No. 101 1/6

TWO VALVE RECEIVERS

Comprehensive instructions for building 5 two valve sets.

1. 2 VALVE HIGH FIDELITY TUNING UNITS
2. 2 VALVE SUPERHETRODYNE
3. LONG RANGE BATTERY "TWO"
4 & 5. TWO LOW VOLTAGE RECEIVERS

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BERNARDS RADIO MANUALS

TWO VALVE RECEIVERS

Comprehensive Instructions For Building 5 Two Valve Receivers

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CONTENTS

A HIGH-FIDELITY TUNING UNIT

It is a reasonable assumption that nowadays every amateur radio constructor has a permanent receiver for general listening in the home. While numerous receivers of every description may be constructed for experimental purposes, the permanent receiver is used by the household for everyday listening. The majority of these receivers are of commercial manufacture and, though often good all-round receivers, they lack some of the refinements required by the more critical listener. Most commercial broadcast receivers are superheterodynes and have excellent sensitivity; but to cope with the large number of stations which may have to be received, the IF bandwidth is narrow, with the unfortunate result that high note response is poor and orchestral programmes lack vitality. The purpose of the two-valve unit shown in Figs. 1 and 2 is to provide an additional unit which may be connected to the gramophone pick-up terminals and which gives a really high quality performance. If desired it could, of course, be fed into an amplifier (such as those shown in Bernards *Wireless Amplifier Manual No.* 2).

It will be noticed that no HT power supply has been included in this design, the reason being that the overall current drawn is very small and may often be drawn from the main receiver without any deleterious effects. An HT supply of about 250 volts 20 mA is required. Filament power is drawn from a small transformer T1, because so many older types of receiver are fitted with 4-volt heater valves; but where a good 6.3v source is available this component can be omitted. When used with DC/AC (or Universal receivers, as they are often called) it must be remembered that the chassis will be connected to one side of the supply mains as will the main receiver chassis and no direct earth connection can be made to it.

The receiver as it stands is not suitable for DC operation though it could be adapted to use series-connected heaters and a ballast resistor. A suitable valve combination would be a 12K7GT and a 25SN7GT. See Fig. 3.

The receiver proper consists of a pentode HF stage followed by an infinite impedance detector which in turn is coupled to an amplifier designed to provide a wide range of tone control. The author considers the provision of tone control an asset. Some think otherwise; but the fact is that it enables the response of the receiver as a whole to be adjusted to suit the accoustics of the room in which the receiver is being used. Futhermore it can be adjusted to suit the ear of the listener and that is really the most important thing The detector is the infinite-impedance detector which may be unfamiliar to some constructors, as it is not often used. It is one of the most distortionless available—in some respects being better than a diode —but it is not suitable for producing AVC volts which prohibits its

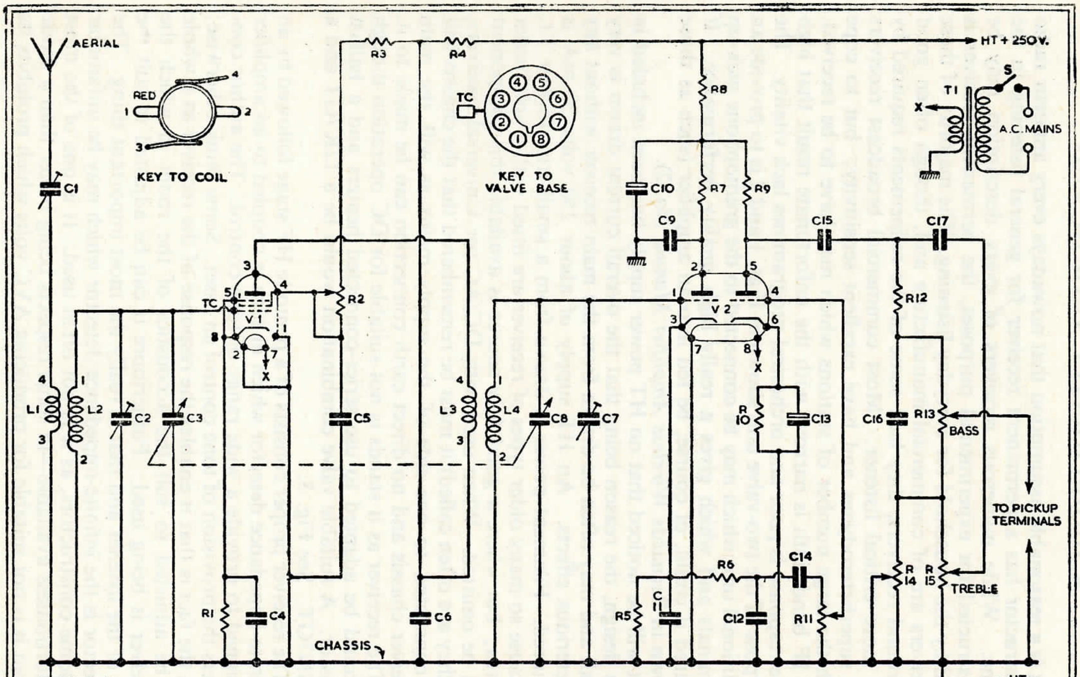


FIG. 1 A HIGH-FIDELITY TUNING UNIT.

