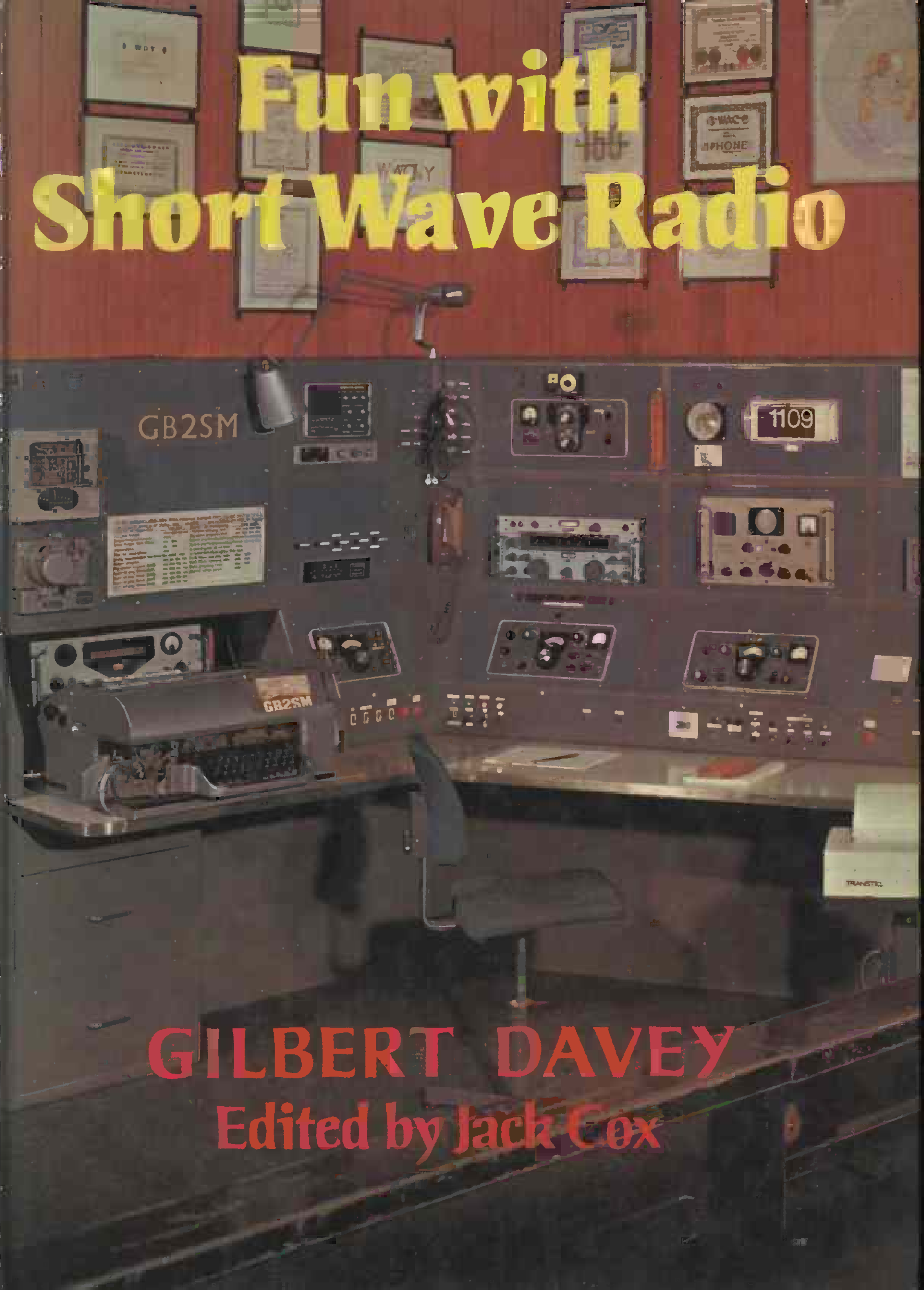
Fun with Short Wave Radio



GILBERT DAVEY

Edited by Jack Cox

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FUN WITH SHORT WAVE RADIO

Third Edition (completely revised)

KAYE & WARD · LONDON
in association with Methuen of Australia
and New Zealand

Every effort has been made by the Author to ensure that proper application of the advice and information given will produce satisfactory and pleasing results. But no responsibility can be accepted by the Author, Editor or Publishers for damage, loss or injury resulting from the application of the information and guidance given in this book.

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FOREWORD

This is a practical handbook written in simple language for practical boys and girls whose hobby is amateur radio construction and short wave radio. It is the second of five titles in the same series by Gilbert Davey. *Fun with Radio, Fun with Electronics, Fun with Transistors* and *Fun with Hi-Fi* are the other titles, all of which are published by Kaye & Ward Ltd and kept absolutely up-to-date.

It was written originally in 1960 for readers of *Boy's Own Paper* and based on monthly features and special eight-page pull-out supplements, all written and produced by Gilbert Davey. I edited this famous periodical, founded in 1879, for more than 21 years, and still edit the *Boy's Own Annual,* which I revived in 1959 after a 20-year lapse, and with which the magazine was merged in 1967. Throughout my 33 years' association with the *Boy's Own* projects of all kinds Gilbert Davey has remained the Amateur Radio contributor.

Today the hobby has spread in many directions and boys no longer have the field to themselves! Indeed, there are almost as many girl enthusiasts as boys and this book is intended as much for them as anyone else; in addition the book can be read and used by any radio enthusiast of any age, either here or overseas.

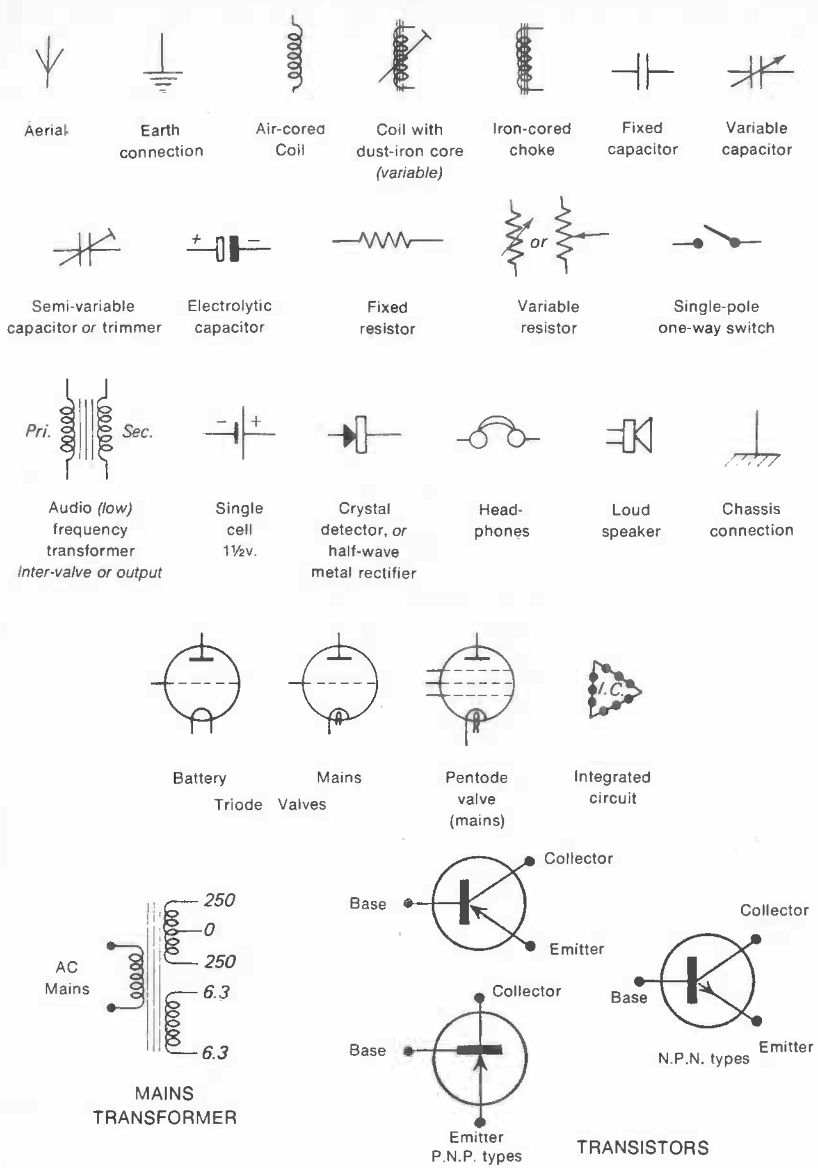
Radio is a leading interest in the modern Scout programme of training, and one of the outstanding features of the remarkable World Scout Jamboree held at Lillehammer in Norway in the summer of 1975 was the emphasis on modern technology and electronics. Scouts who were fortunate enough to be selected to represent their countries were linked by means of the Jamboree radio and television stations with their brother Scouts in all parts of the world in a vast 'join-in' Jamboree network linking boys everywhere. This shows the scope and potential of modern radio as a hobby. Scouting's own 'Jamboree of the Air' celebrated its 21st birthday in real style in 1978-79. Guides continue to show keen and lively interest in this Scout activity.

Home radio construction has proved itself as a popular hobby that never fails to interest intelligent boys and girls with a practical, scientific and technical bent. Gilbert Davey had managed to retain the enthusiasm and lively interest of the amateur probably because at no time in his life has he ever been professionally connected with radio. It has always been a hobby with him and for that reason he has retained the outlook of the amateur who raises his standards to high levels and keeps up-to-date, interested in all aspects of his hobby for its own sake and helping boys and girls to get the utmost out of it.

Gilbert Davey's object has always been to interest more and more boys, and now girls as well, in his own hobby and to encourage them to get as much fun out of their own home-made sets as he has done. As an editor, and broadcaster on home and overseas radio programmes, I have always found it fun to work with Gilbert Davey, knowing that his enthusiasm would never fail to rub off on me as it has done for so many other people. I am sure this new edition of *Fun with Short Wave Radio* will win many new friends for the author.

1979 JACK COX

SYMBOLS AND ABBREVIATIONS



Wavelength	= λ	Resistance	= R	volt	= V
Frequency	= f	Impedance	= Z	ampere	= A
Voltage	= E	Capacitance	= C	watt	= W
Current	= I	metre	= m	henry	= H
Power	= P	frequency/ unit (c/s)	= Hz	ohm	= Ω
Inductance	= L			farad	= F

Prefixes for Abbreviations

One million millionth = micro micro = $\mu\mu$
usually known as pico = p = $(\times 10^{-12})$
One millionth = micro = μ = $(\times 10^{-6})$
One thousandth = milli = m = $(\times 10^{-3})$
One thousand times = kilo = k = $(\times 10^{3})$
One million times = mega = M = $(\times 10^{6})$

Examples: megohm = M ; microfarad (mfd.) = μF; milliamp = mA.

The International Code is as follows:

(i) Resistors

6Ω8	=	6·8Ω
6K8	=	6·8K
6M8	=	6·8M

(ii) Capacitors

5p6	=	5·6pF
5n6	=	5,600pF = 0·0056μF
560n	=	560,000pF = 0·56μF
5μ6	=	5·6μF

Chapter 1

INTRODUCTION TO SHORT WAVES

This chapter is intended for the beginner, but even if you already have some experience it is worth reading and noting. Short Wave Radio is real fun!

The first edition of *Fun with Short Waves* was published in 1960 and dealt exclusively with designs utilizing valves. At that time, transistors were only twelve years old and the successful use of them in high-frequency circuitry was in its infancy. The transistor, however, had too many useful properties for it to be neglected. The achievements of large research organizations during the past few years have made transistors available for high-frequency (short-wave) work on comparable terms almost with valves. This book includes details of transistors as well as valves.

In the 1920's there were two types of waves, long and short. The long were very long by modern standards, and are still in use in the United Kingdom. The United States does not use them and never did. The short waves were what we then called the medium waves of today, that is, the band on which you receive, in Britain, Radios 1 and 2 and Radio Luxembourg. In the United States it is the band normally used for broadcasting. Both these bands are likely to be superseded eventually by the VHF bands on which we in Britain now receive frequency-modulated broadcasting.

In the early days of radio the lower limit of wavelength in use was probably about 150 metres. Gradually the amateurs of the day found that they could use wavelengths around the 100-metre mark, and then the fifty-metre band and so on down to twenty metres. Those were called ultra-short waves. As the use of lower and lower wavelengths became common, standard designations were given to the various bands. These are shown at the foot of the page.

This book deals with the Decametric waveband, or as we call it, the short wavelengths. We shall touch, slightly, on the metric waveband and shall mention the Decimetric and Centimetric wavebands, but our main interest is going to be practical set-designs for the short-wave band. You are probably wondering what the right-hand table refers to, and what is meant by the term 'frequency'; but I must leave the technical considerations of this to your own reading.

Mr M. G. Scroggie explains it very neatly in his excellent book on radio theory

Waveband (Metres)		*Frequency Band (Kilocycles)*	
Names	*Range*	*Names*	*Range*
Myriametric	10,000 and above	Very low frequency	30 and below
Kilometric (Long)	10,000 to 1,000	Low frequency	30–300
Hectometric (Medium)	1,000 to 100	Medium	300–3,000
Decametric (Short)	100 to 10	High	3,000–30,000
Metric	10 to 1	Very high	30,000–300,000
Decimetric	1 to 0·1	Ultra high	300,000–3 million
Centimetric	0·1 to 0·01	Super high	3 million–30 million

(*Foundations of Wireless,* published by Iliffe). I will merely give you an equation, which is

$$\lambda = \frac{300{,}000{,}000}{f}$$

Where λ = wavelength and f = frequency, the wavelength being in metres and the frequency in cycles per second. From this you can quite easily relate wavelengths to frequencies, and it is modern practice to talk about high frequencies instead of short waves. You will see from the equation that a wave-length of 100 metres is equal to a frequency of 3,000,000 cycles. This is a rather clumsy figure to be constantly writing and we can express it as 3,000 kilocycles (kilo = 1,000) or three megacycles (mega = 1 million). It is handy to remember that the lower end of the short-wave band (ten metres) is equal to thirty megacycles and to note that as wave-lengths become lower, frequencies become higher. (We could have called this book *Fun with High Frequency Radio* which means exactly the same as the present title.) Some years ago (was it to do with the EEC, I wonder?) we were told to abandon the word 'cycles' as a measure of frequency and to use 'Hertz' instead. So instead of kilocycles we now have kiloHertz and MHz for 'megacycles'. Hertz was a German scientist who discovered electro-magnetic ('radio') waves. I prefer kilocycles as I think it describes 'frequency' more clearly. So in some places I have left it in and in others have used kiloHertz. I am in good company as the RSGB title *A Guide to Amateur Radio* has done the same.

In listening to broadcast stations on the medium wavebands you have probably noticed that reception of distant stations improves greatly after dark, and it is very probable that during the daytime you cannot receive some at all, whereas during darkness a great deal are available. This is due to the ionized layers which exist above the earth and reflect the radio waves and which are themselves affected by the sun. They lose their effect on these waveband during hours of daylight but reflect them strongly in darkness. Widely differing effects occur on the lower wavebands due to these layers, and different bands react to them in different ways. This reaction is also varied from day to day, indeed hour to hour, by the atmospheric conditions and solar conditions (such as sunspot activity) and signals can be reflected all over the earth from the 'covering' of ionized layers around it.

Some signals will fly out into space, then be reflected back to earth many thousands of miles away, nothing at all being heard of them in the intervening distance (called 'skip distance'). Others add a hop to their skip and are reflected between layer and earth one or more times, thus being received at several locations on their way to their final reception point. The signals in the very, ultra- and super-high-frequency bands are not reflected from the ionized layers, disappearing into the void once they have left the earth's surface. These waves act in a similar manner to optical waves, which do not follow the curvature of the earth but disappear at the 'horizon'. You are probably familiar with the effect of television signals and FM broadcasts which can only be received in Britain within a limited range, fifty miles being about the useful maximum distance. Even then hills, towns and large buildings are liable to deflect them or block them altogether. To sum up, we find that short waves consist of many more wave-bands than the two which we are familiar with on our broadcast receivers, and that each of those bands has some characteristic of its own. This was discovered

some years ago and countries were quick to make use of the fact. By using a different band of waves at different times of the day a world-wide service could be maintained for ships at sea, aircraft or inter-country telegraph and telephone services. Many countries broadcast to the world continuous propaganda of one type or another, some of it interesting and useful, but much of it malicious and mischievous.
Today so many satellites circle the world that long-distance communication is carried out using very high frequency transmissions which are 'bounced off' a satellite and picked up elsewhere in the world at places very remote from their normal range. In this way, for instance, the World Cup competition in football can be seen on TV live from, say, South America or anywhere else throughout the world.

Nevertheless, to the short-wave listener everything is of interest. To people who live in remote parts of the world it is the only link with civilization, whether for the purpose of receiving news, music and entertainment, or for chatting with a neighbour or calling for medical aid. Think, for instance, of the Radio Doctor of the Australian Outback. When I was overseas for some years I had a transmitter operating and was able to keep in touch with my home. I was a 'Radio Amateur' or a 'ham'! It is in listening to 'hams' that so much of the 'fun' in radio comes about. To understand their special jargon called 'radioese', to hear of their experiments, indeed, to receive any of them at all, transmitting with low power at thousands of miles' distance, makes short-wave a fascinating hobby . . . a hobby with a future, because even if it does not make you decide to become a professional radio engineer, you will almost certainly want to progress to the stage of operating your own transmitter one day.

The short-wave amateur radio movement is world-wide and controlled by international regulations. Each country's stations have a call-sign prefix letter. As you probably know, England is G. Scotland and Wales have GM and GW respectively. In the USA and Canada besides the letter, respectively W and VE, a number is added which indicates the State. Here is a list of some of the prefixes. More complete details are given in the RSGB publication *A Guide to Amateur Radio*:

Prefix	*Country*
AC3	Sikkim
AP	Pakistan
BL	Tibet
BV	Formosa
BY	China
CE	Chile
CM, CO	Cuba
CN8	Morocco
CP	Bolivia
CR4	Cape Verde Is.
CT1	Portugal
CT2	Azores
CT3	Madeira
CX	Uruguay
DA, DB, DC, DF, DL, DJ, DK	West Germany
DM	East Germany
DU, DX	Philippine Islands
EA	Spain
EA6	Balearic Islands
EI	Eire
EL	Liberia
EP	Persia (Iran)
ET3	Ethiopia
F	France
FC	Corsica
G	England
GB	United Kingdom (Special uses)
GC	Channel Islands
GD	Isle of Man
GI	N. Ireland
GM	Scotland
GW	Wales
HA, HG	Hungary
HB4, 9	Switzerland
HC	Ecuador
HC8	Galapagos Is.
HE,HBO	Liechtenstein

HH	Haiti
HI	Dominican Republic
HK	Colombia
HL, HM	Korea
HP, HO	Panama
HR	Honduras
HS	Thailand
HV	Vatican City
HZ	Saudi Arabia
I, IA, IB, IC, ID, IE, IF, IG, IH, IL, IP, IZ	Italy
IS, IM	Sardinia
IT	Sicily
JA, JH, JE, JF, JR	Japan
JY	Jordan
K, KN	USA
KA, etc.	US Stations in Japan and Pacific
KL7	Alaska
KM6	Midway Islands
KP4	Puerto Rico
KZ5	Panama Canal Zone
LA, LB	Norway
LU	Argentina
LX	Luxembourg
LZ	Bulgaria
OA	Peru
OD	Lebanon
OE	Austria
OF, OH	Finland
OK, OM	Czechoslovakia
ON	Belgium
OX	Greenland
OY	Faeroe Islands
OZ	Denmark
PA,PE	Netherlands
PJ	Dutch West Indies
PY	Brazil
PZ	Dutch Guiana
SK, SM	Sweden
SP	Poland
ST	Sudan
SU	Egypt
SV	Greece and Crete
TA	Turkey
TF	Iceland
TG	Guatemala
TI	Costa Rica
UAI-6	European Russia
UA9-0	Asiatic Russia
UB5	Ukraine USSR
UC/UO	Russian Republics
UP2	Lithuania
UQ2	Latvia
UR2	Estonia
VE, VO	Canada, Labrador and Newfoundland
VK	Australia and Dependencies, e.g. VK9 — Papua
VP1-7	W. Indies
VP8	Falkland Islands and Dependencies
VP9	Bermuda
VR1-6	British Islands in Pacific
VS5	Brunei
VS6	Hong Kong
VU2	India
W, WA, WB, WN, WV, K, KN	USA
XE, XF	Mexico
XZ	Burma
YA	Afghanistan
YI	Iraq
YK	Syria
YN	Nicaragua
YO	Rumania
YS	Salvador
YU	Yugoslavia
YV	Venezuela
ZA	Albania
ZB2	Gibraltar
ZE	Rhodesia
ZK1	Cook Islands
ZL, ZM	New Zealand
ZP	Paraguay
ZS	Republic of S. Africa, etc.
3A2	Monaco
3V8	Tunisia
3W8	Vietnam, Cambodia
4S7	Sri Lanka
4X, 4Z	Israel
5A	Libya
5B4	Republic of Cyprus
5N2	Nigeria
5W1	British Samoa
5Z4	Kenya
6Y	Jamaica
7X2	Algeria
9G1	Ghana
9H1	Malta
9V1	Singapore

W1	Connecticut, Maine, Mass., New Hampshire, Rhode Island, Vermont.	W9	Illinois, Indiana, Wisconsin
W2	New Jersey, New York	WØ	Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, N. Dakota, S. Dakota
W3	Delaware D.C., Maryland, Pennsylvania	VE1	New Brunswick, Nova Scotia, Prince Edward Islands.
W4	Alabama, Florida, Georgia, Kentucky, N. Carolina, S. Carolina, Tennessee, Virginia	VE2	Quebec
		VE3	Ontario
		VE4	Manitoba
W5	Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, Texas	VE5	Saskatchewan
		VE6	Alberta
W6	California	VE7	British Columbia
W7	Arizona, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming	VE8	Yukon and North West Territories
		VO2	Newfoundland
		VO6	Labrador
W8	Michigan, Ohio, West Virginia		

The joy of short waves is the fact that simple receivers will receive stations from all over the world and a young constructor with a one-valve receiver can hear almost as much at times as one with a larger professional receiver. The fact that must be remembered is that radio waves behave in rather curious ways at times. One minute a band will be 'dead', the next, signals will tumble in from everywhere. They are greatly affected by sun-spots which, it appears, arise in eleven-year cycles of activity. In 1947 their activity was at its maximum and it faded to minimum in 1952 - 3 and returned to maximum in 1958. At the moment of writing (1978) it is at a fairly high level rising to a peak in 1980. Also it must be realized that times vary all over the world. When it is bedtime in England, the people in New York are taking afternoon tea (or is it coffee?). In San Francisco they have only just finished lunch. In Australia they are thinking about getting up on the next morning. In order that you may watch times for reception so as not to be searching for a country which has closed down for the night, I give you the following times relative to *Greenwich Time.* (Remember it must be adjusted for British Summer Time or other local time, as necessary.)

