Constructional Project

PRACTICAL RADIO CIRCUITS

RAYMOND HAIGH

Part 3: Regenerative Receivers – A modern-day version of Armstrong's 1913 circuit.

Dispelling the mysteries of Radio. Circuits for the set builder and experimenter.

In Part Two we reviewed the history and theory of regeneration and used the technique to improve the performance of two, portable, radio receivers. This month a regenerative receiver designed for serious listening on the long, medium and short wave bands will be described.

BASICS

For a regenerative receiver to perform well, three basic requirements have to be met. (1) Its regeneration control must be smooth, completely free from backlash, and have a minimal effect on tuning.

(2) The tuned circuit to which the *Q* enhancing positive feedback is applied must be isolated from the aerial: failure to do this will result in reaction dead spots on frequencies (or harmonics) at which the aerial is resonant.

(3) Provision must be made, at the receiver input, for the attenuation of powerful signals, otherwise the regenerative circuit will lock onto strong carriers and it will not be possible to receive weak transmissions on adjacent channels.

ARMSTRONG UPDATED

A modern, transistor version of Armstrong's circuit, patented in 1913, is shown in Fig.3.1. In the original, the feedback coil (tickler coil in the USA), L3, was connected in place of the radio frequency choke, L4, and regeneration controlled by adjusting its proximity to tuning coil L2. This was eventually superceded by the variable capacitor system shown here, where increasing the capacitance of VC1 increases feedback through L3.

Choke L4, in the drain (d) circuit of TR1, acts as a load for the radio frequency component of the amplified signal, controlled amounts of which are fed back through L3 to overcome losses in the tuned circuit (L2/VC2) and increase its efficiency or *Q* factor.

Armstrong discovered that the technique permits the amplification of weak signals by a factor of more than 1000. Further, because tuned circuit *Q* is raised, there is also a dramatic improvement in selectivity.

Source bias is developed across resistor R3, which is bypassed by capacitor C2, and signal detection occurs by way of rectification at the gate/source junction of transistor TR1. (In the original valve versions, diode rectification between grid and cathode resulted in detection or demodulation). Low value blocking capacitor C1 prevents the audio voltage developed across gate resistor, R1, being shorted by the tuning coil.

AUDIO SIGNAL

The amplified audio signal is developed across drain load resistor R2 and coupled to the audio amplifier stages via d.c. blocking capacitor C3. Residual radio frequencies are bypassed by capacitor C4.

In some versions of the circuit, a transistor type audio transformer (e.g., an LT44) is substituted for the resistive load in order to maximize signal transfer. However, even with this arrangement, the audio output is very low, and at least one additional stage of pre-amplification will be required ahead

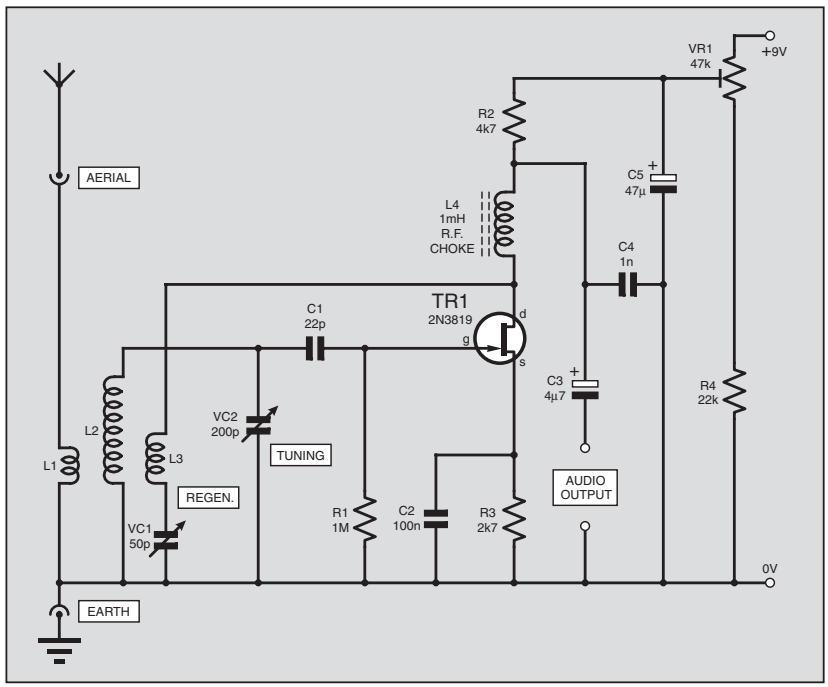


Fig.3.1. Circuit diagram for a modern transistor version of Armstrong's Regenerative Detector. In Armstrong's circuit, patented in 1913, feedback coil L3 is connected in place of r.f. choke L4 and its proximity to L2 is adjusted to control regeneration. VR1 presets regeneration control range.

of the headphone or speaker amplifiers described in Parts 1 and 2.

The gain of TR1, and hence its willingness to regenerate, is determined by preset potentiometer VR1, which adjusts the drain voltage. By this means the circuit can be optimized for different transistors and coil feedback winding ratios.

POPULARITY

Using gradually improving versions of Lee de Forest's triode valve as the amplifying device, Armstrong's circuit, followed by a one or two valve audio amplifier, remained popular as a domestic receiver until the end of the 1920s in the USA and well into the 1930s in the UK. Regenerative receivers were still being manufactured by Ever-Ready (their Model H) as late as the 1950s, and they were constructed by amateurs up to the close of the valve era.

It is not easy to use low impedance, current amplifying bi-polar transistors in this circuit. However, it saw something of a revival in amateur circles following the introduction of the field effect transistor (f.e.t.), with its more valve-like characteristics, in the late 1960s.

IMPROVED CIRCUITS

Smooth regeneration can be obtained more readily, and with simpler coils, by configuring the *Q* multiplier, or regenerative detector, as a Hartley oscillator. A typical circuit is given in Fig.3.2, where feedback from the source(s) of the dual-gate MOSFET, TR1, is connected to a tapping on the tuning coil L2.

