RADIO CIRCUITS
AND DATA

BY

C. A. QUARRINGTON
A.M.Brit.I.R.E.

A recognised Authority on Radio and Television
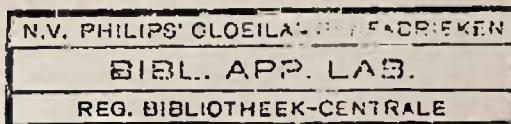
THE CAXTON PUBLISHING COMPANY, LIMITED
CLUN HOUSE, SURREY STREET, LONDON, W.C.2

The Publishers guarantee that the Binding, Printing, Paper, and Blocks for Illustrations used in this book are the products of British workers

Various circuits, devices and principles described in this volume form the subject-matter of letters-patent or provisional protection

FOREWORD

THE absence, among contemporary works on radio engineering, of a concise data book has become increasingly more apparent. It is true that numerous text-books contain a few tables, formulæ or other matter, but a shelf of books is necessary before all normal information of this class is available, and even then, much valuable time can be wasted in finding it ; when found it often leaves much to be desired, particularly from the point of view of covering modern needs or presenting facts and figures in a form that is immediately usable.

It is perhaps not unreasonable to form the conclusion that very little original work has been done on tabular data for more than a decade, old tables being published anew without being brought up to date or remoulded to suit changing needs.

The aim of this small volume has been twofold. Firstly, to present a very carefully selected series of circuits, data and formulæ ; and secondly, to reshape information so that it covers present-day requirements, is freed from errors and inconsistencies of the past, and in addition, includes both English and American standards.

The very complete index which follows these remarks permits quick reference to the information required, since the cross indexing reveals the presence of any particular subject under any reasonable heading. The main subjects are, however, briefly described below.

(i) A representative selection of the circuits of modern receivers marketed by Britain's leading radio manufacturers is included primarily to illustrate present-day design tendencies.

(ii) A selection of useful circuits designed to perform a variety of functions.

(iii) A selection of relatively simple test gear circuits with full component values.

(iv) Formulæ and data selected and presented in such a manner that considerable saving of time can be effected by regular use. Particular care has been taken to so devise tables that all related data are available in a single table. The author wishes to thank Mr. S. S. D. Jones, M.A., of St. Peter's Hall, Oxford, who checked the formulæ and made a number of useful suggestions.

(v) Valve equivalent tables and valve base connections.

This volume is essentially complementary to *Modern Practical Radio and Television*, since the latter is broad in its conception, whereas the former is precise in character and is intended for quick reference as opposed to systematic study.

<div align="right">

C. A. QUARRINGTON.

</div>

INDEX

References to Circuit Diagrams are shown in italics

INDEX

USEFUL CIRCUIT SECTION

THE following forty-one pages contain a selection of useful circuits presenting a broad picture of commercial practice and contemporary design and also show, by a series of " unit " circuits, everyday alternatives and refinements associated with specialised rather than domestic equipment. The commercial circuits in this section will also be found helpful when fault-finding, since the task of tracing connections without the assistance of the appropriate circuit diagram is simplified by reference to a selection of typical arrangements. A close study of these circuits will suggest ideas for the systematic stage-by-stage isolation of a faulty receiver, a procedure so essential to efficient servicing ; the use of the Information Bureau service for assistance when diagnosing a fault in a particular receiver is impracticable, since those who are able to select the appropriate facts and figures would not normally require such advice.

Commercial circuits which form the subject of pages 2–18 are followed by thirteen representative circuits ; four of these circuits are rearrangements of those published in *Modern Practical Radio and Television*, Chapter 5, Volume II, with component values added. The rearrangement has been undertaken, since the original circuits were designed for the sole purpose of forming a basis for comment, and many functions were deliberately duplicated for the purpose of broadening discussions. These rearranged circuits can be regarded as an individual interpretation of the original circuits, and form a most interesting subject for comparison.

In the various circuits illustrated in the following pages values have, of necessity, been specified, since in certain cases component values are peculiar to the valves selected. The author desires to make it clear, however, that he considers valves made by any member of the British Valve Association to be satisfactory providing, of course, they are associated with suitable component values. In short, the selection of valves in the following pages has been almost entirely influenced by the types in the author's possession.

Pages 32–42 contain a variety of " unit " circuits useful when modifying or adding to existing equipment, and much thought and trouble has been expended in selecting circuits that will have wide appeal. One or two circuits have, however, been added on account of their intrinsic interest and originality.

Component values have been specified in these " unit " circuits wherever possible. Where values are omitted, it is because they are influenced by the complete circuit of which these " unit " circuits are intended to form only a small part ; in nearly every case, however, the missing value can be determined from studying the fundamental principles involved in the relevant section of *Modern Practical Radio and Television*.

The author welcomes suggestions for " unit " circuits, or indeed any other items for possible inclusion in future editions of this data book.
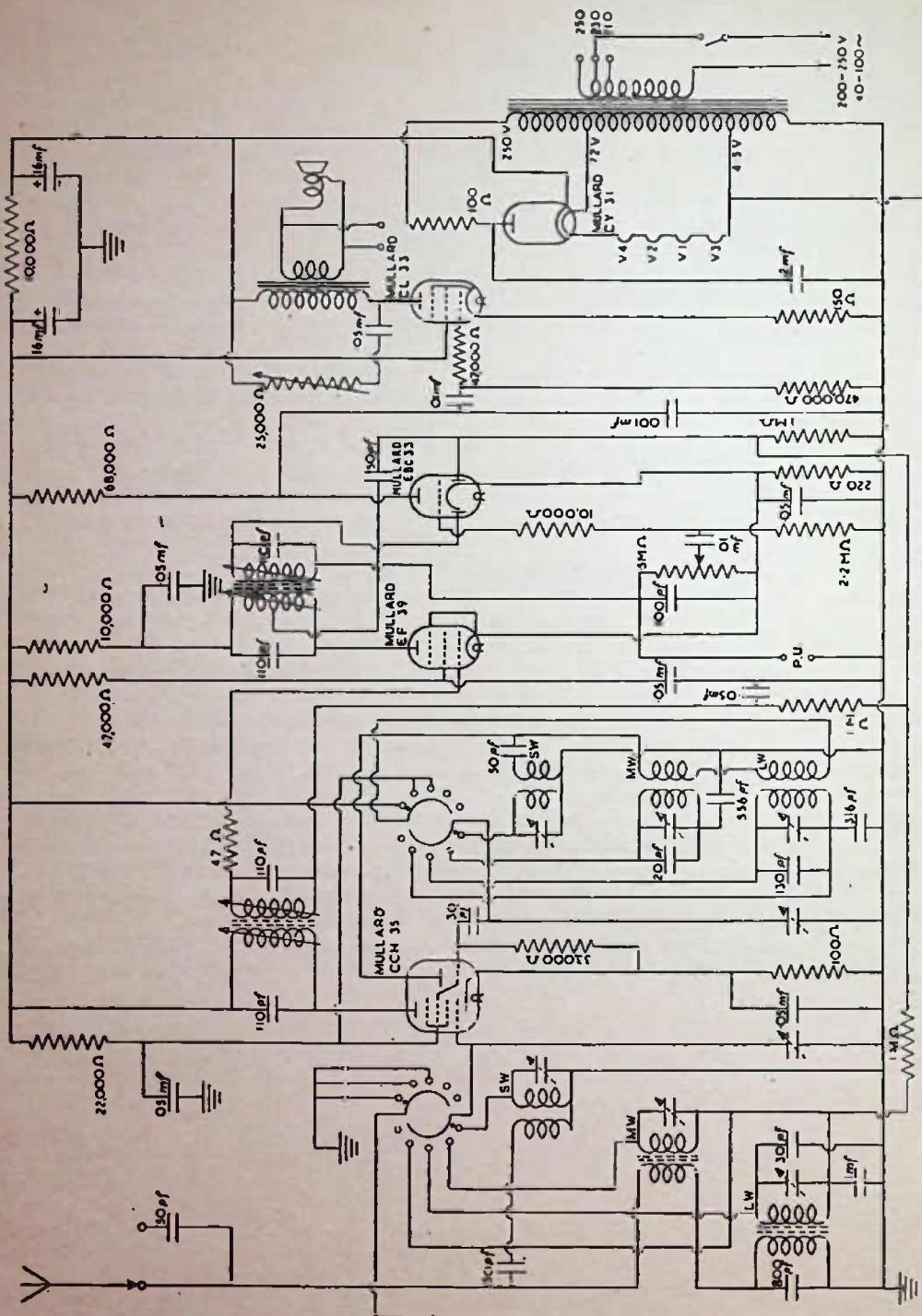
The Bush Model A.C.81

Attention is drawn to the output stage in which negative feedback is introduced by the omission of a cathode by-pass condenser; note that the output valve anode is fed from the unsmoothed side of the H.T. supply, also the parasitic stopper in the I.F. amplifier grid lead.
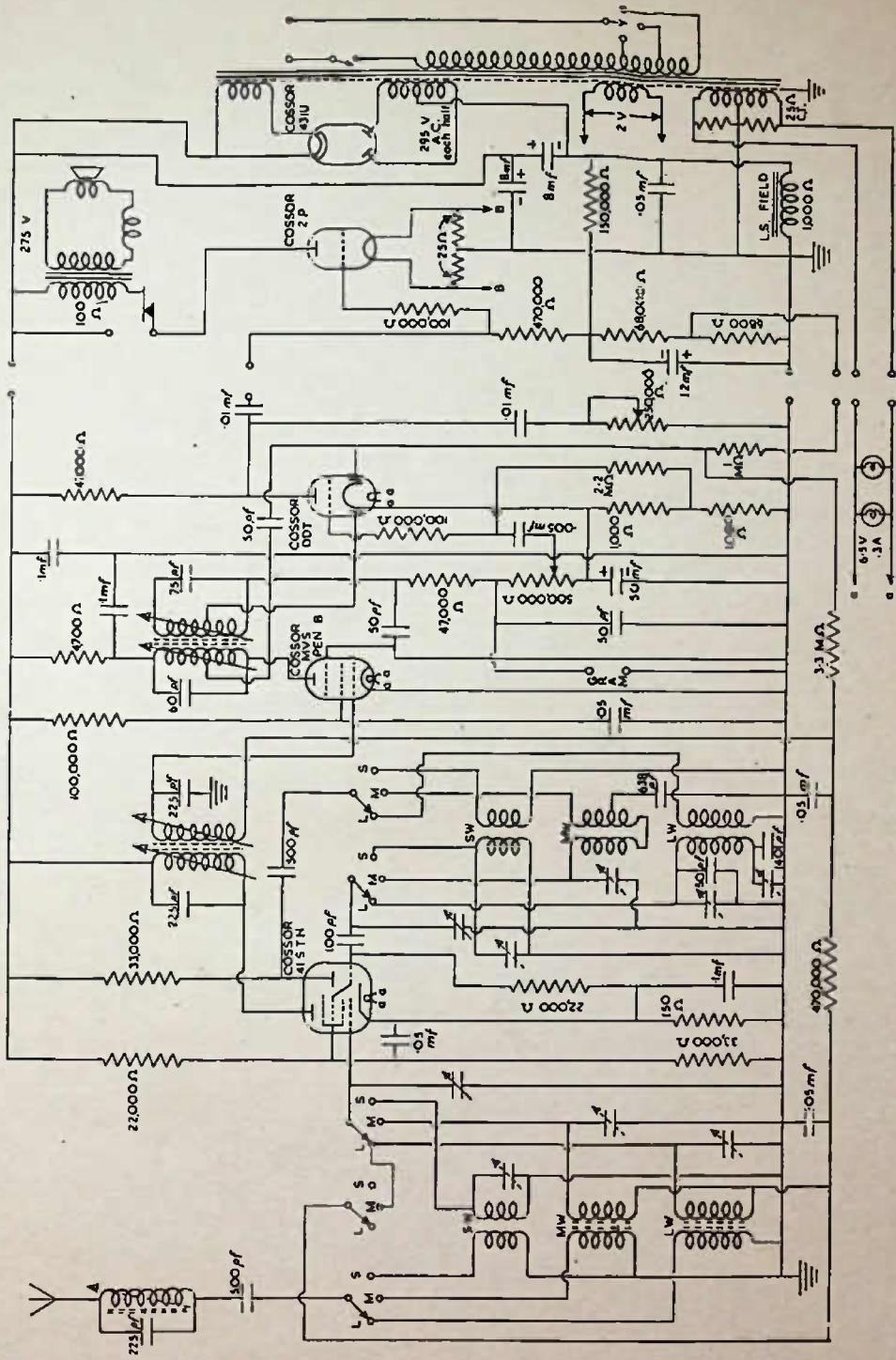
The Cossor Model 456 A.C.

Note the directly heated low filament voltage output valve, the bias for which is developed across the loudspeaker field coil placed in the negative H.T. lead.
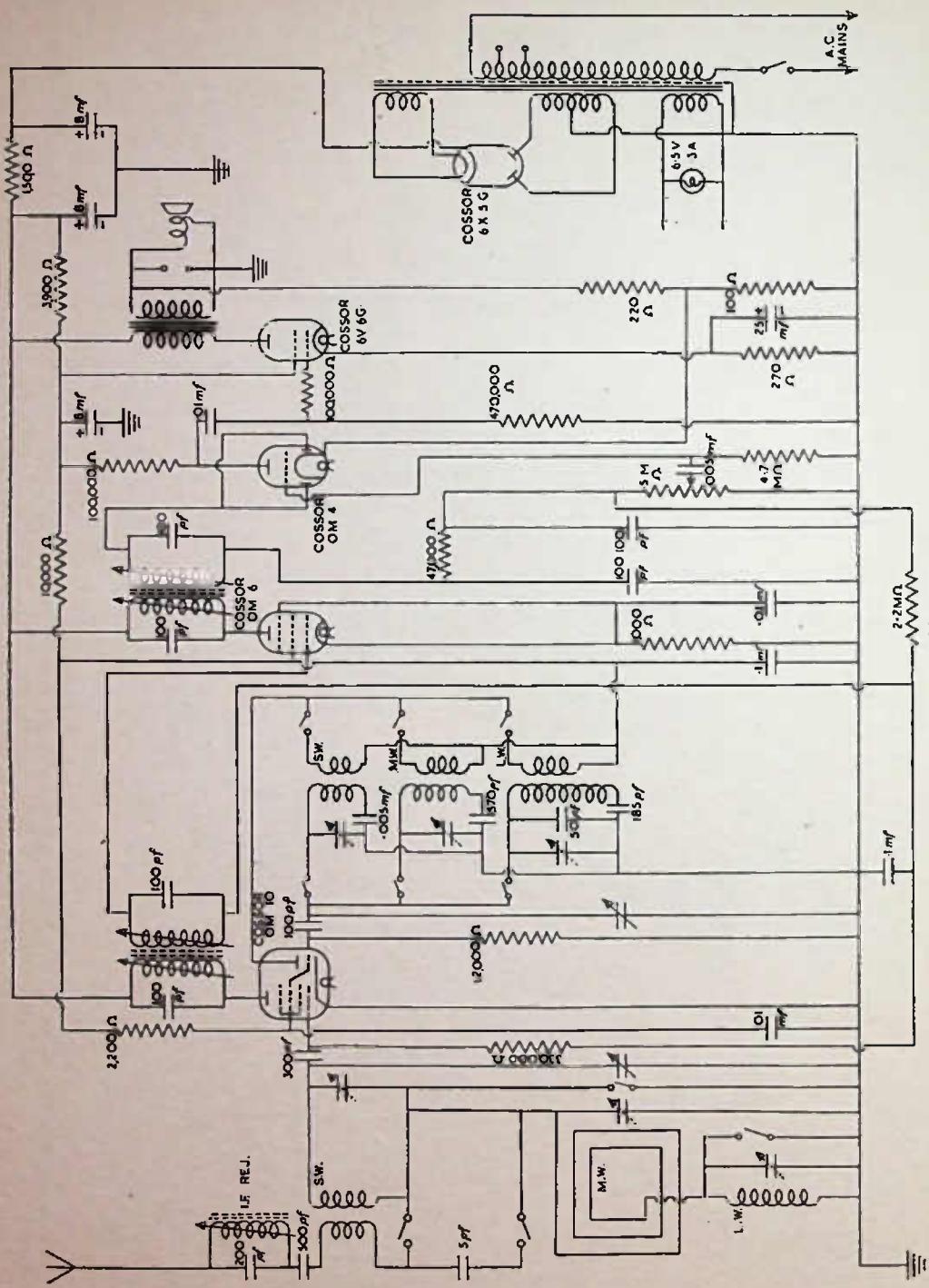
THE COSSOR MODEL 404

The aerial circuit arrangements are interesting and are worthy of careful study. Attention is also directed to the method of applying negative feedback and the resistance capacity two-stage H.T. smoothing.

4
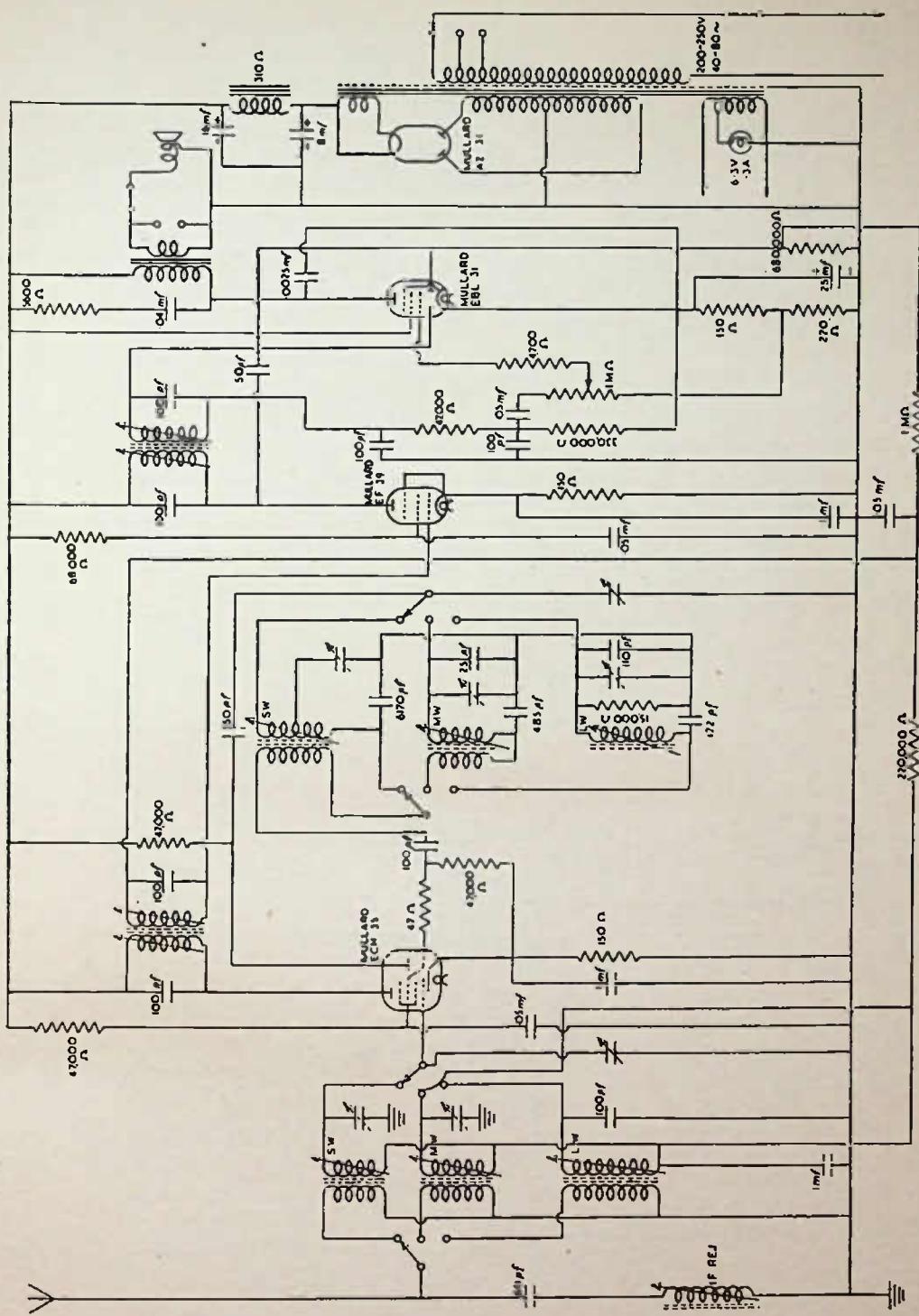
THE EKCO MODEL A22

Points of interest are the oscillator coupling and the method of obtaining negative feedback.

5
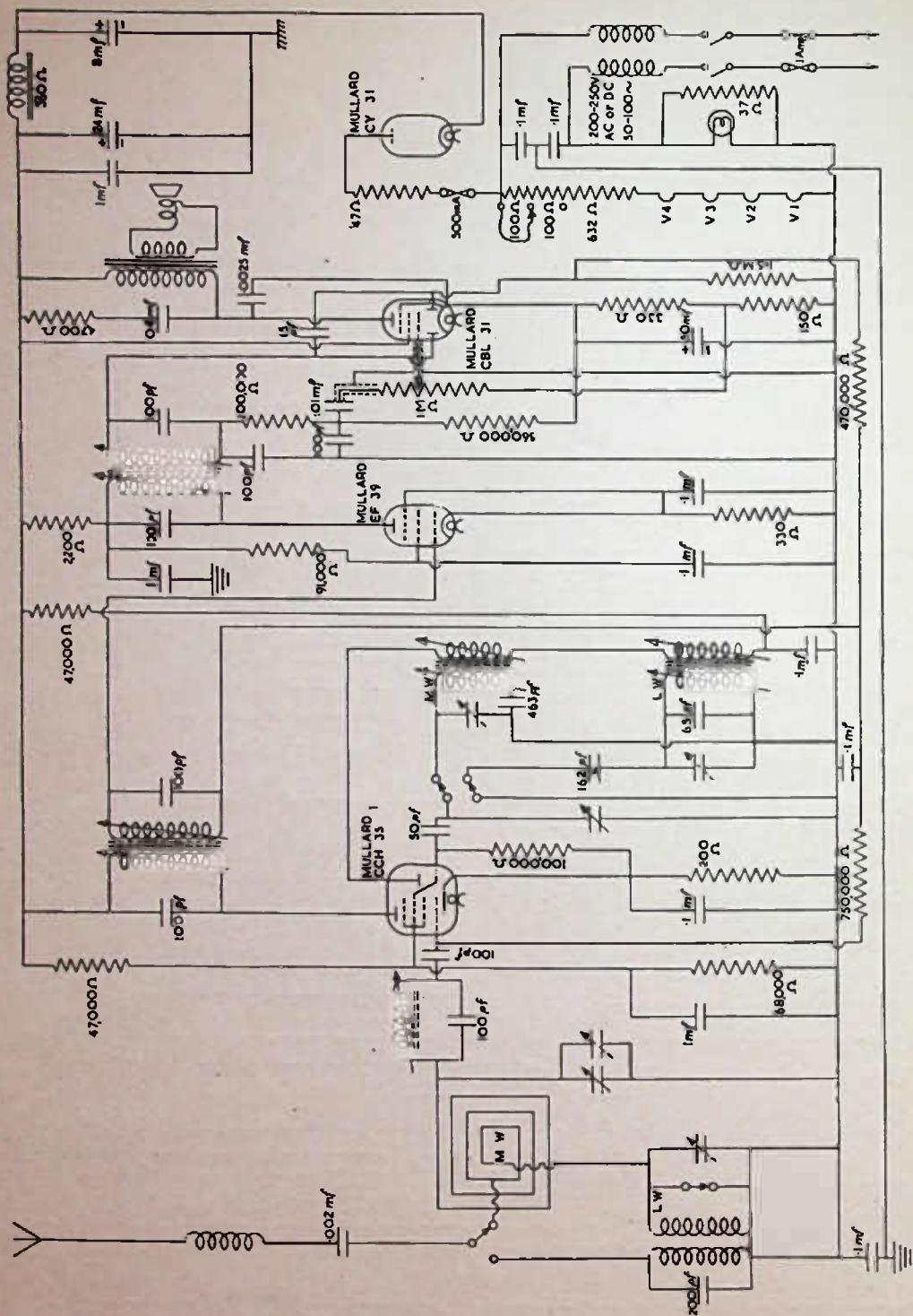
THE EKCO MODEL U29

Note the rejector inductance in the aerial lead and the position of the I.F. rejector circuit between the frequency changer grid and aerial circuit. Observe that fuses are provided in both mains leads and rectifier anode lead, observe also the mains filter.

6

The Ferguson Model 450
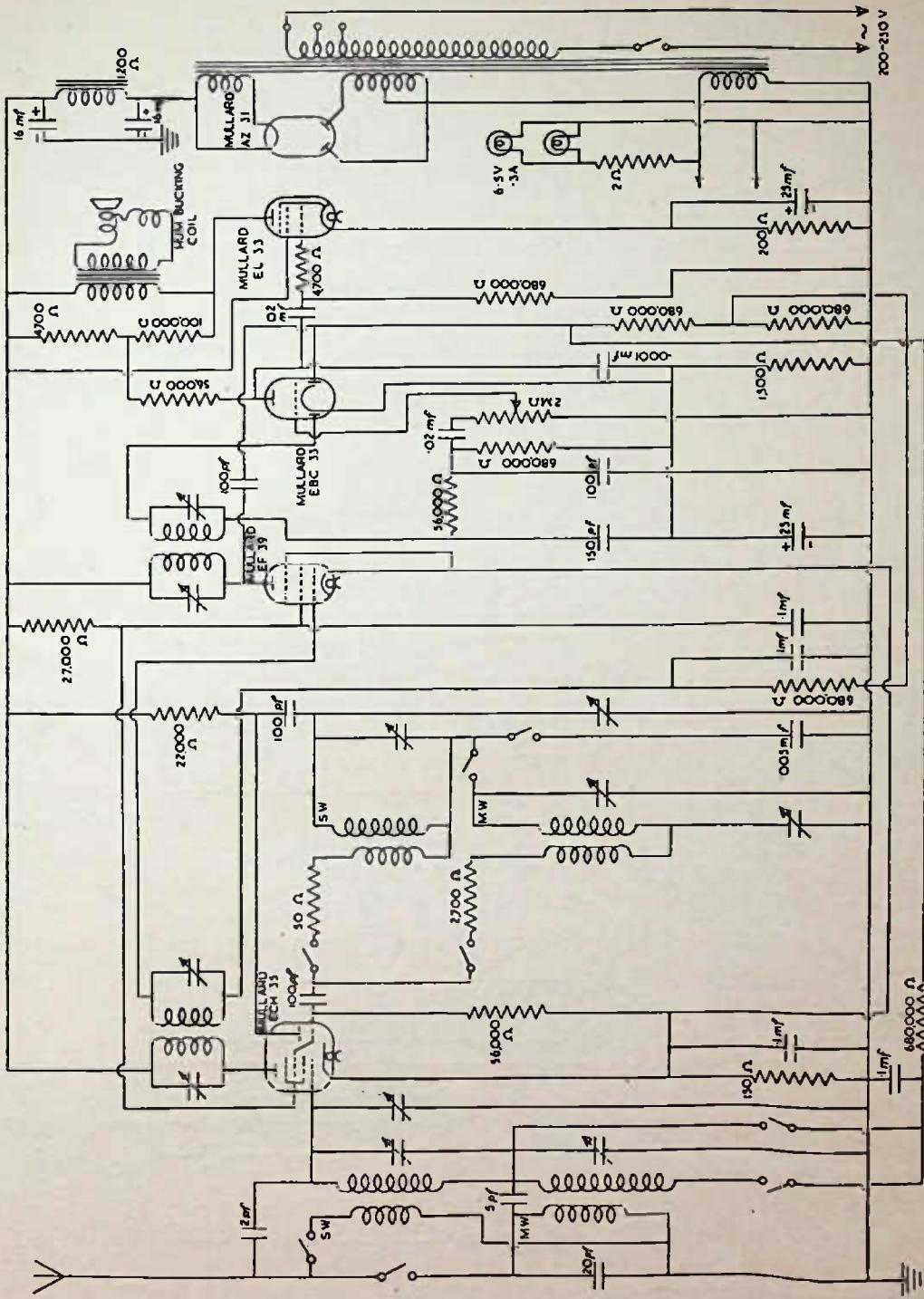
Points of interest are the use of very small condensors in the design of the aerial couplings, anti-squegging resistance in the oscillator grid circuits and the series negative feedback arrangements.
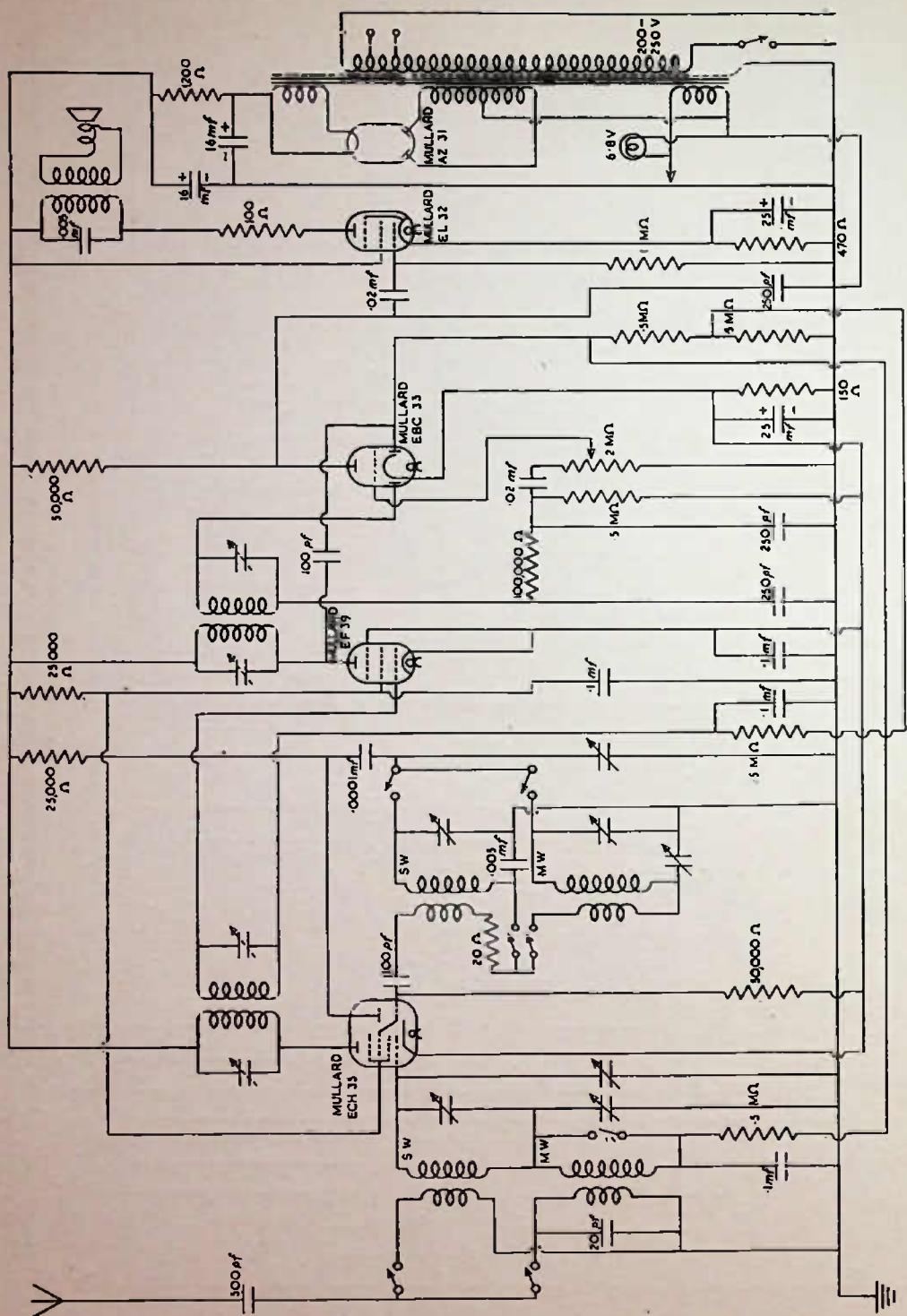
THE FERGUSON MODEL 910

Points to note are parasitic stoppers in the oscillator grid and output anode circuits, resistance capacity smoothing and the fact that A.V.C. is derived from the anode of the I.F. amplifier to reduce sideband shriek when tuning.

8
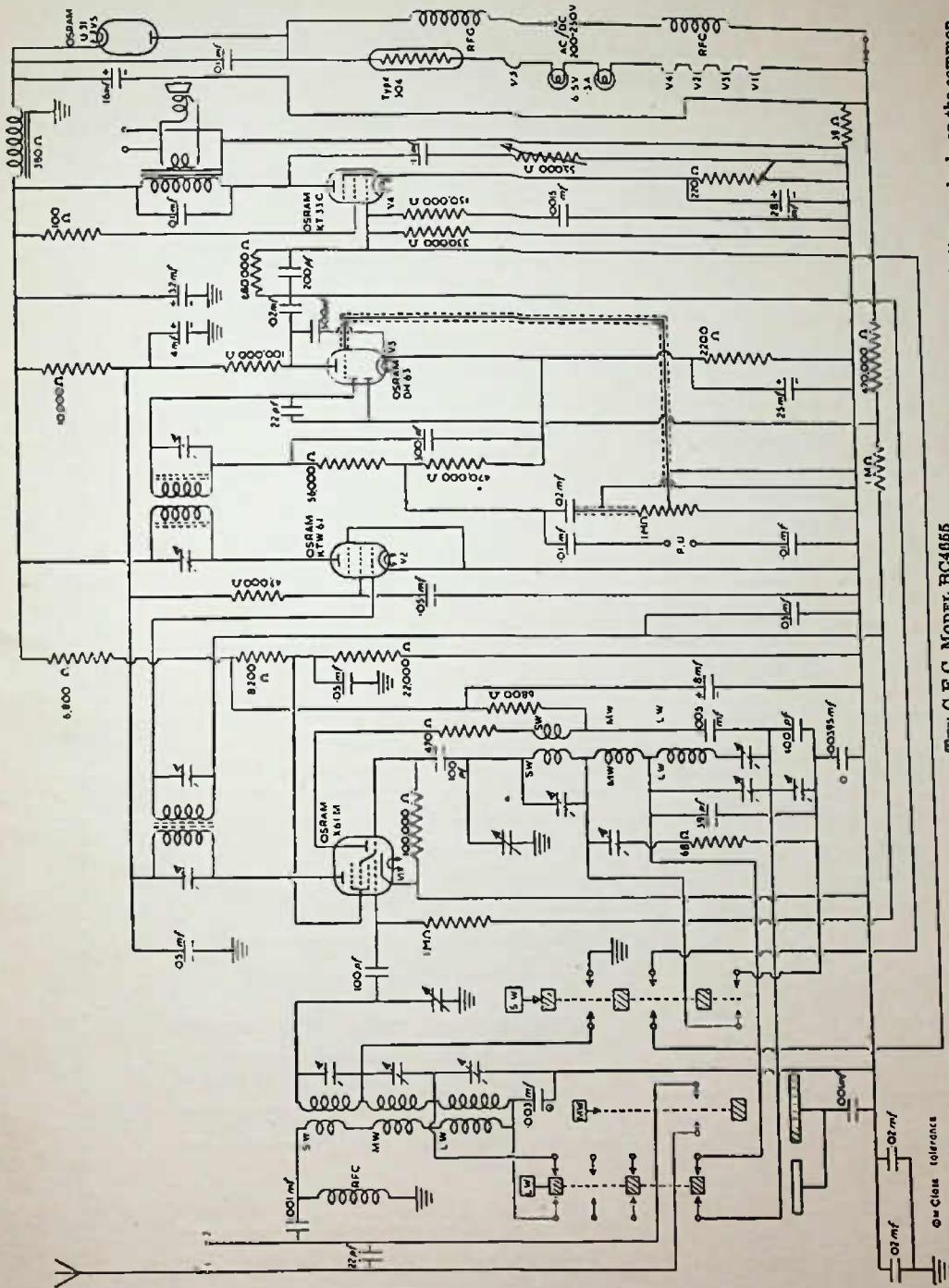
THE G.E.C. MODEL BC4055

Both aerial and oscillator coupling is unusual, the medium and long wave sections have only single turn primary windings and rely on the common impedance of the condensers marked close tolerance. Attention is also drawn to the R.F. choke in the aerial circuit which eliminates any tendency to modulation hum.