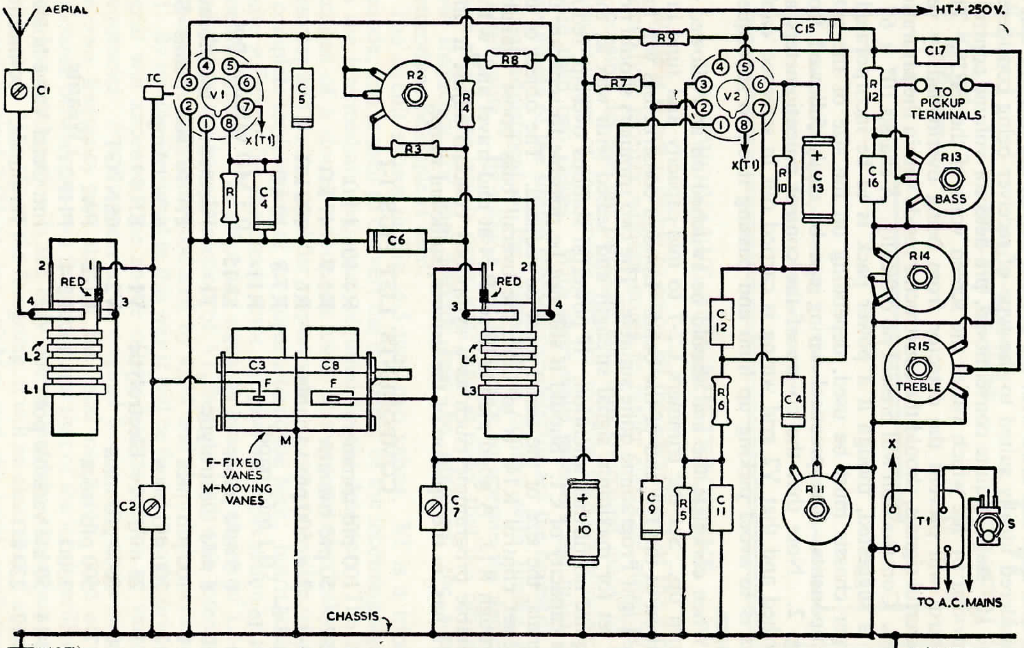


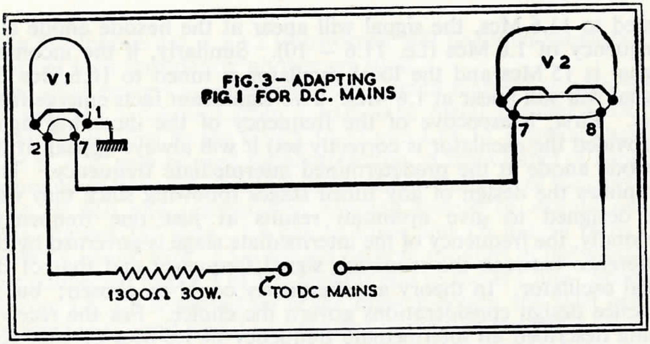
FIG. 2 A HIGH-FIDELITY TUNING UNIT.

use for most designs. Since the question of AVC (automatic volume control) does not arise with the present design the detector can be considered ideally suited to the type of receiver being considered. The HF stage is quite conventional, pre-detector volume control is provided by R2 which varies the screen volts of the EF39. This control will prevent the detector from being overloaded by very powerful signals, should the constructor reside within the saturation area. Construction will present no difficulty. A chassis 10″ × 6″ × 2″ is suggested, though if a power pack is to be incorporated a larger chassis must be used, depending on the size of the extra components. The practical wiring can be easily followed from Fig. 2. Note that the covers of the control potentiometers are earthed and that V2 grid wiring is carried out in screened cable, this is to avoid picking up hum and passing it on to subsequent stages.

When complete the unit should be switched on and allowed to warm up. Set the trimmers C2-7 to mid-capacity and tune in a station at the HF end of the band. London constructors will find the Light Programme quite suitable. The two trimmers should now be set for maximum signal strength and sealed with wax as they require no further attention. If powerful stations overlap, reduce the capacity of C1. Should it still not be possible to separate the signals, the size of the aerial must be reduced. The object of the pre-set control R14, is to limit the overall bass boost available through R13. A good plan is to set R14 at mid-travel and, with a suitable programme (such as a symphony concert) adjust it until R13 has, in the opinion of the listener, sufficient range.

COMPONENTS' LIST FIGS. 1-2

C1	100 pfd trimmer	R4-10	1 kΩ
C2-7	50 pfd trimmer	R5-9	47 kΩ
C3-8	2 × 500 pfd variable	R6	100 kΩ
C4-5-6-14-15	0.1 mfd paper	R7-8	10 kΩ
C9	0.5 mfd paper	R11-13-15	0.5 MΩ variable pot
C10	8 mfd Electrolytic	T1	Filament transformer Pri to suit mains Sec 6.3v 1Amp.
C11	100 pfd mica		
C12	200 pfd mica		
C13	25 mfd 12v Electrolytic	V1	EF 39
C16	5000 pfd mica	V2	6SN7GT
C17	500 pfd mica	L1-2	PA2 Wearite
R1	330Ω	L3-4	PHF2 Wearite
R2-14	50 kΩ variable pot	2	Int. Octal Valve holders
R3-12	220 kΩ		Terminals, connecting wire, etc.



A TWO-VALVE SUPERHETERODYNE

While it is not possible to enjoy all the advantages of the superheterodyne receiver without going to rather elaborate circuitry, it is possible to use the principle and thus overcome many of the disadvantages of the simple straight receiver without recourse to more than two valves. With short-wave receivers the main disadvantages of the simple regenerative detector are the necessity for critical adjustment of the regeneration control with tuning and "dead spots." By using a low frequency to operate the detector these effects are largely overcome; and in order that this required low frequency for the detector may be obtained, the superheterodyne principle is used.

