BULGIN RADIO SERVICE MANUAL

No.44

2/6

BERNARD'S (PUBLISHERS) LTD.

CONTENTS

New Edition, 1944-45

Foreword . .

Only rarely, amongst the host periodically issued, does there appear a Radio Book, to which can be truly ascribed the term "Outstanding"

It is with considerable pride therefore, that the present work is introduced, possessing unusual distinction, in that its contents represent the fruits of the combined knowledge and experience of the technical staff of one of the most universally known and respected radio component manufacturing companies, *viz.*,

Messrs. A. F. BULGIN & CO., LTD.

The same high degree of knowledge and skill which has made the name of BULGIN the Hall-Mark of quality and reliability throughout the radio world, has also produced this book, and in thus making so readily accessible the knowledge gained only by years of painstaking research, Messrs. BULGIN render a service to radio science, for which the general public cannot be other than eternally indebted . . .

USEFUL FORMULÆ

(1) Theoretical voltage gain with a resistance coupled amplifier is :

$$\mu\frac{R}{R+Ra}$$

where μ = amp. factor of valve; Ra = internal resistance of valve; and R = external anode resistance.

(2) Roughly, the requisite value of grid bias for an L.F. valve is given by :

$$\frac{\text{Anode volts}}{2\times\mu}$$

where μ = amp. factor of valve.

(3) Ohms Law :

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}},\ \textit{or}\ \text{mA} = \frac{\text{Volts}\times 1{,}000}{\text{Ohms}}$$

(4) Dissipation of Power :

$$\text{Watts} = \text{Amperes}^2\times\text{Ohms}.$$

(or) $= \dfrac{\text{mA}^2}{1{,}000{,}000}\times\text{Ohms}.$

(or) $=$ Volts $\times$ Amperes.

(or) $= \dfrac{\text{Volts}\times\text{mA.}}{1{,}000}$

(5) Reactance of a condenser :

$$\text{Ohms} = \frac{1{,}000{,}000}{6{\cdot}28\times\text{c/s}\times\mu\text{F.}}$$

(6) Resistance of Meter Shunt :

$$\text{Ohms} = \frac{\text{Meter Ohms}}{\text{N}-1}$$

Where N = no. of times full scale deflection is to be increased; e.g. 100Ω meter, 0-1 mA., for conversion to 0-10 mA.

$$\frac{100}{9} = 11{\cdot}11\Omega\ \text{shunt}$$

(7) Standardised abbreviation :

$\omega = 2\pi f = 2\times 3{\cdot}14\times$ cycles-per-second (c/s)

(8) *Reactance* of an inductance (i.e., neglecting d.c. Ω) :

Ohms $= 6{\cdot}28\times$ c/s $\times$ Henries.

(9a) Resistances in Parallel *or* Condensers in Series :

$$\frac{x_1\times x_2}{x_1+x_2}$$ (Individual values to be similar —i.e *all* μF., or $\mu\mu$F., or Ω. etc)

(9b) Resistances in series or Condensers in Parallel : *Add* the values.

(10) Valve Formulæ :

(i) Internal Resistance (impedance) :

$$\text{Ro}\ (\Omega) = \frac{\text{Change in anode Volts.}}{\text{Change in anode current (mA.).}}$$

(ii) Mutual Conductance :

$$\text{g (mA./V.)} = \frac{\text{Change in anode current (mA.)}}{\text{Change in grid volts}}$$

(iii) Amplification Factor :

$$\mu = \frac{\text{Change in anode volts}}{\text{Change in grid volts.}}$$

(11) Resonant frequency of Tuned Circuit

$$f = \frac{1}{2\pi\sqrt{LC}}$$

(12) Dynamic Resistance of a Tuned Circui at Resonance :

$$R = \frac{L}{C\times r}\ (\Omega)$$

where r = equivalent series resistance at the wavelength or frequency concerned.

(13) Magnification ("Q") of Tuned Circuit :

$$\text{m (or Q)} = \frac{\omega L}{r}$$

[r, see (12)]. (L in μH.)

(14) Wavelength =

$$1885\sqrt{L.C}$$

(L. in μH.; C. in μF.)

(15) Ratio of Output Transformer :

$$\text{Ratio (to ONE)} = \sqrt{\frac{\text{Valve loading }(\Omega)}{\text{Speaker or coil impedance }(\Omega).}}$$

(double the anode-load for two similar valves in push-pull; speech-coil impedance = 1·5—2 × d.c. Ω of coil).

N.B. Usual Units: Henries, Farads, Amperes, Ohms, etc., except where stated otherwise. Abbreviations and Symbols see page 80.

USEFUL TABLES

IMPERIAL STANDARD WIRE GAUGE

S.W.G.	Dia. inches.	Sectional area, sq. inches.	COPPER WIRE Ohms per 1,000 yds.	Length per ohm.	Amps. at 1,000 amps. per sq. in.
10	·128	·01286	1·87	535 yds.	12·9
12	·104	·00849	2·83	353 ,,	8·5
14	·080	·00503	4·78	208 ,,	5·0
16	·064	·00322	7·46	135 ,,	3·2
18	·048	·00181	13·27	53 ,,	1·8
20	·036	·00102	23·6	42·4 ,,	1·0
22	·028	·000616	39·0	25·6 ,,	0·61
24	·022	·000380	63·2	15·8 ,,	0·38
26	·018	·000254	94·3	10·6 ,,	0·25
28	·0148	·000172	139·5	7·18 ,,	0·17
30	·0124	·000121	199·0	5·03 ,,	0·12
32	·0108	·0000916	262·0	3·82 ,,	0·09
34	·0092	·0000664	361·0	2·77 ,,	0·07
36	·0076	·0000453	529·0	1·89 ,,	0·05
38	·0060	·0000282	849·0	1·18 ,,	0·03
40	·0048	·0000181	1326	27·15 in.	0·018
42	·0040	·0000125	1910	18·87 ,,	0·0126
44	·0032	·0000080	2985	10·77 ,,	0·0080
46	·0024	·0000045	5307	6·78 ,,	0·0045
48	·0016	·0000020	11941	3·02 ,,	0·0020
50	·0010	·00000078	30568	1·18 ,,	0·0010

TURNS PER INCH *

S.W.G.	Enamelled.	Single silk covered.	Single cotton covered.
10	—	—	7·4
12	—	—	9·0
14	—	—	11·4
16	14·8	15·0	14·1
18	19·7	20·0	18·3
20	26·1	26·3	24·1
22	33·3	33·3	29·8
24	42·1	42·1	37·0
26	50·6	50·6	43·5
28	61·4	60·4	50·5
30	73·3	72·0	57·5
32	83	81·3	63·3
34	98	93·4	70·5
36	116	110	86·5
38	143	133	100·0
40	180	152	112·5
42	217	192	—
44	270	227	—
46	357	278	—
48	526	—	—
50	633	—	—

* Square the figures for Turns per square inch.

LOW FREQUENCY RESONANCE

Frequency.	L.C value for resonance.	Frequency.	L.C value for resonance.
50	10·1	3,000	0·0028
100	2·52	4,000	0·0016
200	0·63	4,500	0·00125
300	0·28	5,000	0·001
400	0·16	6,000	0·0007
600	0·07	7,000	0·0005
800	0·04	8,000	0·0004
1,000	0·025	9,000	0·00031
2,000	0·0063	10,000	0·00025

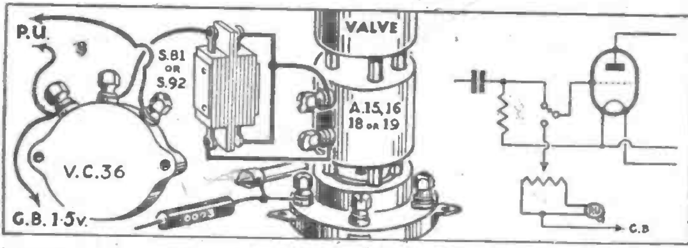
Note.—The higher the L/C. ratio the sharper the tuning, providing the D.C. resistance is not great. High values of D.C. resistance tend to flatten the resonance curve. (L in Henries, C in μF.) (& see p. 37.)

FREQUENCY AND WAVE-LENGTH

Frequency (kilocycles per sec.).	Wave length (metres).	L.C value, μH. and μF.
300,000	1	0·00000281
100,000	3	0·00000253
50,000	6	0·0000101
25,000	12	0·0000407
15,000	20	0·000113
10,000	30	0·000253
5 000	60	0·00101
3,000	100	0·00281
1,200	250	0·0176
1,000	300	0·0253
800	375	0·0396
600	500	0·0704
400	750	0·154
200	1,500	0·633
150	2,000	1·13
100	3,000	2·53

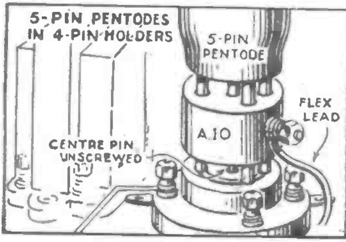
DECIBEL—VOLTAGE RATIO TABLE

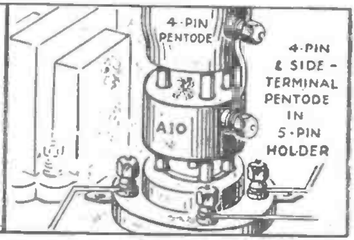
Decibels.	V2/V1.	V1/V2.	Decibels.	V2/V1.	V1/V2.	Decibels.	V2/V1.	V1/V2.
0·1	1·0116	0·98855	3·5	1·4962	0·66834	32	39·811	0·02512
0·2	1·0233	0·97724	4·0	1·5849	0 63096	34	50·119	0·01995
0·3	1·0351	0·96605	5·0	1·7783	0·56234	36	63·096	0·01585
0·4	1 0471	0·95499	6·0	1·9953	0 50119	38	79·433	0·01259
0·5	1·0593	0 94406	7·0	2·2387	0·44668	40	100·00	0·01000
0·6	1·0715	0·93325	8·0	2·5119	0·39811	44	158·49	0·00631
0·8	1·0965	0·91201	9·0	2·8184	0·35481	46	199·53	0·00501
1·0	1·1220	0·89125	10·0	3·1623	0·31623	48	251·19	0·00398
1·2	1·1482	0·87096	12·0	3·9811	0·25119	50	316·23	0·00316
1·4	1·1749	0·85114	14·0	5·0119	0·19953	52	398·11	0·00251
1·6	1·2023	0·83176	16·0	6·3096	0·15849	54	501·19	0·00199
1·8	1·2303	0 81203	18·0	7·9433	0·12589	56	630·96	0·00158
2·0	1·2589	0·79433	20	10·0000	0·10000	58	794·33	0·00126
2·2	1·2882	0·77625	22	12·589	0·07943	60	1,000·00	0·00100
2·4	1·3183	0·75858	24	15·849	0·06310	70	3,162·3	0·00032
2 6	1·3490	0·74131	26	19·953	0·05012	80	10,000·0	0·00010
2 8	1·3804	0·72444	28	25·119	0·03981	90	31,623·0	0·00003
3·0	1·4125	0·70795	30	31·623	0·03162	100	100,000·0	0·00001



Probably the most useful form of split valve adaptor of all the many types which are available is the Split Grid or Pickup Adaptor. This adaptor can quite simply be used for connecting a pickup or a microphone into a set which is not provided with terminals for doing this, and the arrangement may be with or without a switch. If a switch is not to be employed the adaptor is simply inserted between the valve and the holder, and the pickup is connected between grid bias and the top terminal of the adaptor.

*BULGIN List No. A.*15, 4-*pin.* *BULGIN List No. A.*16, 5-*pin.* *BULGIN List No. A.*18; 7-*pin.*

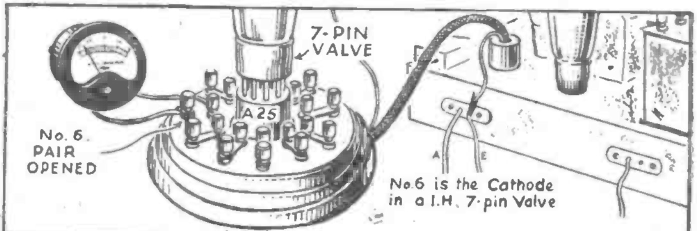




Many sets use pentodes of the four-pin type with a side connection for the priming grid. In replacing such pentodes it may be found that five-pin types only are available. The A.10 is then used with the centre-pin unscrewed and the flexible lead in the receiver connected to the side terminal of the adaptor.

Conversely a receiver may be wired with a five-pin holder, but a pentode be used which has only four pins and a side-terminal. The adaptor should be simply inserted into the holder with its middle pin in position, the terminal on the valve being linked on the adaptor.

*BULGIN List No. A.*10.



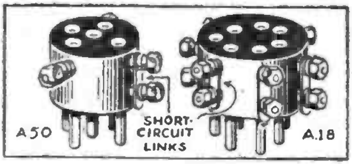
This extremely useful adaptor, known as the V.T.14, will cover all types of valves and the testing of same in all types of receiver. It is a nine-pin all-split adaptor which, for convenience, has the plug member on a short length of flex (not too long so as to cause instability) connecting it to the socket. Each of the nine connections and a tenth connection for the flexible lead to a valve is provided with a split. Our diagram shows an indirectly heated valve removed from a set and inserted in the V.T.14 adaptor with a reducing adaptor, type A.25, to bring down to the requisite number of pins.

*BULGIN List No. V.T.*14. *All-valve Testing Adaptor.*

ADAPTORS FOR VALVE CHECKING

WHEN a wireless set is not operating satisfactorily, or when it has altogether refused to operate, probably the first thing that is suspected is one of the valves. This is, perhaps, not always entirely just because nine times out of ten it is not a valve at all. However, as the valves are the heart of the set and as the proper working of a valve is essential to the stage which it occupies in a set, and, probably more important still, because it is more easy to tell by the performance or non-performance of a valve what else may be wrong in the set, it is generally necessary to attend to these matters first.

The most important thing to do in a set which is not operating satisfactorily is to measure the valve anode current. It is not always easy to do this without breaking wires unless



we employ some form of split adaptor. The Bulgin range covers split adaptors for 4, 5, 7 and 9-pin valves (the 9-pin adaptor is dealt with at the foot of page 4). With these adaptors it is possible simply to remove a valve from its socket, fit in the adaptor and then replace the valve on top of it, and, if the adaptors are suitably chosen, a pair of terminals is ready to hand which can be opened and to which we may then connect the milliammeter so as to show the anode current.

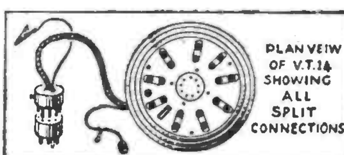
Reference to the valve makers' data or to measurements which have previously been made or, indeed, reference to the makers' book in the case of a commercial receiver. will show exactly what sort of anode current ought to be expected and we shall at least have some definite information as to how to proceed. Let us suppose that a receiver has fallen off considerably in performance and that the result is rather crackly, very distorted and definitely weaker than it was before. Let us suppose also that, to take one particular case, the crackly noise experienced coincides with loud passages of music.

It is extremely probable that we should suspect the emission and the resulting anode current of the output valve, which is probably a pentode. Let us take the 5-pin split anode adaptor, List No. A.8, and insert it into the holder, replacing the valve. The two terminals are now to be connected to a milliammeter, the terminal nearest the bottom of the adaptor being, for reference purposes, the positive terminal, and thus to be connected to the positive terminal of the milliammeter. Reference to makers' data will show us (to take a hypothetical case) that since the valve is fed with 150-V. H.T. and has its proper grid bias (we have verified this with a voltmeter) it ought to pass about 30 mA. The milliammeter—a reliable type, please, so as not to give misleading results—shows 10. This, of course, is quite useless. We switch off the set and reduce the grid bias one or two sockets (it should be pointed out that this should not be done unless the valve shows an excessively low current, otherwise it would be damaged). Switch on again and see what has happened; the anode current has, perhaps, gone up to 12. This, of course, is quite unreasonable, and the only conclusion is that the valve has lost a very great deal of its emission; it must be replaced.

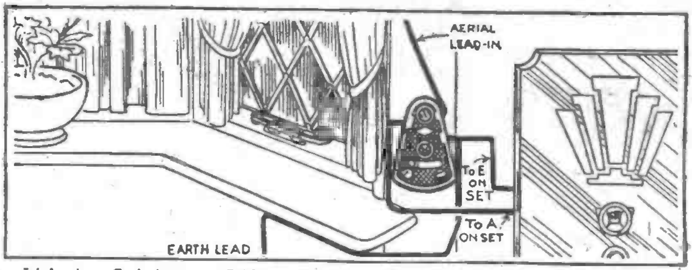
Similarly we may proceed through other stages of the set, bearing in mind that we must not always expect the set to operate as regards sound from its headphones or loudspeaker when these adaptors are being used We must also be careful when testing H.F. or detector valves, for we shall probably cause instability by the use of the adaptor in the leads of the milliammeter, and we might get fallacious current due to valves being provoked into oscillation.

With detector and H.F. valves, therefore, it is always a safe measure to connect a condenser of about ·1 μF. directly across the terminals of the adaptor or across the terminals of the milliammeter in addition to the latter instrument. Still using adaptors and having checked through a receiver and found that all anode currents are quite reasonably normal, a set may still be absolutely silent. Other adaptors there are with split filament connections, split grid connections, etc., which we may use to check supply currents and voltages.

In case of seven and nine-pin types it is essential to refer to the makers' data as regards the pin connections for the type of valve being tested, because the same

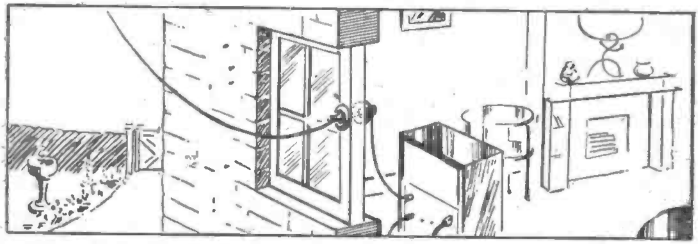


numbers are not always used for the same sort of electrodes in different types of valve. Ammeters can be inserted into the filament circuit (be careful! it is necessary to use an A.C. type of ammeter in A.C. and A.C./D.C sets), and we can also use the adaptors without opening any of the split pins as tapping points for voltmeters, the negative points of such voltmeters being returned to earth.



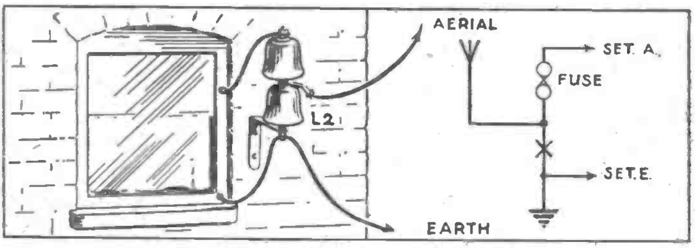
The Lightning Switch type S.99 may be fitted inside or outside a window. Our diagram shows the switch fitted with the aerial lead taken in and connected to the middle terminal of the switch. The top terminal of the switch—connected to the fuse—is then connected to the aerial terminal of the switch. The right-hand terminal of the switch is connected to the earth lead and a further connection is taken from this terminal to the set. When the switch is pushed over to the right the aerial is earthed.

BULGIN List No. S.99, Lightning Switch.



The Universal Lead-in Insulator may be fitted to any window-frame or wall between 1 in. and 5 in. in thickness. A half-inch hole is bored and the raised porcelain insulators will then be found to wedge into this hole so that when the nuts of the centre rod are tightened up a water-tight seal is given, and the actual leading-in conductor is surrounded by air, the best possible insulator, for the greater part of its length. The two remaining nuts are used to secure the lead-in wire on the outside and the lead to the aerial terminal of the set on the inside. The nuts and washers will clamp large cables.

BULGIN List No. L.11.



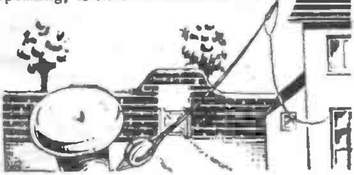
The L.2 fitting is an automatic leading-in wire stay and an arrester. The theoretical diagram on the right of the picture shows the internal arrangment, gap, and fuse. The aerial is connected to the terminal between the two cup-insulators, and the aerial lead to the set is then taken to the top terminal of the fitting. The universal Lead-in Insulator shown in the diagram above can also be used if desired. The earth lead must be connected to the bottom terminal (i.e. the bracket) and the set.

BULGIN List No. L.2.

AERIAL EFFICIENCY

THE aerial is the most important part of any receiving or transmitting installation. It is certainly true that many modern receivers do not require highly efficient aerials or, to put it in another way, will work satisfactorily off aerials which are relatively poor collectors. This, however, is no excuse for putting up with an inefficient aerial installation when the utmost efficiency of reception is required. The ordinary type of aerial, usually an inverted " L " or inverted " T " aerial, is much too well-known to require any description whatsoever. Short-waves have called for aerials of differing types, and a very popular type of aerial is that known as the Doublet. This is illustrated in pictorial form in this column, while a diagrammatical representation of the doublet aerial appears at the head of the second column.

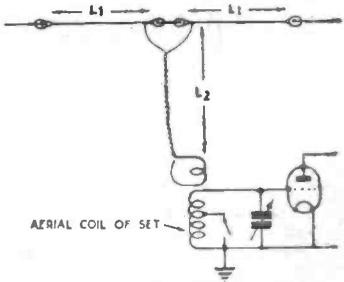
The doublet aerial should be erected with the two spans marked " L.1 " as nearly horizontal as it is possible to make them. It is not essential that they be in a straight line, as some forms of doublet aerial have the two sections "L.1" at right angles. It is then, however, considered important that the angle be exact. A doublet aerial, properly speaking, is most effiicient at one



particular waveband, but in practice it is found that a doublet aerial designed for resonance at a particular wavelength or frequency is actually efficient over quite a wide band is and generally so used.

The most popular type of doublet aerial is one designed to resonate at 40 metres, approximately in the middle of the useful short-wave band. Under these conditions each of the sections " L.1 " should be a quarter of a wavelength (i.e. $\frac{1}{4} \times 40$ metres) long. When converted into ft. and " it is found that this is approximately thirty-three feet per section.

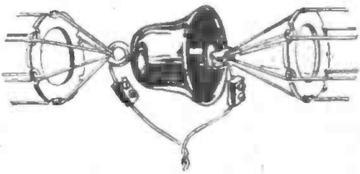
Varying forms of lead-in are employed, one of the simplest is twin-twisted rubber-covered wire, and very satisfactory indeed this is for experimental purposes. For continuous use, when exposed to atmospheric conditions, the rubber covering of the wire should be protected by a bitumised compound to avoid it perishing, and it is perhaps because of this reason that another form of down-lead is sometimes employed. This second type of down-lead in connection with doublet aerials may be made of simple bare wire with what



is termed " transposition " blocks or insulators interposed at equal distances; about ten to fifteen such blocks are generally used, and the two wires are crossed over at each block, so that this, it will be seen, is very much like the twin-twisted flex, but the twists are less frequent.

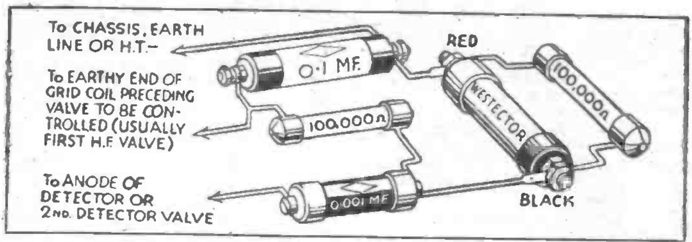
For coupling to the set these two lead-in wires must be specially arranged. Neither is to be earthed, and if the input coil of the set does not incorporate special doublet winding (some factory-constructed sets do) the difficulty must be overcome by winding a few turns of wire around the first coil in the receiver and connecting these in the doublet as shown in the diagram at the head of this column.

Some little experiment will probably be necessary as to the number of turns which give the best result, but this is easily determined. In any case the number of turns will be small; for 20-80 metres it is unlikely that a number of turns greater than eight will at any time be required. Most probably a less number will be found more satisfactory. The length of the down-lead L.2 should, strictly speaking, be half a wavelength



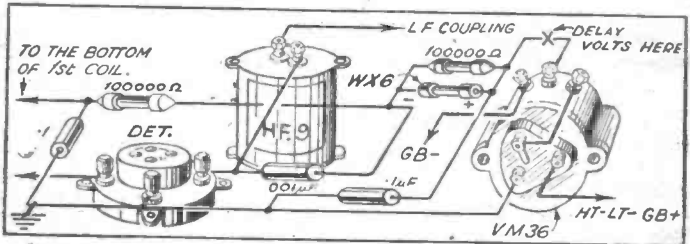
It is not necessary, however, to insist upon a length of 66 feet for the L.2 part of the aerial, although this will give the best results.

The final picture on this page shows a way of converting our Wallaerial Kit with an additional L.3 insulator in the middle into a doublet aerial. It will be seen that the two sections of the aerial, L.1, to use the figures of the diagram before referred to, are then of the cage type, a refinement which, on progressively shorter wavelengths, may be found to be an improvement.



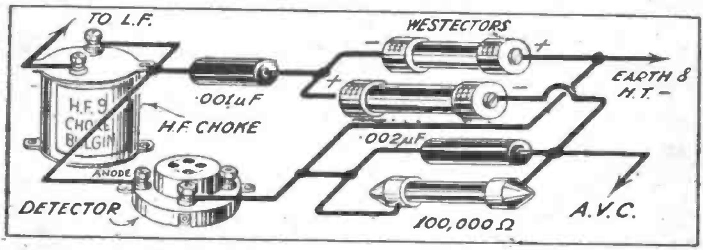
Here is a simple system of automatic volume control applicable to all sets with one or more H.F. stage. It is quite easily added to any set having one or more H.F. stage, but cannot be used with sets having none. The middle arrow must be connected to the coil winding, which is at its other end connected to the grid of the H.F. valve, and if part of this coil is switched to earth it must be no longer so connected, but must be switched to the bottom end of the coil, or the A.V.C. system may become inoperative.

BULGIN List No. H.W.25, 100,000 Ω Resistors. *BULGIN List No. P.C.201, Condensers.*



This circuit shows a different form of A.V.C. Simple half-wave rectification is employed as before, but a volume control is brought into circuit so that in addition to the automatic volume control employed, the manual volume control can be used to set the desired strength of signal. This diagram will hold good for all sets with simple A.V.C. where manual H.F. volume control is to be incorporated as well. If the A.V.C. be delayed, a separate delay battery may be inserted at the point marked "X."

BULGIN List No. V.M.36, 50,000 Ω Volume Control.



Here is an even more elaborate system of A.V.C. which can be applied to many sets. Two Westectors are used, and (if you have studied the Westinghouse publication "The All-metal Way," as you doubtless will do when you purchase Westectors) you will see that this system gives considerably increased A.V.C. voltages, and much better control. The wiring is very straightforward and the arrow in the bottom right-hand corner marked "A.V.C." goes to the bottom of the coil or coil-winding which feeds the H.F. valve or valves which are to receive A.V.C. voltages. See details above regarding coil switching.

BULGIN List No. P.C.202, 0·002 F. Condensers *BULGIN List No. H.W.25, 0·1 MΩ Resistances.*

AUTOMATIC VOLUME CONTROL

MOST commercial sets to-day include some form of automatic volume control, and indeed most of the circuits for home-construction do so also. There is hardly a superheterodyne receiver which does not incorporate it, and most of the so-called straight sets with one or more H.F. stages do so, for the enormous advantages which this modern refinement confers upon all such receivers. We have all listened to distant stations on a set and have heard them fading.

This fading is caused by variations in various reflecting media or layers which are believed to exist above the earth's atmosphere and which play a large part in reflecting radiation waves down again to receiving point. The only way (it was found) to combat such fading satisfactorily was to have a receiver which gave considerably more amplification than was wanted, so that the signals could still be received quite satisfactorily when it had faded away to quite a weak value, and then to arrange some automatic arrangement which would weaken the signal down in more or less exact relationship when it faded upwards and became louder in receiver strength. It was found that this could quite easily be done by taking the carrier wave, after it had been amplified by various H.F. and possibly I.F. stages, and rectifying it, care being taken not to have the modulated part, i.e. the part of the signal which reproduces noises in the loudspeaker—the carrier wave only is what is required. (Generally speaking, a diode or a number of diodes are employed for a rather particular reason which we shall come to later.)

The circuits shown on the opposite page use Westinghouse metal rectifiers which are, of course, unheated diodes, and when connections are made as shown the carrier wave is rectified and appears as a voltage across a resistance connected between the diode and H.T. negative (i.e. the earth also).

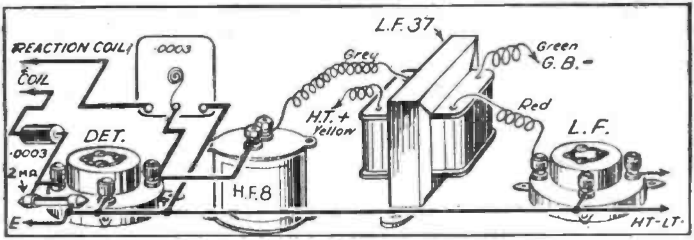
The end of the resistance which is nearest to the diode anode of the valve or which is nearest to the negative end of the rectifier and the point at which the carrier wave is fed in from the coil or the anode of the detector valve, becomes very much more *negative* than H.T. negative and the earth line of the set when a large or strong carrier wave is being received and rectified. We then feed off through a resistance (the middle 100,000 Ω in the top diagram on the opposite end page) to the bottom end of the coil of an H.F. valve and, of course, through this coil to the grid of the H.F. valve. When a strong carrier wave comes along we rectify, as aforesaid, quite a strong negative voltage. When this is applied to the valve it commences to cut down its amplification. This, of course, cuts down the carrier wave which it passes on in amplifying and to some extent cuts down the negative voltage, which we are rectifying and, after filtering, returning to an H.F. valve or valves. A state of stability is soon arrived at (we say " soon "—in most A.V.C. systems it happens in a minute fraction of a second) and with a properly arranged A.V.C. system the negative voltage fed back will so balance matters and reduce the amplification with a strong signal coming through that the output of the loudspeaker is very nearly constant. As soon as the signal starts to fade the rectified carrier wave is less, the produced negative voltage is less, the H.F. valve starts to give more amplification. It will be seen, if you care to go into the mathematics of the matter, that actually we can never have a perfectly constant output, but in practice the system works so well, as you have probably experienced when listening to receivers incorporating it, that the output level from the loudspeaker does become very nearly constant.

Of course, if the receiver is being worked " all-out," we cannot expect the receiver to work properly, because when we want to reduce the negative bias on the valves so that they can give greater amplification, we find of course, that there is no more amplification to give—we have used it all. Under these conditions weak stations will fade even though an A.V.C. system is employed.

Some A.V.C. systems are what is termed " delayed " : this simply means that in battery sets a little separate negative bias must be applied to the rectifier (diode valve, or metal rectifier) which we are using to produce A.V.C. voltages. Under these conditions, no A.V.C. voltage will be generated until the signal to be rectified exceeds the value of the delaying voltage. This is a certain advantage in many cases. It is, however, generally only employed in multi-valve receivers.

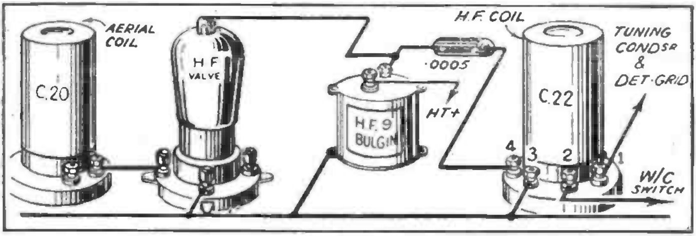
A.V.C. voltage can also be delayed, as it is termed, in mains-driven receivers and the system adopted is, in most cases, the same, whether the set be operated from A.C. mains or whether universal connection is employed. The A.V.C. diode anode is arranged to be returned through its load resistances to a point which is more negative than the cathode of the diode. Very often the bias voltage existing across a resistance for an L.F. valve is employed for the purpose. Either the full voltage may be fed to the diode or the voltage may be tapped. Where a separate diode valve is employed there is not, of course, sufficient current flowing between its cathode and anode to give the required voltage-drop for delay purposes. It is therefore customary either to connect this cathode to a tapping on a resistance network between H.T. positive and H.T. negative or to connect the cathode to the cathode of an L.F. valve.

All H.F. valves which are fed with A.V.C must have what is termed a variable-mu characteristic. If valves which are not of the variable-mu type are employed rather curious results may sometimes be obtained.



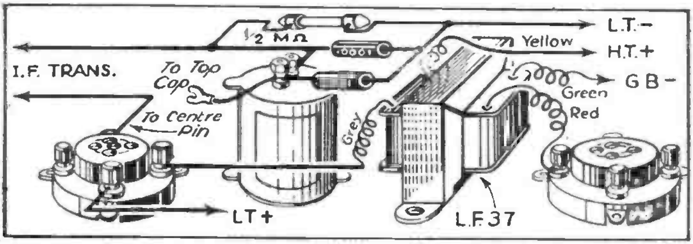
The most important place for an H.F. choke is in the anode circuit of the detector valve. This ensures that reaction is smooth and that H.F. currents do not stray into the L.F. amplifying stages, causing distortion at relatively low signal levels. The H.F. choke is simply connected between the anode of the detector valve and the coupling component, which in the diagram above is the Bulgin L.F. 37, a general purpose transformer. The lead to the reaction condenser must be taken from the anode side of the choke.

BULGIN List No. H.F.8, General Purpose H.F. Choke.



When a tuned grid coil is used the H.T. to the anode of the H.F. valve is fed through an H.F. choke, since the H.F. choke has low D.C. resistance and will not "lose" H.T. voltage to any appreciable extent. From the anode of the valve a feed condenser connects to the coil which is then at low battery-potential. It will be seen that the H.F. choke is virtually in parallel with the coil. It is absolutely essential to use a type which has a smooth curve, otherwise amplification may fall down seriously at resonant points, causing weak signals and inexplicable "dead spots" to prejudice performance.

BULGIN List No. H.F.9, Standard H.F. Choke.



When dealing with intermediate frequencies in superheterodyne receivers it is very important to filter carefully. Our diagram shows the connections with a diode detector feeding into a half-M Ω half-watt type of resistance as load, this being connected to L.T negative. From the top end of the resistance connection is taken through a choke type H.F.10 to the grid of the valve (the top-cap in this type of multiple battery valve is the grid of the triode section). From either terminal of the H.F. choke a ·0001 μF. fixed condenser is taken to H.T. negative to perfect the filtering, and to keep H.F. out of the L.F. stages.

BULGIN List No. H.F.10, Super H.F. Choke

CHOKES H.F. AND THEIR USES

BULGIN H.F. chokes represent the finest value for money obtainable in this class of component to-day. This is a very bold claim, but one which we are able to substantiate in every way. Do not be misled into buying low-price and worthless H.F. chokes; it were better to use none at all than to use these, but naturally it is best of all to use a good and efficient type which can be relied upon Remember that in nine circuits out of every ten an H.F. choke is, in effect, in parallel with the tuning coil, and if it is not absolutely of the best quality and has a smooth and even choking curve it will seriously lower the efficiency of the tuned circuit concerned.

The inductance value of an H.F. choke should be high. High values of inductance in components of this class are only obtained by winding many thousands of turns of high conductivity wire. Even if the inductance is raised as it is in many good chokes by the introduction of an iron core, you have to pay for this. The only thing which can be introduced without increase of price is air, and except for keeping the self-capacity down, air is of little use at all

In an ideal choke the self-capacity factor would be non-existent, but in practice this cannot be, and so designers have to compromise and bear in mind the ultimate use of the particular model upon which they are working. It is always desirable to have the self-capacity as low as possible because, on increasingly high radio-frequencies, the self-capacity factor becomes the most important.

For short-wave and ultra-short-wave working self-capacity is probably more important than anything else and, naturally, lower values of inductance can be tolerated providing that the self-capacity is low. The Bulgin range of screened chokes incorporates types for all requirements. The super-screened H.F. choke is used with super-heterodyne circuits having a low intermediate frequency. With this frequency it is necessary to have a very high value of inductance.