The level of feedback is controlled by VR1, which varies the gain of the transistor by adjusting the voltage on its gate g2. Preset potentiometer VR2 (wired as a variable resistor) determines the source bias and optimizes the action of the regeneration control for individual tuning coils and transistors.

Audio output is developed across drain load resistor R3. The stage is decoupled from the supply rail by resistor R2 and capacitor C5, and the filter network formed by C4, R4 and C6 removes radio frequencies from the output.

SEPARATION

During the valve era, the functions of signal detection and *Q* multiplication or regeneration were invariably carried out by a single device. This combining of functions can make it more difficult to obtain the smooth, backlash-free control of regeneration which is crucial to the efficient operation of a receiver of this kind. Best modern practice uses separate transistors.

The dual-gate MOSFET circuit illustrated in Fig.3.2 can be used just as a *Q*-multiplier by increasing the value of capacitor C4 to 100nF. Filter components, R4, C6 and coupling capacitor C7, can be omitted when the stage is configured in this way.

The "hot" end of the tuned circuit must, of course, be connected to gate g1 of the transistor, and resistor R1 is best retained to hold gate g1 at 0V during coil changing.

DETECTORS

A field effect transistor (f.e.t.), biased into the non-linear region of its characteristic curve, forms an excellent detector stage. The "drain bend" version (the transistor equivalent of the valve "anode bend" detector) is included as TR3 in the Regenerative Receiver design illustrated in Fig.3.4. This arrangement is discussed later.

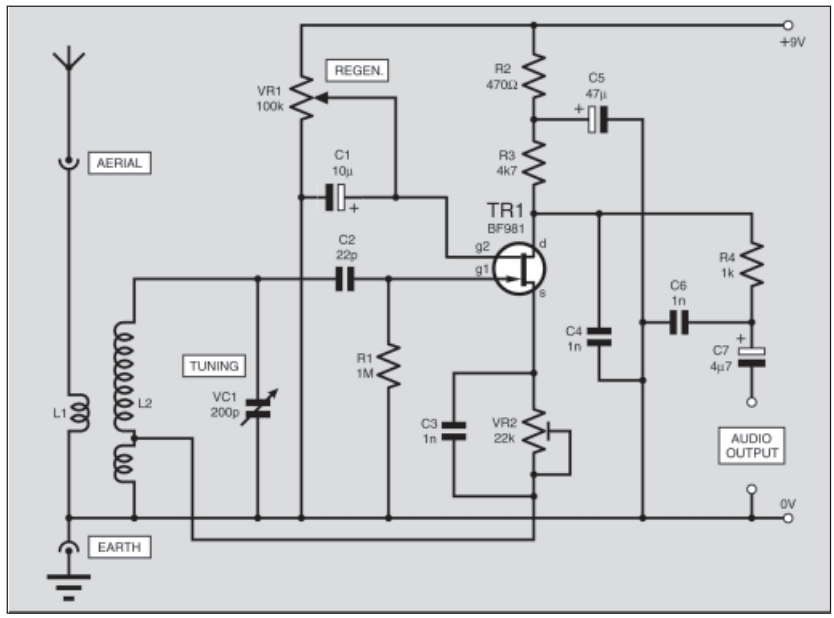


Fig.3.2. Circuit diagram for an improved Regenerative Detector based on a Hartley oscillator. VR2 presets regeneration control range. This circuit forms an excellent Q-Multiplier for use with a separate detector, in which case increase capacitor C4 value to 100nF and delete C6, C7 and R4.

Alternatively, the audio output can be taken from the source of the f.e.t. We then have the transistor equivalent of the valve "infinite impedance" detector. The modified circuit, using the component numbering of Fig.3.4 for ease of comparison, is shown in Fig.3.3.

High-value source bias resistor R9 is bypassed only at radio frequencies by capacitor C10 (C9 is omitted), and C13 is increased to 47μF to decouple the stage which is now in the common drain mode. The r.f. filter components, R8 and C15, and the original decouplers, R6 and C11, are not required.

There is little to choose between the two detectors: both work well, imposing very little damping on the tuned circuit. In theory there is some gain with the drain bend version whilst the gain of the source follower is slightly less than unity.

In practice, the need to ensure non-linearity over a range of f.e.t. characteristics results in the drain bend circuit providing very little gain. If the value of r.f. bypass capacitor C10 in Fig.3.3 is reduced, the source-follower detector may become unstable when the regeneration control is critically set.

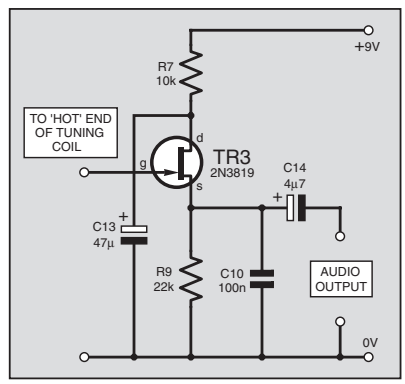
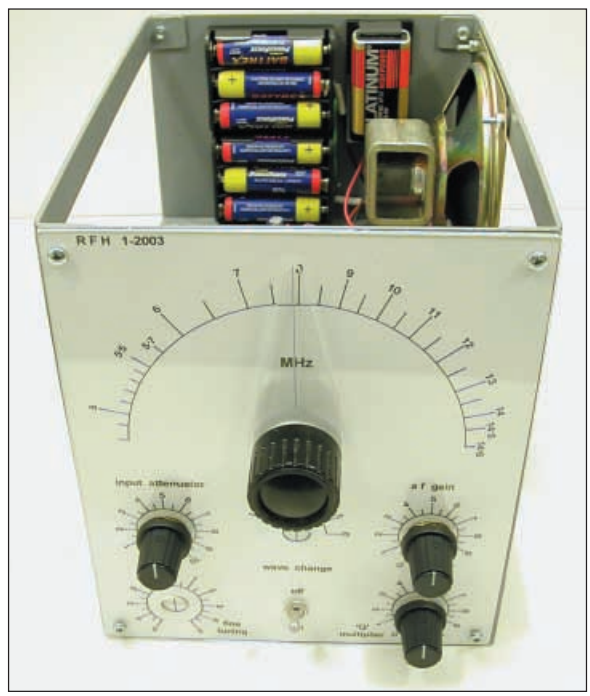
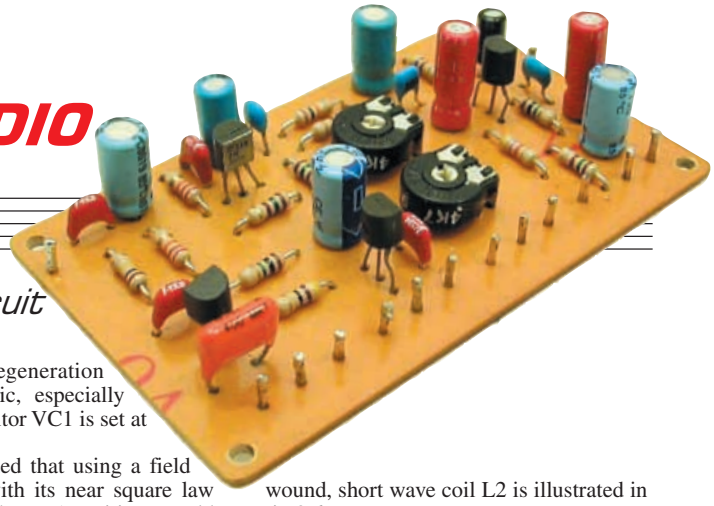