Great Britain, Belgium, France, Portugal, Spain and Ireland	Greenwich Time
Austria, Denmark, Germany, Italy, Norway, Switzerland	1 hour ahead
Egypt, Turkey, South Africa	1½ – 2 hours ahead
Japan	9 hours ahead
Australia	8 – 10 hours ahead
New Zealand	11½ hours ahead
Canada and USA	4 – 8 hours behind

Before discussing constructional details there are some items of general interest. In the way of tools all you need are a screw-driver (two are better, one for ordinary screws and one for grub-screws in knobs), a pair of pliers (again two pairs are better, one larger pair with wire-cutters and a smaller pair with rounded noses for wire turning). One of each will do very well for a start; you can buy more tools as you

progress. 'Bib' wire cutters are also very useful. You require a soldering-iron. I use two, a large electric one for heavy soldering jobs, which I rarely use preferring the other which is also electric and known as an instrument soldering iron. It is small, light in weight and very easy to use with modern small components. I recommend this type to you, therefore, if you are buying an iron. There are many available at reasonable prices. Beginners will need to learn, without a doubt, the radio theoretical symbols given in *Fun with Radio* (see pages 6 and 7). The radio resistor colour code is always in demand by both beginner and expert alike, so that also appears again from *Fun with Radio,* in Fig. 2. As this is not a textbook teaching theory, I recommend you to read: *Foundations of Wireless* by M. G. Scroggie (Iliffe).

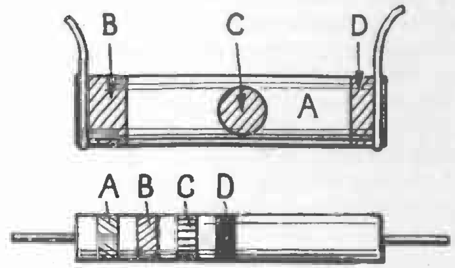


Figure 2

Resistor Colour Code

Colour	*Figure*
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Purple	7
Grey	8
White	9

Read in the following manner:
A or body—first significant figure
B or end—second significant figure
C or spot—indicates the number of noughts following the figures
D or other end—indicates tolerance of the resistor
Gold ± 5%
Silver ± 10%
Unmarked ± 20%
e.g. A = yellow
B = purple
C = orange
D = silver
= 47 kΩ at 10% tolerance

In *Fun with Radio* I called fixed and variable capacitors by that name, whereas in this book I have reverted to the name by which I have always known them – namely, condensers. My copy of *Foundations of Wireless* uses that term. However, the latest copy of the RSGB *Guide to Amateur Radio* says 'capacitors' although 'condensers' occurs in some places. The Americans too favour 'capacitor', so that, they will know, is what I intend by 'condenser'. Finally in the USA a 'moving-coil' speaker is called a 'dynamic' speaker. As we use no other kind today in general save an expensive electrostatic one, any speaker means the same to both nations.

Good luck with your construction and your station 'logging'! May you soon have 'heard all continents'!

Chapter 2

AMATEUR RADIO

If radio is to flourish as a hobby of worth-while and lasting interest, then we must look to keen young amateurs for its future. Join the Radio Society of Great Britain now. It is a step you will never regret.

The Radio Society of Great Britain, known as RSGB for short, says in *A Guide to Amateur Radio* that 'the term "amateur" is, strictly speaking, applied only to persons who hold official licences to operate transmitting stations'. That is a very reasonable description, although many amateurs are professional radio men, and many non-professional 'amateurs' are interested in the hobby without transmitting. These the RSGB describes as SWLs (short-wave listeners), or, if members of the RSGB, as BRS (British Receiving Stations). Now, you can receive broadcast short-wave stations and amateur short-wave stations, if you wish, without being a member of the RSGB. But I am sure you will find your hobby much more enjoyable if you are a member of the national amateur radio society which has over 20,000 members. I am in no way trying to 'sell' membership of the RSGB to you but I am convinced of its importance to the amateur radio movement in Britain. If it is to continue to flourish it must look to you young enthusiasts for its future. In this chapter, therefore, I am going to tell you something about the RSGB and about amateur radio generally throughout the world.

In 1913 the London Wireless Club was founded by a small group of enthusiasts who were interested in the science of communication without wires, then in its early infancy. Telegraphy using Morse code was well known by then but this new technique was 'wire-less'.The name was soon changed to the Wireless Society of London and during the 1914 – 18 War many others besides members of that Society came into contact with wireless transmitting and the rather crude apparatus and valves in use at that time. After the First World War much 'ex-Government surplus' stock was available, and radio experimenting and the Wireless Society of London flourished. Much was done during those years by that Society to assist those keen experimenters who wanted to receive and transmit wireless messages and who also, indeed, wanted to explore and experiment in the new hobby of radio. In 1922 the Society became the Radio Society of Great Britain and it was incorporated in 1926. During these years its keen members made invaluable discoveries in the bands below 100 metres. Their interests and rights have been watched, guarded, fought for if necessary, both nationally and internationally, throughout the sixty-five years of its existence. There is no need for me to tell you more. The literature of the RSGB has the complete story. Their *Guide to Amateur Radio* is invaluable for it tells you about receivers, transmitters, set designs, coil-winding and many other radio matters, including examinations.

You may not operate a transmitter without a licence from the Postmaster General. This costs £5.50 a year and to get it you must pass a comprehensive examination on radio theory, formulae, circuits and transmitters. You must also pass a Morse test,

sending and receiving both at least twelve words per minute. You must be over 14 years of age.

The best thing you can do if you are under 18 is to become an associate member of the RSGB. Then each month you will be sent a copy of their magazine called *Radio Communication*. This will assist you in your studies of both receiving and transmitting. You can also use the QSL bureau which will deal with QSL cards for you, and there are many activities organized by the Society in which you can take part. There are also a number of invaluable RSGB publications as well as ties, badges, note-paper and many other items. If you are interested in joining the Society, write direct to The Secretary, Radio Society of Great Britain, 35 Doughty Street, London, WC1N 2AE.

If you are going to listen to Amateurs and collect the QSL cards which they issue for reports verifying reception, you will need to have the following details of the bands in which they operate:

1.8 MHz (160 metres). Known as 'top-band'. You will receive mainly Morse and telephony from fairly local stations on it. I have heard stations about 300 miles away but up to seventy-five miles is a more usual distance.

3.5 MHz (eighty metres). Somewhat similar to the above band but giving a rather longer distance. In England most of Europe will probably be within its range.

7.0 MHz (forty metres). Long-distance stations will be received at times on this band. There are a lot of broadcasters intruding on it which makes reception a bit difficult. I find it often crowded and noisy.

14.0 MHz (twenty metres). The good all-round long-distance band.Generally there is something going on at all times though it is apt to be a bit 'crowded' at times.

21 MHz (fifteen metres). An excellent day-light band but signals have a habit of disappearing entirely immediately after day-light has gone.

28 MHz (ten metres). Similar to the 21 meg. band. I concentrated on this band when I had a transmitter. It is such an interesting one and I 'worked' stations all over the world.

70 and 144 MHz (four and two metres). Very-high-frequency bands which will not be reflected from the ionospheric layers and will therefore only allow fairly local reception. Their behaviour is similar to that with which we are all familiar in connection with TV and FM stations. Up to fifty miles or so for good reception, with liability to be screened by ranges of hills and reflected from high buildings and so on.

425 MHz (seventy cm.), 1,215 MHz, 2,300 MHz, 5,650 MHz, 10,000 MHz. All these bands need specialized technique and equipment. The first two are used by Amateur Television Transmitters. Much rewarding experimental work can be carried out on these bands, but they are beyond the scope of this book and the present knowledge of most of my readers.

If you are interested in reporting reception of stations on the amateur bands, most stations will generally be pleased to have particulars of any operation you are able to pick up on the 40-metre band and below, or, in frequency, above. On the 160-metre band any station you hear which is a long distance away will be glad to hear from you, but on the other bands it is unlikely that your reports will be over-welcome unless the operator happens to be trying out a new station or aerial and has asked especially for reports from all who receive him. Special expeditions are sometimes glad to have reports of their transmissions. Reports are easily given in the RST code which is as follows:

Readability

R.1.—Unreadable.
R.2.—Barely readable, occasional words distinguishable.
R.3— Readable with considerable difficulty.
R.4.—Readable with practically no difficulty.
R.5.—Perfectly readable.

Signal Strength

S.1.— Faint signals, barely perceptible.
S.2.— Very weak signals.
S.3.— Weak signals.
S.4.— Fair signals.
S.5.— Fairly good signals.
S.6.— Good signals.
S.7.— Moderately strong signals.
S.8.— Strong signals.
S.9.— Extremely strong signals.

Tone Scale for Reporting CW

T.1.—Extremely rough hissing note.
T.2.—Very rough a.c. note, no trace of musicality.
T.3.—Rough low-pitched a.c. note, slightly musical.
T.4.—Rather rough a.c. note, moderately musical.
T.5.—Musically modulated note.
T.6.—Modulated note, slight trace of whistle.
T.7.—Near d.c. note, smooth ripple.
T.8.—Good d.c. note, just a trace of ripple.
T.9.—Purest d.c. note.

If the note appears to be crystal-controlled add X after the T number appropriate. If there is a chirp add C, if a drift add D or if clicks add K. The Tone scale applies only to telegraphy.

You may find some older operators using the old QSA-QRK code but you should adopt the RST version for your reports. There is an International Q code in existence, originally designed for international telegraphic communication. It has obvious advantages in that every nationality understands the same meaning from a code symbol. This I reproduce here.

INTERNATIONAL Q CODE

Abbreviation	*Question*	*Answer or Advice*
QRA	What is the name of your station?	The name of my station is . . .
QRB	How far approximately are you from my station?	The approximate distance is . . . miles.
QRD	Where are you bound and where are you from?	I am bound for . . . from . . .
QRG	Will you tell me my exact frequency in kilocycles?	Your exact frequency is . . . kc.
QRH	Does my frequency vary?	Your frequency varies.
QRI	Is my note good?	Your note varies.
QRJ	Do you receive me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
QRK	What is the readability of my signals?	The readability of your signals is R . . .

QRL	Are you busy?	I am busy. Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (. . . words per minute).
QRS	Shall I send more slowly?	Send more slowly (. . . words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRW	Shall I tell . . . that you are calling him on . . . kc?	Please tell . . . that I am calling him on . . . kc.
QRX	Shall I wait? When will you call me again?	Wait (or wait until I have finished communicating with . . .). I will call you at . . . GMT.
QRZ	Who is calling me?	You are being called by . . .
QSA	What is the strength of my signals?	The strength of your signal is . . . (S1–9)
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt.
QSM	Shall I repeat the last telegram (message) I sent you?	Repeat the last telegram (message) you have sent me.
QSO	Can you communicate with . . . direct (or through the medium of . . .)?	I can communicate with . . . direct (or through the medium of . . .).
QSP	Will you retransmit to . . .?	I will retransmit to . . .
QSV	Shall I send a series of Vs?	Send a series of Vs.
QSX	Will you listen for . . . (call sign) on . . . kc?	I am listening for . . . (call sign) on . . . kc.
QSZ	Shall I send each word or group twice?	Send each word or group twice.
QTH	What is your position in latitude and longitude?	My position is . . . latitude . . . longitude.
QTR	What is the exact time?	The exact time is . . .

MISCELLANEOUS INTERNATIONAL ABBREVIATIONS

Abbreviation	*Meaning*	*Abbreviation*	*Meaning*
AA	All after . . .	N	No.
AB	All before . . .	NW	I resume transmission.
AL	All that has just been sent.	OK	Agreed.
BN	All between . . .	TXT	Text.
C	Yes.	UA	Are we agreed?
CL	I am closing my station.	W	Word.
CS	Call sign.	WA	Word after . . .
GA	Resume sending.	WB	Word before . . .
MN	Minute/minutes.	XS	Atmospherics.
73	Best Wishes.	88	Love and Kisses.

While on the subject of codes I will give you the International Morse code, although if you propose to learn it I suggest you should purchase the RSGB booklet *The Morse Code for Radio Amateurs*. It is written by Margaret Mills (G3ACC) who was a Signals Officer in the WRAF during World War Two. It is one of the best books of its kind available.

INTERNATIONAL MORSE CODE

LETTERS

A	de dah	• —	N	dah de	— •
Ä	de dah de dah	• — • —	Ñ	dah dah de dah dah	— — • — —
B	dah de de de	— • • •	O	dah dah dah	— — —
C	dah de dah de	— • — •	Ö	dah dah dah de	— — — •
CH	dah dah dah dah	— — — —	P	de dah dah de	• — — •
D	dah de de	— • •	Q	dah dah de dah	— — • —
E	de	•	R	de dah de	• — •
É	de de dah de de	• • — • •	S	de de de	• • •
F	de de dah de	• • — •	T	dah	—
G	dah dah de	— — •	U	de de dah	• • —
H	de de de de	• • • •	Ü	de de dah dah	• • — —
I	de de	• •	V	de de de dah	• • • —
J	de dah dah dah	• — — —	W	de dah dah	• — —
K	dah de dah	— • —	X	dah de de dah	— • • —
L	de dah de de	• — • •	Y	dah de dah dah	— • — —
M	dah dah	— —	Z	dah dah de de	— — • •

NUMERALS

1	de dah dah dah dah	• — — — —	6	dah de de de de	— • • • •
2	de de dah dah dah	• • — — —	7	dah dah de de de	— — • • •
3	de de de dah dah	• • • — —	8	dah dah dah de de	— — — • •
4	de de de de dah	• • • • —	9	dah dah dah dah de	— — — — •
5	de de de de de	• • • • •	0	dah dah dah dah dah	— — — — —

PUNCTUATION SIGNALS

Apostrophe	de dah dah dah dah de	• — — — — •
Brackets	dah de dah dah de dah	— • — — • —
Comma	dah dah de de dah dah	— — • • — —
Fractional Bar	dah de de dah de	— • • — •
Full stop	de dah de dah de dah	• — • — • —
Hyphen	dah de de de de dah	— • • • • —
Inverted Commas	de dah de de dah de	• — • • — •
Note of Interrogation	de de dah dah de de	• • — — • •
Separation (used between whole number and fraction)	de dah de de dah	• — • • —
Underline	de de dah dah de dah	• • — — • —

PROCEDURE SIGNALS

Acknowledgment of Receipt	de dah de	• — •
Break Sign	dah de de de dah	— • • • —
End of Message	de dah de dah de	• — • — •
End of Work	de de de dah de dah	• • • — • —
Error	de de de de de de de de	• • • • • • • •
Invitation to Transmit	dah de dah	— • —
Preliminary Call	dah de dah de dah	— • — • —
Understood	de de de dah de	• • • — •
Wait	de dah de de de	• — • • •

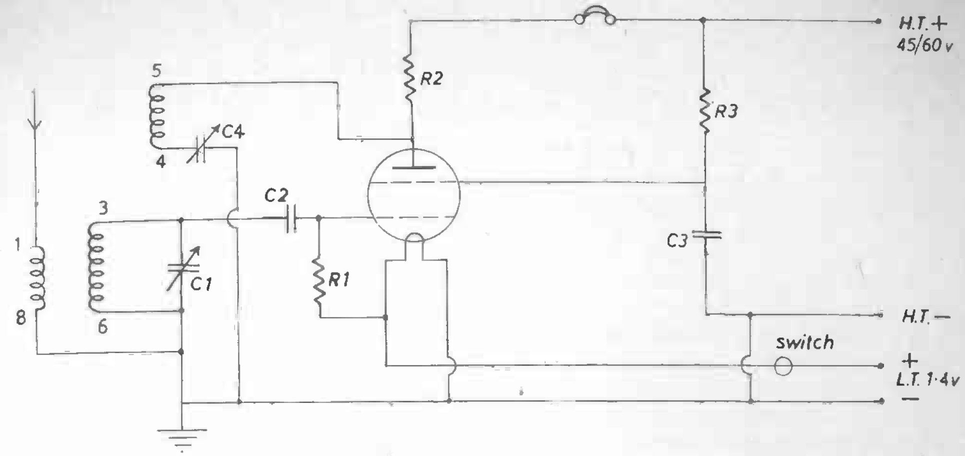


Figure 3 ONE-VALVE BATTERY SHORT-WAVE RECEIVER

Components required:

CONDENSERS:
- C.1. 100 or 140 pF variable (s/wave)
- C.2. 100 pF fixed
- C.3. ·1 μF fixed
- C.4. 100 or 140 pF variable reaction

RESISTORS:
- R.1. 2 MΩ (¼ W)
- R.2. 10,000 (10 k) Ω (¼ W)
- R.3. 47,000 (47 k) Ω (¼ W)

L.1. Coil Denco
Valveholder B7G
Valve 1·4 V pentode (see text)
A/E and phones sockets
On-off switch
Wire, flex, plugs, etc.

NOTE:
See text regarding purchasing of components. It is probable that these will be obtained through Mail Order Houses.

Chapter 3

BATTERY ONE-VALVE RECEIVERS

Here is your first simple and very useful design; a One-Valve Battery Receiver. It is quite safe for you to use headphones with this battery receiver. However, it is better to avoid doing so with a mains-operated receiver.

This is the simplest receiver you can make for listening on the short-wave bands and it uses a small valve operated from batteries. In the United Kingdom today the electricity grid system brings electric current into the remotest homes, even those in country hamlets and outlying farms. As a result valves which we used for many years, and which were once operated from 2-volt accumulators, became obsolete. Battery valves are still manufactured, however, for use in portable equipment and small personal radio sets but again are rapidly becoming obsolete due to the use of transistors. There are two types of these valves available, both taking a voltage of 1·4 on the filament. One type requires 50 mA of filament current and the other 25 mA and you will see from this just how economical they are; the HT voltage is normally 90 volts. These valves are not nearly as efficient as mains valves. Nevertheless they are very useful for a beginner to use in making a short-wave receiver. I repeat here what I have written many times in *Boy's Own Annual*. **If you use headphones do not use them with a mains-operated receiver.** In certain conditions, with certain connections, it is safe to do it. When you are more experienced, you will undoubtedly be connecting them to mains receivers, but at present please accept it as a general rule that it is better not to do it. This then brings me back to the one-valve set and to say that, being battery-operated at 90 volts, it is quite safe for you to use headphones with it. Indeed, you must do so, as a one-valve set will not operate a loudspeaker. (In the next chapter I tell you how to add another valve to enable it to do so.)