The circuit shown in Fig. 4-5 uses two valves. V1 is a triode-hexode, and is used to convert the frequency of the incoming signal to the intermediate frequency required by the detector. The two sections of a double triode are used as a regenerative leaky grid detector and audio amplifier respectively. It is not possible to give a complete explanation of the superheterodyne here; but it will be quite sufficient for the constructor, to give an explanation of the essential points. The incoming signal is tuned by means of L2-C2 and fed to the hexode section of V1, being mixed with internally generated oscillations produced by L3-4 and the triode section of V1. By mixing the signal in this way it will be found that the original signal will appear at the anode of the hexode section at various frequencies It will appear at its original frequency; at the *sum* of its own frequency and that of the local oscillator, and at the *difference* between its own frequency and that of the local oscillator. This last combination is the only one of interest: the others may be ignored. Now, from the foregoing, it will be clear that if a signal is tuned in by L2-C2 at, say, 10 Mcs and the local oscillator is tuned to 11.6 Mcs, the signal will apear at the hexode anode at a frequency of 1.6 Mcs (i.e. 11.6 – 10). Similarly, if the incoming signal is 15 Mcs and the local oscillator is tuned to 16.6 Mcs the signal will still apear at 1.6 Mcs. Two significant facts emerge from this. First, irrespective of the frequency of the incoming signal (provided the oscillator is correctly set) it will always appear at the hexode anode at the predetermined intermediate frequency. This simplifies the design of any tuned stages following since they may be designed to give optimum results at just one frequency.) Secondly, the frequency of the intermediate stage is governed by the difference between the incoming signal frequency and that of the local oscillator. In theory any frequency could be chosen; but in practice design considerations govern the choice. For the receiver being described an intermediate frequency of 1.6 Mcs or 1600 Kcs was chosen and accordingly L5-C5 are designed to give optimum results at this frequency, L6 being the regeneration winding. At this point it may be mentioned that the local oscillator can be designed to work either above or below the signal frequency, though for normal working it is usual to operate the oscillator above the signal frequency. Constructors will notice that the local oscillator is tuned by two condensers C8-9. C8 has the larger capacity and is called the band-set condenser. C9 is the band-spread condenser, has a very small capacity and is fitted with a good quality slow-motion dial. In practice C8 is set to the required part of the band and the final search is carried out by C9. This sytem is called *Electrical Band-spread.* Constructors will understand that, since the capacity of C9 is small compared with C8, the former acts as a vernier to the latter. For example, if the coil in use covers 5-10 Mcs and it is desired to explore the amateur band on 7 Mcs, C9 is set to half mesh and C8 to 7.25 Mcs. The band on either side of 7.25 Mcs can now be comfortably explored by means of C9. After leaving the hexode anode of V1 the signal is rectified in the normal way by one half of V2. The rectified output is transformer-coupled to the second half of V2 which functions as an audio or LF amplifier. The resultant output can be fed either to a loud speaker or head-phones. If a speaker is used the output transformer should be designed to present a primary load impedance of 20,000Ω. The turns ratio of the transformer may be found by dividing the required load impedance (20,000Ω) by the speech coil impedance, and taking the square root of the dividend.

EXAMPLE

For a speech coil impedance of 5Ω

required turns ratio = $\sqrt{\frac{20000}{5}} = \sqrt{4000} = 63.2$

∴ turns ratio = 1 : 63

For headphone use, a 1 : 2 transformer will be found satisfactory if normal high impedance 'phones are used.

The valve heaters are supplied from a small filament transformer (T2) and HT is derived from a half-wave metal rectifier (MR1). Smoothing is done by the filter C14-15 and LFC1. A metal chassis 10" × 8" × 2" may be used for construction. A front panel of copper or aluminium, 11" × 9", should be mounted on the front of the chassis.

The IF coil and regeneration winding should be wound on a ¾" dia. former 1½" long. L5 has 52 turns and L6 has 18 turns of 32 S.W.G. enam. wire. L5 is wound on first, the start of the winding being connected to pin 3 of V1, and the end to the HT line. Spaced 1/16" from L5, L6 is wound on *in the same direction*, the start being connected to C7 and RFC1 and the end to pin 2 of the 6SN7.

All the tuning coils are wound on Eddystone plain 6-pin coil formers. The L2 and L4 windings are spaced to give a winding length of 1½". L1 and L3 windings are close-wound, spaced about ⅛" from the L2 or L4 windings. It can be seen from the practical diagram that all windings are wound in the same direction.

COIL DATA

Range	*Number of Turns* L1	L2	L3	L4
3.5-7 Mcs (80 metres)..	8	32	9	27
5.5-10 Mcs (40 metres)..	8	18	9	22
9.5-18 Mcs (20 metres)..	8	10	3½	12
15-30 Mcs (10 metres)..	4	6	3	6

L2 and L4 windings are wound with 20 S.W.G. enam.
L1 and L3 windings are wound with 24 S.W.G. enam.

On completion the receiver should be switched on and the IF circuit checked.

Insert one of the high frequency coils (L1-L2) but omit the oscillator (L3-L4). The test to be made is to ensure that the detector oscillates properly. Advance C7 from its minimum setting until it goes into oscillation, which is indicated by a soft hiss and should occur when the condenser vanes are enmeshed about half way. If oscillation does not occur, check L5-L6 connections, for, unless L6 is wired in the correct sense to L5, there will be no regeneration. Assuming the connections are correct add a few turns to L6 which should adjust matters If the detector oscillates at a very low C7 capacity, a few turns should be removed from L6 to bring the point of oscillation at about mid-scale.

