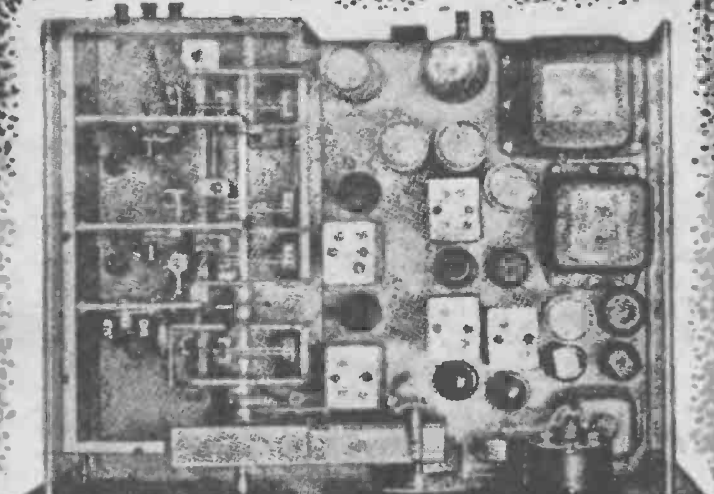
RADIO constructors Manual



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Radio Constructors Manual

No 1

by

Lewis George

No. 53

BERNARDS (PUBLISHERS) LTD
LONDON W 6

INTRODUCTION.

For some time past I have been receiving a considerable number of letters, the majority of which requeet not eo much information of a technical nature, but rather information regarding practical and constructional matters. Similarly, conversations with the retail Radio Trade generally has revealed the demand for a book, or series of books on "How to make" lines.

One would suppose that during the war, with nearly a complete absence of new components, home construction of Radio Receivers and the like would have practically ceased. Paradoxically, perhaps, the reverse has happened and considerable ingenuity has been exercised by amateurs in the pursuance of their hobby. Reliance has had to be placed on secondhand or surplus components, and although prices are somewhat high a comprehensive selection is fortunately available.

In the present book my aim has been to give particulars of a range of receivers and amplifiers made up from currently available components and considerable latitude of choice is possible. Each piece of apparatus has been constructed with facilities possible to any amateur and no difficulty should be experienced in similating the results obtained from the prototype in each case. Fine limits of performance have been avoided in the interests of stability and provided that good quality componente of practically any make are used, resulte should be satisfactory.

However, if difficulty is experienced, the Technical Staff of Messrs. Bernards will be pleased to assist in any way they can.

One last word. As this book is intended to be the first of a series of primarily constructional publications I should take it as a favour if Readers would let me have their views both on the present book and on designs which they would like included in the rest of the series. In other words, my staff and myeelf wish to give you exactly what you want in the way you want it.

LEWIS GEORGE.

London, April, 1945.

CONTENTS.

Chapter

BERNARDS (PUBLISHERS) LTD
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RADIO CONSTRUCTORS MANUAL,
No. 1.

Chapter 1. A Modern Crystal Receiver.

Parts Required:

C1 100 mmfd. (Max.) "Postage Stamp" Condenser.
C2 .0005 mfd. Variable Condenser.
C3 .001 mfd. Mica Fixed Condenser.
1 Crystal Detector Semi-Permanent Type.
1 Paxolin or Ebonite Panel 6"×5"×3/32" thick.
Knobs, Terminals (4), Connecting Wire, etc.

Coil Details.

50 turns 38 SWG enamelled wire on 3" diameter × 2" long former, close wound and tapped every ten turns.

To me it has always seemed strange that the beginner to Radio who commences by making a Crystal Receiver must, to obtain satisfactory results, exercise more care in avoiding losses than the more advanced amateur making, shall we say, a three valve receiver. The point here is that, with the possible exception of one type of valve rectification, the crystal receiver produces results dependent only on signal input from the aerial since no amplification is possible. For this reason three principal things are important.

(1) The Aerial and Earth system.
(2) Low loss design in the receiver itself.
(3) The use of sensitive headphones.

With regard to (1), the maximum length of 100 feet of stranded copper wire should be used, well insulated at either end and situated as far as possible from any earthed object. The lead-in from the horizontal portion must be kept away from metal objects such as gutters and stack pipes, and where entry is made to the house a glass lead-in tube should be used. Joints (even soldered ones) should be avoided at any point exposed to the elements, and if possible the lead-in wire should be taken direct to the aerial terminal on the receiver. If trouble is experienced through moisture running down the wire and through the lead-in tube, this may be obviated by means of a metal cone fixed on the wire in such a manner as to shield the entry to the tube from rain, etc.

The earthed connection should be made by the most direct route possible to a main water pipe. Gas pipes are not recommended as the joints between each section of pipe often effectively insulate them one from the other. It is definitely preferable to take a direct heavy gauge stranded wire from the receiver, down the outside wall of the house and to a well buried metal object, than it is to run a long wire round innumerable corners and rooms to a water pipe inside the house.

Loss of signal strength within the receiver mentioned in (2) above may be reduced considerably by efficient coil design and the use of a semi-permanent detector which excludes dust from the crystal face; but the question of selectivity somewhat limits the efficiency one is able to obtain from a coil designed for optimum conditions. Consider the circuit of the receiver as shown in Fig. 1. It will be seen that the aerial input is taken via a pre-set

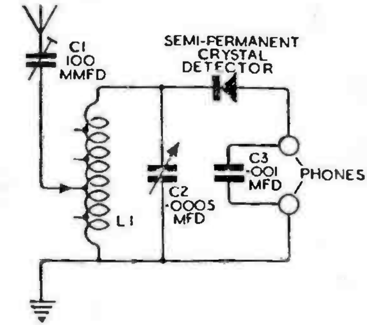


FIG 1. CRYSTAL RECEIVER. CIRCUIT DIAGRAM.

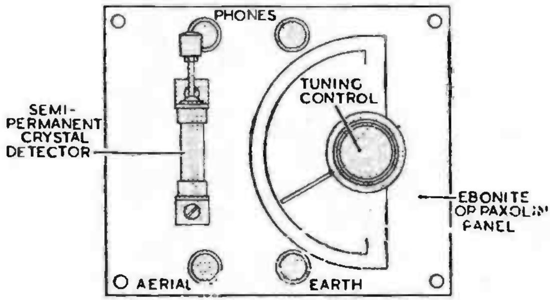


FIG 2. CRYSTAL RECEIVER. PLAN OF PANEL.

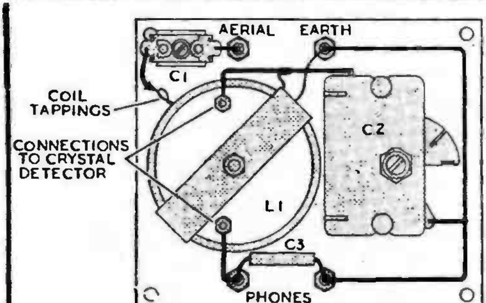


FIG 3. CRYSTAL RECEIVER. WIRING DETAILS.

condenser C1 to tappings on the aerial coil L1. The nearer to the earthed end of the coil the aerial tap is situated the greater will be the selectivity as the damping effect of the aerial on the tuned circuit is reduced. The signal strength, however, will suffer the further the aerial tap is from the detector end. It is obvious, therefore, that the only solution is to effect a compromise between selectivity and signal strength, and it is for this reason that tappings are made at every ten turns down the whole length of the coil. These enable the constructor to find the best tapping point for his particular location so that maximum signal strength may be obtained together with the amount of station separation he needs. The tuning condenser C2 may be one of the bakelite types as dielectric losses on medium waves are not very serious. But here again an air dielectric condenser as shown in the constructional drawings is necessary if maximum efficiency is required. The fixed condenser C3 is necessary in order that correct conditions for rectification are obtained for the crystal detector.

Little need be said concerning the question of telephones (3), except that they should have a resistance of approximately 4000 ohms and should be of a reputable make. It is false economy for a beginner to buy a cheap pair of phones as there are so many uses to which he will ultimately put them that the acquiring of good instruments in the first place is a sound investment.

The method of construction shown in Figs. 2 and 3 need not be adhered to as layout is not critical - a particularly neat design can be made (if one uses a bakelite tuning condenser) by mounting the crystal detector, terminals, aerial tuning and condensers on a circular bakelite panel 3" in diameter which, after wiring, should be fixed to the "detector" end of the coil so that the coil itself constitutes the receiver case. Protection for the coil windings can be obtained by painting them with Rawlplug "Durafix."

CHAPTER 2 A TWO VALVE RECEIVER FOR BATTERY OPERATION.

Parts Required.

Condensers. C1 .05 mfd. C3 50 mfd. 12 V.W. Electrolytic
C2 .1 mfd. C4 .005 mfd.
Resistors: R1 1 MΩ Variable R3 .5 MΩ ¼ watt
R2 100,000Ω ¼ watt R4, R5, ¼ watt (see Text)
Valves: V1 Mullard PM2HL V2 Mullard PM22A
Valve Holders: 1-4 pin English 1 5-pin English.
On/Off Switch: 1 Double Pole Single Throw.
Terminals: 11. Knob and Dial: 1.
Panel: Paxolin or Ebonite 8"×6"×3/32". Baseboard: Wood, 8"×8"×3/8". Screws, connecting wire, sleeving and small piece of paxolin on which to mount the loud-speaker terminals.
Batteries: 120 V. H.T. 2 V. L.T.

From my remarks in the last chapter it will be apparent that amplification is required following the output of the crystal receiver before a loud-speaker can be operated. For this purpose, therefore, I have designed the amplifier about to be described, but it can also be used after slight modification with the feeder unit shown in Chapter 3 to form an efficient battery-operated 4-valve receiver. In order to fulfil this dual-purpose I have reverted to a modified form of construction which was popular some years ago, namely, the unit system. In circuit arrangements such as those at present under construction the adoption of a uniform arrangement of input and output terminals makes for flexibility, conceals inter-chassis connections and tends to avoid redundancy, as provision is made for chassis containing different circuit arrangements to be used and supplied with power as required. In fact one might summarise these remarks by saying that the present amplifier is an ideal basic design for the constructor or experimenter - quality is good, first and running costs are economical, and the output power is in the neighbourhood of 300 mW.

Further points of interest will be apparent from a glance at the circuit diagram in Fig. 4. C1 is the input coupling condenser and R1 the grid leak for the triode valve V1. R1 is made a variable potentiometer to provide manual control of volume and during adjustment of the crystal this control should be turned to minimum. The phones may then be connected across the original 'phone terminals of the crystal receiver so that objectionable scratching noises are not heard in the loud-speaker. R2 is the anode load resistor of V1 and C2 the coupling condenser between this valve and the output pentode V2. Automatic grid bias for both valves is provided by the network R4, R5 and C3, the latter providing the requisite low-impedance path. The method of obtaining the correct grid bias voltage should be understood so that the necessary modification to the values of R4 and R5 may be made if the amplifier is used in conjunction with any additional apparatus employing valves operated from the same batteries as the amplifier. It will be seen from the circuit that R4 and R5 are between HT- and LT- so that they carry the total H.T. current taken by the amplifier. From the makers' data sheets the PM.22A output valve V2 requires a grid bias voltage of -4.8 volts and has an anode current consumption of 5Ma. and the PM2HL (V1) requires -1.5 volte consuming .5Ma. The total H.T. current of the amplifier, therefore, is 5.5Ma and the maximum grid bias voltage we require is -4.8 volts. Ohms Law gives us the value of the total resistance (R4 and R5) we require (4.8÷.0055 amps.) at 870 ohms and the nearest standard value, 900 , was chosen. This value of resistance actually produces a voltage of -4.95 volts, but this difference may be ignored.

To calculate the position of the 1.5V tap to provide the correct bias for V1, the above calculations are repeated ineerting the new voltage. Thus 1.5÷.0055 equals 272, and the nearest higher value, namely, 300 ohms is chosen for R1. As R4 and R5 are in series and the total value given in the first calculation wae 900 ohms, the value of R5 ehould therefore be 600 . Another point in this connection which should be made clear ie that voltage only ie required for grid bias and thue calculation of taps for voltagee other than those given above should be done in a precisely similar

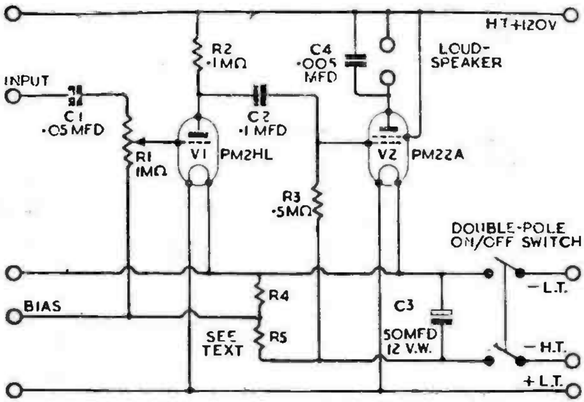
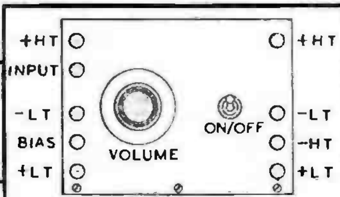


FIG 4. CIRCUIT DIAGRAM.



PANEL LAYOUT.

BATTERY OPERATED TWO VALVE AMPLIFIER.

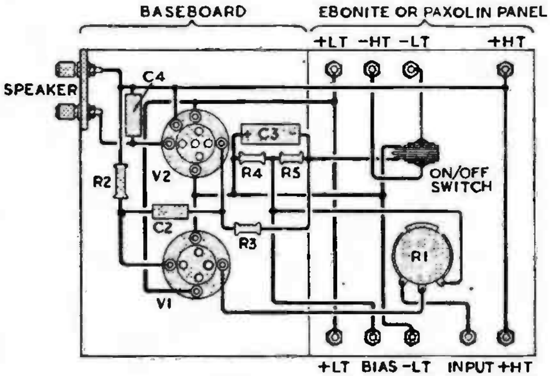


FIG 5. WIRING DIAGRAM.

manner ignoring any current drain at the tapping point. Always remember that it is upon the total current of the valves in the receiver in conjunction with the highest grid bias voltage required that the total value of the automatic bias resistor/s depend.

The condenser C4 across the output terminals was included to limit the overall high-note response, but constructors should try different values in this position according to their personal taste in reproduction. The optimum load resistance of the PM22A value is given as 20,000 ohms, and an output transformer must be chosen allowing the correct matching ratio for the voice-coil impedance of the loud-speaker the reader intends to use.

Layout and under chassis wiring diagrams are shown in Fig. 5, and again the arrangement of components is in no way critical providing a layout is adopted which permits logical point to point short wiring.

CHAPTER 3. ONE/TWO-VALVE RADIO TUNING UNIT FOR BATTERY OPERATION.

Parts required.

Condensers.		Resistors.	
C1, C8	.0002 mfd. Mica Dielectric Variable	R1	1 MΩ ½ watt
		R2	75,000Ω ¼ watt
C2, C7	30 mmfd. Postage Stamp Trimmers	R3	1000Ω ½ watt
		R4	2 MΩ ½ watt
C3, 39	.0005 mfd. Two-Gang Variable	R5	50,000Ω ¼ watt
C4	.0005 mfd. Mica		
C5, C6	.1 mfd.		
C10	.00005 mfd. Mica		
C11, C12	.0002 mfd. Mica		

Valves: V1 Mullard; VP2B; V2 Mullard PM1HL
Valveholders: 1 7-pin Baseboard, English; 1 4-pin ditto.
Terminals: 7; Slow Motion Dial: 1
Knobs: 3
Panel: Paxolin or Ebonite, 8"×6"×3/32"
Baseboard: Wood, 8"×6"×⅜"
Screws, connecting wire, sleeving, etc.