9
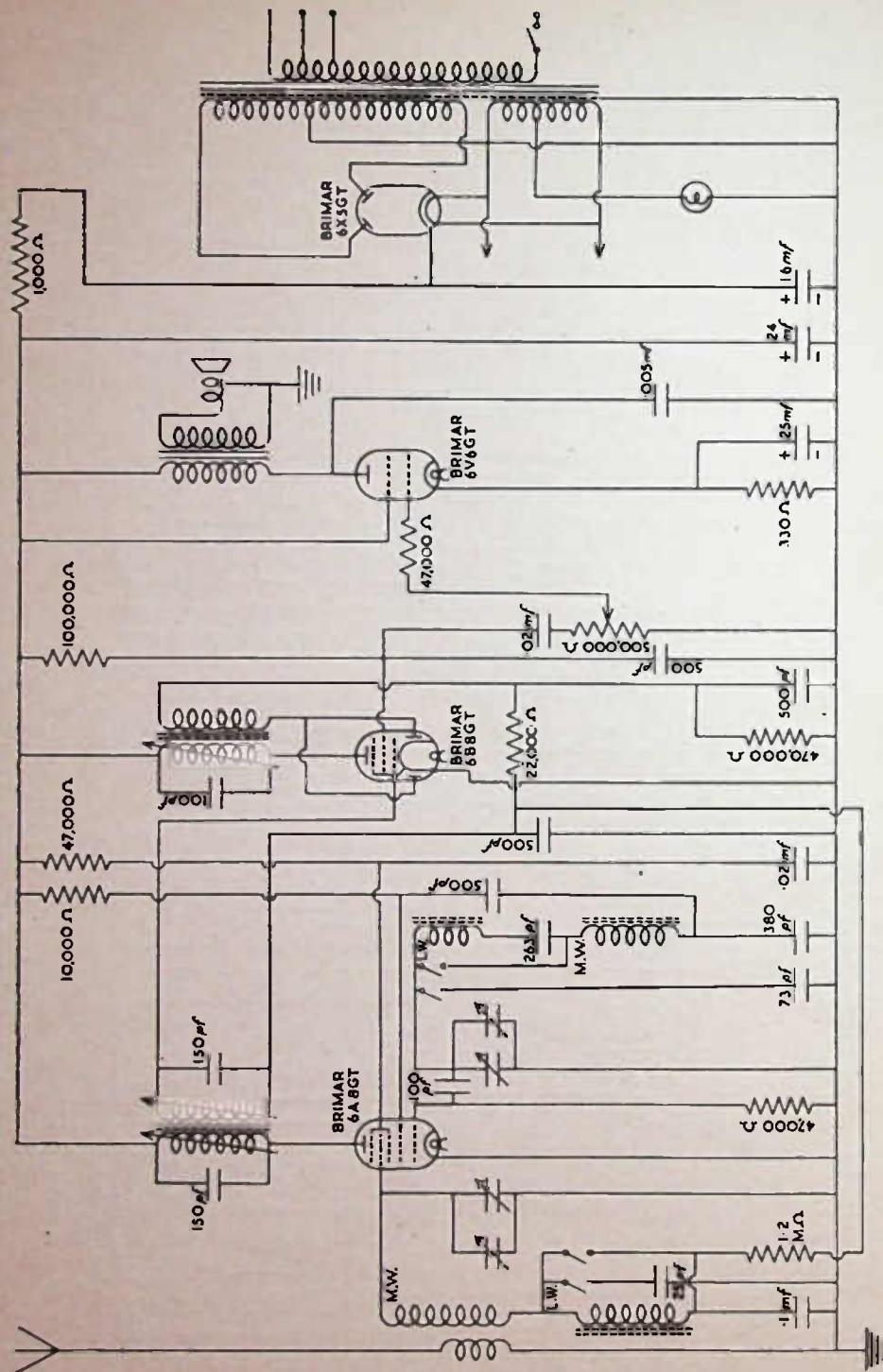
THE KOLSTER-BRANDES BM20

Note particularly the middle stage, which is reflexed, being an I.F. amplifier and a L.F. amplifier; the screen acts as the anode for the latter function.

10
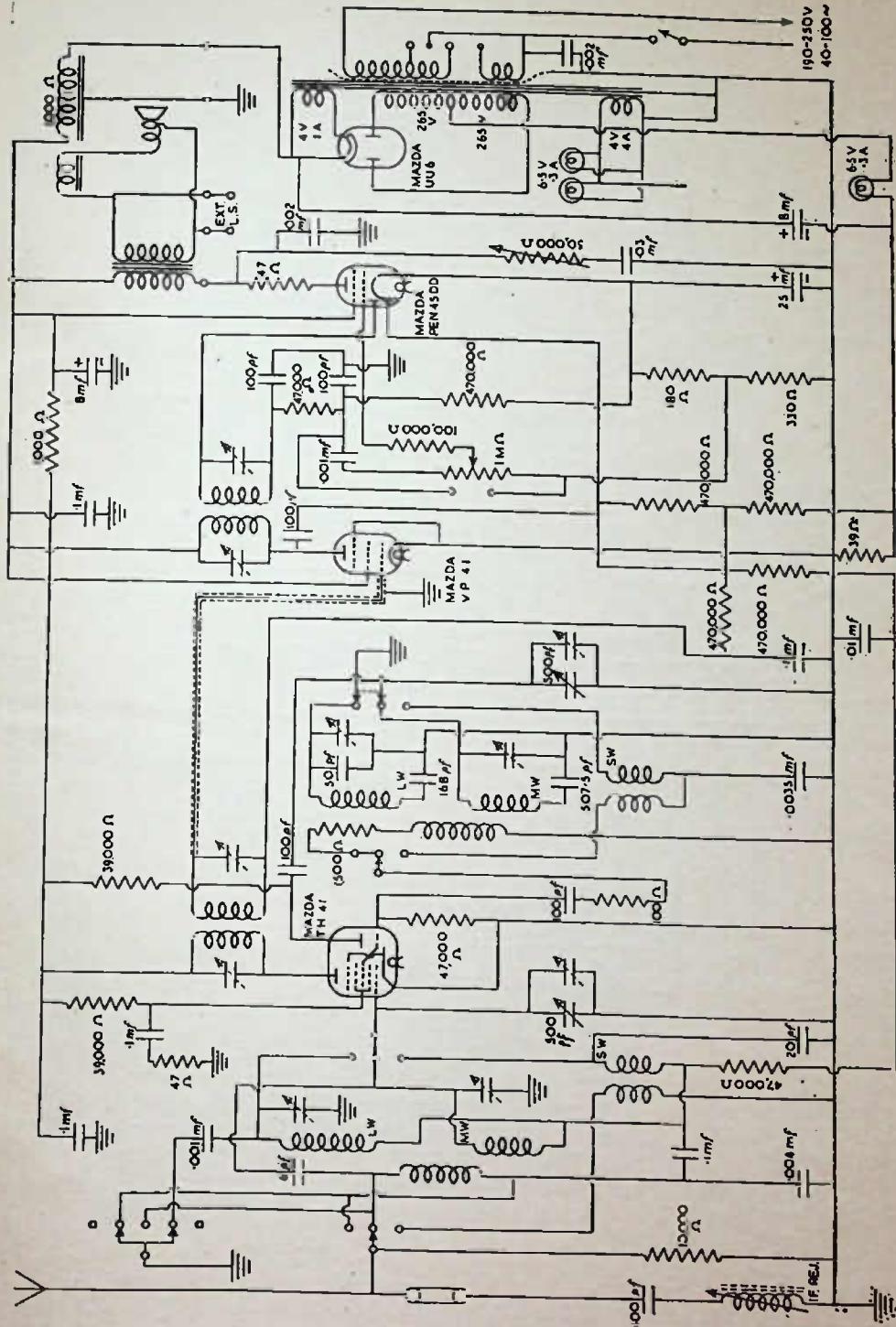
THE McMICHAEL, MODEL 451

There are many detailed points of interest in this circuit, but attention is directed to the aerial circuit and switching, the output valve grid circuit and the mains transformer primary.
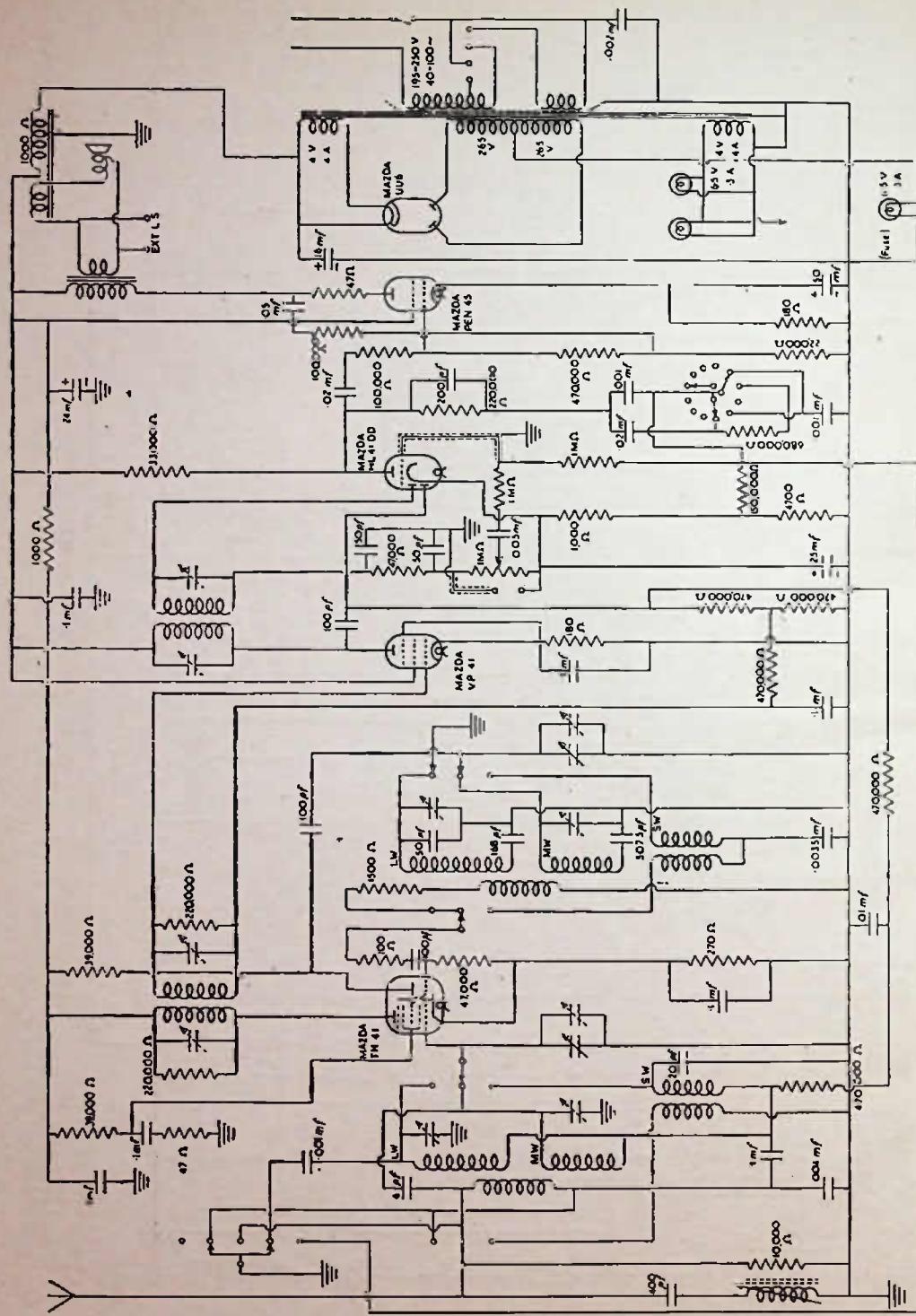
THE McMICHAEL MODEL 452

Note parasitic stoppers in the frequency changer screen load and output valve anode load, also anti-squegging resistance in the oscillator grid circuit. The resistance condenser combinations given by the four-position tone control are of interest; note that negative feedback is employed.

12
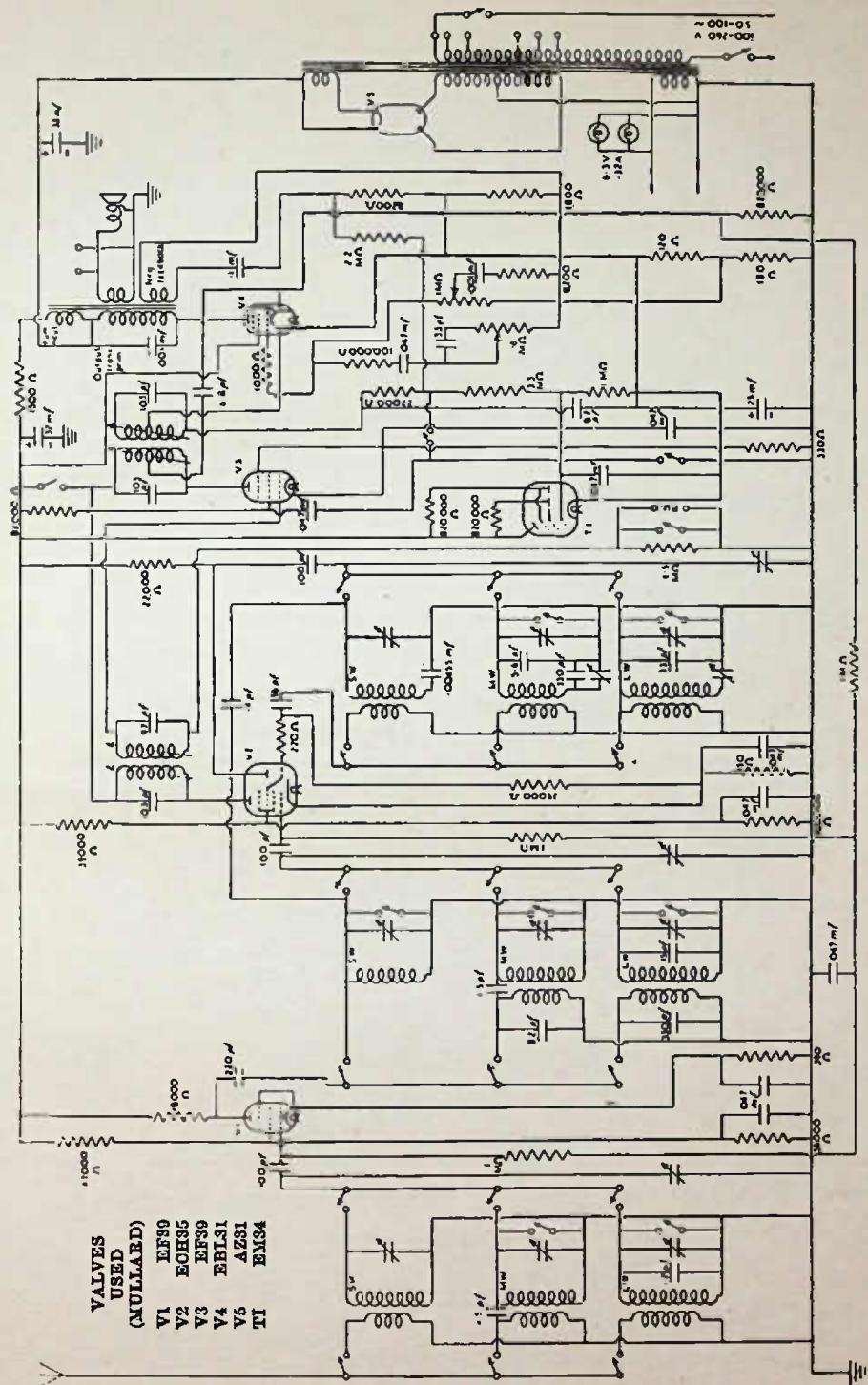
THE PHILIPS MODEL 170A

The negative feedback arrangements are an interesting object-lesson in circuit design; the volume control is compensated by automatically varying negative feedback and the tone control operates by varying the amount of negative feedback at higher frequencies. Note also the hum neutralising arrangements.

VALVES
USED
(MULLARD)
V1 EF39
V2 ECH35
V3 EF39
V4 EBL31
V5 AZ31
TI EM34

13
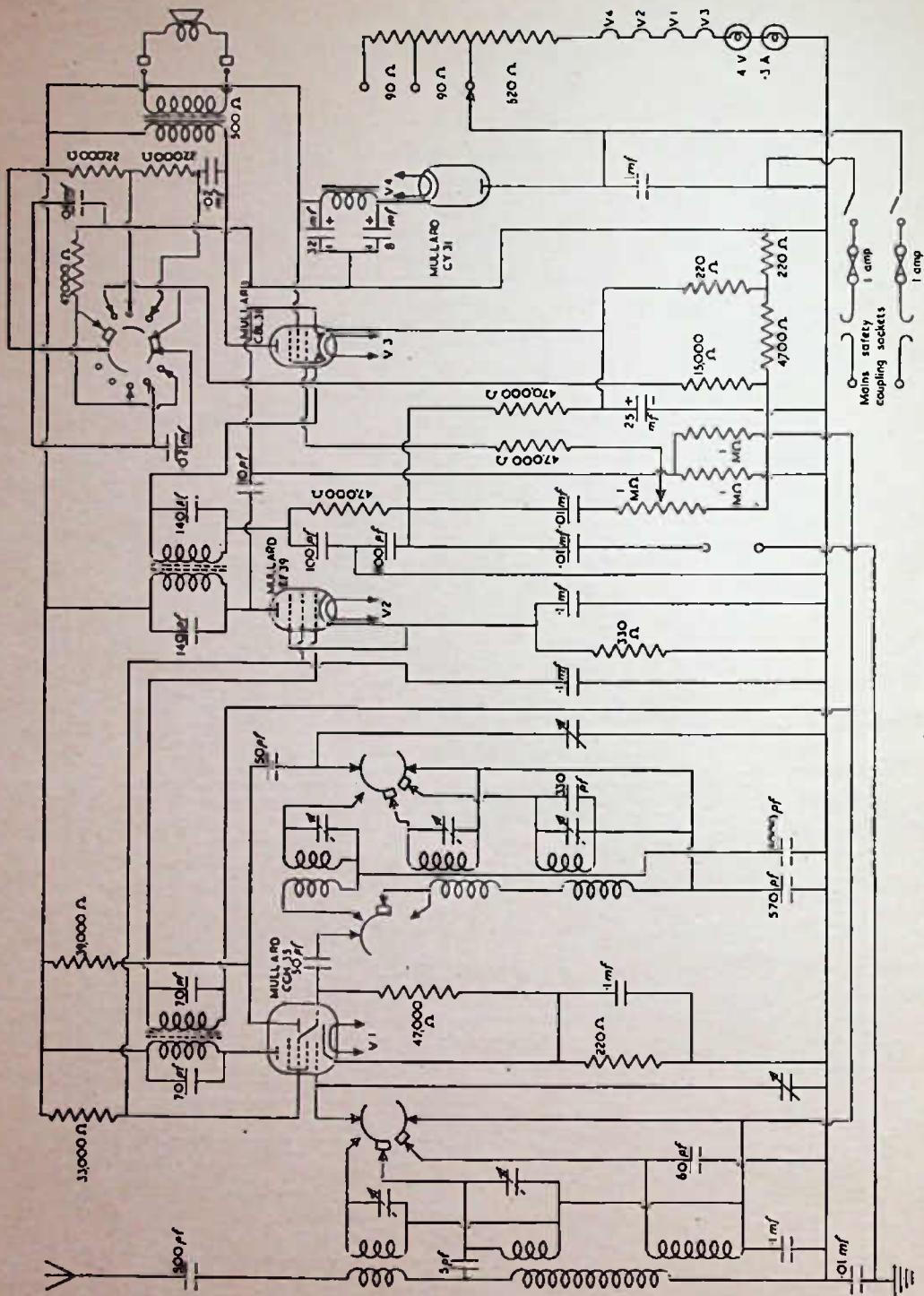
The Pye Model 45A

Like the model 15A, attention is drawn to the tone control arrangements. These two circuits form an interesting comparison between A.C. and D.C./A.C. working.

14
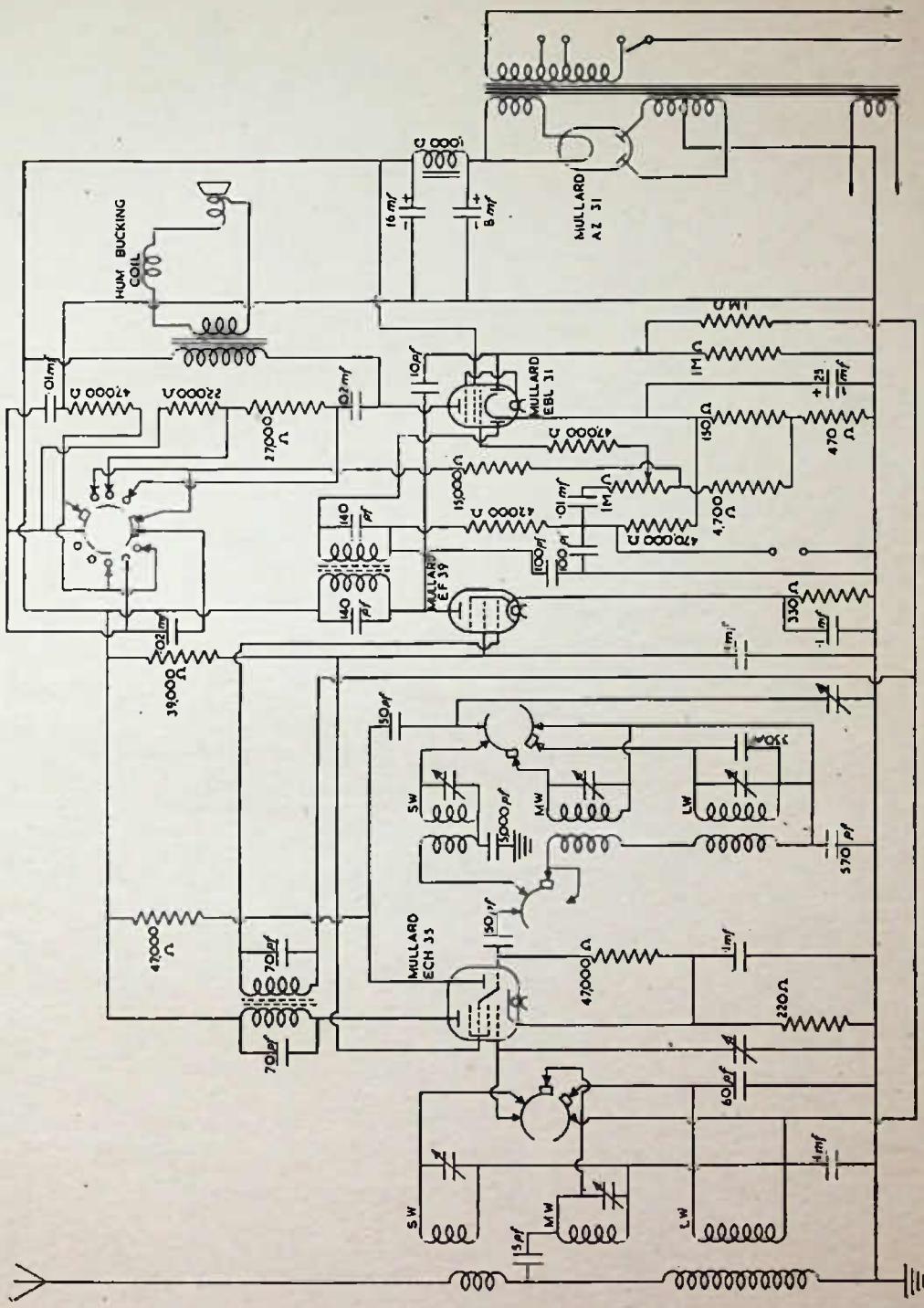
The Pye Model 15A. Attention is directed to the tone control switch, which has four positions. It is well worth following out the connections for each position.

15
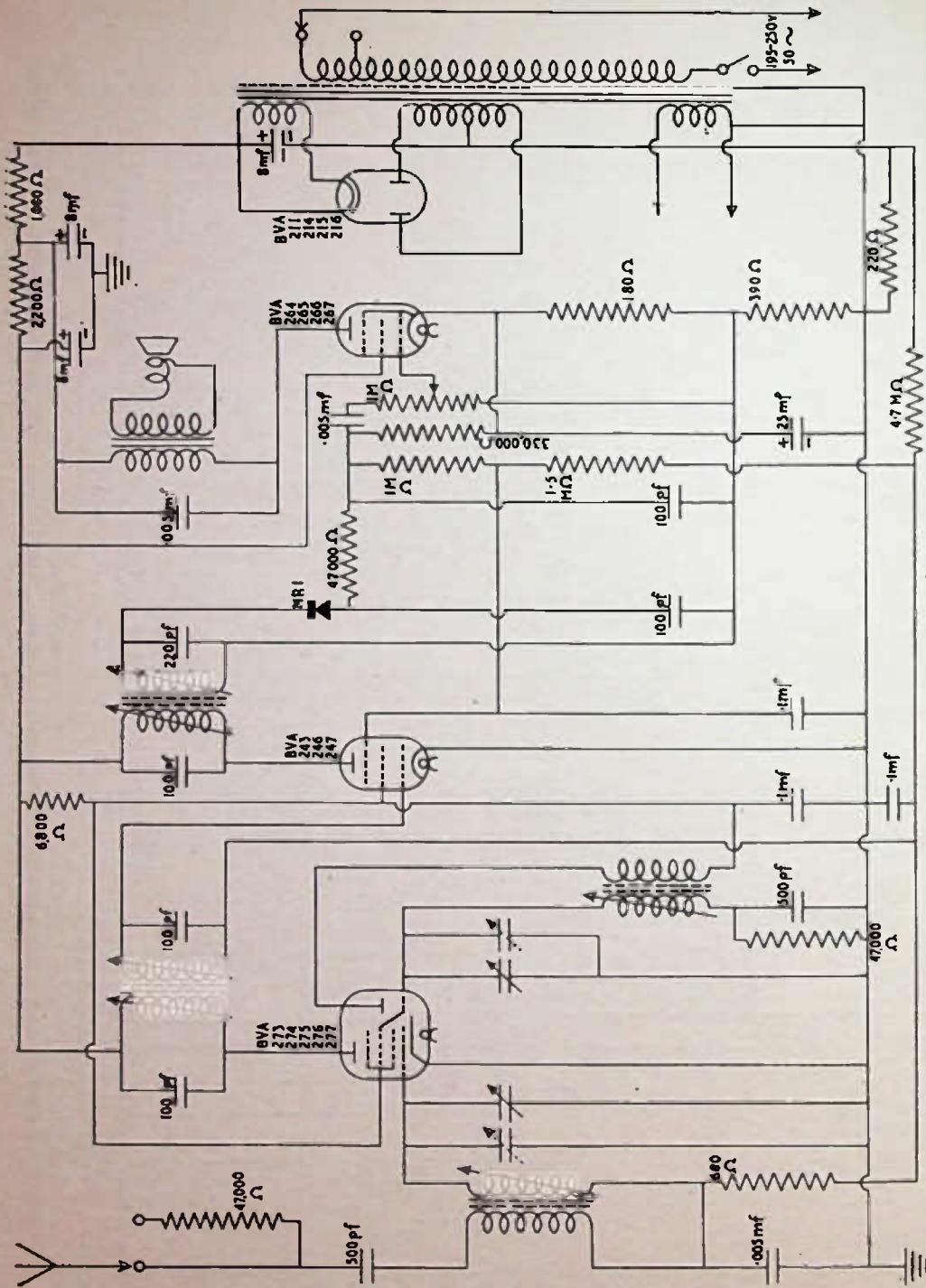
STANDARD WAR-TIME A.C. RECEIVER

This circuit is included as an example of austerity and because of certain ingenious features, notably the use of the I.F. amplifier suppressor (acting in conjunction with the cathode as a diode) to produce A.V.C. The MR1 is a metal oxide detector. This receiver was manufactured by a number of firms who introduced sundry variations.

16
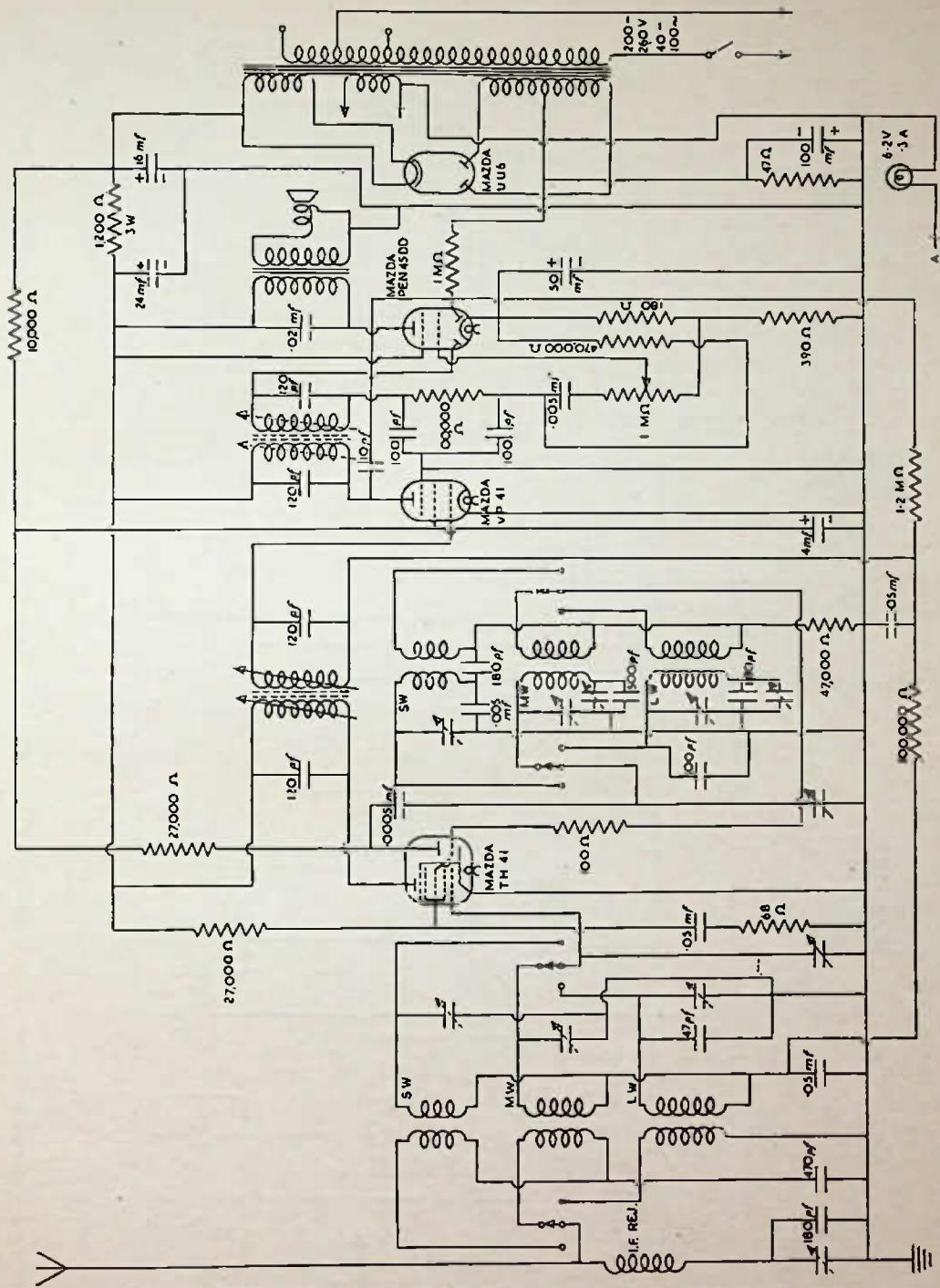
THE ULTRA MODEL T401

Note parasitic stopper in the frequency changer screen lead and anti-squegging resistance in the oscillator grid load. The biasing of the frequency changer and I.F. amplifier and the A.V.C. delay arrangements are additional points of interest.