In any filter or anode circuit dealing with such H.F. frequencies where a choke is to be used, it is necessary to use one having an inductance of between a quarter and a half Henry (250,000 μH. to 500,000 μH.).

In detector circuits H.F chokes are necessary in order to prevent the stray H.F current which appears in the anode circuit of such valves being passed on to the L.F stages. If H.F. is allowed to filter through to the L.F stages complicated effects will take place, which will result in lowered output before distortion sets in on certain frequencies.

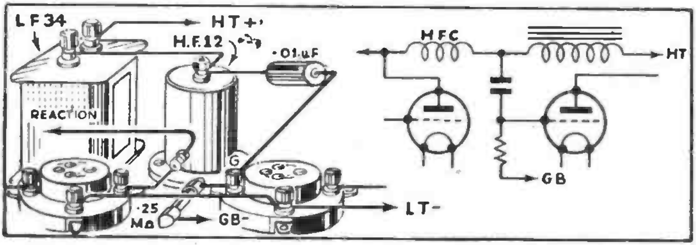
Proper H.F. filtering should be done in the anode circuit of the valve where H.F. is dealt with last of all—that is, of course, the detector valve. Properly connected, a suitable H.F choke in the anode circuit of a detector valve, as shown in the diagram opposite, will enormously assist in obtaining smooth reaction control. It is very simple to add such a choke to any detector valve. Simply remove the wire leading from the anode terminal to the L.F. coupling transformer, resistance, or choke, and connect the Bulgin H.F. choke in its place, leaving the wire going to the reaction condenser connected to the anode terminal of the valve. This is very clearly shown in the diagram at the top of the opposite page.

In H.F. amplifying circuits one very popular arrangement is to use what is known as a tuned-grid coil. In this a coupling condenser from the anode of the H.F. valve connects therefrom to the grid tuning coil, which may have either primary and secondary windings or a single winding only. H.T. is then fed to the H.F. valve through an H.F. choke. This is one of the cases where an H.F. choke is virtually in parallel with the coil—unless the coupling condenser is exceedingly small, often an undesirable feature. If such a choke has peaks and resonances amplification will be extremely uneven, and it is necessary to use a choke which has as smooth a curve as possible.

The curves of Bulgin H.F. chokes are given in the last pages of the complete Bulgin Catalogue, if any proof is needed of our assertion that they are the best types it is possible to design. For short-wave working, as we have said, chokes having very low self-capacities are needed. There are, of course, universal types of choke covering short, medium and long wavelengths, such as the Bulgin screened type H.F.15. This has a very low self-capacity, and can be thoroughly recommended for all-wave sets.

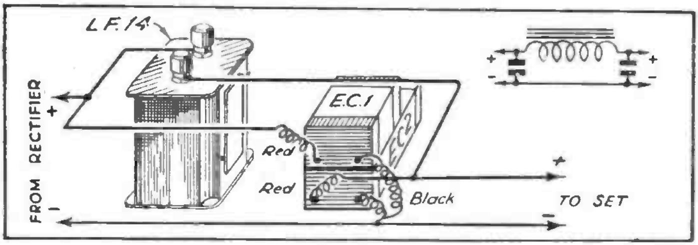
For short-wave sets specifically there are many types of Bulgin short-wave H.F. chokes which are particularly effective. New models have recently been issued wound on glass, having the lowest possible losses and extremely low self-capacity, so low in fact that measurement has to be undertaken with very special apparatus. (Type H.F.21.)

In some short-wave sets, apart from the normal position of a Bulgin short-wave H.F. choke in the anode circuit of the detector valve, in the same manner as for medium-waves, an additional position is found in the output lead to headphones or loudspeaker H.F. at very high frequencies as met with on the shorter wavelengths leaks and strays very easily into L.F. amplifiers, and threshold howl and reaction overlap are often caused by feed-back of H.F. from flexible leads. With such chokes in the output leads to headphones or loudspeaker condensers of ·0002 μF should be connected from the actual anode of the output valve direct to L.T. negative and two direct from the junction of the H.T. positive lead and the second choke to H.T. negative.



In certain battery types of receiver where it is desired to use resistance-coupling for the utmost quality of reproduction, it is sometimes found that the anode resistance inevitably reduces the H.T. voltage unduly. An L.F. choke of high inductance will replace the anode resistance, and we recommend the Bulgin type L.F.34 which has an inductance of over 100 H., but quite a low D.C. resistance, so that less than 2 volts will be "lost" for every milliamp. flowing; since the average detector anode current is about 3-mA. only 6 volts will be dropped, a negligible loss of H.T. pressure.

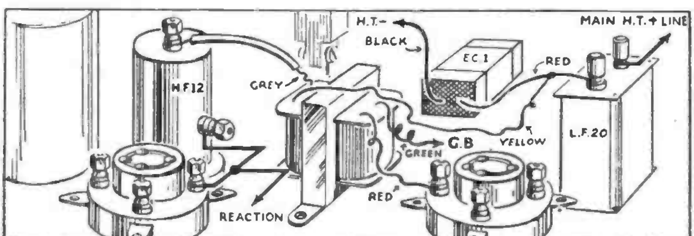
BULGIN List No. L.F.34, 100-Henry Choke.



Probably the most important use for an L.F. choke is that of smoothing in H.T. circuits. The conventional smoothing circuit which is used in 99 per cent. of circuits is shown in the diagram above in both practical and theoretical form. Electrolytic condensers are shown and, since these are of the polarised type with red leads for the positive connection and black leads for the negative connection, this circuit cannot be applied to D.C. mains unless paper condensers (which may be reversed in connection) are used.

BULGIN List No. E.C.1, 4-μF. Condenser.

BULGIN List No. E.C.2, 8-μF. Condenser.



Here is another use for an L.F. choke which is not perhaps very well-known, but which is of enormous advantage. The L.F.37 type of transformer is used, but we will suppose that motor-boating has set in. Decoupling has to be employed without loss of H.T. voltage. The L.F.20 choke may be used, virtually as a decoupling impedance in conjunction with the E.C.1 electrolytic condenser of 4 μF. capacity. Excellent decoupling is obtained with practically no loss of H.T. voltage, and quite a high impedance obtained.

BULGIN List No. L.F.20, 32-Henry Choke.

CHOKES L.F. AND THEIR USES

JUST as practically every set or circuit must contain at least one H.F. choke so we find in all modern receivers, amplifiers and other circuital arrangements that L.F. chokes are used. Probably the most important use for an L.F. choke is in a smoothing circuit. The reason for the use of an L.F. choke is that quite a high value of impedance is presented, while the D.C. resistance compared with the impedance is comparatively low.

In a pure resistance of a non-inductive, or substantially non-inductive, type the impedance—which is the resistance offered to alternating current—is the same as the D.C. measured resistance. In a choke, especially one to deal with L.F. frequencies, the impedance is a function of the inductance and is very much higher than the D.C. resistance.

It is possible without any appreciable difficulty to calculate the apparent resistance of chokes, and the simple formula given below will, in high inductance chokes of relatively low D.C. resistance, give a figure which is close to the actual value, so close that it may be used in all ordinary calculations.

The formula is :—

$$\text{Apparent } \Omega = 6{\cdot}28 \times \text{frequency} \times \text{henries.}$$

A moment's consideration will show that the higher the frequency the higher the Ω figure which results, and this is, of course, true. In smoothing circuits we are dealing, in most receivers, with frequencies of the order of 50 and 100. It will be seen that the L.F. choke generally used, which has a value of about twenty henrys, has a very high apparent resistance compared with the D.C. resistance which, generally speaking, is of the order of 300 Ω.

The D.C. resistance, however, is the figure we have to consider when we talk about voltage-drop as applied to the H.T. current which is being passed through the smoothing circuit to the receiver. The formula for voltage-drop in D.C. circuits is :—

$$\text{Voltage} = \text{Current} \times \text{Resistance.}$$

It is important to note in the above formula that the current must be expressed as a fraction of an ampere. Since we are dealing chiefly with milliamperes in radio circuits we may rewrite our formula :—

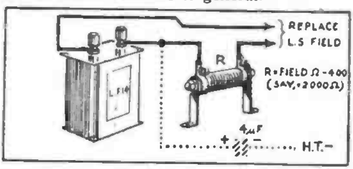
$$\text{Voltage} = \frac{\text{mA.} \times \Omega}{1{,}000}$$

We suggest that you take a piece of paper, sit down, and thoroughly familiarize yourself with the workings of simple equations such as these; after all they are only elementary mathematics and a little familiarity with them will enable them to be worked straight off in the head without recourse even to paper and pencil.

L.F. chokes are not only used in smoothing circuits, but in some cases are used for L.F. coupling where low direct-current voltage-drop is desirable, and also for decoupling purposes for the same reason. Circuits incorporating these uses in practical forms are given on the opposite page.

Sometimes in modern factory-built receivers and also in certain published constructors' designs, smoothing of the H.T. supply is arranged to be effected by the field winding of the loudspeaker. Generally with such an arrangement the mains transformer is arranged so as to feed to the rectifier valve approximately 350 volts, although only 250 volts are required for the operation of the valves in the set.

The voltage-drop across the speaker field is then something of the order of 100, and this multiplied by the current flowing through the field winding will be found to represent the wattage dissipated and turned into speaker "energization." Of course, a set designed for this arrangement may not always be used with such a speaker field. There may be a high-resistance field provided in a speaker which is desired to be used, but for field-smoothing arrangements, a value of 2,500 Ω for the field resistance is general.

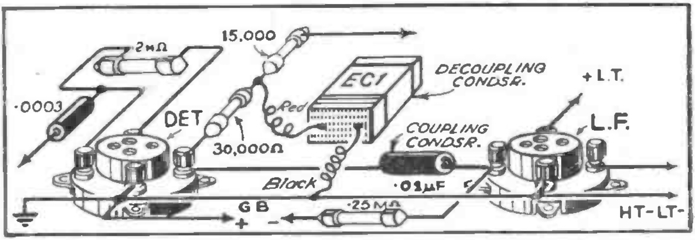


Under such conditions it is no use simply to replace the speaker field by an L.F. choke because, for the reasons aforesaid, its voltage-drop will be low and the valves would be over-run. For such a substitution we must employ a choke with a resistance connected in series with it so as to bring up the total resistance of the substitution to the desired value. Sometimes, when making such a replacement or alteration, it is desirable to use an additional condenser of, say, 4 μF connected from the junction of the choke and resistance to H.T. negative.

The arrangement is shown clearly in the diagram. It is generally advisable to use a power resistance of about 2,000 Ω in series with a Bulgin Choke type L.F.14 and adequate inductance and satisfactory smoothing should result.

L.F. Chokes may also be used for decoupling in L.F. circuits where the lowest possible voltage-drop is an important consideration.

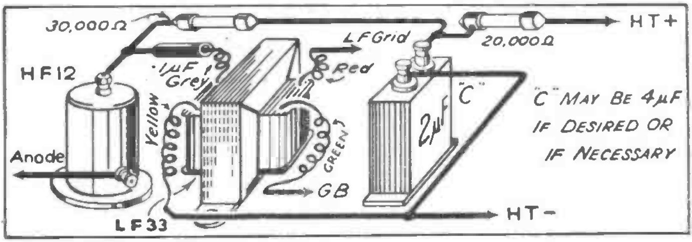
Generally a choke such as type L.F.34 with an inductance of over 100 henries is used. The D.C. resistance of this type is only of the order of 1,800 Ω, which represents a drop of 1·8 volts for every milliampere flowing through it. This is negligible compared with the average decoupling resistance of 20,000 or 30,000 Ω—a drop of 20 or 30 volts per milliampere flowing.



This diagram shows the simplest method of introducing decoupling into a circuit where a detector valve is resistance-coupled to the succeeding L.F. valve. An H.F. choke is not shown; reference should be made to other diagrams for this component's connections. It will be seen that the detector valve has a load resistance of 30,000 Ω with a coupling of 0·1 μF. for the L.F. valve. A further resistance of 15,000 Ω is connected between H.T. positive and the first-mentioned resistance and from the junction of the two resistances a condenser is connected to H.T. negative.

BULGIN List No. E.C.1, 4 μF. Elect. Condenser.

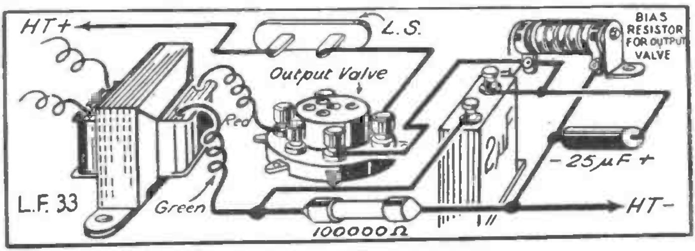
BULGIN List No. P.C.101, 0·01 μF. Condenser.



This diagram shows decoupling in much the same way. It is, however, more applicable to battery circuits, since it shows a paper dielectric condenser of which the polarity can, of course, be reversed without harm. The L.F. coupling is here a fed-transformer, fed through a ·1 μF. condenser with an anode load resistance of 30,000 Ω. The decoupling resistance is here 20,000 Ω connected between the load resistance and H.T. positive, with a condenser connected as before between the junction of the resistances and H.T. negative.

BULGIN List No. L.F.33, 1:4 Fed-Transformer.

BULGIN List No. S.C.20, 2 μF Condenser.



Grid circuit decoupling is often carried out. The lack of it will not cause motor-boating except in rare cases as does the lack of anode circuit decoupling, but if grid circuit decoupling is not always employed loss of bass may result. The bias resistance is connected in the normal way between H.T. negative and the cathode of the valve. The return of the grid circuit, in this case the secondary of the transformer, is made to H.T. negative through a resistance of 100,000 Ω and from the junction a condenser is connected across to the cathode.

BULGIN List No. H.W.25, 100,000 Ω Half-Watt Resistance.

BULGIN List Nos. P.R. —, Power Resistors, 10–60 Watts, values : 25Ω—0·15 MΩ.

DECOUPLING A MODERN NECESSITY

SOME years ago the word decoupling was on everybody's lips. Journals rushed into print with articles on this large subject with pictures and diagrams, and enterprising manufacturers brought out decoupling units guaranteed to do the magic deed. Times have changed, however, and although some of the old modes and manners are still with us they are not always plain to see.

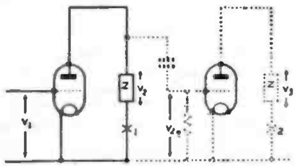


FIG. 1

Let us consider our case. Fig 1 shows a valve amplifier. The signal or other input voltage is applied at V1. We shall find with the proper order of things that if we have the impedance "Z," which is the coupling transformer, choke, resistance or what-not in the anode circuit, another voltage, V2—much larger—will appear across it. Of course, you will say, this diagram won't work because there is no H.T. Precisely so, and it has to be connected at the point marked X1.

The second valve, dotted in the diagram, behaves similarly, receiving V2 substantially and pushing out a still larger signal V3. More H.T. must be applied, so X2 shows where. This, of course, however, would not be considered to be a practicable arrangement. Separate H.T. batteries for different valves—ridiculous! One H.T. battery or eliminator must serve for all, and the need for decoupling then comes in.

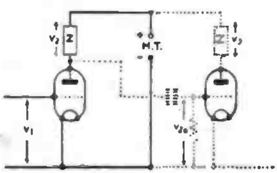


FIG. 2

Fig. 2 should now be studied. It shows our two valves with one H.T. supply. All H.T. sources have some kind of internal resistance. H.T. accumulators usually have very little, H.T. dry-batteries a little more, and most mains rectifying and smoothing circuits a very great deal. For the amplified signals which are produced between anode and cathode this H.T. resistance is in the way. The impedance of the H.T. is, in fact, in series with the anode impedance, and therefore some of the signal voltage, V.2, is unfortunately set up across the H.T. supply.

When a valve amplifies it changes what is known as the phase. The voltages V1 and V2 are out of phase by part of a cycle and so also are V2 and V3. However, since the H.T. is common to both the valve anode circuits some of V2 and some of V3 will appear across the H.T. impedance. Being in opposition they will be cancelled, which means loss of amplification. If transformer coupling were employed to apply V2 to V3 the phase might easily be altered again, so that V2 was actually in almost the same phase relationship to V3.

Supposing this to be the case, the part of V3 appearing across the H.T. supply would also be fed back and oscillation at low-frequencies (or "motor-boating") would take place. Now for the cure. Fig. 3 shows "Z" the coupling impedance as before and a further component "R" (or "Z"), with a shunt path "C." "C" is the decoupling condenser, and "R" (or "Z") is the decoupling impedance or resistance. Now what happens? Signals will be set up across "Z" and must, of course, have a circuit to the cathode. Since the signals are A.C. they will "pass" through a condenser. "C" therefore presents quite an attractive path. "R" (or "Z") is, however, of higher impedance, most unattractive, and very little of the signal voltage will appear across the H.T. supply. The full arrows, therefore, show the real signal path (as we may look at it in this light), and the dotted arrows show the path of very unattractive going.

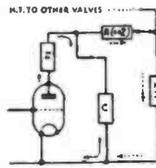


FIG. 3

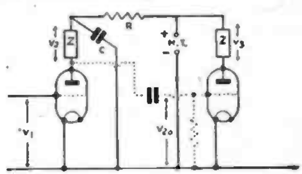
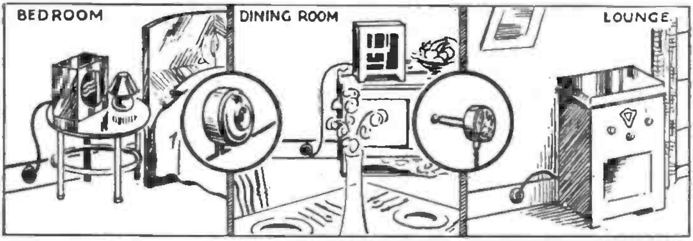


FIG. 4

Fig. 4 shows the scheme in use. We have got to make the path "C" much more attractive than the path "R." The apparent Ω of "C" are given by the formula :—

$$\Omega \text{ of "C"} = \frac{\text{One million}}{6{\cdot}28 \times \text{frequency} \times \mu\text{F}}$$

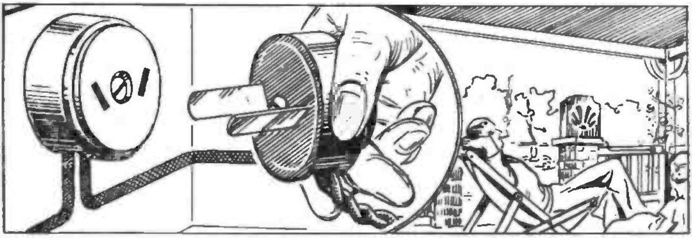
We can see that if "C" is a 2 μF. condenser it will have a reactance of 1,600 Ω at 50 cycles. "R" must be made *at least* ten times as unattractive, vectorially.



Loudspeaker extension circuits are quite readily made with Bulgin wall jacks and plugs and these enable the extension points to be neat and yet easily identified, so that they can at no time be confused with mains connections which might result in dangerous short-circuits and shocks. The fully-equipped modern domestic house should have loudspeaker points in every room in order to enjoy the utmost benefit from wireless reception.

BULGIN List No. W.J.1, Walnut Midget Jacks.
BULGIN List No. P.23, Walnut Flat Plugs.

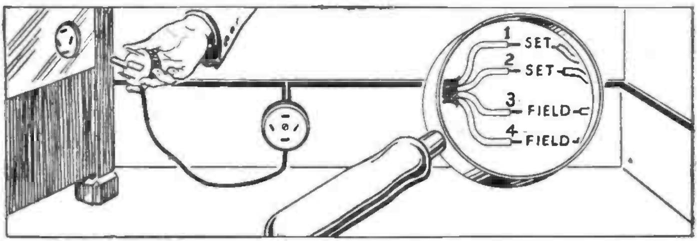
BULGIN List No. W.J.9, Brown Junior Jacks.
BULGIN List No. P.38, Small Black Plugs.



The new flat-pin type of loudspeaker extension plug is a fitting which may be used under many conditions and circumstances where wall jacks and plugs are not employed. The dimensions, etc., have been standardised by the B.S.I. and the Radio Component Manufacturers' Federation, and the plugs are not reversible, thus ensuring correct retention of polarity. In addition, these fittings cannot be confused with electric supply points, thus avoiding danger from this source, and making radio as safe as it should be.

BULGIN List No. P.82, 3-pin Wall Socket.

BULGIN List No. P.83, 3-pin Flat-pin Plug.



Flat-pin plugs and sockets to B.S.I. and R.C.M.F. specifications are also made in four-pin types, an advantage when it is necessary to run to extension points the field winding or remote control wiring in addition to the loudspeaker or speech circuit. Suitable four-conductor cable is made externally braided as one, which will ensure neat extension wiring. These plugs and sockets are not reversible as to polarity, and are so constructed that only the co-operating plugs can be fitted to sockets, an advantage in many instances, making for safety and preventing damage to apparatus.

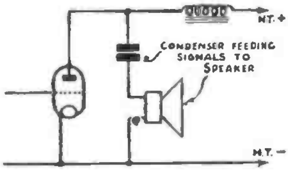
BULGIN List No. P.80, 4-pin Wall Socket.

BULGIN List No. P.81, 4-pin Flat-pin Plug.

EXTENSION LOUDSPEAKERS

NOBODY can possibly enjoy the advantages of wireless installation unless it is possible for them to listen to it in at least more than one room. The very fact of having to be tied to one room in order to enjoy wireless programmes tends to mar and spoil the entertainment. There is to-day no reason why wireless should not be available at will just as is electric light or artificial warmth. No house can be considered really modern in these days unless it is fitted with radio wiring.

In another part of this Manual you will find details concerning remote control systems, which may be used in addition to loudspeaker extensions to render even more complete the advantages and enjoyment which can be



obtained. Radio house-wiring can easily and quickly be installed in any home without damaging or destroying decorations or structure. New houses should be so wired when they are built.

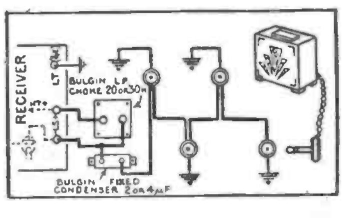
The best kind of wiring to use in an existing house, unless decorations are to be carried out succeeding the operation, will be surface wiring, and there are many multi-conductor cables of small and inconspicuous dimensions and appearance which can be used. In addition, the fittings or plugs and sockets for extension purposes, of which there are many various types, can be obtained to harmonise with schemes of decoration or can in many cases be sunk or concealed.

The simplest type of loudspeaker extension system will be one having two wires and, as the name implies, this is merely an extension of the loudspeaker terminals or sockets on the set. Extension points connected to such a wiring system will generally be connected in parallel, so that one or more loudspeakers can be connected to extension points. There is a second method of carrying out a parallel connected system of extension points and this is shown in the diagram in the second column. One wire is run only from point to point as an extension line, and the other side of each line is connected as conveniently as possible to the nearest earth or earth connection. With an extension system such as this, which renders a great economy in cable, etc., it is essential to use an output filter circuit as shown. This filter circuit is quite simple and, to many, will be well known. An L.F. choke is connected as shown in the first figure in place of the loudspeaker to the set so that the anode from H.T. positive to the valve passes through it. From the anode side of the choke connection is taken to one side of a fixed condenser, the other side of which is thence connected to the line. The loudspeaker circuit for signals can be returned through earth to the cathode or filament of the output valve, which in the set is, of course, connected through H.T. or L.T. negative to the earth terminal.

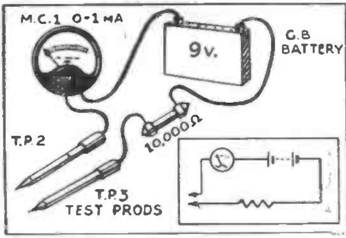
The same system would be applicable with a 1:1 output transformer; one side of the secondary of the transformer would be earthed and the other would be taken to part of the high potential line. With all wiring extensions it is advisable, if possible, to ensure that an output filter or transformer system prevents the passage of H.T. current (anode current) through the wiring system, or danger from shock may be had if the extension system has to carry current at a considerable voltage above earth—250 volts for anode potential in the case of many modern output stages—also demanding insulation of a high order.

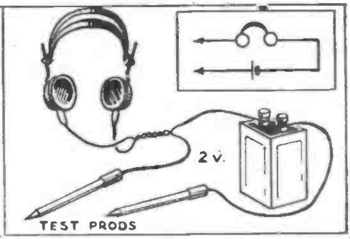
The system of an earth return shown in our diagram is one which has an additional advantage. It will be realised that when two wires are run from the set without the interposition of a step-down transformer considerable capacity will exist, and it is probable that, in long and complicated extensions, this may result in a certain loss of upper treble, especially with pentode output valves.

The single-wire system with earth return can be so arranged—since the earth is the return conductor—that the capacity from the live or feeding wire to earth is quite small. Loss of treble cannot then result to such an extent as would be experienced with a double system.



Where earth returns are not practicable it is possible to use two conductors and still quite satisfactorily keep the capacity between them low. That which is connected to earth or to H.T. positive—but see note before, this should be avoided if possible—will be considered as the earthy wire, and may be run at a lower level. The high potential wire can, for example, by spaced adequately from the first conductor by being run along picture rails, etc., and then dropped to meet the other conductor at extension points.

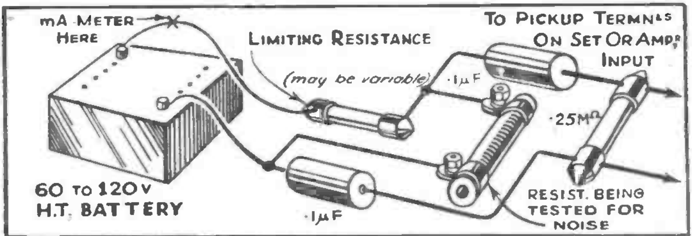




Here are two methods of making practical tests with simple apparatus for continuity, etc. With an 0—1 milliammeter and a 9-volt grid-bias battery we have a 10,000 Ω resistance in series, so that on full short-circuit of the test prods just under 1-mA. will flow. This will prevent damage to the meter. Chokes, coils, transformers, valve filaments, etc., can all be tested with this simple continuity tester. With headphones we can indeed test resistances and continuity up to values of the order of 1 M Ω.

BULGIN List No. M.C.1, 0-1 mA. Meter.

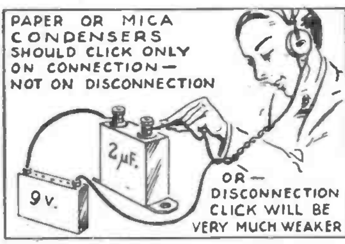
BULGIN List No. T.P.1, Plain Test-prod.

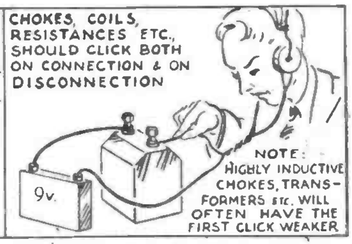


Here is a simple method of testing a resistance, grid leak, or even the primary of a transformer for suspected intermittent noises. It will be seen that through a limiting resistance current is applied from an H.T battery. A milliammeter can be inserted if desired in order not to overload the resistances by passing an unknown and excessive current. From either side of the suspected resistance a ·1μF. condenser is connected, and the other ends of these are connected to a ¼-MΩ grid leak, from which two further leads are taken to the pickup terminals of the set or amplifier. A frying noise will indicate a bad resistor.

BULGIN List No. H.W.28, ¼ M Ω, ¼-W. Resistor.

BULGIN List No. PCP.1, 0·1μF. Condenser.





Here is a method of testing condensers. A nine-volt battery and a pair of headphones is used. Upon connecting, as shown in the diagram, quite a strong click should be experienced, but upon disconnection there should be no click or, at most, a very weak click. A leaky condenser will, however, give the second click of almost the same strength as the first. A broken-down condenser will give two equal clicks. The second diagram shows the same method of testing for circuits and components which are continuous to D.C. Coils, resistances, chokes, valve filaments, etc., should all click both upon connection and upon disconnection, although chokes, etc., will have a slurred *first* click.

FAULTS IN RECEIVERS AND TESTING

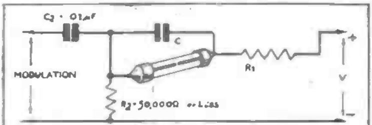
IT must be emphasised that in any testing whatsoever it is very important to see that the apparatus used for the testing is entirely above suspicion, and if you are not sure about what you are using it is best to be guided by this simple precaution—use the simplest apparatus. There is no right royal road to testing and fault finding. It is necessary to bring a certain knowledge and intelligence to testing and to go carefully and methodically stage by stage, eliminating first this and then that.

If you want to measure the resistance of components in a set you should use an arrangement with a milliammeter as shown in the top left-hand diagram on the opposite page. This circuit uses a nine-volt battery and a has a 10,000 Ω limiting resistance, so that the milliammeter can never be overloaded. Let us suppose that you wish to test a 10,000 Ω resistance in a set. Make sure that it is disconnected from its connecting points or that there is no shunt path to it so as to give fallacious results (it is safest to disconnect it or take it out of its holder). Apply the test prods to it. If it is in good order you should get a reading of nearly half a milliamp, which figure can be proved by the use of the following formula :—

$$\text{Milliamperes} = \frac{\text{Volts} \times 1{,}000}{\Omega}$$

In the case before referred to the total resistance will, of course, be 20,000 Ω, 10,000 for the resistance being tested and 10,000 for the limiting resistance which must, of course, be remembered in the calculations.

There are also other methods of continuity testing, and one which should be mentioned is the Bulgin Neon Test Prod. List No. T.P.5. This may be used in conjunction with the mains or an H.T. supply of at least 180 volts, and will show continuity through quite high values of resistance by a glow concentrated in the electrodes of the small internal neon lamp.

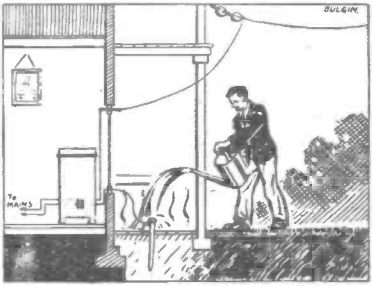


OSCILLATING CIRCUIT FOR BULGIN NL 1 NEON

This type of neon device may also be used to test polarity since with D.C. mains the glow will spread over only one electrode, while with A.C. the glow will be more or less equally spread over both electrodes. Another interesting test circuit using a neon lamp is shown on this page. In this circuit the neon is made to " oscillate " and produce fluctuating current. When a D.C. voltage of at least 180 is applied through R1, a 1-MΩ resistance (values up to 5 MΩ may be used) with a condenser connected across the neon, it will light and then go out at very rapid frequencies.

If the condenser is sufficiently small (say ·0005 µF.) notes of the order of 1,000 cycles can be obtained. With the circuit shown, having a further coupling resistance of 50,000 Ω and a coupling condenser of ·01 µF. an audible note is obtained which may be fed into an amplifier (for example through the pickup terminals, or by means of test prods applied to valve grids and chassis) in order to test L.F. stages right up to and including a detector stage. It is also possible to test condensers with a circuit of this nature. With condensers of sufficiently large capacity the neon will be observed to light and go out at speeds which are quite visible to the eye. If a condenser which is known to be satisfactory is used to do this and then replaced by an unknown one, which is, however, supposed to have the same value, the frequency of the pulses of light should be the same.

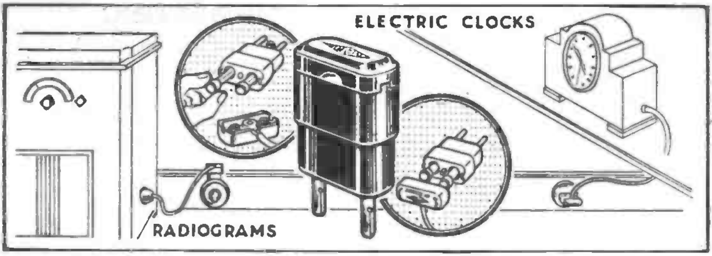
With small values of capacity the same arrangement may be used with a pair of headphones, which would be connected to the point marked " modulation " in the diagram.



Our other picture shows an interesting case which was communicated to us. An earth point had been carelessly put into some rather dry earth beneath an overhanging veranda and an A.C. D.C. set, which had a condenser in the earth lead had a break down.

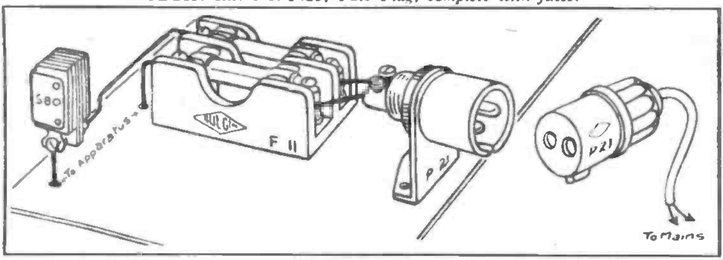
Unfortunately the switch fitted in the set was a single-pole type (contrary to regulations for A.C. D.C. apparatus) and the negative main which was connected to earth through the condenser was actually " above earth " (as it may very often be with D.C. supplies). An unlucky gardener, instructed to water the earth to improve reception, received a serious shock through the column of water from the watering-can, since he himself was standing on damper grass outside the purlieu of the veranda.

This brings us to a very important point. Be sure that a mains set is entirely disconnected from the supply (both poles) before you commence testing.



When using the mains be sure you do so with safety. The very minimum protection which should be utilised is that of having a fuse in each lead. Our illustration shows a very convenient method of fitting fuses to apparatus not so protected. The Bulgin Fuse plug, List No. P.25, incorporates two fuses, one in each lead, and being to standard 5-A. two-pin dimensions can be inserted into any plug or socket. It is impossible for the fuses to be handled at any time whilst the plug is live, because the cover is secured by a screw which is reached by a screwdriver between the pins. It cannot be opened whilst "live."

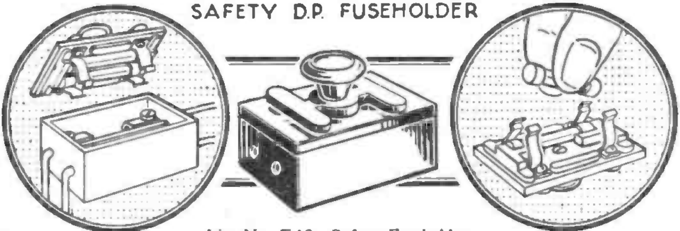
BULGIN List No. P.25, Fuse Plug, complete with fuses.



This diagram shows the very minimum protection which should be employed when building mains-driven radio apparatus. A double-pole fuseholder type F.11 is employed, and, with most radio apparatus, one or one-and-a-half ampere fuses should be used (normally with F.11 one-ampere fuses are supplied). For A.C. apparatus a single-pole on-off switch, type S.80, may be inserted in one of the mains leads after the fuseholder, and it is desirable to make the flexible connection to the set by means of a double-pole plug and socket of suitably insulated and shrouded construction, so that at any time the set can be completely disconnected, and absolute safety assured.

BULGIN List No. P.21. Mains Connector.

SAFETY D.P. FUSEHOLDER



List No. F.19. Safety Fuseholder.

Here is a new type of fuseholder, List No. F.19, which enables fuses to be inserted in both leads of mains driven apparatus, and in which the fuses may be handled with perfect safety. The fuses are actually held in metal clips in the lid part of the apparatus, the contacts of which clip into the box portion. Upon removing the lid for handling the fuses the fuseholder is rendered quite "dead." With most mains-driven receivers one-ampere fuses are quite satisfactory with mains voltages above 200. For apparatus of the ordinary radio class operated from 100—110 volts two-ampere fuses should be used.

FUSES AND THEIR IMPORTANCE

BULGIN Radio Fuses were designed for use with radio receivers and associated apparatus. We were the first firm to realise the necessity of such fuses and to advocate their constant and consistent use. As there is just as much chance of extensive damage being caused in radio apparatus through the lack of suitable fuses as there is in other applications of electricity, readers are strongly advised to obtain only the genuine recognisable Bulgin guaranteed types, which are are made to British Standards Institution and Radio Component Manufacturers' Federation Specifications.