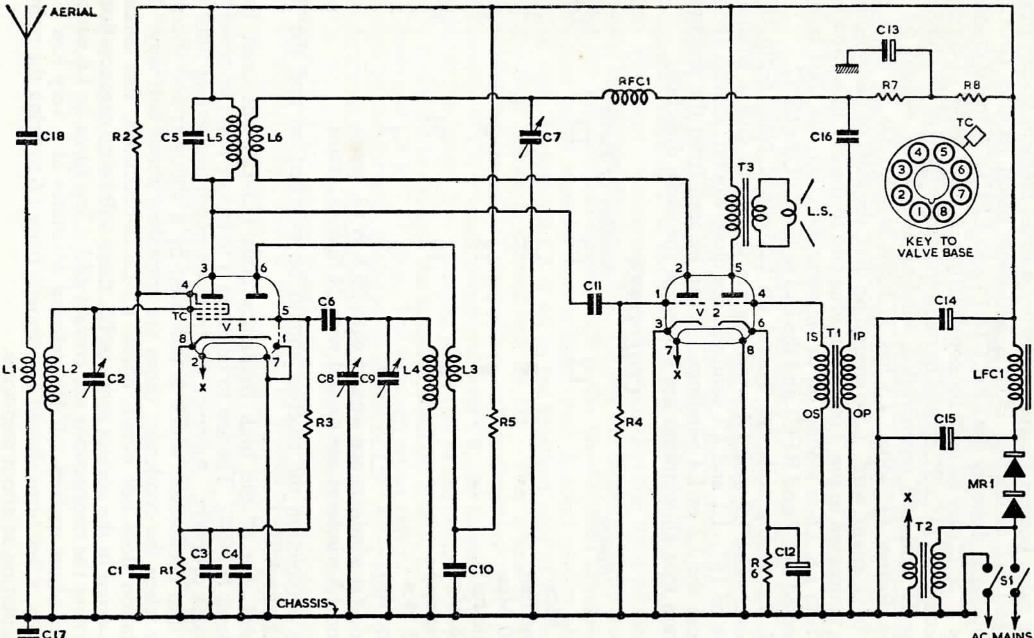


FIG.4 A TWO VALVE SUPERHETERODYNE.

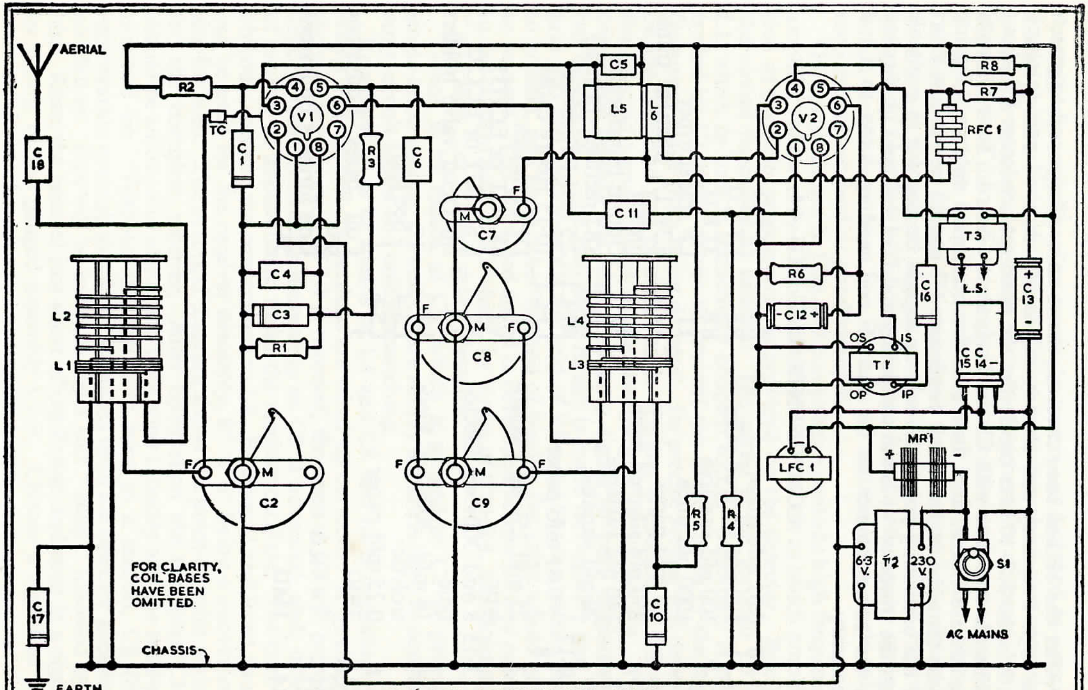


FIG.5 A TWO VALVE SUPERHETERODYNE

After the 1F has been checked, insert an oscillator coil to match the high frequency coil already in circuit. A good pair to check with is the 5.5.-10 Mcs band. Set the band-set condenser C8 about mid-scale and tune with C9 until signals are heard. Tune C2 until signals are heard, and then tune for maximum volume. During these tests the regeneration condenser C7 should be set just short of the oscillating point. Should no signals be heard it is probable that the triode of V1 is not oscillating and L3-L4 should be checked in the same manner as for the 1F coil, adding turns to L3 if necessary.

COMPONENTS' LIST FIGS. 4-5

C1-10	0.01 mfd mica	R5	33 KΩ
C6-11	100 pfd silvered mica	R6	1.5 KΩ
C2-7	100 pfd variable	R8	33 KΩ
C3	1000 pfd mica	T1	LF transformer
C4	0.1 mfd paper	T2	6.3v 1A filament transformer
C5	250 pfd silvered mica		
C8	140 pfd variable	T3	Output transformer
C9	20 pfd variable	MR1	SB3 rectifier (Brimar)
C10-17, 18	0.01 mfd paper	RFC1	2.5 mH RF choke
		LFC1	10-15 Henry choke
C12	25 mfd 25v.wg Electrolytic	S1	DPST switch
		V1	6K8GT or ECH35
C13-15	8 mfd 300v.wg Electolytic	V2	6 SN7GT or ECC32
		2	Int Octal valve holders
C14	16 mfd 300v.wg Electrolytic	L1-2, L3-4, L5-6	See text
C16	0.25 mfd paper		
R1	330Ω	2	Coil bases Eddystone 964
R2, R3-7	47 KΩ		Coil formers Eddystone 537
R4	1MΩ		

THE LONG-RANGE BATTERY "TWO"

While the majority of two-valve receivers are designed to operate a loud speaker, it is possible to design receivers which give reception over a far greater range than a simple regenerative detector, yet at the same time the audio power is still limited to headphone strength. To do this a high frequency stage is placed in front of the detector, i.e. between the signals arriving from the aerial and the detector. In this way the minute signals present at the input of the receiver are greatly amplified before reaching the detector and many stations which would have been too weak to be audible on a single-valve receiver are received at good strength.