The receiver shown in Fig. 3 therefore consists of one-valve of the 1·4 volt type used as a detector valve with reaction which is capable of receiving Morse or telephony signals from all over the world. In the Mullard series the valve to use is the DF 91, DF 92 or DF 96. In the American, or International series, the well-known 1 T 4, or 1 F 2 or 1 F 1. In regard to coils I have used the Denco range for this receiver. Unfortunately, short-wave coils are becoming less and less available, and plug-in coils have almost disappeared. Denco make a useful set of small iron-cored coils which are very efficient. In the United States or Commonwealth you will have to adapt the designs to the coils which are available, though I have no doubt that suitable similar types can be purchased. It is more than likely that Denco or Home Radio can send the coils to you in any country. (Their addresses are given at the end of Chapter 13.) The coils used consist of two; one coil covering from 30 MHz to 10 MHz (or ten metres to thirty metres) approximately, and the other from 12 MHz to 4·5 MHz or twenty-five to sixty-five metres) approximately when tuned with a condenser of about 140 pF. From these figures you will see that the short-wave broadcast and amateur bands of most interest are effectively covered.

Before describing the construction of the receiver I must mention something about the chassis on which it is built. The most effective method is to visit a radio dealer (or write to him) and obtain a small chassis made of metal, almost certainly aluminum. This is the most expensive way and you must have some knowledge of, and have suitable tools for, working in metal, for there are holes to be cut out and drilled. I have always found it very effective, and cheap, and also easy to work, if I use wood covered with metal foil, and I recommend this to you for these battery designs. The way I make the chassis is to take two wooden runners of wood 1 inch square and about 6 inches long and lay them on the bench 10 inches apart. Two pieces of three-ply wood or hardboard are then cut out 10 inches long and 2½ inches wide, and these are laid on top of the runners in such a way that one edge of one piece is level with one end of the runners, and the back edge of the other piece is level with the other end. In between there is a slot which is 1 inch wide. This slot, you will find, is just sufficiently wide to accommodate the B7G valveholder which the DF series valves use. If you use another type of valve it may be necessary to reduce the width of the top-boards slightly in order to form a wider slot. Just try a valveholder in the slot to make sure it is wide enough, and then fix the top-boards to the runners. I always do this with panel-pins, but you can also use small screws. At one end of the runners you have to fix a small panel to accommodate the controls, and this again can be of three-ply wood or hardboard. The size could be 8 inches by 10 inches and it is fixed upright alongside one of the top-boards and screwed or pinned to the ends of the runners. Fig. 4 gives you an idea of the finished chassis.

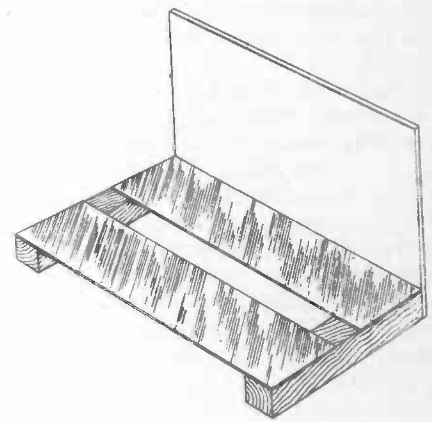


Figure 4. CHASSIS CONSTRUCTION

The aluminum foil which is used for cooking purposes will serve for covering the chassis. No doubt the small amount required can be purloined from the kitchen at home. Glue a piece, preferably with a waterproof-type glue, on to the back of the upright front panel, bring it down and over the top of the front top-board, as far as the slot. The rear top-board can be covered with a small piece of its own, leaving the slot open. You will see now that components on the top of our chassis are shielded from those below it, and *vice versa,* whereas the controls mounted on the panel are shielded from the operator's hands. I have described the makings of this chassis in some detail because it is so cheap, simple and adaptable and can be used for all the simpler designs that you will find suggested in this book.

Now the components can be mounted on the panel and chassis. I cannot give exact measurements for this as different components have varying sizes according to the make you are able to buy. The valveholder, which is of a standard size irrespective of the make used, should however just fit between the two top-boards in the slot. This avoids the need to drill holes, for the wires to and from it will pass easily through the slot. Place the valve-holder to one side of your chassis so that if you want to add one or two more valves, as described in later chapters, you will have enough room to do so. Fixing the coils is simple as they plug into a 9-pin valve-holder which is mounted alongside the holder for the valve.

The purpose of the little slot in the studding fixed in the iron-dust core is to enable you to take a screwdriver or trimming tool and adjust the core for optimum results.

The small components, such as fixed condensers and resistors, are fixed in circuit by their own wiring. It is important in all short-wave work to keep all wiring as short and direct as possible, in particular the wiring in connection with the coils, tuning condensers and grid circuits of the high-frequency and detector valves. Years ago we normally used a reacting detector two-valve-set circuit for short-wave work run off batteries. I paid the price many times for poor wiring. The set would not give a spot of reaction effects anywhere on the dial and in a short-waver this spells disaster. Make sure that components are well placed so that connections from coil to tuning condenser and valveholder are as short as you can possibly make them; if you do this you cannot go far wrong.

You must have a good slow-motion dial or epicyclic drive fitted to the tuning condenser. The latter is probably cheaper than the slow-motion dial but whatever you use, make sure it turns the condenser neatly and slowly with no jerks or signs of 'backlash'. 'Backlash' is rare these days due to improved design but it ruins your tuning if there. When tuning, even with slow-motion control, it is essential to turn the dial as slowly as possible, keeping the reaction control so that the set is not actually oscillating but is at that sensitive point just below the oscillation point. That is when you are receiving *telephony* (speech or music); when receiving *Morse* (telegraphy) the set must be oscillating gently. With a one-valve set such as this it is not wise to attempt to receive telegraphy as the set must not be allowed to oscillate. The aerial is connected directly in the grid circuit of the valve and oscillations caused by reaction enter the aerial circuit. These can be broadcast from the aerial and cause interference in other people's receivers and television sets, and to do this is a breach of the PMG licence conditions. If you are going in for telegraphy, build the three-valve set described later on. It will give you better signals and will not react into the aerial.

Finally, a word or two about batteries. There are available in the United Kingdom, and I am sure in the United States, batteries of 60-volt and 90-volt capacity which have combined in them a section giving 1·4 volts for the filaments. These batteries were designed for the portable sets which used to use these small valves and are intended for intermittent use. Even then they do not have an extremely long life and I do suggest that they are not really suitable for our purpose in experimenting with

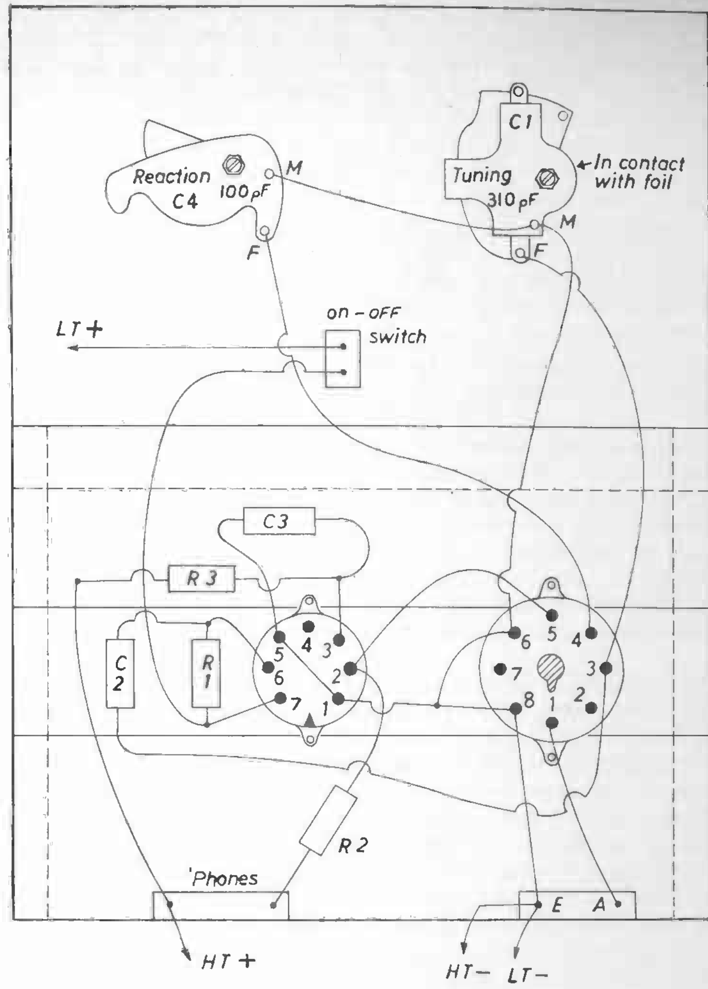


Figure 5

Components required:

CONDENSERS:
C.1. 300 pF variable (s/wave)
C.2. 100 pF fixed
C.3. ·1 μF fixed
C.4. 100 or 140 pF variable reaction

RESISTORS:
R.1. 2 MΩ (¼ W)
R.2. 10,000 (10 k) Ω (¼ W)
R.3. 47,000 (47 k) Ω (¼ W)
L.1. Coil Denco
Valveholder B7G
Valve 1·4 V pentode (see text)
A/E and phones sockets
3-pole, 2-way switch
On-off switch
Wire, flex, plugs, etc.

short-wavers. A much larger size battery is desirable and I advise you to obtain as large a 1·5 volt cell as you can for the low tension (known in the United States as the 'A' battery) and as large a capacity battery as you can afford for the HT battery (in the United States this is the 'B' battery). If you are going to add a valve to work a loud-speaker you want 90 volts; otherwise for the one-valve set only 60 or even 45 volts will do.

This is a long chapter but I believe an important one because many readers, introduced to short waves by this book, will be building a simple one-valver as their first short-wave receiver. Take every care with the construction and tune it carefully and you are certain to obtain good results. Remember what has already been said about the vagaries of the bands due to atmospheric conditions. Listen at the correct times of day for the countries you want and you cannot possibly fail, even with a simple one-valve receiver.

THE H.A.C. ONE-VALVER

At one time in short-wave work the initials H.A.C. meant Heard All Continents, a much-prized success in days when receivers were less efficient and stations less numerous and powerful. Today it is possible to hear all continents (provided one listens at the correct times!) by simply using a one-valve set. This commercial kit is just the set for the amateur.

It is a complete kit of parts which has been on the market for years; difficulties may be experienced in obtaining components but this set provides a very useful method of purchasing all the necessary items for constructing a modern one-valve short-wave set.

Despite my statement at the beginning of Chapter 2 that 2-volt valves are obsolete, this kit uses one, an HL23DD type which is actually supplied as an AR8. This is a so-called Government Surplus valve which operates admirably in this one-valve receiver. Ideally it should be supplied with 2 volts on the filament from a 2-volt accumulator but these are very rare today. The arrangements therefore is for 3 volts to be supplied from a cycle-lamp battery (type Ever-Ready No. 800) and a resistor is wired into the receiver which will drop the voltage down to the required two.

The theoretical diagram is similar to Figure 3 and a full wiring diagram is included in the kit. High tension of 60 to 90 volts is required and a useful size still available is the 90 volt Ever-Ready battery type B.126. An aerial is necessary and so is an earth and careful tuning is required. The main trouble with a simple receiver like this is selectivity but it is a most enjoyable little set to use and can be highly recommended as an introduction to short-wave radio. Indeed, more sophisticated short-wave enthusiasts who would like the challenge of finding out how many long-distance stations they can pick up on a simple one-valve set will also enjoy it.

The kit is purchased direct from H.A.C. Products whose address is in the Appendix. Neither the Editor nor I have any interest in this, or any other product we recommend, other than inviting your attention to its availability.

Chapter 4

BATTERY VALVE AND TRANSISTOR RECEIVERS

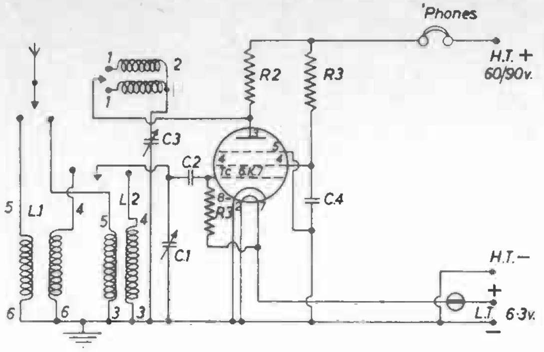
Here are three more designs for battery-operated receivers. The valve is a mains valve, however, run as a battery valve off a heavy-duty battery known as the 'Lantern' battery. It is often used in series to provide 12 volts for running model trains.

This chapter deals more with sets of an experimental nature than the one-valve receiver. It is generally agreed, I feel, that the 'fun' which we get out of radio comes mainly from experimenting and from comparing the results. In Chapter 3 we dealt with one-valve sets which are battery-operated but which due to the limitations of the low current taken by the valve used are only nominally efficient. In radio, as in everything else, we only get results comparable with the effort put in, and also in direct ratio to the cost. A battery valve of the 1·4 volt series takes very little current, costs little to run and compares rather poorly with a mains valve. The latter, on the other hand, takes an enormous current very often, but, in return, is enormously efficient. Thanks to cheap electric current it is, nevertheless, moderate to run, though the outlay in providing the apparatus to supply the current might be initially rather high.

To a certain extent we can capture some of the efficiency of the mains valve by still using batteries with their attendant simplicity and safety, thanks to a heavy-duty battery which is on the market in Britain and, no doubt, elsewhere in the world as well. It is called here the 'Lantern' battery and readers are probably familiar with it when used in series to provide 12 volts for running model trains. Its primary purpose is for use in a 'lantern' torch which country-dwellers still use quite frequently. It will supply a respectable current at 6 volts and can thus be used to heat a mains-type valve which requires 6·3 volts at either ·3 or ·2 amp. current according to type. A valve of this type is rated at 250 volts HT on the anode but for a one-valve set a voltage between 90 and 120 will do very well, with the added advantage of keeping current requirements down.

I have given you a design for a one-valver based on mains valves but run as a battery valve from the Lantern LT battery. The first (Fig. 6) is a highly successful experiment and uses the 6 J 7 (or 6 J 7 G) valve giving a circuit basically the same as the set described in Chapter 3. This valve is an 'International Octal' type and was at one time obtainable all over the world. I have based my design exactly on that of Fig. 3 and only the valve is different.

The diagram in Fig. 6A shows the connections which were correct in the original Osmor coils but are slightly different now. Some shops may, of course, have the older coils so that you should check from the slip supplied with the coil that you are connecting up correctly. Figs. 3 and 5 both feature the latest connections so follow them for this design if your coils are the latest type. The 6 J 7 valve is obsolete but still

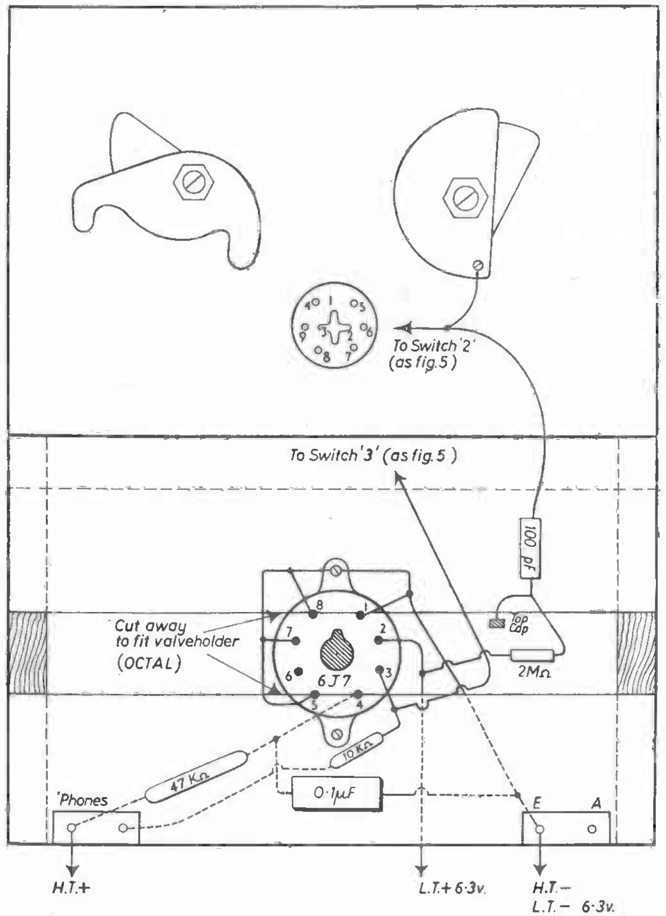


Components required:
CONDENSERS:
C.1. 100 or 140 pF variable (s/wave)
C.2. 100 pF fixed
C.3. 100 or 140 pF variable reaction
C.4 ·1 μF fixed

RESISTORS:
R.1. 2 MΩ (¼ W)
R.2. 10 kΩ (¼ W)
R.3. 47 kΩ (¼ W)
L.1. Coil SWQ1 } Osmor Radio Products
L.2. Coil SWQ2 }
Octal-base valveholder
Valve (see text)
3-pole, 3-way switch
On-off switch
A/E and phones sockets, wire, etc.

Figure 6A. ONE-VALVE RECEIVER

Figure 6B



obtainable in some 'surplus' shops. You are much more likely now to purchase the modern miniature valve such as EF 80, EF 85 or EF89. Therefore in Fig. 7 you have the connection details for these valves with a chart showing the comparison with the 6 J 7. In Fig. 6B you should be able to substitute the correct connecting points if you use one of these modern type valves. You can, of course, run this one-valve set from suitable mains-power supplies feeding its output into one of the amplifiers described in Chapter 7. If you do this, do **not** use an EF 80 for the detector as it is a 'high-slope' valve and may be unstable.

You can build a simple amplifier for the one-valve battery set shown in Fig. 3 in order to give louder signals in the phones or maybe operate a loudspeaker. This is shown in Fig. 8 and can be fitted in alongside the detector in the chassis shown in Fig. 5.

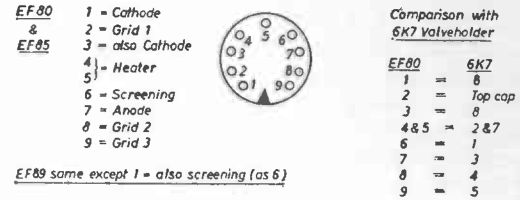


Figure 7

Components required:
Valve: DL96 battery output pentode (Mullard)
CONDENSERS:
C.4. 8 μF electrolytic (150 V wkg.)
C.5. ·01 μF (paper or mica)
C.6. 50 μF electrolytic (12 V wkg.)
RESISTORS:
R.4. 10 K (¼ watt)
R.5. 20 K (¼ watt)
R.6. 0·25 Meg potentiometer
R.7. 1 K (¼ watt)
R.8. 1·1 K (¼ watt)
Seven-pin valveholder, on-off switch (can be combined with R.6)
terminal boards, wire, flex, etc.

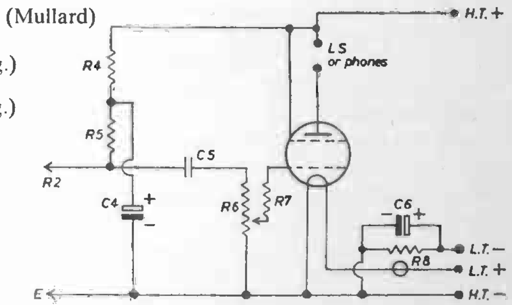


Figure 8. BATTERY AMPLIFIER

I am often asked by readers for a short-wave transistor receiver, but a simple design is not easy to produce. Transistors are best used in a superhet. circuit as described in Chapter 9. It is possible that you have seen the pocket transistor receiver design for medium-wave reception described in Chaper 4 of *Fun with Transistors*. Many readers wrote to tell me that they had used this successfully for short-wave reception by winding special coils with fewer turns than those specified. You could try this but the transistor used in that design is not a special short-wave type, and you would not obtain very good results at the shorter wavelengths.