Fig.3.3. Source-follower detector circuit. Transistor equivalent of the valve "anode-bend" detector.



HIGH PERFORMANCE

REGENERATIVE RADIO



A modern-day update of a 1913 circuit

The full circuit diagram for a High Performance Regenerative Radio incorporating the essential features described here is given in Fig.3.4. It is easy to set up and performs well.

Grounded base stage, TR1, isolates the tuned circuit L2/VC1 from the aerial and TR2 functions as the *Q*-Multiplier. Field effect transistor TR3 is a drain bend detector and transistor TR4 an audio preamplifier.

Although excellent *Q* multipliers can be designed around dual-gate MOSFETS (metal-oxide semiconductor field effect transistors), devices of this kind are becoming more difficult to obtain. For this reason a j.f.e.t. (junction field effect transistor) is used in the *Q* multiplier stage.

Performance is not compromised and these simpler devices are widely available. The circuit in Fig.3.2 should assist any readers who might wish to experiment with dual-gate MOSFETS as an alterative.

INPUT CIRCUIT

Some readers may be plagued by a medium wave transmission which is powerful enough to swamp the receiver, and L1 and C1 act as a Wave Trap, blocking out the offending signal. Wave trap circuits were discussed in Part 2 last month, and component values and a printed circuit board design were also given.

Potentiometer VR1 connected as the emitter resistor for transistor TR1, controls signal input, and resistors R2 and R3 fix the base bias. The base of TR1 is "grounded" at radio frequencies by capacitor C5; and R1, C3 and C4 decouple the stage from the supply. Blocking capacitor, C2, prevents the grounding of TR1 emitter when aerials are connected to the receiver via a balun transformer and coaxial cable.

The grounded base configuration results in a low input impedance and a high output impedance, and the stage can be coupled directly to the tuned circuit without imposing excessive damping. Because TR1 is a *pnp* transistor, its collector (c) can be connected to the 0V rail via coil L2, eliminating the need for a coupling winding.

STABILITY MATTERS

Stability is ensured by stopper resistor R4 and by maintaining a low level of base bias on TR1. Constructors may wish to try reducing the value of resistor R3 (not less than 47 kilohms) to improve performance when low gain transistors are used in the aerial input circuit.

However, if this is overdone the stage will no longer be unconditionally stable, and control of regeneration will become erratic, especially when tuning capacitor VC1 is set at a low value.

It could be argued that using a field effect transistor, with its near square law characteristics, in the TR1 position, would reduce the receiver's susceptibility to cross-modulation.

Cross-modulation occurs when a powerful signal drives the input stage into non-linearity. It then begins to function as a modulator, imposing the strong signal on adjacent weaker signals and spreading it across the dial.

The regenerative circuit of Fig.3.4 will lock onto a powerful signal long before it is strong enough to make TR1 non-linear. The measures taken to avoid this (wave trap and input attenuator) will, therefore, also prevent cross-modulation. Moreover, *p*-channel field effect transistors are not so widely available, and this militates against their use.

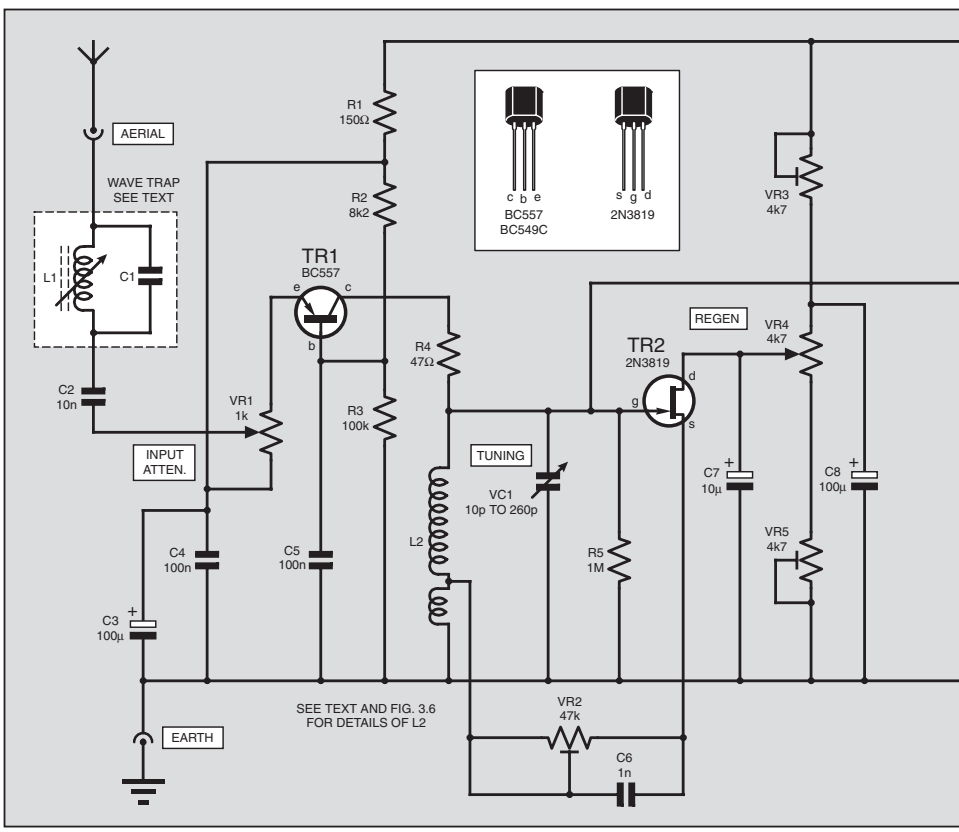
TUNING

The simplest possible tuning arrangement is depicted in Fig.3.4. and the hand-wound, short wave coil L2 is illustrated in Fig.3.6.

