

TRANSISTOR CIRCUITS MANUAL

No. 4

by

CLIVE SINCLAIR

CIRCUITS AND INSTRUCTIONS FOR BUILDING

1. Two transistor superhet.
2. Hi-Fi tape and pick-up pre-amp.
3. Hi-Fi 3-watt amplifier.
4. Miniature mains power packs.
5. 5 Kc/s to 2 mc/s signal injector.
6. Sensitive subminiature loudspeaker radio.
7. Single transistor regenerative receiver.
8. 15-watt public address amplifier.
9. Transistor voltmeter.
10. Simple earpiece reflex receiver.
11. Simple transmitter.

BERNARDS RADIO MANUALS

BERNARDS RADIO MANUALS No. 168

TRANSISTOR CIRCUITS MANUAL

No. 4

by

CLIVE SINCLAIR

LONDON

BERNARDS (Publishers) LTD

BERNARDS RADIO MANUALS No. 168

GENERAL EDITOR: CLIVE SINCLAIR

First published December 1960

© 1960.

Printed by Weatherby and Sons, 182-184 Campden Hill Road, W.8
for Bernards (Publishers) Ltd., The Grampians, Western Gate, W.6.

CONTENTS

	Page
Introduction	5
Notes on use of OC169 transistor	6
1. Two Transistor Superhet	8
2. Hi-Fi Tape and Pick-Up Pre-amplifier	11
3. Hi-Fi 3-watt Amplifier	15
4. Miniature Mains Power Packs	18
5. 5 Kc/s to 2 mc/s Signal Injector	21
6. Sensitive Subminiature Loudspeaker Radio	23
7. The "Mighty Atom" Single Transistor Receiver	25
8. 15-Watt Public Address Amplifier	28
9. Transistor Voltmeter	29
10. Simple Earpiece Reflex Receiver... ..	34
11. Simple Transmitter	39
Addresses of Manufacturers	40

LIST OF ILLUSTRATIONS

Fig. No.		Page
1.	Physical details of the OC169	7
2.	Two Transistor Superhet	9
3.	Pre-amplifier for tape or magnetic pick-up	12
4.	Response curves for circuit in Fig. 3	13
5.	Bass boost circuit for Fig. 3	14
6.	Circuit diagram of the 3-watt amplifier	16
7.	Miniature mains power supply circuits	19
8.	5 Kc/s to 2 mc/s signal injector	22
9.	Circuit for 3 transistor receiver	24
10.	"Mighty Atom" transistor receiver	26
11.	Addition of long wave coil to Fig. 10	27
12.	First 3 stages of public address amplifier	30
13.	Driver and output stages	31
14.	High input resistance voltmeter	32
15.	Simple earpiece reflex receiver	36
16.	Layout for simple reflex receiver... ..	37
17.	Simple transmitter circuit... ..	38

INTRODUCTION

The rapidity with which new components have appeared on the home constructor market in recent months has been pleasantly surprising. It seems that manufacturers are beginning to take a new interest in this outlet for their products.

In the field of transistors a new drift type has been made available, the OC169. This unit has the same parameters as the OC170 but sells for only 18/0d. which makes it far less of a luxury article. As its characteristics are extremely good it may be used in a great many applications that might surprise someone unfamiliar with them. Many of the circuits in this book make use of the OC169 and a chapter on the transistor itself is also included for those of you who like to know exactly what sort of animal you are dealing with. Some of it is rather technical but a little bit of theory does no one any harm.

I have been receiving a great many letters recently concerning the circuits that have appeared in the transistor circuits manuals. Many of them contain some query about one of the circuits and these I am only too pleased to answer although sometimes I get a little behind with them. However, I should like to hear from more of you concerning the type of equipment you are most interested in, so perhaps you could send me a postcard. From the letters I have received so far it appears that receivers are the most popular projects (to borrow an excellent Americanism) and the small pocket sets with loudspeaker are the most popular of all. This has been reflected in this issue and new sets are being designed and tested at the moment. However, there may be other types of unit which have not yet appeared but which would be welcomed.

Transistors continue to replace valves in their traditional applications and the next take over bid is likely to take place in the high fidelity field. Power transistors are now available with performances which are in no way inferior to those of comparable valves and these make it possible to design quality amplifiers with outputs in the region of 20 watts. As a start in this field this manual contains the circuit for a pre-amplifier of extremely high performance and equipment for use with this will appear in the future manuals. Whilst many still tend to think of the transistor in terms of portable usage it has, in fact, many properties which make it preferable to the valve in larger types of domestic equipment. In tape recorders and other Hi-Fi equipment, where the elimination of mains hum is of paramount importance, their large scale adoption may not be far in the future.

In the books we have published and in the magazines, many circuits have appeared for transistor receivers which combine simplicity and low cost with sufficiently high performance for their intended application. Many superhet circuits have also appeared but these have never fallen into the category of the sets just mentioned as they have used, virtually without exception, 6, 7 or even 8 transistors. This may have given the average home constructor the erroneous idea that all transistor superhets are necessarily complicated, expensive and difficult to build. To disprove this theory this book contains superhet circuits of relatively extreme simplicity which are suitable for those who have built their first T.R.F. recovered from their first thrill at hearing it work, and decided that they require something more potent. The arrival of the OC169 has made my task relatively simple in designing these sets for its colossal gain at M.W. frequencies reduces the number of stages required for any given performance.

By the way, I am always interested in hearing how the circuits in these books are built and how well they work in various parts of the country. Many of you, I know, think up new ways of building them and modifying the equipment described. Should you be one of these why not write to me giving details and perhaps, including a photograph or circuit diagram. Better still, if you live or work in the London area you could call in at my office which is in The Grampians building in Shepherds Bush Road. Should you have anything that can be used in one of these manuals you will, of course, be paid for it.

NOTES ON THE USE OF THE OC169 TRANSISTOR

The introduction of the OC169 at a price, which at 18/0d is lower than that of even the OC45, makes it sensible to use it wherever OC45's, OC44's or OC170's have been used before.

The OC169 is made by the alloy diffusion technique which achieves results far superior to the best possible using normal germanium alloy methods by which means the OC45 and OC44 are produced. The incredible improvement in performance achieved when using the OC169 may be realised when one considers that its alpha cut-off frequency is 100 mc/s or more compared with only 15 mc/s for the OC44 and that its power gain at 450 Kc/s is 61dB. in a unilateralised circuit compared with 37 dB. with the OC45. That is 1,000,000 times as compared with 5,000 times. When used as a medium wave band frequency changer it will provide a conversion gain of 40 dB. compared with the 28 dB. obtainable from an OC44.

The high frequency cut-off makes the OC169 ideal for use in F.M. receiver I.F. stages which normally operate at 10.7 mc/s. At this frequency each stage will provide a gain of 28 dB. Another application that is likely to be really popular is in radio control receivers operating in the 27 mc/s band. At this frequency the

ALL DIMENSIONS IN mm.

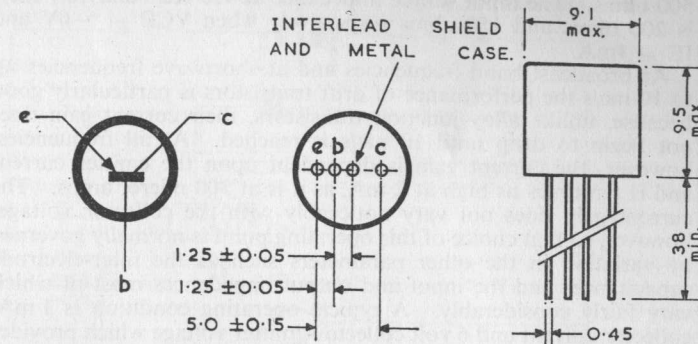


FIG. 1. PHYSICAL DETAILS OF THE OC 169.

OC169 operates excellently, particularly in super regen. circuits.

The OC169 will, in fact, replace the Mullard OC170 or the Ediswan XA131 in any circuit and may be used in super regen. circuits at frequencies up to about 90 mc/s.

If you wish to incorporate this transistor in circuits of your own design here are the limiting values which must not be exceeded:—

—VCB	20V.
—Ic	10mA.
Ic	10mA.
—Ic	1mA.
Pc (Tamb = 45°C)	50mW.

The average value of common emitter current gain is 100.

The characteristics at an ambient temperature of 25°C are as follows:—

	Normal	Minimum	Maximum
—ICBO (—VCB = 6V)	= 1.5microamps		<13
—VCB { —IC = 50mu.A IE = 0	= 80V.	>20V.	
—VEB { —IE = 50mu.A IC = 0		>0.5V.	
—IB { —VCB = 6V IE = 1mA	= 15mu.A.		<50
—VBE { —VCB = 6V IE = 1mA	= 260mV.	>210mV.	<330mV.
F* { —VCB = 6V IE = 1mA f = 1Kc/s	= 18dB.		<40dB.

* Spot noise figure measured with an input source impedance of 500 ohms. The input source impedance at 450 Kc/s and 10.7 mc/s is 200 ohms and 150 ohms respectively when $V_{CE} = -6V$ and $I_E = 1mA$.

At broadcast band frequencies and at shortwave frequencies up to 10 mc/s the performance of drift transistors is particularly good because, unlike alloy junction transistors, their current gain does not begin to drop until 10 mc/s is reached. At all frequencies, however, the current gain is dependent upon the emitter current and is ten times as high at 2 mA. as it is at 300 micro. amps. The current gain does not vary noticeably with the collector voltage, however, so that choice of this operating point is normally governed by variation in the other parameters such as the inter-electrode capacitances and the input and output impedances most of which vary fairly considerably. A typical operating condition is 1 mA. collector current and 6 volt collector-emitter voltage which provides a close approximation to optimum gain conditions. In special circuits such as those to which A.G.C. is to be applied, the collector current may be considerably less and is typically only 100 micro. amps in the first I.F. stage of transistor receivers.

As the output impedance of drift transistors is considerably higher than that of normal junction types, I.F. transformers with tapped primaries are not usually required.

The OC169 has four lead out wires in place of the usual three, the extra lead being an internal shield internally connected to the case of the transistor.

TWO TRANSISTOR SUPERHET

The average transistor superhet on the market uses six transistors in a circuit which varies very little from one manufacturer to another. The first stage is usually an autodyne converter, which combines the functions of local oscillator, mixer and I.F. amplifier, the second and third are I.F. amplifiers and the remaining two stages provide the necessary A.F. gain, the last stage using two transistors in a push-pull circuit to drive the speaker. When loudspeaker operation is not required the final stage can be dispensed with and the driver used to drive an earpiece. This results in the saving of two transistors. Using two OC169's for the first two stages makes the second I.F. transistor unnecessary because of the extra gain provided. Finally, the A.F. Driver may be eliminated by reflexing the I.F. stage to fulfill this function. Our original six transistors have now been whittled down to only two without loss of performance. Sensitivity and selectivity remain very much the same the only difference being that the set now drives an earpiece instead of a speaker.