Bulgin Radio Fuses are made in cartridge type, having the actual fusible element enclosed in a glass tube fitted with metal end contacts. The fuse is thus hermetically sealed, and is suitable for low-tension and mains circuits. It may also be used in H.T. circuits which normally carry large currents and which are themselves inductive so as to definitely require a fuse which gives a large break in the circuit when it melts.

Fuses should always be fitted as a safety precaution in circuits, but it is not out of place here to explain exactly what a fuse is and why it is to be used. In any circuit where electric current is to flow a certain normal current is allowed for in regard to size of conductors, heating of components, etc. If, for some reason, obstacles which normally oppose or limit this current are removed or altered, or an easier path, by means of a short-circuit, becomes available, a much greater current will flow and damage will be done.

If a current above the handling capacity of the circuit should flow and not be checked it is a definite maxim that the weakest link in the circuit will be burned out. It is very natural, therefore, deliberately to *make* a certain weak link in the circuit and this weak link is known as a fuse. A fuse may be regarded as an automatic switch which will break the circuit in the event of things going wrong and which, without deliberate intervention, cannot restore the circuit.

It is, of course, an understood thing that fuses should be low priced so as to facilitate replacement, and that they should be accessible for the same reason. It also goes without saying that a fuse—which operates by means of a fine piece of wire or a conductor melting or burning out—must be definitely fire-proof in construction.

How, you ask, should I decide the size of fuse which I need? Under normal circumstances you would not determine this by the current which the circuit carries under its proper working conditions, but by the current which may be safely carried without damage. And in consideration of H.T. circuits let us consider what would be the first thing to be damaged upon the passage of an overload current.

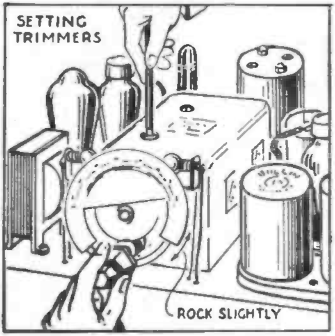
In many cases the filaments of the valves are the weak links and such filaments are usually connected in parallel. We will suppose that added together they normally pass ·25 ampere, and it may reasonably be assumed that they would be damaged by the passage of 300 mA. Our H.T. current in such a set may normally be only 30 mA. This does not definitely mean that one must use a 30 mA. fuse. Even if one such could be obtained it would be extremely fragile and unnecessarily expensive. It would be best to use a fuse rated at 150 mA. in this case, because such a fuse would blow (upon 75% overload) before it passed a current likely to damage the valve filaments, and it would at the same time never be blown by certain surge currents flowing from the H.T. supply to charge up condensers, etc., at moments of switching on. In selecting mains fuses we must adopt the same plan.

One-ampere fuses are generally recommended because they give good protection. This does not mean that the set normally handles a current of one-ampere from the mains. Nor does it mean that because the handling current of the set is about a quarter-ampere that you should fit quarter-ampere fuses; they might easily be blown by short-duration surge currents, and we have to realise that it is most certainly only currents over one-ampere, etc., which would damage mains transformers, flexible leads, etc.

Finally, when using such fuses always use them in approved and insulated types of holder so as to give safety and conform to regulations. There are many Bulgin types available, all of special design to ensure shock-proof use and the utmost reliability, in varying forms and designs to meet all requirements.

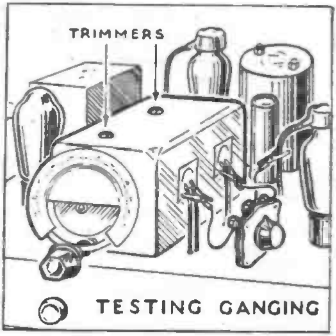
Many are combined with double-pin connectors, for convenience, and permit of *complete* mains isolation for testing, etc., a most necessary provision. These may be used to form the mains entry into the receiver, eliminator, or like apparatus, or can be had in plug form to fit to ordinary wall sockets.

Certain types of circuit which exhibit unusual characteristics have called, in recent times, for fuses of special types. In the mains circuits of sets operated from A.C. supplies, for example, it is sometimes found that the initial current, at the moment of switching on, is many times the normal for a fraction of a second. While there is no actual harm in this fact, it can cause a quick-acting fuse to be blown unnecessarily. Conditions such as these have fostered the development of the Bulgin "Pak" or Delay Fuses, types which can withstand an initial current many times greater than the value at which they will eventually blow, either after a minute or so, or after they have—like the valves—been allowed time to warm up. Such fuses may be employed in many cases.



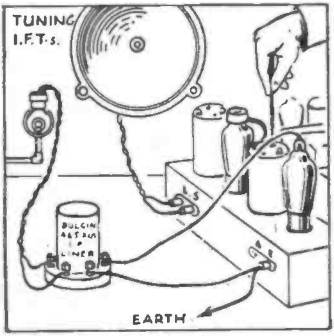
It is no difficult matter to set about ganging a set correctly. Trimming the ganged condensers is carried out on both superheterodyne and straight receivers in exactly the same fashion. Perhaps the dial shows that a station is received at 280 metres instead of the indicated 261. This will imply that we are using more capacity than we should. The trimmers require to be screwed up somewhat. Screw them up half a turn at a time, first one and then the other, rocking the dial slightly all the while.

BULGIN List No. T.T.1, Trimming Tool.



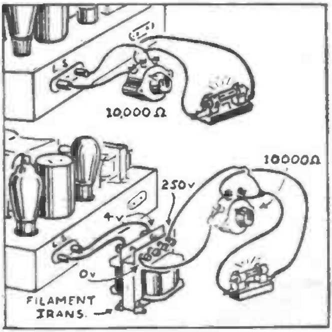
Here is another method of testing the ganging. A differential condenser having a capacity of about ·0001 μF. per side is connected with one set of fixed plates by means of crocodile clips to each of the fixed plates of the gang condenser. The middle terminal is earthed. Now *any* station should be most satisfactorily received with the moving plates at half mesh, but if you have to mesh more with one side than with the other it indicates that the trimmer on that side, for optimum results, needs to be screwed up slightly.

BULGIN List No. N.23, Diff. Condenser.



Here is a convenient method of tuning I.F. transformers. It does not require the reception of any station to do so and indeed the aerial should be disconnected. Remove the grid connection to the top of the frequency-changer valve, and substitute a lead taken from the Bulgin I.F. Liner, List No. V.T.17. The two mains terminals of this should be connected to the mains as shown. This liner is accurately tuned and set before leaving the factory and gives an output of exactly 465 k.c/s, the modern intermediate frequency.

BULGIN List No. V.T.17. 465-kc/s I.F. Liner.



It is not always best to use a loudspeaker and to judge by ear how the ganging is proceeding. Here are two methods of judging the output visually (the eye is a much more reliable judge) and shows the Bulgin N.L.1 Midget Neon Lamp with an adjustable volume control type of resistance connected to the output of the set. If the set does not incorporate a step-down transformer the upper method should be employed, but when it does use a spare filament transformer to step-up the output again.

BULGIN List No. N.L.1, Midget Neon.

GANGING IN MODERN SETS

IT must be understood that modern receivers employing ganged condensers can only operate at optimum efficiency if the tuning in every circuit is correct. For this reason ganged circuits are usually provided with trimmers, which may be fitted integrally with the ganged tuning condenser, or which may be separate midget type trimmer condensers.

Modern manufacturers of coils and ganged condensers take every precaution and work to extremely fine limits in order to ensure that their products shall "gang up"—as it is termed, but there are still many factors which are outside their control—stray capacitities introduced by wiring, extra inductances intruduced by abnormally long leads, loading effects, and so forth. Let us say at the outset that entirely perfect ganging can never be obtained because there are always limits (usually expressed as percentages) to which ganged condensers and coils can be made.

However, owing to certain loading effects of inherent resistance, and external resistances in regard to coils, condensers, etc., tuning is always slightly broad, although you may attempt to overcome this by using numbers of tuned circuits in what is called cascade. Fortunately, therefore, although in theory we may never gang or tune a set absolutely accurately, the arrangement which we arrive at is at least workable. Remember that ganged condensers and coils are very delicate pieces of apparatus. The former are always provided with covers when they are likely to be handled much, but where they are not, for reasons of cost or lack of necessity or by reason of screening being not needed between vanes, etc., handle them *extremely carefully*.

Many condensers, you will notice, have the end vanes split, and these have been very carefully set and adjusted by the manufacturers so as to match the capacities. On no account, then, bend them, and keep your set in a dust-proof cabinet so that you will never have to use the often suggested pipe-cleaner to remove dust from between condenser vanes. To do that in a modern ganged condenser would be to throw its ganging right out. Without the apparatus used by the makers during manufacture you could never attempt to restore the balance.

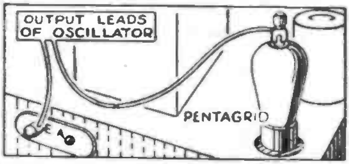
In most modern superheterodyne receivers, a plain, or "untracked," tuning condenser is used. The necessary frequency-difference between signal and oscillator circuits is maintained by (a) an initial inductance difference in the oscillator coil, and (b) padding condensers. Padding condensers are, primarily, so connected as to be virtually in series with the main tuning condenser, oscillator section, reducing the maximum capacity. The oscillator frequency is therefore *higher* than that of the signal. Suitable padding and inductance values, with some parallel padding capacities in certain circuits, maintain remarkably constant frequency—differences and "accurate tracking" (i.e., to the I.F.) results. The adjustment of padding condensers, often *after* the I.F. tuning is accomplished (p.p. 26, 27) is therefore a part of "ganging-up."

Hints on ganging are given on the opposite page in practical form. As far as possible do not use a loudspeaker unless you have had a lot of practice at ganging, for the ear is very easily deceived with small changes in signal strength and cannot be relied upon. If possible, use a neon indicating device (it is quite inexpensive) as shown on the opposite page, or, better still, use an A.C. voltmeter across the output. One of the inexpensive Bulgin U.M. types on a steady signal, such as a tuning note from the local station or injected from a local oscillator, will do very well.

All ganging and trimming adjustments should, of course, be directed at obtaining as large a reading on the meter as possible, this being directly indicative of signal strength. Under certain conditions it may be necessary, especially with a high-resistance voltmeter, to connect a resistance across the loudspeaker terminals of the set as well as the meter. The two are then in shunt, or, to use another electrical term, in parallel. Such a load resistance should be of a value to which the output valve is accustomed to work, probably five or six thousand ohms with high-potential loudspeaker output. It may be found necessary to tap down the voltmeter across this resistance so it only measures the voltage across part of it.

Always use an oscillator for ganging if you can; it is much more reliable than outside signals received in the aerial.

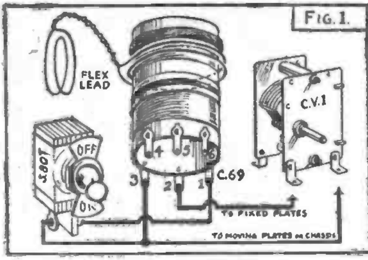
We have heard of a case where ganging attempted on a somewhat distant though nominally "local" station was considerably spoiled by a swaying aerial which was picking

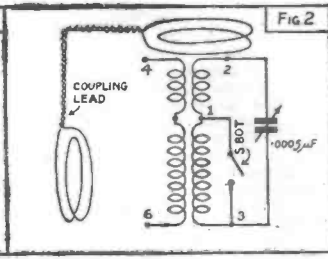


An Oscillator giving signals at I.F. may inject into a set as shown for I.F.T. lining-up.

up changing signal strength. A local oscillator, of course, prevents this difficulty, providing it is a piece of apparatus upon which you can rely.

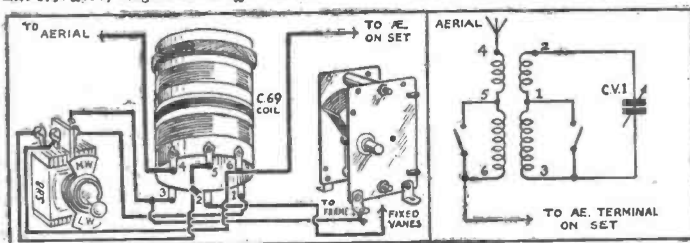
In many cases with a local oscillator you can inject the signals into a later valve than the input stage, so that you can trim up the circuits one at a time working backwards. Our diagram shows, for example, how you may inject I.F. signals into the grid of a pentagrid frequency-changer valve. Be sure that in so doing you have a conductive path from grid to cathode or you may damage your pentagrid by running it with an open grid circuit.





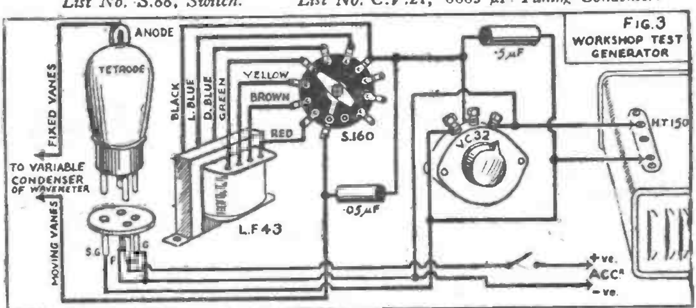
A calibrated wave-meter of this simple type is invaluable when calibrating and experimenting with receivers having unscreened H.F. coils. Coupling may consist of ordinary lighting flex, the turns on the top of the C.69 Coil in the wave-meter being held in place by Chatterton's Compound or sealing wax. About 1 ft. of twisted flex should connect this with another two or three turns which will be placed, in use, round the aerial input coil of the receiver.

List No. S.80, Single Pole on-off Switch. *List No. C.69, Dual Range Coil.*



For use with receivers in which the tuning coils are screened by cans (when coupling by a few turns of wire is often inadvisable) the C.69 Dual Range Coil may be used as a "wave-trap" absorption meter. A double pole on-off switch changes the wave-range on both windings. Used as a permanent fixture, the above arrangement will also enable a strong local station to be prevented from interfering with the reception of weaker foreign transmissions, often without weakening the wanted station.

List No. S.88, Switch. *List No. C.V.21, ·0005 µF Tuning Condenser.*



In conjunction with a screened grid valve connected as a dynatron oscillator, the C.69 Dual Range Coil and the C.V.1 Condenser may form a useful workshop test oscillator. The H.F. signals generated are modulated at audible frequency with a tapped choke in series with the Dual-Range Coil. Note that the control grid of the valve is connected to filament −. To obtain satisfactory oscillation, the correct anode voltage must be regulated by adjustments of the potentiometer.

List No. L.F.43, Tapped Choke. *List No. S.160, 10-way switch.*

GANGING WITH WAVEMETERS

WHEN experimenting with, or servicing, the H.F. stages of a receiver, two factors are continually in demand : one is a knowledge of the wave-length or frequency of the signal upon which adjustments are being carried out, and the other is the ability to generate such a signal at controllable intensity. To provide these two factors, wave-meters and oscillators are in widespread use. Although such apparatus may cost hundreds of pounds in laboratories, it can be set up in simple but useful form in any radio workshop.

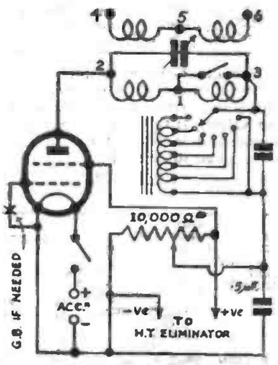
First we may consider the plain wave-meter. A practical and efficient form of such an instrument is shown at the top of the opposite page. It consists of a C.69 Bulgin Dual Range Coil and a C.V.1 tuning condenser with a switch for wave-band changing. This extremely simple piece of apparatus is all that is needed for work on receivers where the aerial input coil is unscreened. In use, the C.69 Coil is loosely coupled (using this term in the electrical sense) to the unscreened aerial input coil by a loop of insulated flex wire, a couple of turns only round each coil being necessary. The wave-meter acts by absorbing from the aerial coil of the receiver, when both are in resonance to the received signal, so much energy that there is a sudden dip in the volume heard or measured in the speaker. Hence, the wave-meter may be calibrated in the first place from a receiver in good working order. This receiver is tuned to transmissions of known wave-length in the broadcast band, one after the other, and the wave-meter, coupled by the flex turns to the aerial input coil, brought to resonance with each transmission by noting the sudden drop in volume as the resonance point is reached. The wave-meter dial readings are noted in each case, and from them a simple graph or chart can be made up for permanent reference : with this, the wave-meter is now ready to measure the wave-length of any signal tuned in by a receiver, so that its dial may be calibrated in terms of wave-length or frequency. The flex turn coupling, by the way, should not exceed two or three turns or even less; too tight a coupling would give a wide "spread" of absorption, and it is good practice, when calibrating, to use weak coupling so as to provide a small but sharply defined dip of volume.

Another way of using this wave-meter is shown in the middle diagram. This is for use with receivers of which all the coils are enclosed in cans, so that the flex wire coupling cannot be easily applied. The connections are plainly indicated—the wave-meter is used as a species of wave-trap with its primary windings in series with the aerial lead—and the outfit can be calibrated as was described in the previous paragraph.

AN H.F. VALVE OSCILLATOR.

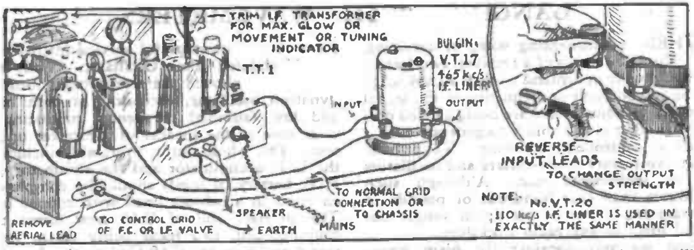
The arrangement of C.69, and C.V.1 described above may comprise the basis of a form of that most useful service instrument, the Modulated Test Oscillator. With the components shown, the arrangement forms a dynatron oscillator, oscillating at both high and low (aubible) frequency, producing a clear note in the speaker of a receiver under test. The whole outfit, preferably including the L.T. accumulator and the eliminator (or H.T. battery, if used) should be completely enclosed in a cabinet lined with copper foil. The primary coil of C.69 now forms the coupling coil, two leads being taken, from tags 4 and 6 on the C.69 Coil, to the A and E terminals of the receiver, and the oscillator tuned until its audio frequency modulation note reaches a peak of volume in the speaker of the receiver under test. This means that the oscillator is now tuned to the same wave-length as the receiver. Hence, it is possible to calibrate the oscillator by the aid of a receiver in good working order, a number of stations of known wave-length being tuned in, the oscillator brought to resonance with them, and the oscillator dial readings noted. These noted readings will give points for the construction of a chart for permanent reference when using the oscillator with other receivers.

Provision is made, by means of the multi-way switch and tapped L.F. choke, to vary, not only the H.F. wave-length, but also the frequency of the modulating audio note, so that it may be rather shrill or rather deep, according to choice.



The circuit of the lower drawings on the opposite page, in theoretical form. The switch between coil tags 5 and 6 is not shown. Generally speaking grid bias is not used, but can be introduced where indicated.

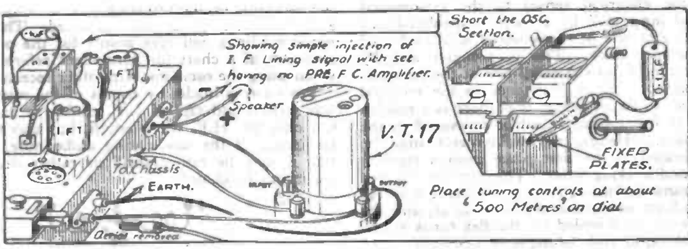
The pitch of the audio note depends upon the value of the parallel condenser as well as upon the inductance value (selected by the switch). High audio frequencies can be injected into receivers, and the effect of tone control, etc., can be noted.



Above is shown the use of the 465 K/Cs Liner. The H.T. supply to the input terminals of the Liner is obtained from the L.S. + socket of the receiver of and the chassis. If the receiver has a visual tuning indicator connected in the anode circuit of the frequency-changer valve, it is necessary to retain the A.V.C. on this valve, otherwise the V.T. indicator will be inoperative. This is done by connecting the output leads of the Liner in series with the valve cap and connector, as shown above. In other cases, these leads are taken, one to the valve cap and the other to the chassis.

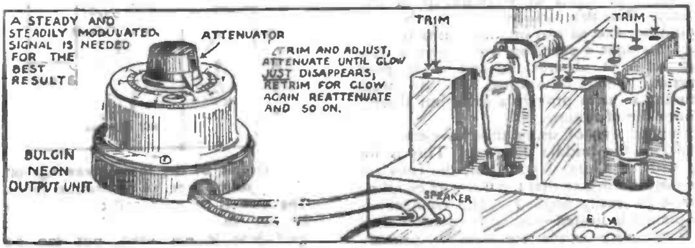
BULGIN List No. V.T.17, 465 kc/s Liner.

BULGIN List No. V.T.20, 110 kc/s Liner.



This diagram shews a simpler method of using a neon liner with a receiver having no h.f. amplifying stage before the frequency-changer valve. If the oscillator section of the gang-condenser is shorted (to r.f.) and the set is left tuned towards the upper end of the M.W. band, the I.F. signal will pass through sufficiently, in most cases, for accurate I.F. trimming. Power for the liner can be drawn from H.T. + and chassis (–), and reversal of leads will control the output intensity.

BULGIN List No. PCP.1, 0·1 μF. Tubular Condenser.



This output unit, used on a *steady* signal, is adjusted until the glow ceases. Any adjustments to the set which cause it to glow again mean an increase in amplification. The process is repeated *ad lib.* For connections with different speaker circuits, see opposite page. In the absence of a signal generator (see p. 24, Fig. 3) use the tuning note of your local station for precise adjustments.

BULGIN List No. V.T.19, Neon Output Unit.

GANGING WITH I.F. LINERS

ALTHOUGH a scientifically designed modulated test oscillator is essential for advanced work in ganging and lining up I.F. Transformers (see pp. 23, 24), an inexpensive beginning may be made with the Bulgin range of Neon Oscillators. There are two types available : (1) the V.T.17, which provides a signal at 465 k.c/s; (2) the V.T.20, which provides a 110 k.c/s signal.

Both V.T.17 for 465 k.c/s, and V.T.20, for 110 k.c/s (in earlier sets) are used in the same manner. The signal is fed into the control grid of the frequency changer valve (in modern receivers, nearly always the top cap), and it will suffice to remove the connector and to clip on istead one output lead from the Neon Liner, the other lead being taken to the chassis. In earlier sets, where the control grid is at the base, the existing grid lead will have to be unsoldered, and, in its place, one output lead from the liner clipped to the grid socket; after lining up, the grid lead is re-soldered in place. In the case of receivers having visual tuning indicators connected in the anode circuits of the frequency changer valves, the visual tuner action may be retained, to assist in lining up, by clipping one output lead of the liner to the valve cap and the other lead to the cap connector. The signal will be fed through the frequency changer into the I.F. circuits. These must be accurately tuned to the signal by means of their trimmers. When adjusting the trimmers, distinct peaks of volume will be heard, and on these peaks the trimmers must be left. Should it seem difficult to obtain sharp peaks, it will probably be because the signal from the Neon Liner is strong enough to bring the A.V.C. of the receiver into operation; to reduce the signal strength, it is only necessary to reverse the H.T. *input* leads to the input terminals of the liner.

With some types of receiver, especially those which are not provided with an R.F. amplifying stage before the frequency changer, it is possible to adopt an even simpler injection of modulated I.F. signals from a Bulgin Neon Liner. In the absence of highly selective pre-F.C. tuning prior to the frequency-changer, and with the comparatively robust signal from the Liner, it often suffices to inject into the aerial and earth sockets of the set, as shown on the opposite page.

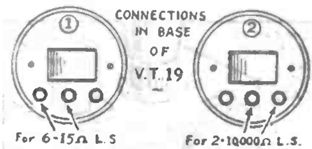
It is definitely advisable, in such a case, to short circuit the *oscillator* section of the gang-condenser; the short-circuit must be an R.F. one, and a fixed condenser of 0·01—0·1 μF. will provide the necessary by-pass, without short-circuiting anode current.

It is of assistance—at any rate when trimming of the I.F. Transformers is commenced, by giving an initial signal of good strength—to tune the set to as near to 500 or 550 *m.* as possible—that is, to as near to the I.F. of 465 k.c/s. But with a set having an I.F. of 110 k.c/s, tune the set to the upper end of the *long* wave-band, the oscillator section being by-passed as before.

Where the foregoing method is effective—and there are few cases where it is not—it will be seen that there is no need to disturb the receiver at all, which will speed up the work considerably.

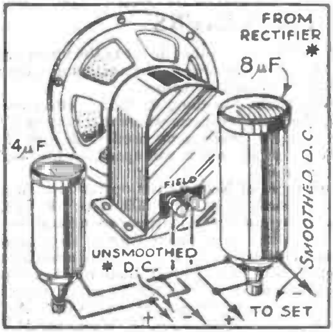
All types of Neon Liners operate on direct current only of at least 200 volts. If D.C. mains are not available, there are several ways of supplying the requisite energy. Negligible current is consumed—about 1/5th of a milliamp. Hence, two 100-volt H.T. batteries could be joined in series to provide an ample supply. But a very convenient way, when only A.C. mains are available, is to draw from the H.T. supply circuit of an A.C. receiver—and this receiver may be the very one that is being lined up. Connect one liner input lead to the chassis and the other to the side of the L.S. or output load.

Another use for the Neon lamp has been found in the form of an inexpensive output unit for indicating, by eye, the strength of the signal as it is put out to the speaker. The brightness of the glow seen through the window of the output unit varies with the power of the signal. When starting to line up the I.F. transformers of, or gang, a superhet, therefore, the output unit should be connected to



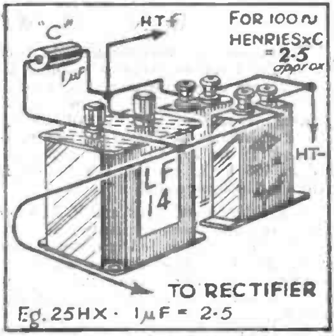
The Connections under the Unit. Speech coils of M.C. speakers are of low impedance: primaries of speaker transformers are of high impedance. Note that impedances of 6—15 or 2,000—10,000 Ω can be dealt with.

the speech terminals of the receiver. When the receiver is switched on and the oscillator is delivering its signal, the glow of the unit should be reduced, by turning the knob at the top of the unit, until it is only just visible. Then, as the trimmers are adjusted, this glow will be seen to rise to peaks of brightness. The aim should be to trim the receiver until the glow is at maximum brightness even after further reduction of the output unit setting. The reason for the use of visual device of this type will be obvious. The eye is much better able to judge the magnitude of small changes than is the human ear. Readers who use visual tuning meters can confirm this point from practical experience. When using the Neon Output Unit it is interesting to note the small changes of volume which increase the glow, but which the ear does not detect, the loud-speaker remaining connected for the test.



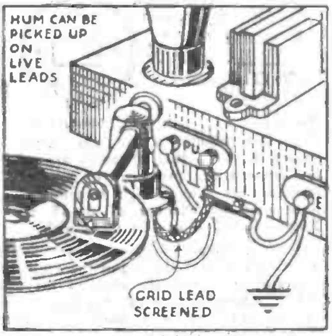
As we said in an earlier section, loudspeaker fields are often used both for automatic smoothing and for energisation. It is very important when so doing to see that the loudspeaker is a type which is fitted with what is known as a humbucking coil. Otherwise the unsmoothed D.C. from the rectifier will set up voltages which will appear in the loudspeaker as uneradicable hum. The connections are also shown in this diagram for the condensers in such a smoothing circuit.

List No. E.C.2, 8μF. Electrolytic Condenser.



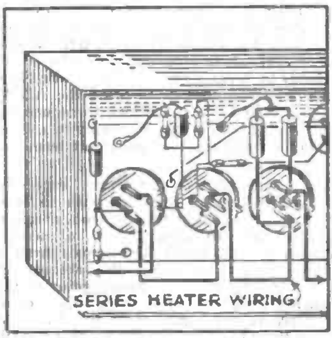
Have you ever tried tuning the smoothing choke to see whether you can eradicate the last trace? It is often very effective. With full-wave rectification from fifty-cycle mains the predominating hum is generally 100 cycles. It can be shown that, for resonance (which is what we want) at 100 cycles, the henries, or inductance of the smoothing choke, when multiplied by a parallel condenser expressed in micro-farads should equal 2·5 approx.

List No. PCP.1, ·1 μF. Condenser.



A prolific cause of hum is long pickup leads. One of the leads from a pickup, you must remember, will be connected to the grid of a valve—rather an important point as regards 'liveness', as any one can test for themselves by putting a finger under the grid terminal and noticing the introduction of hum. The use of a screened pickup lead especially as regards the grid lead will often be of enormous benefit. It is important, however, that the screening be earthed, and it may also be necessary to earth the metal parts of the pickup, in addition.

List No. W.S.2, Screened Wire, 3 ft. Coil.



A prolific cause of unwanted hum in sets is bad arrangement of heater wiring. Whether the heaters of indirectly heated valves are connected in parallel, as they will be when run from an A.C. transformer, or in series, as they will be when run with a resistance from the mains in the case of universal sets, the heater wiring should always be kept so that the conductors are quite close together where they run parallel, and they should always be kept well away from other wiring. It is always possible to reduce even quite low hum level by careful attention to this very important part of the set.

HUM—CAUSES AND CURES

THE best way to trace mains hum—and we ought to deal with tracing before we deal with causes—is to work backwards. It is necessary to exonerate the loudspeaker from blame because, as we have seen on the page opposite, it may easily cause hum, although otherwise doing its work quite satisfactorily. A very simple way of testing the loudspeaker is to disconnect it from the set output sockets and to short H.T. positive to the valve anode. Now connect a resistance equivalent to the internal A.C. resistance of the output valve across the loudspeaker, or loudspeaker transformer primary, if this transformer is a part of the speaker. The field connections remain as before and the set should be switched on and operative.

There should now be no hum, but if there is, it is "in" the loudspeaker. If the speaker has a humbucking coil, though, it is unlikely that it will be troublesome. Let us suppose that there is no hum, however. It is therefore earlier in the set, so you may reconnect the speaker and test back one stage further. If the set has always "hummed" you may suspect the smoothing circuit. Try short-circuiting the smoothing choke providing it has an internal resistance of not more than about 400 Ω. This should give an enormous rise in hum level, but if there is only a small increase it is safe to suspect the choke. Replace it temporarily by another one and see what effect the substitution has.

Try, also, increasing the smoothing condensers as regards their values. This is quite easily done by connecting another condenser in parallel. Be careful, if you are using electrolytic types, see that the polarity is correct. The negative is always connected to H.T. negative.

Sometimes hum is introduced because a directly heated output valve is employed and H.T. negative is returned to the centre-tapping of the transformer winding feeding this valve. If the winding is not accurately centre-tapped hum may result. Try the effect of an artificial centre-tap by means of two low-value resistances (say ten Ω each) which are substantially accurate and close to each other in value. Connect them in series across the filament and take H.T. negative to their junction instead of to the transformer winding centre-tap. If hum is reduced by so doing it is safe to assume that the previous "centre-tap" *was not* symmetrical. Do not use it, but employ the two resistances instead. A low value variable resistor could be used for this purpose, and you will then have some assurance by adjusting the tapping provided by the moving arm.

Still working backwards in the set, hum can be introduced by direct pickup of fluctuating magnetic fields from the power transformer by other components of an inductive nature such as chokes and L.F. transformers.

If you think that this is happening remove its ordinary connections and give it a short length of flexible connection, not more than about nine inches long for each. Unscrew the transformer and move it about, taking care not to touch any of the terminals with your finger so as not to introduce additional hum. If the hum varies at all you have certainly got some pickup on this component, and you should refix in a position which gives a minimum of hum.

Don't try screening it with an aluminium can such as is used for coils because this would have not the slightest effect. To slip such a can over a transformer and then to say that it is not picking up any hum because the can makes no difference is quite fallacious. An aluminium can would have very little screening effect to a 50 or 100 cycle magnetic field.

Supposing that you only get hum when you are using the pickup. Here is something which happens in about eight cases out of every ten. Very often such hum can be minimised if not entirely cured by using a volume control, if such is used with the pickup, of much lower resistance. You may even go down to 10,000 Ω or 7,500 Ω and still get quite satisfactory results from the pickup with a considerable minimisation of hum.

What you are then doing is to lower the resistance of a grid circuit, and it must be remembered that hum is usually lower with low-resistance grid circuits. Therefore, in the design of quality amplifiers, bear in mind that low-resistance grid leaks (of course, you will have to pay attention to the associated grid condensers as regards their values also) are definitely an advantage. Finally, remember that hum may even be introduced to a detector valve from an H.F. valve, although such a valve does not normally amplify low frequencies.

If the H.T. supply is not particularly well smoothed and tuned grid or tuned anode coupling is employed, try the effect of a *very small* grid condenser for the detector valve.

When H.F. stages are coupled to the detector valve by means of an H.F. transformer or double-wound coil it is found that the capacity between the windings is sufficiently low as to prevent the passage of hum of this kind, and the trouble does not appear. Insufficiently smoothed H.T. to H.F stages may, however, produce a kind of modulation hum which will not respond to the cure that is usually then adopted. It is well, therefore, to make verification on this point.

Hum which is due to insufficient smoothing should always be cured by attention to the obvious cause. In such cases, however, as will not permit of the use of extra smoothing chokes because of the added D.C. resistance, the effect of tuning the choke to the predominant hum frequency can be tried.

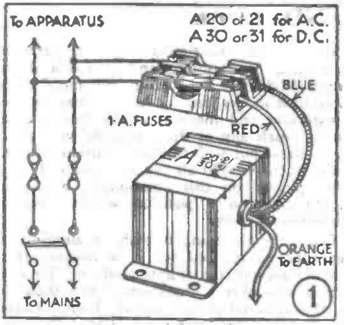
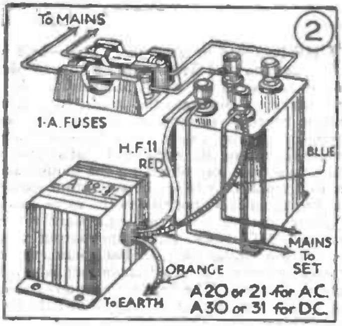


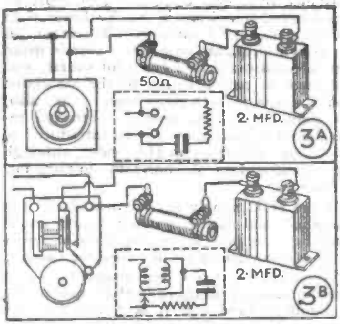
Figure No. 1 above shows the very simplest form of interference suppressor. Two condensers built as one complete unit are connected with their centre points to earth (i.e. their junction) and their outers, one to each of the mains wires. This connection should be made near to the entry of the supply mains in your house, just above the mains switch and fuses shown symbolically in the diagram. Sometimes, connection may be made similarly, but near the set. Experiment may be necessary.

BULGIN List No. F.11, Fuseholder 1A.
BULGIN List No. A.30, Suppressor.



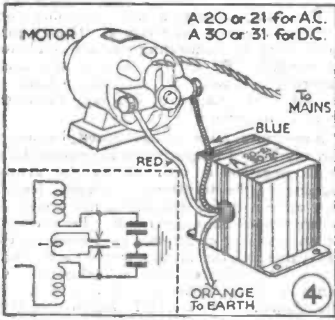
If interference is experienced which, in addition to rushing, hissing and like noises, incorporates sharp and sudden clicks, etc., chokes are necessary in conjunction with condensers. To put chokes in the mains lead for the entire house to carry the entire house current would demand expensive types, and a cure can generally be had or minimisation achieved by fitting chokes in the mains leads to the set only. The current through the chokes should not exceed ·25 A.

BULGIN List No. H.F.11, Double Choke.
BULGIN List No. A.31, Suppressor.



Above we show two cures for interference at the source or point of cause; it is always better to cure interference at source if possible. The first diagram shows a condenser connected across a switch with a damping resistance so as to minimise clicks produced by the switch being made and broken in circuit. The second diagram shows how a similar condenser with a damping resistance is connected across the spark point of an ordinary trembler bell, which may easily radiate interference.

BULGIN List No. A.R.50, Resistor.
BULGIN List No. S.C.20, Condenser.



