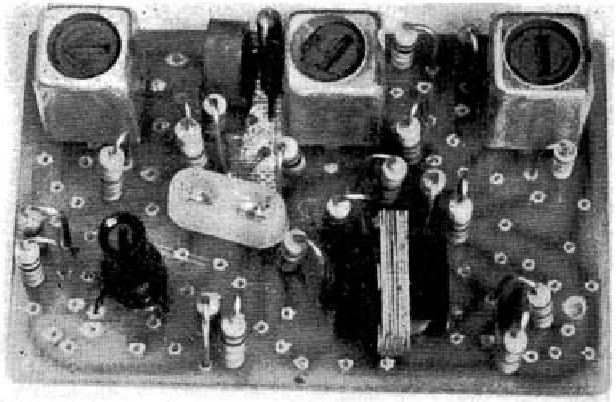
Before proceeding with testing, check everything over thoroughly or, better still, have someone else do it. Inspect all soldered joints—there are 137 of them and they must all be beyond suspicion! Only when you are absolutely certain that nothing is amiss, should testing be commenced.

Testing and alignment

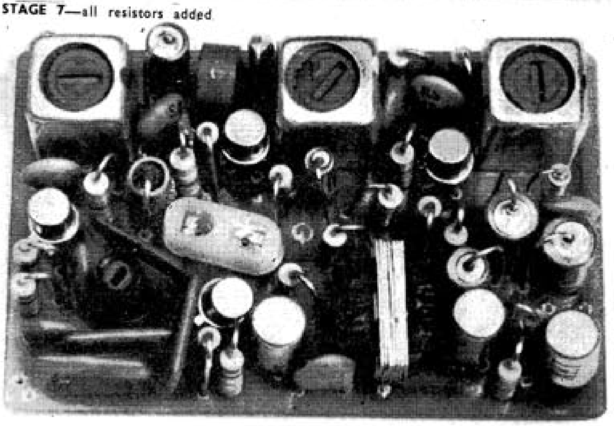
Alignment should be carried out with the receiver working under the conditions in which it is to be used—i.e. driving an actuator or relay, and from the appropriate supply. The recommended voltage source is a 4.8 V Deac pack, but the circuit operates satisfactorily from 4.5 V or 6 V batteries. Do not use a 6 V Deac since when freshly charged, its voltage is considerably higher. **For alignment, the Deac should be fully charged or the dry batteries fresh.**

Do not connect the actuator or relay yet Connect the battery positive to the positive terminal of the test meter, and the receiver negative to the battery negative. With the meter switched to a current range of, say, 0-5 or 0-10mA, touch the receiver positive lead to the negative probe of the meter. A current in the order of 3.5mA should be indicated. If a considerably larger reading is obtained, disconnect and inspect the p.c. board for a possible short circuit between a pair of conductors or component leads. If the reading is very low, look for an open circuit or poorly solded joint and rectify accordingly.

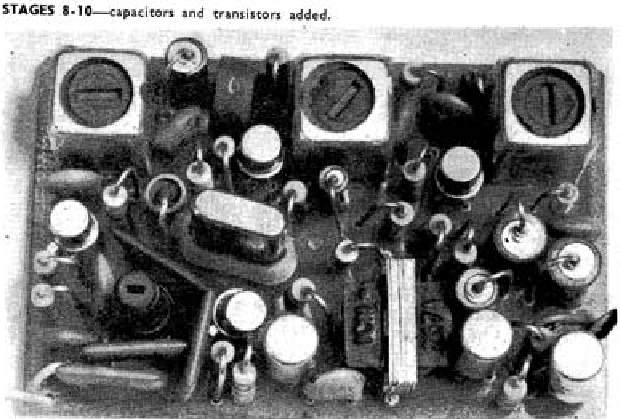
Connect the actuator or relay between the "output" lead (green)



STAGE 7—all resistors added



STAGES 8-10—capacitors and transistors added.



STAGES 11 & 12—leads, aerial and crystal fitted, to complete.

and the negative supply for 4.5 V or 4.8 V (or in the case of a 6 V supply with an actuator or relay of less than 25 ohm coil resistance), between the output and 4.5 tapping point on the battery pack.

Take two 10K ohm resistors and connect them to the free ends of the meter leads. Connect the resistor on the negative meter lead to the positive battery terminal, and the resistor on the positive meter lead to the top end of the diode (the band or dot end). **Remember that the test meter should have a d.c. sensitivity of at least 5,000 ohms per volt.** Borrow one from a friend if your own is not good enough.