The advantages of this type of set over the less expensive regenerative detector type of receiver are it's superior quality,

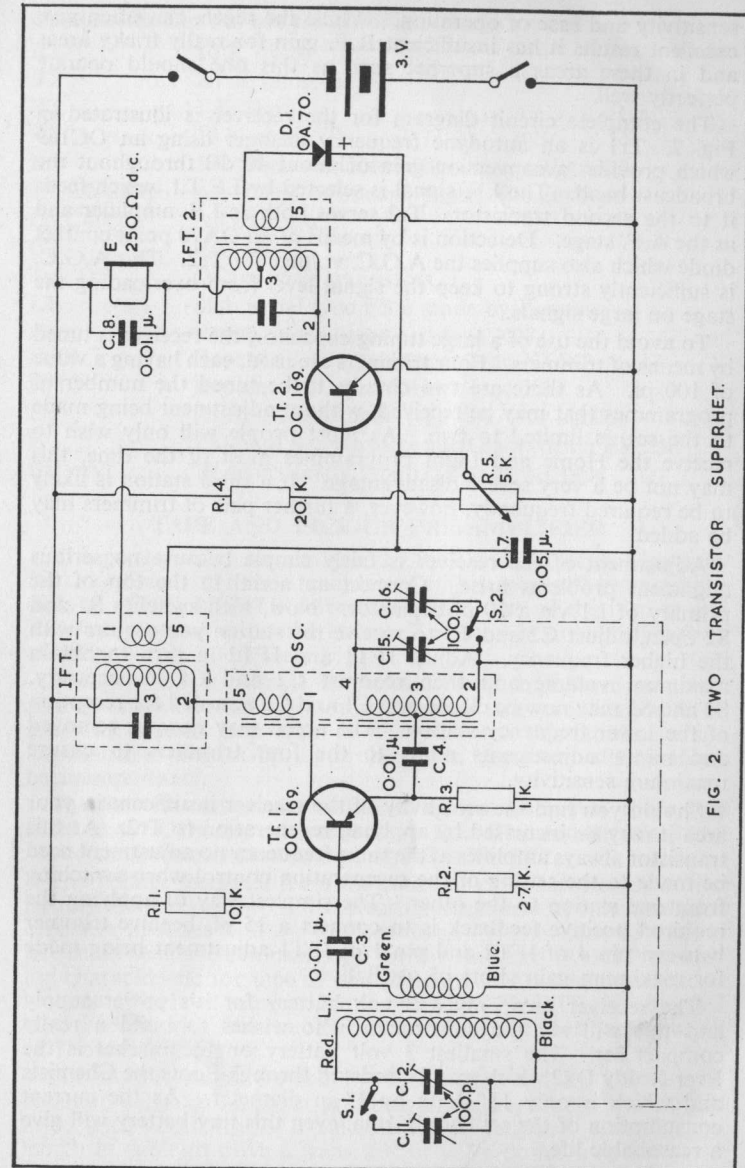


FIG. 2. TWO TRANSISTOR SUPERHET.

sensitivity and ease of operation. Whilst the regen. can often give excellent results it has insufficient R.F. gain for really tricky areas and in these areas a superhet such as this one should operate perfectly well.

The complete circuit diagram for the receiver is illustrated in Fig. 2. Tr1 is an autodyne frequency changer using an OC169 which provides a conversion gain of about 40 dB throughout the broadcast band. The I.F. signal is selected by I.F.T.1. which feeds it to the second transistor. Tr2 serves both as I.F. amplifier and as the A.F. stage. Detection is by means of an OA70 point contact diode which also supplies the A.G.C. voltage for Tr2. This A.G.C. is sufficiently strong to keep the signal level from overloading the stage on large signals.

To avoid the use of a large tuning capacitor, the receiver is tuned by means of trimmers. Four trimmers are used, each having a value of 100 pf. As there are two circuits to be tuned the number of programmes that may be received, without adjustment being made to the set, is limited to two. As most people will only wish to receive the Home and Light programmes most of the time, this may not be a very severe disadvantage. If a third station is likely to be required frequently, however, a further pair of trimmers may be added.

Adjustment of the receiver is fairly simple because no serious alignment problems arise. Connect an aerial to the top of the primary of L1 via a 10 pf capacitor. Now, with switches S1 and S2 open, adjust C2 and C5 to receive the station you require with the higher frequency. Adjust IFT1 and IFT2 in turn to obtain maximum volume and then readjust C2 and C5 if necessary. S1 and S2 may now be closed and C1 and C6 adjusted for reception of the lower frequency station. The aerial may now be removed and minor adjustments made to the four trimmers to ensure maximum sensitivity.

Should you find the sensitivity of the receiver insufficient in your area it may be increased by applying regeneration to Tr2. As this transistor always amplifies at the same frequency no adjustment need be made to the setting of the regeneration control when switching from one station to the other. The simplest way of applying the required positive feedback is to connect a 15 pf. beehive trimmer between pin 4 of IFT2 and pin 1 of IFT1 adjustment being made for maximum gain short of oscillation.

The receiver uses only a 3 volt battery for its power supply and this will aid the constructor who wishes to build a really compact set. The smallest 3 volt battery on the market is the Ever Ready D22 which may be ordered through Boots the Chemists and which is only 1 3/4" long by 3/8" in diameter. As the current consumption of the set is only 1ma. even this tiny battery will give a reasonable life.

Components List for two transistor superhet

✓ R1	10 K ohms
✓ R2	2.7 K ohms
✓ R3	1 K ohm
✓ R4	20 K ohms
✓ R5	5 K ohms variable with single pole switch
✓ C1, C2, C5, C6	All 100 pf. trimmers, postage stamp type
✓ C3, C4, C8	All 0.01 mu.f.
✓ C7	0.05 mu.f.
✓ Tr1, Tr2	OC169 drift transistors
✓ L1	Slab aerial type FS 3 made by Repanco
✓ Osc	Repanco oscillator coil type X08
✓ IFT1	Repanco I.F. transformer type XT6
✓ IFT2	Repanco I.F. transformer type XT7
✓ D1	Point contact diode type OA70 or similar
✓ E	250 ohm d.c. earpiece such as Ardente ER.250
✓ Battery	3V Ever Ready type D22 or larger type

TAPE AND PICK-UP PRE-AMPLIFIER

This pre-amplifier was designed by the General Electric Company for use either with a tape recorder or with a magnetic gramophone pick-up, giving NARTB correction in the case of the former and RIAA compensation to the latter. The total harmonic distortion of the pre-amp. is less than 1/2%.

The pre-amp is suitable for virtually any impedance magnetic pick-up because the input impedance of the amplifier will be generally higher than that of the pick-up. Variations in the impedance of the pick-up due to changes in frequency will, therefore, be unimportant.

The first two stages are stabilised against temperature changes of up to 40° C by current feedback via R2. This resistor should be varied until the collector voltage of Tr2 is 2 volts.

The voltage feedback from the collector of Tr2 decreases at low frequencies because of the increasing reactance of the feedback capacitor in series with the treble control. This is done to achieve frequency selective compensation for the standard NARTB recording characteristic for tape or the standard RIAA for gramophone records. The level response from a standard NARTB pre-recorded tape occurs with the treble control (R12) at mid position or 12 K ohms (see Fig. 4).

The output stage, formed by Tr3, is an emitter follower or common collector amplifier and has, therefore, a very low output impedance which makes it suitable for feeding into virtually any length of cable to drive a transistor or valve power amplifier.

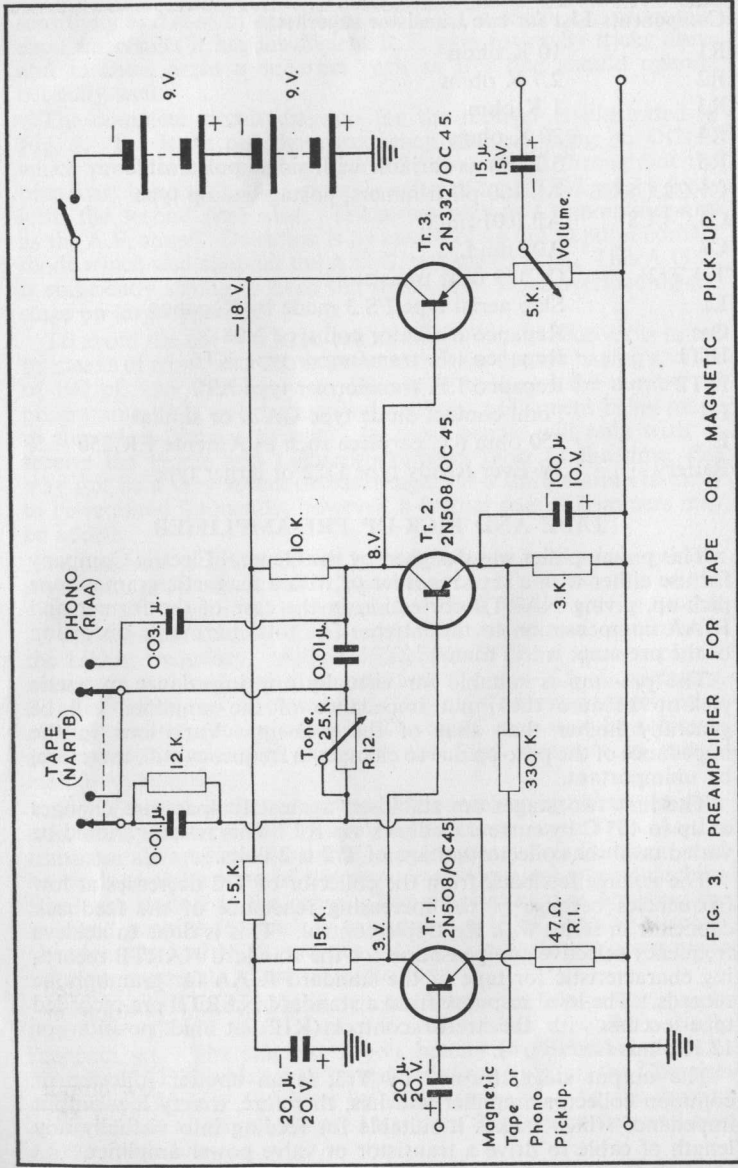


FIG. 3. PREAMPLIFIER FOR TAPE OR MAGNETIC PICK-UP.