Coils:
Both formers 7/8" diameter
L1-121 turns 36SWG enamelled wire
L2-35 turns 36 SWG enamelled wire wound over "earthy" end of L1
L3-121 turns 36 SWG enamelled wire
L4-40 turns 36 SWG enamelled wire wound over "earthy" end of L3

For those locations situated some distance from a B.B.C. transmitter, and for constructors who like listening to Continental programmes, this tuning unit, in conjunction with the amplifier described in Chapter 2, will provide a very satisfactory receiver. One outstanding feature of the design is that it is exceptionally easy to make and no snags will be met with when construction is completed. Selectivity is ample for the majority of districts, but it is not claimed that this is of the "razor edged" variety. However, in cases where higher selectivity than that

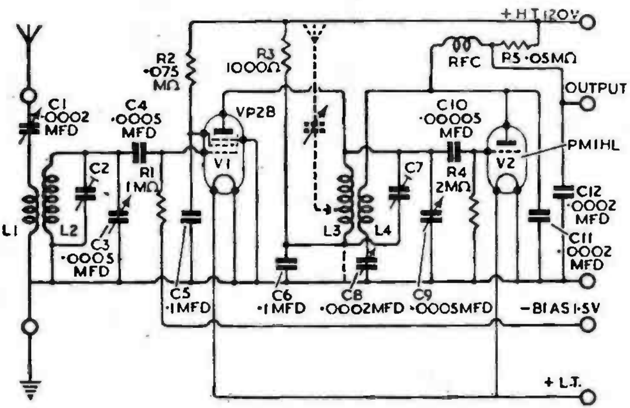
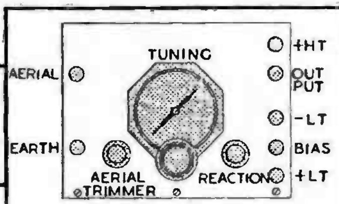


FIG 6. CIRCUIT DIAGRAM.

BATTERY OPERATED TWO-VALVE TUNING UNIT.



PANEL LAYOUT

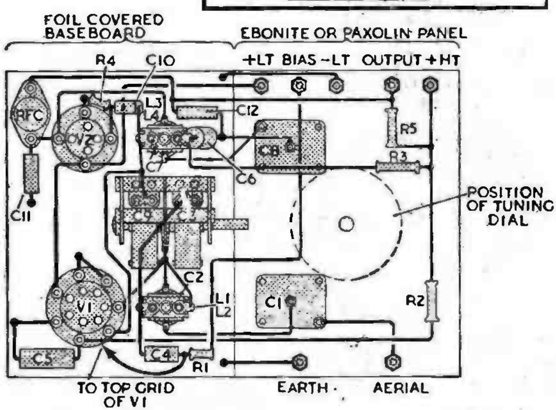


FIG 7. WIRING DIAGRAM.

provided is desired some considerable improvement may be obtained by operating the receiver on a smaller aerial. It is not always realised the benefits this procedure can confer, the principle one being that it enables the operator to utilise added selectivity gained when the reaction control is operated near its maximum point. My reader will realise that using the reaction control in this manner seriously affects the quality of reproduction, so one's aim should be to effect a suitable compromise between aerial length and reaction—two seemingly very different subjects but in this instance rather closely related.

The theoretical circuit is illustrated in Fig. 6, and it will be seen that the arrangement comprises a pentode R.F. stage (V1) followed by a triode detector (V2). Tuned anode coupling is provided by L3, C9, and reaction is obtained by means of L4 and C8. The circuit is straightforward except, perhaps, the method of applying grid bias to V1. The condenser C4 is inserted to allow the R.F. impulses to reach the grid of V1, but it also blocks the D.C. path to earth from the signal grid through L2, enabling a bias of 1.5 volts to be applied via the decoupling resistor R1. While on the subject of grid bias I think it will be as well to consider the changes in value of R4 and R5 (Fig. 4, Chapter 2) necessary when the tuning unit at present being described is used with the amplifier We will, therefore, regard the two units together as a complete four-valve receiver. The R.F. stage takes 3ma, the detector 1 ma approximately, the amplifier (as we have previously seen) takes 5.5 ma—a total of 9.5 ma. The highest bias voltage we require is still for the output valve - 4.8 volts, and thus our calculation for the total resistance R4 and R5 becomes 4.8÷.0095 or 505 ohms. The calculation for the 1.5 volt tap will now be 1.5÷.0095 or 158 ohms, and the nearest standard value of 150 ohms will be in order. This is the new value allotted to R4. R5 can now be found by deducting 150 (R4) from the calculated total resistance 505 and the answer will be 355. A resistor of 350 ohms will be quite near enough for our purpose.

It will be noted that an aerial connection is shown dotted between V1 and V2 on Fig. 5, and this is intended to indicate the circuit arrangement if the constructor wishes to make only the detector portion. The aerial tap should be approximately 1/3 of the total number of turns counted from the "earthy" end.

The R.F. choke in the anode circuit of V2 should be of a reputable make, as smooth reaction control depends, to a great extent on the efficiency of this component. If the reader wishes to construct his own choke, 1500 turns of No. 36 SWG enamelled wire wound in 5 sections on a half-inch former will prove satisfactory.

If the constructional and wiring drawing in Fig. 7 is followed carefully, no difficulty should be experienced and the method of adjustment described in Chapter 4 for the AC/DC Midget Receiver will be found to be all that is necessary.

CHAPTER 4. THREE VALVE PLUS RECTIFIER T.R.F. "MIDGET" RECEIVER FOR AC/DC OPERATION.

Parts required.

Condensers.

C1, C10	.0002 mfd. Mica
C2	.05 mfd. 400 V.W.
C3, C8	30 mmfd. "Postage Stamp" Trimmers
C4, C9	.0005 mfd. Two-Gang Variable
C11, C16	.1 mfd. 350 V.W.
C12	.0003 mfd. Mica
C13	.01 mfd. 350 V.W.
C14	.005 mfd. Mica
C15	25 mfd. 25 V.W. Electrolytic

Resistors.

R1	100,000 Ω ½ watt
R2	450 Ω ¼ watt
R3	10,000 Ω Variable Carbon
R4, R8	50,000 Ω ½ watt
R5	15,000 Ω ½ watt
R6, R7, R9	1 MΩ ¼ watt
R10	450 Ω 1 watt
R11	10,000 Ω 1 watt
R12	Tapped mains dropping resistor to suit valves used (see Text).

Valves: V1-6K7; V2-8J7; V3-25A6; V4 25Z6 or equivalents.
Valveholders: Four American Octal.
Mains Switch: Double Pole Single Throw Ganged to R3.
Knobs: 2. Epicyclic Slow Motion Gear: 1.
Grid Connectors: 1 for V2 (screened); 1 for V1 (unscreened).
Choke L6: 20 henry at 50ma if permanent magnet speaker is used.
Mains Connector: 1.
Speaker: 3" "Midget" with output transformer.
Sockets: One 2-way (aerial and earth).
Chassis: 7"×5"×2½" 20 SWG mild steel.
Screws, connecting wire, sleeving, etc.
Coils: Both formers 7/8" diameter×2" long.
L2 121 turns 36 SWG enamelled wire close wound.
L1 35 turns ditto ditto wound over "earthy" end of L2.
L3 121 turns 36 SWG enamelled wire close wound.

The principal difficulty one experiences in designing receivers of this class is summed up in the proverb about "trying to put a quart into a pint pot." In peace time it was possible to obtain "midget" components which went far to solving this problem, but as these are now few and far between, the receiver illustrated and described in this chapter has been built with standard sized components.

Reference to Fig. 8 will show the circuit diagram, and it will be seen that a variable-mu R.F. pentode is used in the R.F. stage, the variable-mu characteristics being utilised to control volume by means of R3. This control also permits application of reaction to this stage, resulting in considerably increased sensitivity and selectivity. V2 is a "straight" R.F. pentode operating as a grid detector and was chosen in the interests of the increased sensitivity possible with this arrangement, as compared with others. A 2-4 watt output pentode completes the valves in the receiving chain. AC. mains power is rectified by means of the half-wave rectifier V4 and is then filtered and smoothed by the condensers C17, C18 and the speaker field L6. In the case of D.C. the rectifier becomes a resistance and the H.T. for the receiver is then filtered and smoothed exactly as for rectified A.C. If the constructor wishes to use a permanent magnet speaker L6 will

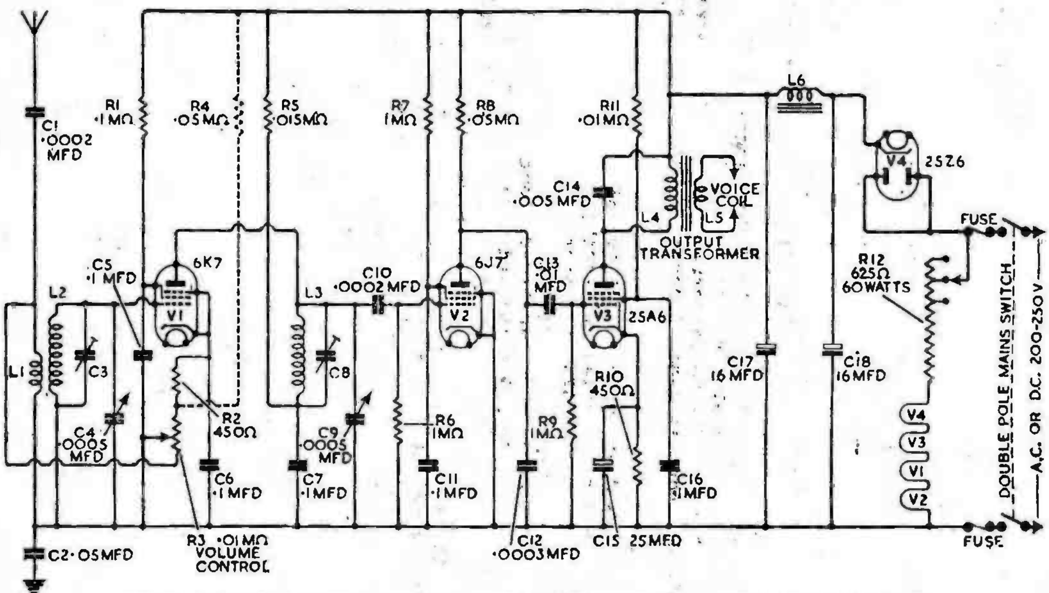


FIG 8. THREE-VALVE AC/DC MIDGET RECEIVER. CIRCUIT DIAGRAM.

then be a choke of, say, 20 henries at approximately, 50 milliamps. The inclusion of resistor R4 is sometimes found beneficial in providing control of volume but may generally be omitted.

The choice of alternative valves is dealt with in Chapter 14, but it should be borne in mind that to avoid complicating the heater supply circuit, valves taking similar heater current must be employed. For instance, if it was desired to use valves of American origin or their British counterparts, V1 would be a 6K7G, V2 a 6J7G, V3 a 25A6G, and V4 a 25Z6. All these valves take 0.3 amps heater current, and it will be seen that their respective voltage ratings total 62.6 volts (6.3+6.3+25+25). The difference between this last mentioned voltage and the incoming mains voltage is absorbed by R12. To obtain the correct value for this resistor one must subtract 62.6 from 230 (or whatever your mains voltage is), leaving 167.4 volts. This latter figure must then be divided by .3 (the heater current consumption), and the answer, 558, will be the resistance in ohms of R12. The reason that a value of 625Ω is given on the circuit diagram is because this figure is correct for a mains input of 250 volts with the above-mentioned valves.

To quote another example. Assuming a Mullard EF39 was chosen for V1, a Cossor OM5 for V2, a Cossor OM9 for V3, and a Mullard CY32 for V4. In this case the total heater voltage required is 48.9 (6.3+6.3+6.3+30 volts respectively) and the current consumption is 0.2 amps. Assuming a mains voltage of 210 the difference will be 161.1 volts., and this figure divided by 0.2 shows that for this valve combination R12 would be 805.5 ohms.

To summarise the above points:

(1) Choose valves of the same heater current rating.
(2) Add the voltage ratings of the valves together.
(3) Subtract the answer in (2) from the mains voltage.
(4) Divide the answer in (3) by the current rating of the valves.

The resultant will then be the value (in ohms) of the dropping resistor required.

To my more advanced readers I apologise for treating the matter of mains dropping resistors in such detail, but correspondence has shown that some confusion does exist on this point. It will be apparent that the above calculations are merely an application of Ohms Law, and the following simplification of this Law should help some readers to calculate similar problems easily and quickly. If we arrange the three symbols, volts, amps., and ohms, thus,

$\dfrac{\text{volts}}{\text{amps} \times \text{ohms}}$ any desired solution may be obtained by covering up the unknown quantity and performing the operations left. Thus if resistance is required, volts are divided by amps, and again if, say, volts are required, amps are multiplied by ohms.

However, to return to the "Midget" receiver, mention should be made concerning the electrolytic smoothing condensers C17 and C18. This type of condenser is in such

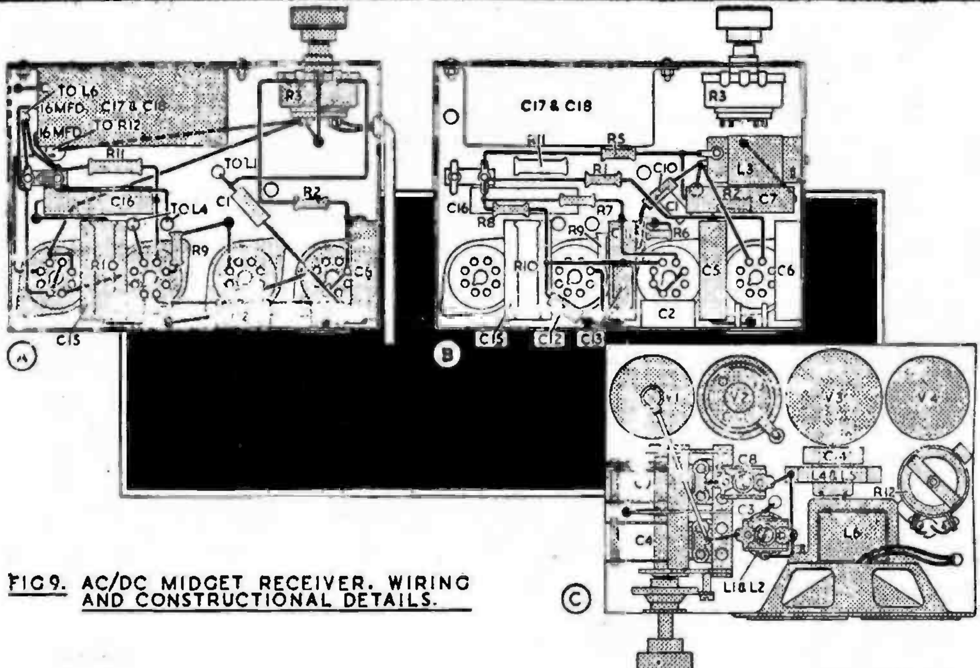


FIG 9. AC/DC MIDGET RECEIVER. WIRING AND CONSTRUCTIONAL DETAILS.

short supply that it may be necessary to effect some compromise in the capacities used. In any case their working voltage rating should not be less than 350, but it is sometimes possible to reduce capacity if a little hum can be tolerated in the reproduction. Another matter which has a bearing on this subject is the bass response of the loud-speaker used. The majority of "Midget" speakers on the market (with some notable exceptions, however) have a fairly sharp cut-off below about 200 cycles, and it will be understood that the use of one of these will mask quite a big deficiency in the smoothing equipment. I remember some years ago being "caught" over this problem: I was repairing an American "Midget" for a friend and instead of using the speaker in the "Midget" for my tests I utilised a rather good speaker in my laboratory. I remember spending a considerable time trying to cure a very loud "hum" which was not in the least apparent when the receiver was subsequently operated with its own 3" speaker.

Before turning to the construction of the receiver there is another point which requires our consideration. In all mains supply systems one conductor is earthed, and it will be understood, therefore, that the inclusion of C2 is vitally necessary. Without it, connection of the unearthed side of the mains directly to earth would be possible should the mains plug be inserted the wrong way round, resulting at least in blowing the fuses. This condenser must have a working voltage of not less than 400. C1 is also included for the same reason of isolation and its capacity has been chosen to limit the aerial damping effect on the tuned circuit L2-C4. In some locations where maximum selectivity is unnecessary the capacity of C1 may be increased with a corresponding gain in volume, but the value shown is a suitable compromise.

