SECTION 5

MINIATURE RECEIVER HR/14

Introduction

The HR/14 is an a.m. receiver primarily intended for use in television studios by floor managers, enabling them to receive speech from the producer in the control cubicle. It is a portable receiver contained with its l.t. and h.t. batteries in a metal case measuring approximately 6 inches by 3 inches by 1 inch and is normally carried in a leather sling suspended from the shoulders. The a.f. output is fed to headphones, the lead to which acts as the receiving aerial. The general appearance of the receiver in its case is illustrated in Fig. 5.1.

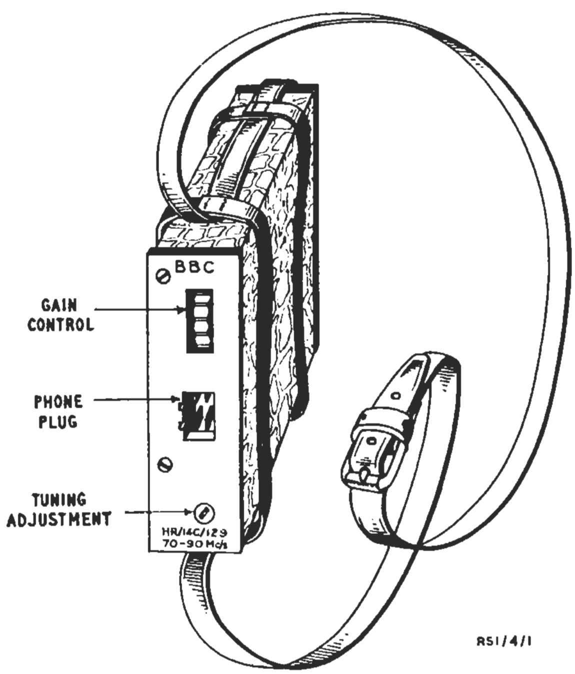

Fig. 5.1. General view of HR/14 Receiver

The receiver is a super-regenerative type using three valves and operates in the band 40 to 50 Mc/s (HR/14A), 50 to 70 Mc/s (HR/14B) or 70 to 90 Mc/s (HR/14C).

A receiver for an application such as this needs high sensitivity and good a.g.c. but the quality of a.f. output need not be high. A super-regenerative type of receiver satisfies these requirements and because of the simplicity of the circuit can be made very compact. A brief description of the super-regenerative principle will be given before the detailed description of the HR/14.

Super-regenerative Principle

The gain of a grid-leak detector can be increased by applying positive feedback (which is usually known as reaction in this context) but the circuit bursts into oscillation when the feedback is increased beyond a certain value and the full benefit of the positive feedback is thus not obtained. The super-regenerative principle enables full advantage to be taken of the positive feedback. This is achieved by forcing the grid-leak detector in and out of oscillation (a process known as 'quenching') at a supersonic frequency such as 50 kc/s. In practical circuits the output of a quench oscillator is applied to the detector screen grid (or anode) the mean potential of which is adjusted in the absence of the quench to the point where oscillation just begins.

Consider now a complete cycle of the quench oscillation, from the instant when the screen grid has its minimum potential. As the screen potential rises, the mutual conductance of the detector rises, the amount of positive feedback increases, building up the amplitude of a.f. output in the manner of a detector with increasing reaction. When the screen potential reaches the critical value, oscillation is initiated and rapidly builds up to the limiting value set by the valve parameters. The oscillation persists at this amplitude until the screen potential falls below the critical value again, when oscillation can no longer be maintained; the oscillation amplitude then decreases exponentially, the rate of decay being determined by the damping of the tuned circuit. This cycle of variation is shown diagrammatically in Fig. 5.2.

Consider now the conditions at the instant when the screen voltage just exceeds the critical value. Although the stage can sustain oscillation, oscillation does not commence automatically; a disturbance must be applied. If an r.f. signal is present at the grid-circuit resonant frequency the oscillation will build up from this signal as shown in Fig. 5.3 (a).