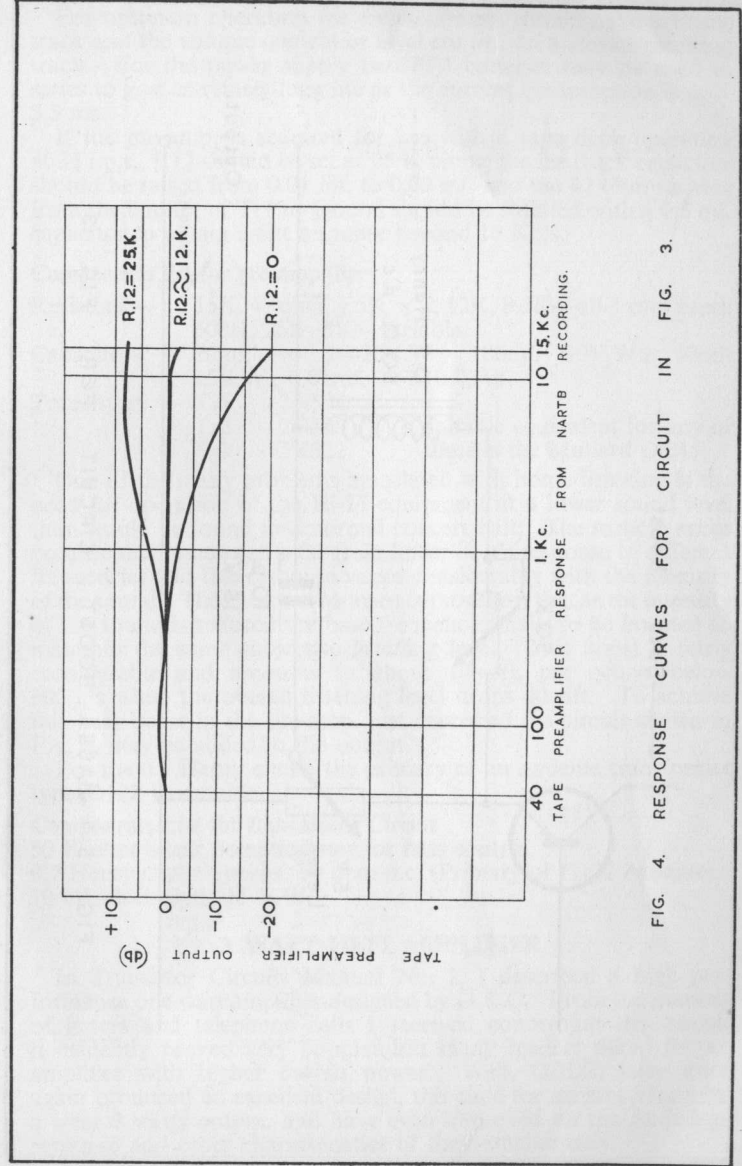


FIG. 4. RESPONSE CURVES FOR CIRCUIT IN FIG. 3.

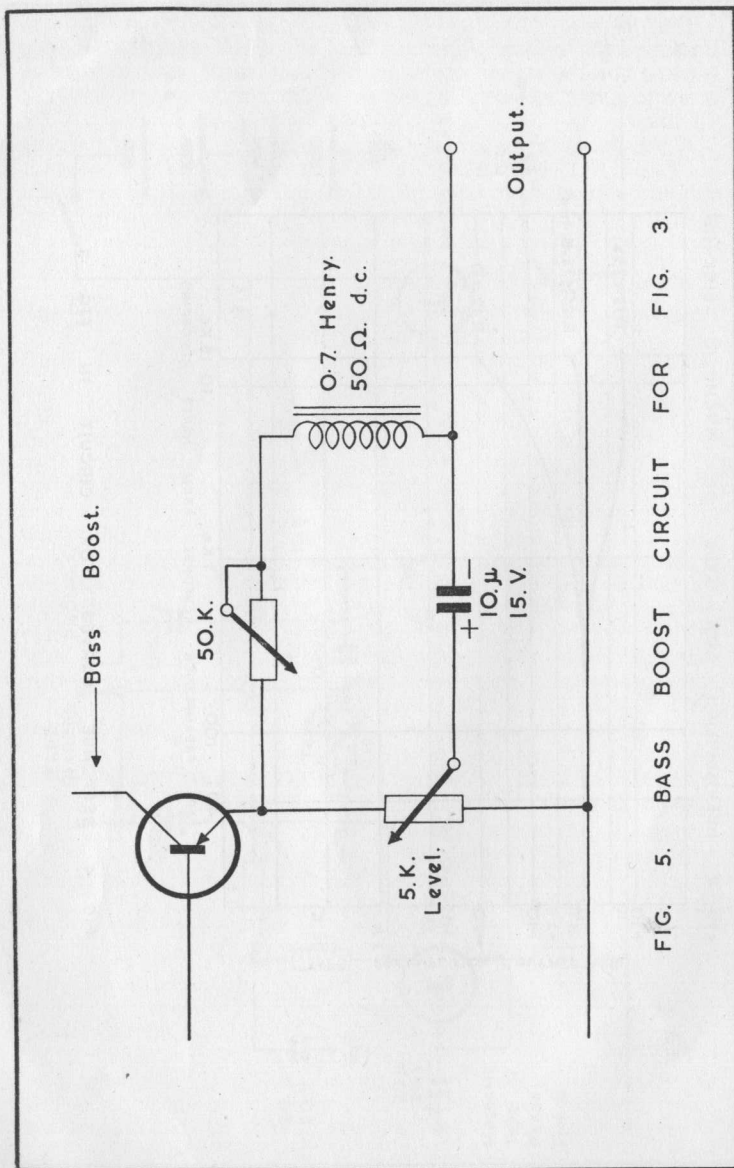


FIG. 5. BASS BOOST CIRCUIT FOR FIG. 3.

For optimum operation the treble control should have a linear track and the volume control or level control an audio or semi-log track. For the power supply two PP3 batteries may be used in series to give extremely long life as the current consumption is only 3.5 ma.

If the pre-amp, is required for use with a tape deck operating at $3\frac{1}{2}$ i.p.s., R12 should be set at 25 K ohms, the feedback capacitor should be raised from 0.01 mf. to 0.02 mf. and the 47 ohm resistor from the emitter of Tr1 to ground should be shunted with a 0.5 mf. capacitor to obtain a flat response beyond 10 Kc/s.

Components list for pre-amplifier

Resistors:— 15K, 47 ohm, 1.5K \times 2, 12K, 8.2K—all $\frac{1}{2}$ watt fixed, 500K, 25K, 5K—variable.

Capacitors:— 20mf. \times 2—20V.W., 100mf. 10V.W., 10mf. 15V.W., 0.01mf. \times 2, 0.03mf.

Transistors:— Tr1 2N508
Tr2 2N508 A suitable equivalent for any of these is the Mullard OC45.
Tr3 2N322

One of the many problems associated with home listening is the need for operation of the Hi-Fi equipment at a lower sound level than would be found in a normal concert hall. The trouble arises because the human ear is far from linear in its response to different frequencies and this response varies considerably with the intensity of the sound. The Fletcher-Munsen curves show that as the intensity of the sound is reduced the base frequencies have to be boosted to maintain the same subjective listening level. This boost is fairly considerable and amounts to about 10 dB. per octave below 300 c/s when the overall listening level drops 40 dB. To achieve this bass boost in the pre-amp. just described the circuit shown in Fig. 5. may be added to the output.

For the 0.7 Henry choke the primary of an Ardente transformer type D122 is suitable.

Components List for Bass Boost Circuit

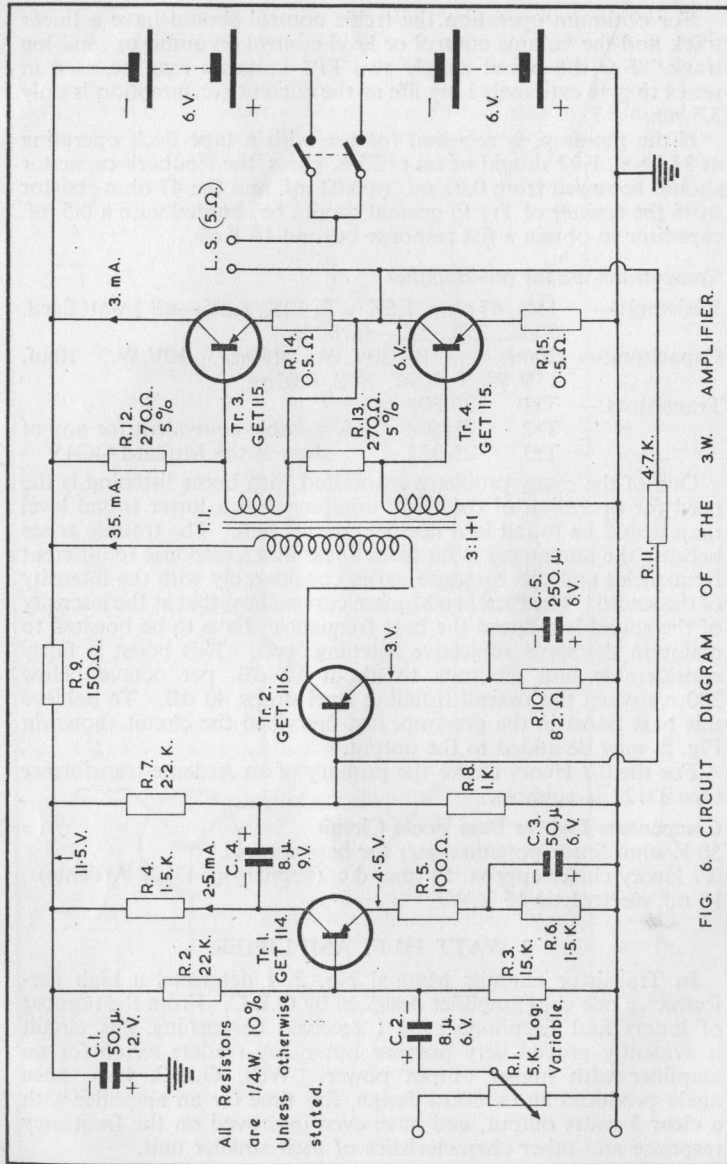
50 K ohm linear potentiometer for bass control.

0.7 Henry choke approx. 50 ohm d.c. (Primary of D122 Ardente).

10 mf. electrolytic 15 V.W.

3 WATT HI-FI AMPLIFIER

In Transistor Circuits Manual No. 2, I described a high performance one watt amplifier designed by G.E.C. From the number of letters and telephone calls I received concerning this circuit it evidently proved very popular but many readers asked for an amplifier with higher output power. Well, G.E.C. have once again produced an excellent design, this time for an amplifier with a clear 3 watts output, and have even improved on the frequency response and other characteristics of their smaller unit.



All Resistors
are 1/4 W. 10%
Unless otherwise
stated.

If the amplifier is used with the pre-amplifier of Fig. 3., the first transistor, Tr1, may be omitted and the output from the pre-amp. connected to the base of Tr2.

To avoid the use of an output transformer, which would be rather bulky because of the low d.c. resistance that would be required, a single ended output stage is used, directly coupled to the loudspeaker which should have a voice coil of from 3 to 5 ohms.

The output transistors are in series across the power supply so that each operates from only 6 volts. Forward bias of between 2 and 5 ma. is applied by means of R12 and R13 to prevent cross-over distortion. 6 dB of negative feedback at 400c/s is applied from the loudspeaker to the base of the driver. The output transistors are GET115's mounted on 3" x 3" fins to act as heat sinks.