The circuit shown in Figs. 6-7 comprises a pentode high frequency amplifier followed by a triode detector. To obtain as much amplification as possible, regeneration is provided on the detector. Briefly, the circuit functions as follows: The aerial is fed through C1 to L1, which in turn is inductively coupled to L2. Selectivity is controlled by C1 which serves to prevent the tuned circuit of the high frequency stage from being damped Its precise setting will depend on the type and size of aerial used. Tuning is effected by C2 and the selected signal passed to the control grid of V1 via C4. This condenser permits the high frequency signal to pass unhindered, but blocks DC. The grid earth return is made through R1 and the grid bias cell. Without C4 the grid of V1 would have a return path to ground, and some other method of biasing the valve would have to be used. The amplified signal is developed across L3 and passed to the control grid of V2 which, by virtue of C10-R4, functions as a " grid leak " or " leaky grid " detector.

Tuning is by means of C9, which is ganged to C2 to provide single-knob tuning. C3 and C7 are simply trimmers used to equalise stray circuit losses and coil mismatching.

Regeneration is by means of L4 and C8 and its is important to watch that the coil connections are wired up correctly. If by chance the winding direction of L4 is reversed, the control C8 will provide degeneration, sensitivity decreasing as C8 is advanced, and, it will of course, be impossible to make the receiver oscillate. The cure is obvious: reverse the connections to L4. Baseboard and front panel can be used for the receiver assembly, 8″ × 6″ being a convenient size for both. The practical diagram shows the point to point wiring for the complete receiver. After completion the trimmers C3-7 should be adjusted to about half their total capacity and the receiver switched on. Without attempting to tune in a station, C8 (the regeneration control) should be advanced until the detector goes into oscillation. This will be indicated by a soft " plop " followed by a hiss. Reset the control just short of oscillation and tune in a signal by means of the ganged assembly C2-9. Choose a signal at the

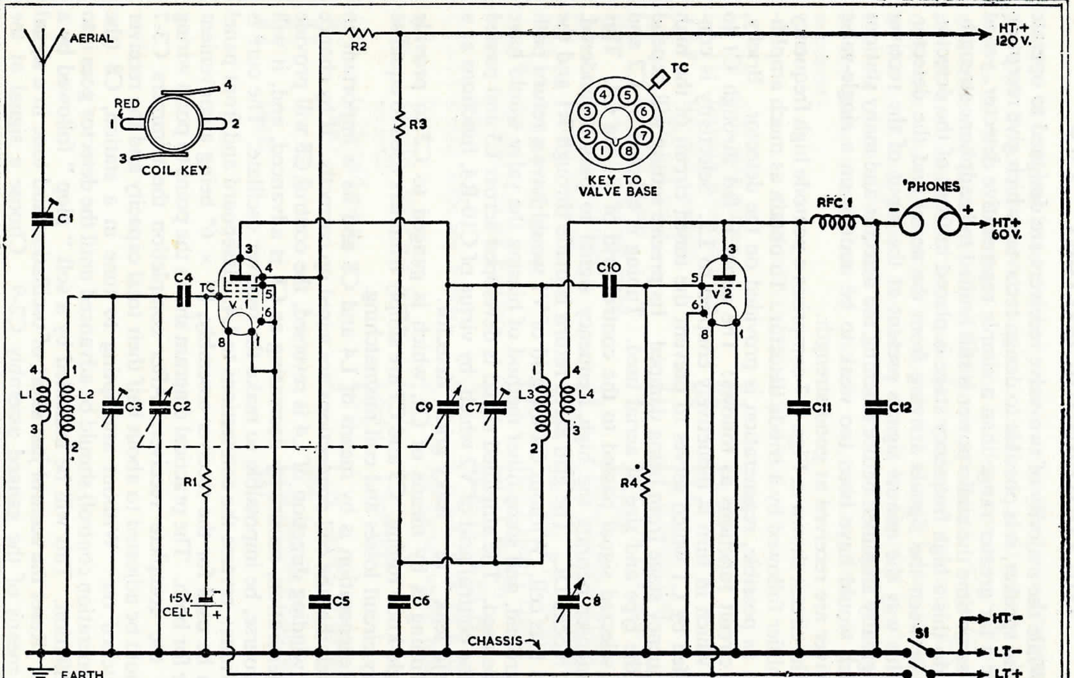


FIG.6 THE LONG-RANGE BATTERY 'TWO'