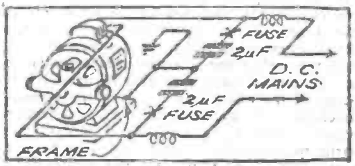
Here is another method of curing interference at source, where it is caused by small motors, etc. If the motor is internally wired so that each of the two (usually) field coils are interposed between brushes and mains leads, even better suppression with a series-wound motor will result. Certain interference units are supplied with two red and one black lead. The black lead is then earthed, and the red leads connected to the brushes of the motor as shown above, both pictorially and theoretically.

BULGIN List No. A.20, Suppressor.
BULGIN List No. A.21, Suppressor.

INTERFERENCE SUPPRESSORS

THE word "interference," as applied to radio in these days, is generally accepted to mean intermittent or continuous rhythmical noises, hissings, buzzings, or cracklings produced by electric sparks such as may be produced by faulty electric switches, bad contact, or, more generally, electric motors and allied apparatus. It is safe to say that this style of equipment causes over ninety per cent of the interference experienced by users of receivers at the present time.

Interference is experienced to a much greater extent by users of mains-driven sets, the reason being that any spark or succession of sparks in any electrical apparatus produces a radio frequency wave of indeterminate wavelength or covering a wide band of frequencies which is highly damped. This



means that the space wave dies out after having travelled for a short distance, but a good deal of the radiation travels on any wiring connected to the source of interference, so that a mains-driven motor sparking badly at its brush-commutator contacts produces little interference in (for example) a battery receiver in its vicinity, but it may easily set up serious interference in a mains-driven set two or three houses or even *roads* away.

The best way of overcoming interference is to deal with it at the source. This point cannot be emphasised too much, because it must be realised that any attempt to combat interference at the point of its reception is merely a palliative. A single piece of apparatus causing interference may trouble hundreds of wireless receivers. A single cure at source will overcome all this difficulty, but a suppressor fitted at the set may not be as effective by half, and it will, of course, only minimise interference at the set to which it is fitted. So, the first thing to do in dealing with interference is to try and deal with the apparatus itself before dealing with fitments for it.

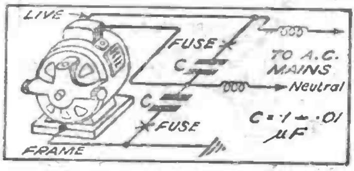
For example, bad sparking at brush-commutator contacts can often be reduced by keeping the contacting faces of the brushes clean and free from grease and the commutator plates clean and smooth, and by keeping domestic apparatus switches in good working order so that they make rapid making and breaking of the circuit which they control and any small arc they produce is quickly quenched by the speedily winding air-gap. It should be noted, in passing, that all Bulgin mains switches are specially designed and made with attention to this point so that the make and break may not only be speedy but that arcing may not burn the contacting suffaces so as to give intermittences and, in result, worse arcing.

Our first diagram shows the ordinary cure for a D.C. motor, which is radiating interference. A large motor will be shunt wound, and therefore the connection shown is equal to the condensers being connected to the brushes. Fuses are desirable in the condenser leads as shown in the practical diagram on the opposite page. Chokes may also be necessary, and would then be connected as indicated.

It is important to ascertain the maximum current which the motor takes in order to arrive at the rating for such chokes.

The second diagram is more applicable to A.C. mains. It is important that the neutral main be connected to the point shown. The arrangement of condensers is such as not to pass an out-of-phase current to earth. It should be noted that smaller condensers are used.

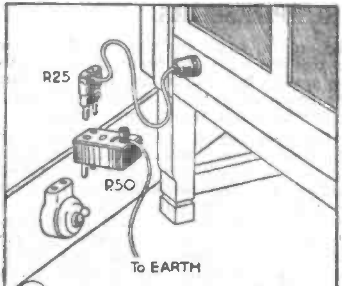
In connection with the suppression of switches, sparking-contacts in contact-breakers, and sign-switching systems, it is sometimes important to bear in mind that it is not sufficient just to connect a condenser across the two contacts; this may even intensify the interference, and it is desirable



to have a non-inductive resistance, usually of about five or ten-watts rating connected in series with the condenser as a "damper." A highly inductive resistance should not be used; it may effect a cure on medium and long-waves, but will often be found to intensify interference on short-wavelengths.

Never use a condenser having a value which is larger than that just necessary to effect a cure; there is no point in using a larger value of capacity and it may lead to trouble.

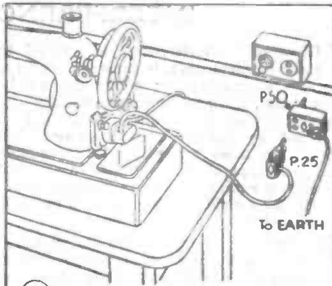
With A.C. supplies and out-of-phase current can easily be passed to earth which, with a large value of condenser, and assume quite "shock-ful" proportions if resistance in the form of part of the human body (for example) is inserted between the condensers and earth. It is this out-of-phase current which causes the small spark noted when a condenser, connected between A.C. mains and earth, is disconnected. The out-of-phase current is substantially wattless.



(5) P.50 for A.C. or D.C.

When interference is to be cured at the point of reception, and when it is not wished to disturb wiring, an interference suppressor adaptor is a useful fitment. The type illustrated has pins which will co-operate with all standard two-pin five-ampere switch plugs or outlets, and is provided with sunken sockets which will receive a standard two-pin five-ampere plug. It is important that the suppressor be earthed, otherwise it is practically useless. In some cases a separate earth from that used by the receiver may be desirable.

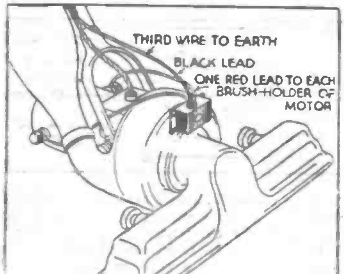
BULGIN List No P.50, Suppressor.



(6) P.50 for A.C. or D.C

This diagram shows another use for a suppressor adaptor, cure of interference at source. In this case a sewing-machine motor radiating a certain amount of interference has the suppressor adaptor fitted between its leads and the wall point. Again it is essential to use an earth, and it may also be desirable to earth all the metal framework of the sewing-machine. Do not use the earth connection which is used for a wireless set, and do not earth to a supply conduit. Make a proper, *short* earth connection. A water pipe is quite a good connection.

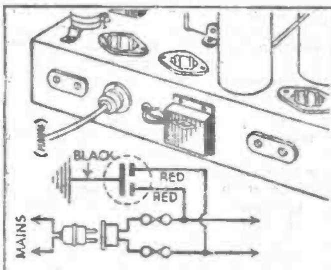
BULGIN List No. P.25, " Fuse Plug."



(7)

This diagram shows the method which may be adopted when a vacuum-cleaner or other motor operated from D.C. mains is causing interference. The suppressor, which should have a capacity of not less than 2+2 μF. may be bolted to the motor framework and should have its black lead connected to earth. This means that three-core flex is essential. It is not desirable to connect this lead to the framework of the motor without an earth, but with an earth the motor frame should be earthed also. The red leads are connected as shortly as possible to the brush terminals.

BULGIN List No. A.30, Suppressor



(8) A.20 for A.C.
A.21 or 30 for D.C.

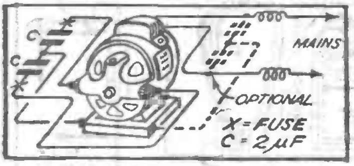
A type of interference which is often experienced with mains-driven receivers is what is known as "modulation hum." This is a hum which rises in intensity when a station is tuned in. The effect is best noted when you tune in a carrier wave in one of the silent intervals between items. The trouble responds to the use of two small condensers—a suitable double-condenser unit is more convenient—connected across the mains on the apparatus side of the input fuses and plugs and with the common plates or centre point earthed. A bad earth may result in no cure at all.

BULGIN List No. A.20, Suppressor.

INTERFERENCE SUPPRESSORS

UNFORTUNATELY for those people who experience interference there is no legislation at present compelling the owners of offending apparatus to make it interference-free and to maintain it in this condition, and any radio set owner who desires to effect the necessary modification to such interfering apparatus may have to do so at his own expense even after he has obtained the owner's permission to do so.

If this is the case, then, with a cure-at-source not possible, attention has to be turned to cure at the receiving end, but, as we have already said, this is not quite so effective. Generally speaking, most interference is received at wireless sets via the mains wiring, but, and this is important, such interference, although arriving via the wiring to your house or flat, may not necessarily be imparted to the set entirely in this manner. There is always a certain amount of radiation from the house-wiring, which may be picked up on the aerial wires, or, more especially, on the lead-in.



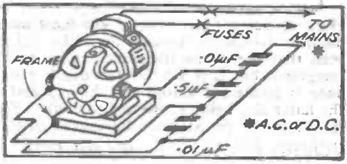
A cure for interference radiated from a motor is often achieved by the use of two condensers connected in series across the brushes, the centre point being earthed. Unless the motor frame is already earthed the centre point of the condensers should be taken to earth.

A suppressor fitted near to the set therefore, when a cure is to be attempted at the point of reception, may not prove effective, but would probably prove quite effective if fitted near to the entry of the supply mains in the house or flat. Speaking of the latter type of residence, it must be remembered that interference may be radiated from the electric wiring of the flat below or the flat above, so that if you suitably suppress your own wiring you are still open to trouble.

In such cases it is better to fit suppressors at the point of entry of the supply mains to the block of flats. This, however, is a job which needs to be very carefully done. Quite large values of condensers may be needed in certain cases and proper iron-clad fuseboxes, etc., are generally required by the electric supply authorities because, you see, any fault occurring would have the serious effect of putting many residences into complete darkness. Be liberal, therefore, in the use of fuses; they will probably never blow and cause additional expense, but in the event of breakdown they are there and, while interference suppressor condensers nowadays are made to restrictions of very high quality and to rigid specifications, there is always the possibility of breakdown which should be guarded against in this manner.

Standard interference suppressors are fitted with two red leads and one black lead. Internally they have one condenser between each of the red leads and the black lead, making two in all. With D.C. mains it is quite satisfactory to connect one red lead to each of the mains wires through a suitable fuse and for most capacities up to and inclusive of 2 µF. one-ampere fuses may be used. For capacities of 4 µF. two-ampere fuses are often needed because of the relatively heavy though momentary charging current.

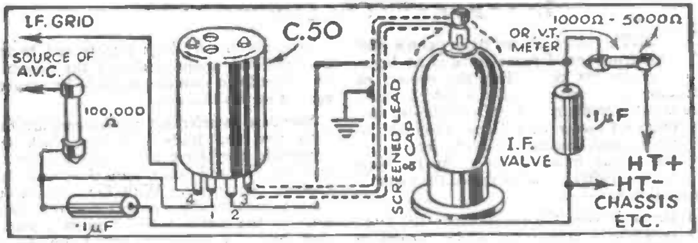
With A.C. mains, however, an out-of-phase current will be passed to earth through one of the condensers. The condenser which behaves in this fashion is that connected to the live main, by which term we mean the main which is not earthed at the power station; the earthed main is known as the neutral. With a good and low-resistance earth, this out-of-phase current does not register on the meter and need cause no alarm whatsoever, although if the earth connection (black) be removed or broken momentarily a spark will be noted. If a part of the human body, such as a luckless hand, be interposed between this wire and the earth connection a shock will be felt because resistance is then



Interference-elimination connections for a small motor which cannot have the frame earthed. Small values of capacity are used, ·01 µF. from each brush to earth and ·5 µF. across the brushes.

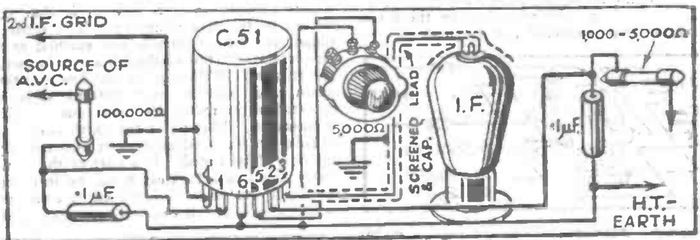
interposed in the circuit and the current ceases to be wattless and non-registering as far as the meter is concerned. For this reason another mode of connection is often adopted, as will be gathered from this page. One red lead is connected to the live main and the black lead is connected to the neutral main. The other red lead is connected to earth.

Under these conditions a wattless current is passed from the live main to neutral, but it does not register on the meter, and practically no current whatsoever, even with high-resistance earth and earth leads, is passed from the neutral main through the other condenser to earth. Suppression is just as effective, but do not use high values of capacity



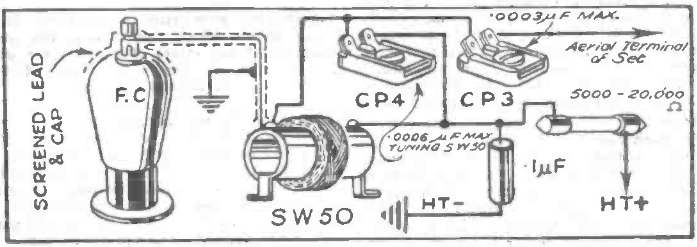
In modern super-heterodyne receivers much amplification is carried out at the "intermediate frequency." Generally, for various reasons, the modern figure for this is 465 k.c/s. Our diagram shows the normal connections for the Bulgin type C.50 transformer which tunes to 465 k.c/s. The connections are shown fully. No. 3 is connected to the anode of an I.F. valve through a screened lead and with a screened cap, or to the anode pin of a frequency changer. No. 2 connects to H.T. positive, usually via a decoupling resistance which *may* be provided by a visual tuning meter. Decouple with ·1 μF.

BULGIN List No. C.50 465 kc/s I.F Transformer.



Here we see another type of 465 k.c/s intermediate frequency transformer. It will be seen that the connections are similar to the foregoing, but that a 5,000 Ω variable resistance is connected across tags Nos. 5 and 6, the latter also being connected to earth. This is a type of transformer having electrically variable selectivity by means of a small coupling coil between tags Nos. 5 and 6, shunted by the variable resistance shown When the resistance is turned to zero-Ω, coupling is weak and selectivity high. When the resistance is 5,000 Ω coupling is normal with a band width of approximately 9—10 k.c.s.

BULGIN List No. C.51, 465 kc/s I.F.T. BULGIN List No. V.C.44. 5,000 Ω Vol. Control.



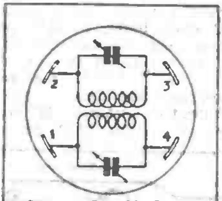
The I.F. coupling coil, List No. S.W.50, shown in the above diagram is a special type for use in short-wave converters which are intended to feed into a normal receiving set. The anode of the frequency-changer valve (sometimes, with certain types, this is a pin at the base) is connected to one side of the coil, the other side of which is connected to H.T. positive with a decoupling resistance and a condenser of between 5,000 and 20,000 Ω and ·1 μF. respectively. Across the coil is connected a pre-set tuning condenser of ·0005 μF. or ·0006 μF. maximum capacity to tune the S.W.50 coil to the (long-)wave-length of the set.

BULGIN List No. S.W.50, S.W. I.F. Coil. BULGIN List No. C.P.4, ·0006 μF. Pre-set

INTERMEDIATE FREQUENCY TRANSFORMERS

THE modern super-heterodyne receiver is an extremely useful circuital arrangement for many reasons, among which the following are, perhaps, some of the more important. At quite an early stage in a super-heterodyne receiver we convert our incoming signals of whatever wavelength, by means of what is called an oscillator, into one definite and standard frequency, at which frequency both the main amplification and arrangements for selectivity are carried out.

Here are the internal connections of a popular fixed-selectivity I.F. transformer. The primary is between 2 and 3, and the secondary between 1 and 4.

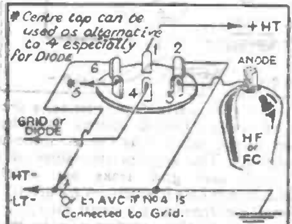


BULGIN COIL No. C.50

Whatever the wavelength (and thus frequency) of the station received the intermediate frequency is always the same. This is something which is of enormous advantage because arrangements for selectivity and amplification do vary to quite a large extent at different wavelengths or frequencies.

With only the one (intermediate) frequency we can arrange matters so that we have constant selectivity for stations of equal strength, although widely differing wavelengths, and we can also have quite stable amplification, in many cases worked to the reasonable limit for any valve with its associated tuning coils or I.F. transformers, since because we are not changing the frequency, we shall in no way tend to run into instability. By this means selectivity can be made quite high and really useful amplification obtained.

The selectivity given by a super-heterodyne receiver is often no greater than that given by a set having a number of tuned radio-frequency stages, but it is much easier to design, very much cheaper to make, and much simpler to handle. In other words, its results are more certain for less expenditure.



BULGIN COIL No C.11

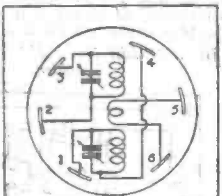
The coupling between valves which are amplifying at the produced intermediate frequency is generally by means of what is really an H.F. transformer, although known by the more popular name of Intermediate Frequency Transformer. This is shortened, in popular parlance, to I.F.T. or I.F. Transformer. The internal connections for a typical type are given on this stage.

Since the tuning does not have to be varied pre-set condensers are used, and in nearly every case of I.F. transformer are built into the screened coil. Once set in trimming and ganging or setting up the receiver they need never be touched.

Two popular intermediate frequencies are used in this country, 465 k.c/s. and 110 k.c/s. The latter, being of a lower frequency, permits of greater amplification per stage. For various reasons, however, it is not so satisfactory generally, and what is termed "image signals" and repeat whistles are more prevalent; 465 k.c/s is more generally used.

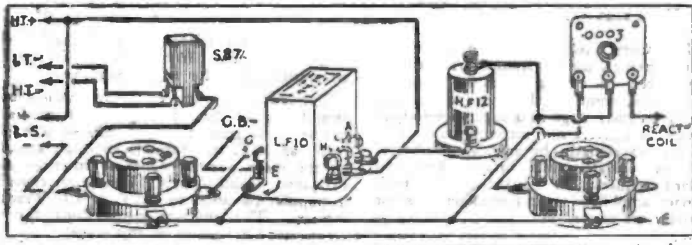
However, in certain districts, 110 k.c/s. is an advantage, and the connections for the Bulgin Coil C.11, which is a transformer of this type, are also given. We said that we can have constant selectivity with I.F. transformers; we may also have means for adjusting the selectivity and variable types are on the market. Some are mechanically variable, the coupling between the primary and secondary windings being adjustable quite readily, and one quite useful type is electrically variable. A small coupling coil situated between the primary and secondary windings is arranged to be shunted by a variable resistance so as to alter the field leakage between primary and secondary, and thus affect the coupling, resulting in selectivity which can be narrowed down if desired to 5 k.c/s.

The internal connections of another popular type of I.F. transformer with a tertiary winding between tags 5 and 6. In use 5 and 6 are shunted by an 0—5,000 Ω variable resistance.



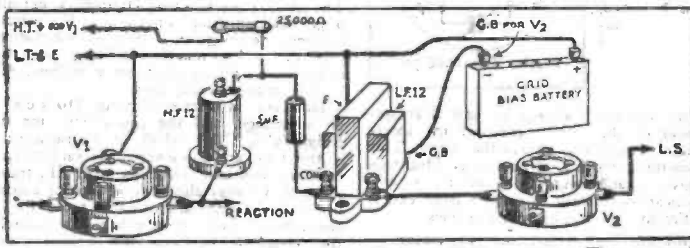
BULGIN COIL No. C.51

There are other methods of arranging for variation of selectivity in I.F. circuits, one of which, as aforesaid, involves the alteration of primary and secondary intercoupling by mechanical means. Another, quite good, but not often used, involves the use of high-Q circuits, with external damping.



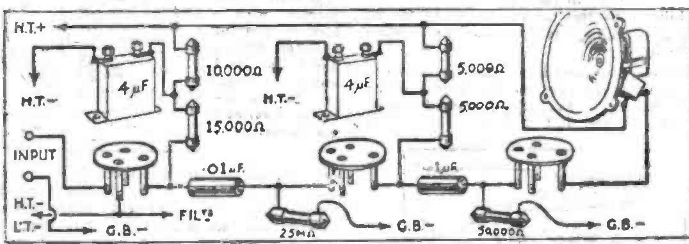
One of the most popular types of modern intervalve L.F. couplings for even response is the fed-transformer unit which incorporates a small high-permeability-core nickel-alloy transformer with the necessary coupling condenser and resistances built into the case. Where a detector valve in the set (that on the right in our diagram) has an internal resistance of about 10,000 Ω, H.T. positive should be connected to the terminal of the Bulgin Transcoupler, List No. L.F.10, marked " LOW." Where the valve has higher internal resistance connect H.T. positive instead to terminal " HIGH."

BULGIN List No. L.F.10, Transcoupler. *BULGIN List No. N.23, Differential Condenser.*



Here is a fed-transformer circuit made up of separate components. The midget high-permeability-core nickel-alloy transformer is shown with a ·5 μF. coupling condenser and a resistance of 25,000 Ω as coupling between the H.F. choke and the anode of the detector valve and H.T. positive. The connections are so clearly shown that there is no need for us to enumerate them point by point. It is rarely necessary to use a coupling condenser larger than 0·5 μF., but it is important to use a good and reliable type which will not leak.

BULGIN List No. V.H.19, 4-5-pin Valve-holder. *BULGIN List No. L.F.12, Senator Transformer.*



This diagram shows another method of coupling in L.F. amplifiers. It is the well-known resistance-coupling with grid condensers and grid leaks, and is well-known for the excellent quality which it enables to be obtained from an amplifier using it. The values given are typical for an input valve of about 10,000 Ω internal impedance, a second valve of about 3,000 Ω internal impedance, and an output valve of as low an impedance as possible. The appropriate values of grid condensers and grid leaks for excellent amplification at bass frequencies are given. To use small condensers is a usual mistake.

BULGIN List No. V.H.48, Chassis Valve-holders. *BULGIN List No. S.C.40, 4 μF, Condensers.*

L.F. COUPLINGS

THE term L.F. couplings covers all those devices and arrangements which are used to couple valves after the detector circuit and including the detector valve to output valve. There are many forms of L.F. couplings, all with particular claims for merit. The simplest form of L.F. linking is resistance coupling, a form of which is shown at the bottom of the opposite page together with practical decoupling, a subject which is dealt with elsewhere in this book.

Resistance coupling is one of the simplest methods, because the three necessary components for amplification with a number of valves are :—A coupling resistance, a coupling condenser and a grid leak between each pair of valves. It is usual to make the resistance which is used for coupling about two or three times in ohmic value the internal resistance of the valve which it succeeds. This gives quite a good proportion of amplification and very good quality.

The value of the grid leak and condenser is determined in another way. This matter is more bound up with the valve of whose grid circuit it is considered and should be considered in this light. When in an amplifier the signal from a plate of a valve is passed to the grid of the following valve by means of a grid leak and condenser, it is important to know just what proportion of the signal is being passed to the valve grid, because actually we cannot have all of it.

There are various means of calculating, and since a condenser has what is known as reactance it is usual to make the calculations at the lowest frequency which the amplifier has to deal with satisfactorily. We know that if we choose an arrangement which is satisfactory on a low frequency it will be even better at higher frequency. The reactance of a condenser can be calculated from a formula given elsewhere in these pages in the article dealing with decoupling. Having obtained the value in ohms (and it is usual to work at 50 c/s) we take the following formula and substitute our values in it.

$$\frac{\text{Volts applied to grid}}{\text{Volts from preceding valve.}} = \frac{R}{\sqrt{R^2+X^2}}$$

Where R = Ω of gridleak and X = reactance of grid condenser in Ω

Now you can work it out for yourself, but if you don't care to do so you can take it for granted that if you use a ·01 condenser with a ½ MΩ leak or a ·1 condenser with a leak of either 100,000 Ω or 50,000 Ω, according to what the makers of the valves advise, you cannot go far wrong.

A good method of transformer coupling is what is known as the fed-transformer. With this, direct anode current flowing in a valve is not passed through the primary of the transformer, but is passed through a coupling resistance, signals being fed from the anode of the valve through a condenser to the primary of the transformer (hence the name "fed-transformer.")

By this means we can have quite small transformers which are, moreover, highly efficient and which in many cases are even more efficient than large transformers of the normal straight-connected variety. High-permeability nickel-cores are usually used for such types, enabling the physical dimensions to be small. This usually lowers the self-capacity enormously and greatly improves the top response, while the high inductance given by the high-permeability core gives excellent bass.

Since the primary of a fed-transformer is in series with the feeding condenser, we have what is obviously a resonant circuit and in such cases it is possible to take advantage of this to obtain certain desired results. For example, it is possible to increase the bass response of an amplifier enormously by choosing values of feed condenser which, with the primary inductance (expressed in henries), will cause resonance at, say, 50 c/s. The formula is :—

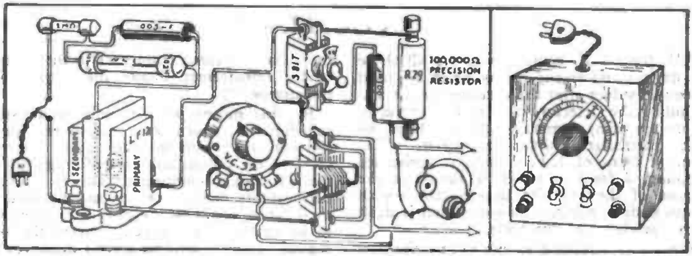
$$\text{Frequency of Resonance} = \frac{159}{\sqrt{L \times C}}$$

where L is in henries and C in micro-farads. For 50 c/s., for example, it will be seen that the product of L and C must be 10·1; for 100 c/s., 2·52 approx.

In passing, and in case you should think that we have contradicted ourselves, it should be noted that these midget transformers are occasionally used in straight connection with anode current passed through their primaries when such current is 1-mA. or less, because the magnetising effect is not then too serious. Such midget transformers are used in portable sets and in pocket receivers with really excellent results as regards quality and amplification.

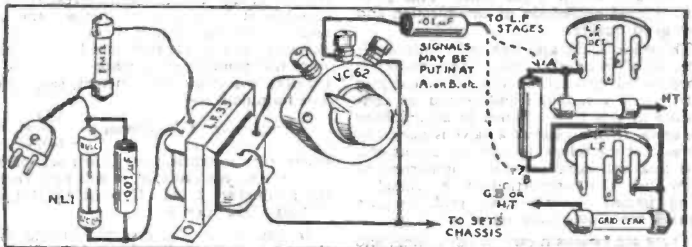
With these modern L.F. coupling arrangements it is very important to attend to another matter—decoupling—a subject which is very fully dealt with in earlier pages. For the reasons given high amplification sets and stages may very easily cause back coupling and L.F. instability which will either lower amplification, or actually produce oscillation of low frequency known as motor-boating.

There is a simple cure which, although not recommended, is very useful as a test. This is to reverse the primary or secondary connections of an L.F. transformer. If instability is due to back-coupling between two stages coupled by a transformer, this will stop it. It will, however, give somewhat lowered amplification in most cases, and therefore cannot be recommended as a permanent cure unless the tendency to motor-boating is only slight, when the reduction of amplification upon reversal of the transformer winding is often hardly noticeable.



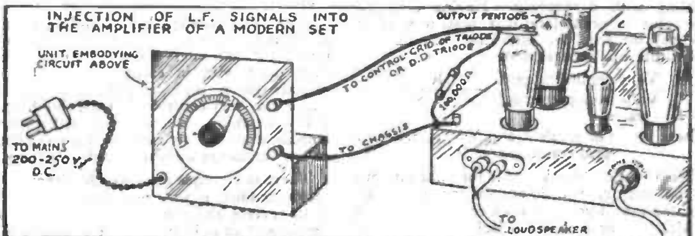
Here are the components and their connections for the construction of a most useful addition to the workshop's equipment—a resistance and capacity bridge meter which can quite easily be calibrated. Condensers as small as ·0001 μF. can be tested for capacity and insulation. High resistances up to 1 MΩ may be measured without recourse to sensitive meters and high voltages.

BULGIN List No. L.F.12, Transformer.
BULGIN List No. V.C.32, Potentiometer.
BULGIN List No. S.81T, S.P. D.T. Switch.
BULGIN List No. R.29, Precision Resistor.
BULGIN List No. N.L.1, Neon Lamp.



As a source of test signal for the L.F. stages of a receiver, the Neon L.F. Signal generator has the advantages of handiness and small size. It is one of the quickest of fault finders, when intelligently used. With one lead clipped to the chassis, a test prod on the end of the other lead may be applied to signal-sensitive points, such as the grids and anodes of valves, L.F. Transformer and R.C.C. Unit terminals, and the signal heard will give a good clue as to how a stage is behaving (see opposite page, Col. 2 also).

BULGIN List No. H.W.33, 1 MΩ Resistor.
BULGIN List No. P.C.201, Cond. .001 μ.
BULGIN List No. L.F.33, Transformer.
BULGIN List No. V.C.62, Vol. Control.

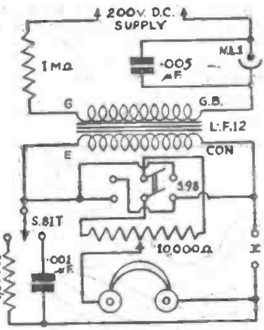


The Neon L.F. Signal generator should be made up in the form of a neat chassis that can be fitted into a cabinet for use as required. Either batteries of at least 200 volts, or D.C. mains, may supply the input. To avoid the grid of a valve being left free, should it consist of a top cap from which the connector is removed to apply the generator lead, a .1MΩ resistor should be taken from the valve cap to either the chassis (as shown) or to the G.B. source for this valve.

BULGIN List Nos. K.70 and K.71,
Laboratory Knob and Cursor.
BULGIN List No. K.73, Ivorine Dial Plate.

MEASUREMENTS WITH BRIDGES

ALTHOUGH the greater part of service and repair work can be carried out with only a multi-test meter of good type, occasions often arise when it is essential to make measurements of very high resistances and of small condensers. For this purpose, an instrument incorporating the Wheatstone Bridge principle is invaluable. It is well within the ability of the service man to construct for himself, if laboratory precision is not an essential requirement. Such an instrument will enable values to be found,

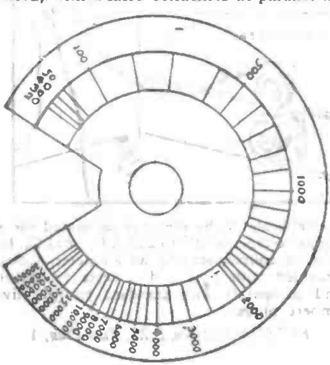


Circuit of Capacity and Resistance Bridge. The energisation is by means of the Bulgin Midget Neon Lamp, connected as a relaxation oscillator.

(See also top diagram on opposite page).

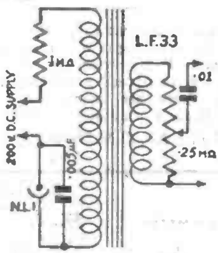
with reasonable general-purpose accuracy, of resistances up to ·1 M Ω and condensers down to as low as ·0001 μF.

The first need is for some source of audio-frequency alternating voltage. This is readily provided by a Bulgin Neon Lamp, N.L.1, in series with a high resistance to limit the current passed, with a fixed condenser in parallel the



value of which determines the frequency. This is made to energise the *secondary* winding of an intervalve type of transformer, off the *primary* winding of which is taken the induced alternating voltages for application to the bridge. The method of using the outfit—which should be made up into a convenient small cabinet form—is as follows: (1) the mains lead is plugged into D.C. mains or an H.T. supply of at least 200 volts (batteries are suitable); (2) a pair of headphones is connected to terminals provided on the cabinet for them and donned; (3) the condenser or resistance to be tested is connected across the remaining two terminals on the cabinet; (4) both switches are snapped over to either the resistance or the condenser measuring position. Then the knob of the potentiometer is turned backwards and forwards until the audio note provided by the Neon lamp circuit is no longer heard or is at a minimum.

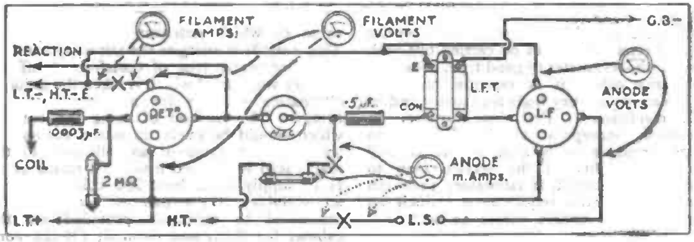
The calibration of this bridge p'meter on both capacity and resistance is already done, on the small marked dial shown at the bottom of the left hand column of this page. To render this dial of practical size, it is only necessary to slip a piece of thin, fine card under the page and prick through it on to the card the centre point and the calibration points of the small dial figures shown. Then, on the card, lines may be drawn *carefully* with a ruler from the pricked centre point to each of the calibration points on the card and



Circuit of Neon L.F. Signal Generator. The transformer is usually connected so as to step down, the secondary being connected to the mains.

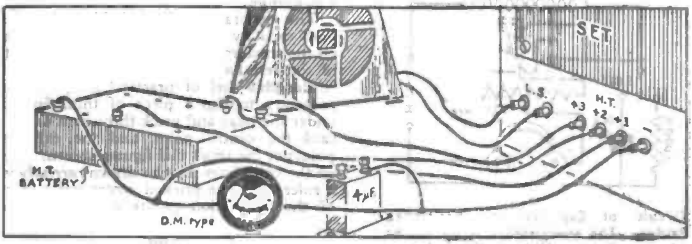
extended as far as it is wished to reach the circumference of the much larger practical size dial to be marked on the card. The reason why a double-pole switch is included in the circuit is in order to reverse the bridge action so that the calibration holds good for both resistance and condenser measurements.

The alternating voltages appearing across the primary of the transformer have another very valuable use. They may provide steady, clearly heard L.F. signals for testing the audio frequency stages of a receiver.



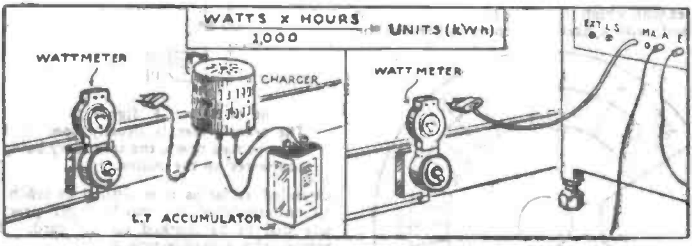
Ammeters are always inserted in leads which are carrying current and which must be "broken" for the purpose. Voltmeters, however, which read the potential across any resistance or source, are always connected across points. Our diagram shows typical instances of the way in which meters would be connected in wireless receivers for purposes of testing, etc. This circuit shows where the connections are broken or made.

BULGIN List No. D.M.4, 0/·5 Miniature Ammeter. *BULGIN List No. D.M.15, 0/15 Miniature mA.meter.* *BULGIN List No. D.M.1, 0/3 Miniature Voltmeter.*



The total anode current to a receiver may be measured by inserting a meter in the H.T. negative lead. It is very important, however, to use as low resistance a type of meter as possible. There are many types of inexpensive though accurate meters, such as our well-known miniature moving-magnet types. These have a certain amount of D.C. resistance, which may provoke oscillation unless precautions are taken. A condenser is connected across the meter so as to form a path of relatively low impedance for signals.

BULGIN List No. D.M.52, 0/30 mA.meter. *BULGIN List No. S.C.40, 4 μF. Condenser.*

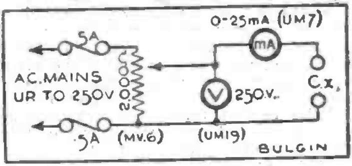


The Bulgin Wattmeter is a useful piece of apparatus for instantly measuring the consumption of apparatus connected to the mains. It may be used to measure the consumption of chargers, radio sets, lamps, soldering irons, etc., with great accuracy and ease. The special scale of the meter is calibrated for all mains voltages of 200 to 250 A.C. or D.C., but it is, of course, actually an ammeter, though provided with pins and sockets to receive and co-operate with standard two-pin five-ampere plugs.