The driver transistor, a GET116, operates as a class A amplifier dissipating 320mW. with a collector current of 35mA. Coupling to the output stage is by means of a 3 : 1 +1 phase splitting transformer which may be either a Colne Electric 05009 or a Parmeko P2943 (see components list). Because of the high current level at which this stage operates the input and output impedances are very low, making it necessary to use a 250 mu.f. electrolytic for decoupling in the emitter. A lower value than this should not be used as it would reduce the low frequency gain by providing frequency selective negative feedback.

The pre-amplifier stage, which, as mentioned above, may be omitted, uses a GET116 biased to a collector current of 2.5mA. The un-bypassed emitter resistor gives rise to a small amount of negative feedback and increases the input impedance to about 5K ohms, thus providing a suitable load for the second detector of a conventional transistor broadcast receiver.

The performance figures given for this amplifier by G.E.C. are as follows:—

Input resistance of pre-amplifier at 400 c/s	5K ohms
Input voltage to pre-amplifier for 3 W output	150 mV.
Input resistance of driver at 400 c/s	75 ohms
Input voltage to driver for 3 W output	80 mV.
Power gain with preamplifier stage	58 dB.
Power gain without preamplifier stage	45 dB.
Total quiescent current at 20°C	65 mA.
Total current at 3 W output	400 mA.
Peak power dissipation of each output transistor	800 mW.
Frequency response	20 c/s to 30 Kc/s \pm 1½ dB.
Total harmonic distortion at 400 c/s, 3 W output	less than 5%

As no output transformer is used problems of component layout do not arise, there being no components to interact. With the transistors specified, stable operation is possible up to a temperature of 55°C assuming normal use on speech and music.

Components List

Resistors all $\frac{1}{4}$ watt 10% unless otherwise stated.

R1	5K ohm log. variable
R2	22K ohm
R3	15K ohm
R4	1.5K ohm
R5	100 ohm
R6	1.5K ohm
R7	2.2K ohm
R8	1K ohm
R9	150 ohm
R10	82 ohm
R11	4.7K ohm
R12	270 ohm 5%
R13	270 ohm 5%
R14	0.5 ohm
R15	0.5 ohm

Capacitors

C1	5mu.f. 12V.W.
C2	8mu.f. 6V.W.
C3	50mu.f. 6V.W.
C4	8mu.f. 9V.W.
C5	250mu.f. 6V.W.

Transistors (G.E.C.)

Tr1	GET114
Tr2	GET116
Tr3	GET115
Tr4	GET115

} matched

Speaker

Voice coil 3 to 5 ohms

TRANSFORMER

The transformer should have the lowest possible d.c. resistance consistent with a high primary inductance. Cross over transients at high frequencies are reduced if bifilar secondaries are used.

The transformer in the prototype had the following characteristics:—

Turns ratio	3 : 1 + 1
Primary inductance	1.1 Henries
Primary resistance	18 ohms
Secondary resistance	8.5 ohms each half

Suitable commercial types are

Colne Electric Limited	05009*
Parmeko Limited	P.2943*

* Bifilar windings.

MINIATURE MAINS POWER SUPPLIES FOR TRANSISTOR EQUIPMENT

Experimentors who use transistor and other low power equipment often find it infuriating to have to use batteries all the time. One never really knows whether or not a particular battery is fresh and one of the exact voltage one requires is rarely on hand. These simple power supply circuits are designed to overcome this problem and, in addition, may be permanently installed into radios or other equipment which would normally require batteries.

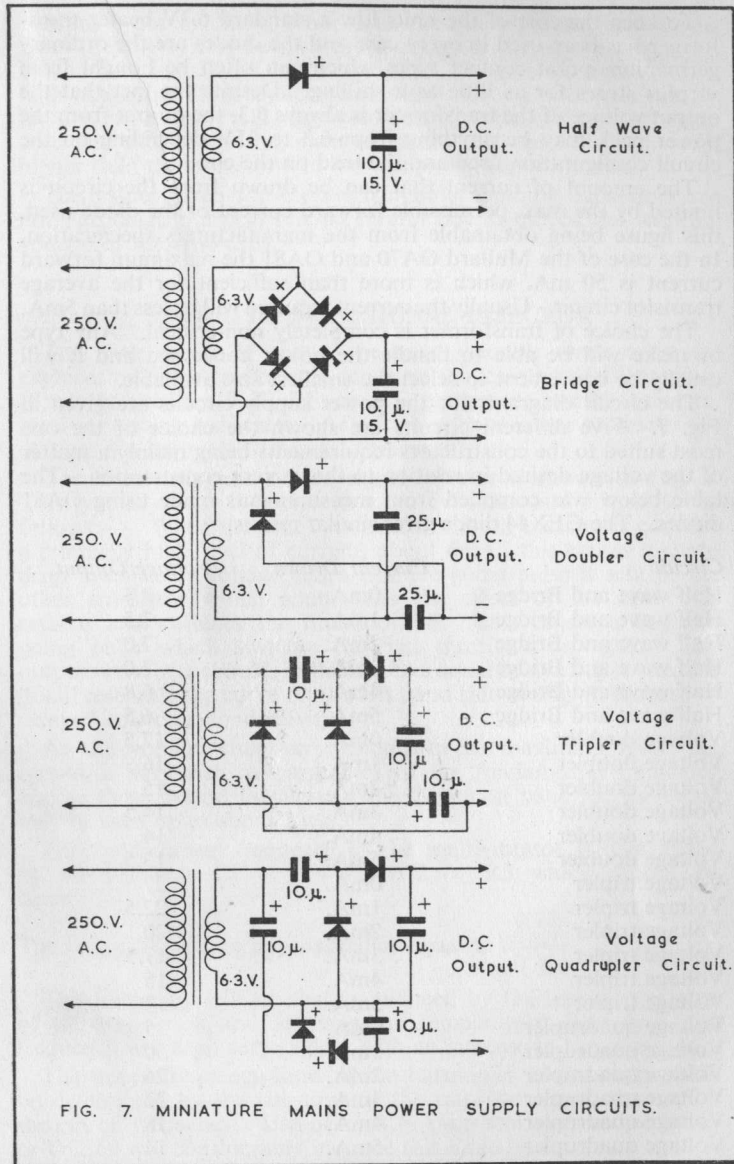


FIG. 7. MINIATURE MAINS POWER SUPPLY CIRCUITS.

To keep the cost of the units low a standard 6.3V heater transformer has been used in every case and the diodes are the ordinary germanium point contact types which can often be bought from surplus stores for as little as a shilling. Despite the fact that the output voltage of the transformer is always 6.3, the output from the power pack may be anything from 6.3 to 35V depending on the circuit configuration used and the load on the circuit.

The amount of current that can be drawn from the circuit is limited by the max. permissible forward current of the diode used, this figure being obtainable from the manufacturers specification. In the case of the Mullard OA70 and OA81 the maximum forward current is 50 mA. which is more than sufficient for the average transistor circuit. Usually the current required will be less than 5mA.

The choice of transformer is completely non-critical. Any type or make will be able to handle the power concerned and it will usually be convenient to select the smallest size available.

The circuit diagrams for the power supply circuits are given in Fig. 7. Five different circuits are shown the choice of the one most suited to the constructors requirements being mainly a matter of the voltage desired in relation to the current consumption. The table below was compiled from measurements made using OA81 diodes. The GEX44 diode gives similar results.

Circuit	Current Drawn	Voltage Output
Half wave and Bridge	0mA.	8.5
Half wave and Bridge	1mA.	7.5
Half wave and Bridge	2mA.	7.0
Half wave and Bridge	3mA.	7.0
Half wave and Bridge	4mA.	6.8
Half wave and Bridge	5mA.	6.5
Voltage doubler	0mA.	17.5
Voltage doubler	1mA.	16
Voltage doubler	2mA.	15
Voltage doubler	3mA.	14.5
Voltage doubler	4mA.	14
Voltage doubler	5mA.	13.5
Voltage tripler	0mA.	27
Voltage tripler	1mA.	22.5
Voltage tripler	2mA.	20
Voltage tripler	3mA.	17.5
Voltage tripler	4mA.	15
Voltage tripler	5mA.	13
Voltage quadrupler	0mA.	35
Voltage quadrupler	1mA.	30
Voltage quadrupler	2mA.	26
Voltage quadrupler	3mA.	22
Voltage quadrupler	4mA.	18
Voltage quadrupler	5mA.	14

Many types of diode, other than the point contact germanium types used here, may be used to advantage in this type of circuitry. Silicon junction diodes, when available, are ideal because of their high power handling capacity and small size. The output voltage for a given current will vary considerably with the type of diode used and care should be taken to ensure that the voltage is never higher than the transistors in the equipment can withstand.

The values given for the electrolytic smoothing capacitors are not particularly critical but be careful not to exceed the working voltage of the type used.

5,000 c/s TO 2 mc/s SIGNAL INJECTOR

This little device is one of the most valuable assets a service engineer or home constructor can have for testing or fault tracing. It may be used for R.F., I.F. or A.F. equipment and is, therefore, ideal for testing radio sets. As a high voltage is not produced the unit cannot harm transistorised equipment.

The circuit diagram of the signal injector is shown in Fig. 8. This type of circuit is known as a multivibrator and it operates as follows:— When the unit is switched on both transistors conduct a relatively high level of current, about 6mA., this causes a sharp drop in collector voltage and a positive going pulse is sent to the other transistor which counteracts the effect of the base bias resistor and switches the transistor off. This causes a negative going pulse which switches the first transistor on again. The output waveform should, in theory, be a square wave but in practice it will resemble the curve on the left hand side of Fig. 8. because of delayed collector conductivity.

As the voltage rises very steeply to its maximum level, the output is very rich in harmonics of the fundamental frequency and as these extend throughout the broadcast band the oscillator may be used up to about 2 mc/s.

The fundamental frequency of the multivibrator is determined by the products $C1 \times R4$ and $C2 \times R3$ which should be equal.

The frequency will be approximately equal to $\frac{0.77}{C1 R4}$

The frequency will be slightly reduced by the leakage currents of the transistors and as these are temperature dependent, the frequency will drop very slightly with an increase in temperature.

The upper frequency limit of the harmonics in the output will be determined by the rise time of the transistor used, that is, by the cut off frequency. Use of an R.F. transistor such as the OC45 or OC169 will considerably increase this limit.