The tuning capacitor VC1 is a 10pF to 260pF unit formed by connecting both a.m. gangs of a polyvaricon (polythene dielectric) capacitor in parallel. Typical connection details are shown in Fig.3.7, and the copper track side of a printed circuit board suitable for mounting most screw or tag fixed variable capacitors of this kind is also shown.

REGENERATION

Regeneration, or *Q* multiplication, is provided by TR2, a field effect transistor configured as a Hartley oscillator. Feedback is taken from TR2 source (s) to a tapping on coil L2 via preset potentiometer VR2 and its bypass capacitor C6. This arrangement enables the control of regeneration to be optimized for different coil and transistor combinations.



COMPONENTS

Approx. Cost Guidance Only

£21 *excl. case & batt. & wire*

REGENERATIVE RADIO

See SHOP TALK page

Resistors

R1, R6, R11	150Ω (3 off)
R2	8k2
R3	100k
R4	47Ω
R5, R10	1M (2 off)
R7	10k
R8, R13	470Ω (2 off)
R9	22k
R12	4k7

All 0·25W 5% carbon film

Potentiometers

VR1	1k rotary carbon, lin.
VR2	47k carbon preset, horizontal
VR3, VR5	4k7 carbon preset, horizontal (2 off)
VR4	4k7 rotary carbon, lin.
VR6	4k7 rotary carbon, log.

Capacitors

C1	only required if Wave Trap fitted (see Part 1)
C2	10n disc ceramic
C3, C8, C11, C12	100μ radial elect. 25V (4 off)
C4, C5, C10	100n disc ceramic (3 off)
C6	1n polyester
C7, C9	10μ radial elect. (2 off)
C13, C15	1n polyester or ceramic – see text and Table 3.1 (2 off)
C14, C17	4μ7 radial elect. – see text and Table 3.1 (2 off)
C16	47μ radial elect. – see text and Table 3.1
C18	10n polyester or ceramic – see text and Table 3.1
VC1	10p to 260p polythene dielectric variable capacitor

Semiconductors

TR1	BC557 *pnp* small signal transistor
TR2, TR3	2N3819 *n*-channel field effect transistor (2 off)
TR4	BC549C *npn* silicon transistor

Miscellaneous

L1	only required if Wave Trap fitted (see Part 1)
L2	tuning coil, hand-wound (see Fig.3.6)
S1	d.p.s.t. toggle switch

Printed circuit boards available from the *EPE PCB Service*, codes 405 (Regen) and 406 (T/Cap); diecast or aluminium box for chassis, at least 200mm x 150mm x 75mm (8in. x 6in. × 3in.), or aluminium sheet to fabricate a base and front panel; aerial and earth screw terminals; one large and three small plastic control knobs; audio type screened leads; 50g (2oz) reel of 24s.w.g. (23a.w.g.) enamelled copper wire for tuning coil; plastic tube, 20mm (3/4in.) outside diameter (o/d) for coil former; 9V battery (PP3) and clip; connecting wire; nuts, bolts and washers; solder pins; solder etc.

Feedback is adjusted by regeneration control VR4, which varies the voltage on the drain (d) of TR2 thereby altering its gain. The range of adjustment is fixed by presets VR3 and VR5, and the action of the regeneration control can be made very gentle and smooth when the swing of VC1 is not too great. Potentiometer noise is eliminated by capacitor C7.

DETECTOR PREAMPLIFIER

Drain bend detector, TR3, is biased into non-linearity by resistor R9, which is bypassed at audio and radio frequencies by capacitors C9 and C10. Audio output is developed across drain load resistor R7, and R6 and C11 decouple the stage from the supply rail. Residual radio frequencies are filtered out by R8, C13 and C15, and the signal is coupled to transistor TR4 through d.c. blocking capacitor C14.

Audio preamplifier stage, TR4, is necessary in order to boost the weakest signals. Emitter bias is provided by resistor R13, which is bypassed by C16; R10 is the base bias resistor, and R12 is TR4's collector load.

Supply rail decoupling is effected by R11 and C12. The output signal is taken from TR4 collector, via blocking capacitor C17, and the audio output level is set by Volume control VR6.