The oscillation amplitude builds up exponentially from the signal amplitude, and rapidly swamps the

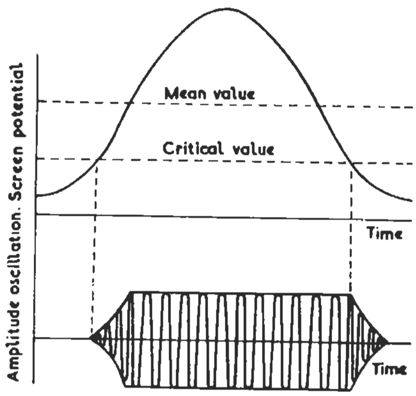

Fig. 5.2. Oscillation Generation in Super-regenerative Stage

signal; however, the time taken for the oscillation amplitude to reach the limiting value is determined by the amplitude of the few cycles of the signal just after the instant when oscillation can be sustained. These determine the initial oscillation amplitude; the rate of increase depends only on the amount of positive feedback. The dependence of time of amplitude build-up on r.f. signal amplitude is shown in Fig. 5.3 (a) and (b) for small-amplitude and large-amplitude input signals. Thus the input-signal

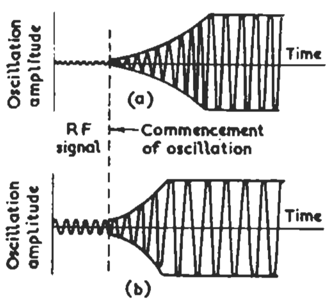

Fig. 5.3. Build-up of Oscillation from Incoming Signal in Super-regenerative Stage

amplitude is 'sampled' for a very short period at the commencement of each 'packet' of oscillation, and determines the time of build-up of the oscillation amplitude to its limiting value. With a modulated signal the time of build-up varies about a mean value (determined by the unmodulated signal amplitude), the difference from the mean value being determined by the amplitude of the modulating signal at the instant of sampling. This is shown diagrammatically in Fig. 5.4.

The control grid and cathode of the detector act as a shunt-fed diode charging the grid capacitor. The time constant of the grid-circuit components is such that the voltage across the capacitor follows the envelope of the ' packets ' of oscillation. There is thus a component of the anode current corresponding to the envelope of the ' packets ' of oscillation. The variation of the areas of these envelopes with time produces an audio-frequency component of the anode current, corresponding to the amplitude of the modulating signal.

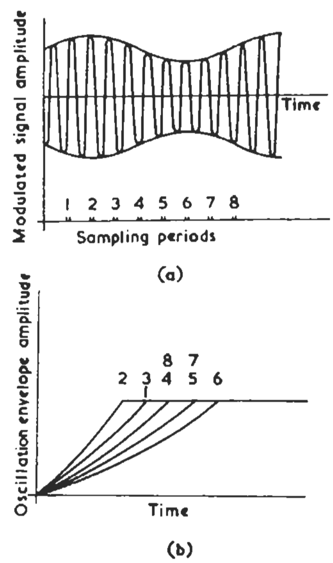

Fig. 5.4. Diagram Illustrating 'Sampling' Process in Super-regenerative Stage

The ' quench ' frequency must be large compared with the highest modulating frequency to be received; for lower frequencies the sampling periods would be too infrequent to reconstruct the modulating signal.

Raising the mean screen potential increases the limiting amplitude of oscillation; this in turn produces a greater variation of the areas of the envelopes of the ' packets ' of oscillation, and thus greater a.f. output.

This type of super-regenerative circuit has five properties of interest:

(1) With a fixed value of mean screen potential the mean time of build-up of oscillation is dependent

only on the unmodulated carrier amplitude; the deviation from this mean time depends only on the depth of modulation. Thus the stage has nearly perfect a.g.c. action, because increase in signal strength (i.e., unmodulated carrier amplitude) decreases the mean time of build-up but not the ratio of build-up time in the unmodulated and modulated states. However, a shorter mean build-up time results in an increase of mean grid bias, and thus reduces the d.c. component of the anode current. It is thus possible to align the receiver by tuning for minimum anode current in the detector.

(2) The input signal is sampled for very short periods; thus between these periods the signal amplitude does not control the output. The stage is thus relatively unaffected by random noise, since much of this will fall in the unexamined periods.

(3) The output from the stage is proportional to the logarithm of the depth of modulation. Thus if the instantaneous modulation depth is expressed as a fraction A, the receiver output is proportional to log $(1 + A)$ on the outward sweeps of modulation, and to log $(1 - A)$ on the inward sweeps. For low depths of modulation each of these two expressions is approximately equal to A, and there is little distortion: for depths of modulation approaching 100 per cent however there is serious distortion.

(4) In the absence of an input signal, the oscillations build-up from noise giving rise to a ' rushing ' noise heard when there is no signal input.

(5) The selectivity is higher than is at first apparent due to the positive feedback applied before oscillation commences, and is better than that normally obtained from a single tuned circuit.