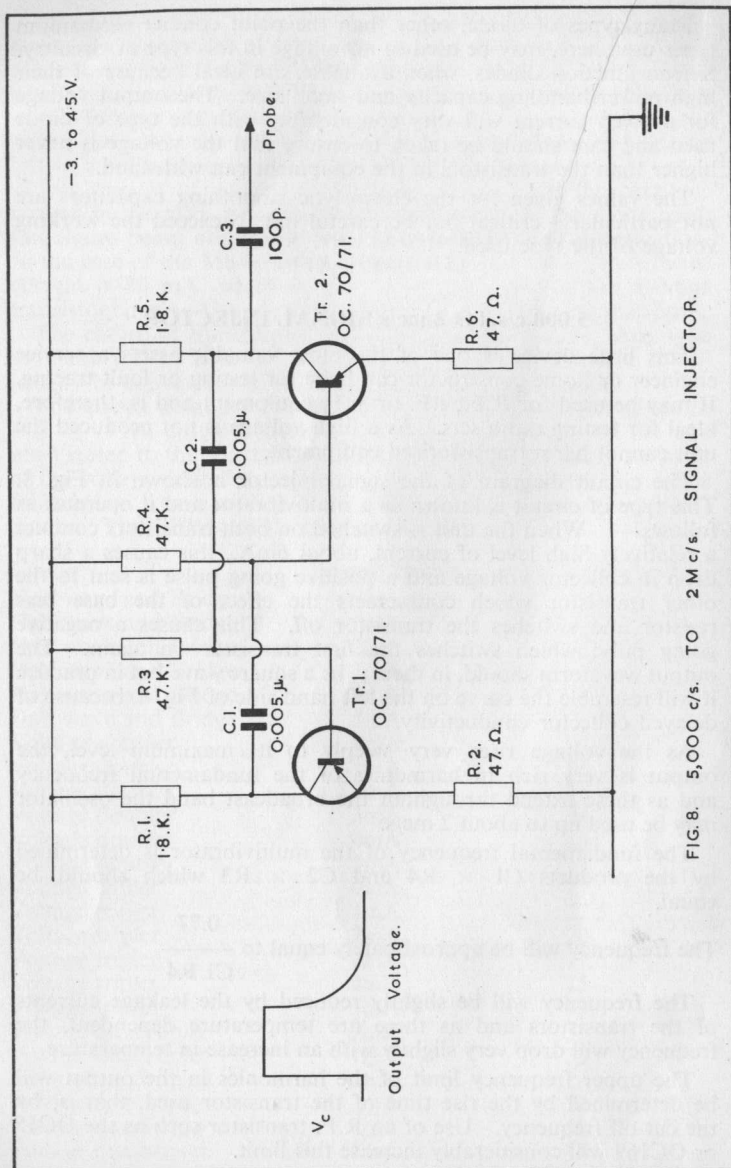


FIG. 8. 5,000 c/s. TO 2 Mc/s. SIGNAL INJECTOR.

Components List

R1	1.8K	C1	0.005 mf.
R2	47 ohms	C2	0.005 mf.
R3	47K	C3	100 pf.
R4	47K	Tr1	OC70, OC71, OC45 or OC169
R5	1.8K	Tr2	OC70, OC71, OC45 or OC169
R6	47 ohms	Battery	3 or 4.5V.

SENSITIVE SUBMINIATURE RADIO USING A LOUDSPEAKER

By using the OC169 a receiver of small size but high sensitivity can be constructed without too many components. To obtain sufficient R.F. gain a regenerative detector is used feeding a high gain two transistor A.F. Amplifier. As a new $1\frac{3}{4}$ " speaker is used the external dimensions of the receiver may be $3" \times 2" \times \frac{5}{8}$ inch or even less.

The speaker is the new TSL/Lorenz LP45F which is a moving coil type and has a depth of only $\frac{3}{4}$ ". The magnet is made from ferrite instead of the more usual alnico and this results in the incredibly high field strength of 9,500 gauss. The voice coil impedance is 10 ohms and the output transformer should have a turns ratio of 10 : 1 to match this. This figure is not, however, particularly critical.

The circuit diagram of the receiver is shown in Fig. 9. The aerial coil should be wound on $\frac{1}{4}$ " or $\frac{3}{8}$ " ferrite rod having a length of $1\frac{3}{4}$ " or more. Wind a layer of paper over the rod wide enough to hold L1. Now wind on L1 providing a tap at the tenth turn as shown in the circuit diagram. Use 26 gauge enamel wire and wind the turns side by side. The whole assembly should be wound sufficiently freely to enable it to be slid along the rod. This makes it possible to alter the inductance of the coil so that the m.w. band can be covered accurately. L2 should be wound with the same gauge wire on a separate strip of paper and should also be able to slide freely along the rod.

The turns ratio of the interstage transformer, T.1 may lie between 4.5 : 1 and 10 : 1 the latter providing slightly more gain than the former. The value of the electrolytic capacitors is not at all critical, 8 or 10 mf. types being perfectly suitable for C4 and C5.

When the assembly of the receiver is completed it should be aligned as follows:—Set C1 and R1 roughly to their mid positions and slide L2 with respect to L1 until the receiver just oscillates. If no oscillations are obtained, reverse the connections to L2.

It will now be possible to bring the receiver in and out of oscillation by adjusting R1. C1 is used to tune in the station and R1 to adjust the amount of regeneration. It may be necessary to move L1 in order to cover the band properly in which case L2 will also have to be moved.

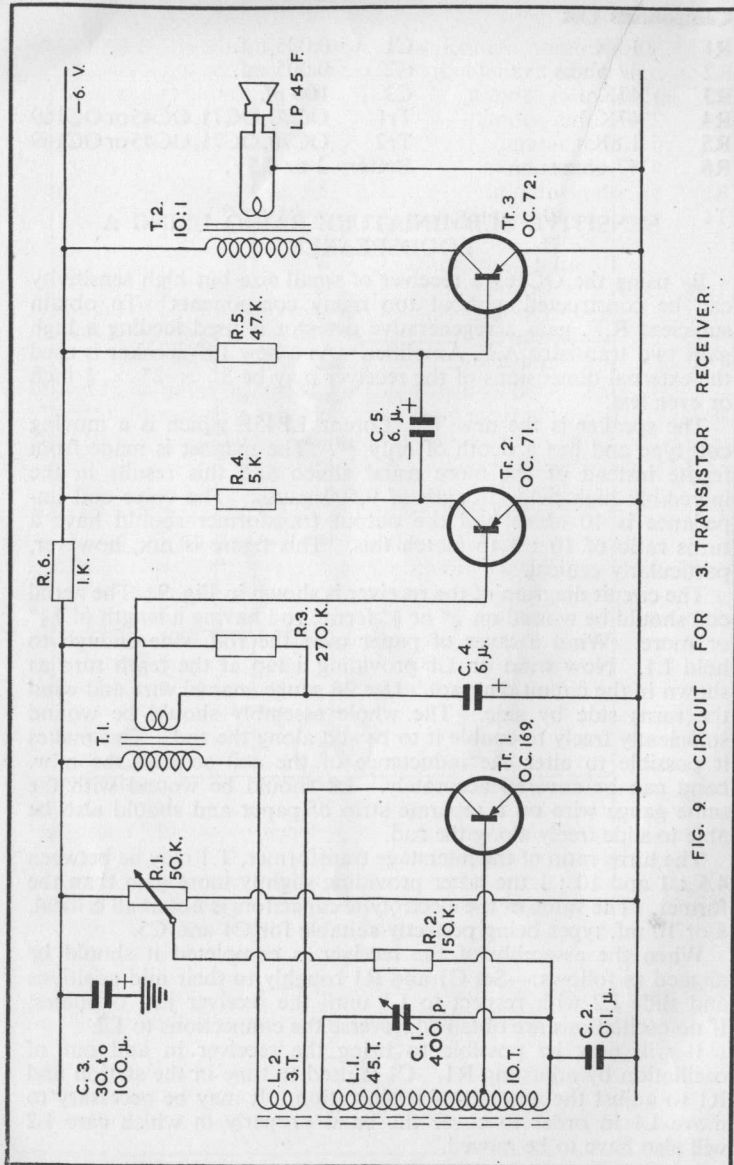


FIG. 9 CIRCUIT FOR 3. TRANSISTOR RECEIVER.

Components List

R1	50K volume control with switch for battery.	Fortiphone type VS26 available from Technical Suppliers Limited.	
R2	150K ohm submin.	C1	400 pf. tuning cap. miniature solid dielectric type or postage stamp trimmer with knob.
R3	270K ohm submin.	C2	0.1 mf.
R4	5K ohm submin.	C3	30 to 100 mf. 6 or more working volts.
R5	47K ohm submin.	C4	6 mf.
R6	1K ohm submin.	C5	6 mf.
T1	4.5 : 1 or 10 : 1 interstage transformer.	C1 and 2	See text.
T2	10 : 1 output transformer	L1 and 2	See text.
Tr1	OC169 Distributed by Technical Suppliers Ltd.	Loudspeaker.	LP45F. Technical Suppliers Limited. Price 25/0d.
Tr2	OC71 or equivalent.		
Tr3	OC72 or equivalent.		

All products listed as distributed by Technical Suppliers Limited should be available from your local dealer but in case of difficulty may be obtained from Technical Suppliers Limited, Hudson House, 63, Goldhawk Road, London, W.12.

THE "MIGHTY ATOM" SINGLE TRANSISTOR RECEIVER

This simple receiver was designed by Weyrad for use with one of their coils and is an interesting example of the excellent results obtainable from a regenerative detector which has been carefully designed.

Many simple transistor receiver circuits are disappointing because they will only receive the local station owing to poor sensitivity. In this design, however, regeneration and a novel form of aerial coupling are employed to improve both sensitivity and selectivity which are good enough to permit the reception of Continental stations. The high performance will also prove attractive to the more experienced constructor who is looking for a simple feeder unit to be used with an existing amplifier or tape recorder. In such applications the overall size may be reduced by careful re-arrangement of the component layout.

The circuit diagram of the receiver is shown in Fig. 10, and in Fig. 11. are shown the modifications required for long wave operation. Before starting work the constructor is advised to look carefully at the diagrams so as to have a clear idea of the sequence of assembly.

Operating Instructions

Although a six volt battery can be used the set will work well on the 4.5 volt type.

Plug in an aerial (a foot or two of wire should be sufficient for the local station) and the best possible earth to the appropriate sockets. The headphones should be of the low resistance type preferably between 40 and 100 ohms.

The receiver requires careful tuning because it is very selective and stations can easily be missed. Switch on and swing the tuning control until the local station is heard. The potentiometer may be used as a volume control but for best reception it should be advanced until oscillation starts. This is shown by a howling noise. Reduce the control until oscillation just ceases as evidenced by the clearer reception of the desired station. This setting of the potentiometer will need to be changed as the tuning is varied and each control has a slight effect on the other. Best results will be obtained by slightly resetting the tuning capacitor after the most sensitive position of the potentiometer has been found.

15-WATT PUBLIC ADDRESS AMPLIFIER

The advantages of transistors in public address systems are, of course, reduced weight, size and power consumption.

This amplifier was designed by Mullard Limited and I would like to thank them for their permission to include it in this manual.

The frequency response, sensitivity and output power are more than sufficient for the application for which the amplifier is intended, the sensitivity being quite high enough to enable a low impedance microphone to be used.