Fig. 9c shows the layout of the components above the chassis, a study of which will show that all vital connections are reasonably short. It may be that the 2-gang condenser you purchase has built-in trimmers, and if this is the case omission of C3 and C8 is possible. The chassis is 7"×5"×2½", but the constructor can use his own discretion on this point. Providing the same physical layout is utilised some increase of the dimensions given will result in easier wiring underneath. A screening cap is shown on the top grid connection of V2, and this was found to be necessary to reduce hum. However, with a larger chassis and consequently increased spacing between components this may be found to be unnecessary.

Figs. 9a and 9b show the underside of the chassis, and it is strongly recommended that the wiring shown in Fig. 9a be completed first. In Fig. 9b all the components in 9a have been shown with the addition of the items and wiring necessary to complete operations. The large black dots indicate earthing points to the chassis, and it was found in the prototype that a reduction in these as shown on the drawing was possible—the rule to follow being to take all earthed conductors to the chassis by the shortest possible route. Either these points can be soldered direct to the chassis or they may be made by means of a 6BA bolt, nut, and soldering tag, and, by the way, don't forget thoroughly to clean the chassis.

The adjustment of the completed receiver is exceedingly simple. Firstly, a strong signal should be tuned in, which can conveniently be either the Home or the Forces programme, and the trimmers C3 and C8 adjusted roughly for maximum strength. Then turn to the minimum of the tuning condenser (vanes nearly all out) and carefully readjust both trimmers again for the loudest signal—the thing to aim at is for minimum trimmer value. It may be found that one trimmer is screwed up rather more than the other, and if this is the case the signal on which the receiver is being lined up should be "followed" with the main tuning control, at the same time slackening off both trimmers until one of them is at its absolute minimum. Failure to carry out this procedure will result in restriction of wave-range owing to a high minimum trimmer capacitance.

CHAPTER 5. T.R.F. RADIO TUNING UNIT WITH TONE CONTROL STAGE for A.C. Mains Operation.

Parts required.

Condensers.	Resistors.
C1, C10 .0002 mfd. Mica	R1 100,000Ω ½ watt
C3, C8 30 mmfd. "Postage Stamp" Trimmers.	R2 450Ω ¼ watt
	R3 10,000Ω variable
C4, C9, C18 .0005 mfd. Two-gang Variable.	R4, R8, R11, 50,000Ω ½ watt
	R5 15,000Ω ½ watt
C11, C15 .1 mfd. 350 V.W.	R6, R7 1 MΩ ¼ watt
C12 .0003 mfd. Mica.	R9, R15, R16 .5 MΩ variable
C13 .05 mfd. 350 V.W.	
C14 25 mfd. 12V.W. Electrolytic	R10 10,000Ω ½ watt
C16 4 mfd. 350V.W. Electrolytic	R12 1,000Ω ½ watt
C17 .005 mfd. 350V.W.	R13 250,000Ω ¼ watt
	R14 See Text.

Valves: V1-6K7; V2-6J7; V3-6C5; or equivalents.
Valveholders: 3 American Octal 1 5-pin English.
Switch: 1 Single Pole Double Throw.
Slow Motion Dial: 1; Knobs: 1 Large, 5 Small.
Group Boards: 1 10-way; 1 6-way.
Screening Cans: 1 for V2.
Grid Connectors: 2 for V1, V2.
Sockets: Two 2-way (aerial, earth and pick-up).
Chassis: 10"×7½"×2½" 20 SWG. mild steel.
Coils: Same as in Chapter 4.
Screened wire, screws, soldering tags, connecting wire, sleeving, etc.

The unit about to be described was designed for localities where the signal strength of the "local" station is not of the highest or for constructors who desire fairly good quality on the local stations with, additionally, a selection of continental stations. It is intended that this unit be used with the amplifiers to be described in Chapters 9 or 11 to complete a medium range radiogram combination.

Fig. 10 illustrates the circuit diagram, and it will be noted that the arrangement adopted is the same as V1 and

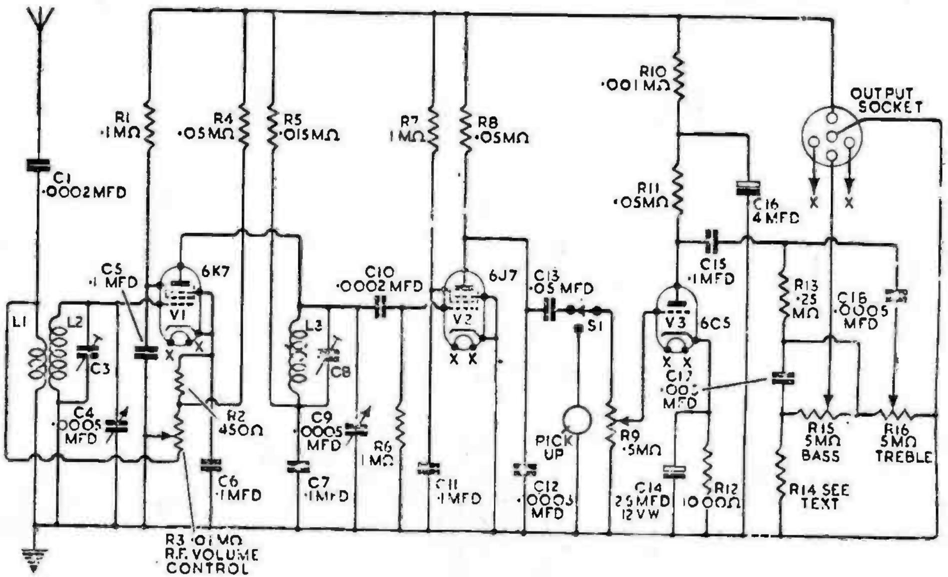


FIG 10. T R F FEEDER UNIT WITH TONE CONTROL STAGE. CIRCUIT DIAGRAM

V2 in Chapter 4 except that V2 is followed by a triode V3 and a network of condensers and resistors to provide tone control.

A few words about tone control. I do not propose entering into a discussion on the merits or demerits of tone control as such, as I consider with true fidelity of reproduction tone control should not be necessary. However, in actual practice certain factors are present which prevent one attaining fidelity even approaching perfect. To quote three: (a) limitations of frequency range introduced by the apparatus itself; (b) the acoustics of the room in which the receiver is situated; and (c) the question of relative volume levels. To deal with the first, some compromise must be made regarding frequency response on any but the local stations in order to preserve reasonable selectivity. Also each stage in the chain of apparatus from the microphone to the loud-speaker introduces some additional distortion. The acoustic trouble mentioned in (b) can be somewhat overcome by careful positioning of the loud-speaker and/or listening position; but this is generally, to say the least, inconvenient. Regarding (c) this is bound up largely in the fact that the human ear is rather a curious instrument. Its response to frequency is by no means linear and, even more important under the present consideration, it goes out of its way to distort what it does hear, especially at low volume levels. This latter fact may easily be proved by listening to good apparatus functioning at low volume level--high and low frequencies will apparently be conspicuous by their absence. I think, therefore, that in these three examples a good case for the adoption of tone control has been made out.

There are numerous ways of accomplishing what we want to do, but these may be divided into two principle classes, (1) "cut" circuits, and (2) "boost" circuits. In the former as the term implies, control is attained by decreasing either treble, middle or bass as required, and in the latter a similar effect is obtained by increasing the desired rango of audio frequencies. The principle advantage in the first method is that harmonic distortion is not increased by the tone control circuits, but it suffers from the drawback that it introduces considerable changes in overall volume. Careful design very largely eliminates harmonic distortion from "boost" circuits, however, and as these are, in my opinion, very much more flexible and preferable, this is the basic system adopted.

Again, there are a considerable number of circuits from which to choose, but as it was decided to provide continuously variable control without introducing hum and constructional problems associated with chokes, the circuit in Fig. 10 was adopted. A point which does need consideration when applying any method of boost tone control is the particular stage of the circuit in which it is introduced. A good general rule to apply is to include the correction circuits as early as possible in the audio chain, the reason being that full advantage is taken of the following amplification. Another point is that the extent

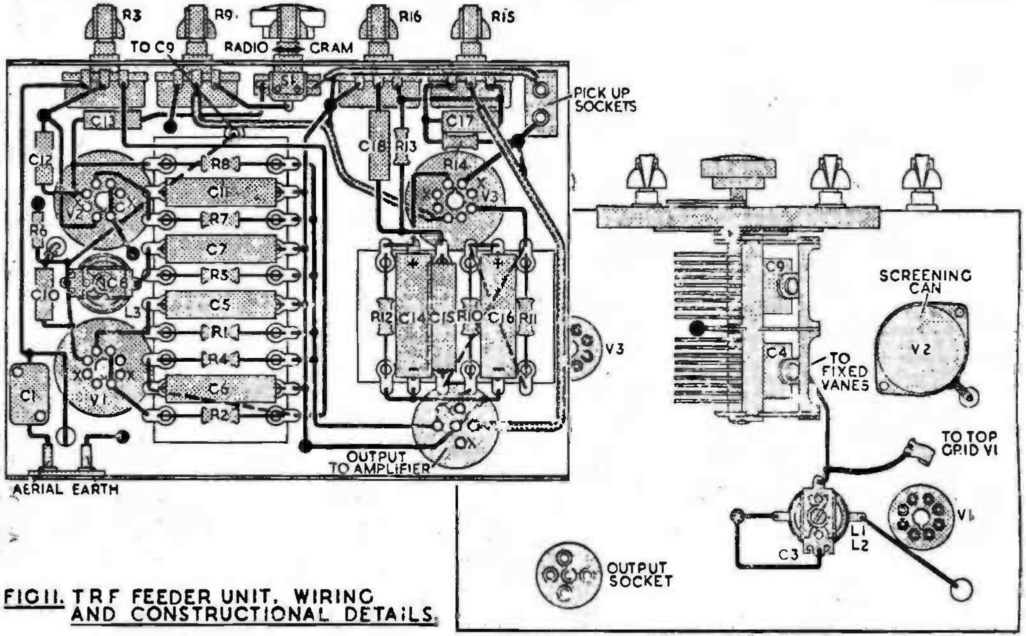


FIG 11. TRF FEEDER UNIT. WIRING AND CONSTRUCTIONAL DETAILS.

of boost should be limited in order that harmonic distrotion is not appreciably introduced. Practically all musical sounds are composed of a fundamental note with a certain number of harmonics, the harmonic strength relative to the fundamental determining the particular timbre or tone colour of the source. For instance, middle "c" on a violin and, shall we say, a trumpet would sound exactly similar if robbed of their respective harmonics. Consider the case of a musical instrument emitting a 1000 cycle note with a relatively strong harmonic at 4000 cycles. Supposing that neither the bass or the treble tone control had any effect at 1000 cycles and the treble control at maximum "peaked" at 4000 cycles, it is easy to see that at these settings of the controls the 4000 cycle harmonic would be amplified in excess of its original relation to the fundamental. So much for a brief resume of some of the considerations involved in the design of a tone control stage.

Turning again to the circuit diagram: the amplification of the triode V3 is controlled over the bass audio frequencies by R15 and at the treble by R16. The value of these components have been carefully chosen to provide adequate control over a suitable range of frequencies, but mention should be made regarding the value of the resistor R14 This resistor effectively limits the amount of bass boost, maximum being obtained with a value of 10,000 and minimum with 50,000 in circuit. It has occurred to me that for certain applications it might be desirable to make this a 50,000 variable resistor. If, then, the feeder unit was used as radio input for public address work or under similar variable working conditions, adjustment of R14 would provide needed flexibility. However, for use in a static home installation a suitable amount of boost can be decided by experiment and a resistor of correct value wired permanently in place.

Radio-gramophone switching is provided by S1, and the tone control operates in both positions of this switch. If this feeder unit is used with either of the amplifiers mentioned in Chapters 9 and 11 adequate stage gain is provided for practically any pick-up.

In the pictorial wiring diagrams depicted in Fig. 11 a form of construction is shown, the adoption of which many amateurs will find beneficial. Apart from the greater rigidity attained, wiring is considerably simplified as the separate group boards of resistors and condensers can be wired separately and then fixed in place. Another advantage is that positive points are easily accessible for test purposes in the event of the failure of a component.

Adjustment is exactly the same as that described in Chapter 4 for the "Midget" Receiver except that the present unit is not self-powered and must therefore be connected to a suitable amplifier and power-pack.

CHAPTER 6. AN ALL-WAVE SUPERHETERODYNE TUNING UNIT WITH TONE CONTROL FOR A.C. MAINS OPERATION.

WAVE-Ranges: 1. 15-50M (19.75MC–6MC).
2. 45-150M (6.67MC–2MC).
3. 190-575M (1507KC–525KC).

Parts required.

Condensers.	Resistors.
C22, 24, 25, 26, 33, 34, 35. 60mmfd. postage stamp trimmers.	R40, R44. .5MΩ ¼ watt
C23, 30, 37, 38, 41, 6. .1 mfd. 350 V.W.	R41. 400Ω ½ watt
C27, C32. .0005 mfd. Two-Gang Variable.	R42, R47. 50,000Ω ¼ watt
C31, 42, 43, 44. .0001 mfd. Mica.	R43, R45. 27,000Ω ½ watt
C36. .01 mfd. Mica.	R46. 250Ω ¼ watt
C45. .02 mfd. 350 V.W.	R48, R16, R17. .5 MΩ variable
C46. 4 mfd. 350 V.W. Electrolytic.	R49, R52, R53. 1 MΩ ¼ watt
C47. 25 mfd. 12 V.W. ditto.	R50. 25,000Ω ¼ watt
C8. .005 mfd. Mica.	R51, R14. 250,000Ω ¼ watt
C9. .0005 mfd. Mica.	R54. 3000Ω ¼ watt
PC1. 400 mfd. Pre-Set.	R15. See Text
PC2. .002 mfd. Mica.	
PC3. .006 mfd. Mica.	

Valves: V11-6A8; V12-6K7; V13-6Q7, or equivalents.
Valveholders: 3 American Octal, 1 5-pin English.
Switches: One 3-Pole 4-Bank for wave changing.
Slow Motion Dial: 1; Knobs: 1 Large, 4 Small.
Screening Cans: Two (V11 and V12).
Grid Connectors: Two unscreened (V11 and V12); One screened (V13).
I.F. Transformers: Two 465KC with built-in Trimmers—One with grid pigtail.
Sockets: One 2-way (aerial and earth).
Chassis: 11"×6¼"×3" 20 SWG. mild steel.
Screened wire, screws, connecting wire, sleeving, soldering tags, etc.
Coils: All formers ⅜" diameter×2" long unless otherwise stated.
L15. 375 turns 36 SWG. enamelled wire Bank wound ¼" wide on ½" former.

L13. 121 Turns 36 SWG. enamelled wire close wound.
L12. 35 turns 36 SWG. enamelled wire wound over "earthy" end of L13.

L17. 26.5 turns 20 SWG. enamelled wire close wound.
L16. 10 turns 36 SWG. enamelled wire wound over "earthy" end of L17.

L19. 7 turns 20 SWG. enamelled wire wound 19 turns per inch.
L18. 3 turns 36 SWG. enamelled wire wound between the last three turns at "earthy" end of L19.

L22. 80 turns 36 SWG. enamelled wire close wound.
L23. 20 turns 36 SWG. enamelled wire wound over "earthy" end of L22.

L24. 22 turns 20 SWG. enamelled wire close wound.
L25. 12 turns 36 SWG. enamelled wire wound over "earthy" end of L24.

L26. 6.5 turns 20 SWG. enamelled wire wound 19 turns per inch.

L27. 4 turns 36 SWG. enamelled wire wound two turns between last two turns at "earthy" end of L26 and the remaining two turns wound close to L26.

Some amateurs would appear to be a little apprehensive of the additional complications involved in making a superhet. receiver, and they would also seem to regard this type of receiver in the light of something mysterious and the necessary adjustments quite outside the scope of their limited equipment. I therefore propose giving a simple explanation of the principles underlying the function of a superhet. of this type. And while the more advanced amateur will recognise some omissions in this explanation I hope it will serve to dispel any misgivings which may exist in the minds of the uninitiated.