BULGIN List No. U.M. 12, 0/250 Wattmeter. *BULGIN List No. P.25, Fuse Plug, 1A.*

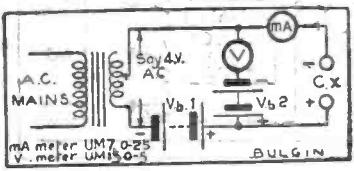
METERS AND THEIR USES

METERS are probably the most important pieces of apparatus that any experimenter, amateur or service-man can make use of. With their intelligent use it is possible, even without any other apparatus whatsoever, to form a very accurate idea of how a set is performing, or, if it is faulty, of what is wrong with it. There is a golden rule which must be observed when connecting and using



such instruments. Current meters are always inserted in a wire which is carrying current so as to measure the current flowing therein. Voltmeters, however, which measure the potential or pressure across different points, usually points separated by some form of resistance so as to produce a voltage difference, are connected to such points, positive to positive and negative to negative. The rule of like polarity to like polarity is also observed in the case of current meters It will be seen that a current meter, therefore, should have as low a resistance as possible. A voltmeter however, should have as high a resistance as possible. The latter should consume the very minimum of current.

The best types of commercial meter used for voltage measurement have a characteristic which is known as 1,000 Ω per scale-volt. This means that for full scale deflection irrespective of voltage, the total current consumed is one-milliampere. It is important in many cases to use meters of this type because where we are measuring voltage from a supply of high internal resistance or through quite high resistances the meter must inevitably draw a little more current for its operation, and this will increase the voltage-drop through such external re-

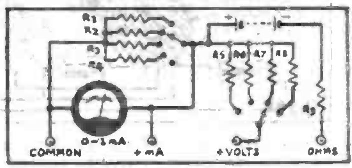


sistances. For a milliammeter the internal resistance should be low; in many cases it must be *very* low, but generally speaking milliammeters of quite medium resistance such as moving-iron and moving-magnet types can be introduced into most circuits without untoward results. In certain cases milliammeters should be shunted by high-capacity condensers, especially if the receiver is operating or its oscillation under certain conditions is to be avoided. The first circuit shows how it is possible to measure the capacity of a condenser with fifty-cycle mains. A large and heavy-duty resistance of the variable type (a 60-watt type is to be preferred) is connected across the mains with fuses and, between one end of the resistor and the moving arm, a voltmeter is connected. One capable of reading A.C. must, of course, be used.

$$\text{Formula :—}\mu\text{F.} = \frac{\text{mA}}{\cdot 0063 \times V \times f}$$

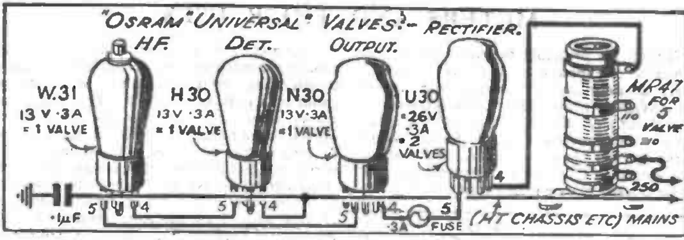
where $f = 50$ c/s in this case

If the measurement of electrolytic condensers is to be undertaken another means must be adopted. A lower A.C. voltage is used and a step-down transformer is desirable. We must, however, remember that polarised electrolytic condensers must not have raw A.C. applied to their plates. Therefore, polarising batteries are necessary. The main polarising battery is shown in the second diagram as Vb1. It must have a voltage greater than one-and-a-half



times the A.C. voltage applied. In order that the voltmeter, which will be a low-voltage type, shall not be affected by this battery, we connect another battery, Vb2, in series with the voltmeter, and in reversed polarity to the first one, so as to cancel the D.C. voltage in the voltmeter circuit. The electrolytic condenser will now be satisfactorily polarised, and will never be reversely connected upon negative half cycles, because the voltage of Vb1 is greater than the peak of the A.C. The same formula is used.

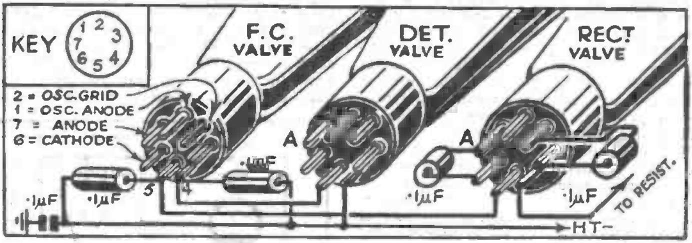
Our third diagram shows the simple layout for a multi-purpose meter, more fully described on other pages. Note particularly the shunts R_1-R_4 which increase the current ranges and the switch which brings them into circuit. The open-circuit point of the switch should be used when the meter is used for voltage readings, additional series resistances for voltage measurement being brought in by the other switch towards the right of the diagram. We must remember that the total current at any time is to be one-milliampere, and that our meter will be what is known as a 1,000 Ω per scale-volt type. This means that for 100 V. we need 100,000 Ω; for 10 V., 10,000 Ω, and so forth, inclusive of meter resistance. (R_5—R_9)



The use of universal indirectly heated valves on A.C./D.C. mains with a voltage-dropping resistance is nowadays very popular. This diagram shows a typical arrangement for a numer of Osram universal valves in circuit. One of the mains leads is connected to the H.T. negative line or chassis in the receiver, and with D.C. mains this would, of course, be the negative main. One of the valve heaters has to be returned to this lead and—usually the detector. A ·3-A. bulb fuse is desirable between the heater of the rectifier and the other heaters as shown to give adequate protection in the circuit.

BULGIN List No. M.R.47, Mains Resistor.

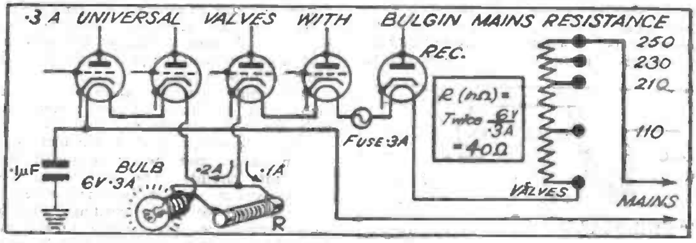
BULGIN List No. B.630, 0·3A. Bulb.



Here we see the heater circuit arrangement of part of a universal super-heterodyne receiver. It will be noted that from the heater pins of the frequency-changer valve ·1 μF. condensers are connected directly to the H.T. Negative line. This is often important in A.C./D.C. sets in order to avoid the introduction of hum, and if you are experiencing this type of trouble, which is not necessarily modulation hum, it is well worth while trying out this modification. It may also be desirable to connect ·1 μF. condensers across anode to cathode in the case of the rectifier valve, which will minimise modulation hum.

BULGIN List No. PCP.1, Condenser, 0·1 μF.

BULGIN List No. M.R.—, Mains Resistors, 29 models.



We are often asked how it is best to connect a pilot lamp in A.C./D.C. circuits. A pilot lamp, if the fuse is not used for this purpose, would be connected as shown, but it is essential to have a shunt. We usually arrange the shunt so that two-thirds of the current pass through the lamp. Take the lamp rating as shown in the formula and multiply by two. This will give the resistance for the shunt. The lamp will then be slightly under-run, but will withstand surges better, and should still give adequate illumination for all requirements.

BULGIN List No. B.630, 0·3A 6V. Bulb.

BULGIN List No. P.R., Resistors, all values.

RESISTANCES. A.C.–D.C.

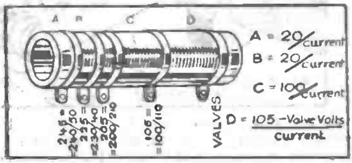
BULGIN D.C. and A.C./D.C. mains resistances are designed for use with directly heated series-heater mains valves of which many types are on the market. They are not intended at any time for use with directly heated valves of standard battery type.

To use directly heated filament valves, except possibly in an output stage, means expensive smoothing of relatively heavy current involving the use of large chokes and high-capacity low-voltage condensers, an extremely expensive proceeding. Modern A.C./D.C. or, as they are sometimes known, "Universal," valves have characteristics which in most cases are equivalent to, or better than, A.C. types, and really excellent results can be obtained by their use. In any conversion of a battery receiver to D.C. or A.C./D.C. working the first consideration is to replace the valves with suitable A.C./D.C. types. These valves have their filaments or heaters all connected in series, so that the total current drawn from the mains is only that of one valve. In other words, it is as inexpensive, to use three valves as six, so far as the cost of the heating current is concerned. Surplus voltage at the current flowing is dropped in a resistance of which many Bulgin types are now on the market, covering most requirements and combinations of these valves.

An important point when using A.C./D.C. sets is that, unlike A.C. receivers where a double wound transformer is employed, the chassis—or, at any rate, most of the wiring of the receiver—is directly at mains potential, and care should be taken therefroe to have adequate insulation, well sunk grubscrews in knobs, etc., so that shocks can never be obtained. The H.T. negative line in the set, which is connected to one of the mains wires, must never be earthed direct, but since an earth is necessary for satisfactory wireless working in most cases, connection must be made through a condenser. The usual value is ·01 to ·1 μF. max. The condenser must have a working voltage rating of at least *twice* the mains voltage for adequate safety, and it is essential to use fuses in both the mains leads. Parts of the chassis which are not directly connected to H.T. negative can, of course, be earthed, and many receivers are constructed on this plan, the H.T. negative line being run in the receiver for return of grid circuits, etc., but connected to the chassis only through a condenser. Under these conditions the chassis must be earthed direct.

As in A.C. sets, grid bias may well be automatic, or "free," as it is sometimes termed. This latter name is somewhat misleading, for the grid bias voltage required is actually in some circuits borrowed from the H.T. supply. With A.C./D.C. sets we have only a limited H.T. voltage. It can never be greater than the mains voltage and is usually less owing to the drop in smoothing chokes, etc. It is well, therefore, when using automatic bias, to choose valves which will work with quite a low value of grid bias, and many output pentodes are available to-day in such valve ranges giving outputs of 2½ or more watts for a grid input, which is quite small, and which require only five or six volts grid bias. Such grid-biasing is usually effected by connecting between the cathode of the valve concerned and the H.T. negative line a resistance shunted by an electrolytic condenser of, in the case of L.F. valves, about 25 μF. working capacity. Grid-biasing resistances for H.F. and other valves are similarly connected, but usually are shunted by paper condensers of about ·1 μF. rating. In L.F. stages grid decoupling is sometimes necessary. This is effected by taking a transformer secondary return wire or a grid leak in a resistance-coupled stage to H.T. negative through a resistance of 100,000 Ω and, from the upper end of this resistance a two or four μF. condenser is connected to the cathode of the valve concerned.

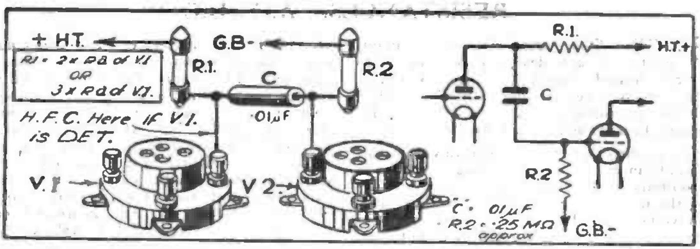
All Bulgin mains resistances are tapped for mains of 200/250 volts, and some types are tapped additionally for mains of 100/110



Normal arrangement of Mains Resistance.

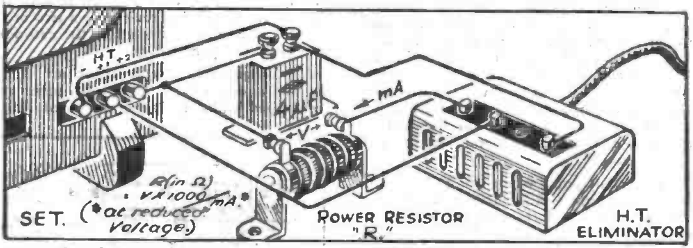
volts. They are provided with a terminal at the far end for "so many valves" of a given type, and it should be noted that some universal ranges have valves which have double heaters and which, therefore, each count as two. For example, in the top diagram on the left-hand page, the type U.30 rectifier is rated at ·3-A. 26-V., and it counts, therefore, as *two* 13V. ·3A. valves, which indeed it has, in one glass envelope.

If you wish to find out the resistance of any such mains resistance you must remember that the 240/250 terminal is calculated by us for a nominal voltage of 245; the 230/240 terminal for 235; the 200/210 terminal for 205, and so forth. Therefore, between any adjacent two of these bands there is a voltage-drop of 20. If this is divided by the current rating of the resistance the ohmic value will result. From the 205 to the 105 band the resistance value will be given upon dividing 100 by the current, and from this band to the band marked "VALVES" you should subtract the total valve-heater voltage from 105 and divide by the current figure to obtain the resistance value.



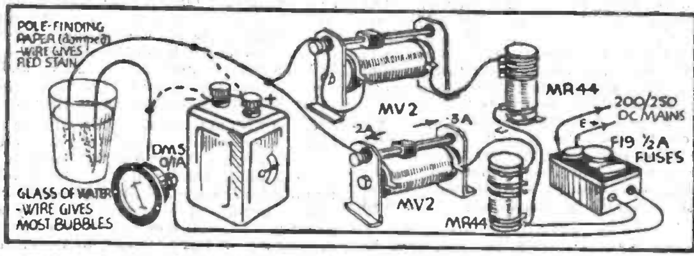
In this diagram we see again the use of fixed resistances in an amplifier. R.1 is the anode resistance for V.1 and R.2 is the grid leak or grid resistance for V.2. The coupling condenser "C" may have a value of ·01 μF., when R.2 should have a value of about a ¼ MΩ. A half- or one-watt type of metallised resistance can be used here quite satisfactorily, for the grid leak has to carry practically no current whatsoever. R.1 should be chosen with care and with due regard to the current which will flow, so that it is not over-run.

BULGIN List Nos. H.W.—, ½-Watt Resistors. *BULGIN List No. P.C. 101. ·01 μF. Condenser.*



We are often asked how to cut down the voltage output of an eliminator, and this is the way in which it is done. The resistance figure is obtained by multiplying the *voltage which is to be dropped* by 1,000, and then dividing by the current which will flow in this wire at the reduced voltage. For example, your eliminator may give 180 V., and you wish to use only 150. The power valve fed by H.T.+2 takes, we will argue, 10-mA. when correctly biased for this voltage. We must then drop 30 V. at 10-mA. A 3,000 Ω resistance, to carry this current, is required.

BULGIN List No. S.C.40, 4 μF. Condenser. *BULGIN List Nos. P.R.—, Power Resistors.*



A simple charging circuit for D.C. mains using standard components. With one M.R.44 resistance and one M.V.2 resistance the charging range can be varied between ·2 and ·3 ampere. With an additional M.R.44 and M.V.2 resistance connected in parallel (at the top of the diagram) the rate can be varied between ·4 and ·6 ampere. One-ampere fuses should then be used. To ascertain polarity use damp pole-finding paper or plunge the two connections for the accumulator in a glass of water; the negative wire will gas more than the other. Polarity being ascertained, connect to the accumulator.

BULGIN List No M.V.2, 500 Ω, 60 W. Resistor. *BULGIN List No. M.R.44, 0·3A. Mains Resistor.*

RESISTANCES—FIXED

BULGIN resistances are made in a variety of types with different current-carrying capacities to suit all purposes. They are used for voltage-dropping, for coupling and for decoupling.

The value of a coupling resistance depends largely on the valve which it follows, and upon the requirements of the circuit, but the value of a decoupling resistor depends, as explained on another page, upon the constance of the circuit and also upon the decoupling condenser.

A glance through the pages of the current Bulgin Catalogue will show many resistances of different types, and you may well ask " why so many types, when such components appear really to be very simple ? " There are non-inductive wire-end resistances, power resistances of high wattage rating, low value resistances, flexible resistances, precision resistances, and, of course, mains resistances.

Let us take them in this order and deal with their respective merits. Miniature wire-end resistances are made in half-watt rating, and in many cases in most receivers resistances capable of dissipating this small amount of power are all that is needed. For example, in providing resistance coupling to a detector valve, which probably passes about two or three milliamps when the anode voltage is 100—a satisfactory working figure (we will say) for the type in question—we may find that the valve requires a load resistance of 30,000 Ω. It will be seen from the tables given in the catalogue that a half-watt resistance of this type will carry up to four-and-a-half milliamperes approximately, so our current figure is well within rating.

At 2 mA. we shall have a drop of 60 volts at this figure of resistance value, so the total H.T. voltage wanted for this stage will be 160. It is very easy to calculate the voltage-drop obtaining across a resistor of known value when the current which is to flow through it is determined.

If the current is in milliamperes take only the thousands figure or figures of the resistance value, and multiply by the current figure. In the case above cited, 30 (the thousands figure) is multiplied by 2, being the figure for the current in milliamperes. If, however, the valve were a larger type passing 5 mA. and requiring a load resistance of 30,000 Ω we should have to use a 1-watt type, which, for this resistance value, is capable of carrying 6 mA.

One formula for wattage is

$$\text{Watts} = \text{Current}^2 \times \text{Resistance},$$

so that to obtain wattage rating when the current and resistance values are known, we must divide the resistance value into the wattage figure, when we shall obtain the square of the current. This is worked in amperes and, naturally, a fraction of an ampere results. It must be remembered that a milliampere is ·001 ampere.

Another formula for wattage, worked in milliamperes, is as follows :—

$$\text{Watts} = \frac{\text{Milliamperes}^2}{1{,}000{,}000} \times \text{Ohms}.$$

To ascertain the milliampere rating of a resistor of which the wattage rating is known, use the following formula :—

$$\text{Milliamperes} = 1{,}000 \times \sqrt{\frac{\text{Watts}}{\text{Ohms}}}$$

In many cases, in eliminators, etc., power resistances are needed. That is to say wire-wound resistances capable of dissipating quite high wattages. Twenty-watt and Forty-watt types are made, while for dial lamp shunts and for small voltage drops, etc., Ten-watt low-resistance power resistors can be employed.

Precision resistances are made and should be used where extremely accurate values of resistance are required, because normally wire-wound and other types of resistance are usually made to an accuracy of plus or minus 10%, unless otherwise stated. This means that if you buy a resistance of 100,000 Ω it may have a value between 90,000 Ω and 110,000 Ω.

Normally, such figures, though not fully appreciated, are quite satisfactory and reliable, but if you want your 100,000 Ω resistance to be never less than 99,000 Ω and never more than 101,000 Ω you must buy a 1% precision type, a necessity in voltmeters, etc., and in like laboratory apparatus.

In most positions in ordinary sets, of course, such high precision types would not be generally necessary, and—despite what you may think—quite wide latitudes, even above the usual ±10%, are permissible before any effect is noted. Even a bias resistor, for example, of a nominal 500 Ω will vary between 475 Ω and 525 Ω if accurate to ±5%. If this is not acceptable, a power resistor of the Bulgin 20-watt type can be adjusted, by the makers or in use, to exact values if needed.

The following formulæ are generally of use when dealing with resistances.

Resistances in Series :

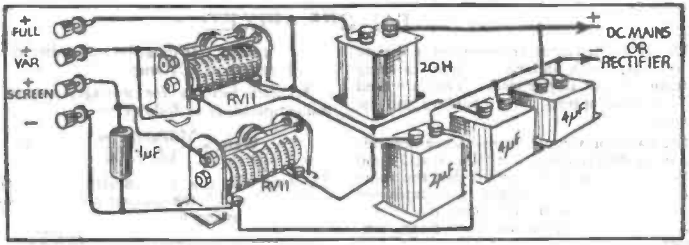
$$\text{Total } \Omega = r_1 + r_2 + r_3 \; - \; - \; - \; - \; -$$

Resistances in Parallel :

$$\text{Total } \Omega = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}}$$

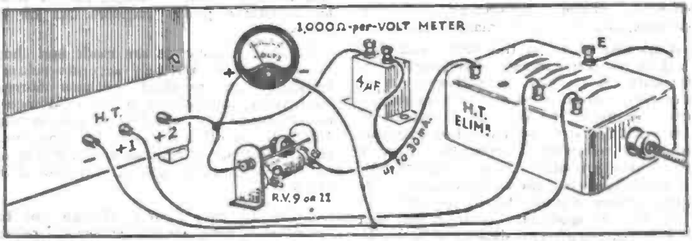
Or, for *two* resistances in parallel :

$$\text{Total } \Omega = \frac{r_1 \times r_2}{r_1 + r_2}$$



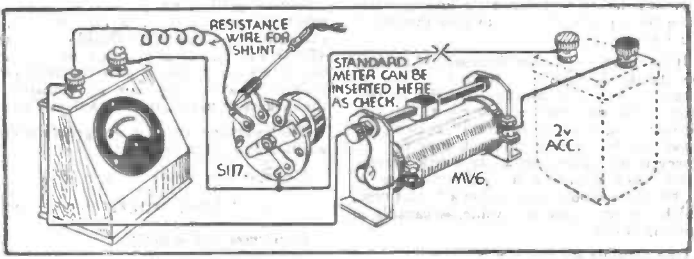
Here semi-variable 10-watt resistances are used in an eliminator, the lower one to provide a variable screen tapping and one to provide a series variable tapping marked +VAR. Such resistances may well be of adjustable type, for continuous variation is not necessary and, like pre-set condensers, when once set such resistances are only altered on occasion. The variable tap has a 4 μF. decoupling condenser; the screen positive terminal, however, takes 0·1 μF., for H. F. currents require only a smaller capacity.

BULGIN List No. R.V.11, 10,000 Ω Variable Resistor. BULGIN List No. S.C.20, 2μF. Condenser.



On an earlier page we saw how it is easy to connect a resistance in the positive H.T. lead from an eliminator in order to give a lower voltage to the set. Perhaps you were stumped by calculations. Then a variable resistance may be used in conjunction with a voltmeter in order to ascertain the desired value. Afterwards, it can be substituted by a fixed resistance of the value discovered or the variable type may be retained. The voltmeter, if used, must definitely be a type requiring only 1-mA. for full-scale deflection, otherwise the voltage at +2 will rise somewhat when the meter is disconnected. A decoupling condenser of at least 4μF. is necessary to provide a good path for signals.

BULGIN List No. M.C.25, 0-250 V. Meter. BULGIN List No. R.V.9, 5,000 Ω Variable Resistor.



Here is quite an easy method of shunting a meter. A variable resistance is used in series with a 2-volt accumulator and the meter is made to read full scale, 1-mA. perhaps. Now connect a piece of resistance wire to one terminal and to a switch tag, make a soldered connection and then gradually shorten the wire, soldering the connections each time firmly, until the meter reads only half scale, quarter scale or one-tenth scale, according to the degree of shunting required. As a check a standard meter is easily inserted if desired.

BULGIN List No. M.V.6, 2,000 Ω Variable Resistor. BULGIN List No. S.117, 3-way Stud Switch.

RESISTANCES—SEMI-VARIABLE

SEMI-VARIABLE resistances are most useful to all dealers, experimenters and amateurs. Various types are made and, as shown in the diagrams on the opposite page, may be used in cases where the desired value of resistance in a circuit is not fully known, or where resistance is to be added.

A variable resistance as such is not required because once a resistance value is obtained it will remain set or will be replaced by a fixed resistance of the same figure. Semi-variable, or, as they are sometimes called, pre-set resistances, are therefore very useful.

Various types are made of which the lowest rating in wattage dissipation is a 10-watt type. These resistances are constructed with a special element with asbestos insulation and spiralled on a grooved porcelain tube. To each 10-watt resistor there are approximately 15 turns of this compound resistance wire with a special rolling slider moving over this element. The resistance is therefore adjustable in about fourteen or fifteen steps.

Such resistances are not intended for continuous adjustment as are volume control or potentiometer types, but are nevertheless capable of withstanding hard and relatively frequent usuage. As in the case of fixed resistances, you may easily determine the wattage rating required for any resistance of this type by the formula here given :—

$$\text{Watts} = \frac{\text{mA.}^2 \times \Omega}{1{,}000{,}000}$$

Another version of this formula is :—

$$\text{Watts} = \frac{\text{Volts} \times \text{mA.}}{1{,}000}$$

so that when two values are known the third is quite easily discovered.

There is a new type of semi-variable resistance of the continuously adjustable type which is known as the Indicator Resistor, a model which is invaluable to Dealers and Service-men. It has a 60-watt element comprised of closely spiralled oxidised nickel-alloy wire, and the bar upon which the adjustable slider runs is calibrated 0, 1, 2, etc., up to 10, with quarter sub-divisions.

Since this type of resistance is made in two models, 10,000 Ω and 50,000 Ω maximum resistance, it will be seen that the 0-10 gradations on the slider bar enable the position of the moving contact to indicate the exact proportion of resistance in circuit.

In servicing a receiver or in replacing resistances it is quite simple to connect this type of resistance with crocodile clips and flexible leads, and then to adjust it so that either the correct voltage reading is obtained across points fed through such a resistance, or until the correct current figure for this part of the circuit is obtained.

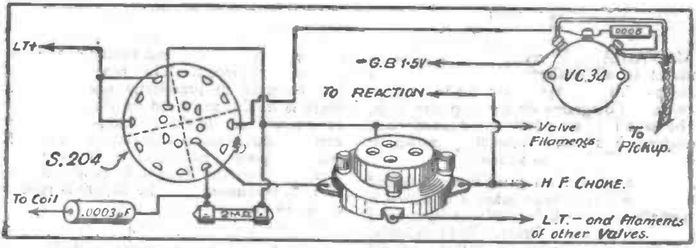
It follows that the resistance value is then quite readily ascertained and a fixed resistance of appropriate value and rating can be connected into circuit. This type of resistance can be used in practically every case, and there is hardly any need to consider whether or no we are likely to over-run it when carrying out tests of this nature. For reference purposes, however, it is as well to mention that the 10,000 Ω type will carry 77 mA. maximum and the 50,000 Ω type will carry 34 mA.

Variable resistances of relatively low values, of which the Bulgin range includes types having a maximum resistance of from 6 Ω to 2,000 Ω, are often used for charging. It is, however, as well always to use, in conjunction with such variable resistances, fixed resistances, otherwise it is possible, by moving the slider too far, to have too little resistance in circuit, so that the charging rate goes up excessively and fuses are blown.

Trickle charging of accumulators from D.C. mains can be carried out with a resultant charging current of about half-an-ampere maximum with simple circuits of such resistances. Let us consider that half the resistance necessary for trickle-charging an accumulator in this way is to be variable, and that the other half is to be fixed—the best arrangement, generally speaking. Examining the figures shown in the Bulgin catalogue, we see that we may have a 60-watt variable resistance which will carry 490 mA. This is substantially half-an-ampere and the resistance value of this type is 250 Ω. When carrying half-an-ampere, therefore, it will give a maximum voltage-drop of about 122. If the mains are 250 volts, we have to drop another 128 volts—less the voltage rating of the accumulator. Our fixed resistance must, therefore, equal 128 divided by 0·5, giving a resultant value of 256 Ω. The 256 Ω resistance should be able to carry half-an-ampere.

This gives a rating of between 40 and 60 watts, and there is no one fixed resistor in the Bulgin range which exactly fulfils requirements; two will have to be used in series, unless a valve-heater type mains resistor is used, when two ·3A. types in parallel should be employed. Using power resistors, however, we see that there is a 100 Ω type of 40-watt rating which carries ·6 ampere, so this will be satisfactory, and it will be best to use two such in conjunction with a further series-connected resistor of 50 Ω which brings us close to the wanted figure. The 50 Ω 20-watt type will carry ·6 ampere.

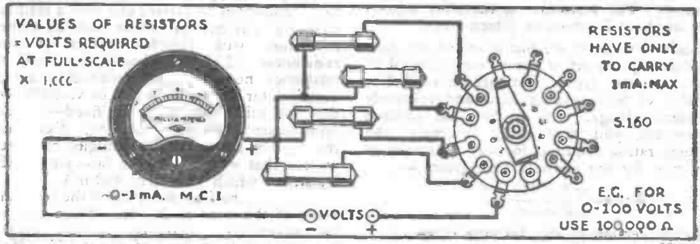
Preset or semi-variable resistances are also used quite often for volume-control adjustment. As anode resistances, for example, the feed- or grid-condenser can be connected from the slider, in order to limit the amplification. Another popular use for such resistances is to form a screen-grid potentiometer. Continuous adjustment is not needed, but a change of value is sometimes required.



A multi-pole change-over type of switch replacing type S.110 is shown in this diagram arranged in a battery set for switching on and off (since this switch has a middle "off" position) and from radio to gramo. Note that one middle tag goes to L.T. positive, and that the two outer tags on the same side go to the filament. The middle tag at the other side of the switch is connected to the valve grid, as shortly as possible. One side tag is connected to the junction of grid leak and condenser (previously connected to the valve) and the other side is taken to the pickup. Some tags are not here used.

BULGIN List No. S.204, 6-pole 3-position Switch.

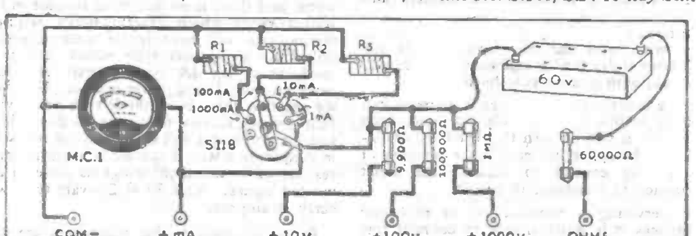
BULGIN List No. V.C.34, 25,000 Ω Vol. Control.



Here is a basic circuit as described on another page for making up voltmeters with 0—1 milliampere meters. The switch model S.160 shown is to be recommended. It is a single-pole ten-way switch, and therefore with all its contacts a ten-range voltmeter is easily made. Resistances are chosen by multiplying the desired full scale voltage for any range by 1,000. Neglect the meter resistance if less than 1% of the total circuit-resistance thus shown to be necessary. Such meters usually have an internal resistance of only 100 Ω. The completed voltmeter has a resistance of 1,000 Ω per scale-volt.

BULGIN List No. M.C.1, 0-1 mA. Meter.

BULGIN List No. S.160, S.P. 10-way Switch.



A very low resistance switch is necessary when used for bringing shunts into circuit across a milliammeter to enable it to read circuital currents of higher value than its nominal rating. The model illustrated, S.118, fulfils these requirements, and can be thoroughly relied upon. R_1, shunting to 1,000 times, will be one-999th of the meter resistance: R_2, one-99th; and R_3, one-ninth. These can be made up easily from copper-nickel wire.

BULGIN List No. S.118, S.P. 4-way Switch.

BULGIN List Nos. H.W.—, Half-watt Resistors.

SWITCHES, LOW VOLTAGE

SWITCHES for use in low-voltage circuits must be very carefully chosen with regard to their characteristics. Their contacts must be so arranged that they are always kept clean in use and that oxide or collected dirt is either scraped out of the way or cannot accumulate.

With switches used in high voltage and mains circuits the formation of a little oxide does not matter, because it is broken down automatically and does not affect the circuit. In any case a minute fraction of residual resistance in the switch would not matter, since with high voltages the current component is usually small and the voltage-drop is therefore negligible.

It is usual to consider a resistance value of about ·01 Ω as the highest permitted figure for a mains voltage switch, but for low-voltage switches we must work to a lesser value, and ·006 Ω is usually all that can be tolerated.

Many modern low-voltage Bulgin switches achieve much lower figures than this by means of their special construction. In many types a minute layer of metal, actually one might say, only a few atoms, is removed from the contacting faces every time the switch is operated. This does not mean that the switch will wear away very rapidly and will have a short life, for life-tests on switches of this class have shown that 50,000 or 60,000 operations are obtained before appreciable wear takes place.

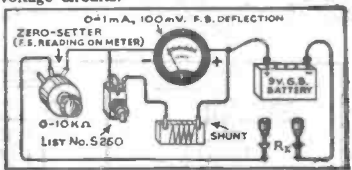
It will be realised, however, that by a suitable clever manufacturing choice of metals so that the thinner metal will wear less than a thicker part in conjunction with it, it is certainly the achievement of an ideal to use a clean and fresh layer of metal for contacting every time the switch is operated.

Such a switch is the Bulgin type S.160, a popular low-voltage model which breaks circuit between its selected points; which is an advantage where such points are connected to parts of a circuit at considerably different potential, since it avoids short-circuiting them when moved from point to point.

Another type of low-voltage switch, of which we may mention the Bulgin models S.117, S.118 and S.119, has a wider blade to rotate over the stator or fixed contacts, although it is similarly constructed with regard to its self-cleaning properties. Under these conditions the blade is always in contact with at least one fixed contact, connecting to a second one when moved before leaving the first.

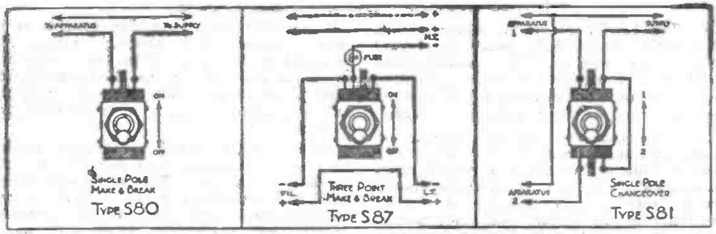
This is of unparalleled advantage with milliammeter shunt switching, because it means that the meter is never at any time left unshunted. It will be realised that this is a most important condition, especially when the current flowing in a circuit is not known, so that the switch is turned first to a very low resistance shunt and then progressively moved round until a convenient reading is obtained on the scale. If the switch were to break circuit between points the meter might easily be overloaded and damaged, although only by the application of a momentary current.

Bulgin toggle switches, although made for mains working, are ideal in many circuits for low-voltage use. This is because their quick make-and-break action is such as to hammer out, when the moving contacts operate, any oxide film which may have formed, thus keeping the metal parts clean. Since these switches have quick make-and break action they can also be relied upon not to crackle, a trouble which is sometimes experienced with inferior switches in low-voltage circuits.



CIRCUIT OF A SIMPLE Ω-METER WHICH MAY BE CALIBRATED FOR 0-100KΩ (R_X=81KΩ=0·1mA) A SHUNT CIRCUIT MAY BE ADDED FOR LO-Ω READINGS, WHEN A VERY LOW-RESISTANCE SWITCH IS NEEDED — *SEE TEXT.*

IT must, however, be remembered that low voltage conditions may involve circuits or part of circuits for which extremely low prospective voltage is met with. By prospective voltage is meant the voltage which results across the opened contacts of a switch which is in the position which leaves the circuit broken. An obvious example is an ammeter, and, for the purpose of discussion here, an ammeter of sufficient ranges with shunts switched in. Its use demands a switch which is capable of maintaining contact without re-course to voltaic rupture of any oxide or sulphide or corrosion surface film. The voltage across a moving coil instrument rarely exceeds 100 mV. (0.1V.) and if the switch, which has to bring in a shunt, fails to make good contact for reasons of contact-film resistance at such a voltage, it is likely that the meter might be over-loaded because the surplus current in the circuit was not diverted through the appropriate shunt For this purpose, it is customary to have switches of special low-voltage types using precious metal contacts which are consequently free from film. It is also customary (when the current to be carried is small) to use precious or semi-precious metal contacts of small area at the point of actual meeting so that the spring forces of the switch, acting on such small areas, provide the equivalent of an enormous pressure in terms of lbs.-per-sq.-inch, thus establishing continuity through the metallic contacts.

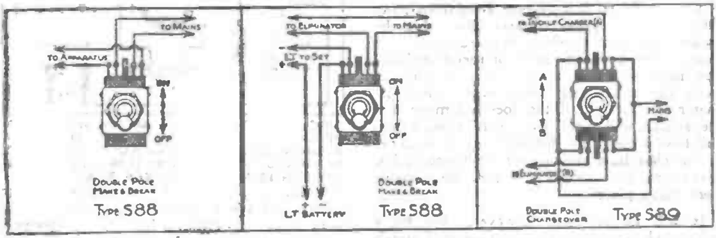


The Bulgin range includes many Q.M.B. toggle switches of which type S.80 is the most common, a single-pole on-off switch which is inserted in one mains lead, or one pole of any circuit. S.87 is a three-point switch; generally it is more used with battery circuits than mains, where it will handle L.T. negative and H.T. negative automatically. Switch type S.81 is a single-pole alternative circuit switch which is usually used for single-pole change-over when two contacts are linked and treated as a centre point, as shown.