Circuit Description of the HR/14

A complete circuit diagram of the receiver is given in Fig. 8. V1 is the super-regenerative stage, V2 and V3 constituting an a.f. amplifier.

V1 is a heptode valve of the type (DK91) normally used a a frequency-changer in battery-operated superheterodyne receivers. In this circuit however the valve is used in an unconventional manner. The anode and G3 are connected to the dust-iron cored transformer TR2 to form a Reinartz oscillator. The capacitor C1 is chosen to give an operating frequency in the range 50 to 100 kc/s. The receiver tuning circuit is the dust-iron cored inductor TR1 which is tuned by valve and stray capacitance to the required carrier frequency. Signals are induced in the tuned winding by two coupling windings connected to the headphone lead which acts as an aerial. The dust-iron core can be adjusted by means of a screw-driver without removing the receiver from the case. The tuning inductor is centre-tapped and is connected to V1 as in a Hartley oscillator, G1 acting as control grid and G2, G4 as anode. The operating voltages on V1 are so adjusted, however, that this circuit does not oscillate continuously but is swept in and out of oscillation at the quench frequency generated at the anode and G3. The a.f. output is developed at G2, G4 and is coupled to the two-stage a.f. amplifier via R3 and C4, unwanted signals at quench and radio frequency being bypassed by the 500-pF capacitor C3.

The a.f amplifier contains two RC-coupled sub-miniature pentodes (type DL66). The first is a voltage amplifier, operating with high-value anode load (2·2 megohm) and screen-feed resistor (4·7 megohm) to give high gain. This stage is coupled to the output stage via the coupling capacitor C6 and volume control R9. The output stage has reasonably high screen and anode voltages to enable it to deliver adequate audio output power to the headphones. The output transformer TR3 feeds the phones via the two r.f. coupling windings on the tuned circuit TR1.

A 60-volt battery is used to supply the heptode V1 but a decoupling network R19C7 is used to drop the supply to the 22 volts which is the maximum recommended operating voltage for the DL66.

An unusual feature of the receiver is the means adopted to supply V2 and V3 with grid bias. The required potential of 0·75 volt is obtained from a 2 : 1 step-down potential divider R7R8 connected across a 1·5-volt voltage-stabiliser cell VS1. The cell is a hermetically-sealed secondary type which is discharged by R7 and R8 when the receiver is left unused. When, however, the receiver is switched on, the h.t. current for all three valves flows through the cell and charges it in a matter of seconds to its nominal voltage of 1·5. This type of cell is designed to provide a stable source of e.m.f. suitable for bias purposes.*

* These cells have a nickel anode and a cathode composed of cadmium and cadmium oxide: between these electrodes is a separator impregnated with electrolyte. D.C. passed through the cell reduces cadmium oxide to cadmium at the cathode and releases oxygen from the anode. The oxygen can reach the cathode where it forms cadmium again. Thus reduction and oxidation occur simultaneously and steady current can flow through the cell without releasing excess gas: a sealed form of construction is hence possible.