17
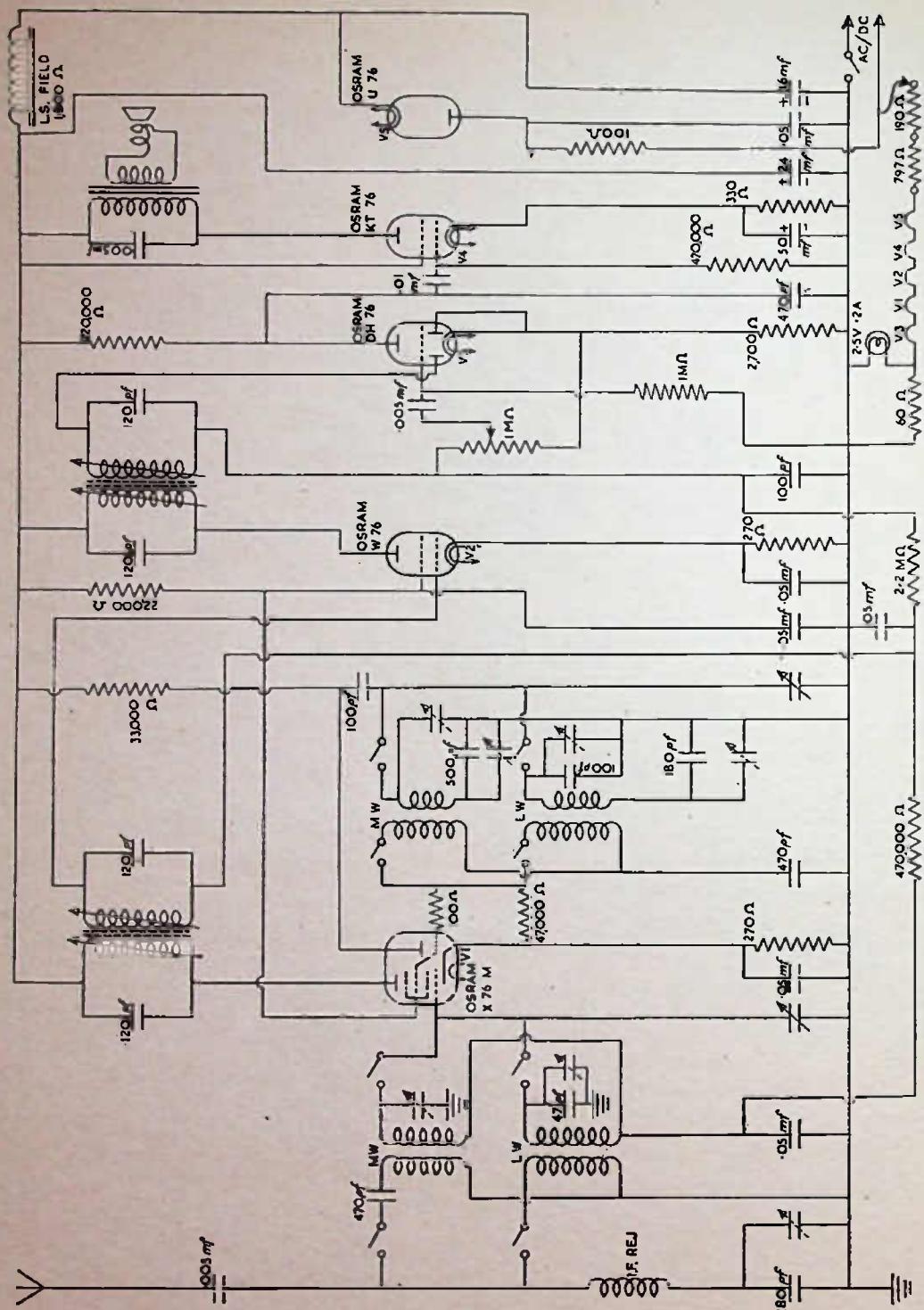
THE ULTRA MODEL U405

Note the anti-squegging resistance in the oscillator grid and the deliberate omission of the by-pass condenser across V3 cathode, introducing negative feedback.

18
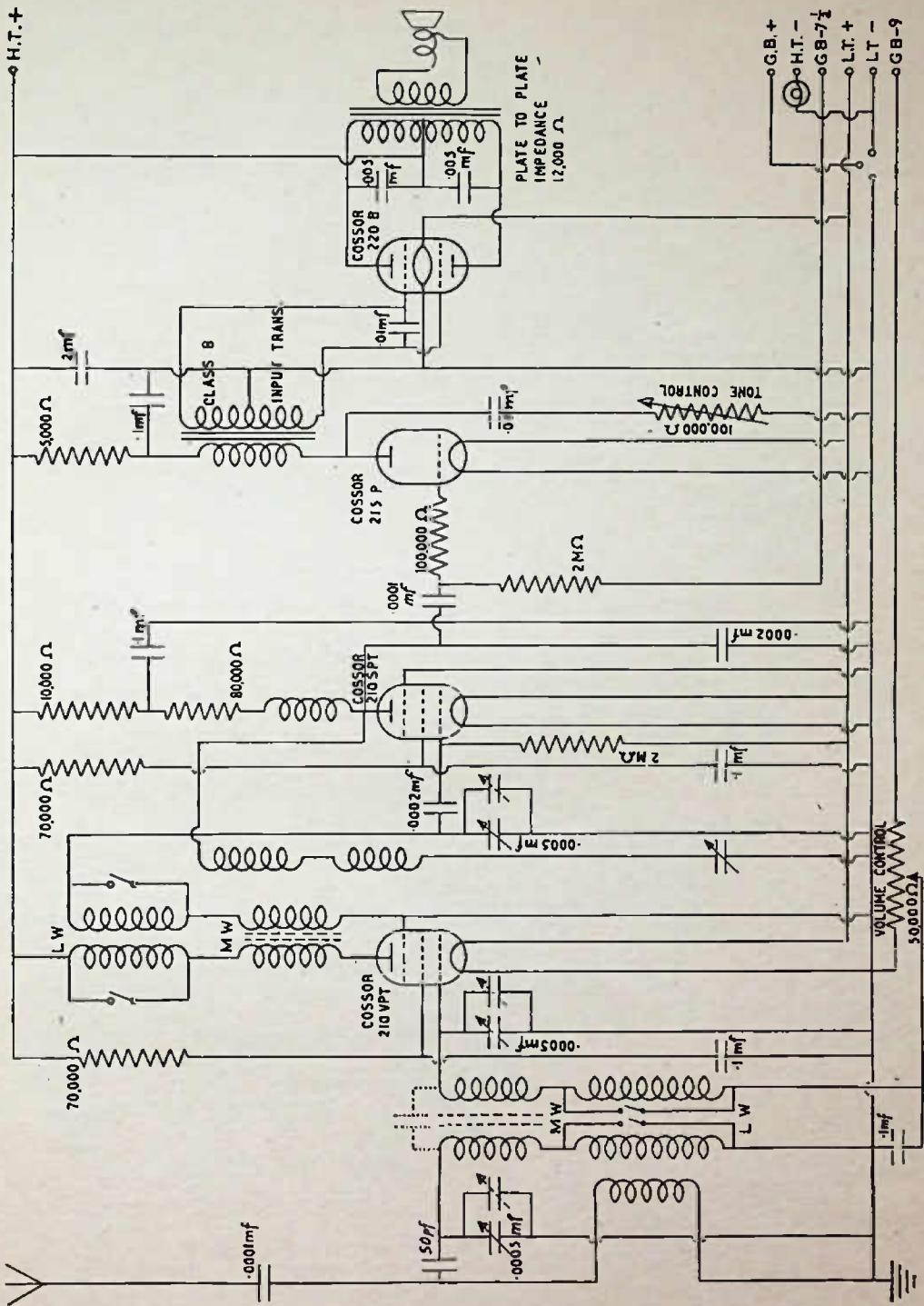
4V Class B Receiver

A slight rearrangement of the class B receiver, shown in Chapter 5, Volume II, but with component values added. The aerial circuit uses bandpass coils which sometimes require small additional capacitive coupling, usually about 5 pf, shown dotted in the above illustration.

19
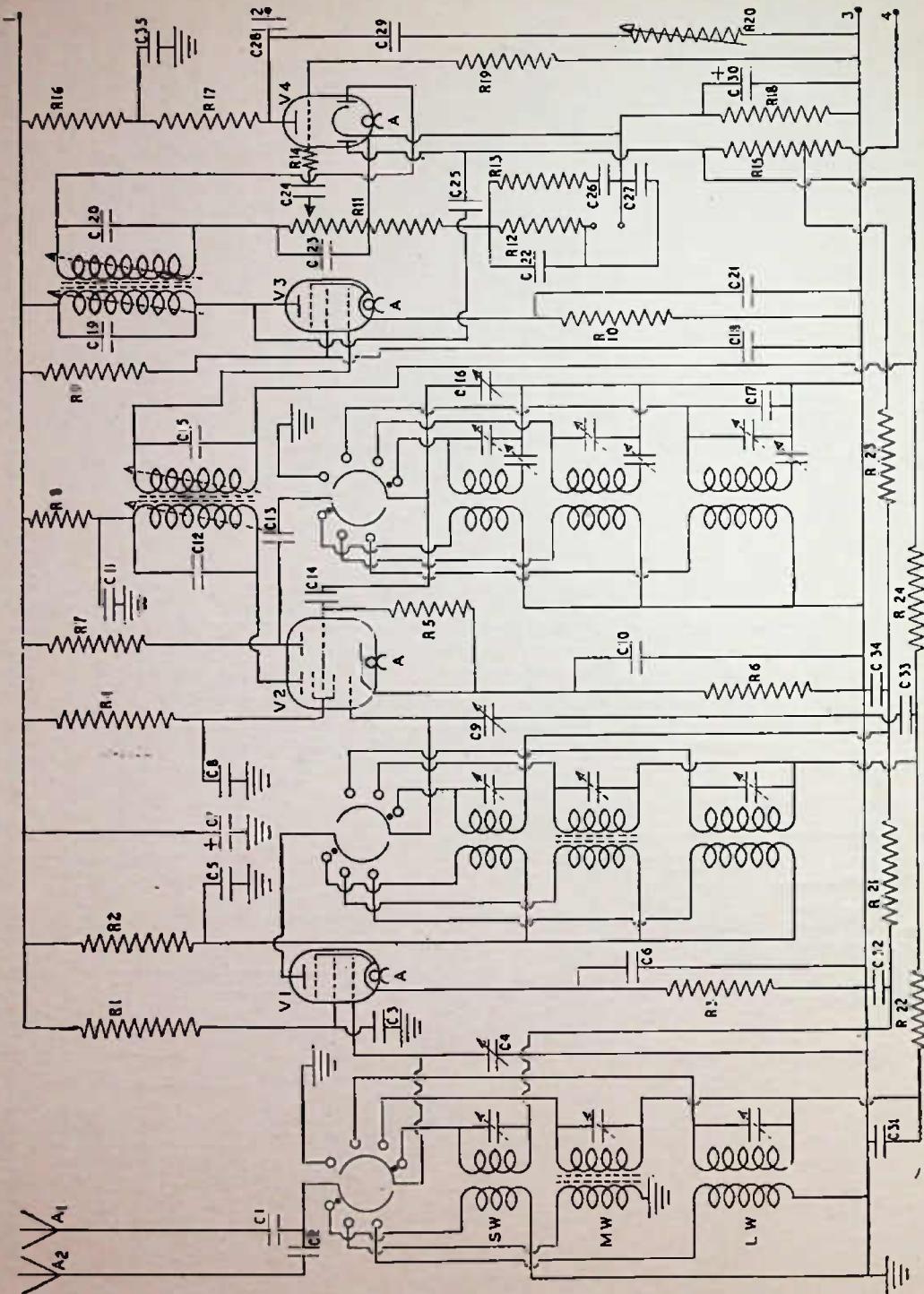
7 + 1 Valve, 3-band Receiver

The output section and component values are on the facing page.

20

7 + 1 Valve, 3-band Receiver
(12 watt, push-pull output)

This circuit is included in response to numerous requests for more details of the circuit shown in Chapter 5 of Volume II; it is presented, however, without the automatic frequency control circuit and with other modifications, so that non-standard components have been excluded. The output stage has also been modified from 8 to 12 watts. Much of the text matter which accompanies the 10-valve circuit in Volume II applies equally to the rearrangement herewith. Triode output valves are used and although less efficient than tetrodes, they still enjoy considerable popularity where H.T. current is not of paramount importance.

Condensers

C1	= 100 pf	C29	= ·02 mf
C2	= 15 pf	C30	50 mf
C3	= ·1 mf	C31	= ·05 mf
C4	= TC*	C32	= ·03 mf
C5	= ·1 mf	C33	= ·05 mf
C6	= ·2 mf	C34	= ·03 mf
C7	= 10 mf	C35	= ·5 mf
C8	= ·2 mf	C36	= ·5 mf‡
C9	= TC	C37	10 mf
C10	= ·2 mf	C38	= ·075 mf
C11	= ·2 mf	C39	= ·075 mf
C12	= IFTC†	C40	25 mf
C13	= 100 pf	C41	16 mf
C14	= 50 pf	C42	4 mf
C15	= IFTC	C43	= ·1 mf
C16	= TC	C44	= ·1 mf
C17	= Padder‡	C45	= ·1 mf
C18	= ·1 mf		
C19	= IFTC		
C20	= IFTC		
C21	= ·1 mf		
C22	= ·01 mf		
C23	65 pf		
C24	= ·02 mf		
C25	= 75 pf		
C26	= ·1 mf		
C27	= ·01 mf		
C28	= ·03 mf		

Resistances (Ohms)

R1	= 15,000	R0	= 15,000
R2	= 5,100	R10	100
R3	100	R11	·5 + ·5 MΩ
R4	8,200	R12	10,000
R5	= 33,000	R13	3,300
R6	300	R14	47,000
R7	= 33,000	R15	1 MΩ¶
R8	5,100	R16	1 MΩ
		R17	56,000
		R18	2,000
		R19	1 MΩ
		R20	20,000
		R21	1 MΩ
		R22	1 MΩ
		R23	1 MΩ
		R24	1 MΩ
		R25	130,000
		R26	2,000
		R27	3,000
		R28	330
		R29	3,600
		R30	100,000
		R31	100,000
		R32	25
		R33	25
		R34	510
		R35	300
		R36	510
		R37	10
		R37	7,500

* Capacity of variable tuning condenser will depend on limits of bands to be covered and inductance of coils selected.

† Capacity as required to tune selected I.F. transformer to intermediate frequency to be used.

‡ Capacity as required to raise total padding capacity to required figure.

§ C36 may, with advantage, be connected across a portion only of R28 to provide a small amount of negative feed-back.

‖ Values shown are preferred values: close non-preferred values can be used with discretion.

¶ Tapped resistance gives any lesser degree of A.V.C. on shortwave band as desired. If very weak stations are required, move tap to top end of resistance and disconnect from grid of V1, when R3 should be ·00 Ω.

V1 Cossor MVS/Pen or MVS/Pen B
V2 Cossor 41 STH
V3 Cossor MVS/Pen or MVS/Pen B
V4 Cossor DDT
V5 Cossor 41MP **
V6 Mazda PP26/400
V7 Mazda PP5/400
V8 Mullard FW4/500

** The author has used a valve of this type for several years with complete success under conditions prevailing in this circuit; nevertheless, a considerable voltage difference exists between heater and cathode. It is advantageous, therefore, to supply the heater from a separate transformer winding, the centre tap being connected to chassis through a ·1 mf-condenser.

21
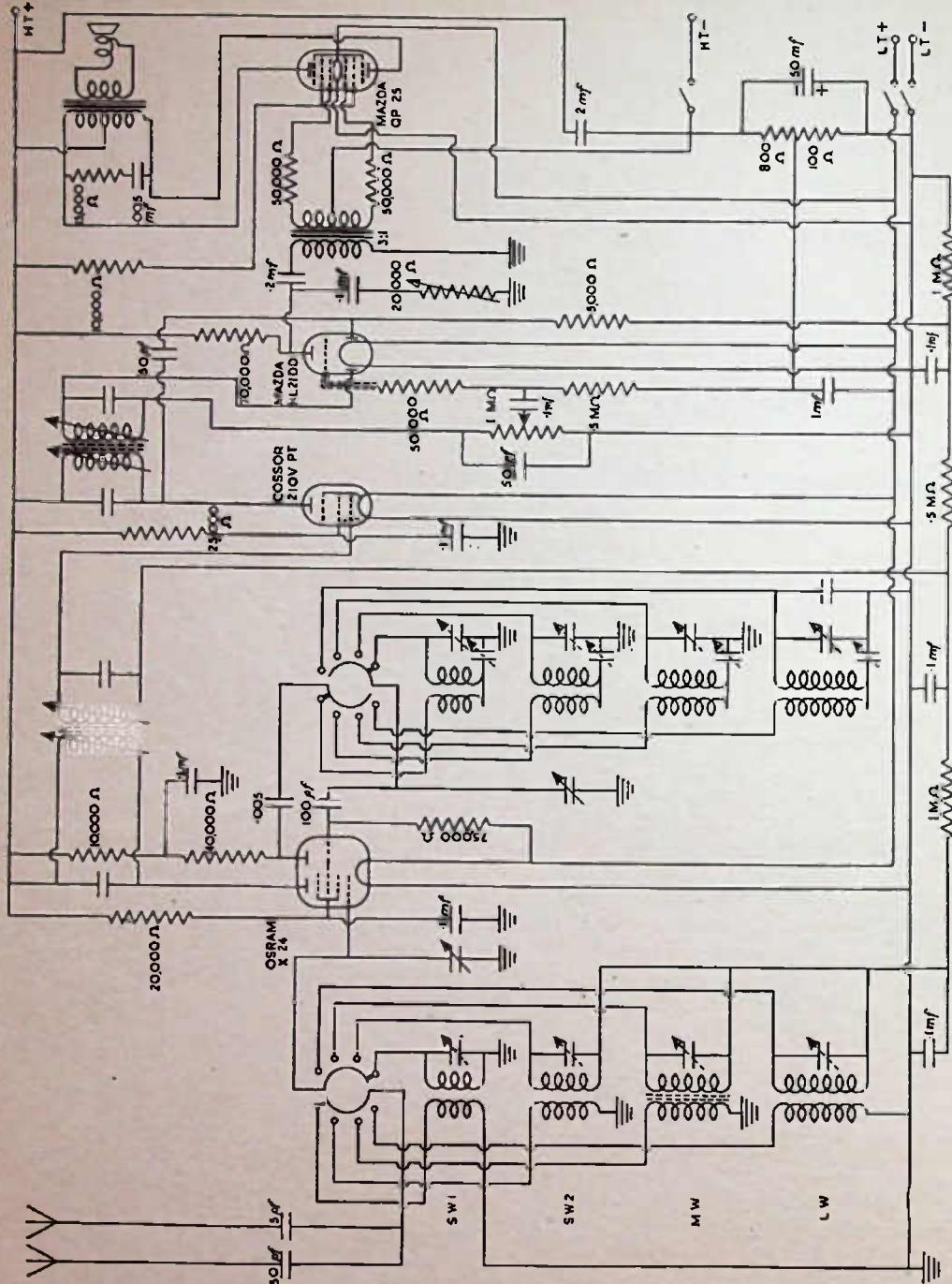
Q.P.P. Surriner Battery Receiver

A modification of the Q.P.P. receiver illustrated in Chapter 5, Volume II, but with typical values shown. Coils covering any desired number of wavebands can, of course, be used, and their selection will determine the values of the pre-set trimming and padding condensers. Should a frequency changer or I.F. amplifying valve be used of a type which passes grid current at zero grid volts, the lower end of the A.V.C. diode load resistance should be disconnected from L.T. — and connected to a point on the main bias resistance, which is just sufficiently negative to prevent the flow of grid current.
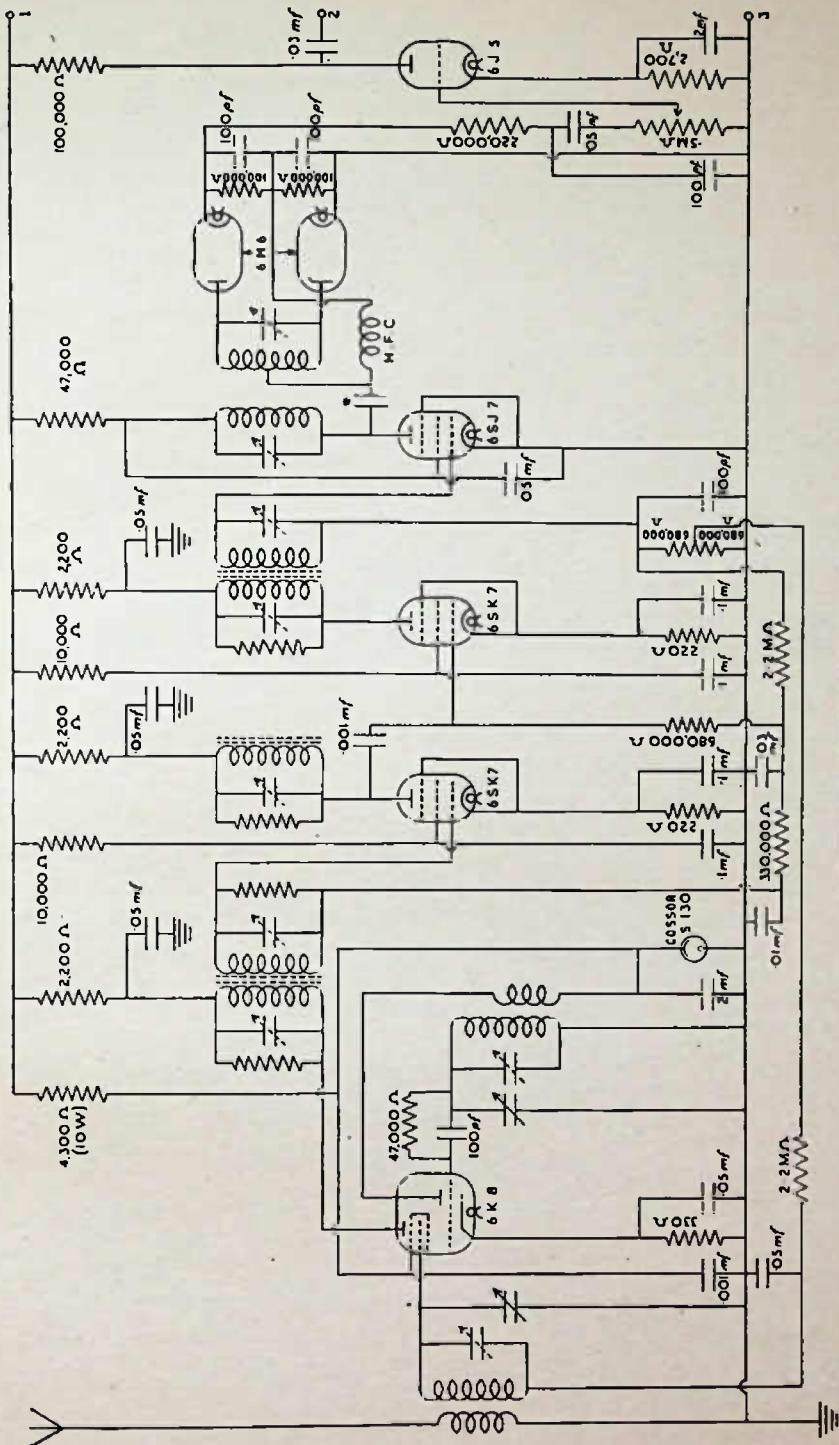
A TYPICAL WIDEBAND F.M. RECEIVER

This typical F.M. receiver is intended to be used with the output and power pack unit shown on page 21, which will need to be modified in the following way: Terminal 4, C44 and R38 are deleted and the points formerly bridged by R36 joined together; the value of R37 becomes 1,000 ohms. The H.F. and oscillator coils and the I.F. and discriminator coils will normally be part of a complete set designed for the waveband or bands to be covered; no value is shown for the condenser marked * as it will normally be an integral part of the discriminator coil assembly.
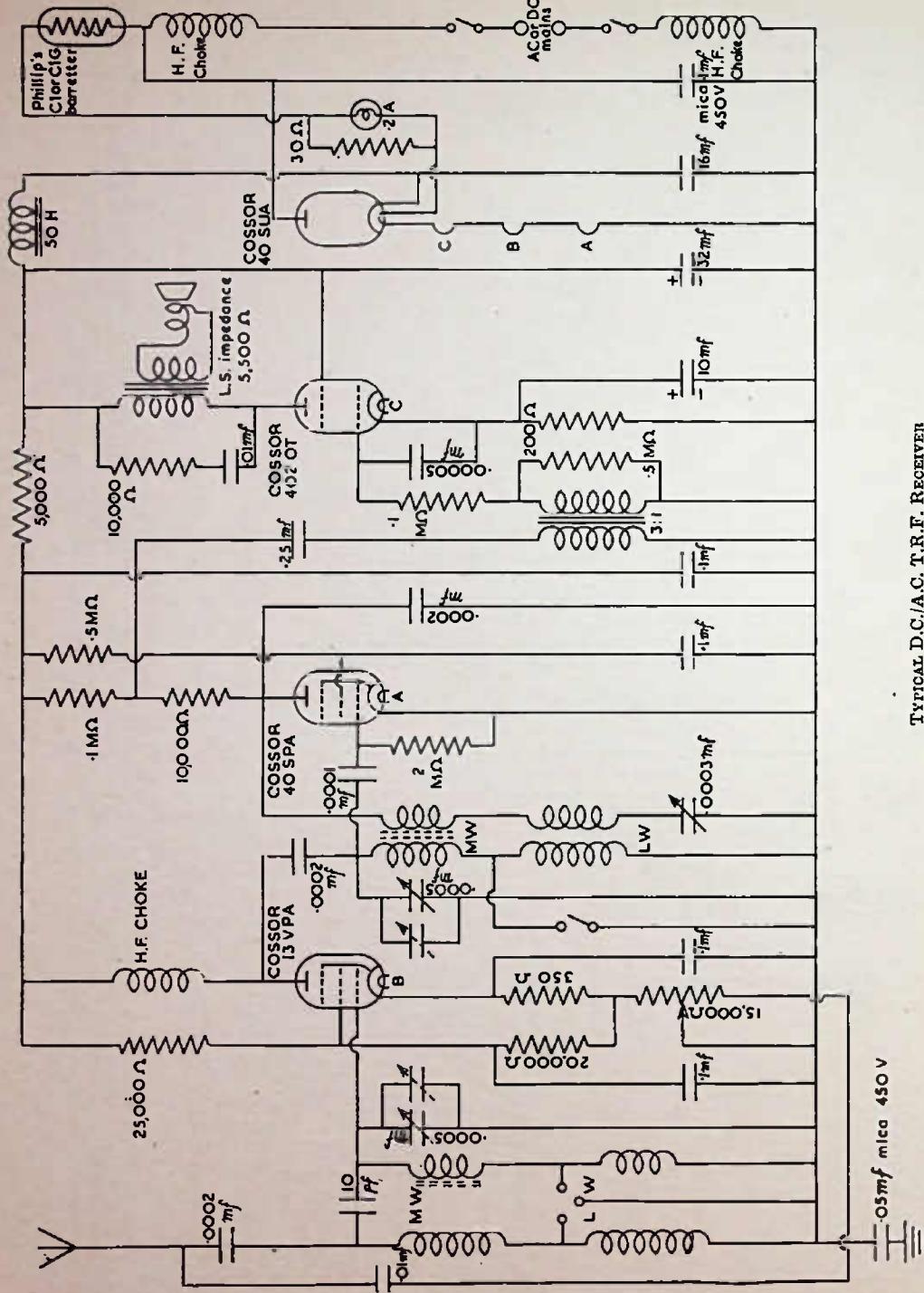
TYPICAL D.C./A.C. T.R.F. RECEIVER

This circuit is generally similar to the D.C./A.C. circuit in Chapter 5, Volume II, but values are shown and some modifications have been introduced. Variable negative feed-back could be introduced by using a potentiometer for the resistance across the L.F. transformer secondary, the slider being connected through a 1 mf condenser to the output anode.

24
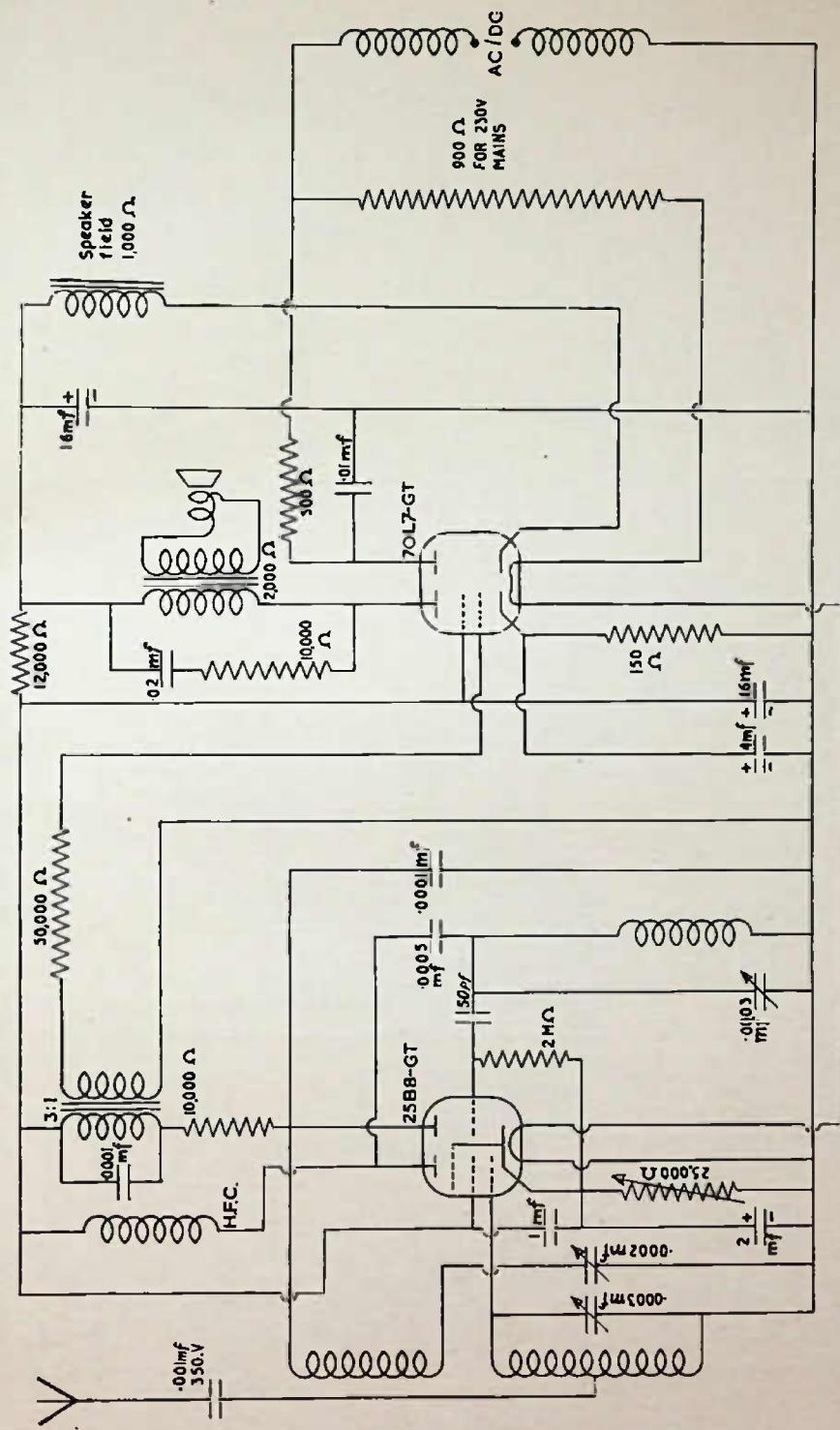
TYPICAL T.R.F. MIDGET RECEIVER

This circuit is typical of many of the cheaper midget receivers manufactured in the U.S.A., and although fundamentally a 3 + 1 valve receiver, only two valves are used, which are only 1¼ inches diameter and 3⅛ inches long, including pins, making possible with the use of midget components a receiver of exceedingly small dimensions. The rectifier anode dropping resistance (800 Ω) assumes a L.S. transformer primary resistance of 350 Ω; these considerations are important as the 70L7-GT has a maximum anode voltage of 117 volts and the 25B8-GT has a maximum anode voltage of 100 volts.