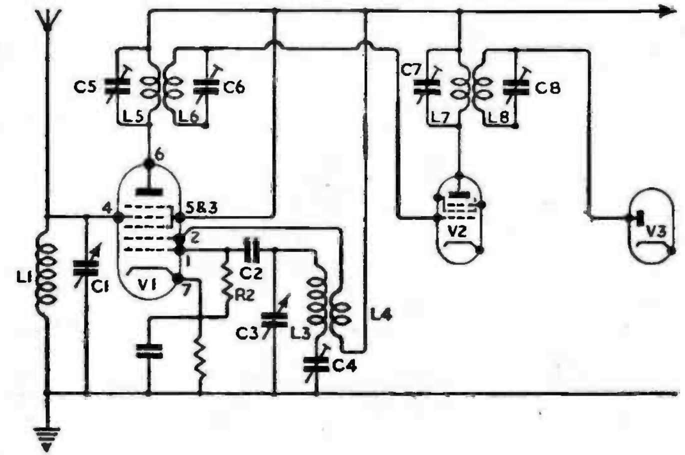


FIG 12. SKELETON CIRCUIT OF A SUPERHETERODYNE RECEIVER.

With the exception of one principle the superhet. may be regarded in exactly the same light as a straight receiver. Fig. 12 depicts a simplified circuit for a pentagrid (5-grid) frequency changer together with a pentode I.F. amplifier, and it will be seen that incoming aerial impulses are fed to one of the grids (No. 4) of the pentagrid by means of a tuned circuit comprising L1, C1. Now consider grids 2 and 1. Grid 2 is connected via L4 to H.T., and being coupled to L3 maintains Grids 1 and 2 in a continuous state of oscillation in the same manner as a reaction coil in a grid detector of a "straight" receiver- in fact, the condenser C2 and the resistor R2 ensure that it is exactly similar. Now look at the valve again, the electron stream from the hot cathode (7) is drawn to the positive anode (6) via all the grids, and thus it will be apparent that any action taking place between grids 1 and 2 will be controlled by successive grids. As we have seen, the incoming signal is fed to grid (4), and it will therefore control the oscillations occurring between grids (1) and (2), resulting in a combination at the anode (6) of both oscillations plus *the sum of and the difference between the local and the incoming.* Grids (3) and (5) are maintained at a suitable potential by the H.T. to accelerate the electron stream and also so that no electrons will cluster in the vicinity of grid (5) with deleterious effects.

To revert to this mixture of incoming and locally generated oscillations and the reason for the italicised phrase in the previous paragraph, we must consider what happens when two separate oscillations are mixed. The combination of these produce two results: (a) the sum of the frequency of the two oscillations; and (b) the difference between the frequency of the oscillations. For instance, if the input circuit L1, C1 was tuned to 1000Kcs (300M) and the local oscillatory circuit L3, C3 tuned to 1465 kcs (205M approx.) we should obtain at the anode 1000 kcs (incoming) 1465 kcs (local) 2465 (sum) and 465 (difference). This "difference" frequency is referred to as the Intermediate Frequency. Actually in practice considerably more combinations than those mentioned appear at the anode but it would unduly complicate this simple explanation to go into the reasons for this.

Looking at Fig. 12 again, a tuned circuit L5, C5 (which together with L6, C6 constitutes a transformer) is interposed between the anode and H.T. in order to take from the anode the one frequency we wish to amplify. But we have a choice of four—two varying (incoming and local) and two fixed (sum and difference). The incoming and local varying because they depend on the setting of condensers C1 and C3, the sum and difference frequencies being "fixed" only if the relation or separation between the incoming and local oscillations is made constant irrespective of the settings of C1 and C3. Let us therefore now examine how it will be possible to arrive at this state of affairs.

We will assume that L1 has a certain inductance which in conjunction with C1 at minimum setting tunes to 1500 kcs. Now to produce the fixed frequencies at the anode the inductance of L3 must be less than that of L2, because C1 and C3 have identically the same capacity. We then turn the knob controlling C1 and C3 until the vanes are fully enmeshed (maximum capacity) and we shall find that because C1 and C3 are identical the relation between capacity and inductance has changed.

To illustrate this point (and without going all mathematical!) we will consider an actual case. A coil of 160 μh (L1) tuned by a condenser (C1) of 0.00005 mfd. (assuming this to be the minimum capacity of a .0005 mfd. condenser, together with stray circuit capacities) resonates (or tunes to) a frequency of approximately 1578 kcs. To obtain a difference of 465 kcs our local oscillator must tune to 2043 kcs, necessitating an inductance value (L3) of only 121 μhenries in conjunction with ths same capacity value (0.00005 mfd.) We now increass C1 and C3 to maximum 0.00055 mfds., and with the inductances remaining the same (160 μh. and 121 μh.) L2 and C1 will resonate at 539 kcs and L3, C3 at 620 kcs.—a difference of 81 kcs. only! As we cannot change the values of the inductances, we must in some way limit the tuning range of L3, C3 so that a difference of 465 kcs. is produced, and the series tracking condenser C4 is introduced for this purpose. Here again I shall not attempt simply to explain how the value of C4 is obtained as it would involve probably a couple of pages of mathematical formulae alone!

We have now seen how our four principle frequencies are produced at the anode and how we select the particular frequency we require. The valve V2 amplifies the I.F. and passes it on to the detector V3, and it is in this particular chain that the popularity of the superhet. lies Dealing with one fixed frequency only it is possible to combine high amplification, selectivity and stability in most efficient manner. It will be understood that the problems underlying the design of the post frequency-changer stages in a superhet. are identically similar to those for a "straight" receiver, and I do not propose, therefore, to deal with them here.

Now refer to Fig. 13 and you will see that included in the aerial lead is a filter L15, C22 to obviate signals at or near the I.F. reaching the signal grid of V11 with the possible production of undesirable heterodyne whistles.

With the exception of the wave-band switching and the fact that the oscillator coils L23, L24 and L27 have been parallel fed to prevent H.T. reaching them the circuit up to the detector valve V13 is reasonably similar to the simple explanation with which I commenced this chapter. Fixed tracking condensers TC2 and 3 are used for the S.W. range and a variable pre-set condenser TC1 for MW.

We will now take a look at the various networks associated with the double diode triode V13. The signal diode is supplied direct from L29 and the rectified I.F. is filtered by R47, C43 and C44. The strength of the audio frequencies is controlled by R48 and fed via C45 to the triode section for amplification in the usual way. R54 provides correct grid bias for the valve and the low potential end of R48 is returned to the cathode end of the bias resistor in order that a delay voltage may be provided for the A.V.C. The A.V.C. diode is fed via C42 from the anode of the I.F amplifier (V12) and the rectified voltage across the load resistor R53 is taken to the grids of both V11 and V12 to provide the additional bias necessary to control the variable mu characteristics of these valves.

The amplification of the triode section is utilised to provide separate treble and bass tone control making use of the same circuit as described in Chapter 5.

Construction of the receiver should present no difficulty if the drawings shown in Fig. 14 are studied carsfully. V11 and V12 are fitted with screening cans and V13 has a grid shield. The connections to the fixed vanes

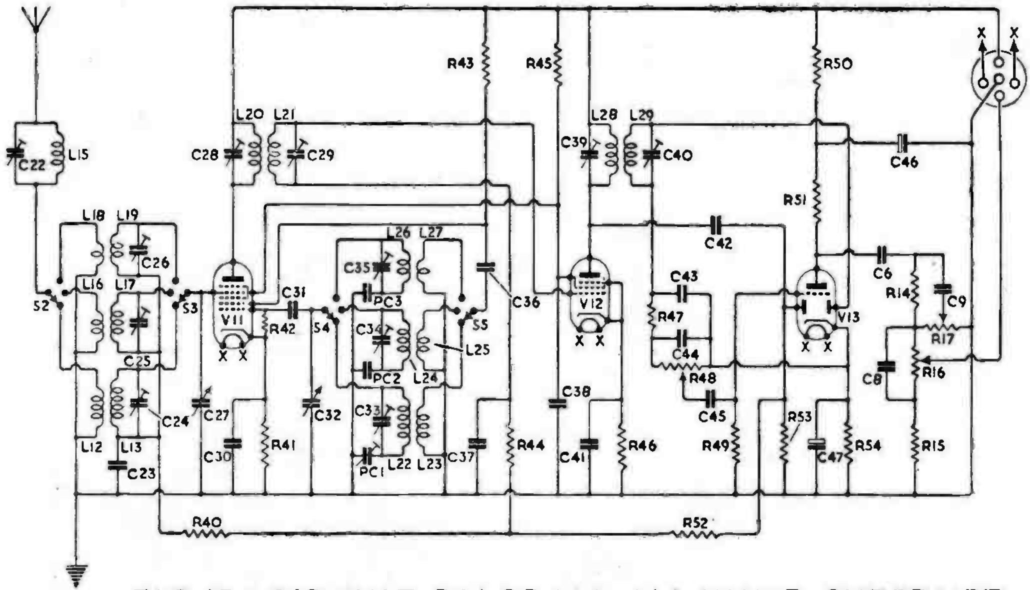


FIG 13. CIRCUIT DIAGRAM ALL-WAVE SUPERHET.

of the gang condenser C27 and C32 on the under-chassis view will be seen disappearing through holes to the right and adjacent to the "common" connections to S3 and S4, and these holes should be large enough to prevent fraying of the insulation if movement of the gang condenser occurs. I mention this point as the majority of gang condensers available to-day are secured to the chassis by means of rubber grommets in order to provide a resilient mounting. The lead from the junction of C45 and R49 to the top grid of V13 should be screened and the screen bonded both to chassis and the grid screening cap. Provided wiring is done in logical steps, heaters first, coil connections next, etc., no trouble should be encountered.

I think the best way to deal with the adjustment of the receiver will be to describe the procedure step by step.

(1) Unscrew all trimmers with the exception of the tracking condenser TC1 which should be adjusted to approximately mid-capacity position.

(2) Remove the top grid connection to V11 and short S5 to earth.

(3) Adjust your modulated oscillator to give a high output at 465 kcs. (646 metres) and attach its output lead to the grid connection on the top of V11.

(4) Adjust the trimmers on the I.F. transformers in the sequence C40, C39, C29, and C28, reducing the oscillator output control as required.

(5) Remove oscillator output lead from V11, transfering it to the aerial terminal. Replace top grid connector on V11 and remove shorting link S5 to earth.

(6) Reset oscillator to give a medium output at 200 meteres (1500 kc.).

(7) Switch the receiver to Medium Waves and set the gang condenser to practically its minimum position (vanes nearly all out) and make a pencil mark on the dial corresponding with the position of the indicator.

(8) Adjust C33 until the modulated oscillator signal is heard at maximum strength in the loud-speaker without moving the gang condenser. Adjust trimmer condenser C24 to its optimum point reducing the oscillator output as necessary.

(9) Reset your oscillator to 500 metres (600 kcs.) and adjust the tracking condenser TC1 in conjunction with the gang condenser (at approximately four-fifths its maximum position) until the oscillator modulation is heard loudest. It is a good idea to "rock" the gang condenser back and forth making adjustments at the same time to TC1.

(10) Reset the oscillator to 200 m. (1500 kc.) and your tuning dial to the previously mentioned pencil mark and adjust C33 until the oscillator note is heard. At this point readjustment of C24 may possibly be found beneficial.

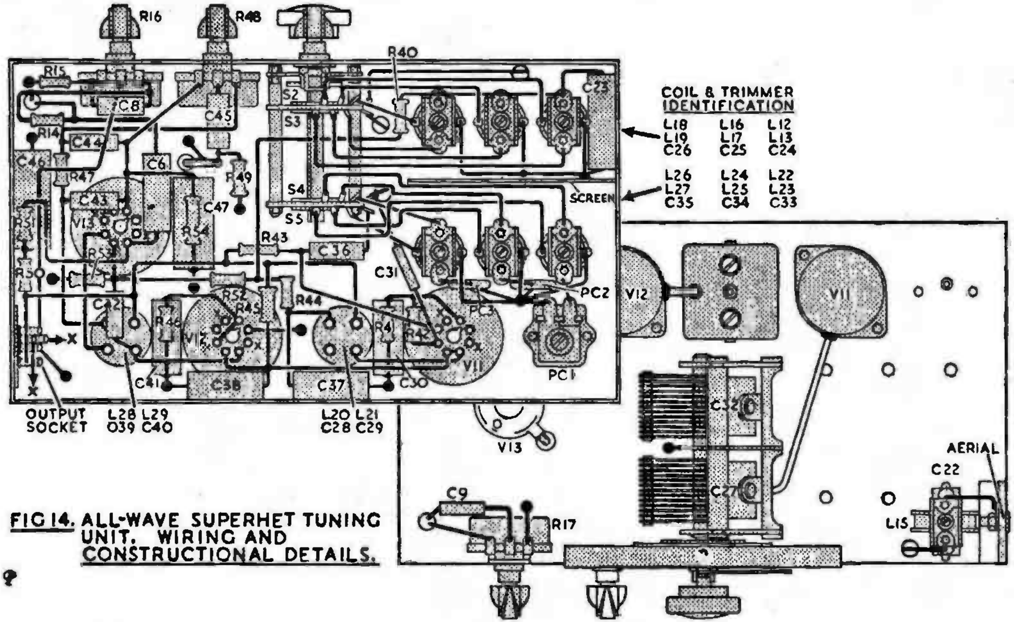


FIG 14. ALL-WAVE SUPERHET TUNING UNIT. WIRING AND CONSTRUCTIONAL DETAILS.

(11) Repeat procedurs in Section 9.

(12) Repeat procedure in Section 10.
The latter two adjustments should be repeated until one ceases to have any effect on the other. It is important to keep the oscillator at minimum strength to avoid operating the A.V.C.

(13) Adjust oscillator for modulated output on about 20 ms. (15 megacyles)

(14) Switch the receiver to the lowest (16-50 m.) wave range and adjust the main tuning control until the oscillator note is heard, and this may require careful searching. Adjust C35 in conjunction with the main tuning control for maximum signal. The aerial trimmer (C26) should also be adjusted at the same time until a position of C35 is reached at which trimmer C26 peaks nearest its minimum position.

(15) Repeat 13 and 19 at 50 ms. (6mc.) for the other short-wave range.

(16) Set test oscillator to 465 kcs. with a fairly strong input to the aerial terminal and adjust C22 for minimum signal.

(17) Slightly readjust all aerial trimmers (C24, C25, C26) on an actual broadcast signal.

Set down on paper the adjustments appear somewhat complicated, but as soon as one is conversant with the correct sequence of operations they actually take a very short time.

While on the subject of adjustments I think a word or two on calibration may not be out of place. If one is fortunate (or unfortunate, considered from quite another angle!) in possessing a modulated oscillator the output from which is rich in harmonics, calibration of any receiver is possible. The procedure is as follows: Tune the receiver exactly to a B.B.C. medium-wave station, say, the Forces programme on 1013 kc. (296.1 m.). The oscillator (preferably unmodulated and at its lowest possible output) should be placed near the receiver and the former (oscillator) adjusted until the beat whistle heard in receiver is exactly at silent point. The aerial should then be disconnected from the receiver (the tuning control of which must not be touched) and the oscillator output connected to the receiver. Harmonics of the frequency to which the oscillator is tuned (1013 kcs.) will then occur on 2,026, 3,039, 4,052, 5,065, 6,078, 7,091, 8,104, 9,117, 10,130, 11,143, 12,156, 13,169, 14,182, 15,195, 16,208, 17,221, 18,234 kcs. to quote to the 12th harmonic, but I have a m.w. oscillator in my possession from which it was possible on the receiver described herein to hear the 18th harmonic! If the positions of these harmonics are marked on the scale interpolation will provide quite a well calibrated dial. I have mentioned the above method of calibration because not every amateur owns an all-wave oscillator, and even if no oscillator at all is possessed making one for medium waves only is an easy undertaking.

CHAPTER 7. LOCAL STATION "QUALITY" TUNING UNIT
incorporating an Infinite Input Impedance Detector. For A.C. Mains Operation.

Parts required.

Condensers.

C1. 100 mmfd. Postage Stamp Trimmer.
C2, C7. 30 mmfd. do. do. do.
C3, C8. .0005 mfd. Two-Gang Variable.
C9. .5 mfd. 350 v.w.
C10. .001 mfd. Mica.
C11. .0002 mfd. Mica.
C2. .1 mfd. 350 v.w.

Resistors.