The Circuit

The circuit diagram of the unit is shown in Figs. 12. and 13. The output stage consists of a matched pair of OC26's in symmetrical class B push-pull. Despite the fact that both collectors are connected directly to the negative side of the battery, the transistors operate as common emitter amplifiers because the input is between base and emitter and not collector and emitter. The reason for using this type of circuitry is that both collectors are at the same potential and may therefore be connected to a common heat sink.

0.5 ohm emitter resistors are used to provide thermal stability at high ambient temperatures. RV19 and RV20 provide a forward bias to avoid crossover distortion and these should be individually adjusted to give a quiescent collector current of 30 mA. in each stage. The output transformer should be in the form of a centre tapped choke having a total d.c. resistance of less than 0.2 ohms and an inductance of more than 100 mH. This component may be home made.

The driver stage uses an OC26 as a class A amplifier dissipating a total of about 1.7 watts. The collector current should be adjusted to the correct level, 125mA., by means of RV14. The transistor

should be mounted with a mica washer between it and the chassis. The specifications for the driver transformer are as follows:—

Turns ratio	2.5 : 1 + 1 (bifilar secondary)
Primary Inductance	>500 mH at 120mA d.c.
Primary d.c. resistance	<6 ohms
Secondary d.c. resistance	5 ohms + 5 ohms

If the resistance of each of the secondary windings is less than 5 ohms \pm 10% they should be brought up to this value by the addition of a series resistor as shown in Fig. 13.

The three preamplifier stages are fairly conventional, the most unusual part of the circuit being the use of direct coupling between the second and third transistors. The high frequency response is limited to 7 Kc/s by including C6 in the feedback network. There is no point in amplifying frequencies of more than 7 Kc/s particularly when to do so results in an increase in cross over distortion in the output stage. As reproduction below 150 c/s is not desirable in a public address amplifier, the low frequency response is limited by making C10 4 mu.f. instead of 10 mu.f.

The supply voltage of 14V was chosen because this is the typical value for a fully charged 12v. accumulator as used in cars. The amplifier will, of course, still operate properly when the supply voltage drops below this value.

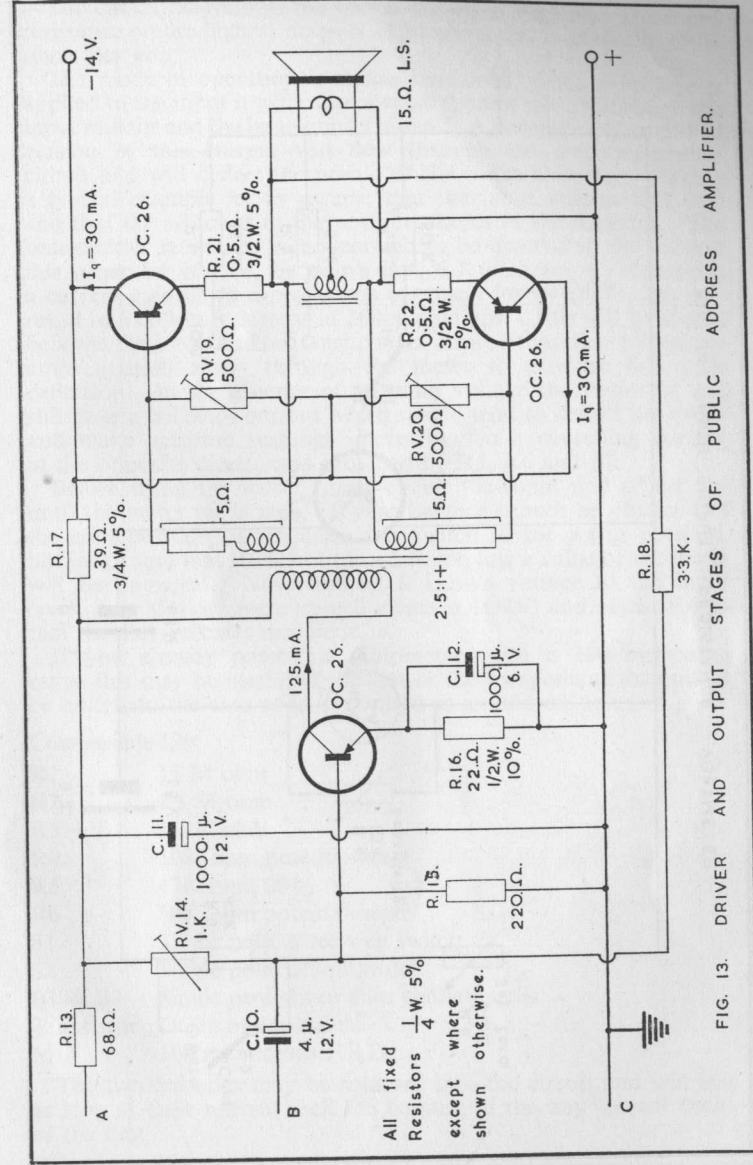
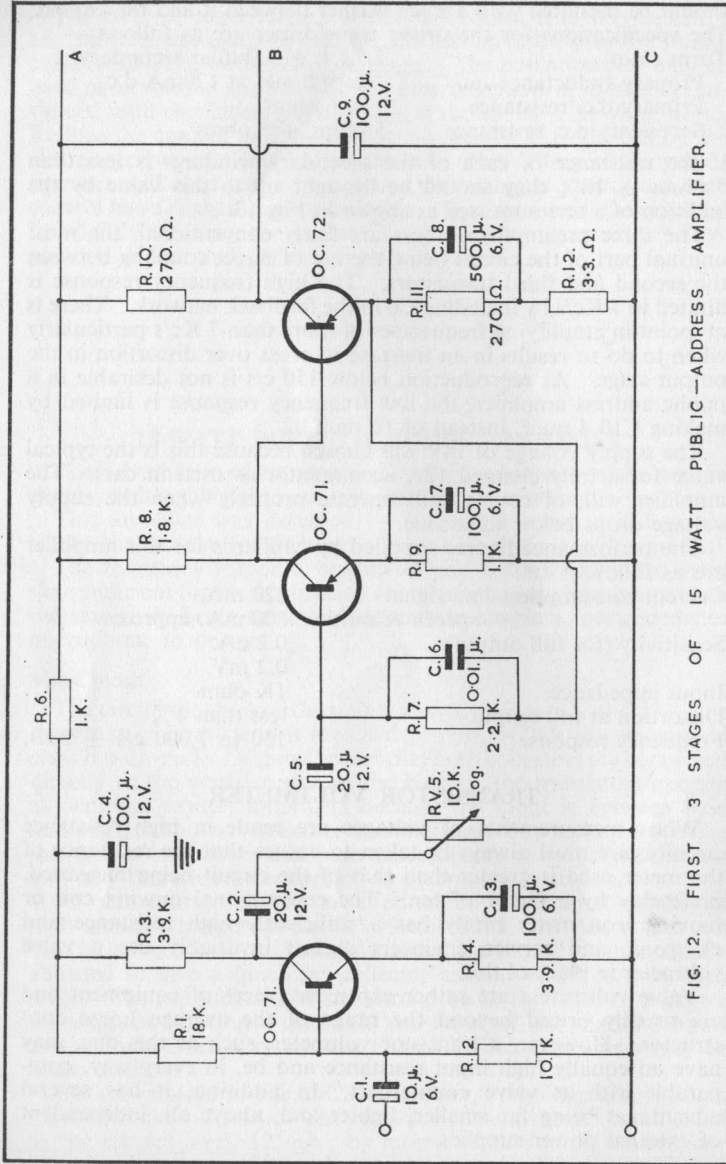
The performance figures supplied by Mullards for this amplifier are as follows:—

Current consumption—no signal	220 mA.
speech & music	800 mA. approx.
Sensitivity (for full output)	0.2 uA.
	0.2 mV.
Input impedance	1K ohm
Distortion at full output	less than 4%
Frequency response	150 to 7,000 c/s \pm 3dB.

TRANSISTOR VOLTMETER

When measurements of voltages are made in high resistance circuits care must always be taken to ensure that the resistance of the meter used is greater than that of the circuit being measured, preferably by a factor of ten. The conventional moving coil or moving iron meter rarely has a sufficiently high resistance and electronic and service engineers almost invariably use a valve voltmeter in place of this.

Valve voltmeters are rather expensive pieces of equipment and are usually priced beyond the range of the average home constructor. However, a transistor voltmeter, such as this one, may have an equally high input resistance and be, in every way, comparable with its valve counterpart. In addition, it has several advantages being far smaller, lighter and, above all, independent of external power supplies.



All fixed Resistors $\frac{1}{4}$ W. 5% except where shown otherwise.

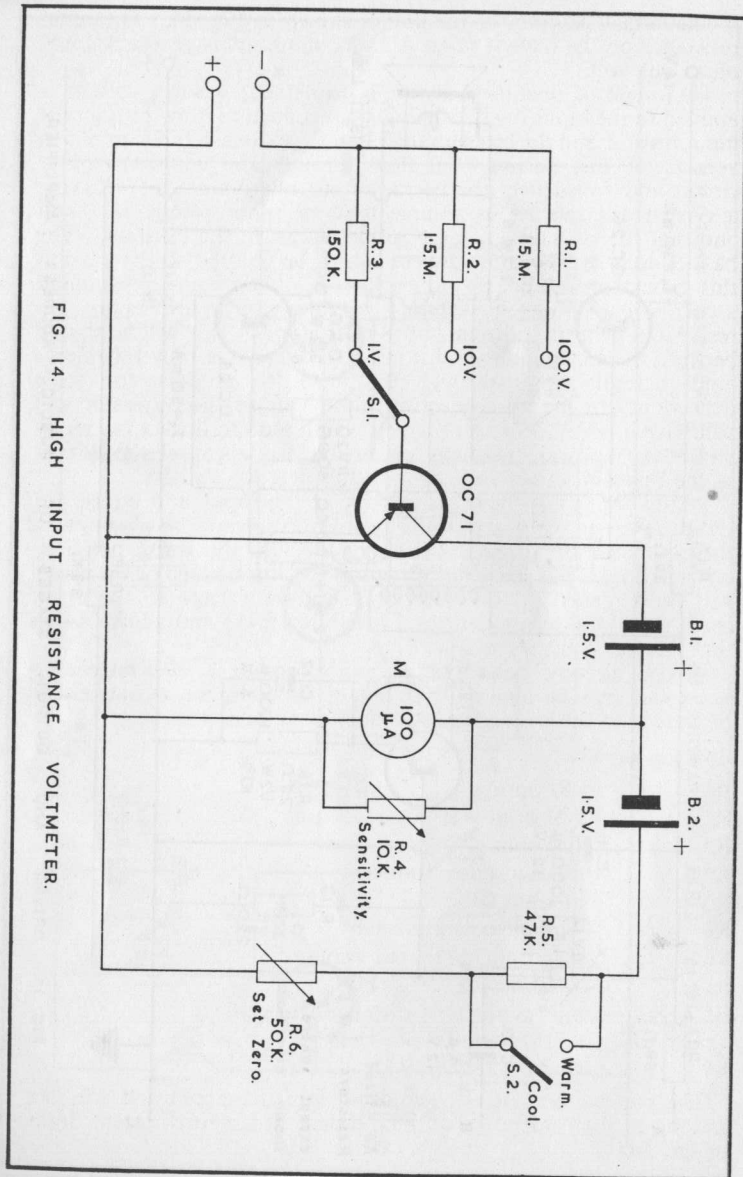


FIG. 14. HIGH INPUT RESISTANCE VOLTMETER.