I have adapted a popular circuit, sometimes used for experimental pocket portables, as a transistor short-waver. It is shown in Fig. 9. I have used an Osmor short-wave coil, as in the one-valve receiver, an SWQ 1 or SWQ 2. A short aerial would be needed and an earth could be connected to pin 1 of the coil. The transistor Tr. 1 should be a special short-wave type such as the Mullard OC 170 and Tr. 2 would be the customary OC 71. The diodes are Mullard OA 81 type and should be good ones. Feedback or reaction would be controllable by R. 2, using it in the same manner as the reaction condenser in the one-valve receiver. I hope you find this design an amusing experiment and gain some experience in using transistors.

In revising this book in 1978 the Editor and I have not altered this chapter on 'experimental' designs although I am aware that OSMOR coils and mains valves are probably not available any longer. But the experimenter can adapt a design to use coils such as Denco 'Green' types or other coils which may be available locally in other parts of the world. Many readers, I realize, have valves, coils and other components given to them by relatives and friends and so I make no excuses for leaving these designs in the book!

The receiver in Fig. 9 could be tried as a short-wave set by using a ferrite-rod and some *insulated* wire of, say, two turns for 1 - 2, four turns for 3 - 4 and two turns for 5 - 6 wound on a piece of paper over 3 - 4. It may work! Why not try it? It will provide much pleasure.

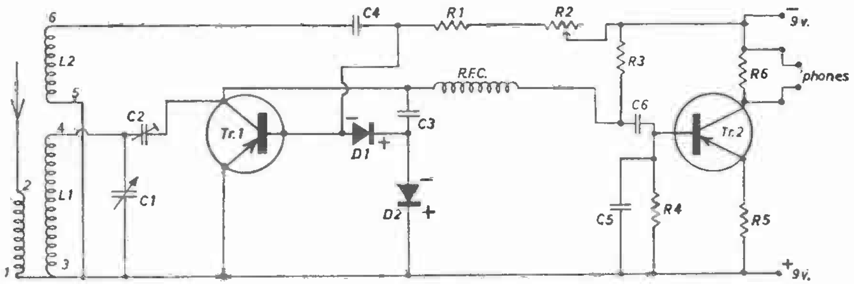


Figure 9. TRF TRANSISTOR EXPERIMENTAL RECEIVER

Components required:
Coil: SWQ1 or SWQ2 (see text) Osmor

CONDENSERS:
C.1. 100 or 140 pF s/wave variable
C.2. 60 pF pre-set or trimmer
C.3. 270 pF fixed
C.4. 1000 pF fixed
C.5. 0·01 μF fixed
C.6. 0·1 μF fixed

RESISTORS:
R.1. 100 KΩ
R.2. 1 MegΩ variable
R.3. 220 KΩ
R.4. 10 KΩ
R.5. 100 Ω
R.6. 5·6 KΩ

Diodes:
D.1. and D.2: OA81 by Mullard

Transistors:
Tr.1. OC 170 Tr.2. OC71 both by Mullard
R.F. Choke suitable for short-wave work. (RFC)
Wire, terminal boards, earpiece (etc.)

Chapter 5

MAKING A TWO-VALVE SHORT-WAVE RECEIVER

Now we deal with the possibility of amplifying the signals from the small one-valve receiver. At the outset, remember that electricity is a very dangerous thing and rarely gives you a second chance. Be sensible and careful. NEVER neglect the simplest precautions. We cannot stress this advice too strongly.

As you read in Chapter 2, much of the investigation into, and development of, short waves was done by amateurs who were experimenting in the 1920s. In those days the popular type of receiver used was the two-valve set and considering the relative inefficiency of the valves of the day, some phenomenal reception was obtained with such simple receivers. Thanks to mains-type valves, today we can build a two-valve receiver which will receive the world as a matter of course. In modern conditions of band crowding, however, its selectivity leaves much to be desired. A design for such a receiver is given in Figs. 10 and 11 and it utilizes a pentode detector feeding into another pentode for audio-frequency amplification and out-put. The first valve is an RF pentode. I have chosen one of moderate slope for stability, whilst the output valve is a high-slope valve capable of converting small signals into powerful output ones. The coils are of a plug-in type for efficiency and economy. We save the cost of a switch and not all the coils need be bought at one time.

These coils are the miniature dual-purpose coils made by Denco and plug into a nine-pin valveholder. Each coil is supplied in a metal box which can be used as a screening can, but we do not use such screening in this receiver. The coils in this range are coloured according to type and the GREEN series is used for this design. There are five coils covering 10 metres to 2,000 metres so that on this receiver you can listen to medium and long waves as well as short. A very useful set to build for your own room!

There is little to tell you about the building of the receiver as the schematic diagram combined with the wiring diagram should make everything clear. The same style of metal-covered wooden chassis is used as shown in Fig. 4, but if you wish to use an all-metal chassis with a front panel of metal or foil-covered plywood this will be in order. You will have noticed that the receiver does not incorporate its own power supplies. These have to be obtained from a separate unit such as that shown in Chapter 7. I have always found this best as it means one has only to spend money on one set of components instead of repeating them in each receiver built. The two mains valves take rather a heavy current both for heaters and anode supplies so that the use of dry batteries is not feasible.

In the more remote areas of the Commonwealth, where mains supplies might not be available, the heaters could run off a six-volt accumulator such as a car battery and high tension from a converter. Note that one side of the heater supply is earthed at

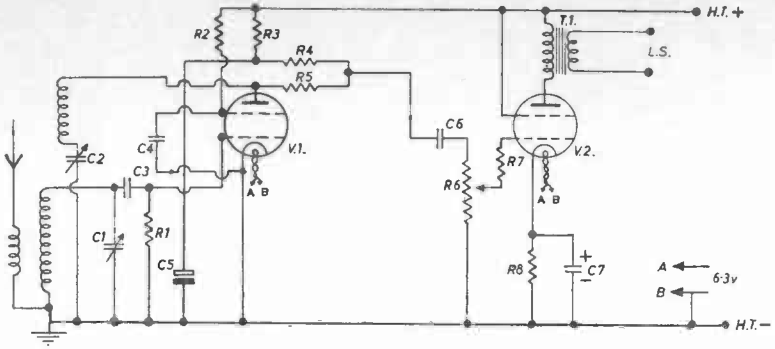


Figure 10. TWO-VALVE RECEIVER

Components required:

Coils: 'Green' series by Denco (see text)
Valves: V1: EF89: V2: EL84: both by Mullard

CONDENSERS:
- C.1. 300 pF short-wave variable
- C.2. 100 or 140 pF short-wave variable reaction
- C.3. 100 pF fixed (mica or ceramic)
- C.4. 0·1 μF fixed (paper)
- C.5. 8 μF electrolytic 250 V wkg.
- C.6. 0·1 μF fixed (paper)
- C.7. 50 μF electrolytic 50 V wkg.

RESISTORS:
- R.1. 2 Meg Ω (¼ watt)
- R.2. 47 KΩ (½ watt)
- R.3. 22 KΩ (½ watt)
- R.4. 47 KΩ (½ watt)
- R.5. 10 KΩ (½ watt)
- R.6. 0·5 MegΩ variable
- R.7. 4·7 KΩ (¼ watt)
- R.8. 210 Ω (3 watt)

T.1. Output transformer (to match L.S. and E.L. 84)
2 nine pin valveholders—that for V.1. skirted.
Knobs, terminal boards, wire, etc.

the detector valve-holder so that it must be ensured that the heater supply is not earthed at the mains unit. The design in Chapter 7 is not, but another type of one purchased may be, and, if so, the remedy is simple – omit the lead between tags 5 and 6 on the valveholder.

Wiring-up can be done with 22 swg tinned copper wire and it is advisable to cover all except the very short leads with plastic sleeving. Remember that in short-wave work particularly it is essential to keep the leads when wiring up as short as possible. The volume control (R.6) is connected to its valve by means of a special piece of screened lead. The inner lead connects to one end of R.7 (which connects to the grid of the valve) and the slider of the volume control. The outer sheath is earthed and thus the connection is screened. We use a couple of electrolytic condensers in this receiver. Do not forget that they are polarized and that the negative side (marked '—' or black, or case) is always connected to HT negative.

You will need a small loudspeaker for this receiver. For long distance work super quality will not be called for so that one of five inch diameter will do in quite a simple cabinet. This is a powerful little receiver which I am sure you will enjoy using. If, however, you prefer to keep to batteries the next chapter describes a three-valve set using the old 1·4 volt series valves.

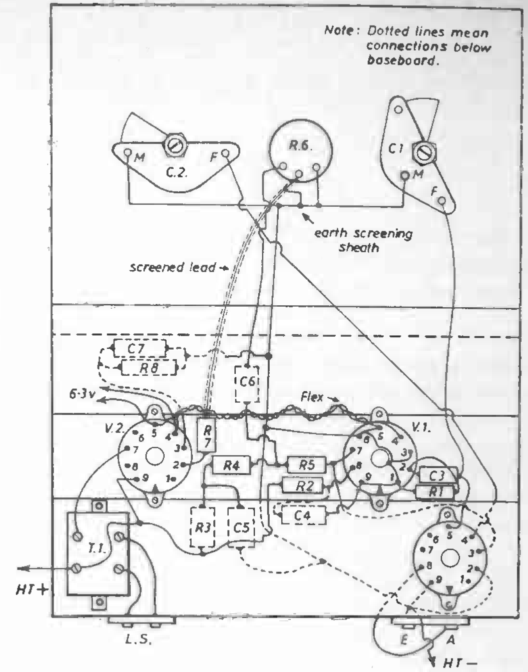


Figure 11. WIRING DIAGRAM — TWO-VALVE RECEIVER

Chapter 6

THE THREE-VALVE SHORT-WAVE RECEIVER

We go one stage further now and add Radio-Frequency Amplification to our set. This is not and elaborate design at all and keen radio enthusiasts will get a great deal of fun from building the set and experimenting with it.

In this chapter I am going to take you a stage further to add radio-frequency amplification to a two-valver comprising the detector in Fig. 3 plus the amplifier in Fig. 8. Briefly, as I expect you know, the radio-frequency amplifier amplifies the signals before they are detected and made 'audible' by the detector, and the audio-frequency amplifier amplifies them after detection. Naturally you wonder why you need both types and not just loads of one or the other. I must refer you to your textbook for the answer to this. On short waves radio-frequency amplication is some-what difficult to apply and may, if you are not careful, result in attenuation, i.e. a loss in signal strength instead of an increase.

New valves and techniques today are assisting in overcoming the difficulty but, in general, for steady reliable reception (such as is necessary on board ship or in aircraft) the superheterodyne communications receiver is the modern answer. For keen amateurs the trouble with those is mainly expense, so we get much fun out of building simpler designs with which we can experiment quite easily.

I expect you will recall that in Chapter 3 I mentioned the fact that you should not allow the receiver to oscillate as it caused radiation from the aerial which would upset other receivers and TV sets in the neighbourhood. By isolating the aerial from the regenerative circuit it is possible to allow the set to oscillate without causing interference to others, and there are one or two ways in which the radio-frequency stage before the detector, which is the way in which the aerial is isolated, can be set up.

First of all, however, I must point out, in all fairness, that there is not going to be a great deal of amplification from this stage. The RF pentode valve used, which is the same as the detector, DF 91/2/6, etc., is, as we have already indicated, fairly inefficient and will not boost signals a great deal at these higher frequencies. However, it has a great deal to recommend it because, apart from the advantage of allowing you to use full reaction for Morse reception and so on, the effect of isolating the detector from the aerial improves its working, particularly in regard to reaction control as the aerial loading is removed and 'dead-spots' where reaction dies off are removed, too. It is agreed, then, that even if there is not going to be a great deal of amplification from the RF stage, it is worth while, and there are two forms which it can take.

The first circuit is an aperiodic one and is illustrated in Fig. 12. A simple RF pentode with an RF choke in its grid circuit and another in its anode circuit. One or two resistors and condensers for decoupling complete the picture. You will see that

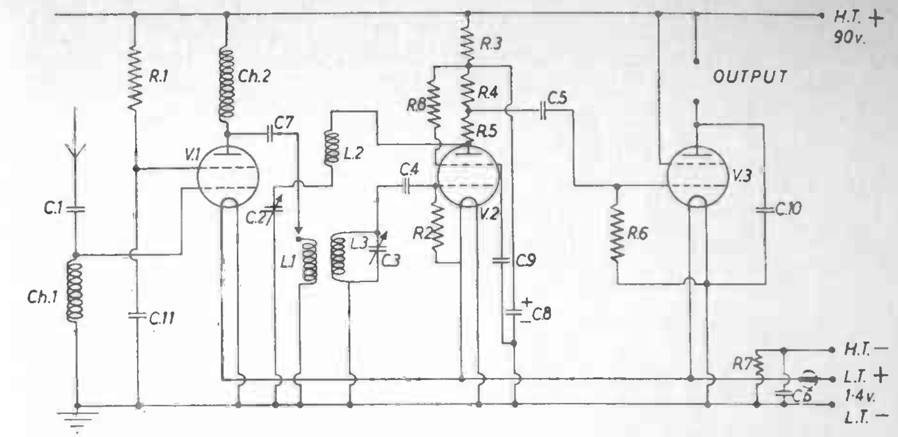


Figure 12. THREE-VALVE TRF APERIODIC RF STAGE SHORT-WAVER

Components required:

CONDENSERS:

C. 1. 100 pF fixed
C. 2. 100 or 140 pF variable reaction
C. 3. 300/310 pF variable (s/wave)
C. 4. 100 pF fixed
C. 5. ·01 μF fixed (150 V)
C. 6. 2 μF fixed (150 V)
C. 7. 100 pF fixed
C. 8. 2 μF electrolytic (150 V)
C. 9. ·1 μF fixed (150 V)
C.10. ·005 μF fixed (mica)
C.11. ·1 μF fixed (150 V)
Ch.1. S/wave RF choke
Ch.2. S/wave RF choke

RESISTORS:

R. 1. 47 k (¼ W)
R. 2. 2 M (¼ W)
R. 3. 47 k (¼ W)
R. 4. 100 k (¼ W)
R. 5. 10 k (¼ W)
R. 6. 1 M (¼ W)
R. 7. 370 (¼ W)
R. 8. ·25 M (¼ W)

L.1/L.2/L.3. Coil – Denco (Green series)
3 B7G valveholders
Valves (see text)
On-off switch, dial, knobs, etc.

the aerial is connected to the top, that is the grid end, of the RF choke, the other end of which goes to earth. The signals coming in from the aerial are thus impressed on the grid of the first valve and amplified by it, leaving at the anode where the other choke prevents them from passing into the high-tension but guides them through the 100 pF condenser into the coil. This coil was the aerial coil in the one-valve receiver, but now becomes the intervalve coil and is still tuned by the same single 300 pF condenser as before. It is obvious that we have no choice of tuning any particular signal in the grid circuit of the RF valve. They all come in together and it is not until we come to tune the intervalve coil that we obtain any chance of merely tuning in the one station we want. This places something of a strain, metaphorically, on that circuit as the whole selectivity of the set is dependent upon it, and it is very rarely that it is able to provide the station selection properties we require.

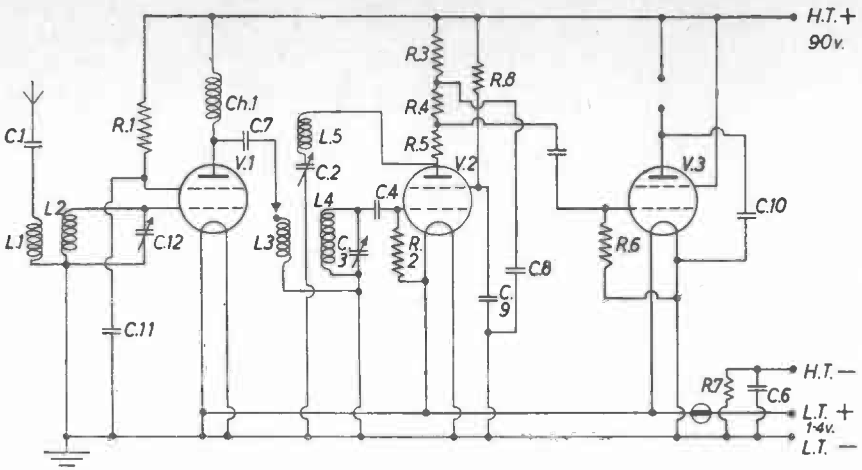


Figure 13. THREE-VALVE TRF SHORT-WAVE RECEIVER FOR BATTERIES

Components required:

CONDENSERS:

C. 1. 100 pF fixed
C. 2. 100 or 140 pF variable reaction
C. 3. 300/310 pF variable (s/wave)
C. 4. 100 pF fixed
C. 5. ·01 μF fixed (150 V)
C. 6. 2 μF fixed (150 V)
C. 7. 100 pF fixed
C. 8. 2 μF fixed (150 V)
C. 9. ·1 μF fixed (150 V)
C.10. ·005 μF fixed (mica)
C.11. ·1 μF fixed (150 V)
C.12. 300/310 pF variable (s/wave), preferably ganged with C.3.

RESISTORS:

R. 1. 47 k (¼ W)
R. 2. 2 M (¼ W)
R. 3. 47 k (¼ W)
R. 4. 100 k (¼ W)
R. 5. 10 k (¼ W)
R. 6. 1 M (¼ W)
R. 7. 370 (¼ W)
R. 8. ·25 M (¼ W)

L.1/L.2 and L.3/L.4/L.5. Coils. Denco, plug-in L.1/L.2 Blue series, L.3/4/5 Green series.
3 B7G valveholders
Valves (see text)
Chassis, switch, sockets, wire etc., knobs, S/M dial

To overcome this we use the circuit of Fig. 13, and unless you wish to be extremely economical in your set building or wish to experiment with all circuits, I advise you to disregard the Fig. 12 design and build according to Fig. 13. In this design the grid circuit has a tuning coil connected in the same manner as the intervalve coil. This coil is tuned by another 300 pF condenser and the advantage of this is that it is possible to tune exactly to each station required. Selection is improved, and by tuning to resonance of each station the amplification at the frequency of the station so tuned is improved enormously to the exclusion of all others, another point which assists in improved selectivity. Now to discuss the methods of tuning the two circuits: one in the grid circuit of the RF valve and the other in the grid circuit of the detector. As I mentioned in Chapter 3, I have used separate condensers and, although I must admit I have had many years of experience at this type of tuning, it is by no means difficult

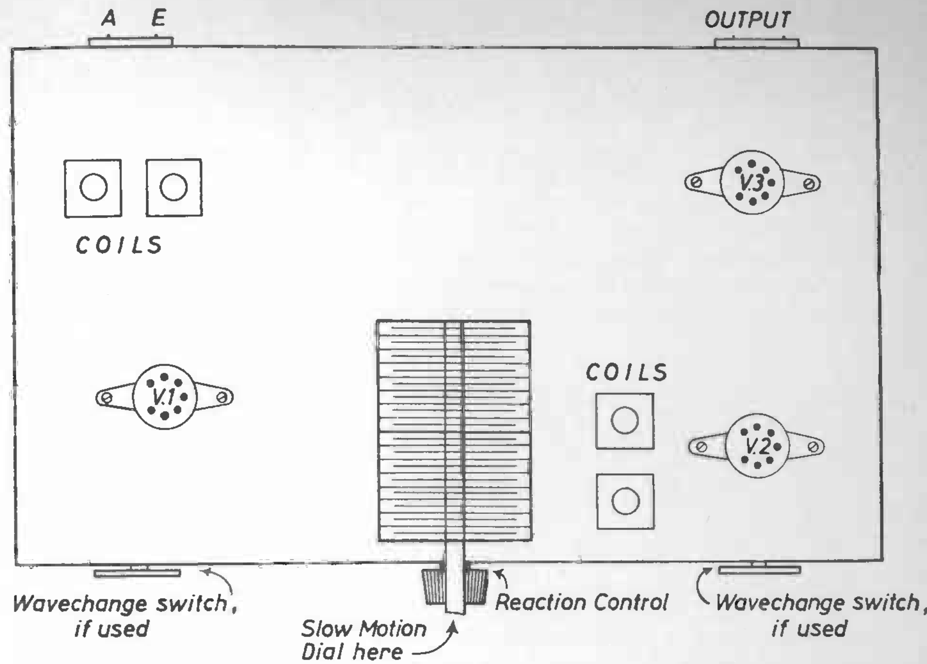


Figure 14

to keep the two circuits in tune. The right-hand or detector condenser is the one which tunes more sharply and it is fairly easy to concentrate on tuning in stations carefully on this dial whilst 'following along' with the left-hand condenser. The coils are the same and if the condensers are also of the same manufacture as each other the two dials should keep roughly in step. When the selected station is decided upon on the right-hand dial, the left-hand one can be tuned carefully to resonance and thus maximum volume.