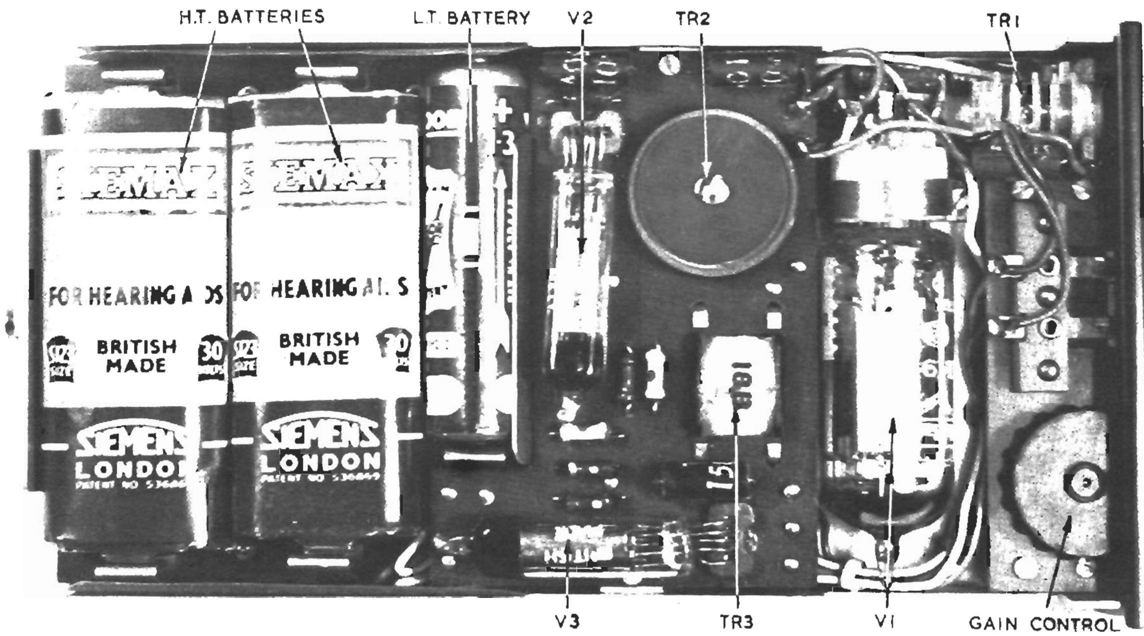

Fig. 5.5. Front View of Receiver HR/14 with Cover Removed

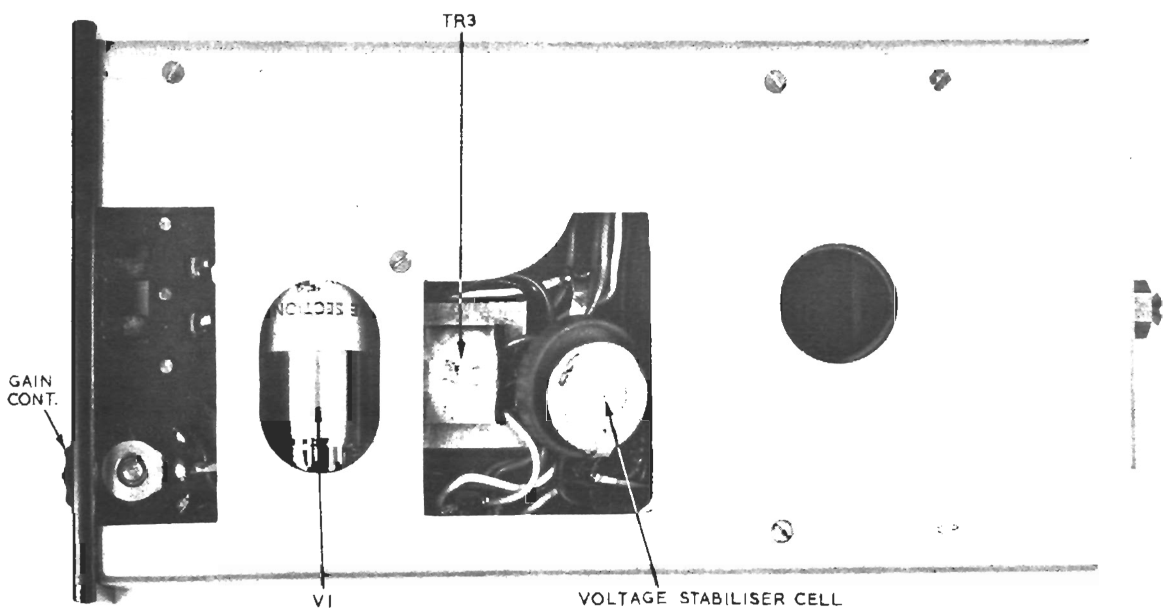

Fig. 5.6. Rear View of Receiver HR/14 with Cover Removde

The receiver is switched on by inserting the 4-pin plug of the headphone lead into the socket of the receiver. This completes the filament circuit for the valves and also connects the headphones to the receiver output.

Construction

The construction of the receiver is illustrated in Figs. 5.5 and 5.6 which show front and rear views of the chassis withdrawn from the case. Most of the components and the two DL66 valves are mounted on a sheet of paxolin in an arrangement similar to that employed in a printed circuit.