The circuit diagram of the unit is shown in Fig. 14. The input resistance on the highest range is 15 M ohms and is generally 150K ohms per volt.

The mode of operation is simply explained; when a voltage is applied to the input it will cause a small current to flow through the input resistor and the base-emitter circuit. A considerably amplified version of this current will flow through the collector-emitter circuit and will deflect the needle of the micro-ammeter. Taking a typical example let us assume that the input voltage is 1 volt and that the switch is in the position shown in the diagram. The base-emitter resistance is low enough to be ignored so the current this generates will be, by ohm's law, 6.7 microamps. Assuming a current gain of 40 times, which is typical for an OC71, this will result in a collector current of 268 microamps. This will be shared between the meter and the sensitivity control so that only 100 microamps actually flows through the meter to produce full scale deflection. In the absence of an input voltage the transistor will still have a collector current which would tend to deflect the meter and make accurate readings impossible, so a cancelling current in the opposite direction is provided by R5, R6 and B2.

Before using the meter, short circuit the input and adjust R6 until the meter reads zero. If zero balance cannot be obtained in the cool position of S2, close this switch to the warm position, but make sure that R6 is not turned to too low a value or the meter will be damaged. Now connect a known voltage to the input (such as a Mallory mercury cell which is 1.34V) and adjust R4 so that the dial indicates this value.

If you already possess a multimeter, with a 100 microamp range this may be used and the rest of the components may either be built into the case or incorporated as an add on unit.

Components List

R1	15 M ohm
R2	1.5 M ohm
R3	150K ohm
R4	10K ohm potentiometer
R5	47K ohm 20%
R6	50K ohm potentiometer
S1	Single pole, three way switch
S2	Single pole, on/off switch
B1 & B2	Single penlight or slim penlight cells
Transistor	OC71 or equivalent
M	100 microamps F.S.D.

The two batteries may be soldered into the circuit and will last as long as their normal shelf life because of the tiny current drain of the unit.

SIMPLE EARPIECE REFLEX RECEIVER

The regenerative/reflex type of receiver has now become quite commonplace and, because of the small number of components required for a good level of performance, is almost invariably used in the cheaper type of kit. The principle of the circuit is simply that the first transistor, besides amplifying at R.F. is reflexed to amplify at A.F. and act as the driver for the output stage. In addition to this, regeneration is often employed to increase the R.F. gain and sensitivity as in the receiver described here.

Many of the designs that have been produced and described in books and journals give excellent performance but they rarely lend themselves to miniaturisation because they use R.F. chokes which are only available in rather large sizes. This set, however, has been designed specifically to avoid the use of any transformers or chokes and may, therefore, be built very compactly.

The tuned circuit consists of a small ferrite rod aerial, L, and a postage stamp trimmer with a knob fitted to its 6BA screw, C1. The aerial coil is tapped to match the input impedance of Tr1, an OC44. The signal is fed to the base from the end of the coil rather than from the tap so that feedback from the collector, which is 180° out of phase with the base, may be applied to the other end. The phase change resulting from the finite transit time in the OC44 is small enough to be ignored at medium waveband frequencies so this arrangement results in positive feedback.

The R.F. output from Tr1 is mainly fed to the two diodes via C4. A small proportion, however, is fed back to the tuned circuit via R1 and C2 to provide regeneration. The collector load for Tr1 is resistive and has a total value of 10 K ohms, split into two 5 K ohm resistors to separate the R.F. and A.F. outputs from the transistor. The R.F. output is demodulated by D1 and D2 and the resultant A.F. signal applied to the base of the transistor. The output from D1 also contains a D.C. component which is proportional to the signal and tends to reduce the base bias on Tr1 thereby reducing the collector current, since the gain is very dependent upon operating current in this type of circuit this system provides a high degree of A.G.C. and also prevents oscillation at high signal levels.

The A.F. output from Tr1 is R.C. coupled to the output stage. This stage drives a hearing aid type earpiece or a pair of high impedance headphones. The impedance is not very critical and reasonable results will be obtained even with low impedance units but high impedance types certainly provide more volume.

The total current drawn from the battery with this set is only about ½ mA so the type of battery you need will depend upon the case size. For very small receivers the Ever Ready D22 is ideal as it is only 1½" long × ⅜" diameter.

Constructional Details

The only component that has to be home made is the ferrite rod aerial. This consists of a total of 55 turns of 34 gauge enamelled wire wound on a 2¼" length of ferrite rod with a tap at the 10th turn. A single layer of paper should be wound between the rod and the wire.

The layout is not critical and may be arranged to suit the constructor. An idea of how small the set may be made is given by the diagram in Fig. 16. This diagram just shows the positioning of the main component and may be used as a guide by the constructor.

Varying the value of R2 may improve the performance. With some transistors 800 K or 500 K may give better results.

In operation R1 is used to control the regeneration and hence the volume. Before tuning in a station it should be adjusted just short of the point of oscillation and then readjusted for maximum performance when the required station has been selected by C1.

Like all receivers using ferrite rod aeriels this set is directional and will receive signals best when turned at right angles to the direction of the transmitter.

If the size of the receiver does not matter, performance being a major consideration, R4 may be replaced by an R.F. choke of 1 to 5 mH. inductance and R5 by an A.F. choke the value of which is not critical. If these additions are made, care must be taken to ensure that no inductive coupling occurs between the R.F.C. and L. For all reasonable signal strength areas, however, these additions are unnecessary.

Components List

R1 & S	50 K ohm volume control with switch (Fortiphone type VS26 is suitable)
R2	1 M ohm or less (see text)
R3 & R4	5 K ohm 20%
R5	220 K ohm 20%
C1	250 pf. postage stamp trimmer
C2	5 pf.
C3	0.001 mu.f.
C4	100 pf.
C5	1 mu.f. 3 volts working or more. Any higher value of capacitor will be satisfactory.
L	55 turns. 34 gauge wire on ¼" ferrite rod (see text)
E	Hearing aid type earpiece. 1 to 8 K ohm impedance
B	3 volt battery
D1 & D2	Mullard OA70
Tr1	Mullard OC44
Tr2	Mullard OC71

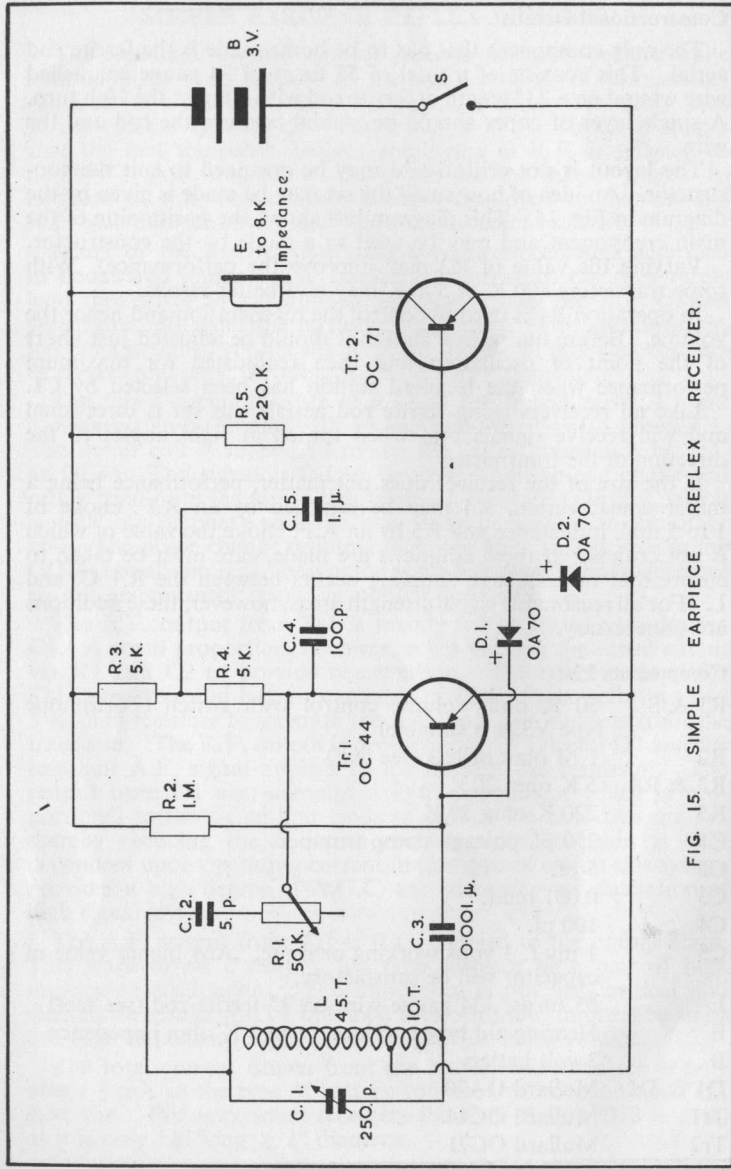


FIG. 15. SIMPLE EARPIECE REFLEX RECEIVER.