25
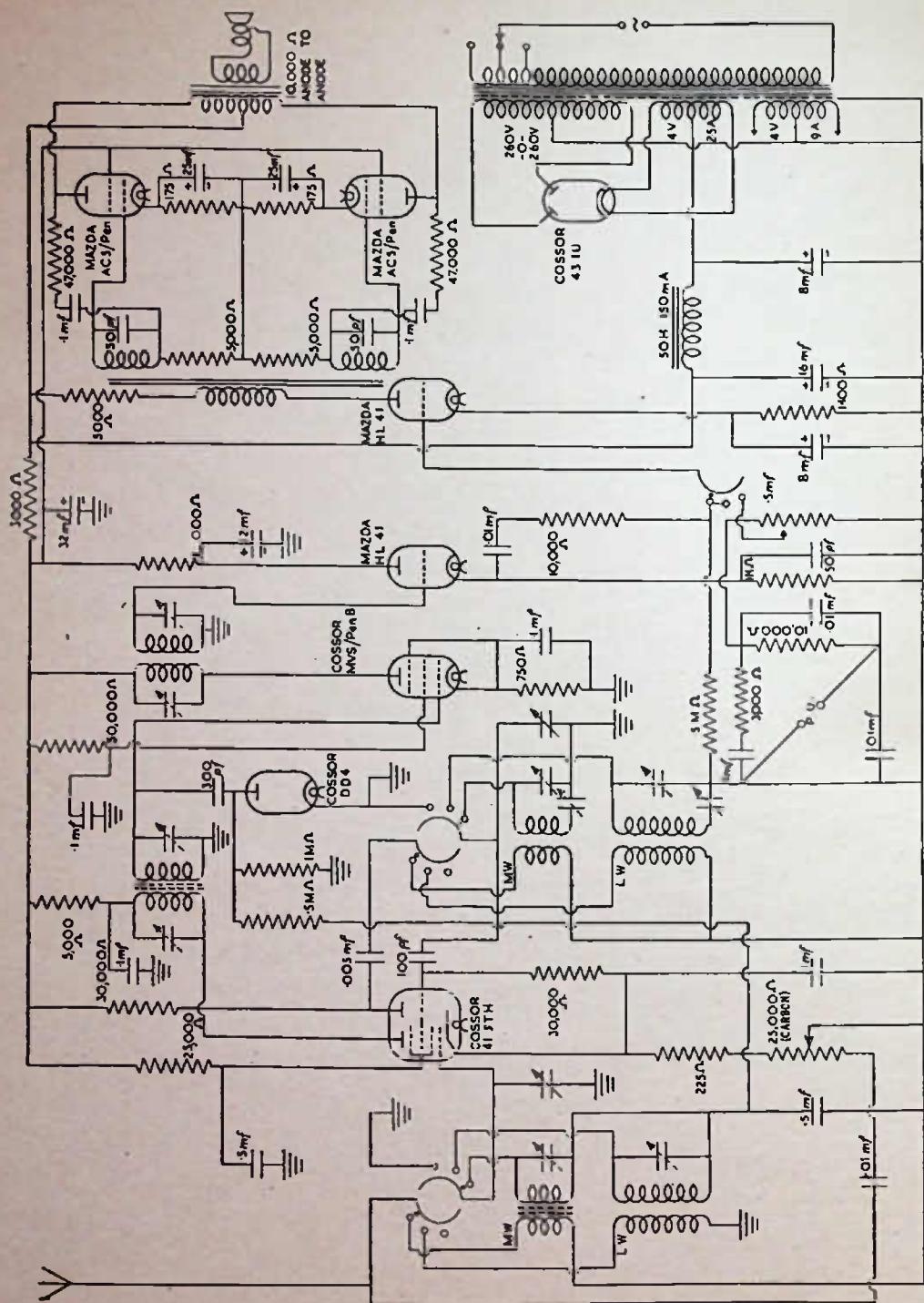
A Most Unusual Receiver

Circuits presented in a book of this character are necessarily orthodox, and this circuit is introduced as a measure of relief and to illustrate that good results can be obtained in more ways than one. The circuit was found by the author in use in a recreation room, where it gave really excellent quality on more or less local stations. The circuit arrangement is probably the result of a series of modifications carried out without regard to the circuit as a whole.
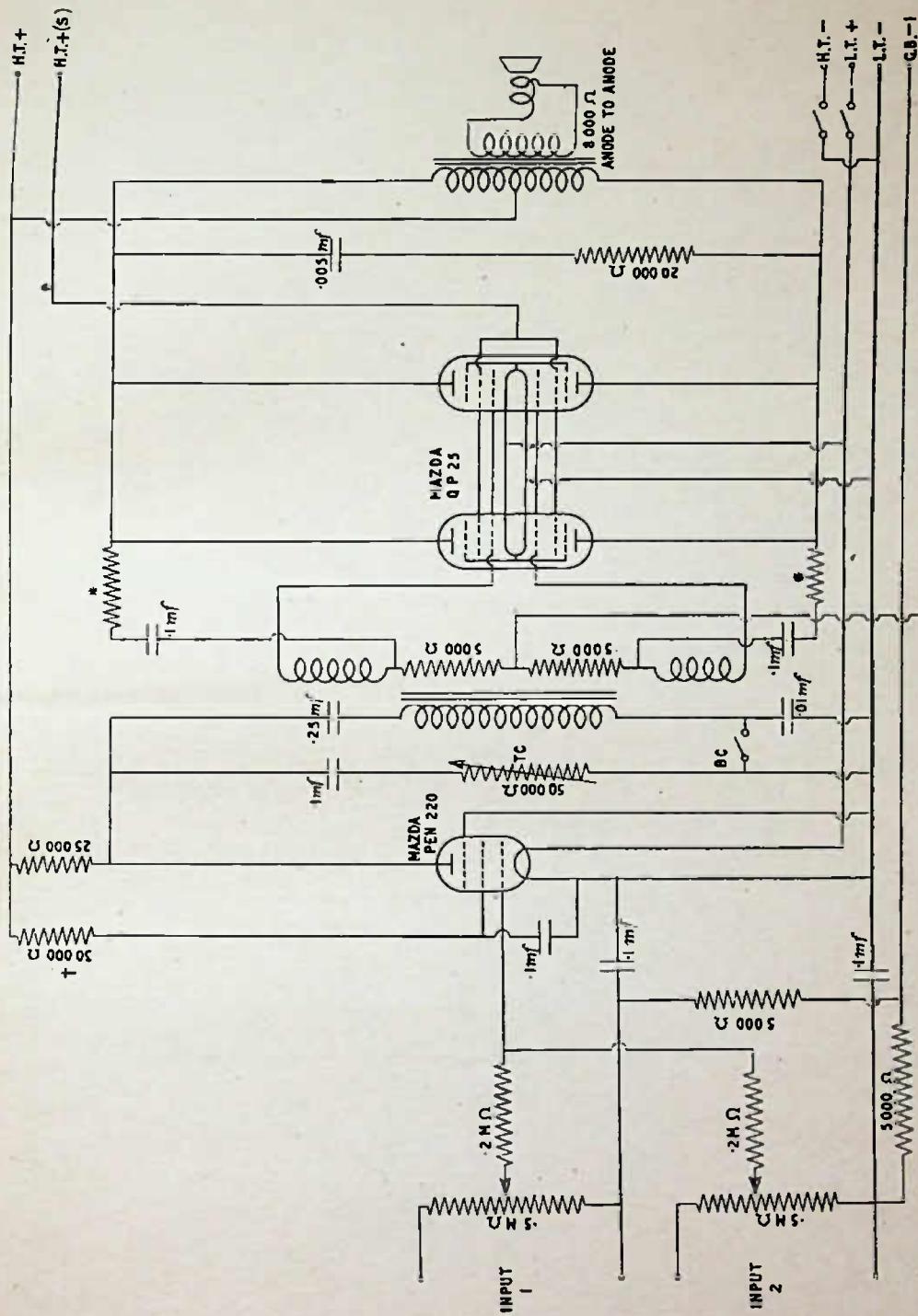
2½-watt Q.P.P. Battery Amplifier

A 2½-watt battery amplifier with a simple two-input mixer. The resistance marked † will normally require selection to ensure that the first amplifier works under optimum conditions. The negative feed-back resistances marked * are best determined by trial, 100,000 ohms being a convenient starting-point. A variable top cut control and a fixed bass cut device are fitted.
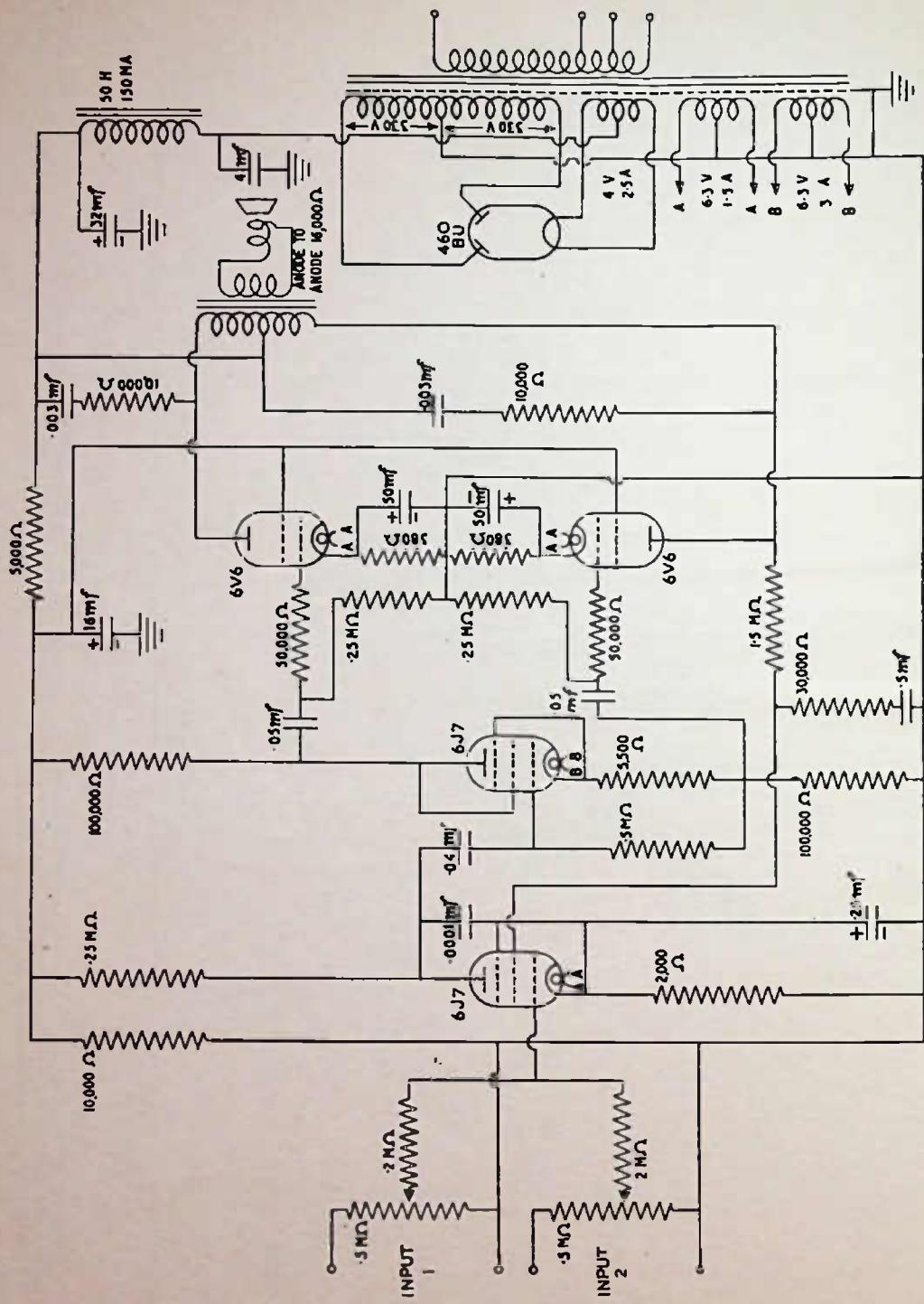
10-WATT A.C. MAINS AMPLIFIER

A conventional 10-watt amplifier employing negative feed-back over all stages. When using this form of negative feed-back it is essential that the two halves of the L.S. transformer primary are tightly coupled. Tone control is omitted as most users will prefer separate tone controls associated with each input.
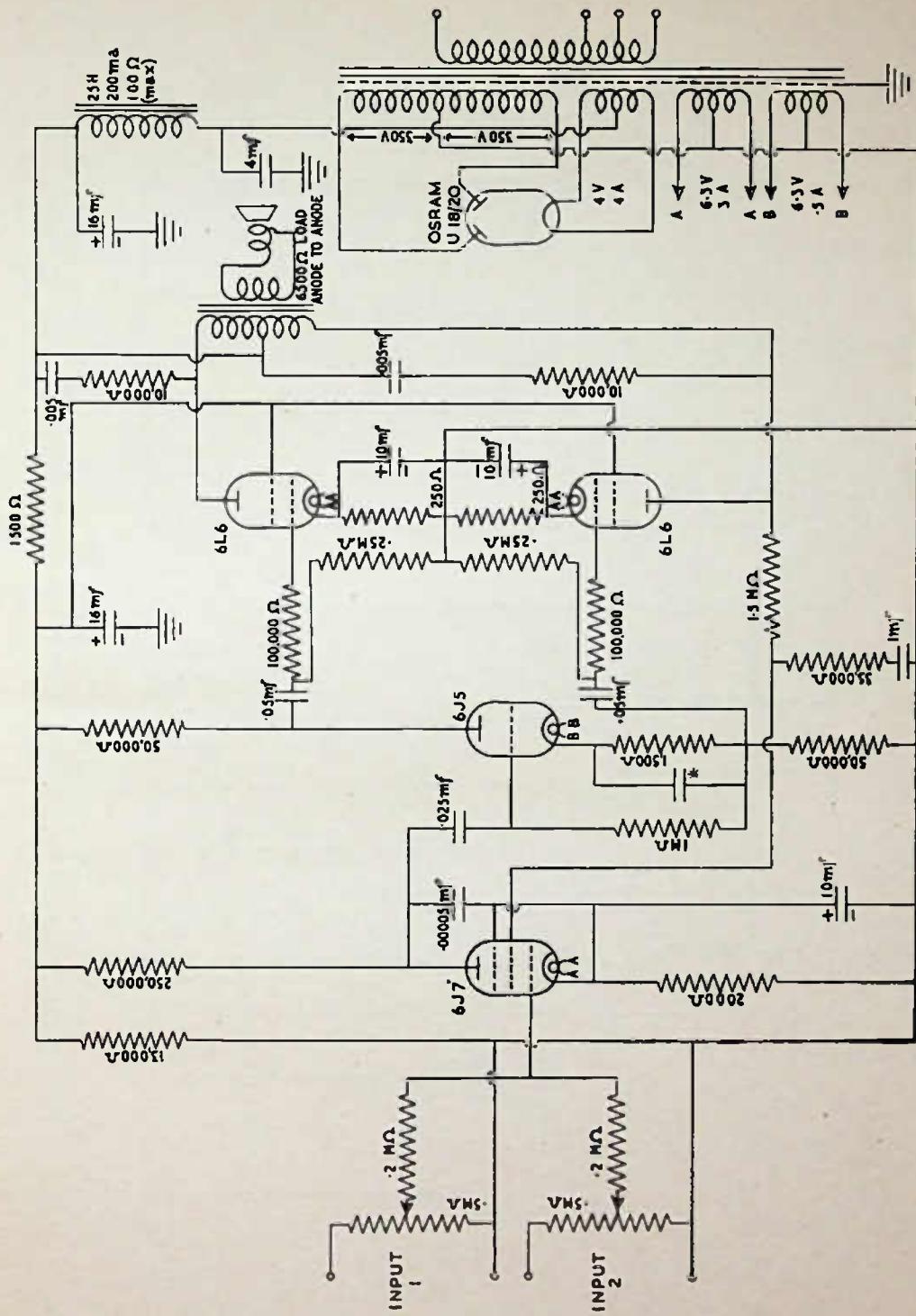
20-WATT AMPLIFIER. An amplifier similar to that shown on page 28, but having an output of 20 watts. The condenser marked with an asterisk was found to have a marked effect on stability in the original amplifier, the value being 10 pf.

25 H
200 ma
100 Ω (max)

16 mf +
4 mf

OSRAM U 18/20

250 V ← → 250 V

4 V
4 A

A
6·3 V
3 A
A
B
6·3 V
·5 A
B

6300 Ω LOAD ANODE TO ANODE

1500 Ω

·005 mf

10,000 Ω
10,000 Ω

·005 mf

6L6
6L6

+ 16 mf

+ 10 mf
250 Ω
10 mf +
250 Ω

·25 MΩ
·25 MΩ

100,000 Ω
100,000 Ω

·5 mf
·05 mf

1·5 MΩ
1·5 MΩ

35,000 Ω
1 mf +

50,000 Ω

6J5

50,000 Ω

1,500 Ω

*

1 MΩ

·025 mf

+ 10 mf

·00005 mf

250,000 Ω

6J7

2000 Ω

12,000 Ω

·2 MΩ
·5 MΩ
INPUT 1

·2 MΩ
·5 MΩ
INPUT 2

An A.C. Mains Preamplifier
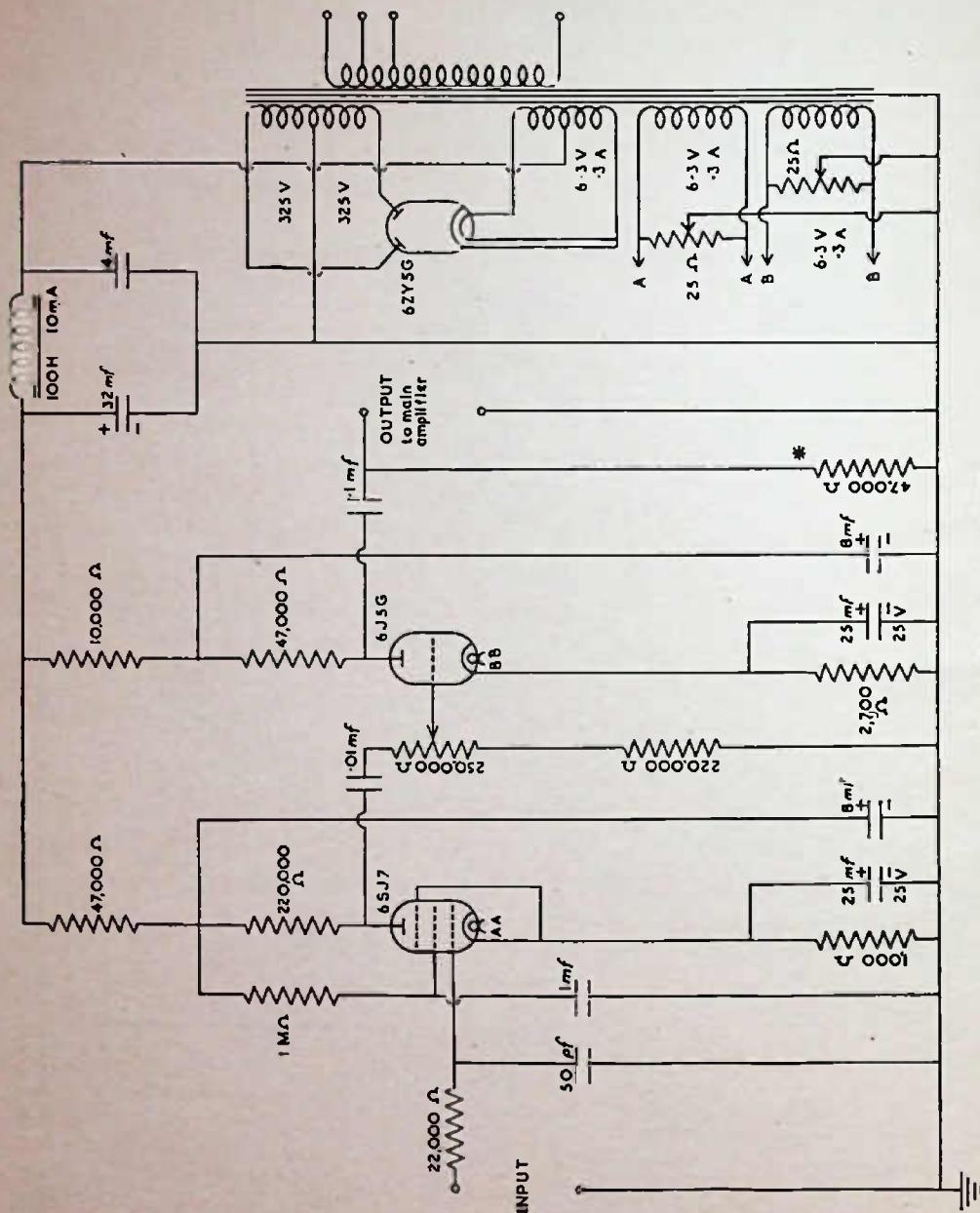
A typical preamplifier for use with crystal or other low output microphones. With certain types it will be necessary to connect the appropriate resistive load across the input terminals; in any case a D.C. path must be provided for the grid of the first valve. Resistance marked * should be omitted when the main amplifier already has a D.C. connection to the grid of its first valve.

30
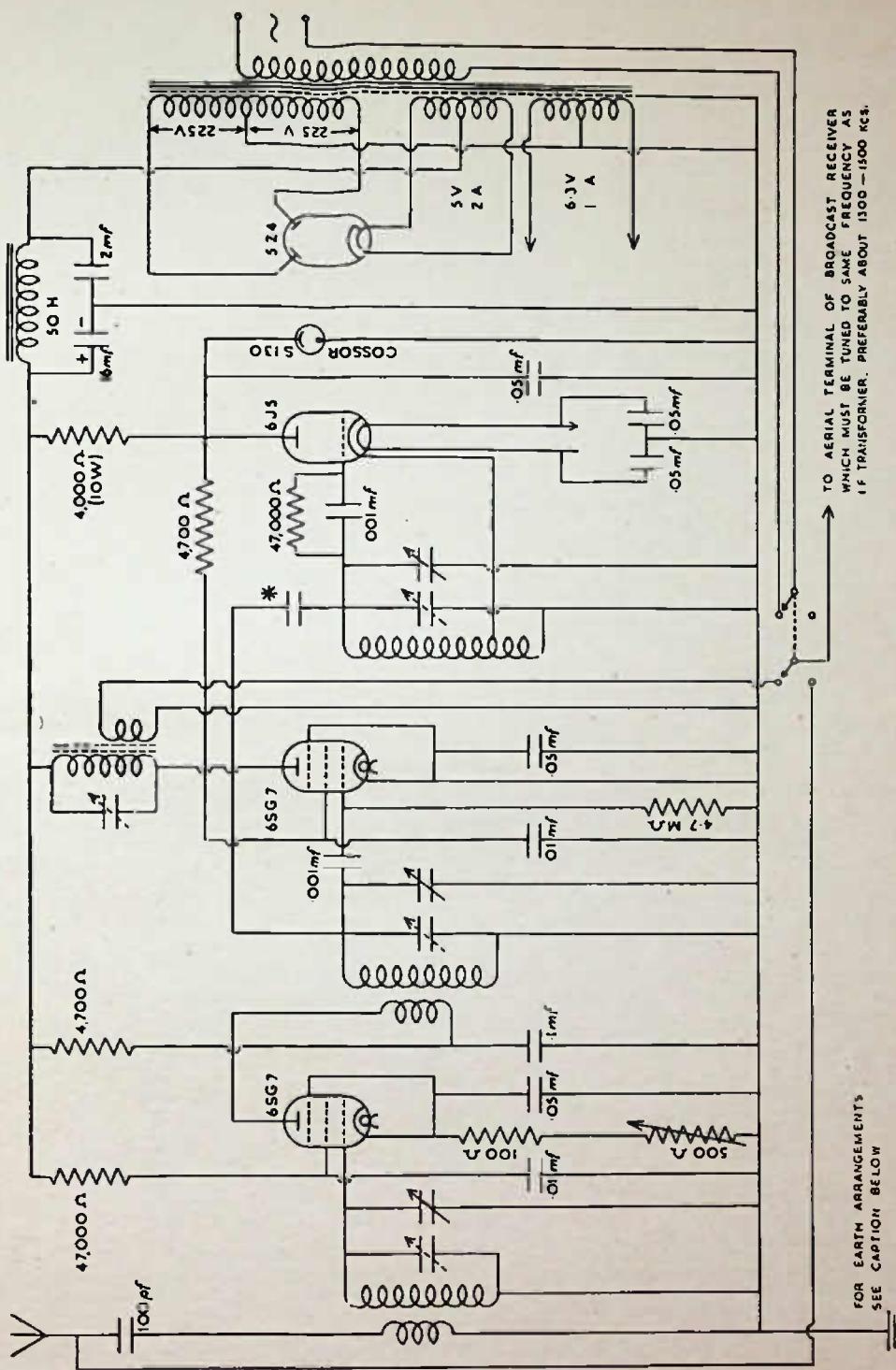
SHORTWAVE CONVERTER FOR A.C. MAINS

A particularly efficient shortwave converter with H.F. amplifier. The aerial coil and H.F. transformer can conveniently be ganged and the oscillator coil separately tuned or the three may be ganged together, in which case padding condensers can be introduced in the oscillator coil or coils. The condenser marked * may take the form of two wires twisted together or a small pre-set, and should be the subject of experiment to obtain maximum results. If the earth lead of the main receiver is short, earth the unit separately; if not, join the two earth terminals together and use a common earth lead. The I.F. transformer should preferably be about 1,300–1,500 kcs, and should have about two-thirds of the secondary removed.

TO AERIAL TERMINAL OF BROADCAST RECEIVER WHICH MUST BE TUNED TO SAME FREQUENCY AS I F TRANSFORMER. PREFERABLY ABOUT 1300 –1500 KCS.

FOR EARTH ARRANGEMENTS SEE CAPTION BELOW

31
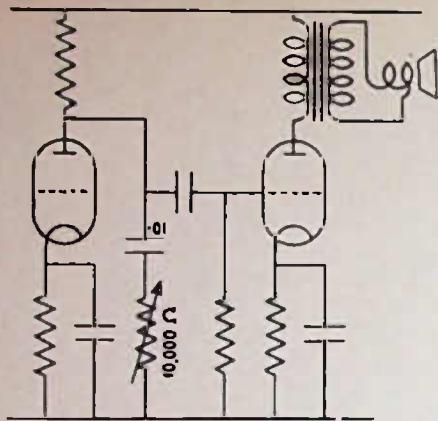
The conventional tone-control circuit for the variable attenuation of the high frequencies.
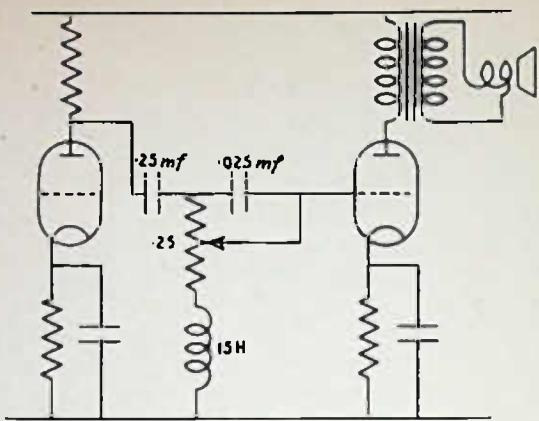
A tone-control circuit for the variable attenuation of the lower frequencies.
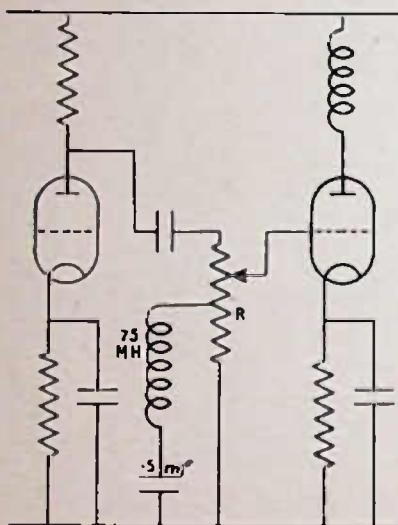
(Above) Bass boosting circuit suitable for use with an average magnetic pick-up. Resistance marked * may be variable, in which case it may be 50,000 Ω.

(Left) Compensated volume control avoiding the apparent serious change in frequency response when volume is varied. R should be 30,000 Ω, the upper portion being 24,000 Ω and the lower 6,000 Ω.
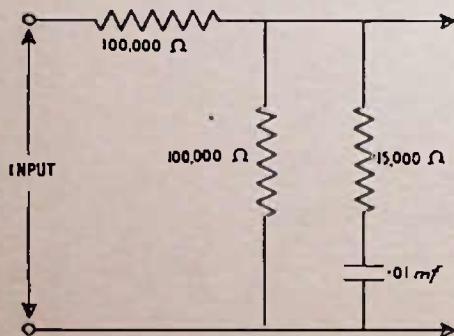
A filter giving a rapid decline in response from 50 to 1,000 cycles followed by a sensibly flat characteristic; useful when really heavy bass response is desired.
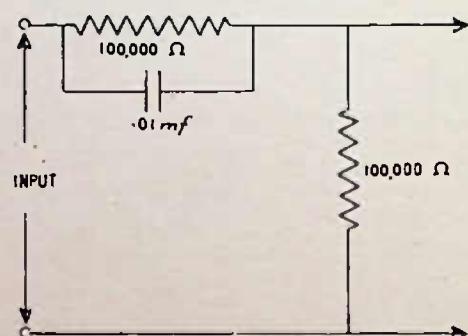
A filter giving sensibly level response up to 100 cycles followed by a rapid increase between 100 and 1,000 cycles, after which the increase tends to become progressively more gradual. Useful for boosting the middle frequencies and increasing the intelligibility of speech.

TONE- AND VOLUME-CONTROL CIRCUITS
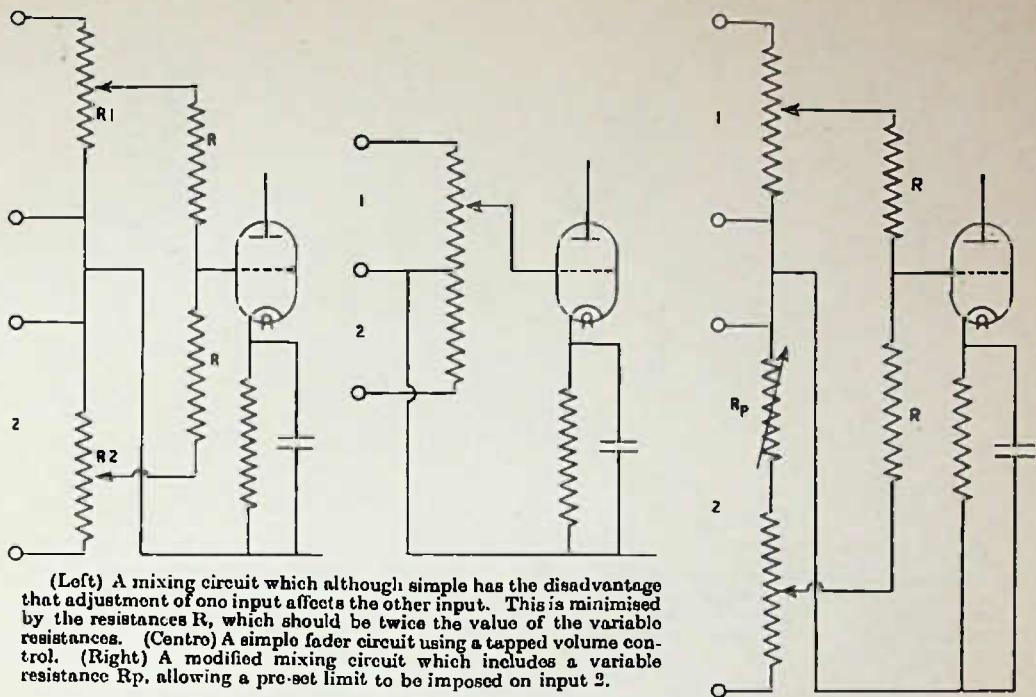
(Left) A mixing circuit which although simple has the disadvantage that adjustment of one input affects the other input. This is minimised by the resistances R, which should be twice the value of the variable resistances. (Centre) A simple fader circuit using a tapped volume control. (Right) A modified mixing circuit which includes a variable resistance Rp, allowing a pre-set limit to be imposed on input 2.
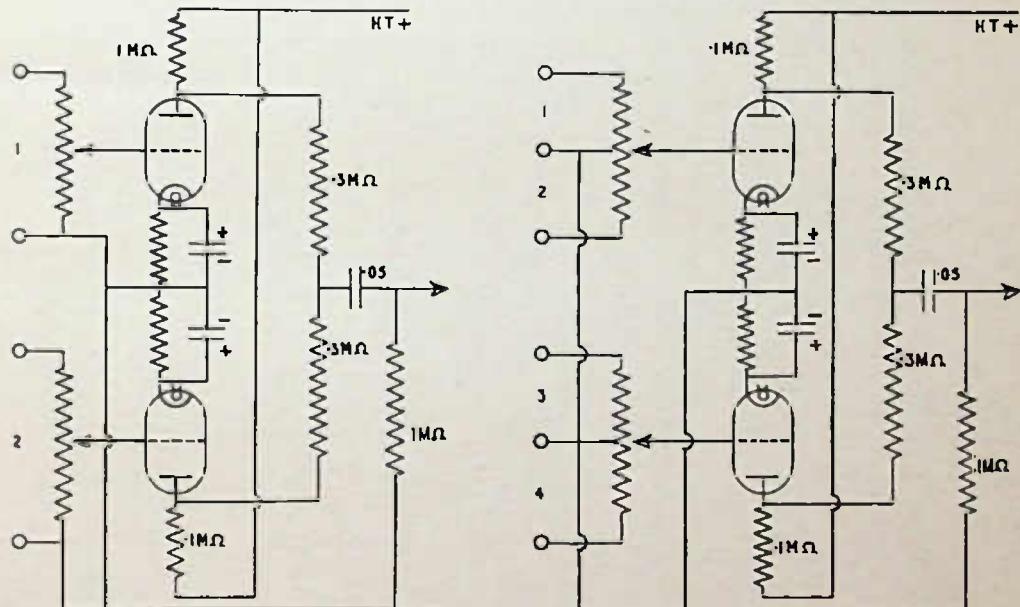
A twin-valve mixing circuit giving completely independent adjustment of both inputs. Values shown are suggested for a fairly high impedance triode.

A similar arrangement to that shown (left), but giving combined fading and mixing for two pairs of inputs.

MIXING AND FADER CIRCUITS
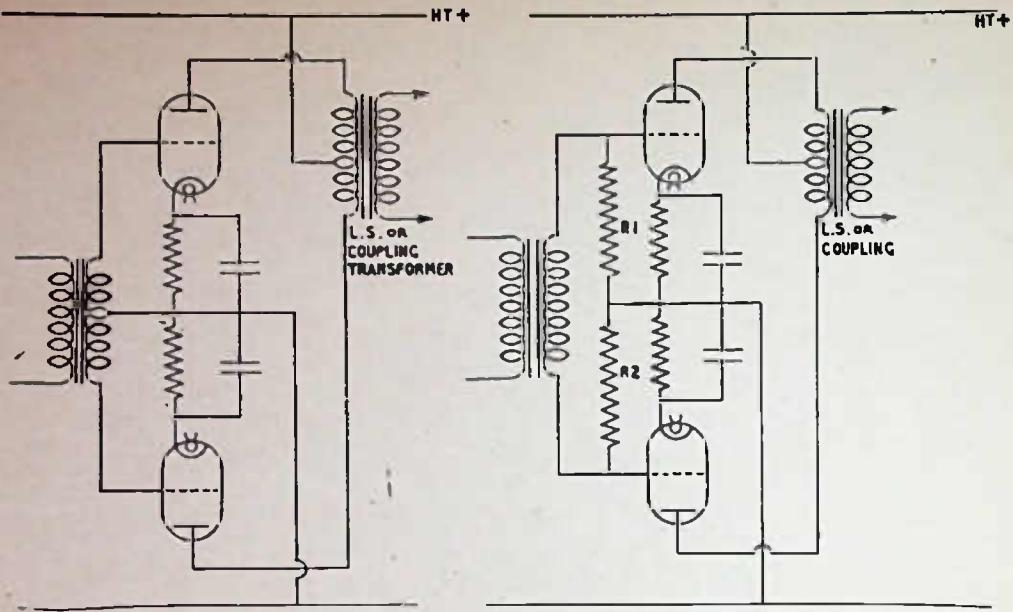
The simplest method of phase splitting, using an input transformer with centre-tapped secondary. Separate bias resistances are shown, but a common bias resistance can be used if desired.