R1. 250Ω ¼ watt
R2. 25,000Ω ½ watt
R3. 50,000Ω variable
R4. 1,000Ω ½ watt
R5. R7. 10,000Ω ½ watt
R6. 50,000Ω ¼ watt
R8. .5 MΩ variable

Valves: V1 6K7; V2 6C5, or equivalents.
Valveholders: 2 American Octal; 1 5-pin English.
Slow Motion Dial: 1; Knobs: 1 Large, 2 Small.
Group Board: 1 6-way.
Grid Cap: 1 unscreened (V1).
Sockets: 1 2-way (aerial and earth).
Chassis: 9½"×5½"×2½" 20 SWG. mild steel.
Screws, connecting wire, sleeving, soldering tags, etc., etc
Coils: As shown in Chapter 3.

If the reader is fortunate enough to be situated near one of the B.B.C. stations high fidelity reception should be an easy matter to obtain. In this connection I do regret the extended use of recorded programmes, but at the same time realise how difficult the provision of adequate studio performances would be under present conditions. However, the good transmissions that remain, still conform to a high standard making, if you are a music lover, the possession of a high quality receiver well worth while.

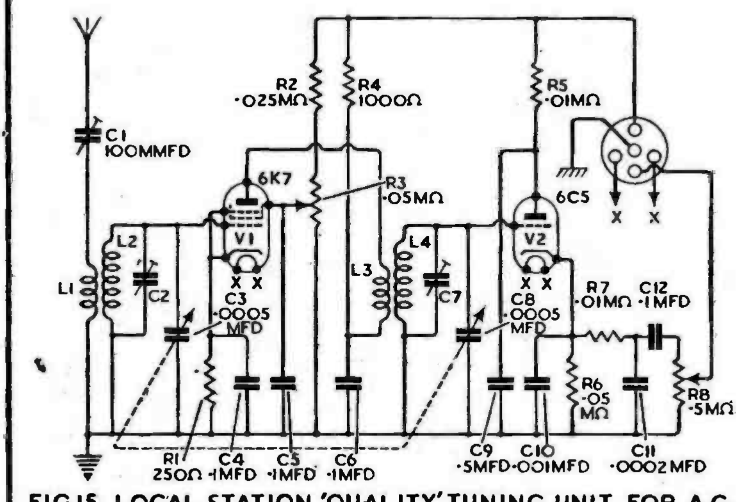


FIG 15. LOCAL STATION 'QUALITY' TUNING UNIT FOR A.C.

The receiver about to be described is intended for use only with the amplifier in Chapter 11, but if it is used with the 4-6 watt amplifier in Chapter 9 results will still be quite satisfactory.

Turning to Fig. 15 we see that the aerial input is taken via a small trimming condenser C1 to the coil L1. This in turn is coupled to the tuned circuit L2, C3, the input oscillations appearing at the signal grid of V1. The inclusion of C1 reduces aerial damping on the tuned circuit, and being variable acts somewhat as a pre-R.F. stage control to avoid overloading V1. By varying the H.T. voltage applied to the screen of V1 satisfactory control of volume is obtained and this control should preferably be of the wire-wound type. The output anode of V1 is transformer-coupled to the detector which is of infinite input impedance type. This method of detection first appeared in, I believe, 1936, or thereabouts, and possesses the merit of inappreciably loading its associated tuned circuit L4, C8. Another name (which more accurately describes it) under which this form of detection is known is the negative feedback anode bend detector. The quality obtainable with this form of detection is as good if not better than that from a diode but cannot compete with the diode for convenience in certain applications. The output from the detector load resistance R6 in the cathode return is taken via R7, the latter forming with C10 and C11 an effective R.F. filter. C12 is the coupling condenser between the detector and the first amplifying valve and R7 controls output volume.

If the reader desires, the tone control stage (V3 in Chapter 5) may follow this detector, and this is actually the arrangement employed in a quality receiver I have in use. There is, however, one slight objection to this scheme, namely, that the treble tone control gives slightly too much boost in a case where the higher audio frequencies are already prominent. This effect can be obviated by operating the treble tone control at slightly less than maximum.

In a receiver of this kind layout is not critical, and Fig. 16 illustrates a sound arrangement of the components and wiring. Both L1, L2 and L3, L4 are unscreened, the former being above the chassis and the latter below. In situations within the swamp area of a transmitter it may prove necessary to screen L1, L2, but L3, L4 can be left as shown, the chassis providing adequate screening.

It will be noted that all inter-chassis connections in apparatus described in this book, are made by means of 5-pin English valveholders, plugs and 5-way leads; and I have found by experience that this is a sound method to follow. The connections are output and input to the grid pin, H.T. to the anode pin, earth to the cathode, and heater supply to the heater pins. The output lead carrying audio frequency potentials should be screened between plugs and the screening bonded to the cathode pin at both ends, thus avoiding the use of a separate earth connecting wire. Care should be exercised in the choice of the screened cable itself as over a length losses must be kept low to avoid

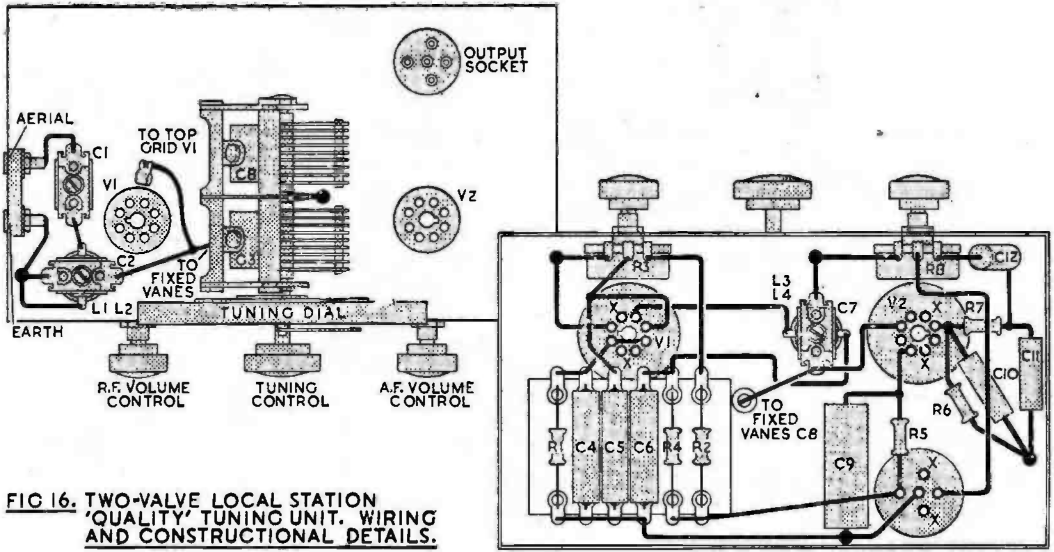


FIG 16. TWO-VALVE LOCAL STATION 'QUALITY' TUNING UNIT. WIRING AND CONSTRUCTIONAL DETAILS.

attenuation of the higher audio frequencies. Some time ago I wae fortunate in obtaining a quantity of screened Systoflex sleeving, and thie used to shield a flexible conductor makes an admirable combination.

CHAPTER 8. A BAND-SWITCHING SHORT-WAVE TUNING UNIT for A.C. Mains operation.

Wave-Ranges: (1) 16.5 m.-32 m. (18.5 mc.-9 mc.); (2) 30 m.-60 m. (10 mc.-5 mc.); (3) 55 m.-112 m. (5.5 mc.-2.2 mc.).

Parts required.

Condensers.	Resistors.
C1, C2, C9. .1 mfd. 350 v.w.	R1, R5. 100,000Ω ½ watt
C3, C6. .00005 mfd. Mica.	R2. 250Ω ¼ watt
C4. .00016 mfd. Short-Wave variable.	R3. 2 MΩ ¼ watt
C5. 15 mmfd. do. do. do.	R4. 250,000Ω ¼ watt
C7. .05 mfd. 350 v.w.	R6. 25,000Ω variable
C8. .0002 mfd. Mica.	R7. 50,000Ω ½ watt

Valves: V1-6J7; V2-6J7, or equivalents.
Valveholders: 2 American Octal; 1 5-pin English.
Wave-Change Switch: 3-Pole 2 Section with earthing ring.
Slow Motion Dial: 1; Knobs: 1 Large, 3 Small.
Coupling Links: 3; grid connectors: 2.
R.F. Chokes: 2 Sectionalised Short-Wave type.
Sockets: 1 2-way (aerial and earth).
Chaesis: 9½"×5½"×3" 20 SWG. mild steel.
Miscellaneous screws, connecting wire, sleeving, soldering tags, etc.
Coils: All formers ⅞" diameter×2½" long.

L1. 9 turns 20 SWG. enamelled wire spaced 13 turns per inch and tapped 3 turns from "earthy" end.
L2. 18 turns 20 SWG. enamelled wire close wound tapped 6 turns from "earthy" end.
L3. 40 turns 20 SWG. enamelled wire close wound tapped 13 turns from "earthy" end.

Much has been written concerning the thrill of short-wave listening, and in this part of the frequency spectrum the amateur has certainly been the pioneer. In the twenty odd years during which I have been associated with Radio I have watched the development of short-wave apparatus with considerably more than a passing interest, and although to-day it has become commonplace to receive practically any station in the world with comparative ease, there still remains immense scope for improvement and development. When contemplating a suitable design for inclusion in this book I found it difficult to decide just which type of receiver would appeal to the large majority of my readers. There are so many types and circuit arrangements from which to choose that finality in design can never be achieved. I accordingly decided to describe a well-tried and simple arrangement which does work very well and to include in the description some pointers to channels of experiment so that the reader may be able to improve the performance. A further reason for the adoption of this method was that I regard a short-wave receiver as the most personal of all receivers. I have heard some fantastic reeults from the simplest circuits and probably the reason for those results lay in hours of patient trial and error experimenting by the owner.

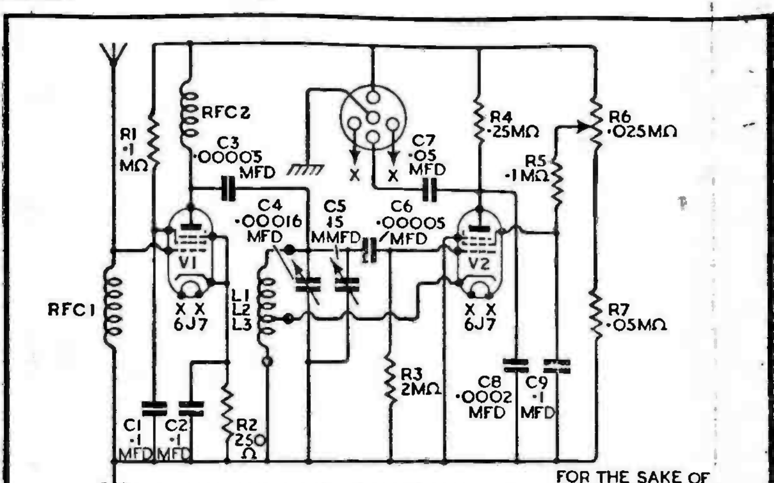


FIG 17. TWO-VALVE A.C. SHORT-WAVE RECEIVER. CIRCUIT DIAGRAM.

FOR THE SAKE OF CLARITY, COIL SWITCHING HAS BEEN OMITTED FROM THIS CIRCUIT.

Fig. 17 illustrates the circuit which was finally chosen, and it will be seen to consist of a pentode detector preceded by a pentode buffer stage. With an arrangement such as this a very fine control of reaction is obtained and complete absence of "blind spots" in the tuning range is ensured by the aperiodic R.F. stage. I personally know of no more satisfactory way of obtaining smooth detector operating conditions. The complications necessitated by the inclusion of a tuned R.F. stage were not considered worth-while in view of the comparatively small amount of amplification attainable at the higher frequencies, but rather was it considered desirable to rely on a smooth reaction control alone to provide the necessary sensitivity. In practice this scheme was found to meet all expectations, and I am passing it on with every confidence.

The question of wave-change switching in a short-wave receiver is a debatable point, and it was felt that any losses that might occur were made up for by the convenience gained. Separate coils for each waveband are slightly more efficient and the constructor may wish to incorporate this refinement, but a glance at the constructional details in Fig. 18 will show that exceptionally short grid and anode leads are a feature and this principle must be adhered to if any modification is attempted.

Experiments with coil design and the exact position of the cathode tap may prove worth-while with different valve specimens, and if it is possible to procure a choke with an inductance of 200 h. at 1 ma. approx. to include instead

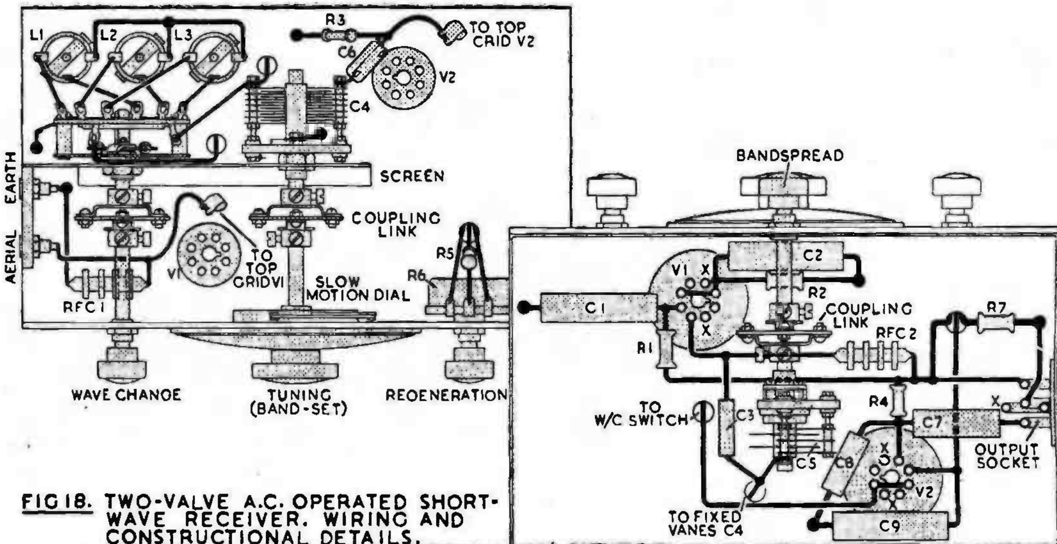


FIG 18. TWO-VALVE A.C. OPERATED SHORT-WAVE RECEIVER. WIRING AND CONSTRUCTIONAL DETAILS.

of the anode load resistor R4 some improvement in amplification should result.

It will be noted that in parallel with the main tuning condeneer C4 a small variable condenser C5 is included. This is for the purpose of band spreading, and it is suggested that the rotation of C4 be divided accurately into twelve divisions so that C5 will spread each division with an adequate overlap. Using this procedure tuning becomes nearly as simple as on medium waves and there is little chance of missing very weak transmissions.

When the unit has been constructed it should be connected to an amplifier—that described in Chapter 9 is suitable—and R4 should then be set towards the H.T. end of the potentiometer and a station tuned in. The setting of R4 should then be decreased until, for a C.W. station, V2 nearly ceases to oscillate. This is the most sensitive operating point, but for telephony transmissions R4 will have to be decreased still more until V2 just stops oscillation.

It will have been noted that I have recommended that this unit be used with the amplifier described in the next chapter, but if the constructor wishes to use another amplifier particular care must be exercised to provide adequate H.T. smoothing. Unless this precaution is taken hum trouble will be experienced and this will unfortunately occur at the most sensitive operating point.

CHAPTER 9. A 4 WATT AMPLIFIER. For A.C. Mains Operation.

Parts required.