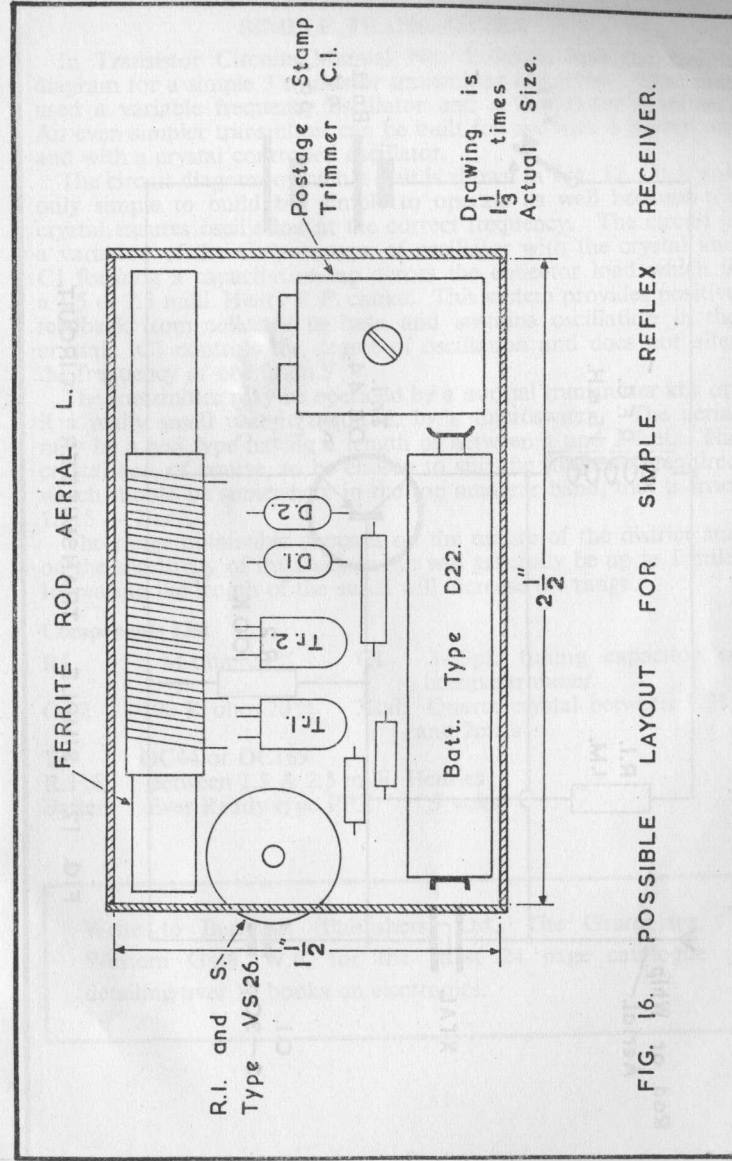


FIG. 16. POSSIBLE LAYOUT FOR SIMPLE REFLEX RECEIVER.

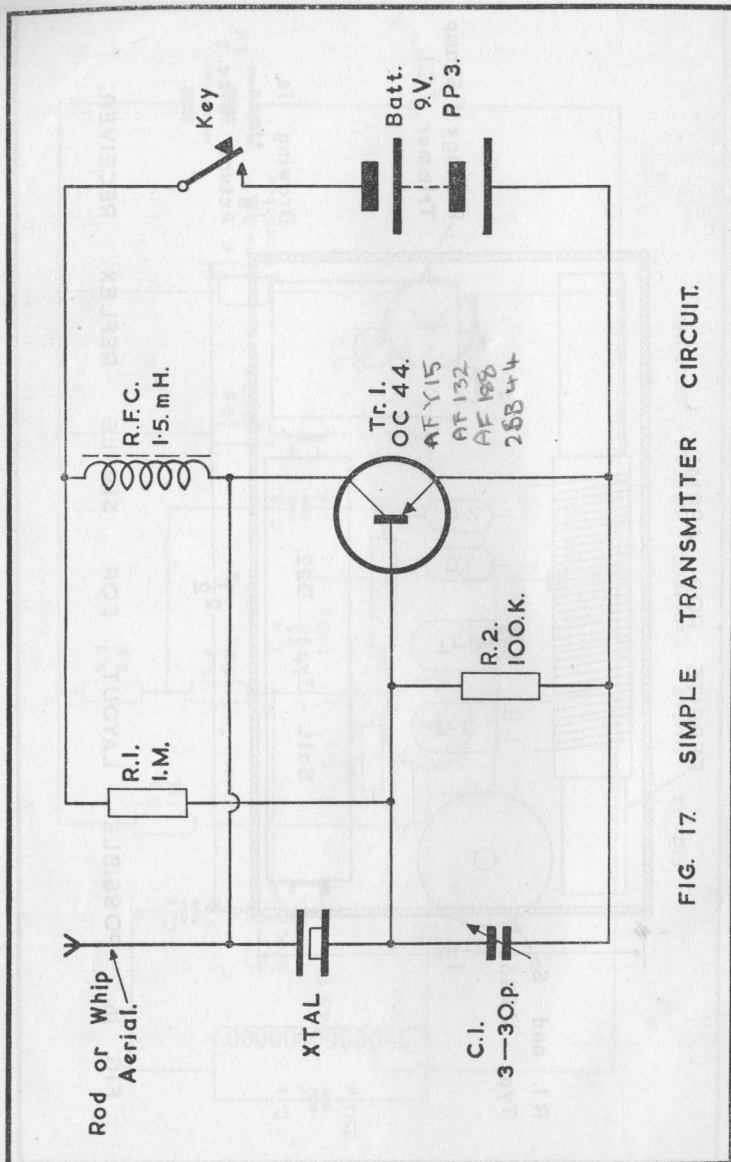


FIG. 17. SIMPLE TRANSMITTER CIRCUIT.

SIMPLE TRANSMITTER

In Transistor Circuits Manual No. 2 details and the circuit diagram for a simple 3 transistor transmitter are given. That unit used a variable frequency oscillator and a modulator amplifier. An even simpler transmitter can be built for use with a morse key and with a crystal controlled oscillator.

The circuit diagram of such a unit is shown in Fig. 17. It is not only simple to build but simple to operate as well because the crystal ensures oscillation at the correct frequency. The circuit is a variation of the Colpitts type of oscillator with the crystal and C1 forming a capacitive tap across the collector load which is a 1.5 or 2.5 milli. Henry R.F. choke. This system provides positive feedback from collector to base and sustains oscillation in the crystal. C1 controls the degree of oscillation and does not alter the frequency of operation.

The transmitter may be operated by a normal transmitter key or, if a really small unit is required, by a microswitch. The aerial may be a rod type having a length of between 1 and 2 feet. The crystal has, of course, to be chosen to suit the frequency required which should be somewhere in the top amateur band, that is from 1.715 — 2mc/s.

The range obtainable depends on the nature of the district and on the sensitivity of the receiver but will generally be up to 1 mile. Increasing the length of the aerial will increase the range.

Components List

R1	1 M ohm 20%	C1	3-30pf. tuning capacitor or beehive trimmer
OR2	100 K ohm 20%	Xtal.	Quartz crystal between 1.715 and 2mc/s
Tr1.	OC44 or OC169		
R.F.C.	Between 1.5 & 2.5 milli. Henries		
Battery	Ever Ready type PP3.		9 volts

Write to Bernards (Publishers) Ltd., The Grampians, Western Gate, W.6, for the latest 24 page catalogue detailing over 50 books on electronics.

NAMES AND ADDRESSES OF MANUFACTURERS

Ardente Acoustic Laboratories, Limited, 8/12, Minerva Road,
London, N.W.10

Brush Crystal Co., Limited, Shore Road, Hythe, Southampton

Colne Electric, Limited, Bury Lane, Rickmansworth, Herts.

Ediswan, Limited, 155, Charing Cross Road, London, W.C.2

Fortiphone, Limited, 92, Middlesex Street, London, E.1

G.E.C. Limited, Magnet House, Kingsway, London, W.C.2

Mallory Batteries, Limited, Rainham Works, Rainham Road
South, Dagenham, Essex

Mullard, Limited, Mullard House, Torrington Place, London,
W.C.1

Newmarket Transistors, Limited, Exning Road, Newmarket,
Suffolk

Parmeko, Limited, Percy Road, Aylestone Park, Leicester

Semiconductors, Limited, Cheney Manor, Swindon, Wilts.

Technical Suppliers, Limited, Hudson House, 63, Goldhawk Road,
London, W.12

Wingrove and Rogers, Limited, Domville Road, Mill Lane,
Liverpool, 13

The OC169 transistor and the LP45 Loudspeaker are distributed throughout Gt. Britain and the British Commonwealth by Technical Suppliers Ltd. and may be obtained from your local dealer.

BERNARDS RADIO BOOKS

35.	Dictionary of Mathematical Data	2/-
56.	Radio Aerial Handbook	2/6
57.	Ultra-Shortwave Handbook	2/6
58.	Radio Hints Manual	2/6
64.	Sound Equipment Manual	2/6
65.	Radio Designs Manual	2/6
68.	Frequency Modulation Receivers' Manual	2/6
73.	Radio Test Equipment Manual	2/6
83.	Radio Instruments and their Construction	2/6
86.	Midget Radio Construction	3/6
96.	Crystal Set Construction	1/-
99.	One Valve Receivers	1/6
100.	A Comprehensive Radio Valve Guide, Book 1	5/-
101.	Two Valve Receivers	1/6
102.	40 Circuits using Germanium Diodes	3/-
103.	"Radiofolder" A. The Master Colour Code Index for Radio and Television	1/6
104.	Three Valve Receivers... ..	1/6
106.	Radio Circuits Handbook No. 4	2/6
107.	Four Valve Receivers	1/6
108.	Five Valve Receivers	2/6
112.	Electronic Multimeter Construction—"Radiochart"	2/6
121.	A Comprehensive Radio Valve Guide, Book 2	5/-
123.	"Radiofolder" F. The Beginners' Push-Pull Amplifier	1/6
126.	The Boys' Book of Crystal Sets and Simple Circuits	2/6
127.	Wireless Amplifier Manual No. 3	3/6
129.	Universal Gram. Motor Speed Indicator	1/-
132.	Reactance-Frequency Chart for Designers and Constructors	1/6
133.	Radio Controlled Models for Amateurs	5/-
134.	F.M. Tuner Construction (Revised Edition)	2/6
135.	All Dry Battery Portable Construction	2/6
138.	How to Make T.V. & F.M. Aerials. Bands 1, 2, 3	2/6
139.	Practical Radio for Beginners, Book 2	3/6
140.	T/V Servicing for Beginners	4/6
141.	Radio Servicing for Amateurs	3/6
142.	Modern T/V Circuits and General Fault Finding Guide	4/6
143.	A Comprehensive Radio Valve Guide, Book 3	5/-
145.	Handbook of AM/FM Circuits and Components	2/-
146.	High Fidelity Loudspeaker Enclosures	5/-
147.	Practical Tape Recording Handbook	5/-
148.	Practical Transistor Receivers, Book 1	5/-
149.	Practical Stereo Handbook	3/6
150.	Practical Radio Inside Out	3/6
151.	Transistor Superhet Receivers	7/6
153.	Miniature Portable Oscilloscope	2/6
155.	Portable Transistor Radio & Radiogram	3/6
156.	Transistor Circuits Manual 1... ..	2/6
157.	A Comprehensive Radio Valve Guide, Book 4	5/-
158.	Radio, Television and Industrial Tube & Semi-Conductor Equivalents Handbook (208 pages)	9/6
159.	Realistic High Fidelity	5/-
160.	Coil Design and Construction Manual	5/-
161.	Radio, Television and Electronics Data Book	3/6
162.	High Fidelity Stereo Gramophone	5/-
163.	Transistor Circuits Manual No. 2	2/6
164.	High Fidelity Tape Recorder	2/6
165.	Radio Tuners	5/-
166.	Public Address Systems	2/6
167.	Transistor Circuits Manual No. 3	2/6
168.	Transistor Circuits Manual No. 4	2/6
	Resistor Colour Code Disc Calculator	1/6
	Engineers' Reference Tables	1/6
	International Radio Tube Encyclopaedia	63/-