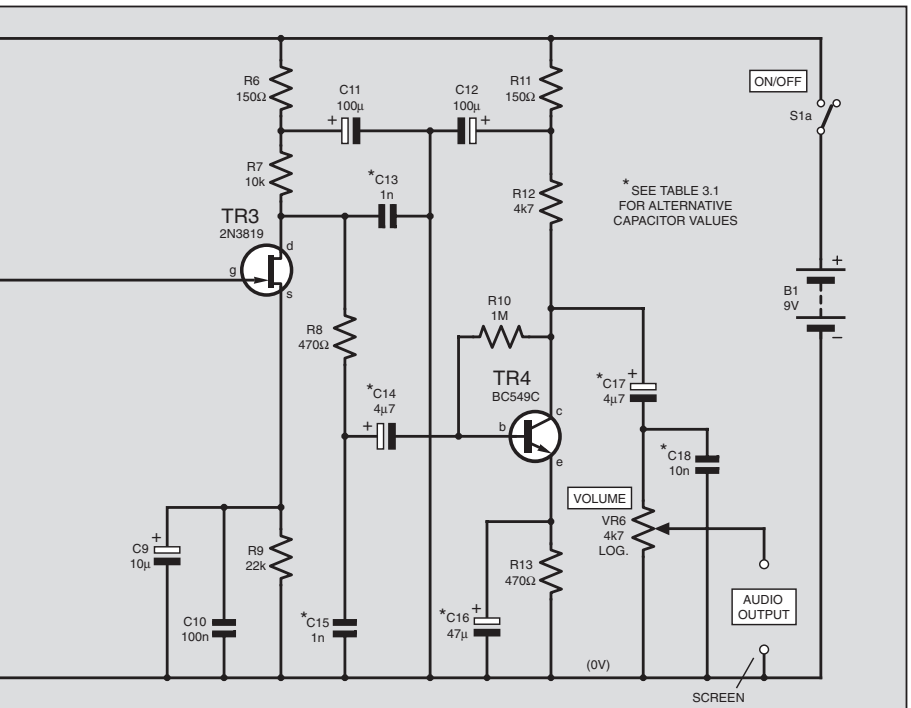


Fig.3.4. Complete circuit diagram for the High Performance Regenerative Radio. See Table 3.1 for alternative capacitor values. Note the Wave Trap is optional – see text and Part 2 (July '03).

Table 3.1. Capacitor Values for a Wide or Narrow Audio Frequency Response

Part No.	*Wide Response*	*Narrow Response*
C13	1n	10n
C14	4μ7	100n
C15	1n	10n
C16	47μ	4μ7
C17	4μ7	100n
C18	10n	330n

AUDIO RESPONSE

Speech signals, especially when they are overlaid by noise, can be greatly clarified by reducing the response of the system to low and high audio frequencies. Telephone companies throughout the world operate on this principle, and heavily attenuate frequencies below 300Hz and above 3000Hz (3kHz). Narrowing the response leaves speech intelligible while removing parts of the spectrum that carry a good deal of the noise.

The values of the capacitors in the receiver's audio signal path, i.e. from the collector of TR3 onwards, can be chosen to tailor the

audio response. Increasing the value of shunt capacitors C13, C15 and C18, will reduce response to high frequencies.

Reducing the value of coupling capacitors, C14 and C17, will attenuate low frequencies. Reducing the value of bypass capacitor C16 introduces selective negative feedback which also inhibits response at the lower audio frequencies.

Suggested alternative values for these capacitors are given in Table 3.1. Readers will no doubt wish to experiment until the audio response meets their needs.

POWER SUPPLY

Even small power amplifiers induce large voltage variations in the supply rail, and the four transistors in this circuit must have their own battery supply (or a supply isolated by an electronic regulator and ample smoothing).

Voltage fluctuations on a common supply will cause erratic regeneration, problems with electronic tuning systems (described next month) and low frequency oscillation or "motor boating". The receiver battery is switched by S1a. The other half of the toggle switch, S1b, can be used to control the supply to the Speaker Amplifier (described last month) or other audio amplifiers.

SEMICONDUCTORS

The *pnp*, bipolar transistor used as the r.f. amplifier, TR1, is not particularly critical. Any small signal device with an f_T of at least 100MHz and an H_{fe} of 200 or more should perform well. The audio preamplifier, TR4, can be almost any small signal *npn* silicon transistor, but low-noise, high gain (H_{fe} at least 400) devices are to be preferred.

Most *n*-channel field effect transistors should function in the detector (TR2) and *Q* multiplier (TR3) stages. In addition to the specified 2N3819's, the BF244A, BF245B, J304, J310, TIS14, K168D and MPF102 have all been "in circuit" tested and found to be satisfactory.

Note that base connections for all of these devices vary and should be checked.

CONSTRUCTION

Most of the receiver components are assembled on a compact printed circuit board (p.c.b.). The topside component layout, together with the full-size underside foil master pattern and off-board wiring are illustrated in Fig.3.5. This board is available from the EPE PCB Service, code 405 (Regen).

The tuning coil L2 and variable capacitor VC1 are mounted separately. This gives greater freedom in the choice of tuning arrangements. A small p.c.b. which will take most miniature screw or tag fixing poythene dielectric variable capacitors is shown in Fig.3.7. This board is also obtainable from the *EPE PCB Service*, code 406 (T/Cap).

Solder pins inserted at the lead-out points ease the task of off-board wiring. They should be inserted into the printed circuit board first. Follow these with the resistors, then the capacitors, smallest first; and, finally, the semiconductors. It is good practice to use a miniature crocodile clip as a heat shunt whilst soldering the field effect transistors in place.

On completion, the p.c.b. should be examined for poor soldered joints and bridged tracks, and the orientation of semiconductors and electrolytic capacitors should also be checked.

It is a good idea to wire the printed circuit board to the controls and tuning components on the work bench, and test it before mounting it in an enclosure. Current consumption of the receiver should be in the region of 4mA.

COIL WINDING

Details of the tuning coil L2 are given in Fig.3.6. It is wound on an off-cut of 20mm (3/4in.) outside diameter plastic electrical conduit and preset VR2 and its bypass capacitor C6 are located at one end of the former. Solder tags are used to anchor the windings and the preset potentiometer.

Plastic electrical conduit for the hand-wound coil is retailed at most DIY outlets. Suppliers of enamelled copper wire and tuning capacitors are mentioned in the *Shoptalk* column. The remaining components are widely available.

The specified variable capacitor (VC1) will tune coil L2 from 4·8MHz to 14·6MHz. This covers the 20, 30 and 40 metre amateur bands, and the 25, 31, 41, and 49 metre broadcast bands.

Details of hand-wound coils covering 150kHz to 30MHz will be described next month, together with switched coil packs, incorporating commercial coils, for general coverage and amateur bands receivers.

Constructors who like to experiment with their own coils should tap longwave inductors at 5 per cent of the total turns, and all other coils at 10 per cent. The shortwave coil covering up to 30MHz may require a 15 per cent tapping point to secure regeneration when the tuning capacitor is set at maximum. Commercial coils in spares boxes can be pressed into service by adding turns to form the source tapping point.