Condensers.	Resistors.
C1. 4 mfd. 350 V.W. Electrolytic.	R1. 1 MΩ (see text)
C2. 25 mfd. 12 V.W. do.	R2. 10,000Ω ½ watt
C3. .1 mfd. 350 V.W.	R3. 50,000Ω ½ watt
C4. 25 mfd. 25 V.W. Electrolytic.	R4. 1,000Ω ½ watt
C5, C6, C7. 8+16+8 mfd. 350 V.W. Electrolytics.	R5. 200,000Ω ½ watt
	R6. .5 MΩ ½ watt
	R7. 250Ω 1 watt

Valves: V1-6C5; V2-8V6; V3-5V4G, or equivalents.
Valveholders: 3 American Octal; 1 5-pin English.
Mains Switch: Single Pole Single Throw on-off.
Group Board: 1 10-way.
Smoothing Chokes: 1 20 h. at 70 ma. (L2); 1 50 h. at 20 ma. (L1).
Mains Transformer:
Primary (L6) 210, 230, 250 v. 50 cycles.
Secondary 1 (L4) 250-0-250 at 70 ma.
" 2 (L3) 5 v. 2 a.
" 3 (L5) 6.3 v. 2 a. centre tapped.
Sockets: 1 2-pin shielded (mains); 1 2-way (loud-speaker).
Chaesis: 12"×6½"×3" 20 SWG. mild steel.
Miscellaneous screws, connecting wire, sleeving, soldering tags, etc.

My aim in designing the amplifier about to be described was to provide reasonably high output with a minimum of distortion, and results will be found to conform to these requirements. A maximum output of 4 watts was considered adequate and a perusal of valve makers' data

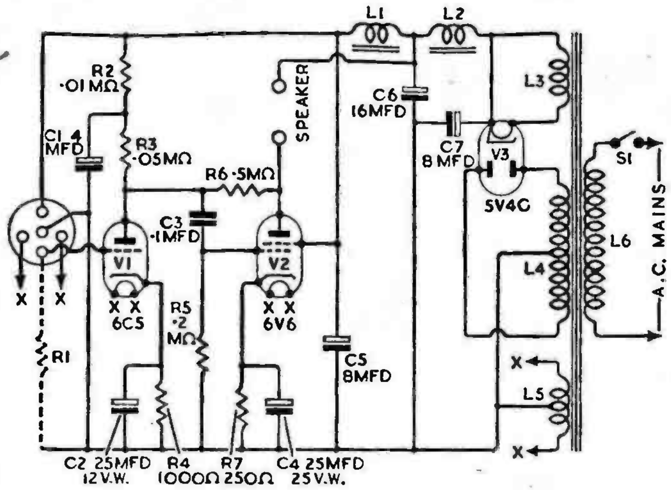


FIG 19. 4-WATT A.C. OPERATED AMPLIFIER. CIRCUIT.

showed that the 6V6G with 250 volts on its anode and screen provides a maximum power output of 4.5 watts; but the total harmonic distortion at maximum output is in the region of 8 per cent., which was very much higher than was required. Two remedies were obvious: Firstly, the valve would be operated at less than maximum output; and secondly, to reduce distortion still further, negative feedback would be applied. Fortunately the 6V6G is a beam tetrode, a type to which the application of negative feedback is particularly successful. The method of application will be immediately apparent from Fig. 19. R6 and R5 together form a potentiometer network so that (depending on the values assigned to them) a portion of the signal voltage at the anode of V2 is fed back to its grid. The output signal voltage of V1 is developed across the anode load resistor R3 and is transferred via C3 also to the grid of V2. These two voltages at the grid of V2 are out of phase because of the phase difference between the grid and anode of the valve, and thus partial cancellation of the input signal takes place with a corresponding drop in harmonic distortion.

An input resistance or grid leak R1 is shown dotted, and this must be included if the amplifier is used with a feeder unit which does not provide a D.C. path to earth. The inclusion of this resistor permits V1 to receive correct grid bias. The resistance R2 and condenser C1 are included so that adequate decoupling is obtained. With some of the tuning units herein described it was possible to omit this network, but its inclusion does ensure trouble-free operation whatever the application of the amplifier.

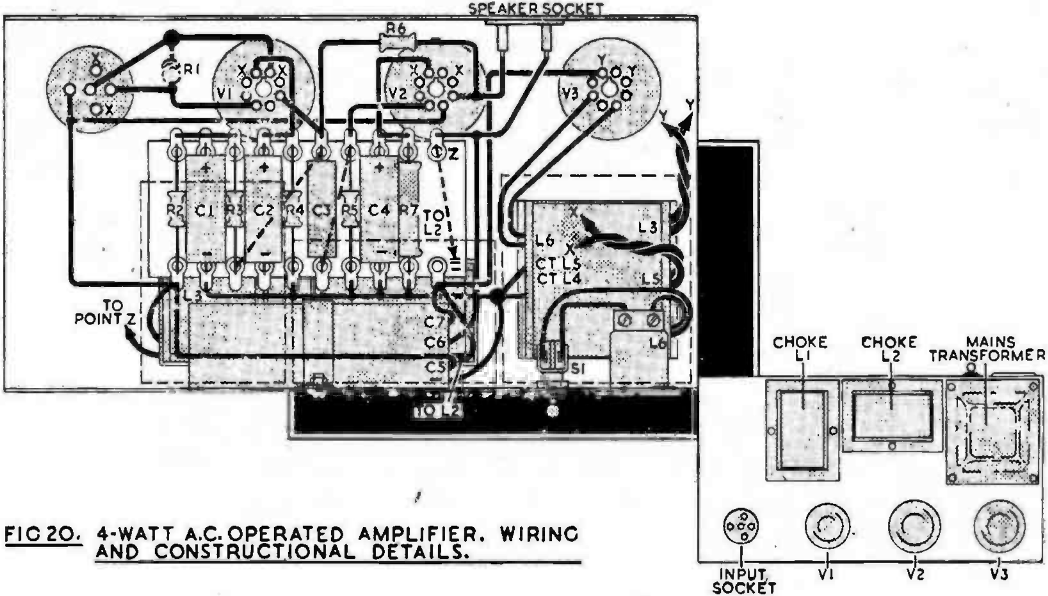


FIG 20. 4-WATT A.C. OPERATED AMPLIFIER. WIRING AND CONSTRUCTIONAL DETAILS.

The optimum load resistance for the output valve is 5,000Ω, and an output transformer must be chosen allowing the correct ratio between this figure and the impedance of the speech coil in the loud-speaker the constructor uses. This matching of loud-speaker to output valve is a subject which seems to be inadequately understood and a few words should not be out of place.

The key to the situation lies in the fact that an output transformer by itself imposes practically no load on the valve except by virtue of its own resistance and losses. To provide the requisite optimum load resistance into which the valve should work it is necessary for the transformer to have a certain step-up ratio between primary and secondary so that a resistance connected to the secondary reflects into the primary the required optimum load value. I think that the confusion arises because the usual method of stating output transformer rating (i.e., 20-1, 50-1) is correct when one is considering the static physical specification of a transformer. But the description is liable to mislead in the case of matching. Correspondence has shown that some amateurs regard the valve as having a resistance which must be matched to the speaker. Consideration of my remarks above should dispel that illusion, and by the way, I have quite deliberately used the incorrect term "resistance" in order to make the question of transformer function clear.

The group board system has again been adopted as an examination of Fig. 20 will show, and construction will be found perfectly straightforward.

CHAPTER 10. A 10-WATT PUBLIC ADDRESS AMPLIFIER for A.C./D.C. Operation.

Parts required.

Condensers.

C1. .1 mfd. 400 V.W. if required.
C2. .5 mfd. 350 V.W.
C3, C8. 4 mfd. 350 V.W. Electrolytic.
C4, C9. 25 mfd. 12 V.W. Electrolytic.
C5, C6. .01 mfd. 350 V.W.
C7. .001 mfd. 350 V.W.
C10, C11, C12. .1 mfd. 350 V.W.
C13, C14, C15. 8×16×16 mfd. 350 V.W. Electrolytics.

Resistors.

R1. 10,000Ω ¼ watt
R2, R3, R9. .5 MΩ variable
R4. 50,000Ω variable
R5, R15, R17. 25,000Ω ½ watt
R6. 1.5 MΩ ¼ watt
R7, R18, R20. 250,000Ω ¼ watt
R8. 1,500Ω ¼ watt
R10. 1 MΩ ¼ watt
R11. 10,000Ω ½ watt
R12. 50,000Ω ½ watt
R13. 3,000Ω ½ watt
R14. .5 MΩ ¼ watt
R16. 1,000Ω ¼ watt
R19. 150Ω 2 watt
R21. Mains dropping resistor

Valves: V1-6J7; V2-6C5; V3-6C5; V4-25L6; V5-25L6; V6-25Z6.
Valveholders: 6 American Octal.
Mains Switch: Doubls Pole Single Throw on-off.

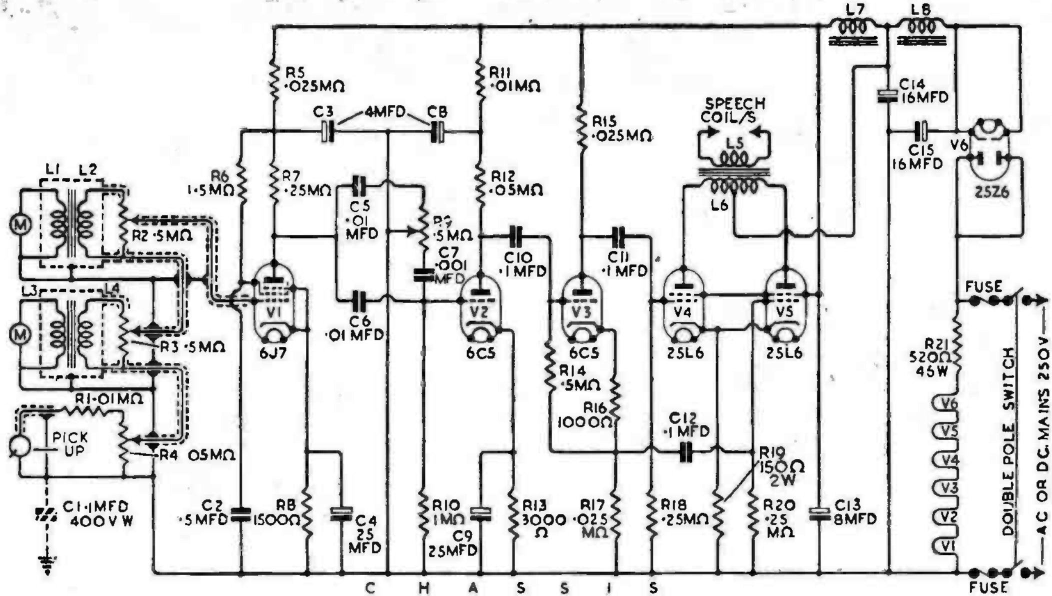


FIG 21. 10-WATT AC/DC PUBLIC ADDRESS AMPLIFIER. CIRCUIT DIAGRAM.

Fuses: 2 1 amp and holders.
Screening Can: 1 (V1).
Grid Connector: 1 (V1).
Group Board: 1 10-way.
Microphone Transformers: 2 (in screening boxes).
Jacks: 3.
Knobs: 4 Small Pointer type.
Output Transformer: 3,000Ω to speech coil/s.
Chokes: 1 15 H. at 120 ma. (L8); 1 50 H. at 20 ma. (L7).
Sockets: 1 2-pin (mains); 1 2-way (speaker).
Chassis: 12"x8"x3" 20 SWG. mild steel.
Miscellaneous screws, screened wire, connecting wire, sleeving, soldering tags, etc.

Quite a number of requests have been received for particulars of an amplifier designed especially for public address work and capable of operating on either A.C. or D.C. mains. Provision to be made for mixing both microphone and pick-up inputs and the output to be in the neighbourhood of 10 watts. Compactness of design and portability were aleo to be features.

I feel sure, therefore, that the amplifier to be described meets these needs, and the design has been tried out under varying conditions. It has proved capable of providing ample microphone gain and volume for a dancing crowd of approximately 400 people, but before consideration is given to the actual amplifier I do not think a few remarks concerning public address work as a whole will be out of place. The majority of mobile public address systems are open to criticism; the principle trouble appearing to be the choice of the relative positions between the microphone/s and the loud-speaker/s. The aim should be to find a suitable compromise for these so that acoustic feedback is at a minimum, enabling the nearest approach to the full gain of which the amplifier is capable. One shudders to think of the times one has seen a vocalist nearly "swallowing" a microphone, and if the system is being used for band-repeater work it will be obvious that complete coverage of the various instruments to enable correct balance to be obtained will be impossible unless microphone sensitivity is of a high order. We will take this question of balance first, and I would refer my reader to page 11 of the manual of Direct Disc Recording by Donald W. Aldous (No. 37 Bernards (Publishers) Ltd. Price 2/-). In this interesting publication Mr. Aldous gives diagrams showing the correct placing of microphone/s for recording under studio conditions, and the same rules apply to public address work.

I have found that it is impossible to do justice to any combination of a number of musicians and a vocalist without the use of at least two microphones, and the only differences between studio conditions and those existing on a platform are (a) artists in a studio can be arranged to suit acoustic conditions; and (b) the actual acoustic conditions (studio sound damping, etc.) can be more easily controlled. I do maintain, however, that many of the difficulties can be overcome by correct positioning of

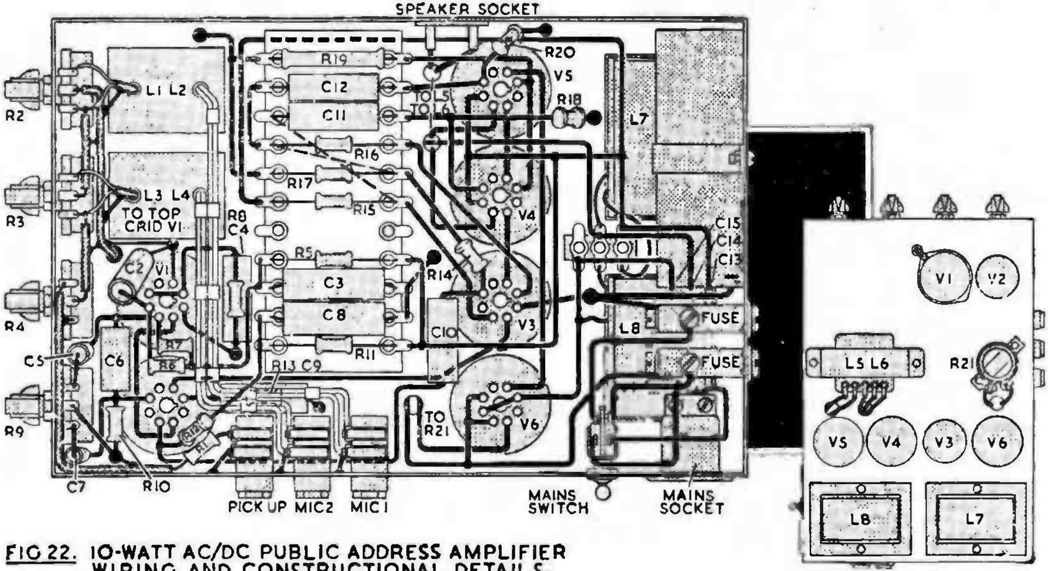


FIG 22. 10-WATT AC/DC PUBLIC ADDRESS AMPLIFIER WIRING AND CONSTRUCTIONAL DETAILS.

microphones, and experiments in this direction have proved well worth while.

My reason for considering microphonee first is that it is usually at this end of the chain that the limitations of positioning are imposed. The opposite is usually the case with the loud-speakere and the structural details of the hall, etc., should be utilised to the full. It is often possible to place speakers behind pillars or inside window openings so that wall anglee prevent a direct acoustic line between them and the microphone. The angle of sound reflection ehould be given consideration, and a good idea in some locations is to fit the loud-speakers with a small horn attachment in order to make them directional so that sound reflections may be more easily controlled. For large halls a number of loud-speakers working at a comparatively lower volume is very much better than a few speakers giving the higheet possible output. To terminate these general remarks on public addrees work, I would add the truism that the best reproduction is obtained when an audience can hear the artiste perfectly without knowing a public address system is in operation.