Switch the meter to a voltage range around **1 V to 2 V** and connect the receiver to the supply. The meter should now read slightly in reverse. Unscrew the tuning slug about half way out of the coil former and switch on a transmitter (with the correct crystal inserted). Observe that the test meter reading now increases to a positive deflection as the transmitter is brought nearer to the receiver. Above a certain level, possibly with the Tx aerial extended, the reading will remain fairly constant as the transmitter is brought closer.

Decrease the transmitter signal strength by retracting the aerial and/or by moving the Tx further away until the meter indicates approximately half the deflection at which the reading was constant. Using an insulated tool about 9 in. long made from a piece of dowel, and **with the hands clear of the receiver,** adjust each I.F. can in turn, by not more than ⅛ th. turn at a time, until the meter reading is seen to increase. On no account screw the slugs in excessively, otherwise irrepairable damage will result to the windings. As the position is found where one I.F. can begins to improve the reading, leave that adjustment and locate a similar setting on each of the others. If at any stage the meter reading reaches the same steady positive value, as before, move the Tx further away to decrease the reading.

Now adjust each I.F. can in turn to achieve a peak deflection on the meter, moving the Tx further away as necessary. When all three are peaked, check over each of the settings by moving the slug slightly to each side of the peak. The transmitter may now be moved away so that the meter deflection is extremely low, and the setting again checked for peaking. Screw in the tuning coil slug to give a peak reading on the meter.

The transmitter tone may now be Keyed, when the meter reading should fall, and the actuator or relay pull in. If the meter reading falls but the actuator does not pull in, a fault exists in the amplifier or output stage, and this should be located before proceeding to the final alignment which can only be done with the receiver fitted in its case.

Case construction

The case is made from 20 swg aluminium for the bottom and 24 swg for the lid. The bottom half is made first, marking out around the P.C. board and allowing enough depth on the end pieces to clear the tallest components, when a piece of insulation is placed under the P.C. board. The aluminium may be cut to size either with a modelling knife or by sawing. Metal shears are not recommended since they distort the material.

Clamp the aluminium in a vice between wooden blocks, aligning a bending line along the edge of a block. Bend the end over with the scribe line on the inside of the bend. Repeat for the other end and check the p.c. board fits between the two bent up ends.

The top half of the case may now be marked out from the outside dimensions of the bottom half, allowing $\frac{1}{16}$ in. at the ends for the flanges.

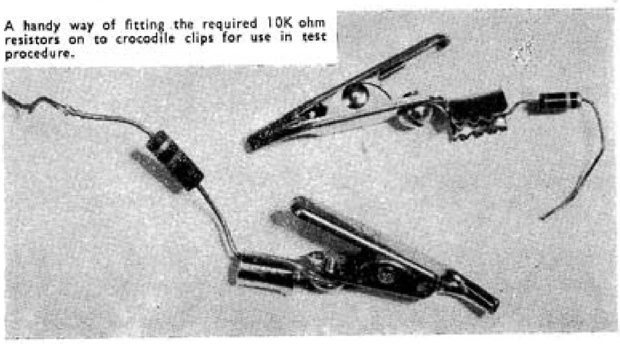
The flanges at each end are bent in one operation, remembering that the guide lines are on the inside of the bend. Using a wooden block of greater depth than the case, the two sides may be bent down. Check that the two halves fit together correctly and clean up the corners with a file. Drill a hole in the lower half for the p.c. mounting screw, and two holes, one at each end, to suit rubber grommets for the connecting leads and aerial. The case may now be rubbed down with fine emery cloth and a finish applied as desired.

Final assembly alignment

Cut a piece of insulating material to the size of the p.c. board and make a hole in it to clear the mounting screw. Mount the p.c. in the lower case half, with the insulation, by means of a single self tapping screw (these are available as Triang railway spares), and feed the leads and aerial through the rubber grommets.

Remove the tuning coil slug and work some Plasticine into the threads to prevent its working loose when the receiver is installed in a model. Now repeat the lining-up procedure described earlier, taking care not to touch the case, aerial or leads when checking the peak settings.

When alignment is complete, fit the case top and carry out a range check. The tuning coil may be peaked up during this if required, although this should not be necessary. The I.F. can adjustments should only be made using the test meter and should not be altered during a range check. ■



A handy way of fitting the required 10K ohm resistors on to crocodile clips for use in test procedure.

CRYSTAL FREQUENCIES

Tx Colour	Tx Crystal	Rx Crystal
Brown	26.995 MHz	26.525 MHz
Red	27.045 MHz	26.575 MHz
Orange	27.095 MHz	26.625 MHz
Yellow	27.145 MHz	26.675 MHz
Green	27.195 MHz	26.725 MHz
Blue	27.245 MHz	26.775 MHz

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