ASSEMBLY AND WIRING

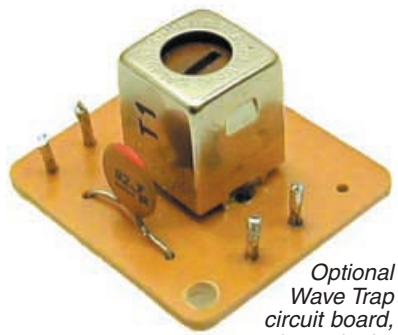
Construction of the set must be rigid and robust or the receiver will not perform well, especially on the shortwave bands. Diecast boxes are best for chassis or enclosures, but receivers assembled on or in aluminium boxes are acceptable. A metal front panel is essential for screening purposes.

Layout is not particularly critical, but locate the tuning components close to the relevant solder pins on the receiver printed circuit board. Keep signal input leads away from output leads. The regeneration potentiometer VR4 can be located in any convenient position (it is decoupled from the signal circuits).

The general interwiring from the p.c.b. to the off-board components is shown in Fig.3.5. Some variable capacitors are secured by screws driven into their front plates. Check the length of the screws to ensure that they do not project too far and foul the capacitor vanes.

Metal potentiometer cases should be connected to the 0V rail. Leads between the aerial terminal, the input attenuator, VR1, and the receiver printed circuit board, should be screened, as should the leads between the volume control, VR6, the power amplifier and the receiver board. The screening must, of course, be connected to the "ground" or 0V rail.

Most polyvaricon capacitors designed for a.m. or a.m./f.m. portable receivers will be suitable. The calibrated dial reproduced (half-size) in Fig.3.8 should be reasonably accurate if the tuning capacitor mentioned in the Components List is used and the coil is wound in accordance with Fig.3.6.



Optional Wave Trap circuit board, not shown in the author's model below.

General layout inside the metal case. The speaker amplifier module is in the foreground. The wave trap is mounted on the underside boxed chassis.

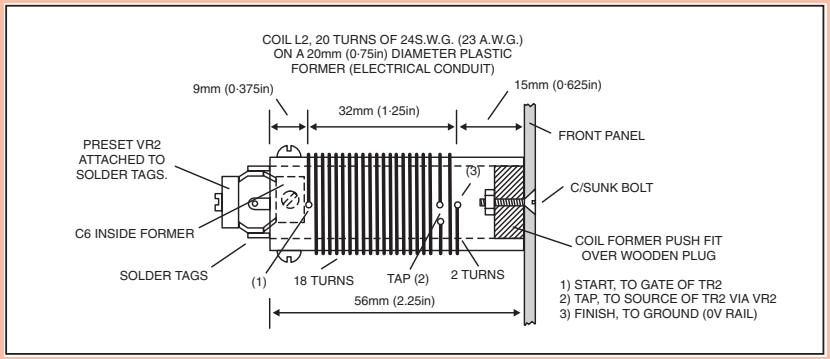


Fig.3.6. Coil winding details for the tuning coil L2. The coil former also carries preset VR2 and capacitor C6 – see photo opposite.

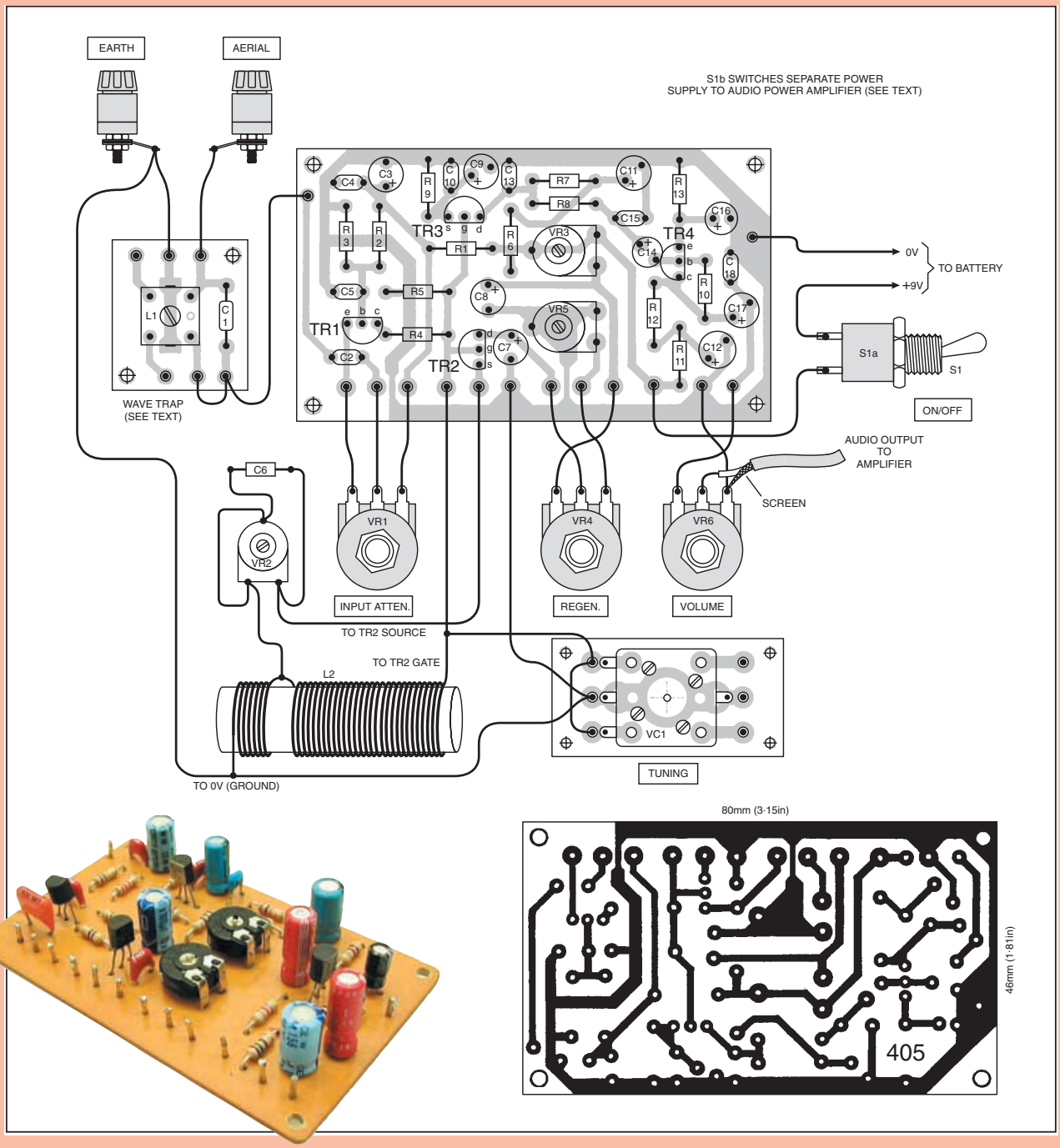
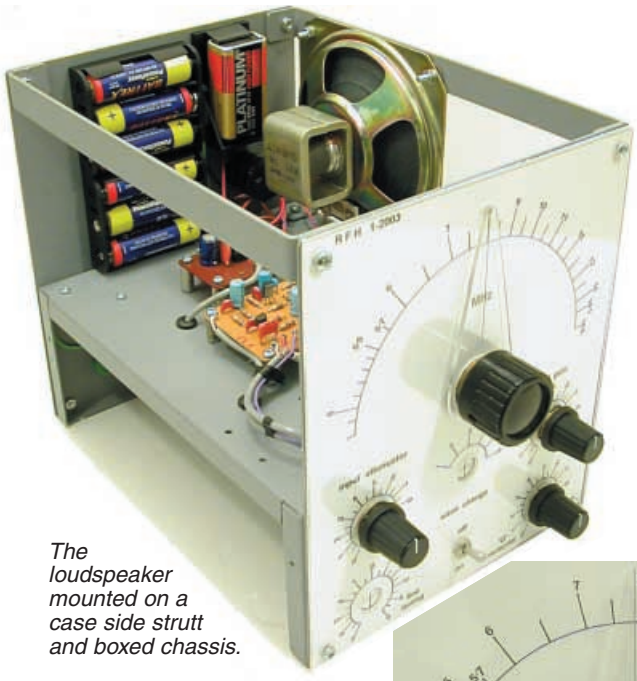