*BULGIN List No. S.*80, 3 *A.*, 250 *V.*, S.P. ON-OFF.

*BULGIN List No. S.*87, 3-*Pt.*, ON-OFF, 1 A. MAX.

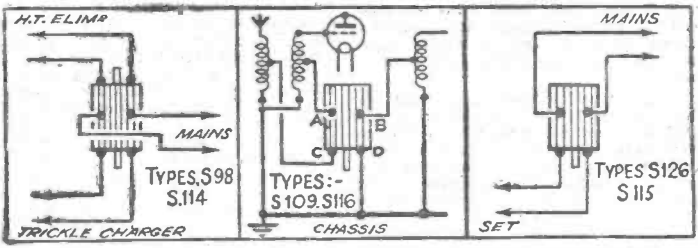
*BULGIN List No. S.*81, 1 *A.*, 250 *V.* S.P. 2-WAY.



Here are double-pole Bulgin switches essential with A.C./D.C. and D.C. sets and apparatus. In the first diagram a double-pole on-off type makes and breaks both poles of a circuit, such as the mains lead to a set. It may also be used, as shown in the second diagram, for simultaneous switching of one pole of each of two circuits, an eliminator working from A.C. mains, for example, and the accumulator of a set. The third switch is of interest, a double-pole alternative-circuit type, of which two contacts may be linked.

*BULGIN List No. S.*88, D.P. ON-OFF, 3 *A.*, 250 *V.*

*BULGIN List No. S.*89, D.P. 2-WAY, 2 *A.*, 250 *V.*



Bulgin Q.M.B. Switches type S.98, a toggle type, and S.114, a rotary type, are two double-pole changeover switches provided with six terminals. The first diagram shows switching between two pieces of mains apparatus. Q.M.B. switches types S.109 and S.116 are four-point switches which, more often than not, are used for wave-change switching, a low-voltage function. Owing to their self-cleaning contacts they are extremely satisfactory and are quite trouble-free. Connections are given for quite a usual circuit.

*BULGIN List No. S.*98, D.P.-COVER, 1 *A.*, 250 *V.*

*BULGIN List No. S.*109, 4-*Pt.* ON-OFF.

*BULGIN List No. S.*126, D.P. ON-OFF. 1 *A.*, 250 *V*

SWITCHES, Q.M.B.

THE first requirement for any switch which is to be used in mains or high-voltage circuits is that it shall have what is known as quick-make-and-break action. The most important part of the action—as regards the speed of operation—is the breaking, because it is upon breaking a circuit that arcing takes place. Arcing is worse in D.C. circuits than in A.C. circuits because, with alternating current, it is extremely difficult (if you do it intentionally) to switch off when the current is at a peak.

You must remember that alternating current rises to its fullest intensity, falls to zero, rises again and so forth fifty times a second in the case of fifty-cycle mains. In fifty per cent. of cases, therefore, the moment when you switch off is when the current is small and the resultant arc is negligible. In addition, prolonged arcing on A.C. supplies is unusual because the fluctuating nature of the current tends towards quenching.

With D.C., however, arcing with a slow action switch is a very real trouble and may easily burn up the contacts and render a switch unusable. In addition, a slow action switch will cause very serious radio interference, as described on another page. Bulgin quick-make-and-break toggle switches are specially designed with due attention to their performance in connection with these matters, and it is interesting to note that tests have been carried out for fifty, sixty and seventy-five thousand operations for life-tests at full electrical load.

When the switch is ON the moving contact makes connection with the fixed contact at a different part from that used at the moment of breaking circuit. The stator or fixed contacts are slightly extended so that breaking takes place on a special short projection used for the purpose. Any minute burning due to the spark at the moment of breaking cannot therefore affect the contacting in the rest position. In addition the quick-make-and-break action keeps *any* sparking down to minimum. It is for this reason that such long and satisfactory life is obtained.

Insulation is, of course, a most important factor with high-voltage switches and all types which have to operate under arduous conditions. The use of only the best bakelite and insulating materials can be countenanced, and during manufacture considerable tests at high potentials must be made. The familiar representation for a single-pole change-over switch is that of three dots or points in a line with an arrow connected to the central one. It is usual, therefore, in talking of change-over switches to speak of the middle point. When, however, you get a toggle switch such as the type S.81, shown at the top of the opposite page, and you are told that it is a single-pole change-over model you may feel that this is wrong because it is fitted with four terminals.

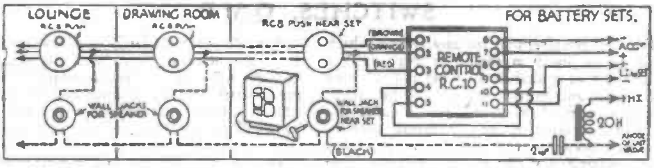
Actually such a switch is of the single-pole alternative-circuit type, and for single-pole change-over use a "centre-point" must be made artifically by linking two of the tags, one at either end. Another use for such a switch, however, is actual alternative switching in two circuits of quite different potentials and uses. Since the moving contact connects alternately, when the switch is operated first to the pair of tags at one end and then to the pair of tags at the other end, *without any internal connection whatsoever*, it is quite possible to use this type of switch to put a mains circuit ON when a battery circuit is to be OFF, and vice versa without short-circuits, etc.

Not only do Q.M.B. switches of the Bulgin toggle type have adequate insulation to earth and to their metal framework, but they are so constructed that the internal insulation between poles, in the case of multi-polar types, is highly effective and withstands test potentials of over 750 volts. Therefore it is quite practicable to use this type of switch for controlling a mains circuit as regards one pair of contacts and a battery circuit as regards the other pair of contacts, the two contacts being ON or OFF simultaneously as shown in the diagram opposite.

Certain new types of Q.M.B. mains toggle switches of the double-pole change-over type have made their appearance, and these come in closer conformity to the conventional theoretical representation. For example, the S.98 double-pole change-over type has only six tags or terminals.

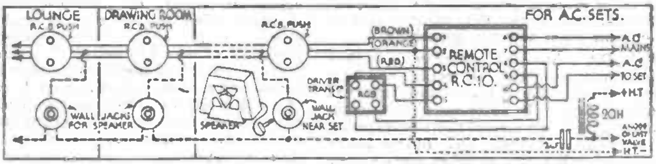
In this latter type of switch the tags which project in the middle from the rear of the switch are the two "centre points" of the theoretical representation. Inside the switch the contacts which are integral with these tags are forked and—if you were to break open a switch and examine it—you would find that the tips of this Y-formation contact in use with the end of the moving contact or roller

The latter too would be found interesting because it is, in shape, like nothing so much as the familiar dumb-bell found in a gymnasium only, of course, on a very much smaller scale. In the type of switch which we are discussing, the handle, or central stem of the dumb-bell is insulated and it must be visualised that in *either* position of the switch contact is made from the end of the dumb-bell, by means of the Y-shaped springs referred to, to the fixed or stator contacts into which the dumb-bell is pressed. Thus, in this type of switch the contact is kept clean partly by hammering and partly by wiping. Silver-plating is generally used because the oxides and sulphides of silver are substantially conducting. This is different from other metals where atmospheric conditions can increase contact resistance, etc. Silver-plating is also much used because it makes any soldering of connections much easier and much more certain in effective low-resistance connection.



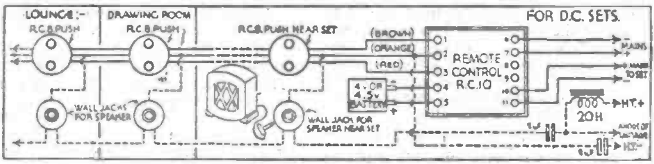
FOR BATTERY SETS.—Mount the remote control near the set. Remove the leads from the accumulator, and connect to terminals 10 and 11. Join 8 to 4 and 9 to 5. Fit an R.C.8 double push near the set and connect to the remote control with a length of three-core cable, middle terminal of R.C.8 to terminal 2. From this push extend with similar connections to the next distant point, and so on. Connect the accumulator to 6 and 7. Existing loud-speaker extensions can remain unaltered, but if a filter-output circuit is used, four wires can carry everything. The dotted L.S. extension wiring above uses one control wire as the L.S. return, which simplifies wiring and lowers costs.

BULGIN Remote Control, List No. R.C.10. *BULGIN Control Pushes, List No. R.C.8.*



FOR A.C. SETS.—Mount the remote control near the set. Take the set's mains lead from the set direct to terminals 10 and 11. Fit an R.C.8 double push near-the set and connect to the remote control with a length of three-core cable, middle terminal of R.C.8 to terminal 2. From here, extend to the next distant point, with similar connections, and so on. Connect the primary of Driver Transformer (marked mains) type R.C.9 to terminals 8 and 9, and its secondary to 4 and 5. Existing loud-speaker extensions can remain unaltered, or if a filter-output circuit is used, four wires only will serve for Control and L.S. extension, as shewn in the dotted wiring above. Note the earthing of terminal 2 to H.T.— to complete the loud-speaker return circuit.

BULGIN Driver Transformers, 200-250 *V. List No. R.C.*9.



FOR D.C. SETS.—The connections of the R.C.8 pushes are the same as those given above, and similarly, the mains connect to terminals 6 and 7, and the set to 10 and 11. No connections are made to 8 and 9, and a battery is connected to 4 and 5. The same remarks concerning L.S. wiring apply, but if the scheme (dotted) above is followed, an additional condenser must be inserted between terminal 2 and H.T.— as shown above.

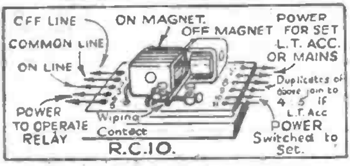
BULGIN Three-Core Cable 50 *ft. or* 100 *ft.* *BULGIN Four-Core Cable.* 50 *ft. or* 100 *ft.*

GENERAL.—The remote control model R.C.10 is provided with a number of terminals, and those on the right hand side are in no way *internally connected* with those on the left-hand side. Those on the left are concerned only with the control circuit and the input at low-voltage for operating the magnets through the control wiring. Those on the right are concerned with regard to 6 and 7 with the input or supply for the apparatus which is to be controlled. Nos. 8 and 9 are duplicates, so that in the case of A.C., for example, a transformer primary used to operate the relay can be connected conveniently. Nos. 10 and 11 are the output, and these two are normally connected to the receiver.

SWITCHES FOR DISTANT CONTROL

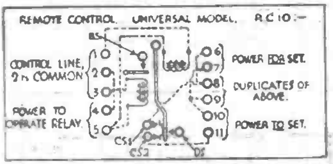
SWITCHES for distant control usually are of the electro-magnetic type. A " relay " is another name for this type of switch, since by the making and breaking of a secondary circuit it makes and breaks or "relays" another circuit. When we require a relay to deal with mains current it must have what is substantially quick-make-and-break action in order to minimise arcing—as described for mains switches on a previous page.

To do this without making the mechanism unnecessarily complicated means that it is essential to have very strong sharp magnetic pull from the electro-magnets employed.



For this we must either have a very high voltage with a reasonably low current, or else —at low voltage—the current must be fairly high. There are two types of relay, one of which is known as the continuous attraction type, wherein the circuit as regards the switched contacts is made only when an armature is attracted; and there is the interlocking type which will work on momentary current.

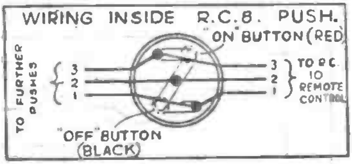
The Bulgin R.C.10 Remote Control is of the latte. type. It operates upon quite high current, in fact one ampere at about 4 volts. It is, however, by means of its interlocking mechanism, arranged to use such current only momentarily and, with two interlocking magnets as employed in the



construction, constant positions as regards the switching contacts are obtained.

With battery sets it will operate from the L.T. supply, or from separate battery. With A.C. mains it may be energised by a special small transformer having a high-inductance primary and a secondary output of approximately 4—6 volts. With D.C. mains it is essential to use a separate battery. Alternatively, of course, an accumulator may be used if desired. The action is interesting, and has been described—perhaps somewhat frivolously —as "flip-flap." The two armatures are disposed at right-angles to each other, and when either is attracted the other armature falls behind it to lock it in position.

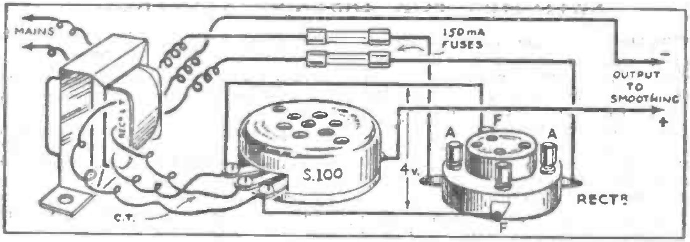
When the current to the magnet concerned is cut off the armature stays in position and cannot be released under the influence of its guiding spring until the second is attracted. The making of the circuit which is to be controlled is carried out when one of the armatures is released from its attracted position, and an extension of the armature which is shown clearly on this page carries insulated contacts which with a wedging wiping action fall into fixed contacts carried on the bakelite base. With a switch which has to control mains current in many of its uses, quick breaking of the circuit is the most important part. This is arranged to be carried out, with the R.C.10 Remote Control, upon *attraction* of the armature carrying the contact extension.



The speed of attraction is always much greater than the speed when the armature is released. With the improved model now listed no adjustments whatsoever are necessary in use and the contacts are definitely self-cleaning. The internal wiring of the device is also shown in the second diagram. The wiring to the control pushes, of which a convenient double button type is available, List No. R.C.8, should be carried out with a wire having three insulating conductors—only low-voltage insulation is necessary—of not less than 18 s.w.g. per conductor, in order to avoid voltage-drop when the control buttons are operated.

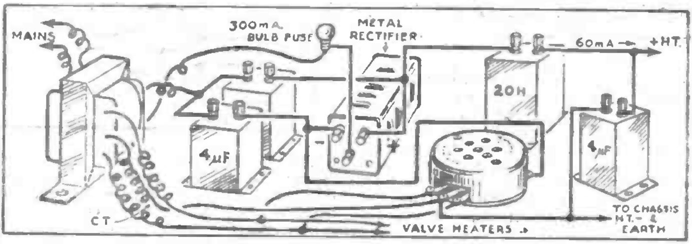
If a high resistance control line is employed it will mean that higher operating voltages for the relay will be necessary. The wiring inside the control pushes is quite simple, and it will be noted that such pushes are connected in parallel.

Loudspeaker extension circuits are usually made to points near the distant control pushes. Where filter output, by means of a choke and condenser, is employed or with an output transformer only four wires are necessary for the on-off control and loudspeaker extension, because one of the loudspeaker wires can quite easily be paralleled to that control wire which is connected to No. 2 on the relay, as shown in the diagram. With D.C. mains take care to ensure that a filter condenser of at least 2 μF. is incorporated in each lead.



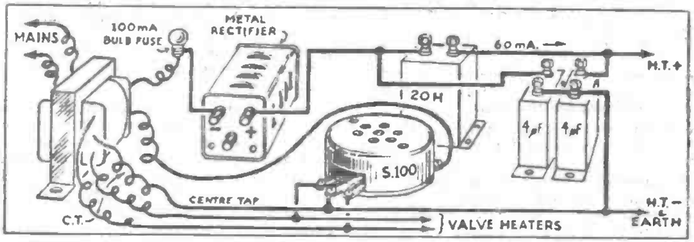
The diagram above shows the connections to a Thermal Delay Switch which is used in conjunction with a thermionic valve rectifier. The H.T. positive lead to the smoothing circuit is usually taken from a centre tapping of the rectifier winding. The middle contact on that side of the switch where there are three is therefore connected to this point. The outer two are connected in parallel with the rectifier valve filaments. The smoothing circuit connects to the fourth terminal on the opposite side of the thermal switch. No alteration whatsoever is made to the connections to the valve anode which most likely will incorporate 150-mA. fuses as a protection in case of any breakdown.

BULGIN List No. S.101, 7½-Volt-heater Thermal-switch for Valve Rectifiers.



When a thermal switch is to be used with a voltage-doubling metal rectifier, different connections must be adopted. The switch must control the negative H.T. lead, since it will probably have to be heated from the valve heaters winding. The negative terminal of the rectifier, therefore, connects to the isolated terminal of the switch and the negative output, return of the smoothing condenser, etc., will be taken to the centre terminal on the opposite side. The heater is connected as shown. The voltage-doubling condensers are not protected from peaks; it is quite unnecessary to do so, because they *work* at peak voltage, and no purpose would be served by connecting otherwise.

BULGIN List No. S.100, 4-Volt-heater Thermal Switch, for Valve- and Metal-Rectifiers.



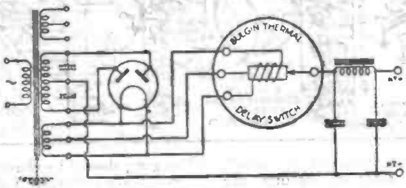
Metal rectifiers are often used in half-wave circuits and similar connections are adopted. The low-voltage winding used for heating the thermal switch is that used for the valve-heaters. The centre-tapping of this winding is connected to H.T. negative and earth, and to the centre terminal of the switch, the isolated terminal of which is connected to one side of the H.T. winding. The smoothing circuit may have capacities larger than shown.

SWITCHES, THERMAL DELAY

BULGIN delayed-action thermal switches are examples of a unique and ingenious type of component which has come into being simply by reason of a special requirement. With H.T. circuits which are designed to operate via rectifiers from A.C. mains a rather peculiar state of affairs can exist.

It is well known that the usual voltage rating of an A.C. supply is not actually the highest voltage which it attains. The rated voltage is actually lower than what is known as the peak voltage, but since in an A.C. supply the voltage and current are continuously rising to a maximum and then falling to zero it will be appreciated that there must be a value of voltage (and also of current, of course) which represents a working value.

The peak voltage for a supply of good waveform is 1·414 times the value of the rated or workable voltage. When we have a transformer with an H.T. secondary which applies, say, 250 volts to the anode or anodes of a rectifier valve, this is the working figure and the peak is nearly 1½ times this value. After the rectifier, valve or metal, we have, of course, condensers in the smoothing circuit. While current is being drawn—as it is normally during the use of the receiver—the condensers are charged up with current at a voltage which is a little lower than the figure appertaining to the H.T. secondary.



With a receiver incorporating modern indirectly heated valves, however, it is a well-known phenomenon that the set does not operate until the valves have had time to warm up, and under these conditions little or no H.T. current flows. The rectifier, however, generally heats up quicker, or, if it is an indirectly heated type, can certainly commence to pass a little current long before, in most cases, the valves of the set have their cathodes sufficiently heated to have any appreciable emission and resultant anode current.

Under these conditions the condensers in the smoothing circuit can quite easily charge up to peak value, which, as we said before, is nearly 12 times the working or mean voltage. This has been known in many cases to cause condenser breakdown. To guard against it, one must use condensers of much higher working voltage rating than is really necessary. This means unnecessary expense.

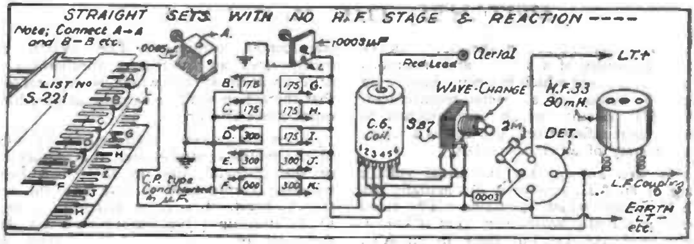
The Thermal Delay Switch operates in a simple manner by following, as it were, the action of the valves. It has a small bi-metal strip which flexes when heated and which is provided with a small mica-insulated heater adapted to be heated from a 4 or 7½-volt transformer winding. The switch also incorporates an interesting mechanism: a little abutting-spring which is adjustable so that the action shall be as close as possible to quick-make-and-break.

When the power is switched on by means of the mains control-switch the temperature of the bi-metal, due to the small heater winding, commences to rise and the strip tries to bend. It is prevented from so doing by the abutting spring, but it soon accumulates sufficient bending force to overcome this restraining effect and it clicks over. This completes the second circuit, which, by the normal method of connection, is arranged to be in an H.T. lead. The bi-metal then remains in position until the receiver power is switched off and the switch cools.

The time taken for the bi-metal to bend and close the contact from the H.T. circuit is usually adjusted so as to be approximately thirty seconds. With correct adjustment as sent out from the factory this type of switch has snappy action and clean contacting which results in one click being heard in the loudspeaker and no more. Adjustment of the abutting spring, however, will, to some extent, alter the time delay, and the anchorage of the bi-metal to a metal bracket in the switch is also provided with an adjusting screw which alters the cold position of the bi-metal and thus the arc or angle through which it has to travel. This is the major adjustment for altering the time delay, which can be varied between approximately five seconds and five minutes.

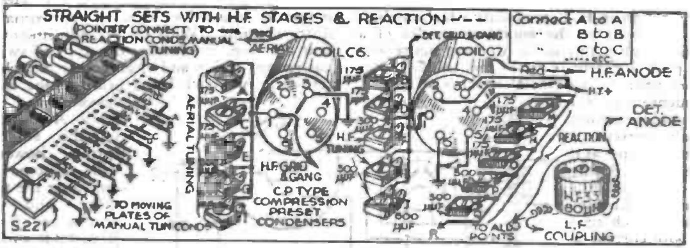
For the average wireless receiver, however, 30 seconds delay is the optimum figure. The diagrams on the opposite page show quite clearly the uses and connections of thermal switches. It is always advisable, although adequate insulation is provided, to keep the bi-metal and the heater element at approximately the same potential: it will be seen that this is always quite easily done.

In circuits where the switch is heated from the same winding as the valve heaters, the secondary contacts operated by the switch are connected in the H.T. negative lead. With valve rectifiers heating is often carried out from the winding heating the rectifier valve. Switching is then carried out in the positive H.T. lead. The bottom circuit shown on the opposite page can, however, apply to valve rectifiers when there is no available extra current (type S.100 consumes 1 A.) from the rectifier-valve filament winding.



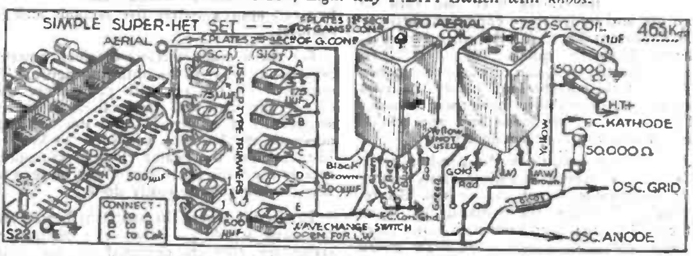
This is the simplest possible application of Push-Button tuning in a circuit—to a set having no h.f. stage. Grid- and reaction-circuit tuning is accomplished, with one button bringing in manual-tuning. The receiver may have l.f. stages as convenient. Note that grid and high-potential leads *must* be short—the layout should arrange this. Existing receivers are easily converted, and five or seven pre-tuned stations become available. Pre-set condensers should be wax-sealed, when adjusted.

BULGIN List No. S.221, 6-way P.B.T. Switch, with knobs.



This circuit is slightly more elaborate; aerial, high-frequency, and reaction circuits are tuned. It is very necessary indeed to keep all high-potential leads short, or instability will result. (If the H.F. stage oscillates, it may be necessary to reduce screen-+ volts. The gang should be chassis isolated, and set at minimum-wavelength for Push-Button control. Wave-change switching is carried out as usual. An eight-button switch may be used instead of that shown. Seal the "pre-sets."

BULGIN List No. S.227, Eight-way P.B.T. Switch with knobs.



One method of using Push-Button Tuning in a simple super-het. circuit (of any I.F.) is here shown. There are other methods, some readily obvious, and circumstances dictate choice; simple switches will not always bring in manual-tuning. It is permissible to take high-potential coil-leads direct to the P.B.T. switch, and earth one pole of every "pre-set" direct. Care should be taken concerning interaction, and reliable components are essential. The circuit shown will guide in many particulars.

BULGIN List No. E.10, 6-way Escutcheon, Brown.

BULGIN List No. E.11, 8-way Escutcheon, Brown.

SWITCHES FOR PUSH-BUTTON-TUNING

IN the keen interest—and, to some extent, excitement—of dealing with what appears to be an entirely new form of component, we are often inclined to forget that the adage about there being "nothing new under the sun" may once again be proving itself to be true. The more especially is this true in the realms of science, for most inventions, great or otherwise, are generally adaptations or improvements of previous ideas, or are altered applications of known principles.

At the present time we are all hearing a great deal about push-button-tuning units, circuits, and switches. The modern applications, principles, and designs of these are very new and up-to-date indeed, but it must not be thought that the idea itself is in the same position; on the contrary, we as pioneers in the field of Radio proudly point back to the year 1927, when we made and supplied special push-button-tuning switches. These were d.p. on-off types of unit construction—the user bought as many as he required, and arranged them to switch pre-set condensers into parallel with a tuning coil or coils.

A switch of similar electrical intention, and working in a very similar-electrically-circuit is to be found, and used, to-day. Modern push-button-tuning switches, however, have reliable interlocking mechanisim, all-steel chassis, silver contacts, etc.

Modern automatic tuning circuits of the press-to-select variety divide into several classes. There is *(a)* the device which, by means of a rack or cam mechanism, rotates the tuning condenser-gang to an appropriate position. The associated circuits appear exactly as normal with such an arrangement. Then we have *(b)* the method of motor-drive, an electric motor—usually of special form, and readily reversible as to rotation—being switched on by pressing switch-buttons so as to rotate the gang condenser to a pre-determined position.

Methods which dispense with the gang-condenser entirely constitute a further two possible schemes, although they are closely allied; there is the method *(c)* of using fixed-inductance coils with adjustable pre-set condensers—which we have already mentioned as being one of tried and proven worth—and there is the method *(d)* of using coils of adjustable inductance (that is to say, permeability tuned with adjustable iron cores) either with or without paralleled fixed-capacitances.

The Push-Button Tuning Switches in the Bulgin range are of the types intended for use with methods *(b)*, *(c)*, or *(d)*. The choice of the precise type used will depend entirely upon circuital requirements.

In many receivers provided with P.B. tuning one of the buttons is used to disconnect the pre-set or pre-selected circuits, and to bring into effect the usual manual tuning. Again, there are several different ways—different contacting combinations, that is—in which this may be done.

It is most essential, in the use of P.B. tuning circuits, to avoid the excessive extension of high potential leads, especially when those from different circuits come closely adjacent. It is an easy matter to provide a suitable layout and scheme of connections to avoid this, although the question of having manual tuning also generally makes for an awkward complication. Reference to the diagrams will reveal this.

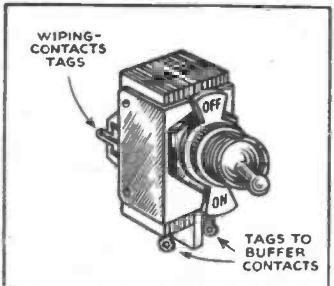
Whenever possible, it is desirable to take high-potential, or semi-high-potential leads—the American term is "hot"—through the switch from contact-combination to contact-combination. This requires a form of double-throw arrangement, either single- or double-pole. The advantage gained in such a case is of shortness of "hot" leads, especially for the higher-frequency tuning points—which should be arranged to be towards that end of the switch where the "hot" leads "enter."

When the actual pre-set tuning is by means of pre-set types of semi-fixed condenser, care should be taken to choose a type which is as unaffected by thermal changes, changes due to vibration, etc., and other possible sources of "creepage" of capacity value. To minimise such a possibility, it is often a good plan to keep the adjustable degree of capacity down to a small value—just sufficient to cover the frequency band allotted to the particular button—and to make up the total value of capacity needed by the circuit by means of a small *fixed* condenser of stable type; a silvered-mica type, which is inherently constant, fills the need excellently.

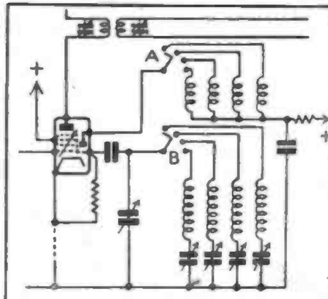
A considerable advantage, on the score of selectivity, can be conferred, and usefully employed, with properly designed P.B.-tuned circuits. It is well-known that the selectivity of a circuit depends enormously on the L/C ratio. The lower the value of C, the better the selectivity. In a circuit which must have a fairly large frequency coverage, and in which the controlling or variable factor is the "C," it becomes inevitable that the selectivity falls off towards the high-λ or lower-frequency end of the scale.

With P.B.-tuned circuits this need not be the case; a number of coils can be employed, each of slightly higher inductance than the preceding one, so that quite a small value of "C" is used each time.

With the method *(d)* aforesaid, a different coil, with its appropriately adjusted iron core, *must* be used for each button or switch-section, so that the possible advantage is immediately and conveniently to hand.



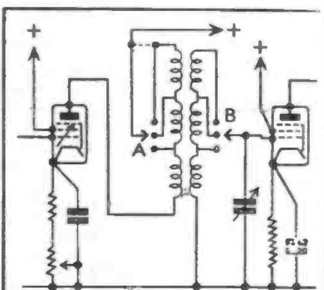
WIPING CONTACTS ARE MORE SUITABLE FOR LOW-POTENTIAL USES; SIGNAL POTENTIALS IN W/C ARE VERY LOW



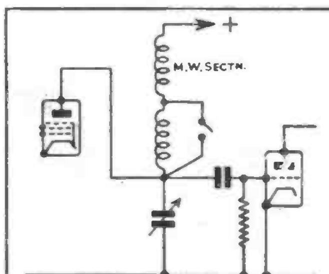
A IS NOT A LOW-VOLTAGE USE; BUT B IS

No. 1. Many Bulgin Toggle Switches are simply of the roller and buffer-contact type and are designed for high voltage working. Other models have different tags projecting from the rear, and, internally, these are fitted with wiping contacts co-operative with the moving member. These have definite mechanical self-cleaning action and are particular suitable for currents not exceeding 1-A. at low voltages.

No. 2. Multi-band receivers have frequency changing stages which are often similar to above, at any rate basically. The difference between low and high-voltage work will rapidly be seen if the text is studied. Diagram shows contact with make before break. This may be combined with short circuiting of unused coils or separate earthing of unused coils as sometimes adopted.



A IS NOT A LOW-VOLTAGE USE; BUT B IS



IN THIS NORMAL W/C SWITCHING, AS IN AERIAL CIRCUITS, THE VOLTAGE IS VERY LOW

No. 3. In this simpler type of wave-change arrangement, the primary sections of the Coils are switched at high voltage whilst the secondary are not. The connection shown dotted is sometimes employed and its use renders the primary section low-voltage since it is the voltage appearing across the contacts with which we are concerned when discussing switches, and not the total voltage to earth.

No. 4. A conventional 2-band circuit with tuned anode (the Condenser is connected between anode and chassis) in which switching is at low voltage. Such switches can be ranged high voltage by inverting the coil to place the medium wave section adjacent the anode connection and using a single-pole change-over switch, moving pole to H.T. positive, so as to connect alternatively to the tapping between sections or to the earthy-end of the whole coil.

SWITCHES FOR WAVE-CHANGING

The opposite page shews a number of typical positions of wave-change switches. Diagram No. 2 shews the oscillator section of a super-heterodyne receiver, with *A.* and *B.* as the two wafer-sections of the wave-change switch-gang. It will be seen that in any of the four positions of *A*. the anode current to the oscillator-anode is being carried. This instance, therefore, is most definitely NOT a low-voltage one, for if the contacts acquire a surface film of oxides and/or sulphides, due to atmospheric corrosion, voltage can exist across the switch-contacts, so as to tend to reduce the ohmic value of such films. Instance *B*., however, in the second diagram, is most definitely a case in which the 'prospective voltage' in the circult is *very low*, so that inappreciable voltage-rupture of contact films can be expected

Diagram No. 3 shows another typical circuit in which much the same conditions obtain, although it is of part a 'straight,' and not a super-heterodyne, receiver. *A.* shews the part where the switching is at high-voltage, and *B.* the part at low voltage. It is, however, worthy of note that it is not uncommon to find that a connexion is made as the dotted line; the purpose of this is to give continuity of anode-current, whilst the switch position is being changed, and its presence usually indicates that the switch has contacts. both fixed and moving, of such relative sizes that the circuits 'break' before 're-make.' (Breaking before making tends to give 'clicking' in the reproducer, due to the momentary interruptions of anode current).

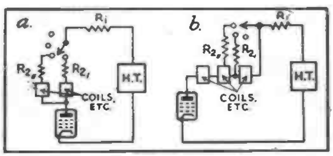
If the dotted linking is employed, the switch is no longer a high-voltage type, for the anode current will flow continuously to the valve, even if the contacts are opened deliberately, so that no voltage could build up across the gap, to rupture the barrier.

The diagram below will make this a little clearer, and shew how it is the 'prospective' voltage—for the switch — with which we are concerned in all such cases In this, *a* shews what we here call high-voltage conditions; R_1 represents any normal resistance in the circuit; $R_{2''}$ and $R_{2'}$ (see diag.) represent switch-contact resistance. If R_2 be high, the current flowing through the valve and R_1 will tend to be low, and the voltage will distribute itself throughout the circuit in exact proportion to the resistances. With R_2 tending towards high values, much of the voltage will here appear, and exercise a breaking-down effect, if at all possible. But in *b* the voltage across $R_{2'}$ or $R_{2''}$ can never exceed the voltage drop across a coil section, for anode-current will continue to flow at all times. Hence the conditions are as for a 'low-voltage' switch.

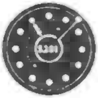
The fourth diagram on the opposite page is a typical one in two-waveband receivers; it will be plain, from what has now been said, that this is essentially a low-voltage scheme of working, so far as prospective voltages across the switch contacts are concerned

It will be seen that the question of whether the type of switch, in any one case, is to be of low-voltage style is answered as follows: (a) is there a high voltage source in the circuit (or part of circuit) concerned? (b) is it possible for the voltage to build up to a high value *across any pair* of switch contacts? If the answer to (a) and (b) is 'yes,' a low voltage type of switch is not essentially needed. But if the answer to either (a) or (b) is 'no,' a low voltage type is essentially needed. The high voltage with which we are concerned, it must be noted, need not be of the signal voltages with which the switch is primarily concerned; for example, in *A*. of the second and third diagrams on the opposite page, the *signal* voltages are of the same order as the signal voltage at *B*. But in *A*. we have the steady anode-current of the valve, supplied at comparatively high voltage, upon which the signals ride in super-imposition.

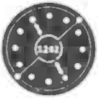
Wave-change switches, in general, are not separately selected by discriminating users; they are frequently of a type or class —e.g., the 4- or 6-position multi-wafer (= multi-polar) ganged, and hence are likely, as more often than not, to be put to what are low-voltage uses. Hence, it is customary to use contacting pairs of comparatively small meeting-areas (so as to ensure a high contact-making pressure in terms of lbs.-per-square-inch), with contacting metal-surfaces (basic, or plated, or applied) such as provide for any normal surface film to be of a mechanically-soft, or readily voltage rupturable, nature. In addition the action of making and breaking of contacts may be of a 'wiping' or 'self-cleaning' nature. In good self-cleaning or wiping designs, the non-contacting matter which is removed from the contacts bases by the mechanical action is *really* brushed aside and does not creep back towards the contacts area. Mention has been made of wave-change switches with means for shorting or earthing those contacts which are not actually being handled in any particular position. This arrangement is neces-



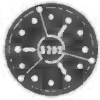
sary with some kinds of circuit. but in general no information can be given to indicate when it is, or is not, to be employed. It depends on the nature of the circuit and on the Coils. and on their physical positions (and consequently any possible inter-action), so that it is not possible, frequently, from the examination of a theoretical diagram, to see whether this particular feature is needed, or not. There



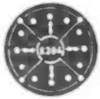
*List No. S.*201.



*List No. S.*202.



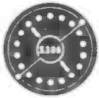
*List No. S.*203.



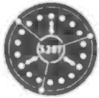
*List No. S.*204.