A variation of the circuit (left) sometimes advocated when a centre-tapped transformer is not available; it is a bad arrangement, since the value of R1 + R2 divided by the square of the transformer ratio appears as a reflected load in the anode circuit of the preceding valve.
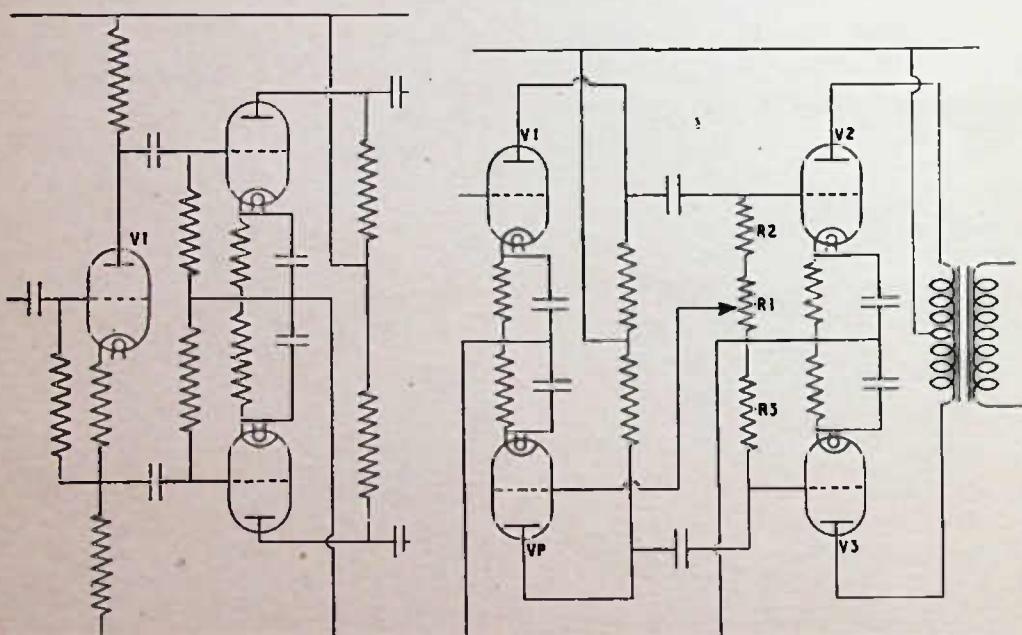
Probably the most popular phase-splitting arrangement; the anode load of V1 is halved, one half being placed between anode and H.T. +, the other between cathode and H.T. −.

A very useful phase-splitting arrangement which offers a simple means of achieving balance. R1 + R2 should equal R3, R1 being just large enough to give the required input to the paraphase valve Vp. This valve makes no contribution to the stage gain of the amplifier.

PUSH-PULL, PHASE SPLITTING
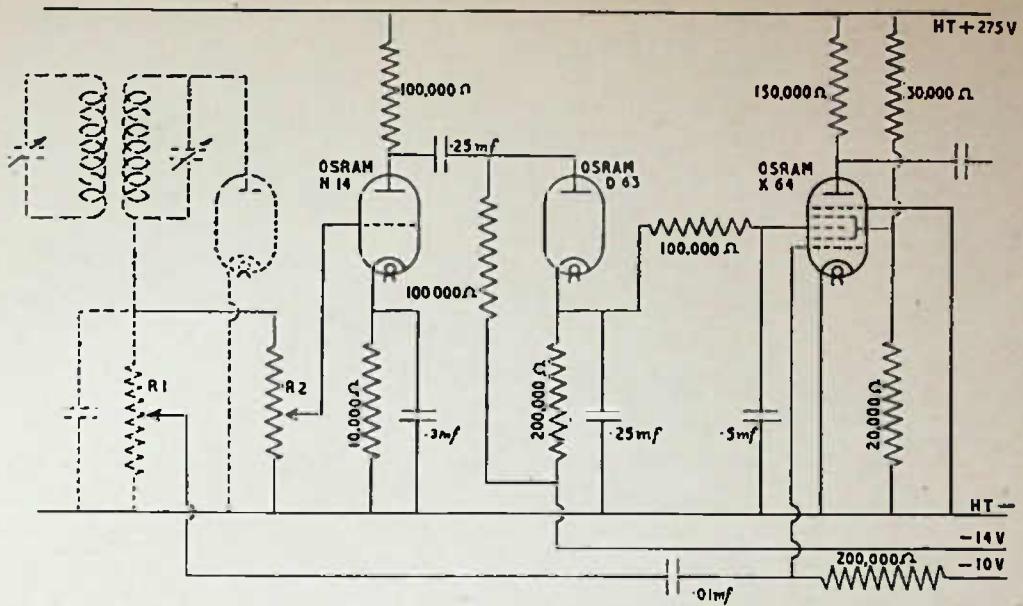
A typical volume expansion circuit, the shaded portion represents a normal diode detector. Considerable difficulty is usually experienced in getting volume expansion to function correctly, and some experiment is invariably necessary.
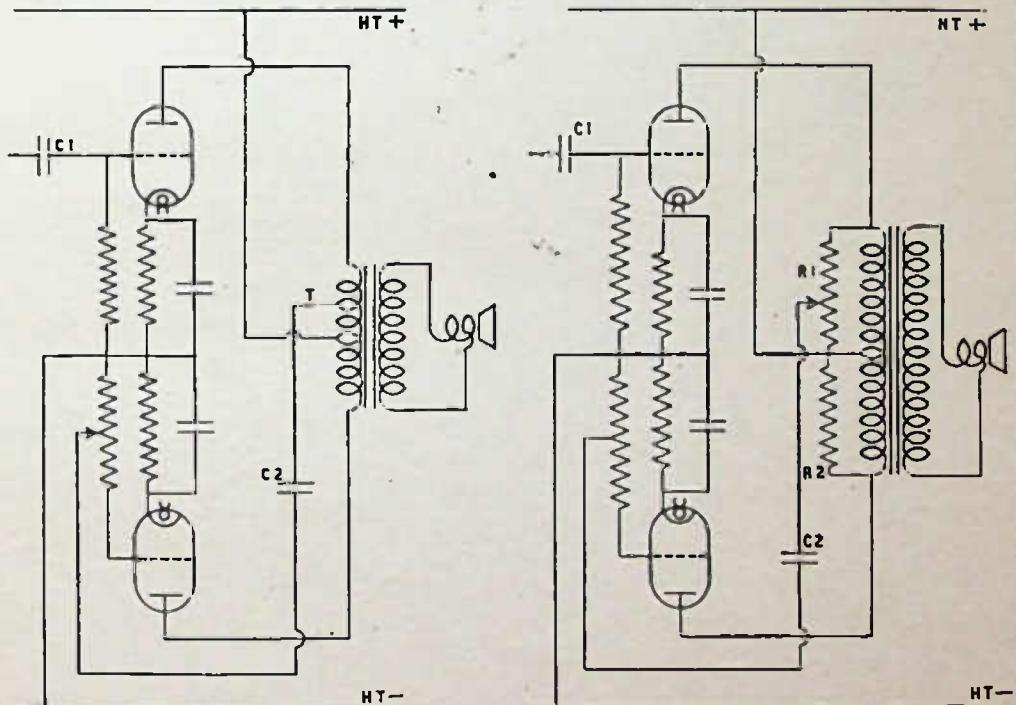
Two-phase splitting arrangements which have serious shortcomings but are very convenient when converting a single output stage to push-pull. The circuit (left) is preferable, but requires a spare tap T on the output transformer primary. The circuit (right) does not require a tap, R1 should be equal in value to R2, and together their resistance should be about ten times the primary impedance. In both circuits C1 is the coupling condenser and C2 the H.T. isolating condenser, and can be about ·1 mf and 1 mf respectively.

PHASE SPLITTING *continued* AND VOLUME EXPANSION
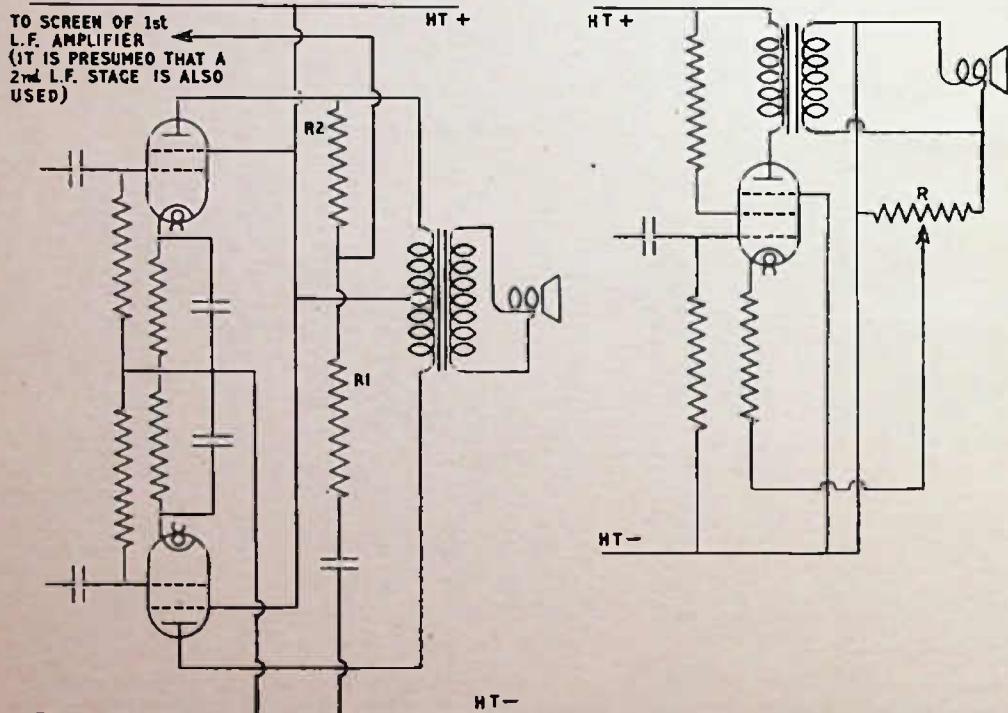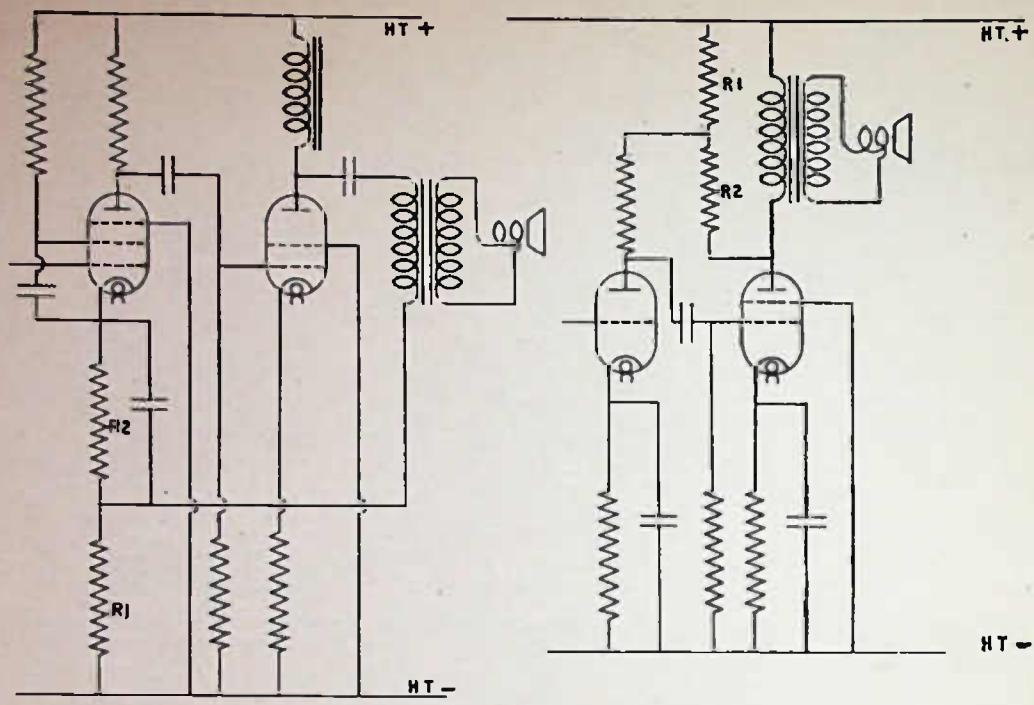
In these typical negative feed-back circuits, where resistances are so marked, feed-back increases as R1 increases in relation to R2. In the circuit (top left) R1 + R2 must equal the correct bias resistance value for the valve. R in the arrangement (bottom right) should be about five times the speech-coil impedance, which must be reasonably low; if positive instead of negative feed-back is obtained, reverse connections between speech coil and resistance R.

TYPICAL NEGATIVE FEED-BACK CIRCUITS

36
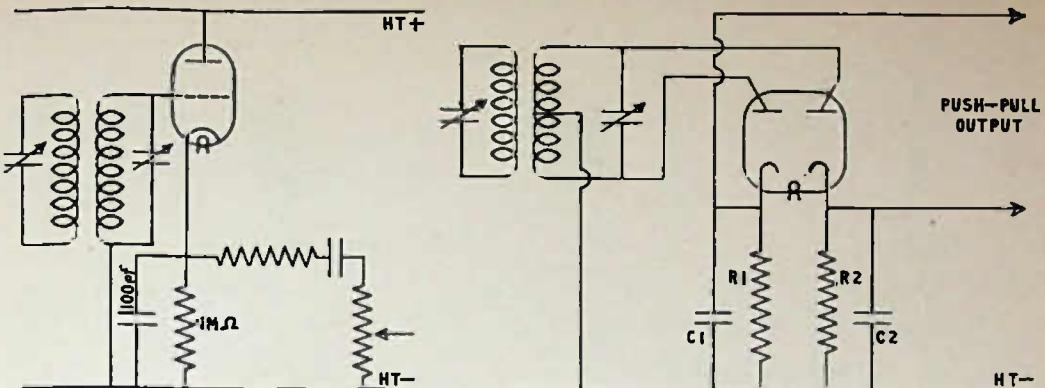
The infinite impedance detector. The volume control is usually about ·5 megohm; the unmarked resistance is intended as a filter and is usually about 10,000 ohms; a suitable value for the blocking condenser is ·1 mf.

A double diode detector arranged to deliver a balanced output, for feeding a push-pull amplifier. R1, C1 and R2, C2 form the diode loads and may be of conventional values.
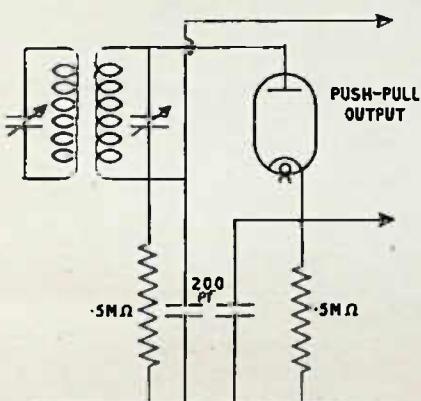
A single diode arranged to deliver a balanced output. It is, however, difficult to reduce mains hum to acceptable limits when using valves of normal construction.
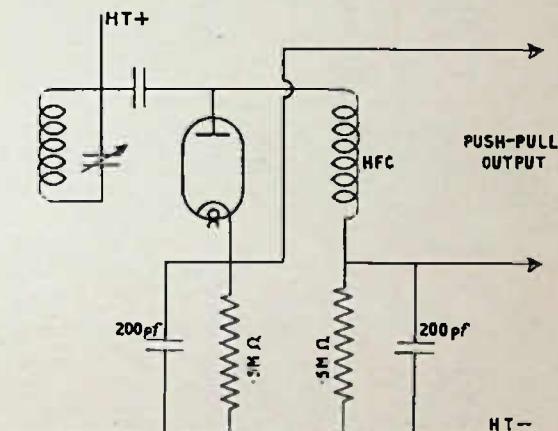
An unusual arrangement giving a balanced output from a single diode for use when the tuned circuit must be isolated in so far as D.C. potential is concerned.
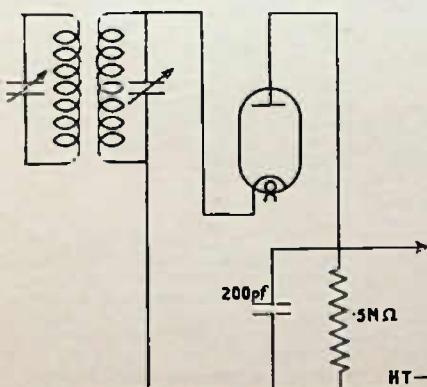
A diode detector so arranged that H.F. is virtually absent across the diode load.
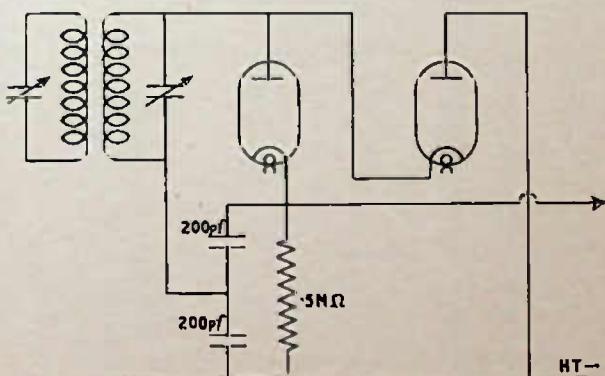
Two diodes arranged for voltage doubling which is sometimes useful in control circuits of various kinds.

INFINITE IMPEDANCE AND DIODE DETECTOR CIRCUITS
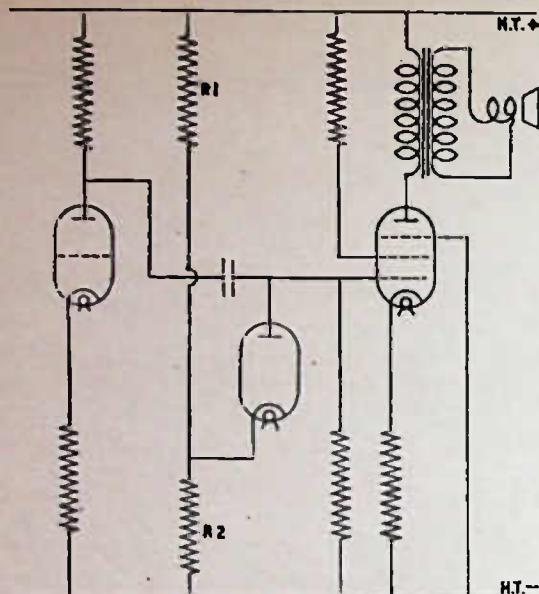
A simple noise-limiter circuit which will mitigate the effect of noise of short duration, the amplitude of which is greater than that of the desired signal. As R2 is increased in respect to R1, the voltage at which the diode commences to cut is increased.
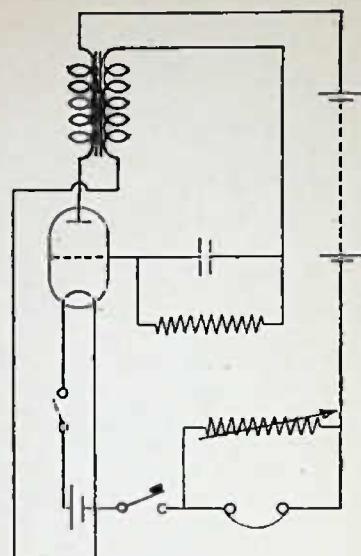
A simple oscillator suitable for Morse-code practice. With the average triode, 12–20 volts H.T. is usually sufficient. Suggested values for grid leak and condenser are ·25 megohm and ·01 mf.
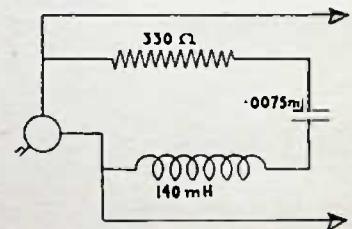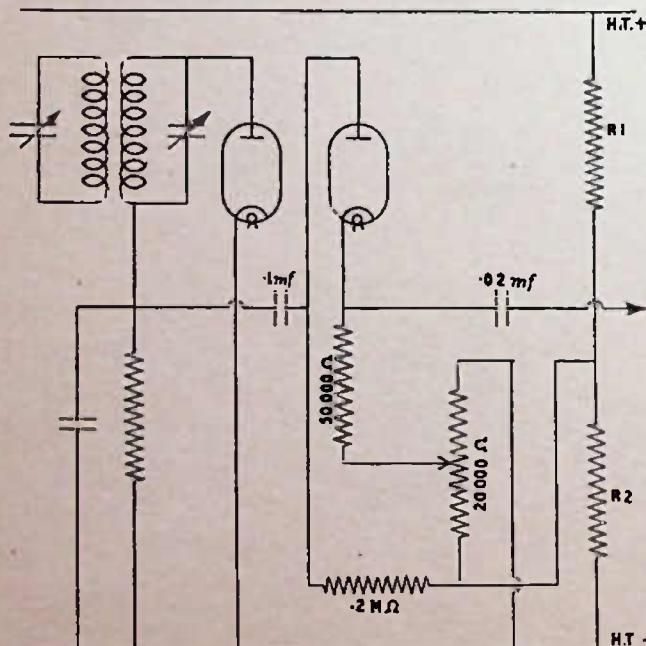
(Above) A tuned scratch filter suitable for use with the average magnetic pick-up. The resistance should have a value of 330 ohms *including* the D.C. resistance of the actual pick-up. If necessary, the condenser value shown can be obtained by connecting the following values in parallel: ·005 mf + ·002 mf + ·0005 mf.

(Left) An improved form of noise limiter, immediately following the detector. The variable resistance controls the amplitude at which limiting commences; R1 can have a value of 100,000 ohms for each 100 volts of H.T. supply; R2 is selected to give the required control.

NOISE LIMITING AND SCRATCH FILTER CIRCUITS

Top circuit labels:

100 pf · 5,000 Ω · 50 pf · OSRAM HL 2 · 10 pf · VHF/HFC · 75,000 Ω · HT + 100V · 100 pf · A · B · 50 pf · 2 MΩ · 01 mf · TO LIVE PICK UP TERMINAL OF RECEIVER · HT− · LT+ · LT− · EARTH OR EARTH TERMINAL OF RECEIVER

Bottom circuit labels:

50 pf · 5,000 Ω · VHF/HFC · 10 pf · R1 · TO LIVE SIDE OF L.S. PRIMARY (OR EXTENSION SPEAKER TERMINAL) · 50 pf · R · OSRAM L 63 · 50,000 Ω · TO LIVE PICK UP TERMINAL · 7·5 pf · A · B · 50 pf · 1 MΩ · ·0001 mf · ·5 mf · ·001 mf · 800 Ω · ·5 mf · AC MAINS

TELEVISION SOUND ADAPTERS

These adapters enable the sound which accompanies television broadcasts to be reproduced on receivers not provided with this facility. The arrangement (top) is for use with a battery receiver, but can also be used with a mains receiver if an accumulator is employed for heating the filament. The coil consists of five turns of 20 S.W.G. wire spaced equal to wire diameter and wound on a ½-inch diameter former, which should be removed, leaving the wire self-supporting. The top tap is two turns from the top and the lower tap between a half and one turn lower.

The A.C. mains version uses the same coil as the battery version and employs a transformer for heater supply; the secondary voltage should be 6·3 volts with the valve shown, or 4 volts if more convenient, when an Osram MHL4 may be employed. R1 should have such a value that the anode voltage is approximately 100; R is intended to smooth reaction, and its value should be found by trial.
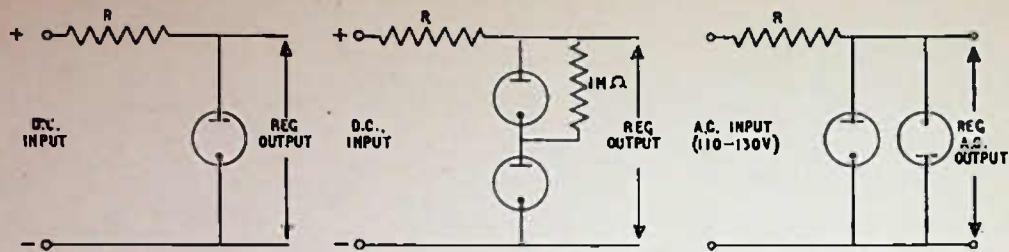
(Left) A simple circuit giving a sensibly constant voltage output irrespective of the current drawn within stated limits. Stabiliser tubes are made by various manufacturers, who publish curves from which the value of R may be determined. The controlled output voltage is usually 120/130 volts. (Right) In this arrangement two tubes are used to double the voltage output.

Two voltage stabiliser tubes in opposite sense, arranged to give a regulated A.C. output. The input voltage shown, 110/130 volts, is R.M.S. voltage, not peak voltage.
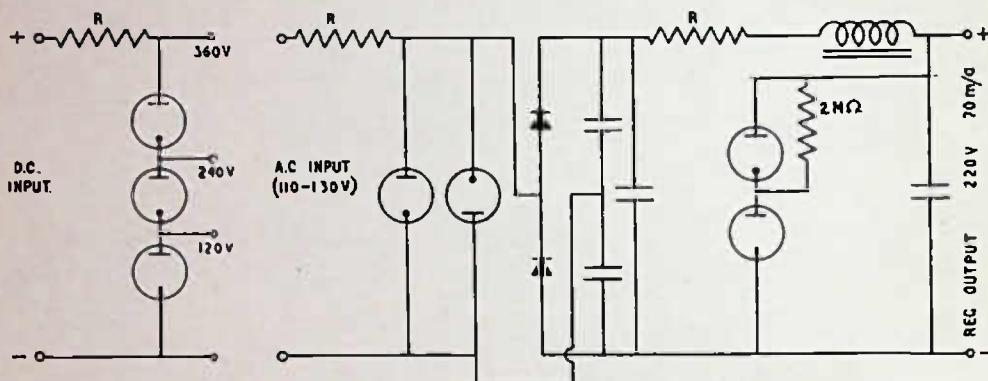
Stabiliser tubes arranged as a voltage divider. This circuit is only suitable where current drawn from the 120-V and 240-V tappings does not exceed about 2 mA each.

An elaborate arrangement in which voltage regulation is achieved in both A.C. and D.C. portions of the circuit. A voltage doubler is employed to compensate for the relatively low-voltage A.C. input. When the value of R in the D.C. circuit is determined, the D.C. resistance of the choke must be considered to be part of it.
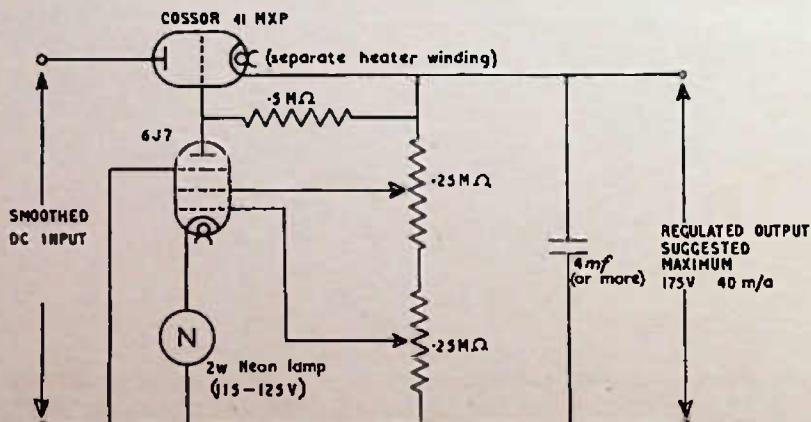
A valve voltage regulator circuit suitable for laboratory use which gives a remarkably constant output voltage. In exacting conditions where the output voltage must be independent of ambient temperature, the neon lamp must be replaced by some source of D.C. bias such as the 24-volt accumulator.

VOLTAGE STABILISATION
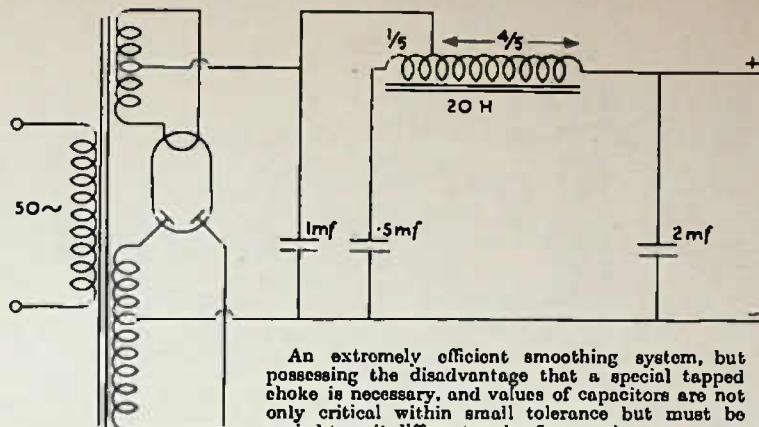
An extremely efficient smoothing system, but possessing the disadvantage that a special tapped choke is necessary, and values of capacitors are not only critical within small tolerance but must be varied to suit different mains frequencies.
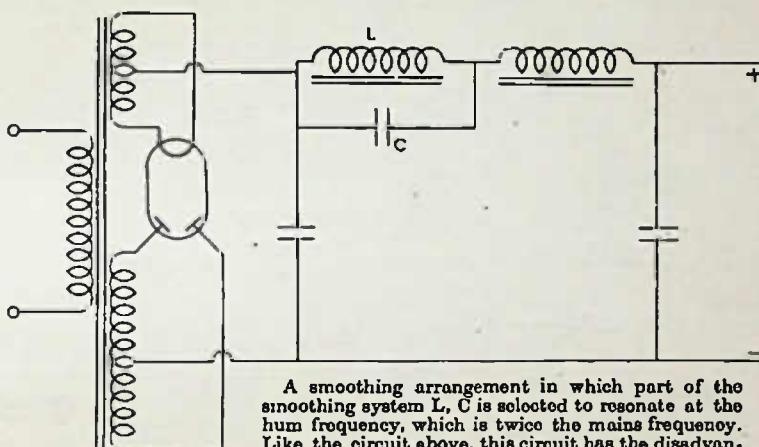
A smoothing arrangement in which part of the smoothing system L, C is selected to resonate at the hum frequency, which is twice the mains frequency. Like the circuit above, this circuit has the disadvantage that values must be selected for a particular mains frequency.
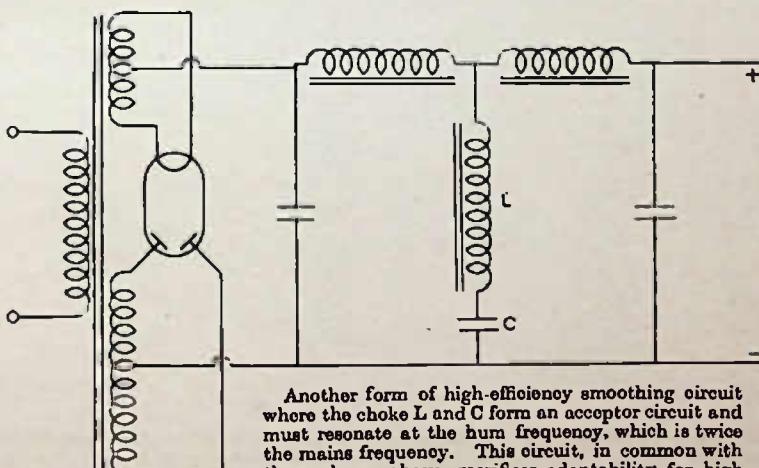
Another form of high-efficiency smoothing circuit where the choke L and C form an acceptor circuit and must resonate at the hum frequency, which is twice the mains frequency. This circuit, in common with those shown above, sacrifices adaptability for high efficiency.

UNUSUAL SMOOTHING CIRCUITS
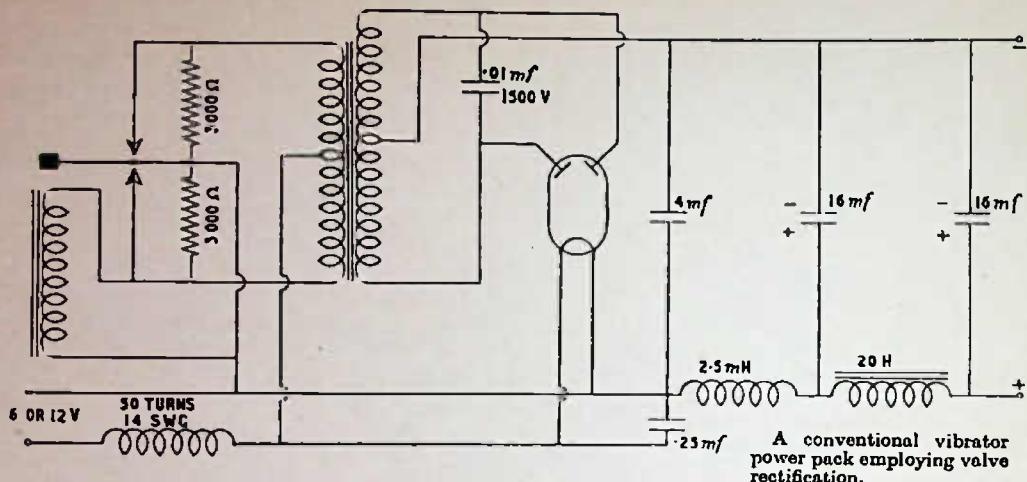
A conventional vibrator power pack employing valve rectification.
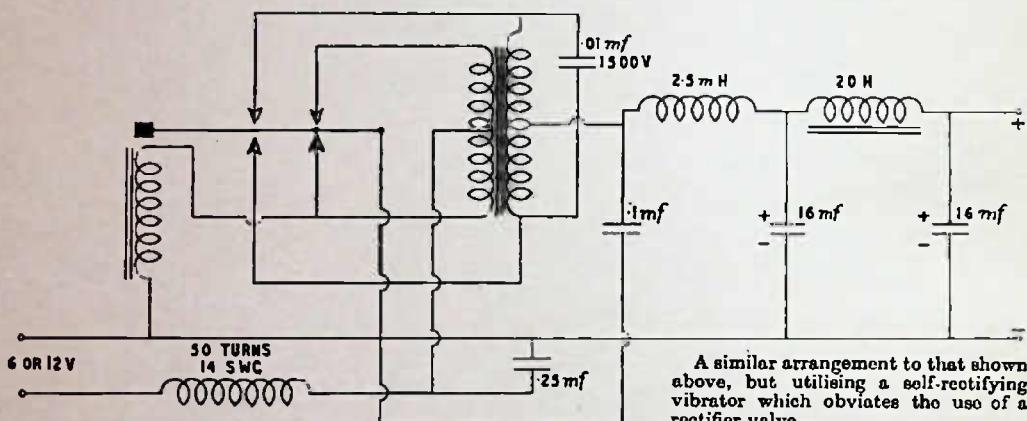
A similar arrangement to that shown above, but utilising a self-rectifying vibrator which obviates the use of a rectifier valve.
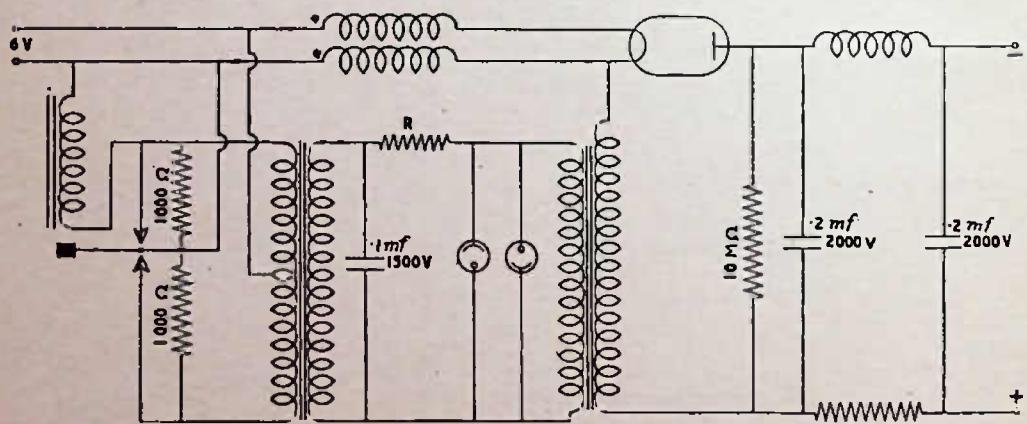
7:1 TRANSFORMER

An interesting vibrator power pack used by the author for the E.H.T supply of a portable oscillograph which worked from a 6-volt car battery. The author has used a similar circuit to obtain the E.H.T. supply for a television receiver converted for use on D.C, mains. H.F. chokes marked * should be inter-wound; R should be adjusted so that the neon stabiliser tubes only just glow. The $10\text{M}\Omega$ resistance must be made up of several resistances in series, e.g. five resistances of $2\text{M}\Omega$ each.