Fig.3.5. Printed circuit board component layout, interwiring details and full-size copper foil master for the Regenerative Receiver. Note you will need an additional VR2 preset and capacitor C6 for each waveband coil.



The loudspeaker mounted on a case side strutt and boxed chassis.

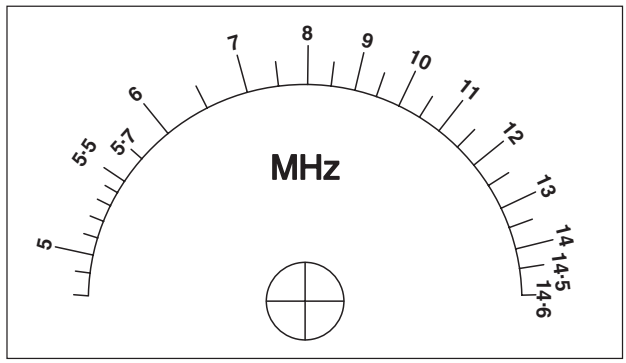


Fig.3.8. Half-size calibrated dial (MHz). Calibration with the specified tuning capacitor and coil L2. Receivers will vary, but it is a good guide to coverage.

Polyvaricons intended for inexpensive 'hi-fi' systems often have 300pF or larger a.m. gangs. These capacitors have a deeper case, around 20mm (^{3}/$_4$in.) compared to the 10mm (^{3}/$_8$in.) or so for the lower value units. Only one gang should be connected if a capacitor of this kind is fitted.

The accompanying photographs show this simple version of the receiver assembled on the metal chassis used to test and evaluate the circuits. A 6:1 reduction drive is fitted to the spindle of the tuning capacitor but this is not adequate for easy tuning over the shortwave bands.

Further, the value of the tuning capacitor, whilst it gives good coverage with the single coil, is too high and regeneration becomes difficult to adjust at the high frequency end of the range. These questions are addressed next month when more refined tuning systems are discussed.

Front panel fascia of single band version showing general layout .

Readers may wish to try connecting only one of the capacitor gangs into circuit. This gives a swing of 5pF to 130pF and coverage with the specified coil is around 6·5MHz to 15·5MHz. Coverage is reduced but control of regeneration, at the higher frequencies, is easier.

SETTING UP

Connect the receiver to the Speaker Amplifier described in Part 2. Connect an aerial comprising at least 30 feet (10 metres) of wire located as high as possible and well clear of any telephone or power lines and earthed objects.

Set preset VR2 to maximum, and presets VR3 and VR5 to minimum resistance. Rotate the slider of Regen. control VR4 to put the maximum voltage on the drain (d) of TR2. Set the other potentiometers to half-travel.

Now connect a fresh 9V battery and tune in a weak signal with variable capacitor VC1, set close to its maximum value.

Reduce the resistance of preset VR2 until the *Q* multiplier begins to oscillate (indicated by a rushing sound or faint whistle). Turn down Regeneration control VR4. The receiver should slide gently out of oscillation.

When regeneration is set close to oscillation, the perceived strength of signals will be greatly increased and tuning much sharper.

Turning down VR1 to attenuate input signals, as necessary, gradually open the vanes of VC1 to tune the receiver up in frequency. Less regeneration will be required to maintain sensitivity as the tuning capacitance is reduced, and VR4 will have to be progressively turned down. When VC1 is fully open, increase the value of preset VR5 until regeneration can be set just below the threshold of oscillation when VR4 is at minimum.