Recent additions to the range of Bulgin Switches include a selection of twelve position types with rotary action. One-, two-, three-, and four-pole types are available, with shafts electrically "dead," for meter-switching, test-oscillators, simple wavechange, etc. They are limited to circuits of 10W. rating, 500 V. max. to frame. Contacts are heavily silver-coated, and the action is very "snappy," so that crackling or uncertain contact is quite impossible. ⅜ in. dia. fixing bush with anti-turn lug: ¼ in. shaft with flat, 1⅛ in. long. Max. dia. of body, 1¼ in. Steel Framework, heavily cadmium-plated, silvered-solder-tags.

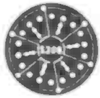
*List No. S.*205.



*List No. S.*206.

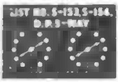


*List No. S.*207.

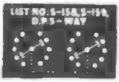


*List No. S.*208.

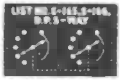
These switches are similar to those above, but are 1⅜ in. dia. and have up to eighteen positions. The enormous number of uses to which switches of this type can be put include meter switching—e.g. S.205 for a universal-range voltmeter; test oscillators—S.203 or S.207; wavechange in many sets; and so forth. It often pays, when repairing or rebuilding sets, to discard existing switches *before* they give trouble—and to save annoyance later—so as to enjoy the years of trouble-free service that modern Bulgin switches so readily give. Modern reliable types of switch have working lives of 25-50,000 operations.



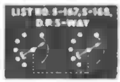
*List No. S.*154.



*List No. S.*159.



*List No. S.*165.



*List No. S.*167.

When confronted with wavechange switching problems there can be no better solution than a quick glance at the wide range of reliable Bulgin types. Eight varieties of five-position double-pole contact units are illustrated, meeting different circuital needs. All have heavily silver-coated contacts. S.153/4 are simple five alternative-circuit types, with a momentary break between selected points—to avoid H.T. short circuit. S.158/9, however, have wide rotors to avoid even momentary "open-grids." S.165/6 have narrow rotors and continuous feed; S.167/8 is similar but with wide rotors. All types fully insulated.

*List No. S.*150. *Drive Unit* (6 *in. shaft*), 2/9 *each; List No. S.*151 (9 *in. shaft*), 3/- *each.*

*List No. S.*211.

*List No. S.*212.

*List No. S.*213.

*List No. S.*214.

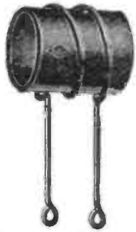
*List No. S.*215.

Some modern circuits call for very elaborate wave-switching and grouping. Interchangeable gangable units such as these help enormously in fulfilling difficult requirements. S.211 is a 3-pole 3-way unit of great utility; S.212 gives 4 positions and 4 poles. When one must "earth" or group *un*selected points, S.213 is a valuable 4-pole 3-way type; still different combination is given by S.214, 2-pole 4 *or* 5-way. Finally S.215 is exceptionally useful and is unique: 11 ways in which every *un*selected position is earthed.

*List No. S.*209. *Drive Unit* (6 *in. shaft*). *List No. S.*210 (9 *in. shaft*).

TELEVISION AERIALS

AT Ultra-High Frequencies as used in the transmission of television sound and vision signals a totally different technique concerning aerials is employed. This is still novel to many persons who have dealings with radio. Briefly, an aerial can be highly efficient if its physical dimensions can be such as to conform to, say, half the wave-length of the signal it is desired to send or to receive.



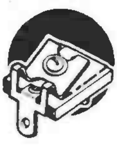
Unscreened Ultra-short-wave tuning coil for direct attachment to terminals of tuning condenser (= 50 $\mu\mu$F. max.). Wound with silver-plated wire.

BULGIN List No. S.W. 61.

When we are concerned with broadcast — "medium" — or "long" wavelengths, the erection of such an aerial is well-nigh to impossible; and other factors enter into account in addition. We are accustomed, therefore, at such radio frequencies, to use an aerial which is considerably smaller than a "half-wave-resonator, and our aerial is usually loaded.

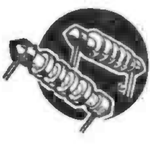
For the present television transmissions, however, we can quite easily arrange a half-wave-length aerial, either centre or end-collected. Since the transmitted wave is polarised in one particular plane, we must usually arrange our aerial so that its length is vertical. Except at a considerable distance, or under exceptional conditions, there is no "twist" to the propagated wave, and our aerial can be precisely erected. Cases have been known, however, where a twist has taken place, and slight turning of the aerial about its centre has slightly increased the received signal.

A convenient form of receiving aerial, therefore, comprises two vertical rods, each of a length nearly equal to a quarter-wavelength, placed end to end and slightly separated at the centre, from whence the lead-in is taken. The overall length, it can quite easily be shown, is then of the order of 11—12 ft.



Mica-dielectric pre-set condensers, on "Ceramite" base, remarkably free from "drift."

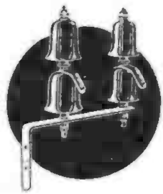
List No. S.W.95.



Short-wave H.F. chokes, section-wound on "Ceramite" former with wire-ends, 2,100 μH., 36Ω, 0.5 $\mu\mu$F.

List No. S.W.68.

An "ordinary" lead-in would be useless—it would have far too much inductance. Consequently, what is called a feeder or "transmission line," is used. This is a twin lead-in cable of special dimensions, which can, within reason, be of any length *greater* than half-a-wavelength. Two or three hundred feet can be used. This lead-in is non-collective if properly arranged—it has no power to act as an aerial—and, therefore confers anti-interference properties. The aerial proper can be erected at a good height (to increase the signal strength, primarily) which should, in most cases, elevate it out of zones of local interference from car-ignition, electrical machinery, etc.



Twin lightning-arrestor and lead-in insulator with internal spark-gaps and lead-in fuses. Low-loss and adequately weather-proofed.

BULGIN List No. L.18.

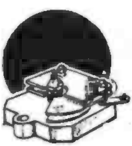
Such an aerial is embodied, with a full supply of twin lead wire, in the Bulgin Kit No. L.15, priced at 7/6.

Television aerials may also use "reflectors." A reflector can comprise another similar vertical aerial, without any lead-in, and of continuous electrical length, placed a quarter of a wavelength behind the aerial (viewed as *from* the transmitter).

The feeder is usually coupled to the input coil in the set by means of a small—say, one-turn—coupling coil, or is similarly coupled direct to the input coil.

With a very high aerial it is often desirable to use a twin lead-in insulator and arrestor; the type illustrated is excellent.

Since the input circuit is not required to be alterably controllable as to wavelength, pre-set tuning can be used with the simple coil needed. Either air- or mica-dielectric types of pre-set tuning condenser can be used, but short leads and short wiring in the U.H.F. circuits are essential.

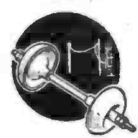


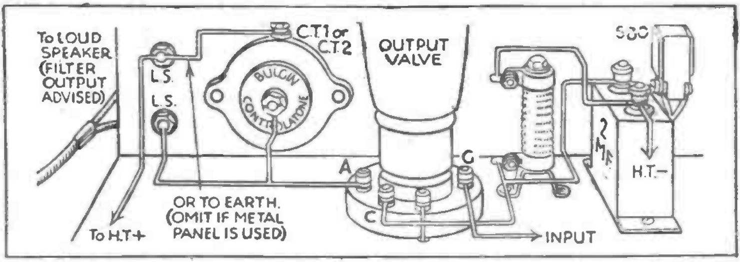
Air-dielectric pre-set condensers assembled on moulded "Microloss" or "Ceramite" base, accurately spaced.

BULGIN List No. S.W. 57, 56 $\mu\mu$F. max.

Universal single-pole lead-in or lead-through long-leakage-path insulator with glazed-porcelain bushings. High-voltage rating.

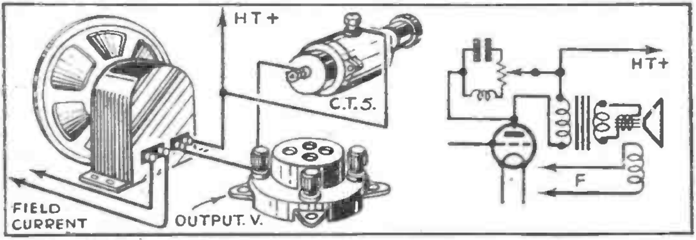
BULGIN List No. L.11.





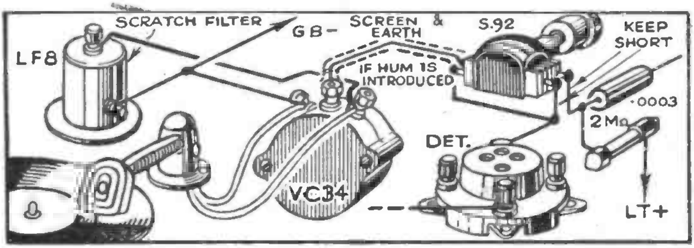
This diagram shows the use of the Bulgin "Controlatone," a resistance and capacity tone control which may be used for the reduction of excessive treble, needle-scratch, mush, hiss, etc. This type of component is connected, across the speaker, or where valves do not operate at a higher anode voltage than 250, between anode and earth. If a metal panel is used the earth connection is made automatically; the anode is always connected to the terminal at the back. In certain cases the "Controlatone" may be used with a penultimate valve. It is then similarly connected, across the "load."

BULGIN List No. C.T.1, General-purpose "Controlatone."
BULGIN List No. C.T.2, Pentode type "Controlatone."



This diagram shows the use of the Bulgin De Luxe "Controlatone," and this is a component which, by means of its special internal arrangement, has its normal tone position in the middle, half-way between the extremes of rotation of its knob. Rotated in the one direction it will remove excessive bass, while rotated in the opposite direction, it will remove excessive treble. It must not at any time be connected across points of potential difference greater than twelve volts. This requirement is fulfilled by connecting it across the loudspeaker, the primary of the output transformer, or the output choke.

BULGIN List No. C.T.5, De Luxe "Controlatone."



Here are the connections for the usual method of connecting a pickup to a receiver. Generally the pickup is fed to the detector valve so that the switch, a single-pole change-over type, interrupts the grid connection from the usual grid leak and condenser, transferring it to the pickup. A screened lead may be needed on the pickup side, but the radio wires must be kept short. Connections are shown for a volume control and for a scratch filter.

BULGIN List No. L.F.8, Scratch Filter. *BULGIN List No. S.92, S.P. 2-Way Switch.*

TONE CONTROLS

TONE is something about which one cannot lay down the law. One person's like is another's dislike. It is generally considered that, although the reproduction of a set should be as perfect as possible and then left at that, some change of tonal balance may very often be desirable for varying reasons.

At the present time it is impossible to get truly perfect reproduction, and although modern scientific progress has made reproduction from modern loudspeakers and reproducing arrangements so *very nearly* perfect that reproduction is practically lifelike, reproduction from domestic receivers in the home often leaves something to be desired.

This is not always the fault of the reproducing apparatus or the wireless receiver. It would indeed be impossible, for example, to attempt to *reproduce* an organ relayed from the Albert Hall in an ordinary sitting-room. The sitting-room contains far too much furniture, which exercises damping on the reproduction effect of the necessary echo and air-of-vastness of a chamber such as the Albert Hall, and therefore we must resort to artificial means.

There are many other cases in which absolutely perfect reproduction is impossible. Mr. Voigt has said that, at the best, a loudspeaker can only be " a hole in the wall," by which he means that with a single loudspeaker or, perhaps, with two or three—medium-frequency, bass-frequency and so-called " tweeter " types—we cannot bring the concert right into our room in actuality and in re-creation.

The hole in the wall simile means that so far as a concert, an organ relying upon the echo effect of the chamber in which it is situated, and, perhaps, a play upon the stage of a theatre, are concerned, we can at best reproduce so that we eavesdrop through an aperture in a dividing boundary.

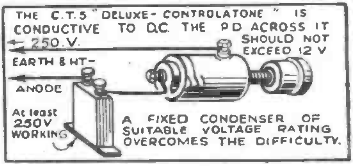
Do not be discouraged, however; to attain this realism in reproduction, although not impossible, is still quite an achievement. With the modern receiver of domestic type in the average living-room, control of tone is quite a simple matter. Unwanted frequencies may easily be by-passed and, in certain elaborate circuit arrangements, wanted frequencies may even be boosted in amplification and accentuated.

The Bulgin " Controlatones " are controls of the former type, designed to by-pass or minimise that which is not wanted. They are usually connected across the anode load to the output or penultimate valve, and, being variable components, permit of exact adjustment to particular requirements.

The C.T.1 and C.T.2 types comprise variable resistances of 50,000 Ω rating, in series with condensers of either ·006 μF. in the case of the second model, or ·01 μF in the case of the first model. The similarity of this arrangement—a resistance in series with a condenser—to the usual fixed filter used with a pentode will be noted. In fact, a " Controlatone " will replace such a filter and will control tone by reduction of treble and removal of shrillness.

The model C.T.1 having the larger value of capacity is the more generally used. With a very high-impedance output valve taking a high impedance load or in a penultimate stage across a high coupling impedance the model C.T.2 may be preferable, since with too large a value of capacity the damping resistance may be insufficient to prevent some loading effect, and then " normal tone " is not at any time obtainable.

The De Luxe " Controlatone " is a model with wider scope, for it removes, also by by-passing, either bass or treble at will. It

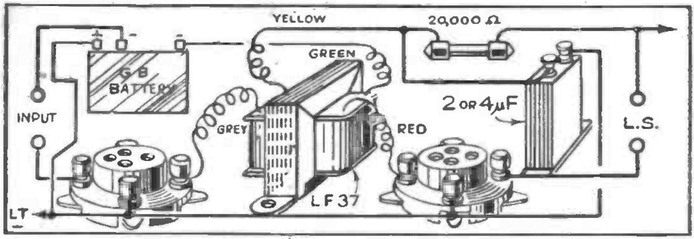


may be used for curing either boominess or shrillness. If your loudspeaker tends to accentuate bass, it may be pleasant with organs, concerts, instrumental solos, etc., but may be definitely unpleasant upon speech, the announcer when reading the News Bulletin possibly sounding extraordinarily chesty and wooden.

The De Luxe " Controlatone " will then be of enormous use, for there is no other tone control which will remove excessive bass so simply and effectively. On the other hand—and even with the same receiver—a soprano or violin solo may sound unnecessarily shrill, especially possibly with an incorrectly loaded pentode output valve. Turn the knob of the De Luxe " Controlatone " in the other direction and you will " mellow " your reproduction.

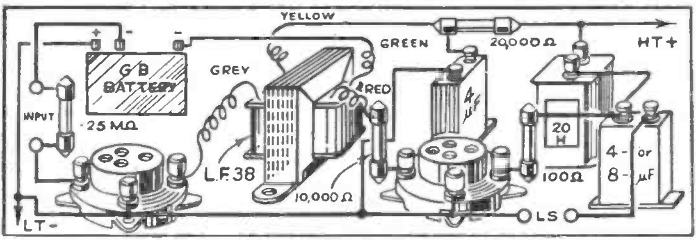
The De Luxe " Controlatone " is connected in a similar manner to the foregoing models across an anode load, transformer primary or loudspeaker; but, and this is important, this model is conductive to D.C., and so is never at any time connected from anode to earth unless a fixed condenser of approximately 1 μF. is interposed. See diagram above.

Tone control is often carried out in conjunction with pickups. Excessive treble may be reduced by shunting a condenser or by using the Bulgin Scratch Filter, a specially designed tuned acceptor circuit which will reduce the pickup output at approximately 4,250 c/s.



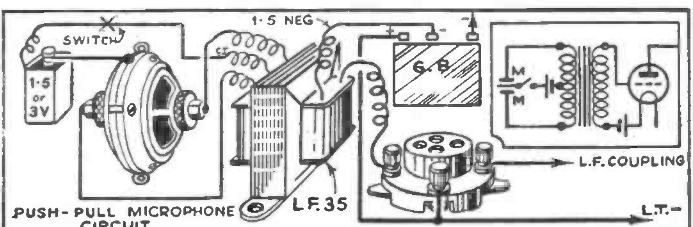
Here are the connections for a straight type of transformer wherein the anode current for the valve which it follows passes directly through the primary winding. This is, of course, the simplest method of L.F. amplification, and the transformer is capable of excellent quality. The transformer should be one capable of handling the steady anode current without damage. With battery type detector valves the latter trouble is not likely to occur. Decoupling may be needed if "motor-boating" sets in, though a temporary cure is reversal of the transformer G. and G.B. connections (Red and Green).

BULGIN List No. L.F.37, 1:4 L.F. Transformer. *BULGIN List No. S.C.20, 2 μF. Condenser.*



For the utmost quality of amplification with L.F. transformers having a ratio of approximately 1 : 4 it is best to use the Bulgin type L.F.38, which has a high inductance ensuring good bass response, and windings with special low distributed self-capacity, which, without going into technicalities, enables response up to approximately 12,000 c/s to be well maintained. It will be seen that the connections are much as before, but one or two refinements are incorporated for the preservation of quality of reproduction.

BULGIN List No. L.F 38, 1:4 L.F. Transformer. *BULGIN List No. H.W. 15, 10,000 Ω Resistor.*



Here is a microphone circuit which will not be very familiar to English readers, although largely used in the United States of America. The special microphone incorporates two carbon buttons on opposite sides of the diaphragm so that they are virtually in push-pull connection. With the L.F.35 Microphone Transformer and this amplification circuit the direct current in the primary of the transformer is cancelled out, preserving quality. It will be seen that the current for one microphone opposes the other.

BULGIN List No. L.F. 35, "Mike" Transformer. *BULGIN List No. V.H. 19, Valveholder.*

TRANSFORMERS—INTERVALVE

THERE are many types of L.F. transformer which are used to couple between valves. The simplest and best-known type of all is the so-called "straight transformer," a name which has been given to it only after the introduction of other types in which, by virtue of certain characteristics or modes of use, were not straight connected, but which were fed, arranged in by-pass, etc., as described on another page.

The ordinary straight L.F. transformer is an apparently simple device having coils of wire on a bobbin. Usually there are two coils, a primary winding and a secondary winding. It is necessary in the design of such transformers to arrange for very tight magnetic coupling, and indeed in certain types both primary and secondary may be wound in different sections, "interlaced" so that magnetic coupling can be as tight as possible.

Coupling can also be tightened in a sense by the use of high-permeability magnetic cores; which also cause increased inductance, of course, and permit of a reduction in size. When we come to very high-permeability cores, however, it is found that although enormously high inductance can be obtained with *relatively* few turns of wire and these quite small and compact, such cores will not stand magnetisation by the passage of direct current, which in any case always polarises the core and (unless special means are adopted) effects a reduction in inductance.

Many Bulgin inter-valve transformers of both straight and fed types are provided with coloured leads for connection and a standardised system has been adopted in respect of these. The primary winding is always terminated in grey and yellow leads, the yellow lead being that which is normally connected to H.T. positive in the straight transformer and to earth in the case of the fed transformer; the grey lead is always towards anode. The secondary of one of these transformers has red and green leads, the red lead being that for connection to the grid.

Another type of L.F. transformer is that for Q.P.P. amplification. The characteristic of this type, so far as its description is concerned, is that it has a much higher turns ratio, and therefore gives greater voltage step-up.

The Q.P.P. transformer always has at least a centre-tapped secondary, since it feeds either two valves arranged in Quiescent Class B. (i.e. Q.P.P.) amplification, but in certain types the secondaries may be centre-split as in the case of the Bulgin L.F.30.

Quiescent push-pull amplification is interesting because it enables battery receivers to be so constructed that a relatively large output is obtained for economical H.T. consumption, but (and since there is always a snag in these things there must be one in this case) it is generally necessary to be very careful as to the type of H.T. battery which is used. It must be one which has low internal resistance and which is capable of giving relatively high currents in output (although for quite short duration) without undergoing any serious voltage-drop. For this reason Q.P.P. circuits cannot satisfactorily be used with ordinary eliminators. Unless they are specially constructed most eliminators undergo a serious voltage-drop when there is any extra demand on their current output.

Where Bulgin L.F transformers other than Q.P.P. types are provided with centre-tappings on the secondary a dark-blue lead is adopted, and if the secondary is split two dark-blue leads are found, being the inner secondary connections. Red and green are reserved for the outers as in other types.

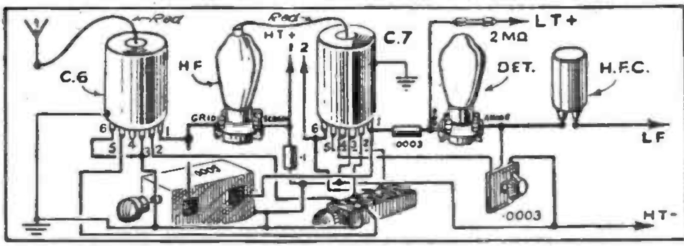
The use of modern deaf-aid apparatus and other midget circuital arrangements, including transceivers, has called for a further type of transformer, which although not strictly an inter-valve transformer, is generally made upon much the same plan. We refer, of course, to microphone transformers.

The Bulgin midget microphone transformer is a most interesting little component less in size than a match-box, but capable of most excellent results. It should be used with carbon microphones having a resistance of between 50 and 100 Ω, and it is provided with a centre-tapped primary having a D.C. resistance of 10 Ω. The over-all ratio is 1 : 35, but if only half the primary is used a ratio of 1 : 70 results. It is capable of standing polarising microphone-current of up to 25 mA. for the 1 : 35 ratio and up to 50 mA for the 1 : 70 ratio.

It is also possible, as shown on the opposite page, to use a push-pull microphone circuit, which is even better since the polarising current is balanced out and maximum inductance is obtained.

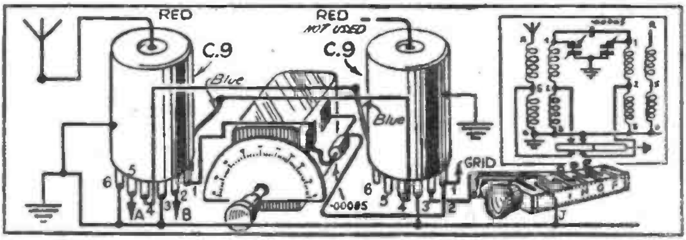
Push-pull microphone circuits are more popular in the United States of America than they are in England, but this is perhaps due to the fact that microphone circuits are, in England, considerably less used at the present time.

Finally there is a type of midget transformer recently introduced, No. L.F.46, which for pocket receivers, etc., forms an excellent output transformer. This is provided with a primary winding terminating in grey and yellow leads as standarised, but having a low-resistance secondary with a ratio step-down of approximately 20 : 1. Good quality is obtained with this type, although it is not always suitable for loudspeaker working. For headphones, however, since the transformer peaks slightly at 1,000 and 5,000 c/s, it is excellent.



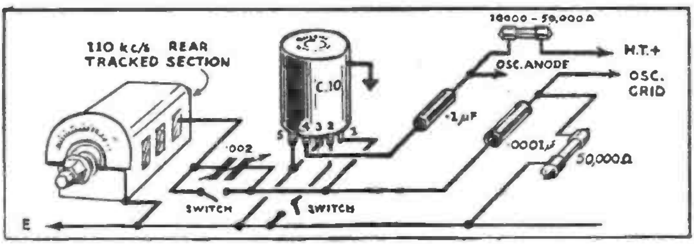
This diagram shows the use of popular types of Bulgin two-range coils in a typical circuit. The C.6 aerial coil is connected prior to a screened grid or pentode H.F. valve, which is followed by the C.7 H.F. transformer coil, the secondary of which feeds a leaky grid detector. The wave-change switching, accomplished with switch type S.121, is clearly shown together with the connections for a ganged tuning condenser of ·0005 μF. per section. The connections for a differential reaction condenser are also shown above.

BULGIN List No. C.6, Aerial Coil. *BULGIN List No. C.7, H.F. Transformer.*



This diagram shows the use of two of the popular Bulgin dual-range coils in band-pass, the types employed having been especially designed for this purpose. The band-pass effect is obtained by means of a top-coupling condenser and coupling windings (not shown). The switch S.121 is again used for wave-change purposes, and it will be noted that a number of contacts are still available, D, E, F, G, and H, for switching further coils as would be used in a complete circuit for a receiver of mains or battery type.

BULGIN List No. C.9, Band-pass Coil. *BULGIN List No. S.121, Wave-change Switch.*



Here are the connections for a C.10 oscillator coil producing, with other standard dual-range coils, an intermediate frequency of 110 k.c/s. This diagram may well be incorporated with that above as the foundation of an excellent super-het. with, we suggest, a pentagrid or octode frequency-changer. Note the ·002 μF. padding condenser (preset) which will be short-circuited on medium-waves. This is the padding adjustment for maintaining the necessary frequency difference on long-waves, and is normally set to about ·001 μF.

BULGIN List No. C.10, 110 kc/s. Oscillator Coil.

DUAL-RANGE tuning coils have hitherto been used exclusively, and although multi-range coils have recently been introduced, there is no doubt whatsoever that dual-range tuning coils will still continue to be most popular for many years to come. Extended working on to short and ultra short-wave bands does not mean that medium and long-waves will be abandoned.

For the reception of these only it must be admitted that the use of two-range coils and the set or circuit in which they are used will still be less expensive.

Let us consider a typical circuit, having one H.F. stage prior to a detector. It is advisable to use band-pass tuning for such a set, preferably in the aerial circuit so as to get a maximum degree of selectivity. This will prevent what is known as adjacent interference or the response of the H.F. valve to unwanted stations a little off tune, and like troubles.

Connections are given on the opposite page for the use of two C.9 coils in band-pass. Coupling is by means of a small coupling coil cross linked from one coil to a similar winding on the other, or second band-pass coil, and additional coupling is given by means of what is popularly known as a " top-coupling condenser " usually with a capacity of ·00005 μF. It is sometimes advisable to increase this capacity even to ·0001 μF., but it must be remembered that the wiring of the set will inevitably increase the capacity. With long leads from the No. 1 tags of the coils to the fixed plates of the tuning condensers a certain amount of capacity will inevitably exist here, and must be allowed for.

This will explain why a satisfactory band-pass effect is sometimes obtained when the condenser shown in the diagram is omitted entirely. Sometimes it is necessary to screen these high potential leads to avoid instability, but this is to be deprecated and usually points to bad lay-out involving the use of long wires from the No. 1 high-potential tags of the coils to the tuning condenser.

Always try and arrange with sets using these coils that they are close to the condenser, so keeping high potential leads short. It is also advisable to arrange the wave-change switch immediately beneath the coils keeping leads short, for coupling can take place between switch leads, which is undesirable, and, whilst spoiling the wanted band-pass response, etc., may easily introduce instability.

Following the H.F. valve in the circuit which we are considering it is best, if possible, to utilise an H.F. transformer, for better selectivity and greater amplification will usually result. In addition, hum from insufficiently smoothed H.T. will not be passed (owing to the low capacity existing between primary and secondary windings), as it would be with the use of a tuned grid or tuned anode coil having condenser coupling, a subject which is discussed fully in an earlier part of this book.

Connections for an H.F transformer, of which C.7 is a popular chassis type with tags for connection beneath the chassis, are given at the top of the opposite page.

Super-heterodyne receivers operating on both medium and long-waves are very popular and for utmost amplification, an intermediate frequency of 110 k.c/s. cannot be bettered, although it is perhaps a little prone to introduce whistles and other parasitic " repeater " noises. Much depends, however, upon geographical locality.

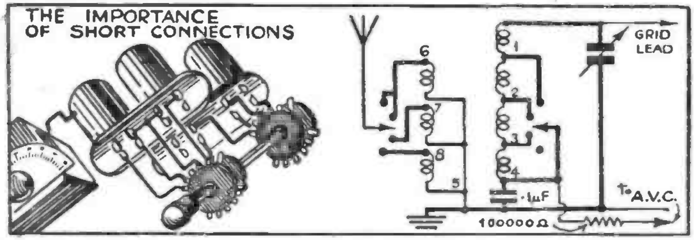
In seaside towns in the vicinity of Morse telegraph stations transmitting in the bands between the top of the medium-wave and the bottom of the long-wave, 465 k.c/s. as intermediate frequency may be troublesome, and sometimes I.F. filters have to be resorted to. The connections for the C.10 oscillator coil for 110 k.c/s. working are given on the opposite page.

Padding with this type of coil to ensure that the necessary frequency difference be maintained is simple, and condensers tracked for 110 k.c/s. are readily obtained. With 465 k.c/s. working on two-band coils the band-pass arrangements with two C.9 coils are quite ordinary, but it must be admitted that oscillator padding is a little more complicated, even though it can be arrived at more accurately.

The Bulgin C.59 oscillator coil which is used with the other type for 465 k.c/s I.F working is not intended to be used with condensers tracked for 465 k.c/s. working, but is generally employed satisfactorily with plain non-tracked condensers. Ganged types are, of course, referred to.

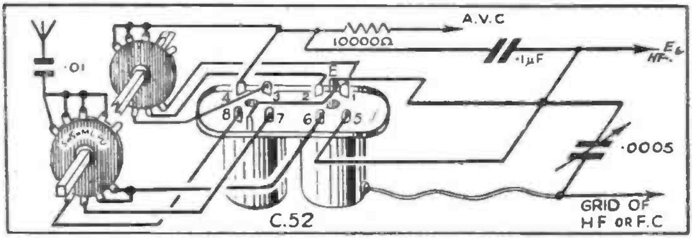
Padding is then carried out on both medium and long-waves by means of pre-set condensers, which can quite accurately be adjusted and left. Generally speaking, wave-change switching of these dual-range coils can be carried out by the ubiquitious S.121 type of switch, but under certain conditions in high amplification sets instability may result, and the use is then recommended, not as a cure, but as a precaution, of the unit base-board type of toggle switches assembled and ganged on a control rod, as previously described.

Such an assembly of separate switches, even when ganged by a common operating shaft, can be shielded as desired, and common couplings, which prevent the attainment maximum amplification. The reason for this is that when coils are switched to LONG waves the switch leads—no longer earthed—can easily couple by capacity; and they are quite high-potential. This, then, is a point to watch if L.W. instability is experienced.



The picture shows the internal connections of a C.52 Bulgin four-range aerial or H.F coil, and the way of fitting the wave-change switch. It will be seen that the necessary short leads are maintained and the theoretical diagram indicates these leads with thick lines. When it is realised that the shortest wave coil contains only about four turns of wire on a one-inch diameter former it will be seen that *ganging* cannot be expected, when leads of the order of more than two-inches are introduced by bad wiring.

BULGIN List No. S.122, Switch Assembly, 7/- complete.

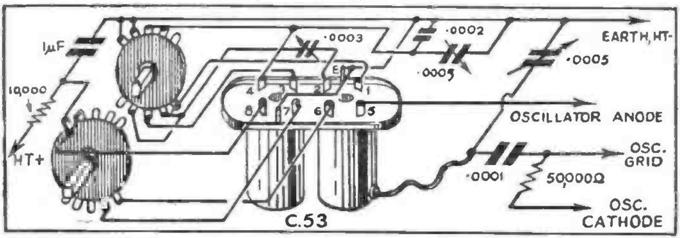


Here are the connections, viewed from the underneath of the chassis, of the Bulgin C.52 coil described above when used as an aerial coil and connected in a chassis-built receiver. The switch would, of course, normally be immediately beneath the coil, as shown in the first picture, but for clarity of connections has been moved to the left.

BULGIN List No. C.52, Aerial Coil (Mains).

Note particularly the earthing tags for the screening cans of the coils which it is essential must be connected to the chassis line. Note also that when the switch is placed in the proper relation to the coil the wires from tags 1, 2 and 3, important switch leads in the oscillatory or tuned circuit fall almost naturally into position, avoiding long wires.

BULGIN List No. C.54. Aerial Coil (Battery).



Here are the connections to the second coil in a simple four-range super-heterodyne receiver. As before, the switch would normally be mounted immediately adjacent to the coil, and for convenience the two discs of the double-pole switch unit have been separated apart, although in practice they are quite close together. Again, it is important that the tuned circuit and tags 1, 2, 3 and 4 be connected as shortly as possible to the tuning condenser. Ganging for medium waves is carried out by means of a ·0002 µF. fixed condenser shunted by a ·0005 µF. pre-set trimmer.

BULGIN List No. C.53, Oscillator Coil (Mains).
BULGIN List No. C.55, Oscillator Coil (Battery).

TUNING COILS—FOUR RANGE

IT is interesting to recollect that Bulgin Four-range Tuning Coils covering long, medium and short waves in four bands were the first to be placed on the market and offered to the amateur and experimenter. Indeed they may well be said to have been in front of their time, and after a year of successful working are still in front.

They represent a high degree of achievement in radio technique, for it is possible to construct receivers with them which will cover wavebands of 15 to 35 and 30 to 85 metres, in addition to the usual medium and long waveband coverages.

Generally they are used in super-heterodyne circuits with an intermediate frequency of between 450 and 465 k.c/s the exact fundamental figure not being critical. In the diagrams on the opposite page we show some of the more important points concerned with their use and on earlier pages dealing with intermediate transformers connections of the associated types used with these coils, List No. C.50, etc., are given.

In the construction of any receiver utilising these coils LAYOUT is an exceedingly important factor, and we cannot stress too highly the fact that you must adhere to the printed word if successful results are to be obtained.

These coils, so far as the short-waves are concerned, have relatively short windings of only a few turns, and carelessly placed leads will not only introduce unwanted capacity effects, making for unsuccessful performance, but will so throw out inductance values that the minimum wavelengths will not be obtained and tracking may even become impossible.

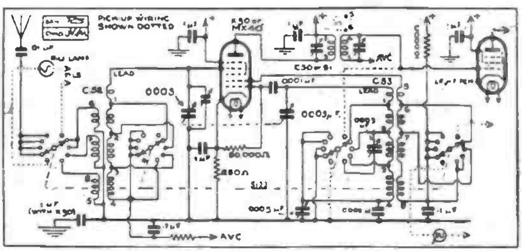
It is important that the wave-change switch be incorporated in the construction immediately beneath the coils, and that the coils be placed at the top of the chassis immediately adjacent to the two-gang tuning condenser. This should have a capacity of ·0005 μF. per section, and which should NOT be of the " tracked " type.

The high-potential condenser connections are made by means of two flexible leads projecting from the coil at a convenient position to connect to the tags of the stator plates of the condenser. It is important that these flexible coil leads be neither shortened or lengthened, as they are in the highest frequency oscillatory circuits.

The connections to the wave-change switch must be as short as possible. With the correct type of wave-change switch, the S.122 assembly incorporating units discussed previously, it will be found that connections fall almost automatically into postion with the very shortest of leads. It is advisable, in constructing a receiver using these coils, to dispose the frequency-changer valve on the top of the chassis with a chassis type valve-holder which should be of the short-wave low-loss ceramic type.

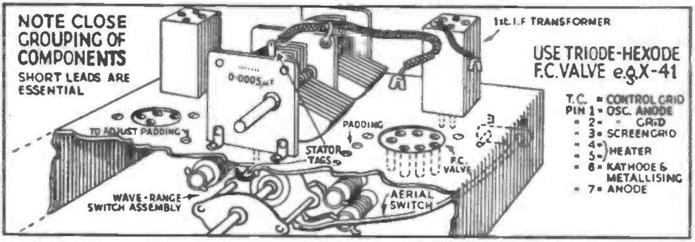
The frequency-changer valve should be placed between the oscillator coil, C.53, and the other coil or coils preceding it. The rest of the receiver once past the frequency-changer stage may be straightforward, and may consist of the usual intermediate frequency detecting A.V.C. and output stages, and may follow the usual conventional laws and sensible arrangement in regard to layout

It is desirable, for accurate results, that the two-gang tuning condenser above referred to be fitted with a single plate trimmer condenser adjustable from the front, or that damping be introduced (when selectivity is not vitally important) on the short-wave ranges. With the trimmer condenser, however, which may be obtained either in a dial to attach to a condenser or built in the condenser itself in many types, it is not necessary to recourse to continual trimming. This means is adopted to obtain the necessary padding, as it is termed, for production of the intermediate frequency difference when tuning on the short-wave band.



This diagram shows the usual four-range coil connections. A mains circuit is depicted, but a battery version, with battery coils, is almost identical.

If you use a separate trimmer condenser (as is often done) its fixed plates must be connected to the fixed plates of the sub-section of the two-gang tuning condenser with leads which are as short as possible and which on no account may be screened. This automatically prohibits the use of long leads, for instability with them would soon set in. With many modern circuits the tuning is broad enough to permit dispensing with the trimmer entirely.