Now it may be that you have decided to build the three-valve set right away without going through the stages of one-valve set, two-valve set, and so on. If you do this you will probably decide that it is a better idea to build the set in the really up-to-date manner with a gang-condenser for tuning. The layout is a little different where the dual condenser is used so I have included Fig. 14 to give you a suggested arrangement.

You will note that the coils are placed well apart and one set each side of the condensers so that the latter act as a screen between.

All that has been said before about batteries, operation from the mains and tuning will also apply to this receiver. More than ever is it now desirable to use larger capacity batteries, as the total current demands, although not high by most standards, will soon run down a small battery usually intended for use with the 1·4 volt type of valves. A mains unit for HT is very desirable to avoid the recurring cost of new HT batteries. The next chapter deals with this.

Chapter 7

MAINS POWER UNITS AND AMPLIFIERS

Battery-operated sets are ideally safe, but for low running costs you will have to consider operating from the mains, with all precautions taken and used constantly. We recommend that you build a quality mains unit which provides HT for any battery set.

Before proceeding to mains-driven receivers I feel it is important to give some consideration to the difference between the two types and the advantages one kind might have over the other. First of all, let us look at battery-operated sets: they are cheaper to build, and more expensive to run because of frequent battery renewals, but they do not suffer from hum and instability troubles which can occur in a mains receiver. They are less efficient and will not give as great a volume as the mains type.

For the beginner the battery-operated set is ideally safe and it is always a delight to use headphones on it because of the dead silent background. To my mind it is a pity that 2-volt valves are now obsolete; they were always so useful in a short-wave receiver. In parts of the Commonwealth no doubt readers are still using these valves and enjoying their silent background, judging by the interest shown in 2-volt valve designs among the many letters I receive.

Considering mains-driven receivers, the first point no doubt is the low running costs which mains-operating gives. Add to this the high efficiency of these valves and all other considerations are of little importance. The receiver must be designed in such a way as to overcome other objections like hum and instability, and unless it does this it is not going to be very easy to handle or pleasant to listen to. In accordance with modern practice it is not considered possible or desirable to give wiring diagrams for the more complicated receivers. By now readers should have learned the theoretical symbols and should be able to translate them into practical receivers. In future diagrams I will merely give the theoretical, or schematic, diagram and a suggested layout for the components. With the diversity of components available and the high efficiency of modern valves it is just not practicable to indicate the wiring from point to point. It is neither fair to the designer nor to the reader to do this, as in these sets a wire an inch or so either way may completely ruin the expected performance of a design.

To return to mains-operated receivers I would say that it is possible to operate a battery-valve set from the mains for HT purposes, retaining the battery for the filament heating. This does not convert the battery valves into mains types with their improved characteristics, but it does save having to buy expensive HT batteries from time to time. It also provides a slightly higher voltage without the steady drop which occurs during the life of a battery. The first design in this chapter is for a mains unit which will provide HT and will also give 6·3 volts for the heaters of mains-type

valves. When, eventually, you wish to build a mains set you have a mains unit already available. I am describing the rather more powerful type of unit here as a simpler one for battery sets only is described in Chapter 9 of *Fun with Radio*. I think you will agree that, for experimenting with different types of receivers, the best method is to have a quality mains unit which can be coupled up to any receiver built. The power requirements of most receivers are about the same so that having the unit always available saves the expense and work involved in building the power side into each receiver constructed. Fig. 15 gives a power unit equal to almost any task delivering an output of around 250 volts at 70 mA, and 6·3 volts at 2 amps., the latter only being needed when it is driving a set incorporating mains-type valves. For battery-type valves the voltage is far too high and if you intend to use it with the battery two- or three-valve set you will have to cut the voltage down considerably.

To do this make up a potential divider consisting of three six thousand ohm 10 watt resistors connected in series to make one large resistor of 18,000 ohms. The two free ends should be connected between HT+ and HT−. An 8μF electrolytic condenser should be connected between HT− and the junction of the first two resistors up from HT−. In other words it is across the resistor which has one end connected to HT− and the other connected to a second resistor. The positive side of the electrolytic condenser should now provide an HT of around 90 volts to work a battery set.

Make a good job of building this HT unit and place in it some form of cabinet or box. **These voltages are dangerous; bear that always in mind, and take every care to safeguard yourself and others from them. It is very unwise to use headphones with mains units and it is better, with mains power available, to build a proper amplifier and to operate a loud-speaker from it. NEVER take risks.**

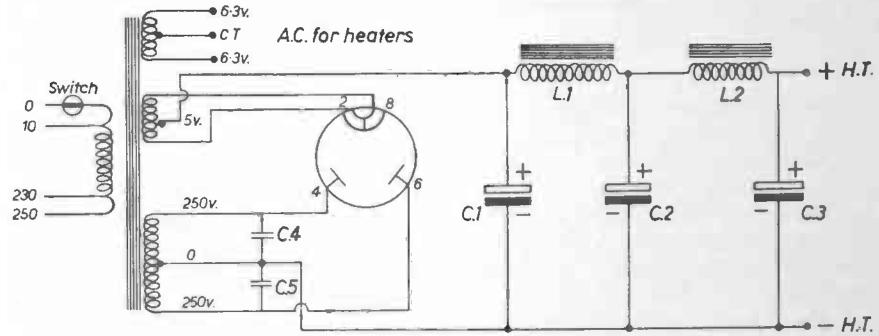


Figure 15. MAINS TRANSFORMER
250-0-250 V, 60/70/80 mA as required, 5V 2a, 6·3 V 3a

Components required:
C.1. *C.2.* *C.3.* 8 μF 500 V working electrolytic condensers (or 1 treble condenser)
C.4-C.5 0·1 μF1,000 V wkg.
L.1. L.2. Smoothing chokes 70-80 mA

Chassis for mounting
Valve: 5Z4, octal valveholder
Or EZ80 and 9-pin valveholder. If EZ80 rectifier is used C.1. and C.2. could be 50 μF each and L.1. a 3,000 Ω resistor also 5 v wdg. should be 6·3 v
On-off switch
Terminals

There is no doubt that many younger readers regard valves as nothing more than a curio from the past, and they will start their radio experimenting with transistors. For them the mains unit just described will have no interest, as transistors are usually worked from batteries of about 9 volts EMF. It is useful, however, when experimenting to have a source of mains supply to avoid run-down batteries or the cost of replacing them. A very suitable unit is available complete from Newmarket Transistors Ltd. It gives an output of 12 to 15 volts, according to load, and is shown schematically in Fig. 16, known as PC 106. The advantage of this unit is that it uses a double-wound transformer so that there is no direct contact with the mains. Available from the same makers are PC 101 giving 9 volts and PC 102 supplying 21 volts for the more powerful transistor amplifiers.

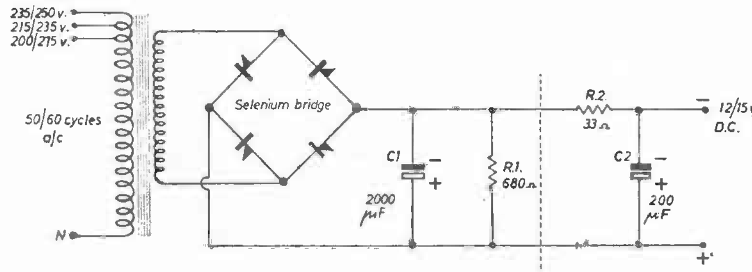
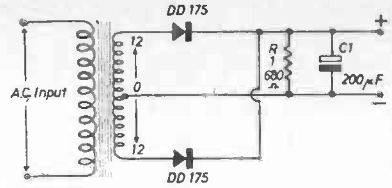


Figure 16. 'NEWMARKET' P.C. 106 TRANSISTOR POWER UNIT

Components required:
Transistor power unit: P.C. 106 (Newmarket Transistor Co. Ltd.)
R.2. 33 Ω
C.2. 200 μF electrolytic 25 V wkg. (C.1. and R.2. are in unit)
Small board and terminals for connection: also on-off switch.
(Preferable to mount whole unit in an enclosed box.)

If you have a transformer giving 12 or so volts and would like to use it to make up a mains unit, details are given in Fig. 17 of one utilizing two DD 175 rectifiers made by the International Rectifier Corporation. Actually the winding shown is a centre-tapped 24 volt one but if you have only a single winding then a bridge circuit can be used but four rectifiers are then needed. International Rectifiers supply the DD 175 in packets of four with a booklet showing circuits. These rectifiers are silicon whilst the Newmarket pack uses a selenium one. In regard to Fig. 17 some designs I have seen have a 390 OHM resistor and 0·25 μF condenser connected in series across the full transformer winding before the rectifiers. You might like to try this.

Having acquired a good mains power unit, it is now a sound idea to build a small mains-valve type amplifier. In all radio sets there are power-supply components and the audio-output section which feeds the loudspeaker. Thus if we build both of these as separate items we can feed the output from any radio-frequency and detector stages we build into the amplifier, and thus avoid the continual expense of duplicating the power and audio amplifier requirements in every set we construct. There is no objection to taking the out-put from a battery one-valve set, if you wish, into the amplifier. The filament of the battery valve can still be lit by a battery. As to the type of amplifier there is a wide choice before us, although there are two categories from which we can choose. Either we can build an amplifier which is very sensitive and



Components required:
Transformer to suit mains voltage with output 12-0-12 volts.
2 Silicon rectifiers—DD 175 (International Rectifier Corp.)
R.1. 680 Ω (1 watt)
C.1. 200 μF 25 V wkg. (electrolytic)
Small board terminals, on-off switch, etc.
(Preferable to mount whole unit in an enclosed box.)

Figure 17. INTERNATIONAL RECTIFIER CORPORATION TRANSISTOR POWER UNIT

gives a large output from a small input, although the quality of that output is not of the highest order, or we can have one which is in the high-quality class and gives first-class reproduction but is not of such high sensitivity, maybe, as the former. Of the first type I give you the schematic and suggested layout diagrams in Fig. 18. This is a small, neat unit which can be tucked away somewhere and run off your power pack giving a large output for a very shall input – just what is required for short-wave work, perhaps, where signals received are often faint and need good magnification. However, background noise and 'mush' will be amplified as well as the signals and the distortion figure at full output (which you will never want to use) is 11·5 per cent. The valves used are the Mullard EF 86 and EL 84.

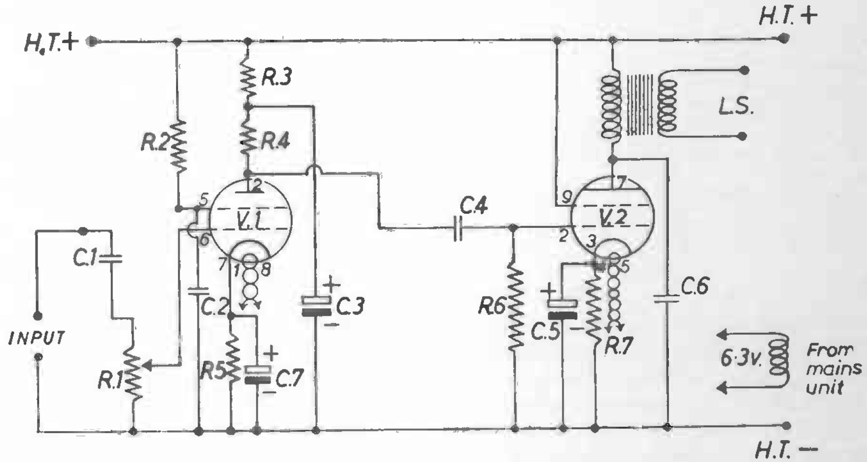


Figure 18. SIMPLE TWO-VALVE MAINS AMPLIFIER

Components required:
CONDENSERS:
C.1. ·01 μF paper (350 V)
C.2. ·1 μF paper (350 V)
C.3. 8 μF electrolytic (350 V)
C.4. ·1 μF paper (350 V)
C.5. 25 μF electrolytic (25 V)
C.6. ·005 μF (mica)
C.7. 25 μF electrolytic (25 V)
RESISTORS:
R.1. ·5 MΩ potentiometer
R.2. 1 MΩ (¼ W)
R.3. 22 kΩ (¼ W)
R.4. 100 kΩ (¼ W)
R.5. 350 Ω (¼ W)
R.6. ·5 MΩ (¼ W)
R.7. 170 Ω (¼ W)
V.1. EF 86
V.2. EL 84
2 B8A valveholders
Sockets, chassis, wire, etc.

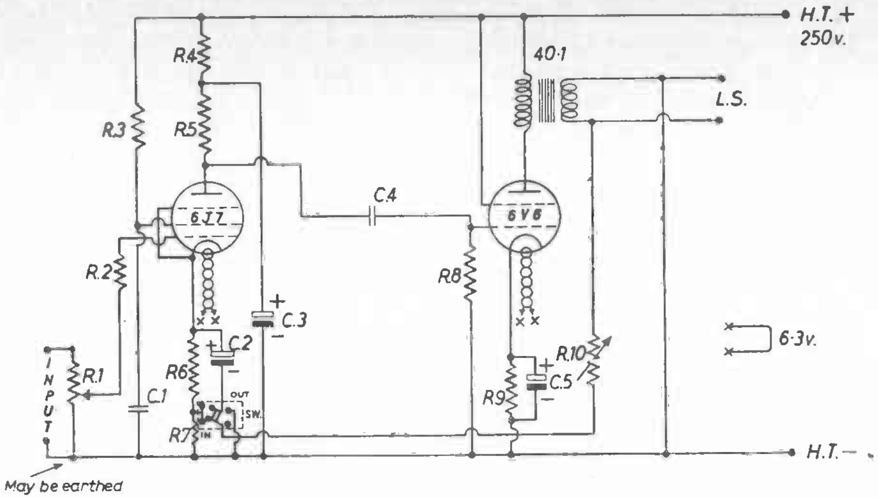


Figure 19. TWO-VALVE AMPLIFIER WITH OPTIONAL NFB

Components required:

CONDENSERS:
- C.1. ·1 μF fixed (350 V)
- C.2. 25 μF electrolytic (25 V)
- C.3. 8 μF electrolytic (350 V)
- C.4. ·1 μF fixed (350 V)
- C.5. 25 μF electrolytic (25 V)

RESISTORS:
- R.1. ·5 MΩ variable
- R.2. 10 kΩ fixed (¼ W)
- R.3. 1 MΩ fixed (¼ W)
- R.4. 22 kΩ fixed (½ W)
- R.5. 220 kΩ fixed (½ W)
- R.6. 1 kΩ fixed (½ W)
- R.7. 100 Ω fixed (½ W)
- R.8. ·5 MΩ fixed (¼ W)
- R.9. 270 Ω fixed (½ W)
- R.10. 5 kΩ variable (R.10 is reduced in value to point where signal almost disappears. Then adjust it back to best volume and quality)

Valves: 6J7 and 6V6, octal valveholders
Output transformer
Chassis, knobs, input and output sockets
SW = double-pole double throw switch

You will probably realize by now, that I prefer an amplifier that gives moderately 'hi-fi' results. A cheap simple amplifier of this type is detailed in Chapter 12 of *Fun with Radio* and can be used as a good all-round amplifier for general work. I also use the Mullard 3-3 Amplifier a great deal. (This is described in *Fun with Hi-Fi*). It is essential to build this carefully as all kinds of instability troubles can arise from bad layout which results in worse, instead of better, quality and also a hum, whereas the amplifier should be as silent when working as when switched off! To round off amplifiers, therefore, I have given you one based on the 6J7-6V6 which does not incorporate a power pack, so that you can build this separately, and which has a switching arrangement for negative feedback. When you are feeding it with your short-wave receiver and want maximum volume and sensitivity you can switch out the amplication-reducing feed-back. If you tune in a loud interesting programme of good quality, and there are many of these on short waves today, the feedback will give you the highest quality of reproduction.

The 6J7-6V6 types of valves (known as International Octal) are obsolete today although I know many of my readers still use them. If you cannot buy them I would suggest you build the design in Fig. 18. If you want a hi-fi design, buy *Fun with Hi-Fi* and build the Three-Watt Quality amplifier.

A first-class Transistor amplifier I am using is the SS 110 made by Stirling Sound. It is a small ready-built affair which gives results comparable to a valve amplifier I have which is six times its size. I have built it on one chassis with the Stirling Sound mains unit to form a useful small self-contained amplifier of high power and quality. The power unit is Stirling Sound's SS 324. They are sold by Bi-Pre-Pak whose address is in the Appendix.

BUILDING A THREE-VALVE ALL-MAINS RECEIVER

Now we can consider a receiver specially designed to operate from the mains unit described in Chapter 7. But you must master the technical symbols of radio and learn Morse if you want to enjoy your hobby thoroughly.

Soon you will reach the stage of wishing to be a transmitting amateur operating your own station. Possibly your hobby will even become your livelihood and then you may either go to sea as a radio officer or work in a similar capacity for an airline. Whichever way it takes you it is certain that you will need to know technical symbols and that you will require to study Morse. Dealing with the latter first, I would say that, as you probably know from your technical studies, you require an oscillating detector in order to pick up and read Morse signals, whether it is a detector in a TRF set which is set into oscillation by reaction, or a superhet detector which is made to oscillate in a similar manner or by means of a 'beat-frequency oscillator' (BFO).

This receiver, being a TRF set which employs reaction on the detector, can be used for Morse reception. I have only given you the theoretical schematic diagram and a suggested component layout diagram because I must by now assume that you can read the 'schematic' and could therefore wire up the set correctly. As explained in the last chapter, in these highly sensitive short-wave receivers no one can guarantee that each model built by readers will be an exact copy of the designer's prototype. Components are not so freely available in these days as in former times and 'solus specification' is no longer possible.

As small differences in layout can easily account for bad performance due to interaction between components, instability and so on, it is I feel, unfair both to designer and reader to try and indicate every wire in the receiver. What I have done, therefore, is to give you the theoretical diagram (Fig. 20) and the layout (Fig. 21) I suggest you should adopt. It should then be fairly easy for you to wire the set up. If you cannot do so, may I gently suggest that you are attempting to build a receiver that is beyond your capabilities both to build and to operate properly.

The valves used can be any three 6·3 volt heater type single-ended miniature valves and I would suggest two EF 89 and an EL 84, the latter being the output valve. These are the Mullard series of marking, but they are known internationally and should be available wherever radio valves can be purchased. The series uses nine pins so that nine-pin valve-holders will be required. For the EF 89 types the valveholders should be skirted to assist screening and to allow a can to be fitted if desired. The spigot in the centre underside of the valveholder must be earthed.