TEST GEAR AND SERVICING EQUIPMENT SECTION

PUBLISHED test gear circuits are very often idealistic in character but presented without component values; this is usually due to the fact that the individual or company responsible for the design feels disinclined to give away the result of weeks or months of patient development work. With the exception of the oscilloscope on page 44, which is a recently designed commercial instrument, the circuits which form the subject of this section do not pretend to be idealistic, but have the compensating advantage that all component values are given; furthermore, they can be relied upon to function properly, since they are precise copies of miscellaneous pieces of test gear built by the author and used for varying numbers of years with the object of reducing wear and tear on precision laboratory instruments when the use of such accurate instruments is not essential.

Those who contemplate constructing one or more pieces of test gear must realise that a considerable amount of thought and care must be expended if such equipment is to be even moderately accurate. Components must be selected with great care, mechanical construction must be above criticism, while certain instruments such as signal generators and valve voltmeters must be efficiently screened.

Any component which controls or affects the calibration of a piece of test equipment must be a very great improvement upon the type of component used in the construction of the ordinary radio receiver. If this remark applies to any one type of component more than another, it is to the variable condenser, mass-produced examples of which cannot be relied upon to repeat the same capacity to within the required limits each time the moving section is rotated to the same position.

When constructing test gear, it must always be borne in mind that the assembly as a whole must possess sufficient mechanical rigidity to prevent calibration from being affected by normal rough handling or the position in which the equipment rests. In conclusion, let it be said that a piece of inaccurate or unreliable test gear is a most dangerous thing to have on the service bench or in the laboratory, and one of the greatest potential sources of wasted time, patience, and energy.
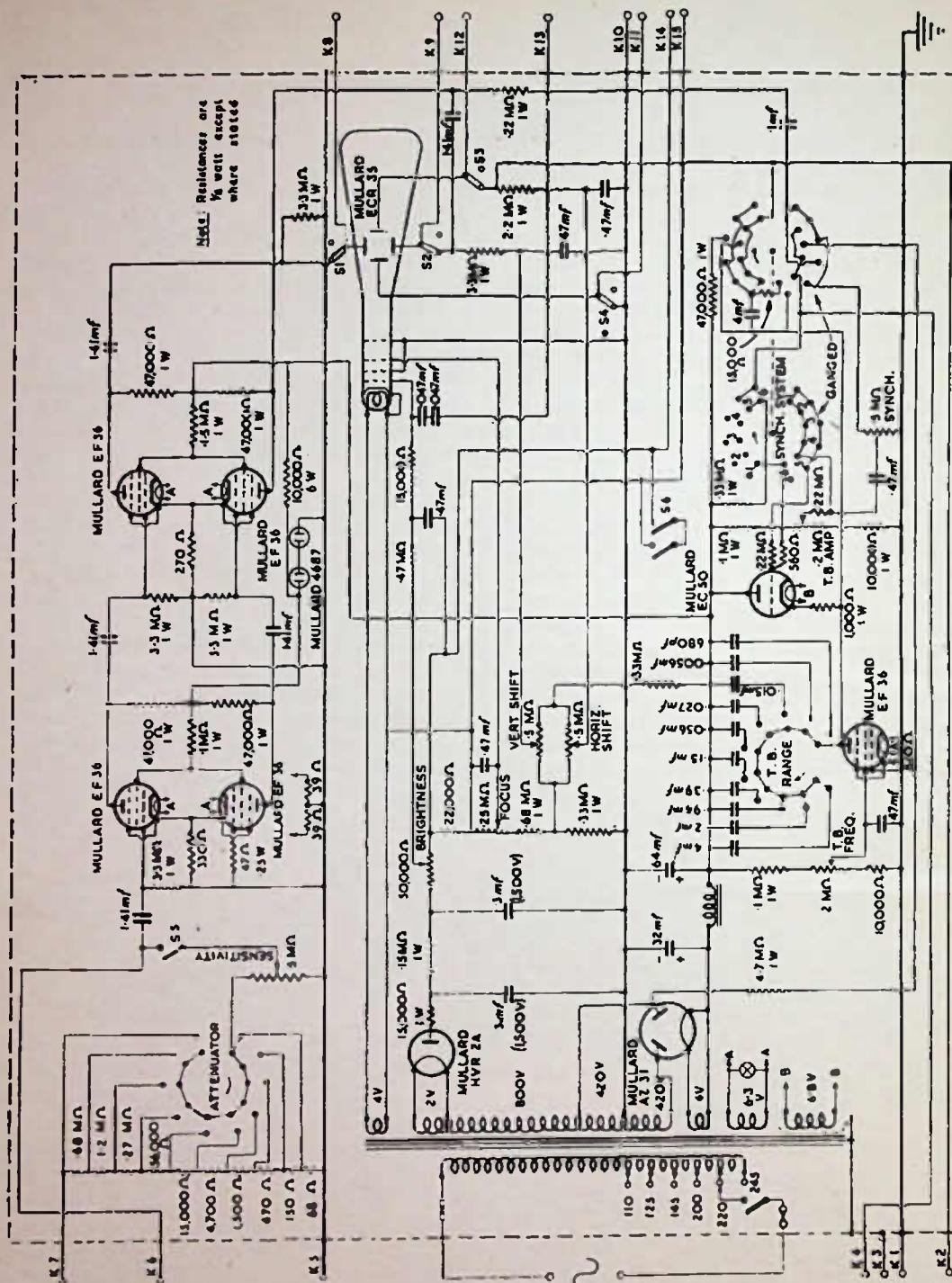
A TYPICAL OSCILLOSCOPE
(See page 45 for description)

44

A Typical Oscilloscope

The circuit diagram on the facing page shows a typical oscilloscope, the Mullard E800, which is included as representative of present-day oscillograph practice. It is neither economical nor practicable to attempt the individual construction of such a comprehensive instrument, but by careful study the various functions can be dissected and the relative parts of the circuit used to form the basis of any workshop instrument that may be contemplated, or as a hookup with an existing oscilloscope that lacks some desired facility. Voltages of the order of 1,500 volts are normal with instruments of this type, and in the case of the example illustrated, two external sockets, K14 and K15, are at a potential of 1,250 volts with respect to earth.

Brief characteristics are: Time-base frequency range ·25—16,000 cps. Vertical deflection sensitivity 7V., A.C. (R.M.S.) per cm. or 21V., D.C. per cm. Horizontal deflection sensitivity 14V., A.C. (R.M.S.) per cm. or 42V., D.C. per cm. The voltage amplifier has a gain of 7,000 approx. with a frequency response from ·1—40,000 cps. flat within 2 db. The synchronism system switch permits a choice of six systems; positions 1, 2, 3 and 5 use the internal time-base. Position 4 permits the use of an external time-base source, while position 6 is single stroke. Synchronism for positions 1, 2, 3 and 5 is derived as follows: (1) From vertical deflection amplifier. (2) From external source applied between K3, K4. (3) From 50-cycle mains. (5) By means of mechanical contact breaker S0; the gas discharge triode fires at "break."

There are fifteen external connections and four external links, which are intended for use in the following manner and give the facilities implied:

K1, K2. Time-base voltage outlet for external use; available when synchronising system switch is in positions 1, 2, 3 or 6.
K3, K4. Same use as K1, K2, but for use when synchronising system switch is in position 4.
K5, K7. Inlet for voltage to be observed; when S5 is opened for high impedance input, K5 and K6 are used instead of K5 and K7.
K8, K9. Give direct access to vertical deflection plates, which can be freed from internal connection by opening the links S1, S2.
K11, K12. Give direct access to horizontal deflection plates, which can be freed from internal connection by opening the links S3, S4.
K10, K13. Inlet for grid modulation voltage.
K14, K15. Are for beam suppression by an external source; the beam is suppressed when K14, K15 are short-circuited.
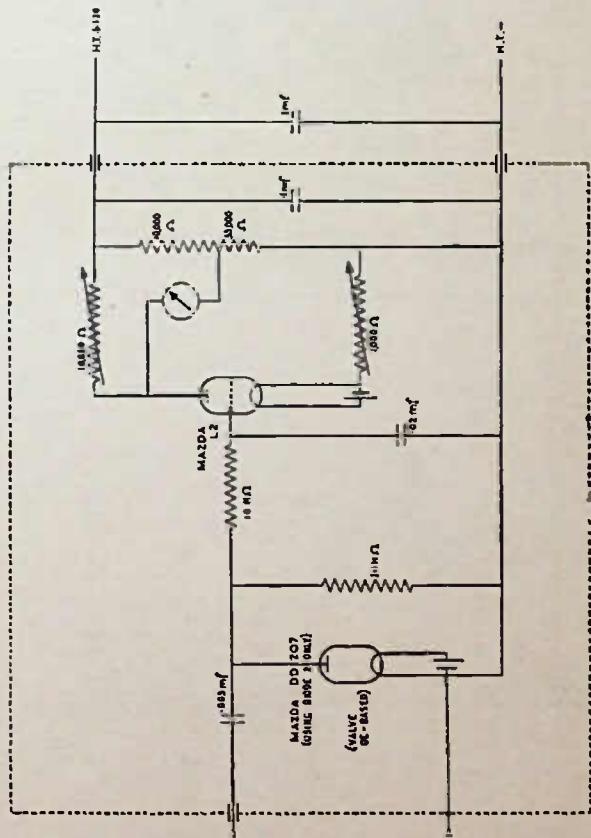
Valve Voltmeter

A simple, but highly efficient diode valve voltmeter with triode amplifier. Note that a separate accumulator must be used for each filament and that they must be housed within the screen or in a separate screened compartment without exposed connecting wires. Resistance values shown are satisfactory when using a standard 250-µA meter, which will give full scale deflection with an input of only about 1·5 volts. If properly designed, calibration does not fall off unduly with frequencies up to 50 Mcs. The 10,000-Ω resistance is so adjusted that the meter reads zero after the 1,000-Ω bias resistance has been set so that the triode is working at the beginning of the straight portion of its characteristic. Larger input voltages can be accommodated by shunting the meter, but a limitation is imposed when the input is large enough to overload the triode.
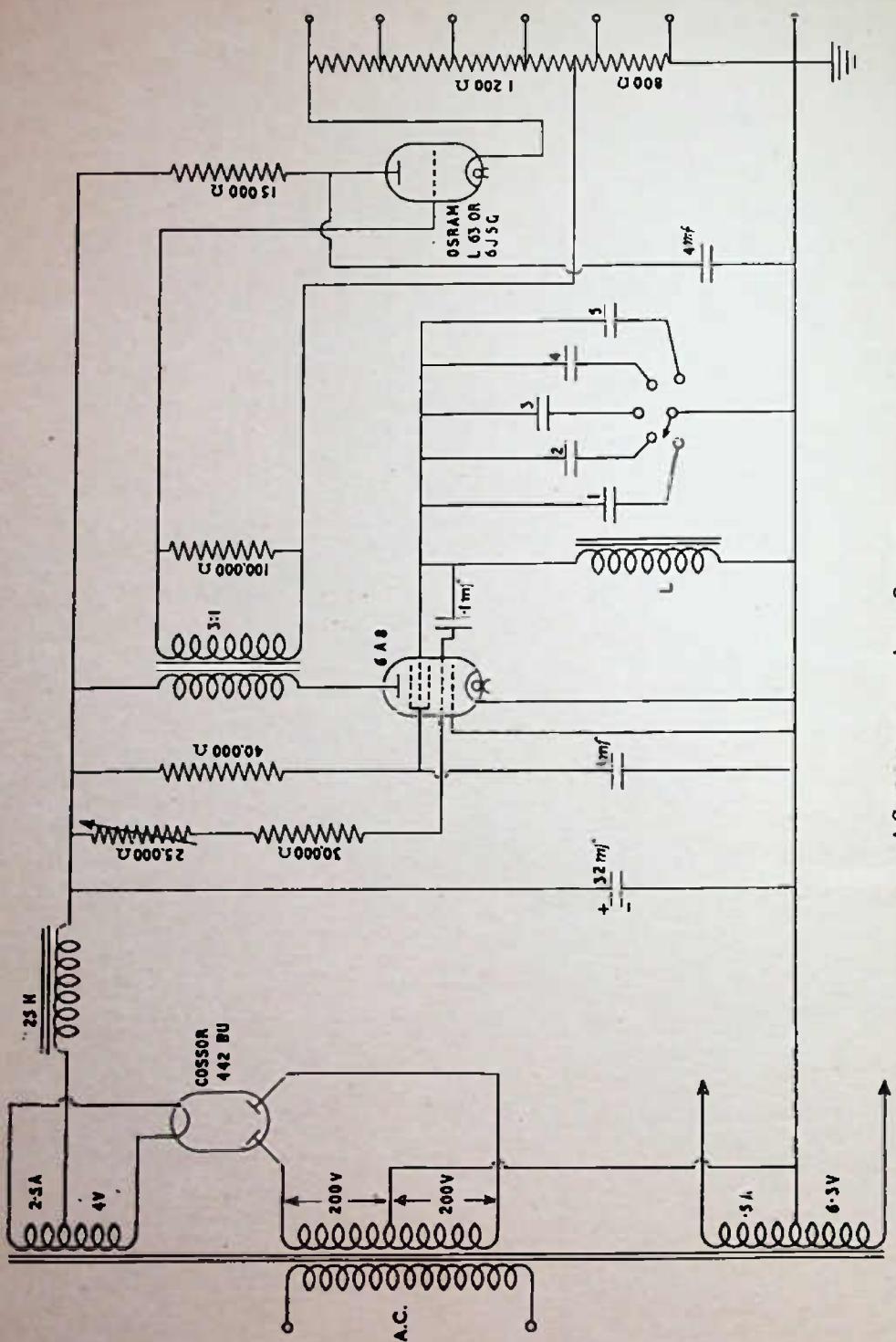
A General-purpose Audio Oscillator

Originally constructed for general purposes, this oscillator has proved very satisfactory. The use of the L.F. transformer is open to criticism, but in practice it is quite satisfactory ; an additional lead may be led out from the top end of the secondary if a high impedance output is desired. The L.F. transformer can, of course, be replaced by resistance capacity coupling, but output is thereby reduced. The output frequency is determined by the value of L and the values of the various condensers ; for formula see page 52.

46
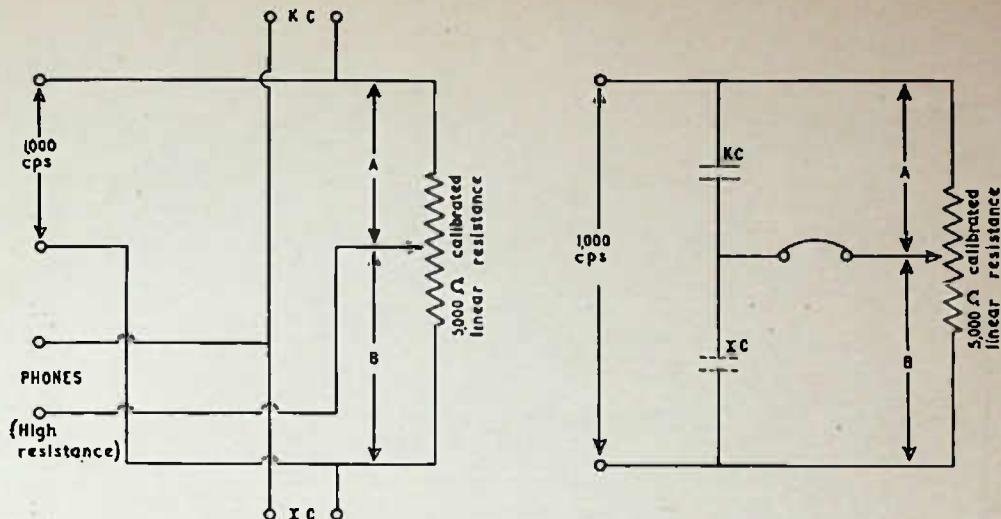
A simple capacity bridge, the accuracy of which is dependent on the accuracy of known condensers available and the calibration of a variable resistance which must be non-inductive. The diagram (left) is a practical wiring circuit, that on the right being a schematic arrangement to illustrate the following instructions. To find the capacity of an unknown condenser XC, connect a condenser of probable similar value at KC and adjust resistance until the injected 1,000-cycle note disappears or reaches a definite minimum, when

$$XC = \frac{R_A}{R_B} KC$$

when XC equals the unknown, and KC the known capacity and R_A is the portion of the resistance across KC and R_B is the portion across XC. If R_A is greatly dissimilar to R_B, greater accuracy can be obtained by selecting a condenser for KC which gives a better ratio.
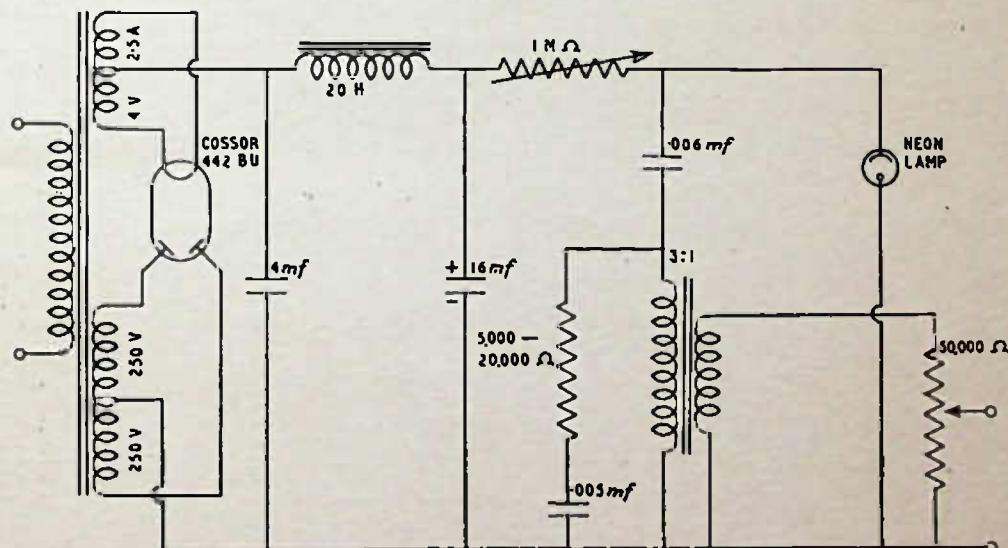
A very simple form of audio oscillator, useful where simplicity and economy are necessary and a bad waveform can be tolerated. An ordinary L.F. transformer is used, but connected to give a step-down ratio to increase output current at the expense of voltage ; where higher voltage is desired at the expense of current the transformer can be reversed. A resistance and condenser in series are shunted across the transformer to limit changes of output at different frequencies. The presence of the transformer is not essential; it limits the frequency range and prevents ready calculation of frequency, but improves the waveform for general purposes.

CAPACITY BRIDGE AND SIMPLE NEON AUDIO OSCILLATOR

47
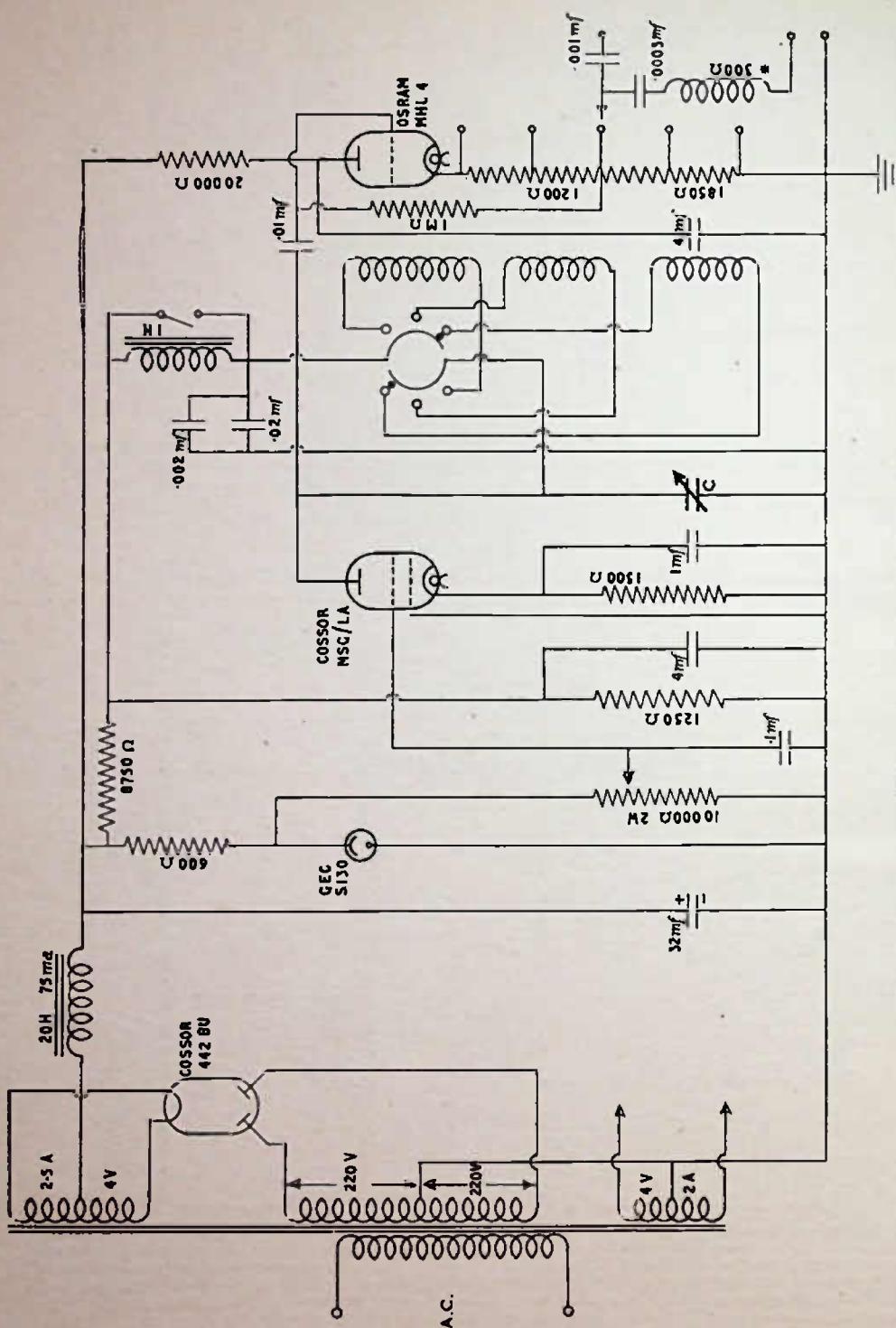
A DYNATRON SIGNAL GENERATOR

The signal generator shown above is not proof against criticism, but has the advantages of simplicity and robustness; it incorporates readily obtainable components and has worked satisfactorily for more than ten years. The variable condenser C must be of impeccable design, and the whole unit must be built into a screening box from which the inductances must be spaced by a minimum of 2 inches. The inductance marked with an asterisk consists of a suitable length of resistance wire wound on a glass tube—or this component and the ·0003-mf condenser can be replaced by a standard dummy aerial. The coils must be so designed and constructed that they are adequately free from temperature and other changes. The output is modulated or not at will, the modulation frequency being approximately 1,000 cps.

48
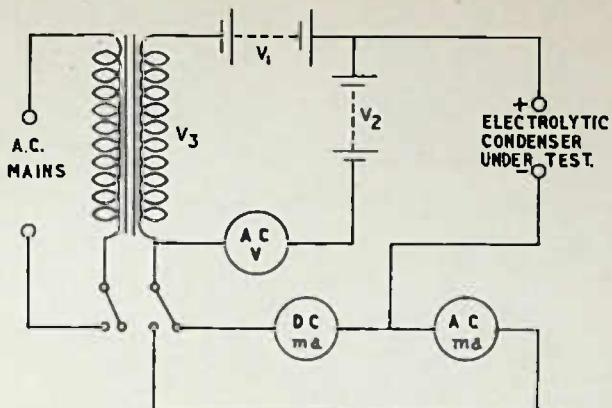
This electrolytic-test set will give leakage current and approximate capacity under working conditions. With switch in position shown, leakage current may be read directly from D.C. milliammeter; V1 should equal D.C. working-voltage of condenser (V2 must exactly equal V1).

To measure capacity, throw switch and read A.C. volts and current.

$$C = \frac{159 \times I}{V \times f}$$

when $\begin{cases} \text{C is in mf, I is in milliamps;} \\ \text{V is in volts (R.M.S.), f is mains} \\ \quad \text{periodicity in cycles.} \end{cases}$

For capacity test, V1 and V2 must be exactly equal, V3 should be about 30 per cent. of V1, and V1 + V3 should preferably be about 75 per cent. of condenser working-voltage.

Warning : Bad connections on V1 or V2 may damage the meters.
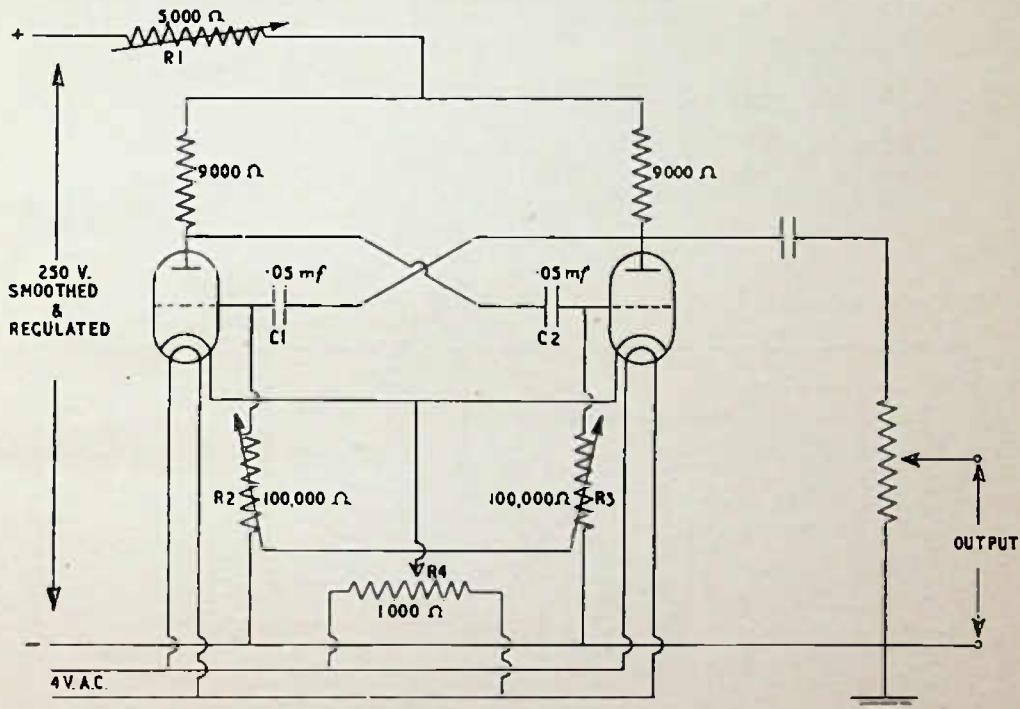
This improved form of multi-vibrator has the advantages of wide frequency range and extreme simplicity ; the multi-vibrator unfortunately, however, has a bad waveform, although with this particular arrangement some improvement can be made by careful adjustment of R1. The ganged variable resistances R2, R3 control the output frequency, R4 allows a small voltage at mains frequency to be used to lock the oscillator frequency at any desired multiple of the mains frequency.

ELECTROLYTIC CONDENSER TESTER AND MULTI-VIBRATOR

49

RESISTANCE VALUES

R1	= 20,000 − Rm ohms.	½ W.
R2	= 180,000 ohms.	½ W.
R3	= 1,800,000 ohms.	2 W.
R4	= $\frac{Rm}{190}$ ohms.	
R5	= $\frac{Rm}{10}$ ohms.	
R6	= 85,000 ohms.	½ W.
R7	= Rm.	
R8	= 17,000 ohms.	½ W.
R9	= 102,000 ohms.	½ W.
R10	= 1,020,000 ohms.	2 W.
R11	= 5,000 ohms.	½ W.
R12	= 5,000 ohms (variable).	½ W.

SWITCH POSITIONS

S1

A.C. = Volts A.C.:
1 = 0-1,000 volts D.C.
2 = 0-100 volts D.C.
3 = 0-10 volts D.C.
4 = 0-100 mA D.C.
5 = 0-10 mA D.C.
6 = 0-1 mA D.C.
7 = 0-250,000 ohms.
8 = 0-500 ohms.

S2

D.C. = Ohms, D.C. volts and amps:
1 = 0-10 volts A.C. (R.M.S.)
2 = 0-100 volts A.C. (R.M.S.)
3 = 0-1,000 volts A.C. (R.M.S.)

Note 1.—When switch S1 is in positions 1–8 inclusive, switch S2 *must* be in position D.C. When switch S1 is in position A.C., switch S2 *must* be in position 1, 2 or 3 as appropriate.

Note 2.—When the switch S3 is closed, the reading on the motor is *halved*, thus doubling all D.C. current and voltage ranges and A.C. voltage ranges *except* 0-10 V. A.C.

Rm = the resistance of the motor used, which must have a full-scale deflection of 0–500 μA; if the internal resistance of the motor selected is 50 ohms or less, R1 can be 20,000 ohms.

Rectifier unit.—Westinghouse Type 1 mA bridge instrument rectifier.

Note.—If high accuracy is required on the 0–10 V. A.C. range, R8 should be varied to suit the individual characteristics of the rectifier used.

A UNIVERSAL TEST SET

(2,000 ohms per volt)

For ranges see table above, left. R1, 2, 3, 6, 8, 9, 10 must be of the high stability 1% tolerance type. R4, 5, 7, must be wire wound. R11, 12 may be normal resistances. In most cases the values shown will not be obtainable as a single component, but must be built up with two or more as required. Switch S1 must be of a type that does not short-circuit contacts when rotated; it may be a single two-pole, nine-way wafer or two one-pole, nine-way wafers; in either case an additional wafer should be ganged on the same spindle so that contacts shown black can be doubled up to reduce contact resistance. Separate scales should be used for range groups as follows: (1, 2, 3, D.C., 1, 2, A.C.), (3, A.C.), (4, 5, 6), (7), (8). Calibration should be checked with the aid of a similar instrument of high accuracy. This instrument has its resistance range extended to 2·5 MΩ. If a 50-volt battery is connected where shown; S1 must be in position 7 and readings taken from the ·25 MΩ scale multiplied by 10. If an H.T. battery is used to supply the necessary 50 volts, the tappings should be adjusted so that a zero reading can be obtained by adjustment of R12; if it is desired to use a non-tapped battery, a variable resistance of 50,000 may have to be placed in series with the + 50V terminal.

USEFUL FORMULÆ AND DATA SECTION

The formulæ on these pages and the tables on the pages that follow are accurate to normal engineering standards and, where appropriate, they are selected for the special use of the radio engineer and are rationalised with due regard to raw materials, tolerances and ranges suitable for radio engineering.

Voltage, Current, Resistance and Power for D.C.

$$V = IR, \quad R = \frac{V}{I}, \quad I = \frac{V}{R}; \quad W = IV, \quad W = I^2R, \quad W = \frac{V^2}{R}$$

when V = volts, I = amps., R = ohms and W = watts.

Voltage, Current, Impedance and Power for A.C.

$$V = IZ, \quad Z = \frac{V}{I}, \quad I = \frac{V}{Z}; \quad W = I^2R, \quad W = VI \cos \varphi$$

when V = volts, I = amps., Z = ohms and φ = phase angle between V and I.

Resistances in Series

$$R = R_1 + R_2 + R_3 + R_4, \text{ etc.}$$

Resistances in Parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}, \text{ etc.}$$

Specific Resistance

$$R = \rho \frac{B}{A}$$

Two Resistances in Parallel

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

when ρ = specific resistance per centimetre cube, R = resistance in ohms, B = length in centimetres and A = area in square centimetres.

Condensers in Series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}, \text{ etc.}$$

Condensers in Parallel

$$C = C_1 + C_2 + C_3 + C_4, \text{ etc.}$$

Two Inductances in Parallel

$$L = \frac{L_1 \times L_2}{L_1 + L_2}$$

Two Condensers in Series

$$C = \frac{C_1 \times C_2}{C_1 + C_2}$$

Inductances in Parallel

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \frac{1}{L_4}, \text{ etc.}$$

Inductances in Series

$$L = L_1 + L_2 + L_3 + L_4, \text{ etc.}$$

Note.—Above inductance formulæ assume no mutual inductance.

Inductive Reactance

$$X_L = 2\pi fL$$

when f = cps. and L = henrys.

Capacitive Reactance

$$X_c = \frac{1}{2\pi fC}$$

when f = cps. and C = farads.