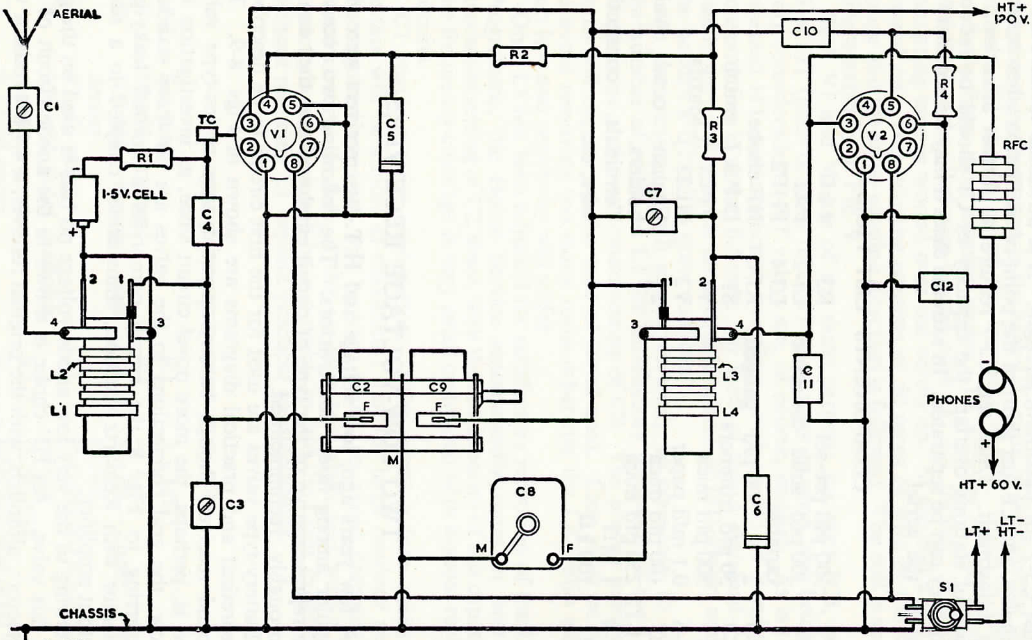


FIG. 7 THE LONG-RANGE BATTERY 'TWO'

high frequency end of the band, i.e. with the vanes of C2-9 out, and adjust C3-7 for maximum strength. It is advisable to have C1 at *minimum*, and C8 just short of the point of oscillation when making this adjustment. Once set, C3-7 require no further attention. If powerful stations overlap, the capacity of C1 should be reduced until they can be separated. In extreme cases it may be necessary to shorten the aerial.

COMPONENTS' LIST FIGS. 6-7

C1	300 pfd pre-set	R3	1 kΩ
C8	300 pfd solid dielectric variable	L1-2	PA2
		L3-4	PHF2
C2-9	2 × 500 pfd ganged	RFC1	HF choke
C3-7	50 pfd trimmers	S1	D.P.S.T. switch
C4	500 pfd mica	V1	VP23 } Mazda
C5-6	0.1 mfd paper	V2	HL23 } Mazda
C10	100 pfd mica	2	English octal valve holders.
C11-12	250 pfd mica		
R1-4	1 MΩ		Terminals, connecting wire, etc.
R2	100 kΩ		

TWO LOW-VOLTAGE RECEIVERS

A few years ago, low voltage and H.T.-less receivers were very popular among home constructors. The following two receivers are representative of the type of circuit employed and they can be thoroughly recommended.

Battery-type valves are used for the first circuit to be described; theoretical and practical diagrams are shown in Figs. 8-9. The second receiver, though battery-operated, uses mains-type valves and is, perhaps, the more novel circuit since, as investigation will show, the grid connections to the valves are far from standard. Referring to Fig. 8 the circuit comprises a normal leaky-grid detector with Reinartz reaction, transformer coupled to a single output amplifier.

Owing to the very low anode voltage no bias is used on the grid of this valve. An HF choke is shown in the anode circuit of the detector: although, with the original receiver, a 4.7 kΩ resistor was found to be quite satisfactory.

The chief feature of the design and, in fact the secret of its exceptional performance, is the high L/C ratio of the detector tuned circuit. C2 should be of the low loss variety, which is readily available from most surplus stores. L1 consists of 140 turns of 30 S.W.G. enamelled wire wound on a 1¼" dia. former. A layer of insulating tape is wound over the earthy end of the coil and L2 is wound on. This winding consists of 50 turns of wire of the same gauge and the same winding direction is followed. The coil is shown diagramatically in Fig. 9.

Both V1 and V2 are of the same pattern: i.e. type IC5, either G or GT (glass or glass tubular) valves may be used, size being the only consideration. GT valves are, of course, smaller. As is to be expected HT consumption is very low: with an HT of 9 volts the consumption is under 0.5 mA. In view of this a standard 9-volt bias battery will provide an adequate source of HT power, and for the heaters a U2 cell is quite suitable.

On completion, it will almost certainly be necessary to adjust the number of turns on L1 for satisfactory reception of the Light Programme at the minimum setting of C2. The precise numbeı of turns will depend on the type of aerial used. Care must be taken to avoid removing too many turns otherwise the L/C ratio will be too low and sensitivity will suffer.

Once L1 has been adjusted for satisfactory reception of the Light Programme, the Home Service automatically tunes in near the maximum setting of C2, since, with the low capacity of this capacitor, the frequency coverage is very small compared with normal receiver circuits.

C1 requires some explanation. With small indoor aeials the setting will be almost at maximum; but for large outdoor aerials the required capacity will be very small, to avoid damping the tuned circuit. In fact, if the aerial is too large, and with a high capacity to earth, it will be impossible to find the Light Programme without reducing L1 beyond practical considerations.