If you wish to use the now obsolete International Octal valves I suggest 6J7, 6J7 and again 6V6. The two 6J7 valves are a little less 'lively' than the EF series and you may find it easier to keep the receiver stable. I think it is a good idea to screen the RF and

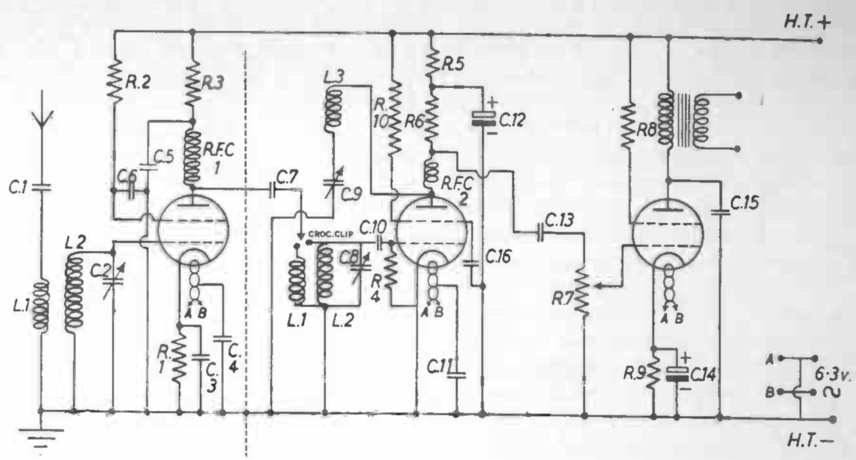


Figure 20. THREE-VALVE MAINS TRF RECEIVER

Components required:

CONDENSERS:

C.1. 100 pF silver mica
C.2. 300/310 pF variable (s/wave)
C.3. ·1µF fixed (350 V wkg.)
C.4. 1,000 pF silver mica
C.5. ·1µF fixed (350 V wkg.)
C.6. ·1µF fixed (350 V wkg.)
C.7. 100 pF silver mica
C.8. 300/310 pF variable (s/wave) (may be ganged with C.2.)
C.9. 140 pF variable reaction
C.10. 100 pF silver mica
C.11. ·1µF fixed (350 V)
C.12. 8 µF electrolytic (350 V)
C.13. ·01 µF fixed (350 V)
C.14. 25 µF fixed electrolytic (25 V)
C.15. 5,000 pF fixed (350 V)
C.16. ·1µF fixed (350 V)

RESISTORS:

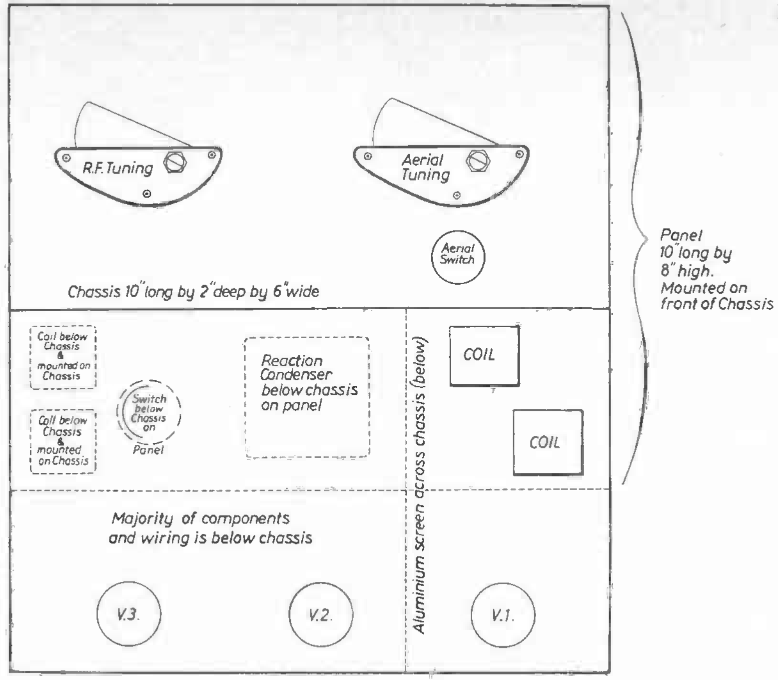
R.1. 200 (½ W)
R.2. 47 k (½ W)
R.3. 27 k (½ W)
R.4. 1 M (¼ W)
R.5. 47 k (½ W)
R.6. 100 k (½ W)
R.7. ·5 M variable
R.8. 100 (¼ W)
R.9. To suit valve 270 for 6V6
R.10. 47 k (½ W)

L1./L2. and L1./L2./L3.: Short-wave coils Denco (L1./L2. Blue) (L1./L2./L.3. Green)
3 valves and valveholders to match (see text)
Output transformer
Chassis, s/motion dial, knobs, sockets, crocodile clip RFC1 and 2.S/wave RF chokes

detector valves with a special aluminium screen which you can obtain for valves. Perhaps it would be preferable to begin by using the screen for the detector valve only; if the set seems a little unstable and difficult to handle, try the effect of also screening the RF valve. Take note that EF series valves are single-ended and all their connections come out at the valve-holder, whereas the 6J7 and similar International Octal valves have their grid connections at the top. I personally like that arrangement, as it assists in isolating the grid circuits from those of the rest of the valve.

If your layout does not permit very short leads to these grid top connectors, and your aim should be to make this arrangement, you had better make the connections to the tops by means of screened leads, the most effective material for this purpose being co-axial cable, generally known as 'co-ax'. You have probably seen it used as lead-in for television sets. A yard of it is not very expensive and will be useful for

Figure 21



many purposes. Its particular virtue is that the inner cable is efficiently screened by the outer, which is earthed, and which is so separated by a special method from the inner wire as to make capacity effects and losses negligible. You can use it a great deal in short-wave work, and if you eventually progress to becoming a transmitting amateur you will find you make a great deal of use of 'co-ax' for linking up the various sections of your apparatus.

You will see that the theoretical diagram (Fig. 20) shows the receiver to be much the same in concept as the battery three-valver in Chapter 6. It is in fact the same basic design, which gains from the fact that we can use the much higher efficiency of mains valves plus the advantage accruing also from higher voltages due to mains HT. Because of these two features we must take greater care to avoid both hum and instability. To assist in avoiding hum, one side of the heater wiring is earthed whilst the other should be 'tucked away' in the bend of the chassis behind the valveholders; 1,000 pF condensers are connected between the heaters and earth on the un-earthed side of the wiring. Further assistance in this respect is given in the design of the mains unit where you will see that high-voltage condensers of $\cdot 1\ \mu F$ are connected across the two halves of the mains transformer secondary winding, carrying to earth any objectionable RF currents entering the transformer from the mains. I always find this an infallible cure for 'modulation hum' or 'tunable hum'. I also like to include two sets of smoothing chokes and associated condensers as you see in the design in Chapter 7. They assist in removing hum and maintaining stability. It is always best to

connect each valve's earthed components to one point alongside the valve concerned. I have drawn the diagrams as far as possible in this way to make the point clear. It is essential that earth returns should not wander about all over the receiver.

This reminds me to tell you again of the importance of arranging for short-wave receivers always to have short, direct connections in their wiring. The output valve is not so important in this respect but the RF and detector stages must be completed with the minimum of long leads. If you are using the International type valves with grid contacts on top you will find that the shortest method of connecting them from the tuning-condenser is to take a lead from the top connectors of each section. Gang condensers are generally made with a contact to 'fixed' plates below and also on top.

The lower one can be used for a short connection through the chassis to coil, and, as mentioned, a direct wire from the top one to valve. In the case of the detector valve the grid leak and associated condenser will have to be connected to the top-cap connector and the lead from the tuner will, in fact, connect to the end of the 100 pF grid condenser. If you make this lead of 'co-ax' (and it may be advisable to do so) the outer shield of the 'co-ax' can be earthed to the tuning-condenser frame at that end. At the other, the valve end, the earthed side of the grid leak resistor can be returned to it quite satisfactorily.

The whole of the satisfactory working of the set is bound up in the reaction control, and the aim must be to get this as smooth and gentle as possible. Shielding between the RF and dectector stages prevents interaction between them, and unsatisfactory reaction control which results from it. Voltages on the detector valve affect reaction control greatly; it may be advisable to try a few different values of resistors in both the anode and screening-grid (G2) circuits of that valve.

Higher resistors to give lower voltages will generally be wanted to tame too 'fierce' reaction, the danger then being lack of reaction if the voltage falls too low. The aim is to strike a happy medium between the two points. Many circuits benefit by a condenser between the anode of the detector valve and the chassis; theoretically it is correct to have one here and I have put it in the theoretical diagram. I never found one essential. Probably my own wiring was so indifferent that there were sufficient capacity losses to form the effect of a condenser!

A condenser from anode of the output valve to earth also is useful both for bypassing any stray RF currents before they get into the output and also for cutting the high-pitched tone which is liable to arise with a pentode. 'Mush' and atmospherics are generally high-pitched in character, and a bit of top-cutting in a short-wave set often helps to cut them down.

If you wish, you could make the condenser in the output into a 'tone-control', or more properly a 'top-cut control', by using a $\cdot 1\ \mu F$ condenser instead of the $\cdot 005\ \mu F$ and putting it in series with a 50 k. ohm variable resistor. Mount this in a convenient place; then varying it will give you real loss of top right down to none at all. It is surprising, however, how often it helps to cut out unpleasant noises which are drowning a signal you particularly wish to read.

Operation of this receiver is quite simple provided you have taken the trouble to get reaction really smooth. A gentle oscillation for reception of CW (Morse) stations and just below the oscillation point for telephony, although, as the aerial is isolated, no harm would be done if the set is gently oscillating and stations are tuned in by the 'chirps'.

A TRANSISTOR SHORT-WAVE SUPERHET RECEIVER

This excellent design is not difficult to build but at the same time it is not suitable for a beginner to tackle. Among the skills needed is a really sound technique of soldering.

As we mentioned elsewhere there may be difficulties in obtaining some components for amateur radio construction, at least as far as the United Kingdom is concerned. Since the invention of transistors and 'chip circuitry' the trend has been towards 'modules' and kits of parts embodying all the required components. One particular difficulty is the question of coils as few are now made for the home constructor. One supplier who has been making coils for many years is Denco. Their 'Maxi-Q' coils have always been first-class. Denco are still manufacturing ranges of plug-in coils and also publish useful catalogues and manuals showing how to incorporate these coils and other components into receivers. These publications are no longer issued free of charge and it is as well to write sending a stamped, addressed envelope for current price lists.

In *A guide to Amateur Radio* (RSGB) a very satisfactory short-wave superhet is described and is known as the RSGB Transistor Four. This uses Denco coils and transformers and also the popular PNP-type transistors. It is relatively inexpensive and simple to build. Outside the United Kingdom readers may be able to find local suppliers of coils and components whose products would be suitable for incorporation in a home-built superhet.

In this chapter and the two following chapters we specify what may be described as 'classic' or 'standard' designs for short-wave superhets. Two of them are transistor designs and one a valve; I know that none of the coils for them are now available but other coils may well be available and can be adapted for the circuit shown. In any event the designs are only suitable for the advanced constructor who should be able to make any alterations necessary to them. For less experienced readers we hope that the chapters will prove of interest and still be instructive. I believe there is much in this Chapter and Chapter 10 which will add to the amateur's knowledge and will spur on their efforts to make more comprehensive receivers.

In Chapter 11, devoted to the Communications Receiver, I have given details of the Heathkit Short-wave superhet SW-717. I am indebted to the Heathkit Company for allowing us to reproduce in full the schematic diagram of the receiver. I hope, therefore, you will enjoy the three chapters which I have left in their original form for your instruction.

The most satisfactory method of using transistors in short-wave work is to incorporate them into a superheterodyne receiver which, as you will know from your study theory, works in a special manner. This design is based on one issued by Repanco Ltd whose coils it uses and I am grateful for their permission to use it in this book. It is similar to the successful design which the Editor and I called *Pegasus* and

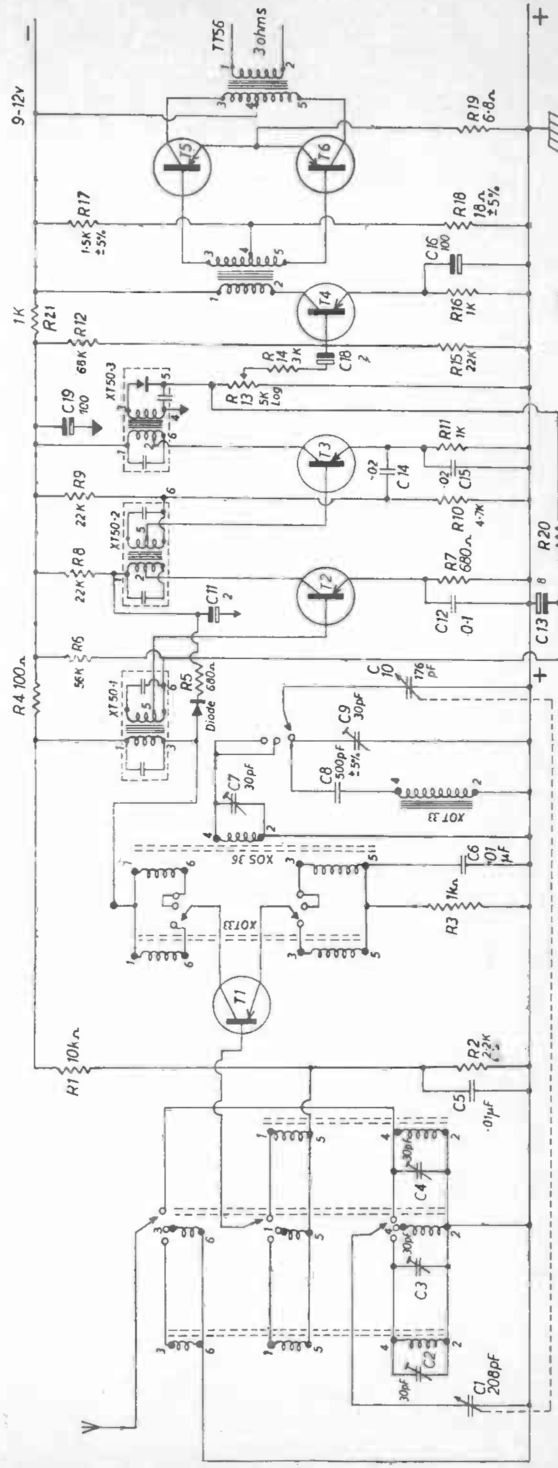


Figure 22. SCHEMATIC DIAGRAM OF TRANSISTOR SUPERHET

Components required:
Coils: XTA 31, XSA 34, XSA 37, XOT 33, XOS 36 (All by Repanco, but see text)
IF Transformers: XT 50-1, XT 50-2, XT 50-3 (All by Repanco)
Transistors:
T.1. OC 170 (or OC 169)
T.2. and T.3. OC 45 or AF 117
T.4. OC 81-D
T.5. and T.6. 2 matched OC81 (All by Mullard)
Variable Condensers:
C.1. and C.10 2 gang 208/176 pF (with screen) Jackson 'O'
C.2/3/4 and C.7 and C.9 30 pF trimmers or two 50 pF variables (see text)
Other Condensers: C.5 to C.18 values as shown on diagram
Resistors R.1 to R.20 values as shown on diagram (R.13, variable)
All condensers maximum working voltage 25 volts
All resistors maximum wattage ⅛th.
Diode: OA 81 by Mullard
Switch: 2 wafer switch, each wafer 3 pole-3 way
Transformers: TT 55 and TT 56 by Repanco

which was published in *BOP* with great success and reprinted in *Boy's Own Annual*. It uses, however, the up-to-date and more efficient intermediate-frequency transformers developed by Repanco and also has a push-pull transistor output stage for good loudspeaker reproduction. It is not difficult to build but is not, I would suggest, one for a novice to attempt.

A certain skill in speedy, efficient soldering with a really hot iron is needed and the customary precautions when soldering transistor or diode leads is necessary. That is to say, a heat shunt should be provided between the soldering iron and the transistor (or diode) so that the heat of the soldering iron will be conducted away by the shunt and not allowed to enter into the component and damage it. A suitable one is available from suppliers and costs only a few pence.

Transistor components are usually quite small as the low currents involved allow them to be used without difficulty. It is a good idea not to allow the heat of the soldering iron to stay on them too long as they could easily be damaged. There are two schematic diagrams for the receiver given. First of all we will consider that of Fig. 22 depicting a design for a six-transistor receiver. In this design the first transistor (T1) is the mixer-oscillator into which the signals are fed directly from the aerial without the benefit of any radio-frequency amplification. This is the normal method adopted in the majority of superhet receivers and works very successfully. Selectivity and certain other features are improved by the addition of an RF stage but this is not essential. The transistor used in this position is the Mullard special short-wave type OC170 and the coils are the Repanco short-wave transistor coils. There are five coils used to cover the range from 16 to 200 metres and additional coils can be added to include the medium and long waves.

At the end of this chapter I give you the Repanco notes on the coils for the short-wave ranges and also the notes on alignment. The latter should not cause much difficulty as the coils have been pre-aligned in a receiver and only need the capacity due to wiring balanced out. Trimming is carried out by a 30 pF trimmer placed across each coil but this figure is not a hard and fast one and a small one of about that size will do quite well. To do away with aerial trimmers, use a small 25 pF ceramic insulation air-tuned condenser in the aerial circuit across the tuning condenser and eliminate the three trimmers on the aerial coils. Trimmers will still be needed for the XOT 33 and XOS 36, but the aerial can be trimmed for maximum efficiency on each wave-band.

The Notes give a colour-code of markings for the coil but this is done in spots of paint which are liable to rub off. What I do is to scratch the coil type designation on the can with a scriber or sharp nail. In this way it is always clear as to which coil is which. It will be noted that only one oscillator coil XOS 36 is required as its second harmonic is used on the lowest wave-range.

Building the receiver is quite simple and although transistor components allow a very compact set to be made, for accurate tuning on short waves I like to have a fairly substantial receiver so that it is possible to operate it without sliding all over the place. I have used pieces of aluminium put together to form a small chassis but any small chassis available would be suitable. The coils have to be mounted as close to the switch as possible so as to keep their leads short and direct, and the best way of doing this is by erecting small metal screens between the wafers of the switch and mounting the coils on these screens. I hope the diagram (Fig. 23) makes this clear.

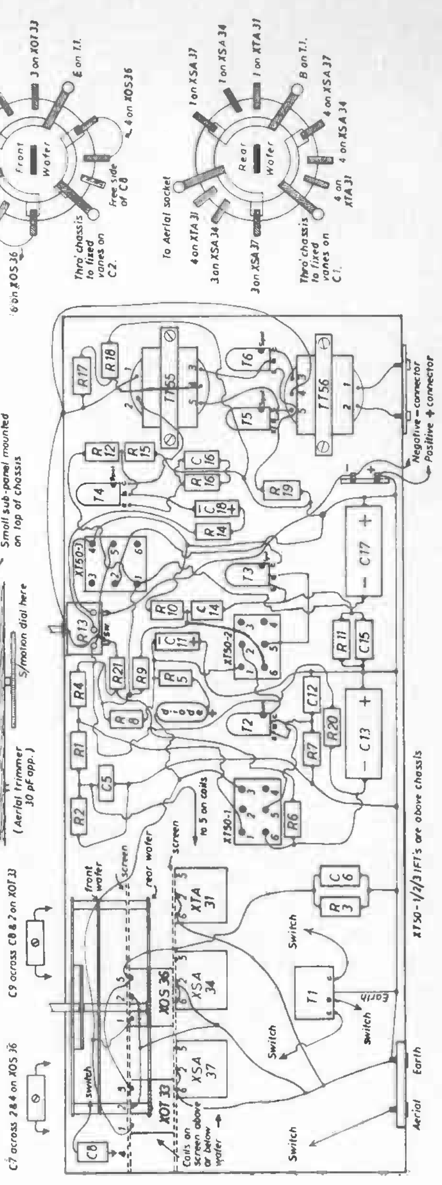


Figure 23. WIRING DIAGRAM OF TRANSISTOR SUPERHET

Components required:

Coils: XTA 31, XSA 34, XSA 37, XOT 33, XOS 36 (All by Repanco)
IF Transformers:
XT 50-1, XT 50-2, XT 50-3 (All by Repanco)
Transistors:
T.1. OC 170 (or OC 169)
T.2. and T.3. OC 45 or AF 117
T.4. OC 81-D
T.5. and T.6. 2 matched OC81 (All by Mullard)

Resistors R.1. to R.20. values as shown on diagram (R.13, variable)
All condensers maximum working voltage 25 volts

Variable Condensers:
C1 and C.10 2 gang 208/176 pF (with screen) Jackson 'O'
C.2/3/4 and C.7 and C.9 30 pF trimmers or two 50 pF variables (see text)
Other Condensers: C.5 to C.18 values as shown on diagram

All resistors maximum wattage $\frac{1}{8}$th
Diode: OA 81 by Mullard
Switch: 2 wafer switch, each wafer 3 pole-3 way
Transformers: TT 55 and TT 56 by Repanco

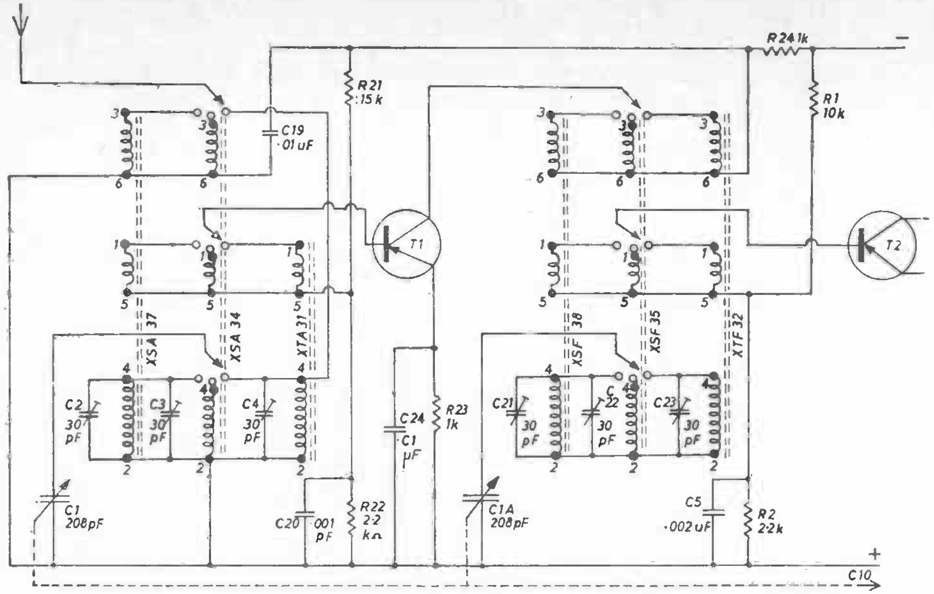


Figure 24. TRANSISTOR SUPERHET RF STAGE

Components required:

Only additional components to those in Fig. 23 are:
Coils: XSF 38, XSF 35, XTF 32 by Repanco
Variable Condensers: C.1/C.1Aand C.10 Jackson 'O' 3 gang

Resistors: R.21/22/23/24 values as diagram
Transistor: T1 OC.170 (or 169) Mullard (T2 is T1 of diagram in Fig. 23)

C.21/22/23 are 3 × 30 pF trimmers or panel mounted trimmer 50 pF
Condensers: C.19/20/24 values as diagram

The best way to mount the coils is to press one on to a piece of paper so that the pins go through and press round the rim of the can giving a template of it. From this carefully drill three large holes on your metal screens (which may run together) down each side for the pins, a hole in the centre so that the core could come through if necessary and two small holes at each end for the holding lugs. It is essential that the pins do not make contact with the metal chassis and, when connecting up, sleeving may be run over them if they seem close to the edge. Although the cans are aluminium and will not take solder, the lugs are of a different metal and should have an earthing wire soldered to them. Mounting the coils is quite simple and I have tried to make it clear in the diagram. The same applies to the IF transformers which are a little larger.