Resistance and Capacity in Series

$$Z = \sqrt{R^2 + X_c^2}$$

$$V = I\sqrt{R^2 + \frac{1}{(2\pi fC)^2}}$$

$$I = \frac{V}{\sqrt{R^2 + X_c^2}}$$

Resistance and Capacity in Parallel

$$Z = \frac{1}{\sqrt{\frac{1}{R^2} + \frac{1}{X_c^2}}}$$

$$V = I\sqrt{\frac{1}{R^2} + (2\pi fC)^2}$$

$$I = \frac{V}{\sqrt{\frac{1}{R^2} + (2\pi fC)^2}}$$

when Z = impedance in ohms, R = ohms, V = volts, I = current in amps. and C = capacity in farads.

Resistance and Inductance in Series

$$Z = \sqrt{R^2 + X_L^2}$$

$$I = \frac{V}{\sqrt{R^2 + X_L^2}}$$

$$V = I\sqrt{R^2 + (2\pi fL)^2}$$

Resistance and Inductance in Parallel

$$Z = \frac{RX_L}{\sqrt{R^2 + X_L^2}}$$

$$I = V\sqrt{\frac{1}{R^2} + \frac{1}{(2\pi fL)^2}}$$

$$V = I\frac{RX_L}{\sqrt{R^2 + X_L^2}}$$

when Z = impedance in ohms, R = ohms, V = volts, I = amps. and L = henrys.

Resistance, Capacity and Inductance in Series

$$V = I\sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fc}\right)^2} \qquad Z = \sqrt{R^2 + (X_L - X_c)^2}$$

when Z = impedance in ohms, R = ohms, V = volts, I = amps., L = henrys and C = farads.

Frequency and Wavelength

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

when f = cps., L = henrys and C = farads.

$$\lambda = 1,884\sqrt{LC}$$

when L = μH, C = μF and λ = metres

$$f = \frac{1,000,000}{2\pi\sqrt{LC}}$$

when f = kcs., L = μH and C = μF.

$$\lambda = 1{\cdot}884\sqrt{LC}$$

when L = μH, C = $\mu\mu$F and λ = metres.

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

when f = kcs., λ = metres.

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

f = mcs., λ = metres.

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

when f = kcs., λ = metres.

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

when f = mcs. λ = metres.

Dynamic Resistance at Resonance

$$R = 2\pi fLQ \text{ or } R = \frac{L}{Cr}$$

when L = henrys, C = farads and r = HF resistance at frequency concerned.

Magnification of a Tuned Circuit

$$Q = \frac{2\pi fL}{r}$$

when L = henrys, C = farads and r = HF resistance at frequency concerned.

Selectivity of a Tuned Circuit

Voltage on tuned circuit $= \dfrac{100}{\sqrt{1 + 4Q^2\left(\dfrac{\delta f}{f}\right)}}$ % of voltage at resonance

when f = frequency of resonance in cycles, δf = amount of detuning in cycles, Q = magnification of tuned circuit.

Optimum Coupling
(for max. signal)

$$M = \frac{\sqrt{r_1 r_2}}{2\pi f}$$

when $r_1 r_2$ = HF resistance at resonance and f = frequency in cps. of resonance.

Coefficient of Coupling

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

when M = mutual inductance, L_1, L_2 = inductance in henrys.

H.F. Transformer Ratio

$$n^2 = \frac{R}{R_a}$$

when n = ratio, R_a = valve impedance and R = dynamic resistance.

LC Constant

$$LC = \frac{25330}{f^2}$$

when L = μH, C = $\mu\mu$F and f = mcs.

Bandpass Tuning, Peak Separation

Inductive Coupling

Peak separation $= \dfrac{\sqrt{(2\pi f)^2 M^2 - }}{2\pi L}$

Capacity Coupling

Peak separation $= \dfrac{\sqrt{\dfrac{1}{(2\pi f)^3 C_m^2}}}{2\pi L} - r^2$

when M = mutual inductance in henrys, r = HF resistance in ohms, L = inductance in henrys and C_m = coupling capacity in farads.

Time Constants

RC = time in seconds for voltage across a discharging condenser to fall to 37% approx. of its original value

RC = time in seconds for a charging condenser to reach 63% approx. of its ultimate voltage

$\dfrac{L}{R}$ = time in seconds for current to reach 63% approx. of its ultimate steady value

$\dfrac{L}{R}$ = time in seconds for a current to fall from its maximum steady value to 37% approx. of that value

when R = ohms, L = henrys and C = farads.

H.F. Feeders

$$Z_0 = \sqrt{\frac{L}{C}}$$

Z_0 of twin feeder $= \dfrac{276, \log_{10}\dfrac{2D}{d}}{\sqrt{K}}$

Z_0 of concentric feeder $= \dfrac{138, \log_{10}\dfrac{D}{d}}{\sqrt{K}}$

when Z_0 = characteristic impedance. L = henrys and C = farads per unit length.

when d = diam. of wire, D = mean distance between conductors, K = dielectric constant.

when D = internal diam. of outer conductor, d = diam. of inner conductor and K = dielectric constant.

Aerials

Length of $\tfrac{1}{2}\lambda$ aerial in feet $= \dfrac{468}{f(mcs.)}$

Length of $\tfrac{1}{4}\lambda$ aerial in feet $= \dfrac{234}{f(mcs.)}$

Length of long wire aerial in feet $= \dfrac{492(N - \cdot 05)}{f(mcs.)}$

when N = number of $\tfrac{1}{2}$ waves on aerial.

Valve Characteristics

$$\text{Impedance} = \frac{\text{Change in anode volts}}{\text{Change in anode current}} \qquad \text{Slope} = \frac{\text{Change in anode current}}{\text{Change in grid volts}}$$

$$\text{Amp. factor} = \frac{\text{Change in anode volts}}{\text{Change in grid volts}} \qquad \text{Slope} = \frac{\text{Amp. factor}}{\text{Impedance}}$$

Relationship between impedance (R_a), amplification factor (μ) and slope (g_m) is :

$$g_m = \frac{\mu}{R_a}, \quad \mu = g_m R_a \quad \text{and} \quad R_a = \frac{\mu}{g_m}$$

when units are volts, amps. and ohms and g_m is in amps. per volt.

Power Output and Distortion of Triode Valves

5% second harmonic distortion is present when the distance $I_{max} - I_o$ is $\frac{1}{9}$ of the distance $I_o - I_{min}$ (I_o is the operating or bias point). The use of a special ruler to satisfy this condition is explained on page 193, Vol. I, of *Modern Practical Radio and Television*. Suitable dimensions for making such a ruler are given on the left; any transparent material may be used, and great accuracy must be observed.

Diagrammatic representation of anode-volt/anode-current curve. I_o is the operating point.

$$\text{Output watts} = \tfrac{1}{8}(I_{max} - I_{min})(V_{max} - V_{min})$$

$$\text{Load resistance} = \frac{V_{max} - V_{min}}{I_{max} - I_{min}}$$

$$\% \text{ 2nd harmonic distortion} = \frac{\dfrac{I_{max} + I_{min}}{2} - I_o}{I_{max} - I_{min}} \times 100\%$$

when V = volts and I = current in amps.

Power Output, Optimum Load and Bias by Formulæ

$$\text{Watts output} = \cdot041\,\mu k\left(\frac{V_a}{\mu}\right)^{\frac{5}{2}} \text{ approx.} \qquad \text{Optimum load in ohms} = 1\cdot9\,\frac{\mu}{k}\left(\frac{V_a}{\mu}\right)^{-\frac{1}{2}}$$

when V_a = anode voltage in volts, μ = amplification factor and k = as below.

Units and value of the constant k are the same as those given, left.

$$k = \frac{I}{\left(\dfrac{V_a}{\mu} - V_g\right)^{\frac{3}{2}}}$$

$$\text{Approx. grid bias} = \frac{V_g \times 1,000}{(I_a + I_{sg})n}$$

when V_a = anode voltage in volts, V_g = grid voltage in volts, I_a = anode current in amps.

when V_g = grid bias in volts, I_a = anode current in mA, I_{sg} = screen current in mA and n = number of valves using common bias resistor.

Voltage Amplification (Stage Gain)

$$\text{Stage gain} = \frac{\mu Z}{Z + R_a}$$

when Z = impedance of anode load, μ = amplification factor and R_a = valve impedance. (If Z is inductive or capacitive, Z and R_a must be added vectorially.)

Output Transformer Ratio

$$N = \sqrt{\frac{R_o}{Z}}$$

When N = transformer turns ratio, R_o = optimum load of valve and Z = loudspeaker impedance.

R.C. Coupled A.F. Amplifier Design

Stage gain at medium frequencies $= \dfrac{\mu R}{R + R_a} = A_{mf}$

Stage gain at low frequencies $= \sqrt{\dfrac{A_{mf}}{1 + \dfrac{1}{(2\pi f)^2 C_2^2 \rho^2}}}$

Stage gain at high frequencies $= \dfrac{A_{mf}}{\sqrt{1 + (2\pi f)^2 C_1^2 r^2}}$

when $R = \dfrac{R_1 R_2}{R_1 + R_2}$ $\qquad r = \dfrac{R R_a}{R + R_a}$ $\qquad \rho = R_2 + \dfrac{R_1 R_a}{R_1 + R_a}$

and when R_a = valve impedance, R_1 = anode load resistance in ohms, R_2 = grid leak resistance in ohms, C_1 = total shunt capacity in farads, C_2 = coupling capacity in farads, μ = valve amplification factor, A_{mf} = see top left, ρ = see bottom right.

Attenuation Network Design

$R_1 = Z_1\left(\dfrac{N+1}{N-1}\right) - R_3$

$R_2 = Z_2\left(\dfrac{N+1}{N-1}\right) - R_3$

$R_3 = \dfrac{2\sqrt{N Z_1 Z_2}}{N-1}$

Unbalanced T type

Balanced H type
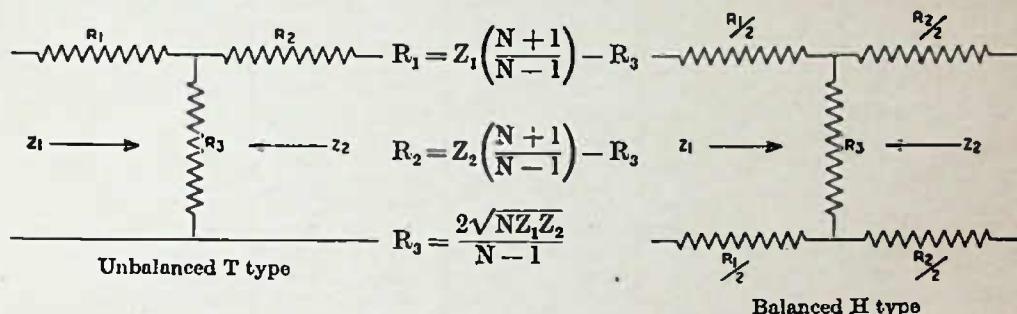
when Z = impedance in ohms, R = resistance in ohms and N = the ratio of power absorbed (by the attenuator) from the source of the power to the output power delivered,

Turns Required for a Given Inductance and Size of Coil Former

$n = \sqrt{\left(\dfrac{L}{a}\right)\left(\dfrac{b}{a}\right) 39 \cdot 88 \left(\dfrac{1}{K}\right)}$

when n = required number of turns, $L = \mu H$, a = diameter of coil in inches, b = length in inches and K = correction, for which see below.

Inductance of a Single Layer Coil

$L = \dfrac{\cdot 0395 a^2 n^2}{b} K$

when $L = \mu H$, a = radius of coil measured from the axis to centre of wire, n = number of turns, b = length, K = correction as below (measurements in inches).

When $\dfrac{D}{B}$ =	·1	·25	·5	·75	1	1·5	2	2·5	3	3·5	4	4·5
K =	·96	·9	·82	·75	·69	·59	·526	·472	·429	·394	·365	·34

when D = mean diameter and B = length of winding.

Capacity of a Fixed Condenser

$C = \dfrac{\cdot 0885 A K (n-1)}{d}$

when A = overlapping area of metal plates in square centimetres, K = dielectric constant, n = number of metal plates. d = distance between plates in centimetres.

GREEK LETTERS.—Greek letters used in these pages of formulæ are pronounced as follows : ρ = rho, φ = phi, π = pi, λ = lambda, μ = mu and δ = delta.

READY-WORKED FREQUENCY—WAVELENGTH CONVERSION TABLE

f in Mcs.	Metres	f in Mcs.	Metres	f in Kcs.	Metres	f in Kcs.	Metres	f in Kcs.	Metres
70	4·29	14	21·43	3,000	100	830	361·4	505	594·1
69	4·35	13·5	22·22	2,950	101·7	820	365·8	500	600
68	4·41	13	23·08	2,900	103·5	810	370·7	495	606
67	4·48	12·5	24	2,850	105·3	800	375	490	612·3
66	4·55	12	25	2,800	107·1	790	379·7	485	618·6
65	4·62	11·5	26·08	2,750	109·1	780	384·9	480	625
64	4·69	11	27·27	2,700	111·1	770	389·6	475	631·6
63	4·76	10·5	28·57	2,650	113·2	760	394·8	470	638·3
62	4·84	10	30	2,600	115·4	750	400	465	645·2
61	4·92	9·5	31·58	2,550	117·7	745	402·9	460	652·2
60	5	9	33·33	2,500	120	740	405·4	455	659·3
59	5·09	8·5	35·29	2,450	122·5	735	408·2	450	666·7
58	5·17	8	37·5	2,400	125	730	411	440	681·8
57	5·26	7·75	38·71	2,350	127·7	725	413·8	430	697·7
56	5·36	7·5	40	2,300	130·4	720	416·7	420	714·3
55	5·45	7·25	41·38	2,250	133·3	715	419·6	410	731·8
54	5·56	7	42·86	2,200	136·4	710	422	400	750
53	5·66	6·75	44·46	2,150	139·5	705	425·5	390	769·8
52	5·71	6·5	46·15	2,100	142·9	700	428·6	380	789·5
51	5·88	6·25	48	2,050	146·4	695	431·7	370	810·8
50	6	6	50	2,000	150	690	434·8	360	833·4
49	6·12	5·9	50·85	1,950	153·9	685	438	350	857·2
48	6·25	5·8	51·73	1,900	157·9	680	441·2	340	882·5
47	6·38	5·7	52·63	1,850	162·2	675	444·5	330	909·1
46	6·52	5·6	53·57	1,800	166·7	670	448·8	320	937
45	6·67	5·5	54·55	1,750	171·4	665	451·1	310	967·7
44	6·82	5·4	55·55	1,700	176·5	660	454·6	300	1,000
43	6·98	5·3	56	1,650	181·8	655	458	295	1,017
42	7·14	5·2	57·69	1,600	187·5	650	461·5	290	1,034·5
41	7·32	5·1	58·83	1,550	193·6	645	465·1	285	1,052·6
40	7·5	5	60	1,500	200	640	468·5	280	1,071·4
39	7·7	4·9	61·23	1,450	206·9	635	472·4	275	1,090·9
38	7·9	4·8	62·5	1,400	214·3	630	476·2	270	1,111·1
37	8·11	4·7	63·83	1,350	222·2	625	480	265	1,132
36	8·33	4·6	65·22	1,300	230·8	620	483·9	260	1,153·8
35	8·57	4·5	66·66	1,250	240	615	487·8	255	1,176·5
34	8·82	4·4	68·18	1,200	250	610	491·8	250	1,200
33	9·09	4·3	69·77	1,150	260·9	605	495·9	245	1,224·5
32	9·37	4·2	71·43	1,100	272·7	600	500	240	1,250
31	9·68	4·1	73·18	1,050	285·7	595	504·2	235	1,276·6
30	10	4	75	1,000	300	590	508·5	230	1,304·3
29	10·35	3·9	76·98	990	303	585	512·8	225	1,333·3
28	10·71	3·8	78·95	980	306·2	580	517·2	220	1,363·6
27	11·11	3·75	80	970	309·3	575	521·7	215	1,395·4
26	11·54	3·7	81·08	960	312·5	570	526·3	210	1,428·5
25	12	3·65	82·19	950	315·8	565	531	205	1,463·5
24	12·5	3·6	83·34	940	319·2	560	535·7	200	1,500
23	13·04	3·55	84·39	930	322·9	555	540·5	195	1,538·5
22	13·64	3·5	85·72	920	326·1	550	545·5	190	1,579
21	14·29	3·45	86·96	910	329·7	545	550·6	185	1,621·6
20	15	3·4	88·25	900	333·3	540	555·6	180	1,666·7
19	15·79	3·35	89·50	890	337·1	535	560·8	175	1,714·3
18	16·67	3·3	90·91	880	340·9	530	566	170	1,764·7
17	17·65	3·25	92·31	870	344·9	525	571·4	165	1,818·2
16	18·75	3·2	93·7	860	348·9	520	576·9	160	1,875
15	20	3·1	96·77	850	352·9	515	582·5	155	1,935·5
14·5	20·69	3	100	840	357·1	510	588·3	150	2,000

READY-WORKED COIL WINDING TABLES

MEDIUM WAVES

Former Diam. (inches)	175 Microhenrys *				200 Microhenrys †				225 Microhenrys ‡			
	S.W.G.	Type	Turns	Length (inches)	S.W.G.	Type	Turns	Length (inches)	S.W.G.	Type	Turns	Length (inches)
1·25	32	S.S.C.	85	1·05	32	S.S.C.	94	1·15	32	S.S.C.	104	1·26
1·25	30	D.S.C.	93	1·38	30	D.S.C.	103	1·53	30	D.S.C.	112	1·72
1·5	30	D.S.C.	74	1·1	30	D.S.C.	82	1·22	30	D.S.C.	90	1·35
1·75	30	D.S.C.	63	·95	30	D.S.C.	68	1	30	D.S.C.	76	1·15
1·75	28	D.S.C.	67	1·16	28	D.S.C.	73	1·25	28	D.S.C.	80	1·4
2	30	D.S.C.	54	·8	30	D.S.C.	59	·89	30	D.S.C.	65	·97
2	28	D.S.C.	58	1	28	D.S.C.	64	1·15	28	D.S.C.	70	1·25
2·25	28	D.S.C.	52	·93	28	D.S.C.	57	1	28	D.S.C.	62	1·1
2·25	26	D.C.C.	70	1·95	26	D.C.C.	77	2·1	26	D.C.C.	87	2·39
2·5	28	D.S.C.	47	·84	28	D.S.C.	51	·9	28	D.S.C.	56	1
2·5	24	D.C.C.	58	1·85	24	D.C.C.	65	2·05	24	D.C.C.	72	2·25

Note.— * For normal broadcast coverage where a trimmer is employed, use 175 μH with ·0005 mf.
† Use with ·0005 mf. for normal broadcast coverage.
‡ Use with ·0004 mf. for normal broadcast coverage.

LONG WAVES

Former Diam. (inches)	2,100 Microhenrys *				3,000 Microhenrys †			
	S.W.G.	Type	Grooves‡	Turns per groove	S.W.G.	Type	Grooves‡	Turns per groove
1	36	Enamel	4	92	36	Enamel	5	95
1	36	Enamel	5	80	36	Enamel	6	85
1·5	36	Enamel	3	80	36	Enamel	3	96
1·5	34	Enamel	5	60	36	Enamel	4	78
2	34	D.S.C.	4	51	36	D.S.C.	4	60
2	34	D.S.C.	5	45	36	D.S.C.	5	53

Note.— * For normal long-wave coverage use ·0005 mf.
† For normal long-wave coverage use ·0004 mf.
‡ Grooves must be ½-inch deep, $\frac{1}{16}$-inch wide and be ½-inch apart ; such formers may be purchased ready-made in ebonite or other suitable insulating material.

READY-WORKED L × C CONSTANTS FOR RADIO AND AUDIO FREQUENCIES

Radio Frequencies L in μH and C in μF		Radio Frequencies—continued		Audio Frequencies L in H and C in μF	
F in Kcs.	L × C	F in Kcs.	L × C	F in cps.	L × C
30,000	·0000282	680	·05477	25	40·545
15,000	·0001129	660	·05815	50	10·136
10,000	·000253	640	·06184	100	2·533
7,300	·0004753	630	·06382	200	·633
6,000	·000704	620	·06484	400	·158
5,000	·001014	610	·06807	600	·07
1,000	·02533	600	·07036	800	·04
950	·02806	590	·07276	1,000	·025
900	·03127	580	·07529	2,000	·0063
875	·03308	570	·07796	3,000	·0028
850	·03506	560	·08076	4,000	·0016
825	·03721	550	·08373	4,500	·00125
800	·03957	465	·11715	5,000	·001
780	·04163	300	·28145	6,000	·0007
760	·04385	250	·40545	7,000	·0005
740	·04625	200	·63325	8,000	·0004
720	·04891	170	·87646	9,000	·00031
700	·05149	150	1·1258	10,000	·00025

Note.—Many formulæ incorporate $\sqrt{L \times C}$; above figures are L × C, the square-root of which can be taken when necessary.

COPPER WIRE TABLE

Imperial or British Standard Wire Gauge S.W.G.	U.S.A. Wire Gauge A.W.G. (B. & S.)	Diameter in inches	Diameter in millimetres	*Ohms per thousand feet	Feet per lb.	† Turns per inch					
						Bare	Enam.	S.C.C.	D.C.C.	S.S.C.	D.S.C.
10	—	·128	3·25	·6210	20·16	7·81	7·03	7·35	7·04	—	—
11	—	·110	2·946	·7570	24·55	8·02	8·33	8·07	7·09	—	—
—	9	·1144	2·906	·7921	25·23	8·74	8·58	8·23	7·01	—	—
12	—	·104	2·64	·942	30·54	9·62	9·26	8·03	8·48	—	—
—	10	·1019	2·558	·9989	31·82	9·81	9·61	9·26	8·85	—	—
13	—	·092	2·337	1·204	39·01	10·87	10·42	10·00	9·43	—	—
—	11	·09074	2·304	1·20	40·12	11·02	10·7	10·4	9·08	—	—
—	12	·08081	2·053	1·588	50·59	12·37	12·00	11·6	11·07	—	—
14	—	·080	2·03	1·592	51·60	12·50	11·90	11·36	10·84	—	—
15	13	·0720	1·828	2·000	63·80	13·89	13·33	12·29	12·08	—	—
16	—	·064	1·63	2·488	80·05	15·59	14·81	14·08	13·10	14·93	14·71
—	14	·06408	1·628	2·525	80·44	15·01	15·1	14·4	13·59	—	—
—	15	·05707	1·450	3·184	101·4	17·52	16·9	16·9	15·00	16·95	16·07
17	—	·056	1·422	3·249	105·4	17·86	16·05	15·87	14·71	18·0	18·2
—	16	·05082	1·291	4·016	127·9	19·68	18·0	17·9	16·5	20·0	19·01
18	—	·048	1·22	4·422	143·3	20·83	19·72	18·18	16·95	21·1	20·2
—	17	·04620	1·150	5·064	161·3	22·1	21·2	10·8	18·2	23·6	22·6
—	18	·04030	1·024	6·385	203·4	24·8	23·7	22·0	20·0	23·81	23·26
19	—	·040	1·016	6·368	206·4	25·0	23·47	21·28	19·61	26·32	25·04
20	—	·036	·914	7·860	254·8	27·78	25·97	23·81	21·28	26·3	25·0
—	19	·03589	·9116	8·051	256·5	27·8	26·5	24·4	22·0	29·41	28·57
21	—	·032	·8138	9·050	322·6	31·25	29·15	26·32	23·20	29·4	27·7
—	20	·03196	·8118	10·15	323·4	31·3	29·5	27·0	24·1	32·7	30·7
—	21	·02846	·7230	12·80	407·8	35·1	33·1	29·8	26·3	33·33	32·26
22	—	·028	·711	12·997	421·2	35·71	33·33	29·41	25·64	33·6	34·1
—	22	·02535	·6438	16·14	514·2	39·4	37·0	33·5	29·5	38·46	37·04
23	—	·024	·6096	17·69	573·4	41·67	38·91	34·48	29·41	40·0	37·5
—	23	·02257	·5733	20·30	648·4	44·3	41·4	30·9	32·1	42·55	40·00
24	—	·022	·559	21·05	682·6	45·45	42·37	37·04	31·25	45·2	41·4
—	24	·0201	·5106	25·67	817·7	49·7	40·5	40·6	34·9	45·51	43·48
25	—	·020	·508	25·47	825·8	50·0	46·51	40·00	33·33	51·81	48·78
26	—	·018	·457	31·45	1,019	55·56	51·55	43·48	35·71	50·0	45·6
—	25	·0179	·4547	32·37	1,031	55·8	52·0	44·6	37·8	50·50	52·91
27	—	·0164	·4165	37·88	1,220	60·98	56·50	46·73	37·88	55·8	50·0
—	26	·01594	·4049	40·81	1,300	62·7	58·4	49·0	40·9	62·11	57·80
28	—	·0148	·376	40·52	1,508	67·57	62·50	50·51	40·32	61·7	54·9
—	27	·0142	·3600	51·47	1,639	70·4	65·3	53·4	44·0	67·11	62·11
29	—	·0130	·3454	55·09	1,786	73·53	67·57	53·76	42·37	—	—

* Resistance of U.S.A. gauges measured at 68° F. and S.W.G. gauges at 60° F.

† Apparent inconsistencies in turns per inch between similar British and U.S.A. gauges are due to differences in thickness of insulation.

COPPER WIRE TABLE (contd.)

Imperial or British Standard Wire Gauge S.W.G.	U.S.A. Wire Gauge A.W.G. (B. & S.)	Diameter in inches	Diameter in millimetres	*Ohms per thousand feet	Feet per lb.	Bare	Enam.	S.C.C.	D.C.C.	S.S.C.	D.S.C.
								†Turns per inch			
—	28	·01264	·3211	64·90	2,067	82·8	73·5	58·4	47·3	68·4	60·2
30	—	·0124	·315	66·27	2,148	80·05	74·03	57·47	44·64	72·99	67·11
31	—	·0116	·2946	75·7	2,455	86·21	79·37	60·24	40·30	77·52	70·92
—	29	·01126	·2859	81·83	2,607	88·8	81·9	63·2	50·5	75·1	65·3
32	—	·0108	·274	87·4	2,832	92·50	85·47	63·29	48·0	82·64	75·10
33	—	·01	·2540	101·9	3,302	100·0	91·74	66·67	50·0	88·50	80·0
—	30	·01003	·2546	103·2	3,287	99·7	92·5	68·9	54·0	83·3	71·4
34	—	·0092	·234	120·4	3,901	108·0	99·0	70·42	52·08	95·24	85·47
—	31	·00893	·2268	130·1	4,145	112·0	103·0	74·6	57·4	91·7	77·5
35	—	·0082	·2082	144·4	4,082	119·0	110·0	80·65	57·47	103·0	91·74
—	32	·0079	·2010	164·1	5,227	125·8	114·0	80·0	60·0	100·0	83·3
36	—	·0072	·193	176·4	5,718	131·0	118·0	86·21	60·25	112·5	99·0
—	33	·0071	·1798	200·0	6,591	141·2	129·0	80·2	64·1	109·0	90·0
37	—	·0068	·1727	220·4	7,143	147·0	135·0	90·21	63·29	123·5	107·5
—	34	·0063	·1601	260·9	8,310	158·0	144·0	92·5	67·5	120·0	97·0
38	—	·0056	·152	283·0	10,174	166·7	148·5	100·0	68·67	137·0	118·0
—	35	·0052	·1428	329·0	10,480	178·0	161·0	99·9	70·9	131·0	104·0
—	36	·0050	·1320	370·8	12,210	192·3	175·4	108·7	70·42	153·8	130·0
39	—	·0048	·1270	414·8	13,210	200·0	181·0	111·0	76·9	142·0	111·0
40	—	·0044	·122	442·2	14,330	208·0	185·7	113·0	72·46	164·0	137·0
—	37	·00445	·1117	520·3	17,060	227·0	206·0	—	—	178·6	151·5
—	38	·004	·1131	532·1	16,060	224·0	204·0	117·0	80·0	153·0	117·0
41	—	·00306	·102	636·8	20,640	250·0	222·0	—	—	192·3	161·2
42	—	·0030	·1007	659·0	21,010	252·0	227·0	125·0	83·3	166·0	125·0
—	39	·00363	·0914	788·3	25,480	277·8	255·0	—	—	208·3	172·3
43	—	·0032	·0897	831·8	26,500	283·0	256·0	133·0	86·9	181·0	133·0
—	40	·00314	·081	905·0	32,260	312·5	277·7	—	—	227·3	185·2
—	41	·0028	·0790	1,049·0	33,410	318·0	285·0	140·0	90·0	196·0	140·0
44	—	·00275	·0711	1,299·7	42,120	357·1	315·1	—	—	250·0	200·0
45	—	·0035	·0698	1,370·0	43,700	363·0	327·0	—	—	—	—
—	42	·0025	·0635	1,600·0	52,800	400·0	378·0	—	—	—	—
46	—	·0024	·061	1,769·0	57,340	416·7	368·3	—	—	—	—
—	43	·00225	·0571	2,050·0	65,300	444·0	421·0	—	—	—	—
—	44	·002	·0504	2,547·0	82,580	500·0	435·5	—	—	277·7	217·4
47	—	·002	·0504	2,600·0	82,600	500·0	471·0	—	—	312·5	238·0
—	45	·00175	·0404	3,390·0	107,900	571·0	523·0	—	—	—	—

* Resistance of U.S.A. gauges measured at 68° F. and S.W.G. gauges at 60° F.

† Apparent inconsistencies in turns per inch between similar British and U.S.A. gauges are due to differences in thickness of insulation.

MISCELLANEOUS WIRE TABLES

FUSE-WIRE TABLE

Fusing Current in amps.	Tin		Tin Alloy (75% Lead, 25% Tin)		Tinned Copper		Lead	
	Diameter in inches	S.W.G.	Diameter in inches	S.W.G.	Diameter in inches	S.W.G.	Diameter in inches	S.W.G.
1	·0072	37	·0084	35	—	—	·0084	35
2	·0113	31	·0136	29	—	—	·0124	30
3	·0148	28	·0164	27	—	—	·0164	27
4	·018	20	·02	25	—	—	·02	25
5	·02	25	·024	23	—	—	·024	23
6	·024	23	·032	21	—	—	—	—
10	·032	21	·048	18	·01	33	·036	20
15	·044	—	·064	16	·0136	29	·048	18
20	·056	17	—	—	·0146	27	·056	17
25	·064	16	—	—	—	—	·072	15
30	·072	15	—	—	·022	24	·08	14

The above figures are approximate owing to the desirability of using S.W.G. and round figures in amps. ; they are, however, sufficiently accurate for practical purposes. Sixty per cent. may be taken as the safe normal current.

FLEX

Description	Sectional Area in sq. ins. (nominal)	Maximum Current in amps.	Description	Sectional Area in sq. ins. (nominal)	Maximum Current in amps.
14/·0076	·0006	2	70/·0076	·003	10
23/·0076	·001	3	110/·0076	·0048	15
40/·0076	·0017	5	162/·0076	·007	20

RESISTANCE WIRE

S.W.G.	Diameter (inches)	Eureka* (ohms per yard)	Nichrome † (ohms per yard)	S.W.G.	Diameter (inches)	Eureka * (ohms per yard)	Nichrome † (ohms per yard)
10	·128	·053	·125	30	·0124	5·633	12·982
12	·104	·08	·189	31	·0116	6·436	14·825
13	·092	·1023	·242	32	·0108	7·427	17·102
14	·08	·1353	·32	33	·01	8·662	19·960
15	·072	·1671	·395	34	·0092	10·23	23·57
16	·064	·2115	·486	35	·0084	12·27	28·277
17	·056	·2762	·636	36	·0070	15	34·563
18	·048	·376	·865	37	·0068	18·74	43·166
19	·04	·541	1·246	38	·006	24·05	55·374
20	·036	·668	1·539	39	·0052	32·03	73·722
21	·032	·846	1·957	40	·0048	37·6	86·485
22	·028	1·105	2·546	41	·0044	44·74	100·15
23	·024	1·504	3·463	42	·0040	54·13	124·7
24	·022	1·789	4·118	43	·0036	66·68	153·875
25	·02	2·166	4·979	44	·0032	84·61	194·94
26	·018	2·673	6·156	45	·0028	110·5	254·6
27	·0164	3·221	7·422	46	·0024	150·4	346·3
28	·0148	4·119	9·107	47	·002	216·6	497·89
29	·0136	4·684	10·793	48	·0016	338·4	779·52

* Values are approximate and are based on an alloy of 40% nickel and 60% copper. This wire should not be used above 575° F. (300° C.). It has an extremely low temperature coefficient.

† The resistance of nichrome varies considerably ; figures given are the average of several different manufacturers, all being alloys of approximately 80% nickel and 20% chromium. Alloys containing a small percentage of iron have a slightly lower resistance ; temperature coefficient is low, averaging + 0·0001 per C°.

READY-WORKED VOLTAGE, CURRENT AND RESISTANCE TABLE

VOLTAGE DROP IN VOLTS

The heavy stepped lines crossing the table mark the constant-power curves: ¼ WATT, ½ WATT, ¾ WATT, 1 WATT, 2 WATTS, 3 WATTS, 4 WATTS, 5 WATTS, 6 WATTS.