COMPONENTS' LIST FIG. 8-9

L1-2	**See text**	R1	3.3 MΩ
C1	50 pfd trimmer	R2	22 kΩ
C2	100 pfd tuning **condenser**	S1	Single - pole toggle switch
C3	47 pfd mica	**T1**	Parallel-fed audio transformer
C4	350 pfd Solid dielectric reaction condenser	V1-2	1C5G-GT
C5	0.1 mfd paper	2	International octal valve holders
RFC	Broadcast HF choke		

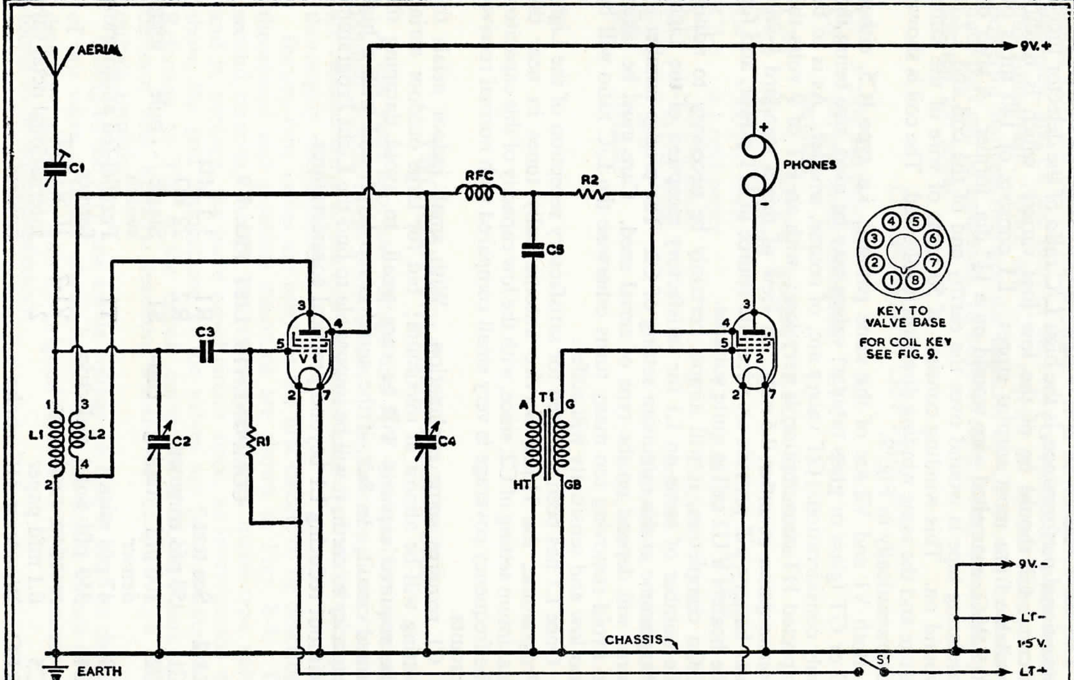


FIG.8. THE 9V. H.T. TWO-VALVE RECEIVER.

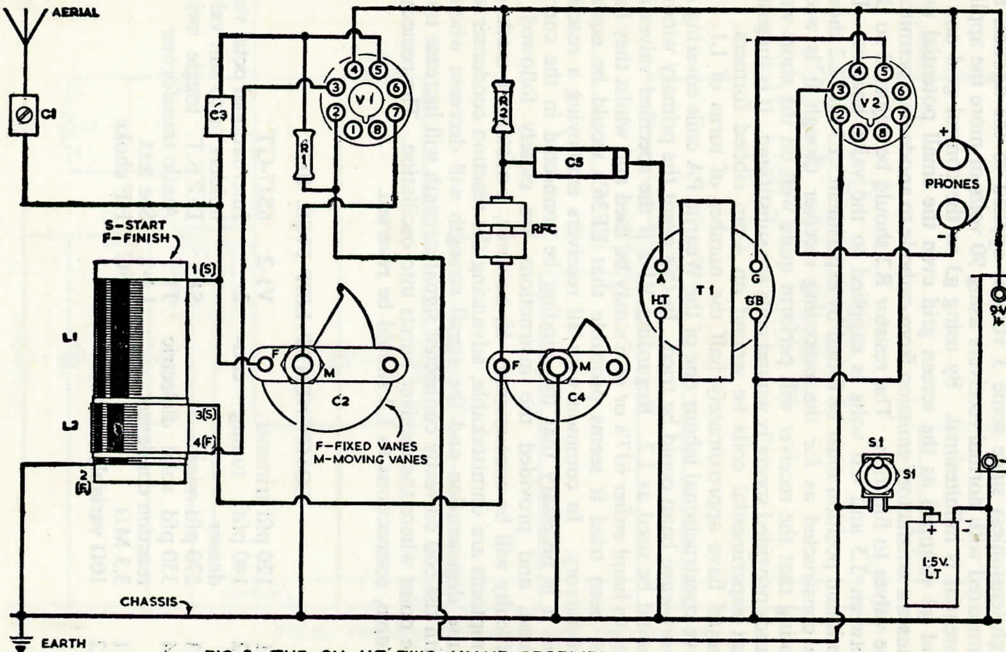


FIG. 9. THE 9V. H.T. TWO-VALVE RECEIVER.

The receiver shown in Figs. 10-11 represents perhaps the ultimate in high-tensionless design. Technically it is incorrect to class it as high-tensionless since some 3 volts is applied to the anodes, but compared with normal receivers using 90 volts or more the applied potential is infinitesimal. By using g3 as the control grid and g1 and g2 strapped as the screen grid even the small potential used causes a satisfactory emission from cathode to anode thus permitting the valves to function. The resistor R2 should be adjusted so that between 3.5 and 4.0 volts is supplied to the valve heaters. The optimum position must be found by experiment. L1 and L2 should be constructed as for the preceding receiver though it is worth noting that the receiver will perform quite well on the short-wave bands provided specially wound coils are substituted. It is suggested that experimental coils be wound on 4-pin ribbed formers. L2 should have approximately half the number of turns of L1. To save constructional labour one of the Wearite PA coils covering the short-wave band could be tried. In this event the primary winding should be used as L2. Regarding V1-2 if the specified valves are not to hand either 6J7's or 6C6's may be used and whilst they have not been tried it seems probable that EF36's would be equally satisfactory. In common with all receivers employing a reaction coil it is necessary that the winding be connected in the correct phase, and provided the instructions are closely followed no difficulty will be encountered. If, however, a mistake is made the symptoms are unmistakable, advancing the reaction condenser will cause degeneration and the signal strength will decrease whereas with the coil correctly connected signal strength will increase up to the point where the receiver bursts into oscillation. The remedy is simple, connections to L2 should be reversed.