The construction of a multi-range receiver is well within the capabilities of the present day amateur providing that certain reasonable and essential precautions are considered and made. In order to keep leads short (see page 59) it is customary to fit the tuning Condenser immediately above the coil-and-switch assembly, separated only by the chassis, with the Valves, concerned with the circuits, extremely adjacent. Modern wave-change switches and modern small Unit Coils provide a convenient method of ensuring short connections as the drawing above shows.

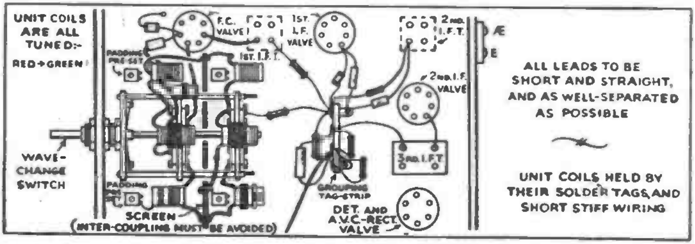


Fig. 2. This drawing shows the typical construction discussed above viewed from beneath the chassis. It is particularly essential to note the short connections of the coils to the switch, padding and pre-set-condensers, and of the Valves. With super-het Receivers, once the frequency has been converted to the I.F., under which conditions the majority of the amplication takes place, the need for extremely short leads, etc., lessens although it is important to attend to the normal principles of receiver lay-out and construction in order to avoid interaction and unwanted couplings.

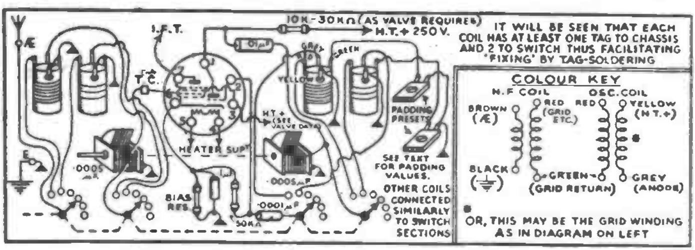


Fig. 3. To assist in any constructional work which may be undertaken with respect to information on these pages, the third drawing shows the basic theorectical connecttions for a frequency changer stage of the triode-hexode types using Unit Coils. For simplicity, only two coils are shown in each of the positions and the first and second drawings on this page relate to the same style of circuit. To make the portrayal as clear as possible, the Condenser sections have been shown separately and the coils have been shown in perspective Bulgin Unit Coils are all provided with the tuned winding between the *Red* and *Green* tags. With Oscillator Coils this is sometimes the anode coil or sometimes the grid coil, dependng on the style of valve and nature of circuit. Irrespective of that, however, this winding is always tuned and padded.

TUNING COILS—FIVE RANGE

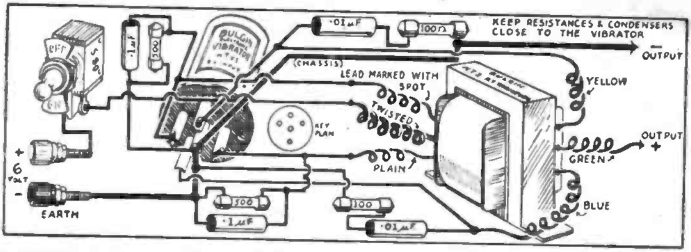
THE design of Radio Receivers has undergone a number of changes during the past few years. The modern Receiver is a vastly different article, in almost every respect, from what was current 10 years ago. The chief feature in this change is the super-heterodyne principle with its attendant advantages, the principle one of which is that its method enables the major part of amplication to be carried out at one fixed frequency—the intermediate frequency, or, as normally abbreviated, 'I.F.' This is not perhaps the best choice of nomenclature because it is really the *final* frequency as far as signals are concerned prior to the detection or signal-rectification. It may at first be thought that its advantage is more apparent than real, but the fact is that with one fixed frequency the amplifying circuits can be arranged to have just that proportion of inductance and capacitance, within fine limits, which will give the desired gain or amplication, compatible with reasonable band width—to deal with the modulation, speech and music frequencies impressed on the radio signal—and with a constant or reasonably constant degree of selectivity. We have seen on page 57 that selective circuits generally need a high L/C ratio; with the majority of the amplication carried out at a fixed frequency with fixed tuning, this state of affairs obtains.

It is not necessary to deal with the theory of the super-heterodyne; suffice to say that a local oscillator-valve circuit is so arranged as to produce—when the ganged-condenser is rotated—a second radio signal which differs from the incoming signal by the figure assigned for the "intermediate" frequency.

The super-het. receiver, with its lessening of the number of tuned circuits which needed to be controlled by the tuning knob in order to receive different stations, overall amplification and selectivity being equal, compared with sets having a number of tuned r.f. stages, made it readily possible to cover more wavebands than the conventional "medium and long." Short waves could be introduced, and received very well indeed, on a set whose prime function was broadcast reception. Before the extended use of the super-het. principle this feature was not so readily to be had; the design of r.f. amplifying stages to deal with *high* radio-frequencies was quite different from those for lower frequency (longer wave-length) signals.

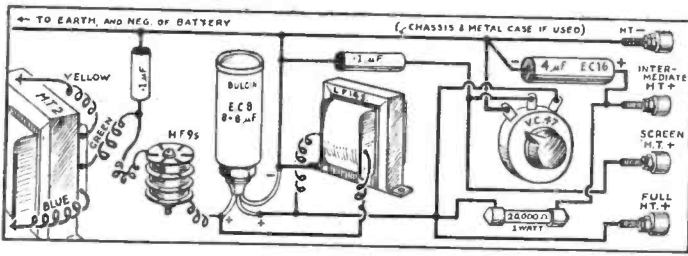
Consequently, the last few years have seen the "all-wave"—that is, really, the *more*-wave"—set coming rapidly to the front. And, apart from a certain retention of a reasonable selectivity to incoming, and adjacent incoming, radio signals, it has become less and less necessary to use tuning coils—coils which tune to the actual signals, and not those for the i.f.—of a high factor of goodness ("Q") The gain can be made up, to a great extent, much more easily in the i.f. stages.

Such a state of affairs is rendered possible with simple multi-wave Receiver construction of the present day. Whilst Bulgin group-coils with switches and padders and trimmers, were at first made available, it has been found more flexible, to meet individual requirements, nowadays to furnish only individual Unit Coils with separate padders, trimmers, etc. Whilst flexibility is possible, there are certain precautions, however, which must be taken and these are referred to on the opposite page and on page 59 in the section "Wave Change Switches." Unit Coils are made both in the signal-frequency and oscillator frequency types for an intermediate frequency of 465 k.c/s. Separate series-padding is employed with each and every oscillator Coil and this facilitates the use of conventional ganged Condensers of standard capacitance in each section, without reference to specially shaped vanes. It will be remembered that oscillator circuits always tune to a frequency which differs from the signal frequency by the value of I.F., and it is conventional to have the oscillator frequency higher. Consequently the inductances of the oscillator sections are lower and the effective capacity of the ganged Condenser is lowered by the provision of series condensers which are known as the padder condensers. To ensure the retention of ganging, each coil in each unit needs paralleled trimmer condensers—to compensate the stray capacitances differing in different receivers—and if trimmers on the actual ganged condenser are provided, they are opened or removed and are not normally used in this style of construction. A large variety of wave-change switches are available from time to time according to circuital needs for numbers of bands, style of frequency changer, and/or pre-f.c. h.f., etc., (and the constructor selects types which best suit his particular needs. It is also necessary to determine whether the switch sections are to short out unused Coils or not. In case of doubt, they may be arranged to be shorted out on the basis of "play for safety," but it is frequently not necessary. American practice in the past has tended towards the use of two I.F. Valves, with appropriate I.F. Transformers, to work at a rather lower gain *per stage* than English practice has generally adopted; one single I.F. amplifier Valve has been current English practice in the greater majority of Receivers. The trend towards much higher gain per stage in American I.F. arrangements is, however, now-a-days to be noted, although extreme high gain or "communication" receivers frequently retain the 2 I.F. stages. Instability, if experienced in I.F. stages, can frequently be controlled by lowering the screen voltages, if not otherwise.



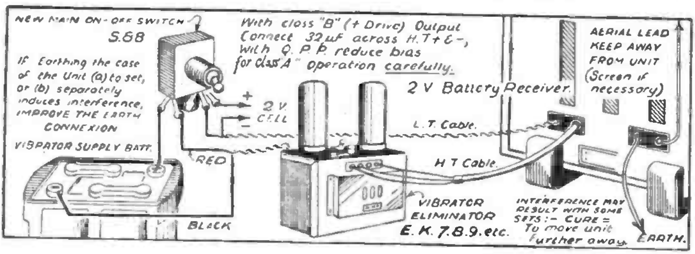
The converter section of a Vibrator H.T. Unit may be built up from the components shown above. The lay-out should be as compact as possible, to reduce the field set up by the action of the Vibrator. The output obtained is smoothed D.C. Smoothing is dealt with below.

BULGIN List No. HTV.117, Bulgin Vibrator.
BULGIN List No. M.T.2, H.T. Transformer.
BULGIN List No. S.80, Input Switch.
BULGIN List No. P.C.P.1, ·1μF. Condenser.
BULGIN List No. H.W.2, ½w. 500Ω Resistors.
BULGIN List No. P.C.101, ·01μF. Condensers.



This is the smoothing filter section of the Vibrator H.T. Unit. Together with the converter section above. It can be assembled into a space no bigger than the standard 120 volt H.T. battery. It closely resembles the filter circuit of an A.C. mains receiver, but the components differ slightly. Three H.T. tappings are provided. One is variable, so that the screening grids of valves may be suitably fed.

BULGIN List No. E.C.8, 8+8μF Condenser.
BULGIN List No. H.F.35, H.F. Choke.
BULGIN List No. W.E.3, 20 KΩ Resistor
BULGIN List No. E.C.16, 4μF. Condenser
BULGIN List No. L.F.14 S, L.F. Choke.
BULGIN No. V.C.47, Potentiometer.

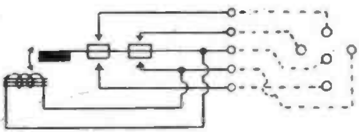


The complete unit is used exactly as if it were a mains eliminator, and replaces H.T. batteries. If the output stage of the receiver is Q.P.P., the bias plugs for this stage should be moved down, until good quality is obtained. so that the output stage now operates in "straight" push-pull. Sets with plain pentode or triode output may be left as they are. The earthing system should be as good as it can possibly be made.

BULGIN List No. E.K.114, 4-volt Vibrator Eliminator (or equivalent type).
BULGIN List No. E.K.115, 6-volt Vibrator Eliminator (or equivalent type).

VIBRATORS

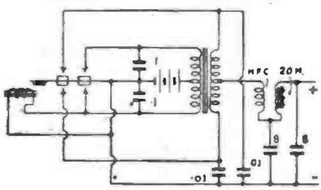
FOR many years it has been known that low-tension direct current may be converted into either high or low voltage alternating current, by means of a self-acting make-and-break electro-magnetic system. The principle has been used in spark induction coils, electric bells, buzzers, motor-car ignition



Internal connections of Synchronous Vibrators. Note that the energising coil is connected across one pair of L.T. contacts, a valuable and unique feature.

systems and a wide variety of other apparatus. The "trembler" or vibrating part of such mechanisms, indeed, is very familiar to all electrical workers. The principle has comparatively recently been applied to the solution of the problem of H.T. battery-less radio receivers, for generating high voltage anode supplies from low-voltage accumulators. The low resistance primary of a specially designed transformer is included in the circuit of a vibrating made-and-break unit. As the current is started and stopped through this primary, it induces comparatively high voltage alternating current in the transformer secondary.

This could be rectified by a valve rectifier in exactly the same way as is done in the anode supply unit of an A.C. receiver. But



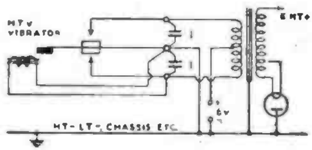
An eliminator circuit with Synchronous Vibrator shown theoretically. It is recommended to parallel the 0.1 μF. condensers with 500 Ω each, and to connect 100 Ω in series with each of the 0.01 μF. condensers, as on the opposite page.

with a suitably designed vibrator unit, a valve is not necessary—the rectification may be done by contacts on the blade of the vibrator itself!

A glance at the top diagram on the opposite page will show all the necessary components for a complete conversion unit. Small tubular condensers have been included at certain points for the purpose of by-passing any high-frequency currents that may be generated by the vibrator's action.

Now, although the output from such a unit is direct current, it will be unsmoothed, i.e., it will contain variations that render it unsuitable for application directly to the anode circuits of valves. Hence, it has to be filtered through a system very similar to the smoothing circuits found in mains eliminators and in the anode supply circuits of A.C. mains receivers. The section that performs this function is shown complete in the middle diagram on the opposite page and its similarity to the smoothing circuits of other sources of H.T. current will be clearly apparent.

The use of a complete vibrator H.T. unit with a battery receiver is shown in the lowest diagram on the opposite page. In this case, one cell of the 6-volt accumulator battery (three cells in series) that supplies the input of the vibrator could be used also to supply the receiver's valve filament cirucit. But



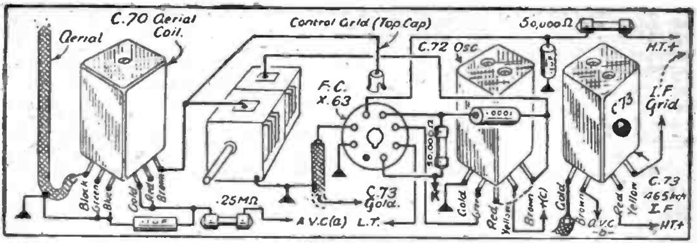
A non-rectifying Vibrator can be used for extra-high-tension supply, as in television sets. A suitable rectifier valve is employed.

generally, it will be much better to use a separate, normal size of accumulator for the valve filaments, which can be recharged independently of the six-volt accumulator battery. Those types of receiver of which the H.F. coils are unshielded by metal cans are rather liable to pick up hum from the vibrator, if this is placed too close to the receiver, so the connecting cables should be made long enough for the vibrator to be positioned well away from the set. The earthing wire should be taken to the receiver's earth socket, and it should be an *extremely good* earthing system, without a long wire and ending in either a *rising* water-main or a large metal plate well buried in damp soil.

The latest types of Vibrators are fully described in current BULGIN Catalogues, and up-to-date circuits and data are always furnished.

A WARNING.

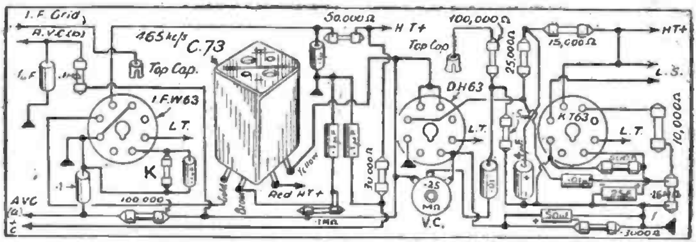
Should any trouble be experienced with a Vibrator H.T outfit, everything except the vibrator unit itself, which is inside a metal can, can be tested by the usual methods, as outlined in this manual for transformers, condensers and the like. But if the trouble is suspected to lie in the vibrator unit itself, no attempt should be made to adjust the vibrating contacts or to take the parts to pieces.



This circuit shews the input side of the simplest reliable car-radio super-heterodyne receiver. It is inadvisable to include long-wave working, so wavechange connexions are omitted. Compactness is essential, so that square-can coils and 6·3V. valves are to be used. It is usually essential to screen the anode lead of the F.C. valve *unless it is very short.* It is permissible to decrease screen volts if instability is experienced. "K" is the connexion to cathode-bias-resistor (and ·1 μF. shunt condenser); allow for 1—2V. *more* G.B. than usual. (Also see circuit below).

BULGIN List No. C.70, Aerial Coil.

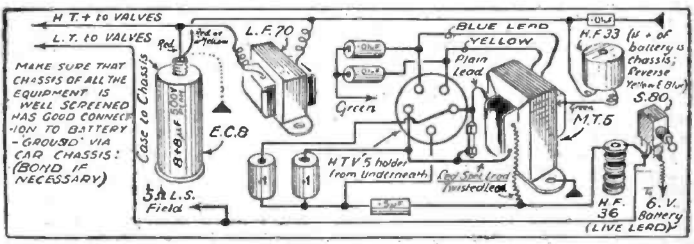
BULGIN List No. C.72, Oscillator Coil.



Continuing the circuit, a single I.F. valve is used, and the same provision in regard to the bias resistor is essential; 1—2V. *more* bias must be developed. The reason for this is the nature of the A.V.C. circuit, which commences to generate from a point about 1—2 V. *positive* above chassis. Decoupling of all feed circuits is, and should be, generous. Simplification *may* be possible, but should only be tried warily. A compensating 0·01 μF. condenser or condenser-resistance network is desirable to shunt the L.S.

BULGIN List No. C.73, I.F. Transformer.

BULGIN List No. V.H.40, Octal Valveholder



The final part of the car-radio circuit is the Vibrator-H.T. supply. Thorough screening, short-leads, and adherence to specification is essential. Adequate filtering, both H.F. and L.F. is depicted here, and no interference from the vibrator will result providing the power supply is built into one fully-screened box, and that this is subsequently enclosed in the screening box of the receiver itself. A good connexion to the chassis is essential everywhere. Correct for output polarity *before* the E.C.8 electrolytic is connected.

BULGIN List No. M.T.5, 250V. Vibrator Transformer.

VIBRATORS

OVER on the other side of the Atlantic Ocean, in the United States of America, the past few years have seen great strides in the development of what is known as the car radio receiver. That is, a radio set of special type and construction, particularly adapted to the particular—and rather difficult—needs of the case. Let us examine the requirements.

Firstly, such a set must be extremely sensitive, for it will have, at best, to work from a comparatively inefficient aerial. The signal input will, it follows, be quite small, under most conditions, so that selectivity need not be very high, although it must be adequate for the conditions of use and reception.

These circumstances point to a super-het. circuit as being, almost without question, the best to adopt.

Further, the car-radio set must be easily tuneable—one knob control of station selection—and it must be able to deal, without giving bursts of unbearable volume, with signal strengths which vary *enormously*. Perhaps no other combination of reception-conditions is so arduous, nor is so likely to undergo wide changes and variations. It follows that an extremely efficient system of rapid action a.v.c. is a further essential, and here again the super-het. circuit must score every time.

Still further, the set must be extremely stable. Not so much electrically, but rather in a mechanical sense. Every part and component, as well as the whole set itself, will be subject to the most appalling vibration and succession of shocks.

Every joint, every nut and bolt, every valve, and every component must be of such rugged design and build that no appreciable change or deterioration will take place however much the set is ill-used.

Construction should be carried out with a strong chassis of iron or mild steel. It is desirable to use a steel all-enclosing case also, for reasons to which we shall come later. Every nut and bolt must have locking washers suitably applied, and every soldered joint must have the conductors first twisted through the hole in the tag, or together, before the solder is applied.

The wiring of the set should not be taut; at the same time, however, excessively loose and flabby wiring will cause changes in performance, and should be avoided.

The problem of possible interference from the electrical system of the car is one which has had a great deal of attention, for it is a major factor in obtaining successful operation of the set. It will be realised that, in a car, we have a small electrical generating station, together with a very high voltage—and very broadly tuned (actually almost *un*tuned) spark transmitter, all connected to wiring carried all over the car so as to constitute an all-too-efficient aerial or radiating system. And, in addition, we cannot have a real earth-connection for the set; a counterpoise—the car-chassis—is the best that is afforded.

At first sight, this state of affairs appears to present insuperable difficulties, but this, fortunately, is not the case. The problem of preventing the electrical system of the car from causing interference through the radio is not difficult to deal with providing it is properly treated.

It is generally found that, in most small and medium-sized cars, the spark-distributor is the most potent producer of h.t. spark-interference. The usual cure is to connect a suppressor-resistance in the H.T. lead from the coil to the distributor, *close* to the latter. Next, if spark-clicking persists with the engine running slowly so as the more readily to detect it, fit suppressor-resistances to the plug-terminals, and if needed, to the H.T. terminal of the coil. Each application will *reduce* the interference, so that ultimately the level of noise is so low as to be negligible or unnoticeable; but no one suppressor, whatever part of the circuit it be fitted in, will form an immediate and 100% cure.

Low-tension interference, if it exists, can next be dealt with. Condensers, instead of the special heat-resisting stable high-voltage resistors, are here needed. Suitable values of capacity lie between 0·1 μF. and 0·1 μF., and the condensers must be non-inductive. Otherwise, their effect may be small, or they may have no lessening effect at all—perhaps, the reverse!

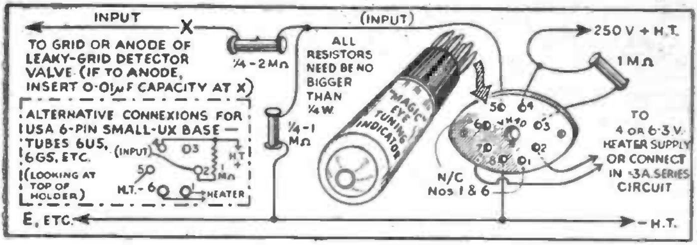
If necessary, connect condensers across the dynamo brushes, across the L.T. make-and-break (the value fitted may be insufficient, or the existing condenser be slightly inductive) and across such long twin leads as that to the roof light, the stop-light, and the tail-light, *all in that order*.

Do not be discouraged by the apparent magnitude of the work; many car-radio installations work very well with one H.T. suppressor resistance only, especially on local stations.

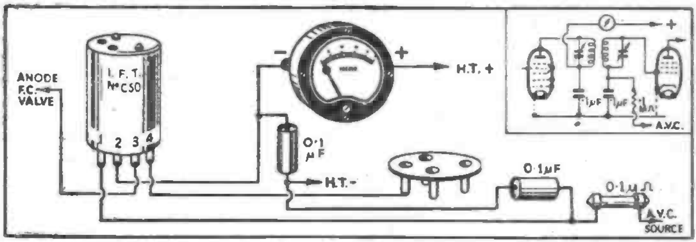
Car-radio sets operate best upon the medium-wave-band only, and as a sufficiency of stations is thus obtained, and price is thus kept low by simplicity of design and interference-suppression, most people prefer to stop at that.

The aerial must be outside the car, and thus as unscreened as possible, for the best results. The lead-in should be screened *for the whole length inside the car;* keep it as short as practicable, and earth its outer screening to the chassis (*car*-chassis) securely about every three feet.

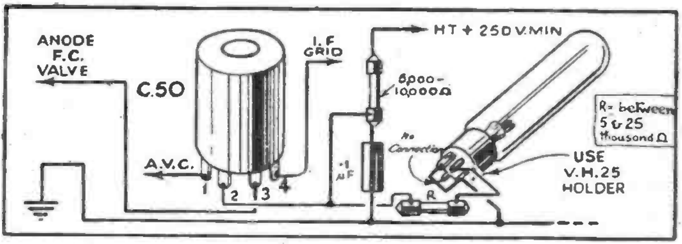
The vibrator itself (dealt with on page 73) is not likely to cause any interference if the precautions outlined in the circuits on the page opposite are followed, and the simple A.V.C. circuit shown, although requiring that an additional counter-acting grid-bias of 1—2 volts more than normal is needed in two places, works exceptionally well.



1. The circuit shows the Magic Eye Indicator which are normally quite readily to be added to almost any mains-driven receiver. Very few components are required. Either International-Octal or 6-pin U.X. bases are common and the connections are shown alternatively. A fixed Condenser is sometimes used between the grid of, and the feed to the magic eye, especially if audio modulation reaches it and renders the edges of the shadow-angle "fuzzy."



2. The diagram shows the simple connections for a visual-tuning-meter used in the anode-circuit of an f.c. or I.F. Valve in a Receiver A.V.C. is generated in the detector stage by a diode-Valve or Velve-Section and fed to the F.C. and/or I.F. Valves. A visual-tuning-meter, if it has an appreciably high resistance will also serve as a decoupler for the stage, and therefore a .1 μF Condenser would be connected from the junction of the meter and the coil, to H.T. negative.



Here are the connections for another popular type of visual meter, a visual tuning indicator, the neon lamp glow-tube in which the cathode is a long electrode along which a glow spreads when a signal is tuned in by reason of the lowered anode current of a valve, usually the frequency-changer, when A.V.C. voltages are generated and applied to it. It is essential that there be a decoupling resistance of 5,000 or 10,000 Ω with a ·1 μF. coupling condenser as before described, and from thence is connected the neon lamp via "R."

BULGIN List No. C.50, 465 kc/s I.F.T. *BULGIN List No. V.H.25, Neon Holder.*

VISUAL TUNING INDICATORS

In a simple receiver having no A.V.C. the anode current of a leaky-grid detector valve is reduced, as you probably know, as soon as a carrier wave is received and rectified, and the degree of reduction from the normal value of current largely depends on the strength of the signal.

It is, of course, important with modern sets that tuning should be set to the exact centre or trough of the band frequencies to be received, otherwise distortion will result. This distortion may not, perhaps, be immediately apparent as such, but one can always definitely detect that something is not quite right with a mistuned receiver.

Especially may the uniniated members of a household exercise such mistuning without realising it and then grumble at the quality of reproduction. Some detector valves, although a few in most modern sets, operate by bottom-bend or anode-bend rectification; they then have a large initial negative bias and a change in anode current takes place when a signal is received.

Actually, with this type of detector, the anode current increases from the low quiescent figure and again the increase is directly dependent on the strength of carrier wave received, the strongest signal being obtained when the set, or tuning circuits to be more precise, are exactly resonant. When a receiver is fitted with A.V.C. a totally different scheme of connection is adopted for the visual tuning meter.

Most sets fitted with A.V.C. derive rectified voltages for automatic volume control from a diode rectifier. In many cases this diode is not a metal rectifier, but is part of a multi-electrode valve such as a double-diode-triode. Also, in sets of this type, it is common to rectify the signals themselves by means of another diode or another diode section of a multiple valve. Thus, since the rectified current of the diode is of the order of micro-amperes only, there is, in most cases, no point where rectifier anode current can change satisfactorily for visual tuning indicator purposes.

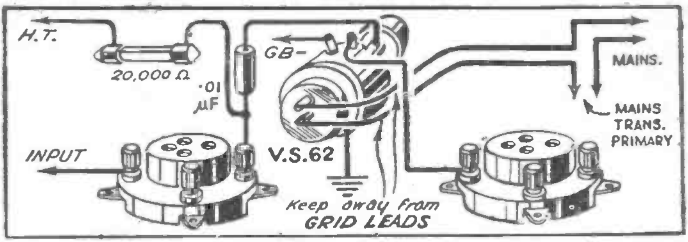
However, the application of varying A.V.C. voltages to the earlier H.F. and also, possibly, frequency-changer valve, which they control alters the normal anode current from these valves quite considerably. It is, therefore, a simple matter to connect the visual meter so that the anode current to an H.F. valve controlled by A.V.C. voltages passes through the meter.

When the visual tuning meter is properly connected and used with a decoupling or by-pass condenser as shown and described, it carries practically no signal or fluctuating potential, and then within reason the length of leads with which it is connected is not materially important. This means then that the meter may be fitted in any convenient position in the receiver, usually on the front panel, possibly above the tuning condenser. Be careful, however, if you wish to depart from the rules given, which you should not if you are wise, that you do not call upon the visual tuning meter to carry signals either L.F. or H.F., for by so doing instability may result, for which not the meter but you would then be to blame.

ONE of the most popular types of visual tuning indicators is the uncalibrated milliammeter which has a dial, in some instances, specially arranged for tuning indications. There are various methods of connecting this, and one circuit, which is so simple as hardly to need a diagram, has such a meter between the anode connection of a particular Valve and the moving point of a potentiometer system which is connected straight across the H.T. negative and positive. The potentiometer is adjusted, with total absence of radio signals, until the meter shows zero at which instant the Potentiometer arm is set at a point of exactly equivalent voltage to the voltage on the anode. The Valve concerned must receive A.V.C. for the working of this system, and under the influence of A.V.C. voltage applied to its grid, undergoes a change of anode current. Providing that there is series resistance in the anode circuit, lowering of anode current means the voltage drop will lessen and consequently the anode voltage will rise at the valve. The meter will therefore then be connected between two points of different potentials and current will flow through it, moving the pointer.

Magic Eye tuning indicators are a very popular modern type of device and very simply fitted in receivers if such an addition is wished for. Rectified signals are taken and fed through a series resistor of not less than 0.25MΩ to the control grid. Continuity of the grid circuit is provided with a further resistor, or, if there is already d.c. continuity in the feed circuit, of appropriate polarity with respect to earth, the grid leak (shown, in the opposite diagram, to earth) will be omitted. A fixed Capacitor is, however, sometimes used in this position (0.1μF. is usually satisfactory) if the shadow bands are "fuzzy" at the edges. The magic eye generally requires an anode resistor of 1-MΩ and a 250V. supply. Its operation is simple. The signal voltage is received and, operating the control grid of the triode section of the eye, reduces the anode current. This reduces the voltage drop through the anode resistor and changes the shadow-angle because a second or target-anode is provided, and internal control electrodes, restricting the target current, are connected to the *triode* anode; consequently these change potential with respect to the target, as the triode-anode-current changes.

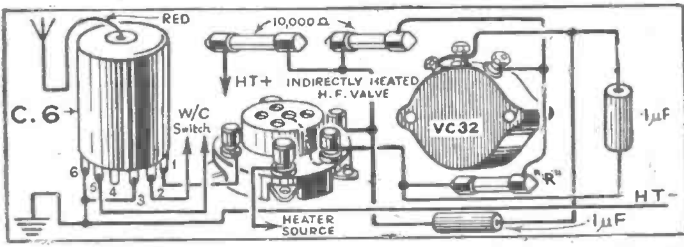
Neon-tube indicators are also used in many circuits; the reader is recommended to study the makers' data in respect of these as, although a circuit is shown, different makes require different uses.



Modern volume controls are often fitted with an automatically operated switch knob, minimising the number of controls in front of a set. In most receivers the volume control switch will he called upon to make and break one of the mains leads. Be careful, therefore, that hum is not introduced and that grid wires are kept well away from power conductors. Where a metal cover is fitted to the back of the volume control this is intended to be earthed to the nearest point of H.T negative or to the chassis.

BULGIN List No. V.S.62, ½-MΩ Volume Control, with Switch.

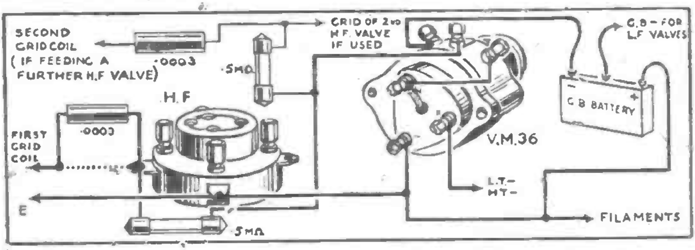
BULGIN List No. H.W.19, 20,000 Ω ½W Resistor.



A popular use of a volume control is in the cathode/H.T. negative lead of an H.F. valve. If the volume control has only two connections, being employed as a variable resistance, a shunt condenser is, of course, necessary to keep the H.F. impedance of the circuit low. In some circuits the lower end of the screen feed potentiometer network is connected to the cathode (or similarly) so as to pass current continually through the volume control. This gives more even variation of volume. " R " is the fixed minimum-bias resistor.

BULGIN List No. C.6, Aerial Coil.

BULGIN List No. V.C.32, 10,000 Ω Vol. Control.



This diagram shows the simple means adopted when it is desired to add a variable-mu valve and associated volume control to a battery set. The grid lead between the coil and the valve to be controlled is broken and a condenser inserted. From the grid, connection is taken through a grid leak to the volume control which (in series with the switch) is connected across the grid bias battery. It is also possible by means of a second grid leak and grid condenser simultaneously to control another H.F. valve later in the circuit, as shown.

BULGIN List No. V.M.36, 50,000 Ω Volume Control with switch.

BULGIN List No. H.W.31, ½-M.Ω ½-W. Resistor.

VOLUME CONTROLS

VOLUME Controls are used in practically every set nowadays. In most cases a volume control comprises either a variable resistance or a potentiometer, the latter being, of course, a variable resistance provided with a terminal at each end of the element, whereas a variable resistance, correctly speaking, has one terminal connected to the moving arm and one terminal connected to one end of the element.

A volume control is usually connected as a simple variable resistance when it is used in an H.F. circuit for providing bias for the H.F. valve in an A.C. or A.C./D.C. set. It is then connected between the cathode of the valve and the chassis and H.T. negative.

In this position the anode current of the valve is passed through the resistance, and if the value of the resistance is increased by rotation of the knob the current naturally produces a greater voltage-drop across the resistance. This is applied through the coil to the grid as bias.

It will be realised that as the valve is biassed more negatively its anode current is reduced, so that under these conditions, if the resistance were variable *ad inf.* a state of affairs would arise when the system would no longer work. To obviate this, therefore, it is usual to pass the standing current from the screen feed potentiometer arrangement through the volume control resistance. This ensures that, despite the valve anode current reduction upon the increase of bias, sufficient current will still flow through the volume control for satisfactory operation.

Volume controls in L.F. circuits are usually of the potentiometer type, so are potentiometer connected. The method of connection of a potentiometer across a pickup, for example, is well-known, and is illustrated on several preceding pages. The resistance element of the component is connected directly across the pickup or source of signal, and voltage for the following L.F. valve is tapped off between one end of the element and the moving arm.

Between L.F. stages a similar arrangement is often employed, and the element of the volume control may serve as grid leak for the valve to the grid of which it is connected, the grid being wired to the moving arm. A similar connection is employed with diode rectifiers, since this use also comes within the L.F. category. The volume control resistance element then becomes what is known as the diode load (resistance) in most cases, although in some circuits it forms a shunt to the true diode load, and is only connected in parallel therewith with a condenser interposed.

Volume controls are also connected to loudspeaker circuits. If the loudspeaker circuit—and usually it is in connection with loudspeaker extension circuits that volume controls are required—is at high potential a volume control of about 25,000 Ω resistance will be required. If the loudspeaker extension is at low potential (the step-down transformer remaining at the receiver) with the line taken direct to the speech coils, a much lower volume control resistance at the speaker will be required.

The most satisfactory connection, in all such cases—the value of volume control having been decided upon—is the potentiometer method. The complete volume control resistance element is connected across the extension line and the loudspeaker itself, or the speech coil of the speaker, is connected between one side of the volume control and the moving arm. Volume adjustment can also be effected by having a volume control in connection with loudspeaker extension used as a variable resistance connected in series with the speech coil.

A moment's consideration, however, will show that for full volume the resistance must be capable of being adjusted to zero Ω, while, for complete reduction of volume, that is to say to nil, the resistance should be capable of having almost infinite resistance in its maximum position.

Although transformer L.F. coupling is still largely used, it is no longer considered satisfactory to connect a volume control, even if of quite high resistance, across a transformer secondary because of the loading effect, usually with consequent loss of treble. It is sometimes advantageous to connect a condenser between the line and the moving arm of the volume control. The value of the condenser depends on the value of the volume control, nature of the impedance of the line of load, etc. With a pickup and a 50,000 Ω volume control, for example, it is sometimes advisable to connect a condenser of ·0005 μF. from the pickup lead which is not common to the set to the moving arm of the volume control.

With a ½-MΩ volume control having a diode load such a condenser connection (to retain treble) would employ a condenser of about ·0001 μF. Volume controls-with-switch are used in exactly the same way as ordinary volume controls and are generally available in the same resistance values. The switches, however, which are automatically operated upon initial rotation of the knob from the low-volume end, give another necessary control without an extra knob. Some precautions are necessary when using these, since the switches are off when opening actual mains current, while the volume control connections may be in the grid circuit. Unless due care is paid to wiring, etc., hum may be introduced. It is therefore sometimes necessary to screen the mains leads, and in any case to keep them as far as possible away from grid wiring.

When a volume control has a metal cover or plate it should be earthed or connected to chassis. This largely avoids hum and prevents self-oscillation in certain circuits.

SIGNS AND SYMBOLS