We will now examine the amplifier, and Fig. 21 shows the theoretical circuit. Series mixing circuits are provided for two microphones and one pick-up input, and the relation between R1 and R4 has been found suitable for the average moving iron pick-up. For a crystal pick-up which is capable of giving a somewhat higher output and requires a load resistance of .5 m, the valuee of R1 and R2 should be changed to .25 m each. Technical criticism can be levelled against series mixing and the system of mixing as shown in Chapter 12 could be ueed as this latter system employs isolating series resistances. However, the method adopted in the present instance works very well in practice. V1 is an R.F. pentode operating under practically maximum A.F conditions and the coupling between V1 and V2 is arranged to provide tone control. When the slider of R9 is moved towarde C5 bass response is apparently increased, the reverse happening when it approaches C7. V2 is a normal triode valve, its output being taken via C10 to the phase splitting valve V3. Here the load resistance is split between anode and cathode (R15 and R17), and the out of phase voltages taken via C11 and C12 to V4 and V5 respectively. R16 is the bias resistor of V3 and should not be by-passed. 25L6 valves were chosen for the output stage as being suitable in the .3 amp. heater range (see Chapter 4), but if it is intended to use .2 amp. valves throughout, the line-up could conveniently be V1, Cossor OM5 or Mullard EF36; V2, Cossor OM5 or Mullard EF36 connected as a triode; V3, the same as V2; V4 and V5, Cossor OM9's or Mullard CL33'e. The rectifier can be either a Cossor OM1 or Mullard CY32 for .2 amp. heater operation.

The optimum loading for all the output valves quoted is ehown in the table in Chapter 14, and the figure given in each case should be doubled for push-pull operation.

Construction and wiring are illustrated in Fig. 22, and if these illustrations are carefully followed this work should be perfectly straightforward. It is imperative to

screened microphone transformers if hum is to be
oided, and it is suggested that the screening cases be
xed initially with only one bolt and nut so that some
ientation can be effected before the final fixing is done.
fficient length of lead to the transformers can be allowed
r this.

CHAPTER 11. 10 WATT "QUALITY" AMPLIFIER

for A.C. Mains Operation.

arts required.

ondensers.

1. 25 mfd. 12 V.W. Electrolytic.
. .05 mfd. 350 V.W.
. 4 mfd. 350 V.W. Electrolytic.
, C5. .1 mfd. 350 V.W.
, C7, C8. 8×16×8 mfd. 500 V.W. Electrolytics.

Resistors.

R1, 1 MΩ ¼ watt (if required)
R2. 10,000Ω ½ watt
R3. 50,000Ω ½ watt
R4, R8. 1,000Ω ¼ watt
R5, R12, R15. 100Ω ¼ watt
R6. 1 MΩ ¼ watt
R7, R9. 25,000Ω ¼ watt
R10. 500Ω ¼ watt
R11, R14. 250,000Ω ¼ watt
R13. 200Ω 2 watt

lves: V1, V2-6C5; V3, V4-6V6; V5-5V4.
lveholders: 5 American Octal 1 5-pin English.
ins Switch: Single Pole Single Throw on-off.
roup Board: 1 12-way.
tput Transformer: 10,000Ω to speech coil/s, primary centre tapped for push-pull.
choring Tag Board: 1 3-way.
okes: 1 15 H. at 120 ma. (L4); 1 50 H. at 50 ma. (L3).
ins Transformer:
Primary (L9) 210, 230, 250 v. 50 cycles.
Secondary 1 (L6) 350 0.350 120 ma.
" 2 (L5) 5 v. 2 a.
" 3 (L7) 6.3 v. 2 a. centre tapped.
" 4 (L8) 6.3 v. 2 a. "
ckets. 1 2-pin shielded (mains); 1 2-way (speaker).
assis: 13"×7"×3" 18 SWG. mild steel.
iscellaneous screws, screened wire, connecting wire,
leeving, soldering tags, etc.

In any discussion on quality audio frequency amplification the two most important points are the design of the output transformer and the response of the oud-speaker. These components are undeniably the weakest inks in the chain between input and output. It is a omparatively simple matter to design a practically istortionless amplifier with a sensibly flat response from y, 30-12,000 cycles up to the anode/s of the output lve/s but equally simple to lose all fidelity after this oint. Regarding the output transformer, two factors are tremely important: (a) low frequency losses due to sufficient primary inductance; and (b) high frequency sses due to leakage inductance between windings. Generous sign and the use of a push-pull output stage go far to

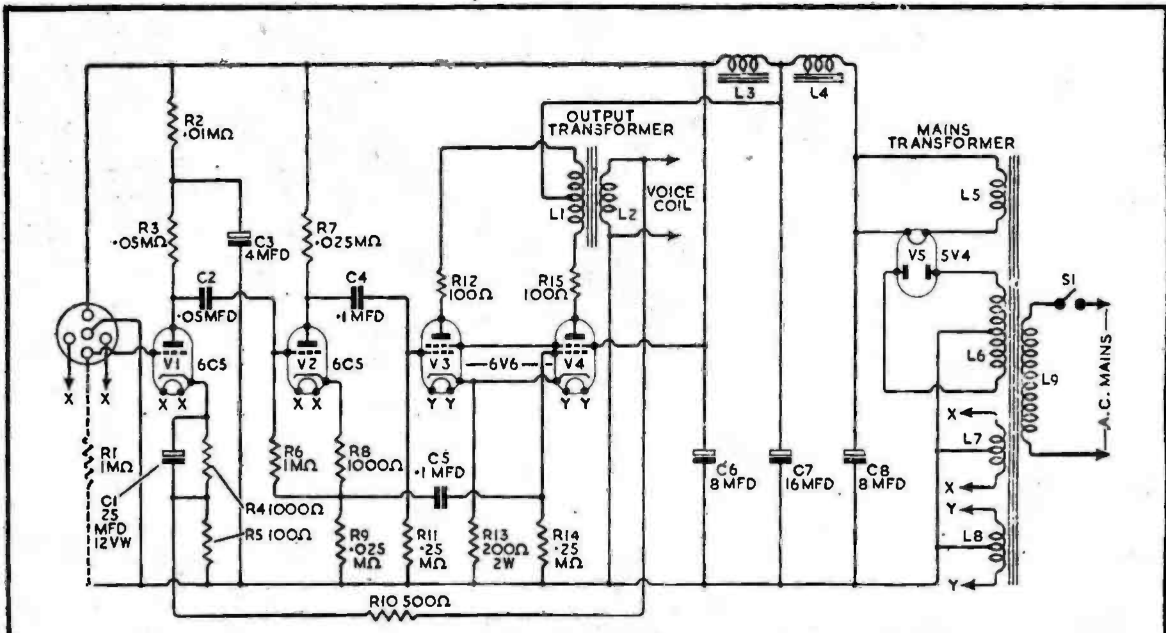


FIG 23. 10-WATT A.C. OPERATED 'QUALITY' AMPLIFIER. CIRCUIT DIAGRAM.

reducing the losses mentioned in (a), while interleaved sectionalised windings are necessary to counteract those in (b). My advice is therefore to buy the best transformer obtainable and preferably one designed to match exactly the output valves to the loud-speaker. There are, however, some very good multi ratio output transformers on the market, and the type OP12K made by the Radio Instrument Co., 294, Broadway, Bexleyheath, Kent, is an exceptionally good exmaple.

The loud-speaker, as mentioned above, can also be a source of bad reproduction; but again there are some very excellent reproducers to be obtained. As a general rule cone diameter should be in the neighbourhood of twelve inches. The cone itself should be capable of easy movement and made from rigid, strong material so that physical distortion does not occur in use. It is possible to supplement high frequency response by utilising a "Midget" loud-speaker as a "tweeter"—a scheme I have had in use for some years. Care must ge taken when "doping" the cone of the "Midget" to increase response to high frequencies, as too much dope will cause distortion, throwing the voice coil permanently out of centre. By experiment I found the best dope could be made from a mixture of Rawlplug "Durafix" and amyl acetate, and it was possible to paint this on to the cone in successive layers until the desired response was obtained. It is also advisable to commence from the centre of the cone, increasing the diameter of the doped portion gradually.

We have now reviewed some of the pitfalls awaiting the quality enthusiast, and if it is remembered that fidelity of reproduction is an expensive business, no compromise by using cheap components is possible.

Fig. 23 illustrates the theoretical circuit diagram, and it will be seen that V1 is a well decoupled triode followed by V2 which is the phase-splitting valve feeding the two push-pull output valves V3 and V4. Full wave rectification is obtained by V5 and its output is filtered and smoothed by L4 and L3 with the by-pass condensers C6, C7 and C8. The supply voltage to the output valves is taken from the junction between L4 and L3 to avoid excessive voltage drop as hum cancellation takes place in this stage.

Negative feedback voltage is taken from the secondary of the output transformer via the potentiometer formed by R10 and R5 and applied to the cathode of V1. This method confers the additional benefit that the output transformer is included in the feedback chain and distortion occurring in this component is reduced. It will be seen that one side of the output transformer secondary is connected to chassis and the feedback voltage is taken from the remaining "high" side, and it will be found that there is a right and a wrong sense in which these connections can be made. Connected one way round feedback becomes positive instead of negative and instability results, while connected correctly the amplifier is perfectly stable. Providing the output valves are reasonably well matched no cathode resistor by-passing condenser is required in the output stage. The power supply follows normal practice.

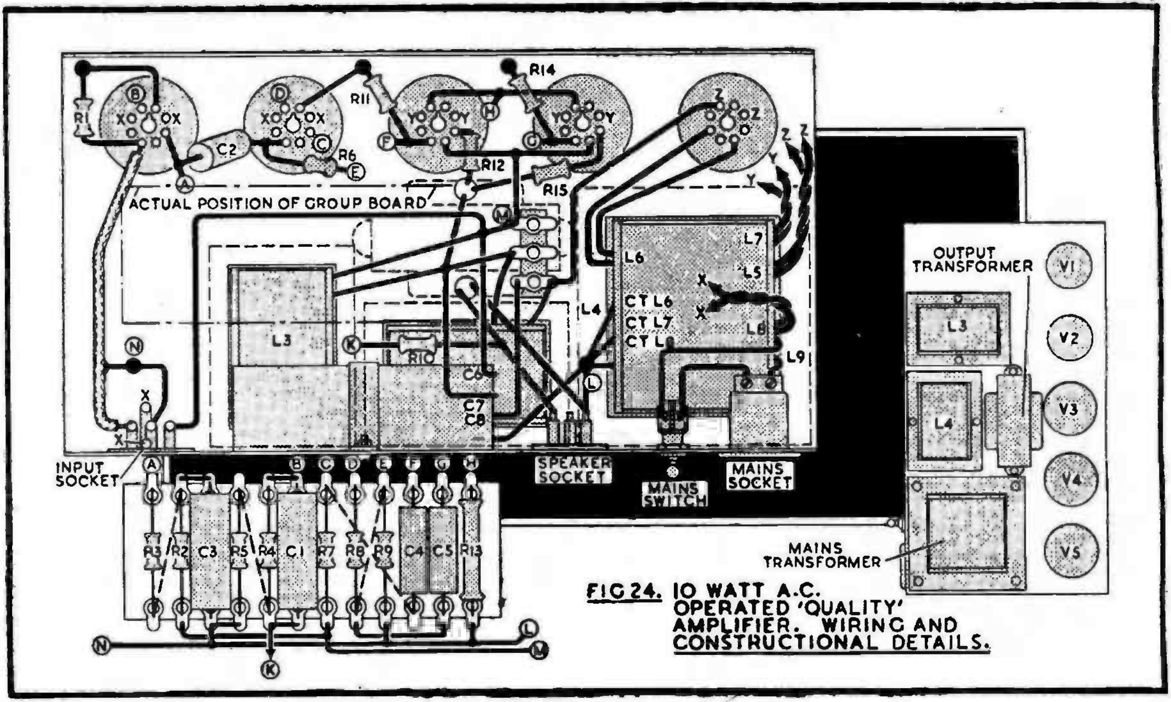


FIG 24. 10 WATT A.C. OPERATED 'QUALITY' AMPLIFIER. WIRING AND CONSTRUCTIONAL DETAILS.

Construction is illustrated in Fig. 24 and the drawings will be found self-explanatory.

I have, in the first part of this chapter, discussed a few points regarding quality reproduction generally, but I think there is one additional matter to be stressed. This is the question of loud-speaker mounting. Nothing less than a solid baffle board at least three feet square is good enough, and although symmetry is lost, the speaker should be mounted out of centre. If it is decided to stand the baffle board on a floor the loud-speaker should be mounted nearest the side resting on the floor and the whole board tilted back slightly to obviate floor covering absorption. If a "tweeter" is used, this should be mounted above and as near as possible to the main speaker, and it is advisable to fit the former with a resilient mounting to avoid its cone being modulated by the bass notes. A method I have found particularly effective is to cut a piece of old motor tyre sufficiently large to support the "tweeter" free of its mounting hole.

CHAPTER 12. A 10 WATT PUBLIC ADDRESS AMPLIFIER

For A.C. Mains Operation.

Parts required.

Condensers.

C1. .25 mfd. 350 V.W.
C2, C5. 25 mfd. 12 V.W. Electrolytic
C3. .05 mfd. 350 V.W.
C4, C7. 4 mfd. 350 V.W. Electrolytic.
C6, C10, C11. .1 mfd. 350 V.W.
C8. .005 mfd. 350 V.W.
C9. .0005 mfd. 350 V.W.
C12. 8 mfd. 750 V.W. Electrolytic.
C13. 16 mfd. do. do.
C14. 8 mfd. do. do.

Resistors.

R1, R16, R17. .5 MΩ variable
R2, R11. 10,000Ω ¼ watt
R3, R22. 50,000Ω variable
R4, R5. .5 MΩ ¼ watt
R6. 1.5 MΩ ¼ watt
R7. 25,000Ω ¼ watt
R8, R14. 250,000Ω ½ watt
R9, R13. 1,500Ω ¼ watt
R10, R25, R26. 1 MΩ ¼ watt
R12, R23. 50,000Ω ½ watt
R18. 1,000Ω ¼ watt
R19, R20. 100,000Ω ½ watt
R21, R24. 270,000Ω ¼ watt

Valves: V1-6J7; V2-6C5; V3-6N7 or 2-6C5's; V4, V5-6V6; V6-5V4.
Valveholders: 6 American Octal.
Mains Switch: Single Pole Single Throw on-off.
Knobs: 4 small pointer; Jacks: 2; microphone transformer: 1 (screened).
Group Board: 1 22-way; Grid Connectors: 1 (V1).
Chokes, Mains Transformer, etc.: Same as in Chapter 11.
Sockets: 1 3-way (speaker); Fuse: 1 1 amp. with holder; 1 2-pin shielded (mains).
Miscellaneous screws, screened wire, connecting wire,

In the previous chapters mention has been made of various aspects of design which cover many points requiring

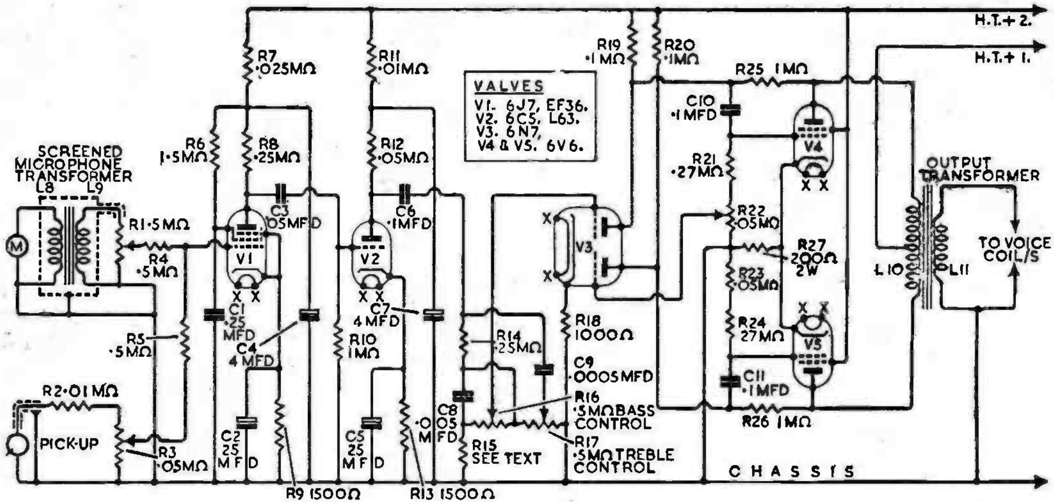


FIG 25. 10-WATT PARAPHASE PUBLIC ADDRESS AMPLIFIER. CIRCUIT.

explanation in the present amplifier. Three details are, however, particular to this design. The first being the system of mixing employed, the second, the circuit arrangement of V3, and the third, the procedure to be followed so that correct balance is obtained in the output stage. Fig. 25 shows the circuit diagram.