The switch used is a wafer type with two wafers for the simpler design, but a third is required for the design with exactly these wafers. You may, for instance, have to take a three-pole four-way. This would be all right and you would only use three of the 'ways'. The thing is, with whatever type you obtain, to watch that the connections are made correctly so that the contacts meet each other in the correct sequence.

I have not given you a wiring diagram of the set with an additional RF stage but

only the schematic (Fig. 24) for I think that if you feel capable of adding this you should be able to do so from their theoretical diagram. You would need another wafer on the switch and another piece of aluminium for screening and mounting the coils. These should come between the two existing wafers so that the aerial wafer remains the first one from the rear and the wafer for the oscillator coils stays nearest the panel.

If you wish to avoid a number of trimmers the easiest way is to mount a small variable condenser similar to the aerial trimmer on the other side of the switch and connect this across the second 208 pF condenser of the three-gang tuner. This can, like the aerial trimmer, be adjusted to line everything up to get optimum results.

If you want to add medium and/or long waves more coils will be needed and these are listed also at the end of this chapter. There should be room for them on the switch screens, but larger switch wafers would be required. Each coil added would mean one more pole and two more 'ways'. A good slow-motion dial is a great aid to tuning and is worth spending a little money on. The set can be operated from a 9-volt battery or from the mains using one of the units described in Chapter 7. A somewhat simpler transistor receiver for headphone use and using plug-in coils is described in the RSGB publication *A Guide to Amateur Radio* and readers may be interested in that very effective design.

NOTES ON REPANCO SHORT WAVE TRANSISTOR COILS

	Type	Colour Code
Range 1. 85–200 *metres*		
Aerial Coil	XTA31	Blue Mauve
H.F. Coil	XTF32	Blue Black
Oscillator Coil	XOT33	Blue Brown
Range 2. 35–80 *metres*		
Aerial Coil	XSA34	Red Yellow
H.F. Coil	XSF35	Blue Yellow
Oscillator Coil	XOS36	Blue Red
Range 3. 16–43 *metres*		
Aerial Coil	XSA37	Blue Green
H.F. Coil	XSF38	Blue White
Oscillator Coil	XOS36	Blue Red. (2nd harmonic for this range).

1. Special high frequency ferrite cores and pots are used to obtain the highest possible 'Q' at the frequencies employed.

2. All coils are pre-aligned in a receiver and will only need slight adjustments to correct for different wiring capacities and component tolerances.

3. The above ranges can be varied to a considerable degree due to the large inductance variation possible, with ferrite cores.

4. The ferrite cores are extremely brittle. The trim tool used must fit the slot in the core and travel the entire length of the core.

5. Figure 22: Aerial and oscillator stages 3 waveband Short Wave receiver using Mullard OC170 or OC169 transistor, and Jackson Bros. '00' gang (208+176 pf) fitted screen.

6. Figure 24: Aerial, H.F. and oscillator stages 3 wave-band Short Wave receiver using two Mullard OC170 or OC169 Transistors, and Jackson Bros. '0' gang (208+176+208 pf) fitted screen.

NOTE: R1 on diagram is reduced to 470 Ω when this circuit is used. Also it is advisable to build this circuit on an aluminium chassis to prevent instability.

Hints on Alignment

1. Switch on and tune to a station, adjust the cores of the three IFTs for maximum output.

2. Fully tighten the oscillator trimmer and release one turn.

3. Select a station with the gang almost open full, i.e. the high frequency end of the band, and adjust the aerial trimmer for maximum output. Then the H.F. trimmer for maximum output if using Figure 24.

4. Select a station at the low frequency end of the band, i.e. band almost fully closed, adjust the core of the aerial coil for maximum output. Then the core for the H.F. coil for maximum output if using diagram B.

5. Repeat Nos. 2 and 4 for each of the other two wavebands.

6. If variable panel trimmers are used, 3 above will not apply.

Chapter 10

AN EASY-TO-BUILD SHORT-WAVE SUPERHET RECEIVER

This is a 'short-waves only' superhet and is therefore a simplified version of a true superhet. Automatic volume control, for instance, has been omitted. But with some experience you can align it properly and then you will find it a powerful 'station-getter'.

Here I describe my own suggested design for a simple short-wave superhet, and in Fig. 25 I show you the theoretical diagram, and the suggested layout in Fig. 26. Again I have not attempted a full wiring diagram; if you are going to make the receiver you should have sufficient knowledge to do so from the theoretical diagram. In the original design I used five valves, these being, from first to last, frequency changer, 6K8; intermediate frequency amplifier, 6K7; detector, 6J7; output valve, 6V6; mains rectifier, 5Z4. These are all in the International range and require a transformer giving 6·3 volts at 2 amps. plus 5 volts at 2 amps. for the rectifier. On the HT side 250–0–250 volts at 60 to 80 mA should be available for full-wave rectification. Modern types in the Mullard range are ECH 81, EF 85 or EF 89, EBC 81 and EL 84, EZ 80.

I have used Osmor coils again in the small superhet range which they make, together with two of their IF transformers. The latter were pre-aligned by the makers and I suggest that you should buy only pre-aligned IF transformers. This mention of coils and transformers brings me to the important question of alignment which is an essential feature of superhets, and unfortunately, a difficult one. If you obtain pre-aligned transformers you may find that only slight adjustment of the cores of the coils will be needed to bring in a fair number of stations, but the receiver really should be aligned properly with the aid of a signal generator. If you have not the apparatus to do this maybe a friend can assist you or perhaps your local radio dealer may be kind enough to do it for a small fee. On the other hand, if you are going to take up radio as a serious hobby, or even as a profession, it is well worthwhile to make a simple signal generator. Designs often appear in the radio periodicals and journals (see the Appendix). A small battery-operated set tuning all wavebands is extremely useful for many applications.

Reverting to the coils, there are three sets of these used tuning from 15 metres to 230 metres and covering all the interesting amateur bands plus the shipping band. These coils are tuned by a condenser of about 500 pF and not by the smaller 140 pF type used in the TRF sets, but as the 500 pF size is so large it is inclined to make tuning difficult even with a good slow-motion dial. To overcome this I have connected a small 25 pF ganged component in parallel with it. This is known as 'bandspread' tuning, the larger condenser being called the 'bandsetter' and simply moved a fraction, say one degree on the dial, at a time while the band is explored with the small condenser, much more simply-handled. It is remarkable how easy this

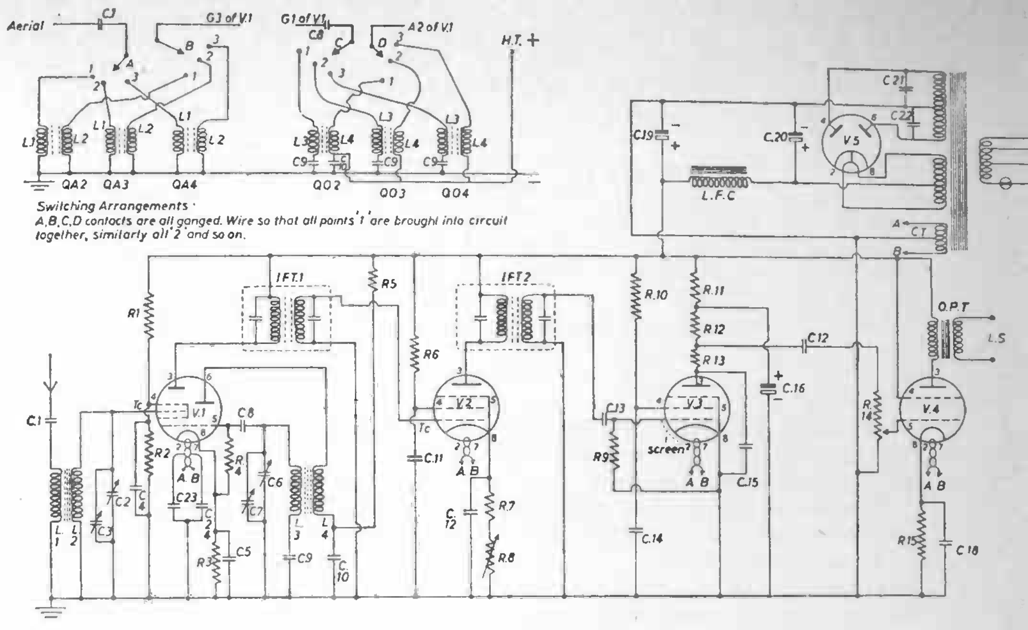


Figure 25. FIVE-VALVE SUPERHET RECEIVER

Components required:

CONDENSERS:
- C.1. ·01 μF paper (350 V)
- C.2. 500 pF variable (preferably ceramic insulation —2-gang with C.6.)
- C.3. 25 pF variable (preferably ceramic insulation —2-gang with C.7.)
- C.4. ·1 μF paper (350 V wkg.)
- C.5. ·1 μF paper (350 V wkg.)
- C.6. 500 pF variable (see C.2.)
- C.7. 25 pF variable (see C.3.)
- C.8. 100 pF silver mica
- C.9. Padder: for QO2 = 4,500 pF; for QO3 = 4,500 pF; for QO4 = 2,500 pF
- C.10. ·1 μF paper (350 V wkg.)
- C.11. ·1 μF paper (350 V wkg.)
- C.12. ·1 μF paper (350 V wkg.)
- C.13. 100 pF silver mica
- C.14. ·1 μF paper (350 V wkg.)
- C.15. 200 pF silver mica
- C.16. 8 μF electrolytic (350 V wkg.)
- C.17. ·01 μF (350 V wkg.)
- C.18 .25 μF (25 V wkg.)
- C.19. 8 μF electrolytic (350 V)
- C.20. 8 μF electrolytic (350 V)
- C.21. ·1 μF (1,000 V)
- C.22. ·1 μF (1,000 V)
- C.23. 1,000 pF silver mica
- C.24. 1,000 pF silver mica

RESISTORS:
- R.1. 15 kΩ (1 W)
- R.2. 27 kΩ (1 W)
- R.3. 330 Ω (½ W)
- R.4. 47 kΩ (½ W)
- R.5. 47 kΩ (½ W)
- R.6. 27 kΩ (½ W)
- R.7. 330 Ω (½ W)
- R.8. 10 kΩ variable
- R.9. 1 MΩ (½ W)
- R.10. ·5 MΩ (½ W)
- R.11. 22 kΩ (½ W)
- R.12. 100 kΩ (½ W)
- R.13. 10 kΩ (½ W)
- R.14. ·5 MΩ potentiometer
- R.15. 270 Ω (½ W)

COILS:
L.1, L.2; QA2, QA3, QA4 } Osmor Radio Products
L.3, L.4; QO2, QO3, QO4 } (but see text)

Mains transformer 250 V 60/80 mA for 5Z4 with 6·3 V 2A, 5 V 1A
Valves: 6K8, 6K7, 6J7, 6V6, 5Z4 ('G' types may be used) or EF range (see text)
5 valveholders, 3 octal top-cap connectors if required.
2 IF transformers (465 kc/s, but see text)
On-off switch, chassis, knobs, LF choke 60 mA
Wavechange switch if 3 ranges used: 2 wafers each 2-pole 3-way, metal for screening.
Sockets: A/E, L/S, output transformer (for 6V6)
Slow-motion dial or dials, wire, flex

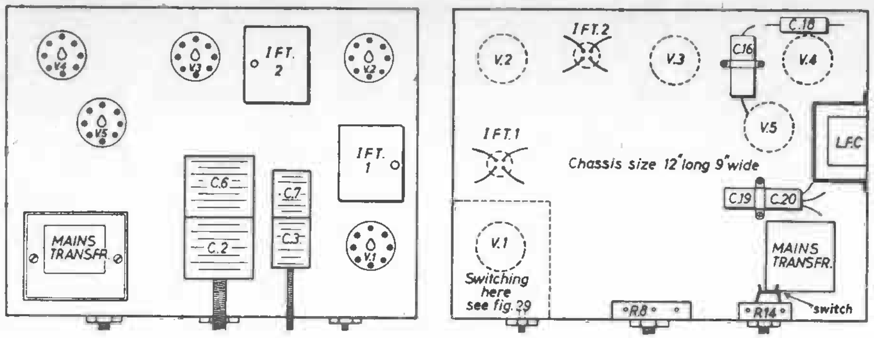


Figure 26

makes tuning in stations, particularly the rather crowded ones on the amateur bands. This 'band-spreading' can be carried out in TRF receivers, if you wish, and a small 15 or 25 pF condenser in parallel with a 140 pF will make tuning very much easier.

The coils are in pairs, Aerial coil and Oscillator coil, and care must be taken not to mix the two up as they are different sizes, the Oscillator coils being designed to work at 465 kc/s above the signal frequency, that being the frequency of the IF we use in this receiver. As a two-gang tuning condenser is used, to maintain tracking throughout its sweep it is essential to use 'padders' in the Oscillator coil circuit and sizes of these are given in the circuit diagram. All these condensers should be of the special small silver mica types which are available for short-wave work.

It is almost essential for good results on the higher frequencies (i.e. the shorter waves) to use first-class material for construction. Many readers write to me and say that they have been given an old radio set to pull to pieces, or a former enthusiast has passed over all his old gear to them. So long as you are prepared to be disappointed, and are possibly prepared to do a lot of work unnecessarily, you can go ahead and try circuits built with the components. But for short-wave sets you will find you need *first-quality components*.

The coils used are in two sets of three, aerial circuit coils and oscillator circuit coils and the waveband covered is in three steps accordingly, the first pair tuning from approximately 15 to 50 metres, the next from 35 to 120 and the third from 70 to 230 metres. You will see that there is quite an appreciable overlap in each case, and that the third coil gives you the shipping band which is always of immense interest to those living fairly near the coast. Also it includes the 160 metre 'top-band' of the amateurs and the lower wavelength BBC broadcast stations plus Radio Luxembourg.

The layout I have suggested follows that of a fairly large chassis which I used because I had it on hand, but it is a standard method of layout for this type of receiver. A chassis can be bought by amateurs, in fact, which is a little smaller than mine but which follows much the same layout as I have adopted. I want to pay particular attention to the layout and fixing of the coils as these are important. I found it was necessary to screen the aerial coils from the oscillator ones and I have done this by means of a small screen fixed to the top of the chassis and coming down between them. A small piece of aluminium will do this excellently. The switch has two wafers

and one of these for the aerial coils has to be in one compartment, in the front, while the other is at the rear and changes over the oscillator coils. It is essential to keep the wiring between coils and switches as short as possible, otherwise you will find you have as much wire in circuit as there is wire on the coils and your minimum wavelengths will be very high.

The coils have details of hole sizes for assembling included within their packing-boxes and you see that they are a gentle 'press-fit'. I suggest that the aerial coils should be fixed to the chassis in the front compartment in a hanging-down position close to the switch-wafer, while the oscillator three can be fixed around their switch-wafer in a position parallel with the chassis by drilling their fixing-holes in the small screen you have fixed to form the two compartments. I feel this to be so important I have tried to give you a diagram of my suggestion in Fig. 27.

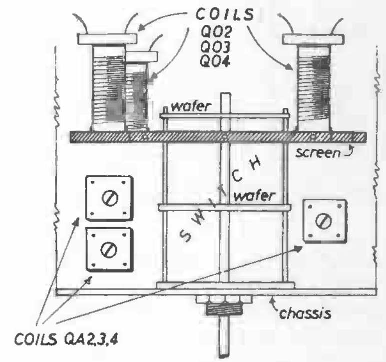
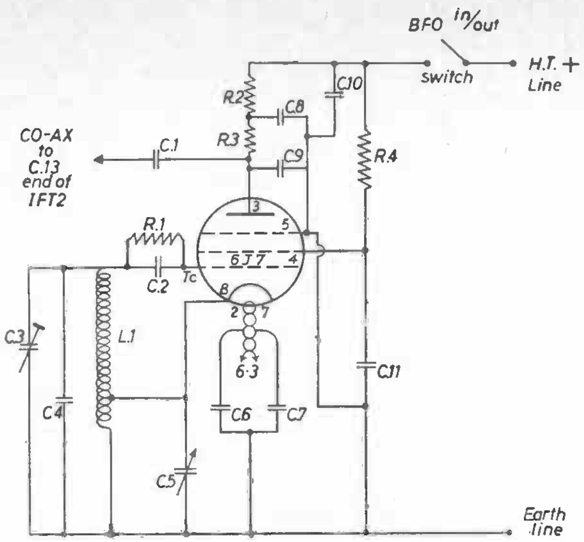


Figure 27

As this is a 'short-waves only' superhet, it is a somewhat simplified version of a superhet in that automatic volume control (AVC) has been omitted. With only one IF stage this is not really desirable as it might cut down volume too much and discard faint stations and, as we have discussed elsewhere, reception of telegraphy, that is Morse or CW, can only be effective when the circuit is oscillating. In a superhet it is usual in what is called a communications receiver to add a special valve called a BFO (beat frequency oscillator) which oscillates at the IF, and this is fed into the detector valve circuit beating with the incoming CW signals to make them audible.

One of the modern methods of transmission which is becoming more and more popular among amateurs is 'single side band' (known as ssb) about which you can read more in *A Guide to Amateur Radio.* To receive ssb signals you require the use of a BFO in the receiver. This is an additional reason for building this into a receiver. It needs to be tunable so that the trimmer (C.3) shown in Fig. 28 should be a small air-spaced variable and mounted on the panel. I have indicated the usual circuit for adding a BFO unit in Fig. 28. There are one or two methods of obtaining the same results in a somewhat simpler manner.