Refine the adjustment of preset potentiometers VR2, VR3 and VR5 until the action of the regeneration control VR4 is as gentle as possible across the entire tuning range. Because of the wide swing of the tuning capacitor, VC1, in this simple version of the receiver, presets VR3 and

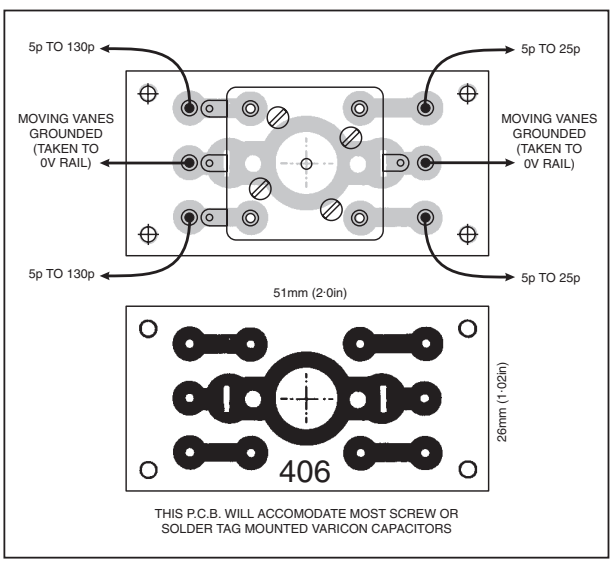
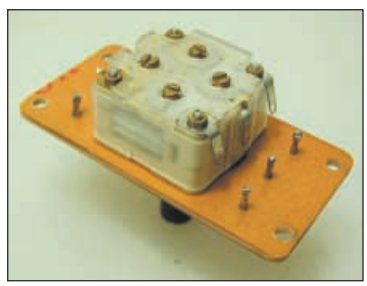
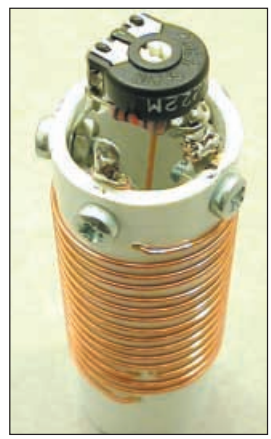


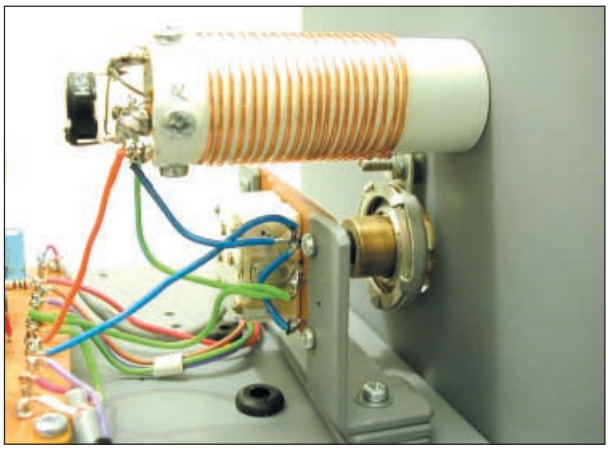
Fig.3.7. Tuning capacitor mounting p.c.b. details. Connections to a typical a.m./f.m. four-gang polythene dielectric variable capacitor. Capacitance values and connections may vary and should be checked.



(Above) The tuning capacitor mounted on the p.c.b.



(Right) Completed tuning coil showing preset soldered to tags bolted on one end of former.



Close-up view of the mounting arrangement for the tuning coil and variable capacitor. Note the reduction drive fitted to the tuning capacitor spindle.

VR5 will have to be set close to minimum resistance to give VR4 sufficient control.

OPERATION

Best results will be obtained if the Regenerative Radio is operated with VR1 set to attenuate the input as much as possible and the audio frequency gain (Volume) control turned up to ensure adequate sound output. This is good practice with complex sets and essential with this simple receiver. If this procedure is not followed it will be impossible to hear weak signals close in frequency to powerful ones.

For best reception of a.m. (amplitude modulated) signals the Regeneration control VR4 must be adjusted, as the receiver is tuned across the band, to keep the *Q* multiplier circuit close to oscillation. When regeneration is correctly set, rocking the tuning control should produce a faint whistle on either side of the station.

A useful technique when searching for very weak signals is to advance the regeneration control until the stage is just oscillating in the absence of a carrier signal. When a station is tuned in its carrier will suppress the oscillation and the weak signal will become audible.

PUBLIC WARNING

This practice was widely adopted when regenerative receivers were popular for domestic listening. Unfortunately there was usually no radio frequency stage to isolate the detector from the aerial, and an oscillating valve with up to 100V on its anode forms a good transmitter.

Reception was, therefore, marred by whistles and howls propagated by neighbouring receivers. The problem became so acute that, in 1928, the BBC issued a handbook guiding the public on the correct operation of the regeneration control. During that year so many complaints were received that listeners were warned that their licenses would be withdrawn if they didn't exercise more restraint.

With this modern transistor design, the grounded base radio frequency stage isolates the very low powered oscillator and interference problems do not arise.

AMATEUR BAND RECEPTION

For the reception of amateur s.s.b. (single-side-band) transmissions, the regeneration control must be advanced until the *Q* multiplier is oscillating. The locally generated oscillation replaces the carrier suppressed at the transmitter so that the signals can be demodulated in the usual way (more about this later).

Very precise tuning is required to clarify these signals, and the simple slow motion drive fitted on this version of the receiver is completely inadequate. Fortunately, the operation of the regeneration control produces a very slight shift in the *Q* multiplier's frequency of oscillation, and this can be used to fine tune and clarify these transmissions (increasing the drain voltage produces a very slight reduction in the gate to source capacitance).

The signals will still be difficult to resolve, however, and next month a tuning system dedicated to the three most popular amateur bands will be described.

An "earth" connection may improve reception. Guidance on constructing an earth system was given in Part 1.

PERFORMANCE

The Regenerative Radio described here is a modern evocation of the 1913 circuit that made man's dream of long distance radio reception a reality. However, it should not be regarded as a historical novelty. Correctly built, connected to a decent aerial and skillfully operated, it will permit the reception of at least 90 per cent of the signals receivable on a modern, high performance communications receiver.

Skilful operation is the key to unlocking its performance. The need for this is, perhaps, the main reason why it was replaced by the more easily controlled superhet receiver.

It lacks automatic gain control, automatic input attenuators and pushbutton tuning. It does, however, offer a standard of performance out of all proportion to the minimal outlay of money and effort involved in its construction.

Next month's article, dealing with more refined tuning systems and general coverage and amateur bands coil packs, will help readers to get the best out of the receiver.

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