COMPONENTS' LIST FIGS. 10-11

C1	120 pfd trimmer	V1-2	6SJ7-GT
C2	140 pfd tuning condenser	2	International octal valve holders or to suit valves
C3	270 pfd mica	S1	D.P.S.T. toggle switch
C4	350 pfd solid dielectric reaction condenser	T1	Audio transformer
		L1-2	See text
R1	3.3 MΩ	RFC	HF choke
R2	10Ω variable resistor		

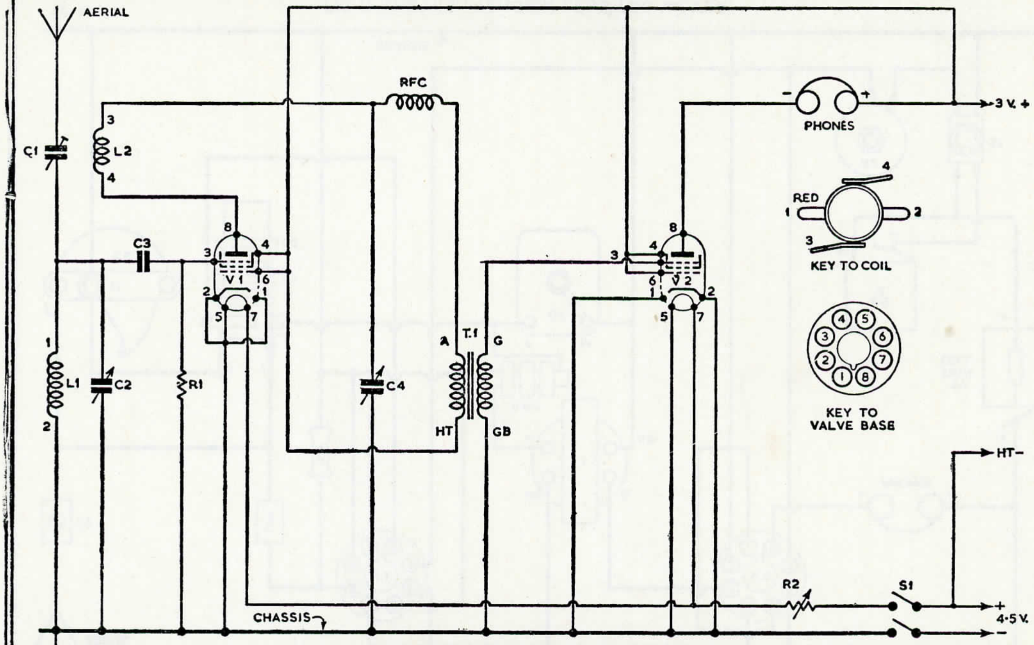


FIG. 10 THE 'HIGH-TENSION-LESS' TWO-VALVER.

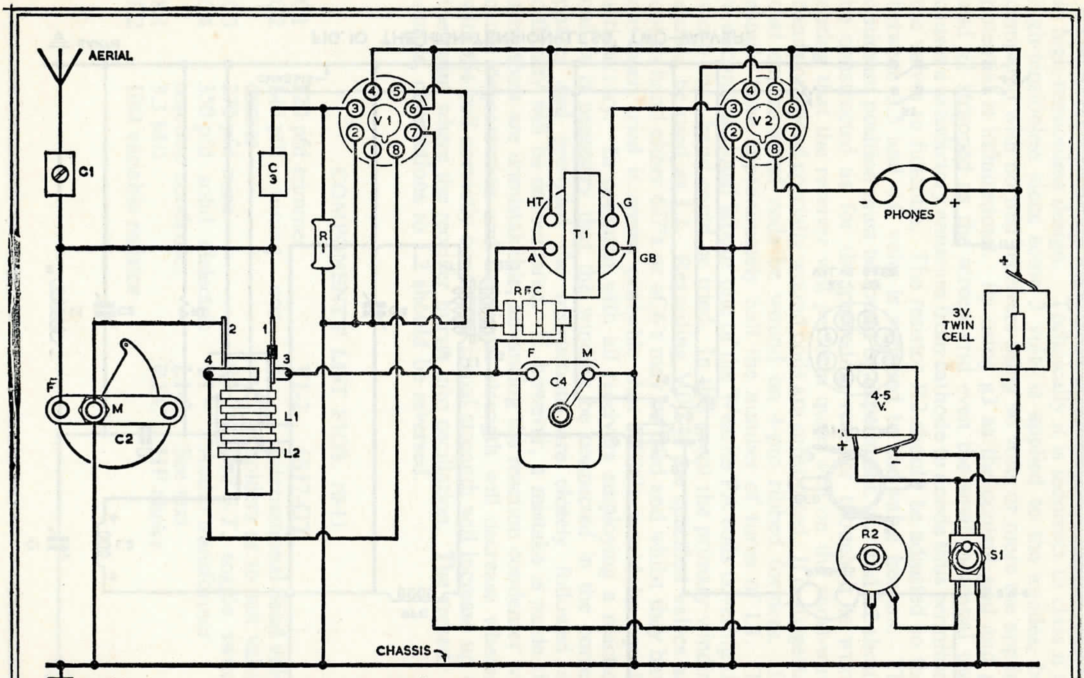


FIG. II THE 'HIGH-TENSION-LESS' TWO VALVER.

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