Components required:

CONDENSERS:

C.1. 5 pF
C.2. 100 pF
C.3. 200 pF trimmer
C.4. 100 pF trimmer
C.5. 25 pF variable
C.6. 1,000 pF
C.7. 1,000 pF
C.8. 1,000 pF
C.9. 350 pF
C.10. ·01 μF
C.11. ·05 μF

RESISTORS:

R.1. 47 kΩ (¼ W)
R.2. 10 kΩ (¼ W)
R.3. 1 kΩ (¼ W)
R.4. 47 kΩ (¼ W)

Valve 6J7 or EF 89
Octal valveholder
On-off switch
Co-axial cable
(Set C5 halfway and adjust C3)

Figure 28. A BFO UNIT TO ADD TO FIGURE 25

A certain amount of feedback can be created between the grid and anode of a valve and it will oscillate. Uncontrolled oscillation is of no use to us, however, so there is inserted a 10,000-ohms resistor in the valve's cathode circuit which, when towards minimum position, will allow the valve to oscillate. This could be tried out in the design shown in this chapter. This resistor is already inserted in the cathode circuit for volume control, so that all that is needed are three turns of wire round the wire from IF transformer to the IF valve's grid, connecting the end of it to the anode pin. Fig. 29 gives some diagrams of this. Finally, as the detector is a pentode valve it is probable that by adjustment of the screening grid voltage the valve can be made to oscillate, and a variable resistor connected across the HT voltage with the slider connected to the screening grid (G2) will provide a variable control of oscillation. If there is any difficulty in getting the valve to oscillate, a little feed-back, as in Fig. 29, will no doubt assist. I would add again that this is a receiver for the more experienced reader who can have it aligned properly after he has built it with care in order to avoid interaction and instability. I wish those of you who do attempt it every success, for well built and handled it can be a really powerful 'station-getter'.

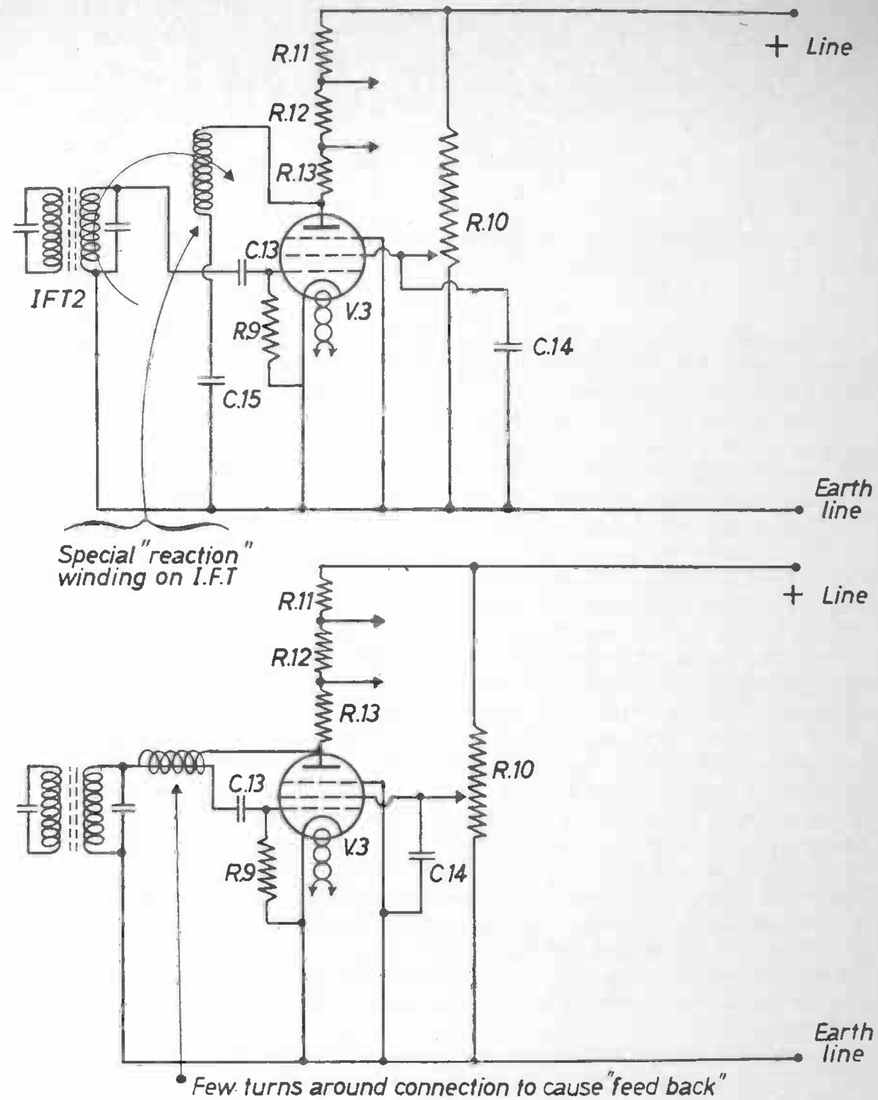


Figure 29.

Two methods of obtaining 'reaction' in Figure 25. Numbers of components relate to that diagram, except R.10, which becomes 100 KΩ potentiometer. These details refer to the detector valve V.3.

Chapter 11

THE COMMUNICATIONS RECEIVER

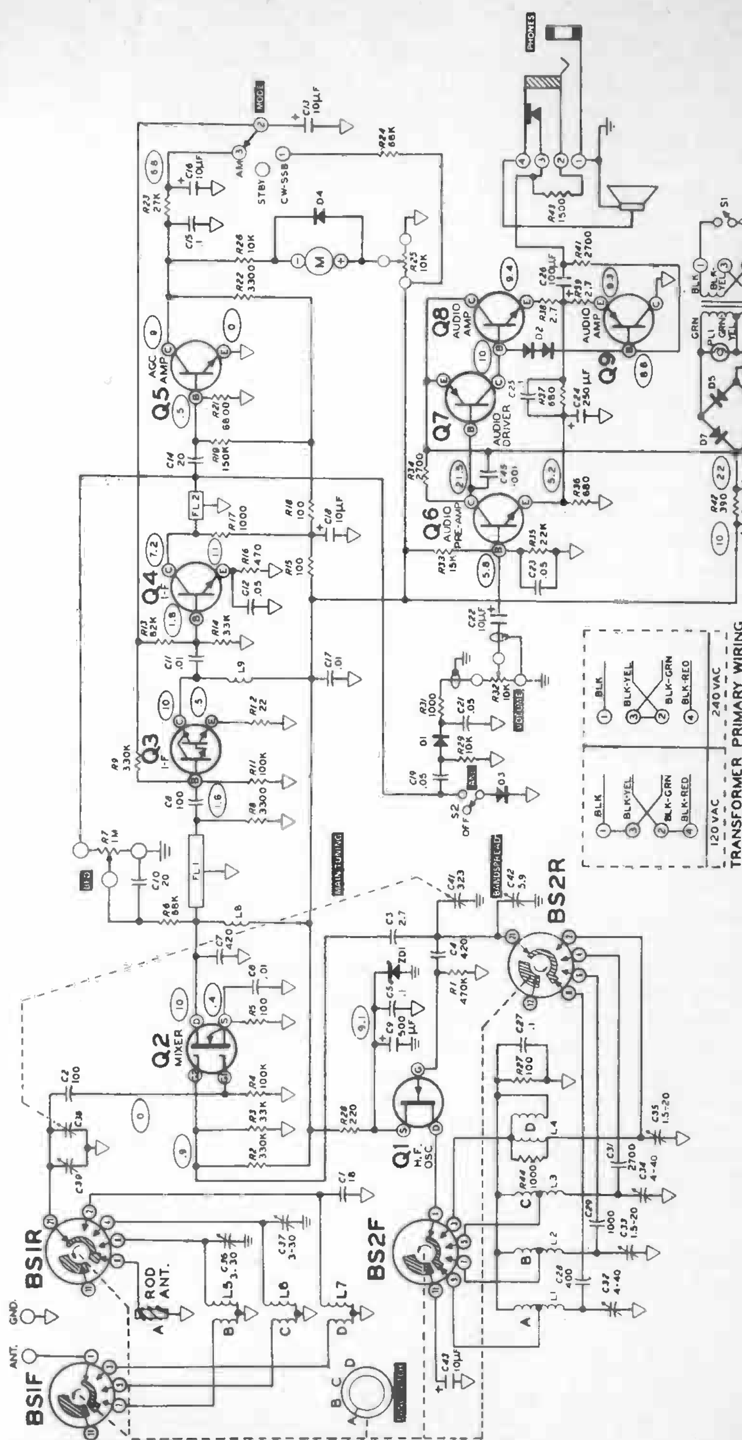
This is a first-rate design for the experienced radio enthusiast. It is solid-state and the layout of the set follows normal superhet practice.

Anyone who uses a simple short-wave receiver today will confirm that the greatest problem is reading the signal you want through the static, mush, beacon noises, broadcasting and commercial stations and every other kind of interference which seems to crowd the short-wave bands. If you add amplification, the 'mush' and stations you do not want are made louder along with what you do want. As a result the communications receiver has been specially developed for the purpose. It usually contains many valves and does not give the highest of fidelity reproduction, being designed to receive mainly Morse or speech from all over the world. Its size and complexity make it expensive. There is a certain skill required in operating some of them to best advantage. For more details of this type of receiver, again I would refer you to the RSGB publication *A Guide to Amateur Radio*.

In the same way that certain makes of motor cars have achieved fame so have certain communications receivers. The name AR 88 comes at once to mind. This was an American design, as were most of the more famous ones, although the Eddystone range of British-made receivers were popular for a long time. After World War II the R.1155 appeared on the war-surplus market and many were successfully adapted for amateur use. They are no longer available, but a very useful range of receivers are marketed in the United Kingdom by the Codar Radio Company. Codar's managing director, Mr. R. E. Ireland is a well-known transmitting amateur G31RE. I have had an opportunity, thanks to his kind assistance, of testing out their excellent communications receiver which gives a brilliant performance and is first-class value. The Receiver is known as Codar CR 70A and is undoubtedly an outstanding short-wave receiver for those who wish to invest in one in the moderate price range.

You can build your own communications receiver provided you have sufficient knowledge to do so coupled with the experience to align it and get it going properly if all does not seem in order. It is a fairly formidable task and not one for the young beginner.

The simplest means of doing this is to purchase a kit from Heathkit (Gloucester) Ltd. who have been selling radio kits for many years. They have kindly given me permission to reproduce the schematic diagram of their SW-717 short-wave receiver shown in Fig. 30. I have built this set from the kit of parts supplied and which includes a most detailed book describing the stage-by-stage construction. Like all radio construction it requires careful soldering and attention to detail; although Heath (Gloucester) Ltd. describe it as a receiver suitable for a novice I think the construction should not be attempted without some basic knowledge of radio compoments



NOTES:-

1. Resistors are ½ watt. All resistor values are in ohms. For values 10,000 and higher, K = a multiplier of 1,000 and M = a multiplier of 1,000,000
2. Capacitor values less than 1 are in µf. Values of 1 and higher are in Pf unless marked otherwise.
3. This symbol indicates a DC voltage measurement taken with an 11 megohm VTVM from the point indicated to chassis ground. Voltages may vary ±20%.
4. Refer to the chassis photographs and the circuit board X-ray view for the parts locations.
5. Bandswitch wafers are viewed from the rear. Switch contacts are on Band A The arrow shows the direction of rotation. A tie pin connects the opposite sides of the rotor of wafer #1.
6. Connections for the Power Transformer Primary Wires are shown in the boxed inset drawing.

and soldering techniques. These you will no doubt have when you have read this book. Do not let me discourage anyone!

The instruction book describes every item and every constructional move with pictorial details. At the time of writing (1978) the cost is in the region of £80 and if you can afford this you will undoubtedly build yourself an excellent receiver.

The whole kit is fully guaranteed and you can write to Heathkit in case of difficulty or if you cannot get the set to work when you have built it! The addresses in the Appendix relate to the United Kingdom, New Zealand and Australia.

A few thoughts on aerials are contained in the next chapter. I myself use no more than sixty feet of insulated wire in the loft and this works very well, but you may like to try a few other ideas suggested.

Chapter 12

AERIALS AND EARTHS FOR SHORT WAVES

Aerials and earths are most important in assisting you to get long-distance reception. So do pay very special attention to them at all times. A really good earth is the first essential. NEVER earth anything to a gas pipe **because it is dangerous and illegal.**

If you have a television or VHF receiver you will know that you have a special aerial for it, and if your TV receiver receives two channels you will have two different aerials, one for each channel on which reception takes place. There is a specific size for each aerial and you will find that the portion on which the signal is actually received, that is the piece of tubing which has the feeder attached to its centre, is half the length of the wavelength. The aerial is known as a half-wave dipole and in the case of TV Channel One is 10 feet 9½ inches in total length. As the wavelength of this channel is around seven metres, you will see it is about half that wavelength. The straight piece of tubing forming the back leg of what is popularly called the H aerial is a little longer than the dipole and is a reflector to 'catch' the waves and concentrate them on to the dipole.

On the higher-frequency channels such as Channel Nine, you will see one or more directors in front of the dipole to 'direct' the waves on to it, as well as the reflector at the rear. These are all often necessary in TV to overcome reflections from hills, buildings and so on which can cause 'ghosts' on the pictures. In short-wave work such elaborate aerials are not generally necessary for reception, although some very complicated 'arrays' are often used to 'beam' signals in certain directions. This means that the directors and reflectors placed around the actual aerial are all rotatable so that the beam which they form can be directed to any chosen part of the globe.

In transmitting, aerials are of utmost importance if maximum power is to be radiated into the air. Books have been written on this one subject alone! Many experimenters study just this one aspect of transmitting all the time, and it can be a fascinating study, although it obviously needs a good deal of room. On the receiving side, if you can get up a decent length of wire it is worth while experimenting with various lengths. Try 66 feet which is half-wave on 7 Mc/s and full-wave on 14 Mc/s. It is also quarter-wave on 3·5 Mc/s so should probably assist reception on that band also. The length is from the aerial terminal to the free end of the wire and it should be well insulated at all points and not allowed to run along pipes, metal gutters and so on. If you can only get up a small aerial you can still apply the same principle by halving 66 and making it 33 feet which will then be half-wave on 14 Mc/s and, as this is a popular long-distance band (called DX band by the 'ham'), you will probably find greatly improved results.

If you have your own bedroom or can use a spare room, you will very likely find you can run the wire from the aerial socket up to one corner of the ceiling and then take it in a 'V' shape from three points in the room. It is not wise to zigzag it across the ceiling. If you live in a flat and find difficulty in putting up an aerial indoors, some form of rod aerial protruding from the window-sill like a car aerial will often give good results. Fix it securely so that it does not fall and injure people or damage property.

As far as earths are concerned, for short-wave work you must have a good earth or none at all. By a 'good' earth I mean a short direct wire to a rising main water pipe or a large metal rod or plate buried in wet soil. A long trailing earth to some remote hot-water tap is useless and it would be better not to use an earth at all than one like that.

If using a water-main take care that it is a metal pipe and not a plastic one which would be non-conducting and quite useless.

NEVER, under any circumstances, attempt to earth anything to a gas pipe. It is dangerous and illegal.

If you are going in for very high frequency work you will need to make a study of, and use, special aerials. They are beyond the scope of this chapter which has only touched the surface of the subject to bring to your notice the fact that aerials are a contributory factor in good reception. For fuller details I refer you again to the RSGB publication *A Guide to Amateur Radio,* an outstanding book in this field.

Chapter 13

COMMERCIAL RECEIVERS AND KITS OF PARTS

I have told readers about the Codar communication receiver CR 70A in Chapter 11 but for those interested in less expensive receivers there is also the Codar Mini Clipper, which is a kit, and another kit called the Multiband 6. Codar produce a R.F. pre-selector PR40 to extend the range of the CR 70A.

The 'H.A.C.' One-valver is described in Chapter 3 and is obtainable from the address in the Appendix. Valves are available from RST Valve Mail Order Company and/or Bentley Acoustic Corporation Ltd. They are listed, with prices, in a reliable radio periodical such as *Practical Wireless.*

Radio Exchange Ltd. sell the Roamer Ten RK3 all-wave kit which employs transistors and covers all waves including VHF. This is a most comprehensive kit at a very reasonable price and covers 3 short-wave bands. Radio Exchange Ltd. ask us to point out that they cannot reply to any enquiries unless a stamped, self-addressed envelope is enclosed. Nor can they supply plans without making a charge. This is in line with all business practice today. Manufacturers and suppliers cannot absorb the high cost of postage in their excellent technical service to amateurs.

Some interesting designs and circuits for short-wave radio enthusiasts are available from Ambit International who also have coils and kits available plus all other types of 'hardware' for radio constructors. Stirling Sound (Bi-Pre-Pak) have some very useful and reasonably-priced modules available; a particularly sound arrangement is the VHF FM tuner coupled to an I.F. amplifier plus a power amplifier. This fed into a good-quality loudspeaker makes a most satisfactory VHF receiver of hi-fi standard.

If you are interested in the possibility of transmitting, write for the leaflet *How to Become a Radio Amateur* to Home Office, Radio Regulatory Department, Radio Regulatory Division, Licensing Branch (Amateur), Waterloo Bridge House, Waterloo Road, London, SE1 8UA. It is free and they do not even want a stamped addressed envelope! In conclusion, I would remind you that I shall be glad to help you with any difficulties you may encounter *but only in connection with the designs in this book.* Write to me c/o the Publishers; please enclose a stamped, addressed envelope or International or Commonwealth reply coupon. It is regretted that no reply can be given without the S.A.E. in the U.K. or I.R.C. outside it. It is meaningless if you live outside the U.K. to send me an envelope bearing your country's stamp, but readers do that.

Finally, we give you the addresses of the manufacturers whose products we have mentioned and who will assist you with problems which arise. It is always better to write to them about components and difficulties: they do all they can to help you.

Now we are going QRT with the wish that you build many first-class short-wave sets which bring in plenty of DX. We hope that you will not be troubled by QRM or QRN and say, in closing, '73s and de de de dah de dah.

BUYING COMPONENTS

It is important to remember that components cannot be purchased at any radio shop which specializes in the sale of complete receivers, TV sets and the like. It is usual now to buy components by Mail Order and this can be done with confidence from reputable dealers who advertise in such journals as *Wireless World*, *Practical Wireless*, *Radio Constructor* and others. It is best to consult the advertisement pages of one of these journals and to write to a dealer specializing in the type of components you require.

One particularly useful supplier is:

Messrs. Home Radio (Components) Ltd., 240 London Road, Mitcham, Surrey, CR4 3HD.

Here are the addresses of firms and societies mentioned in this book (in alphabetical order):

Ambit International, 2 Gresham Road, Brentwood, Essex, CM14 4HN.

Bentley Acoustic Corporation Ltd., 7a Gloucester Road, Littlehampton, Sussex.

Codar Radio Company, Valcon Works, Burrell Buildings, Churchill Industrial Estate, Lancing, Sussex, BN15 8TZ.

Denco (Clacton) Ltd., 355/9 Old Road, Clacton-on-Sea, Essex.

Electroniques (STC Ltd.), Edinburgh Way, Harlow, Essex.

HAC Short-Wave Products, PO Box 16, 10 Windmill Lane, Lewes Road, East Grinstead, Sussex, RH19 3SZ.

Heath (Gloucester) Ltd.,
(1) Gloucester, GL2 6EE (United Kingdom).
(2) Warburton Franki Pty Ltd., 220 Park Street, So. Melbourne, Victoria, Australia.
(3) Warburton Franki Ltd., 42 Oxford Terrace, Lower Hutt, New Zealand.

International Rectifier Co. Ltd., Hurst Green, Oxted, Surrey.

Mullard Ltd., Mullard House, Torrington Place, Tottenham Court Road, London WC1.

Newmarket Transistor Co. Ltd., Newmarket, Suffolk.

Radio Exchange Ltd., 61a High Street, Bedford, Beds., MK40 1SA.

Repanco Ltd., 203/269 Foleshill Road, Coventry, Warwickshire.

Radio Society of Great Britain, 35 Doughty Street, London, WC1N 2AE.

Rank-Wharfedale Ltd., Idle, Bradford, Yorkshire.

RSC(Hi-Fi Centres) Ltd., 102/106 Henconner Lane, Bramley, Leeds13.

RST Valve Mail Order Co., Climax House, Fallsbrook Road, Streatham, London, SW16 6ED.

Stirling Sound (Bi-Pre-Pak Ltd.), 37 Vanguard Way, Shoeburyness, Essex and 222/224 West Road, Westcliff-on-Sea, Essex, SS0 9DE.

Gilbert Davey has written for radio journals, radio and television since 1933. His book *Fun with Short-Wave Radio* has been in continuous publication for almost twenty years, which speaks for its popularity in meeting the needs of amateur short-wave radio enthusiasts. This new edition has been thoroughly revised in order to bring it into line with the simpler aspects of modern practice. The book still aims at the amateur who starts with very little knowledge of building short-wave radio receivers but who can progress in his studies until he is able to build and operate his own amateur transmitter.

Other titles by Gilbert Davey with Jack Cox as Editor are: *Fun with Radio*, *Fun with Electronics*, *Fun with Transistors*, and *Fun with Hi-Fi*.

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