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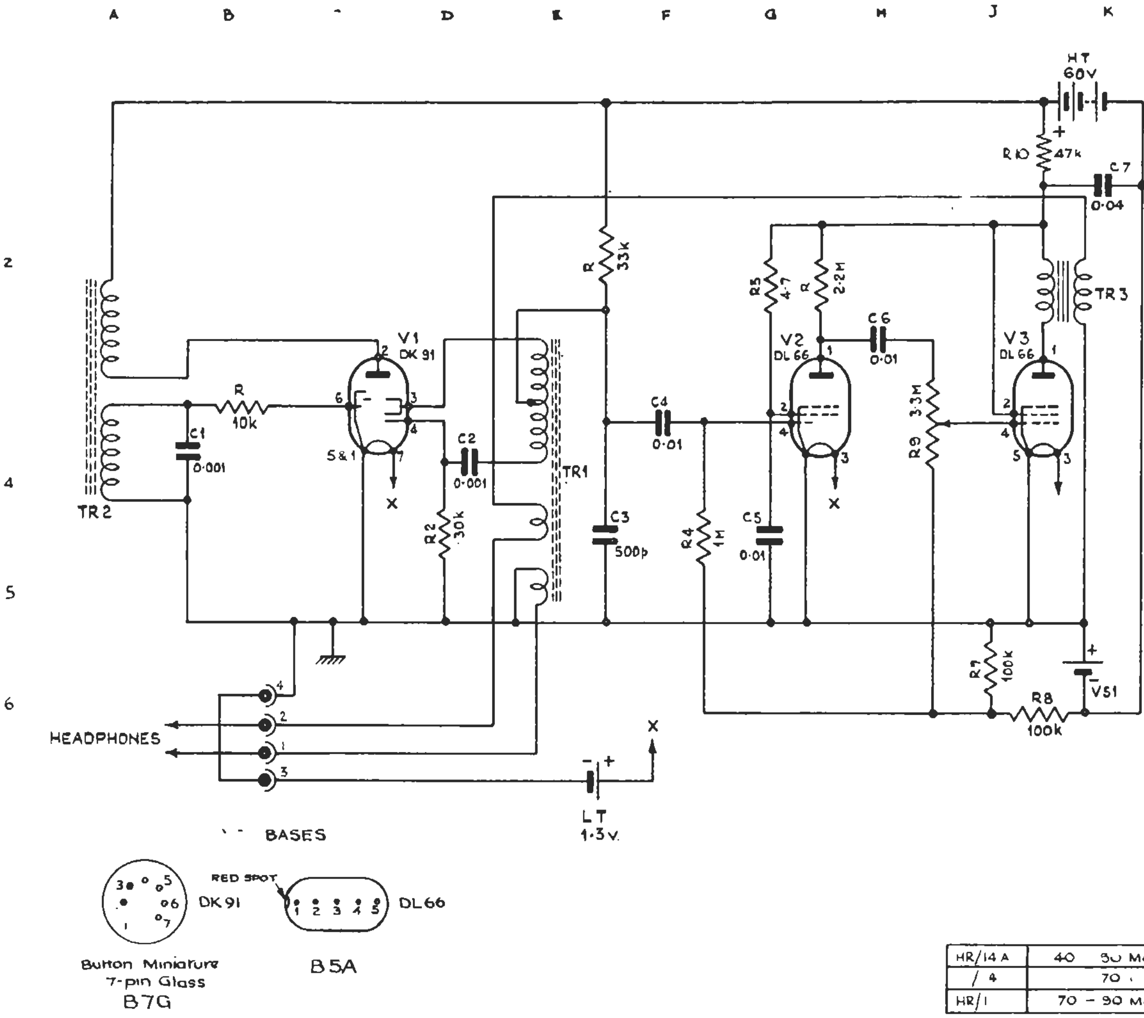
FIG. 8



HR/14 A	40 30 Mc/s
/ 4	70
HR/1	70 - 90 Mc/s

C P	LO	YPE	TOL	COMP	LOC.	TYPE	TOL.	COMP.	LOC.	TYPE	T.
C	A3	HUNTS W99 B819	-	R	B3	ERIE 5B	±20%	R9	H3	VARIABLE FO T. OMR	-
2		H NTS W99 819	-	R2	D4	ERIE 5B	±20%	R10	J1	ERIE 5B	20%
		NTS W99 B820	-	R3	E2	ERIE 5B	±20%				
4	F3	W9		R4	F4	ERIE 5B	±20%	TR1	E4	EA7811 DET. 24A 24B, 24C.	
C5	G4	U V 9 80		R5	G	E 5B	±20%	TR2	A3	EA7811 DET. 23	
C6	H2	HUNTS W99 B800	-	R6		E 5B	%	3		EA 811 DET. 22	
C7	K1	H TS W99 B858		R7	J5	ERIE 5B	- %				
				R8	J5	ERIE 5B	±20%				

HR/14A B & C RECEIVER, MINIATURE : CIRCUIT