The system of mixing shown is somewhat better than that described in Chapter 10, as the inclusion of resistors R4 and R5 effectively isolate the input circuits from each other. Mixing takes place at the signal grid of V1 which is an R.F. pentode operating under A.F. conditions. V2 is a triode amplifying stage in which is incorporated separate treble and bass tone control utilising precisely similar networks to those already described in Chapter 5. Following these networks signal voltages appear at the grid of one of the triodes (which for the sake of convenience will be referred to as V3a) comprising the double triode valve V3. R19 is the anode load resistance of V3a, and a part of the voltage developed across R21 and R22 (which is effectively in parallel with R19) is picked off by means by the slider on R22 and fed to the grid of the other half (V3b) of V3. It will be seen that the output valve V4 is fed via C10 from V3a and V5 from V3b. In this manner push-pull working is obtained but owing to the fact that signal voltages through V3b have two coupling condensers (C10 and C11) in their path before reaching the grid of V5 against one coupling condenser (C10) between V3a and V4, true out of phase conditions are impossible. However, as this short-coming only has an adverse effect at the extreme ends of the frequency range which are inaudible, it can be ignored. The use of a double-triode (6N7G) has the advantage that an extra valve is avoided, but some difficulty may be experienced in obtaining a 6N7G.

As far as I know Messrs. Cossor are the only British manufacturers who have made this type of valve, but owing to the fact that under Class B conditions its rating is in excess of the 10 watts maximum imposed by the Post Office, a permit is necessary before purchasing. To obviate any difficulty which might be experienced I have shown in Fig.26 the circuit to be used for two separate triodes.

Negative feedback is applied in the same manner as shown for the single ended amplifier in Chapter 9. Some readers may wonder why the method in the previous chapter is not adopted in the present case, the reason being that negative feedback voltages from the secondary of the output transformer could only be returned to the cathode of V1 or V2, thereby including the tone control stage in the chain. Under these conditions the application of negative feedback would largely counteract the effect of the tone controls, which, when all is said and done, only distort the frequency response!

I have already explained the function of R22, and it will be apparent that adjustment of this control will be necessary in order that the correct voltage is fed to the

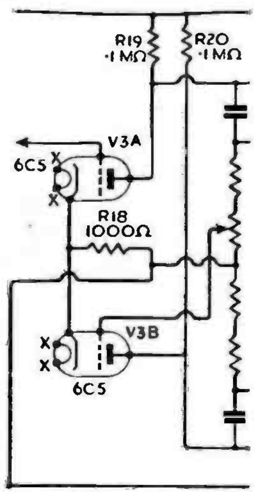


FIG 26. ALTERNATIVE CIRCUIT USING TWO 6C5'S IN PLACE OF THE 6N7.

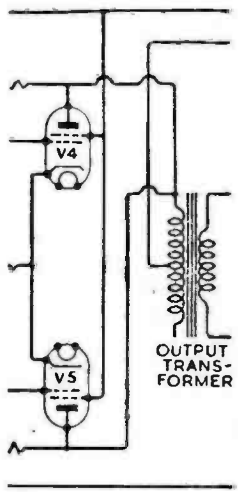


FIG 27. METHOD OF BALANCING THE PARAPHASE AMPLIFIER.

grid of V5 via V3b. Under balanced conditions the output signal voltage from V4 should equal but be opposite in phase to that obtained from V5, so that if we detach the lead between the anode of V5 and the primary (L10) of the output transformer and transfer it to the anode of V4 the outputs of V4 and V5 being in opposite phase when R22 is properly adjusted will cancel one another and no sound will be heard in the loud-speaker. Fig. 27 will make these temporary connections clear and R22 should be adjusted on a weak signal (preferably of constant pitch) until silent point is reached. The connections should then be replaced as in Fig. 25 and the amplifier will function correctly.

It will be noted that the power supply has been omitted from the circuit diagram for the sake of clarity, but that shown for the quality amplifier in the previous chapter is eminently suitable. Wiring diagrams complete with A.C. power supply are shown in Fig. 28. Another reason for omitting the power supply from the circuit diagram was that some constructors may wish to use this arrangement for A.C./D.C. operation. A suitable valve line up with .3 amp heater current consumption would then be V1-6J7G, V2-6C5, V3a-6C5, V3b-6C5. V4 and V5-25L6 and the rectifier, using a circuit similar to that shown in Chapter 10 would be a 25Z6. If this amplifier is constructed for universal operation no external earth must be connected to the chassis except through a .1 mfd. condenser of 400 working volts rating.

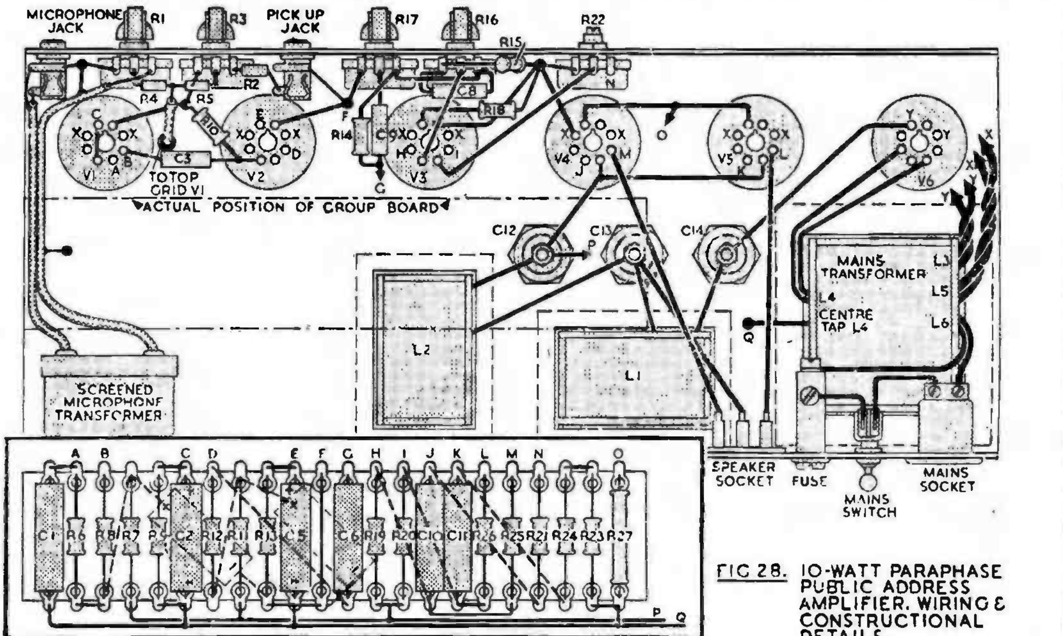


FIG 28. 10-WATT PARAPHASE PUBLIC ADDRESS AMPLIFIER. WIRING & CONSTRUCTIONAL DETAILS.

CHAPTER 13. R.F. AND OSCILLATOR COIL DESIGN AND CONSTRUCTION.

Present-day conditions necessitate an amateur making his own coils, but I consider it practically impossible to equal results obtained with those of factory manufacture. It is exceedingly difficult to wind coils sufficiently accurately at home for use with a ganged condenser, but if reasonable care is taken fairly satisfactory results should be obtained. I have personally made all the coils tabulated at the beginning of each chapter under conditions possible to every amateur. For instance, I wound three medium wave coils using different methods. Firstly, by means of a simple hand-drill winding machine. Secondly, entirely by hand (which was exceedingly laborious), and thirdly, using a standard winding machine. I then measured the inductance of each coil and the discrepancy between them was alarming. However, by carefully adding turns on the coils made by the first two methods, I arrived at a compromise which in practice gives very good results. I remember some years ago making coils to published data and I also remember vividly my acute disappointment when the results of my labours were tried in a receiver! I therefore feel that if reasonable care is taken the details given are correct, but the approximate equivalent in the Wearite range of "P" Type Coils should be obtained and used if possible.

In cases where instructions are given to wind a primary or reaction coil over another coil, this may be done by first wrapping the coil with a double thickness of thin paper, the ends of which should be firmly fixed with Rawlplug "Durofix." With the aid of a safety razor blade parallel small cuts about 1/8" apart should be made in the top layer of paper, two at the commencement and two at the finish of the winding. The beginning of the coil may then be twisted carefully round the projecting "tongue" of paper, and this "tongue" stuck to the lower layer of paper with a small dab of Chattertons compound, before commencing actual winding. Provided no sharp jerks occur this fixing is sufficiently strong for the purpose. In the lower ranges of short-wave coils the primary or reaction windings are specified to be wound between the last turns of the main winding and the former can be pricked for this purpose after the main winding is put on.

All windings are in the same direction and connections are as follows: Commencement of main winding to grid, termination to earth or A.V.C. Commencement of primary or reaction coil to H.T. or earth, termination to anode, etc. If one imagines the coils to be pulled apart so that both windings form a continuation of each other in the same plane, then the two "outers" will be the "hot" connections and the two "inners" the "cold" ones.

CHAPTER 14. MAINS TRANSFORMER AND SMOOTHING CHOKES.

Little difficulty should be experienced in purchasing the mains transformers and chokes to the specifications shown on the circuit diagrams, but for the sake of completeness I have designed a range of transformers and chokes covering the requirements of this book, and these are tabulated in the accompanying table. Both 6.3 and 4 v. heater windings are shown for each type, and as laminations are in short supply I have merely given the approximate area in square inches of lamination window space needed for each winding. For further details of transformer and choke construction I would refer my reader to the "Radio Coil and Transformer Manual," by Radiotrician No. 48 in the series published by Messrs Bernards Price 2/-

CHAPTER 15. VALVES.

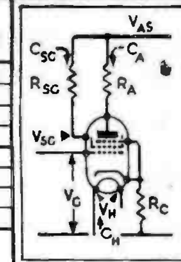
I have in the past received a number of requests from readers that future publications shall deal with apparatus using British valve types, but the difficulty has been to ensure that the necessary valves could be obtained. To these readers I apologise that the valves shown in the circuit diagrams are either American or their British counterparts, but this has only been because of availability of these types. After conversations with many retailers I have prepared the table shown on page 55. Comprehensive details are given of a number of alternatives and circuit values are shown corresponding with the symbols on the diagram in the top right-hand corner. This table, used in conjunction with published data on alternative valves should solve any difficulty experienced.

MAINS TRANSFORMER & SMOOTHING CHOKE DATA.

WINDING	CORE AREA SQ. IN.	TURNS PER VOLT	RATING	TURNS	WIRE S.W.G.	TAPPINGS AT	WINDING SPACE REQD SQ. IN.
TRANSFORMER No 1							
PRIMARY	2·28	3·5	250V 90W	875	24E*	805T (230V) 735T (210V)	·894
H.T.SEC.			350-350V 120MA	2450	30E*	CENTRE	·894
L.T.SEC.1.			6·3V 3A	23	16DCC	2 LAYERS ·152″ THICK	
L.T.SEC.2.			5·0V 2A	18·5	18DCC	2 LAYERS ·118″ THICK	
TRANSFORMER No 2							
PRIMARY	2·28	3·5	250V 100W	875	24E*	805T(230V) 735T(210V)	·894
H.T.SEC.			350-350V 120MA	2450	30E*	CENTRE	·894
L.T.SEC.1.			4·0V 7A	15	14DCC	2 LAYERS ·188″ THICK	
L.T.SEC.2.			4·0V 2A	15	18DCC	1 LAYER ·059″ THICK	
TRANSFORMER No 3							
PRIMARY	1·5	5	250V 55W	1250	38E*	1150T (230V) 1050T (210V)	·113
H.T.SEC.			250-250V 70MA	2500	34E*	CENTRE	·266
L.T.SEC.1.			6·3V 2A	32·5	18DCC	3 LAYERS ·177″ THICK	
L.T.SEC.2.			5·0V 2A	26	18DCC	2 LAYERS ·118″ THICK	
TRANSFORMER No 4							
PRIMARY	1·5	5	AS TRANSFORMER No 3				
H.T.SEC.			AS TRANSFORMER No 3				
L.T.SEC.1.			4·0V 4A	21	14DCC	3 LAYERS ·282″ THICK	
L.T.SEC.2.			4·0V 2A	21	18DCC	2 LAYERS ·118″ THICK	
CHOKE 1							
	1		15H 120MA	4,800	30E	GAP 1/32″ RES: 175Ω	1·29
CHOKE 2							
	1		50H 50MA	11,000	34E	GAP 7/64″ RES: 780Ω	1·65

*PAPER INTERLEAVING BETWEEN EACH LAYER.

VALVE DATA.



CLASS	MAKE	TYPE No.	BASE	V_H	C_H AMPS	V_{AS}	V_{SG}	V_G	C_A MA	C_{SC} MA	R_A OHMS	R_{SC} OHMS	R_C OHMS	VM BIAS	OPTIMUM LOAD OHMS	WATTS OUTPUT
VARIABLE MU R.F. PENTODES	AMERICAN	6K7	OCTAL	6·3	0·3	250	100	−3	7	1·7	–	100K	350	−42·5		
	MULLARD	EF39	"	6·3	0·2	250	100	−2·5	6	1·7		100K	300	39		
	COSSOR	OM6	"	6·3	0·2	250	100	−2·5	6	1·5		100K	300			
	MULLARD	VP4B	7-PIN	4·0	0·65	250	250	−3	11·5	4·25		1000	150	−22		
R.F. PENTODE DETECTORS	AMERICAN	6J7	OCTAL	6·3	0·3	250		NIL	1 MA TOTAL		·25MΩ	1MΩ	NIL			
	MULLARD	EF36	"	6·3	0·2	250		"	1·15	0·35	200K	·5MΩ	"			
	COSSOR	OM5	"	6·3	0·2	250		"	1·6	0·5	100K	·5MΩ	"			
	MULLARD	SP4B	7-PIN	4·0	0·65	250		"			100K	·5MΩ	"			
TRIODES	AMERICAN	6J7* 6C5	OCTAL	6·3	0·3	250		−3	3		50K		1000			
	MULLARD	EF36*	"	6·3	0·2	250		−3	3		50K		1000			
	"	354V	5-PIN	4·0	0·65	250		−3·4	1·9		40K		1800			
	AMERICAN	6N7+	OCTAL	6·3	0·8	250		−4·0	1·66		100K		1200×			
OUTPUT VALVES	AMERICAN	25A6	OCTAL	25·0	0·3	160	120	−18	33	6·5			450		5000	2·2
	"	6V6	"	6·3	0·45	250	250	−15	74●	9●			200●		10,000●	10·0●
	MULLARD	CL33	"	35·0	0·2	200	200	−9	40	7			200		4000	
	COSSOR	OM9	"	6·3	0·2	250	250	−18	32	5			500		8000	4·0
	MULLARD	PEN4VA	7-PIN	4·0	1·35	250	250	−22	36	6			500		6000	3·8
	"	PENA4	"	4·0	1·95	250	250	−5·8	36	6			150		8000	3·8
RECTIFIERS	AMERICAN	5V4	OCTAL	5·0	2·0	375-0-375			175	FULL-WAVE						
	MULLARD	CY32	"	30·0	0·2	250-0-250			120	"						
	COSSOR	OM1	"	30·0	0·2	250			120	HALF-WAVE						
	AMERICAN	25Z6	"	25·0	0·3	235			150	"						
	MULLARD	1W4/350	5-PIN	4·0	2·0	350-0-350			120	FULL WAVE						
	AMERICAN	6Q7⊙	OCTAL	6·3	0·3			−3	1·1		·25MΩ		2500			
	MULLARD	TDD4⊙	7-PIN	4·0	0·65			−4	2		60K		2000			

* CONNECTED AS TRIODE. SCREEN GRID TO ANODE. SUPPRESSOR GRID TO CATHODE.
+ EACH TRIODE UNIT.
× COMMON BIAS RESISTOR.
● FOR TWO VALVES IN CLASS AB_1.
⊙ TRIODE SECTION OF DOUBLE-DIODE-TRIODE.

THE ABOVE TABLE HAS BEEN COMPILED BOTH FROM MANUFACTURER'S PUBLISHED DATA AND DIRECT MEASUREMENT. IT IS INTENDED TO APPLY TO VALVES USED IN SIMILAR CIRCUITS TO THOSE PUBLISHED HEREIN.