CURRENT IN MILLIAMPS	1	2	4	6	8	10	14	18	22	26	30	34	38	42	46	50	60	70	80	100
1	1,000	2,000	4,000	6,000	8,000	10,000	14,000	18,000	22,000	26,000	30,000	34,000	38,000	42,000	46,000	50,000	60,000	70,000	80,000	100,000
2	500	1,000	2,000	3,000	4,000	5,000	7,000	9,000	11,000	13,000	15,000	17,000	19,000	21,000	23,000	25,000	30,000	35,000	40,000	50,000
3	333	667	1,333	2,000	2,667	3,333	4,667	6,000	7,333	8,667	10,000	11,333	12,667	14,000	15,333	16,667	20,000	23,333	26,667	33,333
4	250	500	1,000	1,500	2,000	2,500	3,500	4,500	5,500	6,500	7,500	8,500	9,500	10,500	11,500	12,500	15,000	17,500	20,000	25,000
5	200	400	800	1,200	1,600	2,000	2,800	3,600	4,400	5,200	6,000	6,800	7,600	8,400	9,200	10,000	12,000	14,000	16,000	20,000
6	167	333	667	1,000	1,333	1,667	2,333	3,000	3,667	4,333	5,000	5,667	6,333	7,000	7,667	8,333	10,000	11,667	13,333	16,667
7	143	286	571	857	1,143	1,429	2,000	2,571	3,143	3,714	4,286	4,857	5,429	6,000	6,571	7,143	8,571	10,000	11,429	14,286
8	125	250	500	750	1,000	1,250	1,750	2,250	2,750	3,250	3,750	4,250	4,750	5,250	5,750	6,250	7,500	8,750	10,000	12,500
9	111	222	444	667	889	1,111	1,556	2,000	2,444	2,889	3,333	3,778	4,222	4,667	5,111	5,556	6,667	7,778	8,889	11,111
10	100	200	400	600	800	1,000	1,400	1,800	2,200	2,600	3,000	3,400	3,800	4,200	4,600	5,000	6,000	7,000	8,000	10,000
12	83	167	333	500	667	833	1,167	1,500	1,833	2,167	2,500	2,833	3,167	3,500	3,833	4,167	5,000	5,833	6,667	8,333
14	71	143	286	428	572	714	1,000	1,286	1,571	1,857	2,143	2,429	2,714	3,000	3,286	3,571	4,286	5,000	5,714	7,143
16	63	125	250	375	500	625	875	1,125	1,375	1,625	1,875	2,125	2,375	2,625	2,875	3,125	3,750	4,375	5,000	6,250
18	56	111	222	333	444	556	778	1,000	1,222	1,444	1,667	1,889	2,111	2,333	2,556	2,778	3,333	3,889	4,444	5,556
20	50	100	200	300	400	500	700	900	1,100	1,300	1,500	1,700	1,900	2,100	2,300	2,500	3,000	3,500	4,000	5,000
22	45	91	182	273	364	455	636	818	1,000	1,182	1,364	1,545	1,727	1,909	2,091	2,273	2,727	3,182	3,636	4,545
24	42	83	167	250	333	417	583	750	917	1,083	1,250	1,417	1,583	1,750	1,917	2,083	2,500	2,917	3,333	4,167
26	38	77	154	231	308	385	538	692	846	1,000	1,154	1,308	1,462	1,615	1,769	1,923	2,308	2,692	3,077	3,846
28	36	71	143	214	286	357	500	643	786	929	1,071	1,214	1,357	1,500	1,643	1,786	2,143	2,500	2,857	3,571
30	33	67	133	200	267	333	467	600	733	867	1,000	1,133	1,267	1,400	1,533	1,667	2,000	2,333	2,667	3,333
32	31	63	125	188	250	313	438	563	688	813	938	1,063	1,188	1,313	1,438	1,563	1,875	2,188	2,500	3,125
34	29	59	118	176	235	294	412	529	647	765	882	1,000	1,118	1,235	1,353	1,471	1,765	2,059	2,353	2,941
36	28	56	111	167	222	278	389	500	611	722	833	944	1,056	1,167	1,278	1,389	1,667	1,944	2,222	2,778
38	26	53	105	158	211	263	368	474	579	684	789	895	1,000	1,105	1,211	1,316	1,579	1,842	2,105	2,632
40	25	50	100	150	200	250	350	450	550	650	750	850	950	1,050	1,150	1,250	1,500	1,750	2,000	2,500
42	24	48	95	143	190	238	333	429	524	619	714	810	905	1,000	1,095	1,190	1,429	1,667	1,905	2,381
44	23	45	91	136	182	227	318	409	500	591	682	773	864	955	1,045	1,136	1,364	1,591	1,818	2,273
46	22	43	87	130	174	217	304	391	478	565	652	739	826	913	1,000	1,087	1,304	1,522	1,739	2,174
48	21	42	83	125	167	208	292	375	458	542	625	708	792	875	958	1,042	1,250	1,458	1,667	2,083
50	20	40	80	120	160	200	280	360	440	520	600	680	760	840	920	1,000	1,200	1,400	1,600	2,000
52	19	38	77	115	154	192	269	346	423	500	577	654	731	808	885	962	1,154	1,346	1,538	1,923
54	19	37	74	111	148	185	259	333	407	481	556	630	704	778	852	926	1,111	1,296	1,481	1,852
56	18	36	71	107	143	179	250	321	393	464	536	607	679	750	821	893	1,071	1,250	1,429	1,786
58	17	34	69	103	138	172	241	310	379	448	517	586	655	724	793	862	1,034	1,207	1,379	1,724
60	17	33	67	100	133	167	233	300	367	433	500	567	633	700	767	833	1,000	1,167	1,333	1,667

READY-WORKED RESISTANCE COLOUR CODE

Ohms	Body	Tip	Dot	Ohms	Body	Tip	Dot
10	Brown	Black	Black	820	Grey	Red	Brown
11	Brown	Brown	Black	910	White	Brown	Brown
12	Brown	Red	Black	1,000	Brown	Black	Red
13	Brown	Orange	Black	1,100	Brown	Brown	Red
15	Brown	Green	Black	1,200	Brown	Red	Red
16	Brown	Blue	Black	1,300	Brown	Orange	Red
18	Brown	Grey	Black	1,500	Brown	Green	Red
20	Red	Black	Black	1,600	Brown	Blue	Red
22	Red	Red	Black	1,800	Brown	Grey	Red
24	Red	Yellow	Black	2,000	Red	Black	Red
27	Red	Violet	Black	2,200	Red	Red	Red
30	Orange	Black	Black	2,400	Red	Yellow	Red
33	Orange	Orange	Black	2,500	Red	Green	Red
36	Orange	Blue	Black	2,700	Red	Violet	Red
39	Orange	White	Black	3,000	Orange	Black	Red
43	Yellow	Orange	Black	3,300	Orange	Orange	Red
47	Yellow	Violet	Black	3,500	Orange	Green	Red
50	Green	Black	Black	3,600	Orange	Blue	Red
51	Green	Brown	Black	3,900	Orange	White	Red
56	Green	Blue	Black	4,000	Yellow	Black	Red
62	Blue	Red	Black	4,300	Yellow	Orange	Red
68	Blue	Grey	Black	4,500	Yellow	Green	Red
75	Violet	Green	Black	4,700	Yellow	Violet	Red
82	Grey	Red	Black	5,000	Green	Black	Red
91	White	Brown	Black	5,100	Green	Brown	Red
100	Brown	Black	Brown	5,600	Green	Blue	Red
110	Brown	Brown	Brown	6,000	Blue	Black	Red
120	Brown	Red	Brown	6,200	Blue	Red	Red
130	Brown	Orange	Brown	6,800	Blue	Grey	Red
150	Brown	Green	Brown	7,000	Violet	Black	Red
160	Brown	Blue	Brown	7,500	Violet	Green	Red
180	Brown	Grey	Brown	8,000	Grey	Black	Red
200	Red	Black	Brown	8,200	Grey	Red	Red
220	Red	Red	Brown	9,000	White	Black	Red
240	Red	Yellow	Brown	9,100	White	Brown	Red
250	Red	Green	Brown	10,000	Brown	Black	Orange
270	Red	Violet	Brown	11,000	Brown	Brown	Orange
300	Orange	Black	Brown	12,000	Brown	Red	Orange
330	Orange	Orange	Brown	13,000	Brown	Orange	Orange
350	Orange	Green	Brown	15,000	Brown	Green	Orange
360	Orange	Blue	Brown	16,000	Brown	Blue	Orange
390	Orange	White	Brown	18,000	Brown	Grey	Orange
400	Yellow	Black	Brown	20,000	Red	Black	Orange
430	Yellow	Orange	Brown	22,000	Red	Red	Orange
450	Yellow	Green	Brown	24,000	Red	Yellow	Orange
470	Yellow	Violet	Brown	27,000	Red	Violet	Orange
500	Green	Black	Brown	30,000	Orange	Black	Orange
510	Green	Brown	Brown	33,000	Orange	Orange	Orange
560	Green	Blue	Brown	35,000	Orange	Green	Orange
620	Blue	Red	Brown	36,000	Orange	Blue	Orange
680	Blue	Grey	Brown	39,000	Orange	White	Orange
700	Violet	Black	Brown	40,000	Yellow	Black	Orange
750	Violet	Green	Brown	43,000	Yellow	Orange	Orange

READY-WORKED RESISTANCE COLOUR CODE (*contd.*)

Ohms	Body	Tip	Dot	Ohms	Body	Tip	Dot
47,000	Yellow	Violet	Orange	390,000	Orange	White	Yellow
50,000	Green	Black	Orange	400,000	Yellow	Black	Yellow
51,000	Green	Brown	Orange	430,000	Yellow	Orange	Yellow
56,000	Green	Blue	Orange	450,000	Yellow	Green	Yellow
60,000	Blue	Black	Orange	470,000	Yellow	Violet	Yellow
62,000	Blue	Red	Orange	500,000	Green	Black	Yellow
68,000	Blue	Grey	Orange	510,000	Green	Brown	Yellow
70,000	Violet	Black	Orange	580,000	Green	Blue	Yellow
75,000	Violet	Green	Orange	600,000	Blue	Black	Yellow
82,000	Grey	Red	Orange	620,000	Blue	Red	Yellow
91,000	White	Brown	Orange	680,000	Blue	Grey	Yellow
100,000	Brown	Black	Yellow	750,000	Violet	Green	Yellow
110,000	Brown	Brown	Yellow	820,000	Grey	Red	Yellow
120,000	Brown	Red	Yellow	910,000	White	Brown	Yellow
130,000	Brown	Orange	Yellow	1 MΩ	Brown	Black	Green
150,000	Brown	Green	Yellow	1·1 MΩ	Brown	Brown	Green
160,000	Brown	Blue	Yellow	1·2 MΩ	Brown	Red	Green
180,000	Brown	Grey	Yellow	1·3 MΩ	Brown	Orange	Green
200,000	Red	Black	Yellow	1·5 MΩ	Brown	Green	Green
220,000	Red	Red	Yellow	1·6 MΩ	Brown	Blue	Green
230,000	Red	Orange	Yellow	1·8 MΩ	Brown	Grey	Green
240,000	Red	Yellow	Yellow	2 MΩ	Red	Black	Green
250,000	Red	Green	Yellow	2·2 MΩ	Red	Red	Green
270,000	Red	Violet	Yellow	2·4 MΩ	Red	Yellow	Green
280,000	Red	Grey	Yellow	2·7 MΩ	Red	Violet	Green
300,000	Orange	Black	Yellow	3 MΩ	Orange	Black	Green
330,000	Orange	Orange	Yellow	4 MΩ	Yellow	Black	Green
350,000	Orange	Green	Yellow	5 MΩ	Green	Black	Green
360,000	Orange	Blue	Yellow	10 MΩ	Brown	Black	Blue

THE RESISTANCE COLOUR CODE (British and U.S.A.)

Colour	Body	Tip	Dot	Colour	Body	Tip	Dot	
Black	0	0	·0	Green	5	5	00000	
Brown	1	1	0	Blue	6	6	000000	
Red	2	2	00	Violet	7	7	0000000	U.S.A. only
Orange	3	3	000	Grey	8	8	00000000	
Yellow	4	4	0000	White	9	9	000000000	
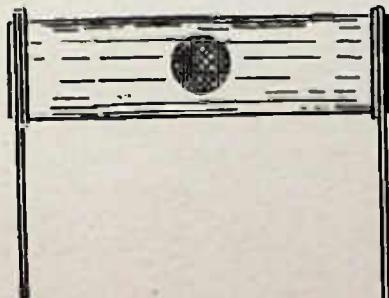
The body colour denotes the first digit, the colour of the tip the second digit, and the colour of the spot the number of noughts after the second digit.

TOLERANCE
DOT
TIP
BODY
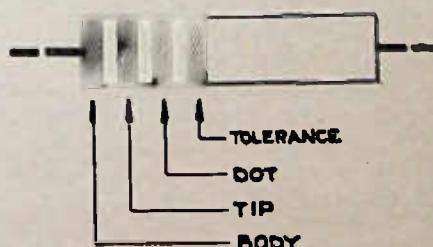
The modified colour code used for resistances with axial leads.

READY-WORKED REACTANCE TABLE (in ohms)

A.F. INDUCTIVE

Inductance in Henrys	30 cps.	50 cps.	100 cps.	400 cps.	1,000 cps.	3,000 cps.	5,000 cps.
100	18,800	31,400	62,800	251,000	628,000	1,880,000	3,140,000
75	14,130	23,550	47,100	188,400	471,000	1,413,000	2,355,000
50	9,420	15,700	31,400	126,000	314,000	942,000	1,570,000
25	4,710	7,850	15,700	62,800	157,000	471,000	785,000
10	1,880	3,140	6,280	25,100	62,800	188,000	314,000
1	188	314	628	2,510	6,280	18,800	31,400
·1	18·8	31·4	62·8	251	628	1,880	3,140
·01	1·88	3·14	6·28	25·1	62·8	188	314
·001	·188	·314	·628	2·51	6·28	18·8	31·4

A.F. CAPACITIVE

Capacity in mfd.	30 cps.	50 cps.	100 cps.	400 cps.	1,000 cps.	3,000 cps.	5,000 cps.
·00005					3·18 MΩ	1·06 MΩ	637,000
·0001				3·98 MΩ	1·59 MΩ	531,000	318,000
·00025			6·37 MΩ	1·59 MΩ	637,000	212,000	127,000
·0003			5·31 MΩ	1·33 MΩ	531,000	174,000	106,000
·0005	10·6 MΩ	6·37 MΩ	3·18 MΩ	796,000	318,000	106,000	63,700
·001	5·3 MΩ	3·18 MΩ	1·59 MΩ	398,000	159,000	53,100	31,800
·005	1·06 MΩ	637,000	318,000	79,600	31,800	10,600	6,370
·01	531,000	318,000	159,000	39,800	15,900	5,310	3,180
·02	265,000	159,000	79,600	19,900	7,960	2,650	1,590
·025	212,000	127,000	63,700	15,900	6,370	2,120	1,270
·03	174,000	106,000	53,100	13,300	5,310	1,740	1,060
·05	106,000	63,700	31,800	7,960	3,180	1,060	637
·1	53,100	31,800	15,900	3,980	1,590	531	318
·25	21,200	12,700	6,370	1,590	637	212	127
·5	10,600	6,370	3,180	796	318	106	63·7
1·0	5,310	3,180	1,590	398	159	53·1	31·8
2·0	2,650	1,590	796	199	79·6	26·5	15·9
25·0	212	127	63·7	15·9	6·37	2·12	1·27
50·0	106	63·7	31·8	7·96	3·18	1·06	·637

R.F. INDUCTIVE

Inductance	100 Kcs.	250 Kcs.	465 Kcs.	500 Kcs.	1,000 Kcs.	1,500 Kcs.	5,000 Kcs.
·1H	62,800	157,000	292,000	314,000	628,000	943,000	3,140,000
·01H	6,280	15,700	29,200	31,400	62,800	94,300	314,000
1,000 μH	628	1,570	2,920	3,140	6,280	9,430	31,400
200 μH	126	315	484	630	1,260	1,890	6,300
100 μH	62	157	292	314	628	943	3,140
50 μH	31	78	146	157	314	476	1,570

R.F. CAPACITIVE

Capacity in mfd.	100 Kcs.	250 Kcs.	465 Kcs.	500 Kcs.	1,000 Kcs.	1,500 Kcs.	5,000 Kcs.
·00001	159,000	636,000	34,200	31,800	15,900	10,600	3,180
·00005	31,800	12,720	6,850	6,300	3,180	2,120	636
·0001	15,900	6,360	3,420	3,180	1,590	1,060	318
·0005	3,180	1,272	685	630	318	212	63·6
·001	1,590	636	342	318	159	106	31·8
·005	318	127·2	68·5	63·6	31·8	21·2	6·36
·01	159	63·6	34·2	31·8	15·9	10·6	3·18
·05	31·8	12·72	6·85	6·36	3·18	2·12	·636
·1	15·9	6·36	3·42	3·18	1·59	1·06	·318
·25	6·36	2·544	1·37	1·272	·636	·424	·127
·5	3·18	1·272	·685	·636	·318	·212	·064
1·0	1·59	·636	·342	·318	·159	·106	·032

READY-WORKED DECIBEL TABLE

| LOSS | | db | GAIN | |
Current or Voltage Ratio	Power Ratio		Current or Voltage Ratio	Power Ratio
1	1	0	1	1
·989	·977	·1	1·012	1·023
·977	·955	·2	1·023	1·047
·966	·933	·3	1·035	1·072
·955	·912	·4	1·047	1·096
·944	·891	·5	1·059	1·122
·933	·871	·6	1·072	1·148
·923	·851	·7	1·084	1·175
·912	·832	·8	1·096	1·202
·902	·813	·9	1·109	1·23
·891	·794	1	1·122	1·259
·871	·759	1·2	1·15	1·32
·851	·724	1·4	1·17	1·38
·832	·692	1·6	1·2	1·44
·813	·661	1·8	1·23	1·51
·794	·631	2	1·26	1·58
·750	·562	2·5	1·34	1·78
·708	·501	3	1·41	1·99
·668	·447	3·5	1·5	2·24
·631	·398	4	1·59	2·51
·596	·355	4·5	1·68	2·82
·562	·316	5	1·78	3·16
·531	·282	5·5	1·88	3·55
·501	·251	6	1·99	3·98
·473	·224	6·5	2·11	4·47
·447	·199	7	2·24	5·01
·422	·178	7·5	2·37	5·62
·398	·158	8	2·51	6·31
·376	·141	8·5	2·66	7·08
·355	·126	9	2·82	7·94
·335	·112	9·5	2·98	8·91
·316	·1	10	3·16	10
·282	·079	11	3·55	12·6
·251	·063	12	3·98	15·8
·224	·05	13	4·47	19·9
·199	·04	14	5·01	25·1
·158	·025	16	6·31	39·8
·126	·016	18	7·94	63·1
·1	·01	20	10	100
·056	·00316	25	17·78	316
·032	·001	30	31·62	1,000
·0178	·000316	35	56·23	3,160
·01	·0001	40	100	10,000
·0056	·0000316	45	177·8	31,600
·00316	·00001	50	316	100,000
·002	·000003l6	55	562	316,000
·001	·000001	60	1,000	1,000,000
·0006	·000000316	65	1,770	3,160,000
·000316	·0000001	70	3,160	10,000,000
·0002	·0000000316	75	5,620	31,600,000
·0001	·00000001	80	10,000	100,000,000
·00006	·0000000032	85	17,800	316,000,000
·0000316	·000000001	90	31,600	1,000,000,000
·00002	·0000000003	95	56,200	3,160,000,000
·00001	·0000000001	100	100,000	10,000,000,000

INSULATING MATERIALS

Substance	Dielectric Constant* (K)	Substance	Dielectric Constant* (K)
Air	1	Mica	2·5–7·5
Asphalt	2·7–3	Mica, first-quality Indian	6·2–6·7
Bakelite, fabric base	4·6–7	Micanite, non-flexible	7
Bakelite, moulded	4·4–7·8	Mycalex	8·5
Bakelite, paper base	4·5–6·3	Nylon	3·5–3·7
Bakelite, wood filled	4·2–8·1	Paper, varnished	2–3
Casein	6·1–6·8	Paraffin	2·1–2·4
Cambric (varnished)	3·3–5·3	Paraffin oil	2·1–4·7
Celluloid	4–15	Paraffin wax	2–2·5
Celluloid, photographic	6·6–6·7	Paraffined paper	2–3·5
Cellulose acetate	4·5–5·4	Polyethylene	2·5
Cellulose acetate, moulded	3–6	Polystyrene	2·5–2·59
Cellulose acetate, sheet	3–4·5	Polyvinyl chloride	6–12
Dilectene 100	3·6–3·75	Porcelain	5·5–6·8
Ebonite	2–3·3	Pyrex (glass)	4·5–5
Ebonite, P.O. standard	2·8	Quartz	4·5–5
Empire cloth	2	Rubber	2–3·5
Ethyl cellulose	2–2·9	Shellac	2·9–3·7
Fibre (red)	2·5–4·8	Slate	6–7·4
Fullerboard	3–5	Steatite	6·1
Glass	5·1–9·9	Trolitul	2·2–2·25
Glass, common window	7·9–8·2	Urea-formaldehyde resin	6·6–7·6
Glass, photographic	7·5	Vinylite	3–3·4
Glass, plate	6·5–7·5	Wood (dry)	2·5–7·7
Gutta percha	2·5–4·9	Wood, bakelised	4·5–8
Isolantite	6–6·1	Wood, paraffin-waxed	2·5–8

* Figures are average, but exceptions will be found outside the tolerances quoted. Temperature and frequency also introduce variation ; above figures are at 1 mcs. with the exception of cellulose, rubber, shellac and wood.

MANUFACTURERS' BRAND NAMES

Alvar	Polyvinyl Acetal.	Lumarith E.C.	Ethyl Cellulose.
Ameroid	Casein.	Lustron	Polystyrene.
Bakelite	Phenol Formaldehyde.	Makalot	Phenol Formaldehyde.
Bakelite	Urea Formaldehyde.	Melmac	Melamine Formaldehyde.
Bakelite	Polystyrene.	Micanito	Mica Compounds.
Becolate	Ebonite.	Nixonite	Cellulose Acetate.
Beetle	Urea Formaldehyde.	Nixonoid	Cellulose Nitrate.
Butvar	Polyvinyl Butyral.	Nylon	Super Polyamide.
Catalin	Phenol Formaldehyde.	Perspex	Methyl-Methacrylate.
Catalin	Melamine Formaldehyde.	Plaskon	Urea Formaldehyde.
Crystalite	Acrylate and Methacrylate.	Pressphan	Laminated Synthetic Resin.
Dexine	Ebonite.	Protectoid	Cellulose Acetate.
Dilectene 100	Aniline Formaldehyde Synthetic Resin.	Prystal	Phenol Formaldehyde.
		Pyralin	Cellulose Nitrate.
Distrene	Polystyrene.	Resinox	Phenol Formaldehyde.
Durite	Phenol Formaldehyde.	Steatite	Ceramic Porcelain.
Durite	Phenolic Furfural.	Styraflex	Polystyrene.
Ebonestos	Synthetic Resin.	Styron	Polystyrene.
Erinofort	Cellulose Acetate.	Super Styrex	Polystyrene.
Erinoid	Casein.	Tenite	Cellulose Acetate.
Ethocel	Ethylcellulose.	Trolitul	Polystyrene.
Fibestos	Cellulose Acetate.	Vinylite A	Polyvinyl Acetate.
Hereaite	Phenol Formaldehyde.	Vinylite Q	Polyvinyl Chloride.
Lucite	Methyl Methacrylate.	Vinylite X	Polyvinyl Butyral.

ELECTRICAL CONVERSION TABLE

(For Mechanical Conversion Table, see page 69)

MULTIPLE AND SUB-MULTIPLE CONVERSION

To Convert	Into	Multiply by	Conversely, multiply by
Amps	Milliamps	1,000	·001
Amps	Microamps	1,000,000	·000001
Cycles	Kilocycles	·001	1,000
Cycles	Megacycles	·000001	1,000,000
Farads	Microfarads	1,000,000	·000001
Farads	Micromicrofarads (pf)	1,000,000,000,000	·000000000001
Henrys	Millihenrys	1,000	·001
Henrys	Microhenrys	1,000,000	·000001
Kilocycles	Megacycles	·001	1,000
Millivolts	Microvolts	1,000	·001
Mhos	Millimhos	1,000	·001
Mhos	Micromhos	1,000,000	·000001
Ohms	Micro-ohms	1,000,000	·000001
Ohms	Megohms	·000001	1,000,000
Volts	Millivolts	1,000	·001
Volts	Microvolts	1,000,000	·000001
Volts	Kilovolts	·001	1,000
Watts	Milliwatts	1,000	·001
Watts	Microwatts	1,000,000	·000001
Watts	Kilowatts	·001	1,000

INTER-UNIT CONVERSION

Horsepower	Watts	746	·0034
Horsepower	Force de Cheval	1·0139	·986
Horsepower	B.T.U. per minute	42·4	·02357
Micromicrofarads	Centimetres (capacity)	1·1	·9
Microfarads	Centimetres (capacity)	1,100	·0009
Atmospheres	Inches of Mercury	29·92	·03342
Atmospheres	Centimetres of Mercury	76	·01316

PREFIXES USED IN RADIO NUMEROLOGY

Prefix	Abbreviation	Definition
conti	c	one-hundredth of
mil or milli	m	one-thousandth of
micro	μ	one-millionth of
micromicro	mm or $\mu\mu$	one-millionth of a millionth of
pica	p	one-millionth of a millionth of
kilo	k	one thousand times
meg or mega	M	one million times

SIGNIFICANCE OF INDICES

Expression	Simple Equivalent	Expression	Simple Equivalent
10^1	10	10^{-1}	·1
10^2	100	10^{-2}	·01
10^3	1,000	10^{-3}	·001
10^4	10,000	10^{-4}	·0001
10^5	100,000	10^{-5}	·00001
10^6	1,000,000	10^{-6}	·000001
10^7	10,000,000	10^{-7}	·0000001
10^8	100,000,000	10^{-8}	·00000001
10^9	1,000,000,000	10^{-9}	·000000001
10^{10}	10,000,000,000	10^{-10}	·0000000001

TWIST DRILL SIZES

FRACTIONS—DECIMAL—MILLIMETRE EQUIVALENTS

Drill Number	Dia. (in.)	Drill Number	Dia. (in.)	Fraction of inch	Decimal of inch	Millimetre	Fraction of inch	Decimal of inch	Millimetre
1	·2280	41	·0960	1/64	·0156	·397	33/64	·5156	13·097
2	·2210	42	·0935	1/32	·0313	·794	17/32	·5313	13·494
3	·2130	43	·0890	3/64	·0469	1·191	35/64	·5469	13·891
4	·2090	44	·0860	1/16	·0625	1·588	9/16	·5625	14·287
5	·2055	45	·0820	5/64	·0781	1·985	37/64	·5781	14·684
6	·2040	46	·0810	3/32	·0938	2·381	19/32	·5938	15·081
7	·2010	47	·0785	7/64	·1094	2·778	39/64	·6094	15·478
8	·1990	48	·0760	1/8	·1250	3·175	5/8	·6250	15·875
9	·1960	49	·0730	9/64	·1406	3·572	41/64	·6406	16·272
10	·1935	50	·0700	5/32	·1563	3·969	21/32	·6563	16·688
11	·1910	51	·0670	11/64	·1719	4·366	43/64	·6719	17·085
12	·1890	52	·0635	3/16	·1875	4·762	11/16	·6875	17·462
13	·1850	53	·0595	13/64	·2031	5·159	45/64	·7031	17·859
14	·1820	54	·0550	7/32	·2188	5·556	23/32	·7188	18·256
15	·1800	55	·0520	15/64	·2344	5·953	47/64	·7344	18·653
16	·1770	56	·0465	1/4	·2500	6·350	3/4	·7500	19·050
17	·1730	57	·0430	17/64	·2656	6·747	49/64	·7656	19·447
18	·1695	58	·0420	9/32	·2813	7·144	25/32	·7813	19·843
19	·1660	59	·0410	19/64	·2969	7·541	51/64	·7969	20·240
20	·1610	60	·0400	5/16	·3125	7·937	13/16	·8125	20·637
21	·1590	61	·0390	21/64	·3281	8·334	53/64	·8281	21·034
22	·1570	62	·0380	11/32	·3438	8·731	27/32	·8438	21·430
23	·1540	63	·0370	23/64	·3594	9·128	55/64	·8594	21·827
24	·1520	64	·0360	3/8	·3750	9·525	7/8	·8750	22·224
25	·1495	65	·0350	25/64	·3906	9·922	57/64	·8906	22·621
26	·1470	66	·0330	13/32	·4063	10·319	29/32	·9063	23·018
27	·1440	67	·0320	27/64	·4219	10·716	59/64	·9219	23·415
28	·1405	68	·0310	7/16	·4375	11·120	15/16	·9375	23·812
29	·1360	69	·0293	29/64	·4531	11·509	61/64	·9531	24·209
30	·1285	70	·0280	15/32	·4688	11·906	31/32	·9688	24·606
31	·1200	71	·0260	31/64	·4844	12·303	63/64	·9844	25·003
32	·1160	72	·0250	1/2	·5000	12·700	1	1·0000	25·400
33	·1130	73	·0240						
34	·1110	74	·0225						
35	·1100	75	·0210						
36	·1065	76	·0200						
37	·1040	77	·0180						
38	·1015	78	·0160						
39	·0995	79	·0145						
40	·0980	80	·0135						

WHITWORTH SCREWS

Size (in.)	Turns per inch	Tapping Drill
1/8	40	41
3/16	24	29
1/4	20	12
5/16	18	1/4"
3/8	16	5/16"
1/2	12	13/32"
5/8	11	17/32"
3/4	10	21/32"
1	8	7/8"

B.S.F. SCREWS

Size (in.)	Turns per inch	Tapping Drill
7/32	28	12
1/4	26	7/32
9/32	26	1/4
5/16	22	9/32
3/8	20	21/64
7/16	18	23/64
1/2	16	27/64
9/16	16	31/64
5/8	14	1/2

B.A. SCREWS

B.A. Number	Diameter	Core Diam.	Turns per inch	Clearing Drill	Tapping Drill
0	·2302	·189	25·4	½″	9
1	·2087	·1661	28·2	½	17
2	·185	·1469	31·4	10	24
3	·1614	·1268	34·8	18	29
4	·1417	·1106	38·5	25	32
5	·126	·098	43·0	29	37
6	·1102	·085	47·9	32	43
7	·0984	·0756	52·9	37	46
8	·0866	·0601	59·1	42	50
9	·0748	·0563	65·1	46	53
10	·0669	·0504	72·6	49	54
11	·0591	·0445	81·9	52	56
12	·0512	·0378	90·7	54	60
13	·0472	·0354	101·0	55	63
14	·0394	·0283	110·0	58	68
15	·0354	·0256	121·0	62	70

Tapping Drill sizes are recommended for brass. For soft substances use the next smaller size drill.

WOOD SCREWS

Gauge Number	Shank Diam.	Clearing Drill
1	·066	48
2	·080	43
3	·094	38
4	·108	32
5	·122	29
6	·136	26
7	·150	21
8	·164	17
9	·178	14
10	·192	9
11	·206	4
12	·220	1
13	·234	½″

Where danger of splitting is great, use next larger size drill.

AMERICAN SCREWS
(As used in Radio Manufacture)

Size Number	Diameter	Tapping Drill
2–56	·0860	49
3–48	·0990	44
4–40	·1120	43
5–40	·1250	36
6–32	·1380	33
8–32	·1640	28
10–24	·1900	23
10–32	·1900	20
12–24	·2160	17
¼–20	·2500	7

MECHANICAL CONVERSION TABLE

To Convert	Into	Multiply by	Conversely, multiply by
Centigrade	Fahrenheit	(C° × ⁹⁄₅) + 32	(F° − 32) × ⁵⁄₉
Cubic inches	Cubic centimetres	16·39	·06102
Gallons (British)	Gallons (U.S.A.)	1·20094	·83268
Grams	Grains	15·432	·0648
Grams	Ounces (a.d.p.)	·03527	28·35
Inches	Centimetres	2·54	·3937
Inches of mercury	Lbs. per sq. in.	·49116	2·0360
Knots	Miles	1·152	·86836
Litres	Pints	1·76	·5682
Metres	Feet	3·2808	·3048
Metres	Yards	1·094	·9144
Metres per minute	Feet per minute	3·281	·3048
Miles per hour	Feet per minute	88	·01136
Miles per hour	Feet per second	1·467	·6818
Sq. inches	Sq. centimetres	6·452	·1550
Watts	B.T.U. per minute	·05688	17·58
Watts	Horse-power	·00134	745·7

READY-WORKED METER SHUNT AND SERIES RESISTANCE TABLE

The table below gives values of shunt resistance for increasing the current range of a milliammeter and the values of series resistance for converting a milliammeter into a voltmeter to cover various ranges. A practical example of this technique is given on page 50. The internal resistance of the milliammeter is a controlling factor. The average 0–1 milliammeter, for example, has an internal resistance of something less than 50 ohms ; in drawing up the tables below the author intends that the resistance of the meter shall either be made up to 100 ohms by the use of a suitable series resistance, or, preferably, be made up to 50 ohms with an additional 50 ohms added, the latter being provided with a press-button shorting switch, so that its depression will double the meter reading when desired. By incorrect switching arrangements, serious errors can be introduced by switch contact resistance ; attention is therefore drawn to page 12, Vol. III, of *Modern Practical Radio and Television*.

Required Voltage Range (volts)	Series Resistance in Ohms for Milliammeter with range as below				
	1 mA	2 mA	3 mA	5 mA	10 mA
2	*1,900	*900	566	300	*100
3	2,900	1,400	*900	500	200
5	*4,900	2,400	1,560	*900	*400
10	*9,900	*4,900	3,230	*1,900	*900
15	15,000	7,400	*4,900	2,900	1,400
20	*20,000	*9,900	6,560	3,900	*1,900
30	30,000	15,000	*9,900	5,900	2,900
50	*50,000	25,000	16,600	*9,900	*4,900
100	*100,000	*50,000	33,300	*20,000	*9,900
150	150,000	75,000	*50,000	30,000	15,000
200	*200,000	*100,000	66,600	40,000	*20,000
300	300,000	150,000	*100,000	60,000	30,000
500	*500,000	250,000	166,000	*100,000	*50,000
1,000	*1,000,000	*500,000	333,000	*200,000	*100,000

Note.—The above resistance values have been adjusted to convenient values so far as possible consistent with a maximum error not exceeding 1 per cent. Figures marked with asterisk indicate ranges that read conveniently on the meter scale.

SHUNT RESISTANCE IN OHMS FOR MILLIAMMETER WITH TOTAL RESISTANCE OF 100 OHMS

Multiplying Factor		Multiplying Factor		Multiplying Factor		Multiplying Factor	
2	100	10	11·11	60	1·695	400	·251
4	33·33	20	5·26	80	1·266	500	·2
5	25	30	3·45	100	1·01	600	·167
6	20	40	2·56	200*	·503	800	·125
8	14·29	50	2·04	300	·334	1,000	·1

* It is inadvisable to attempt multiplication factors above 100 unless fully conversant with test gear and very low resistance shunts.

COMPARATIVE RESISTANCE		RESISTIVITY, ρ OF METALS	
Material	*Relative Resistance*	*Material*	*μ Ohms per cu. cm. at 0° C.*
Copper	1	Copper, standard	1·589
German silver	11·7–18·5	Copper, hard-drawn	1·6
Eureka	30 average	Eureka	48 average
Nichrome	55 average	Nichrome	112 average
Silver	·94	Silver	1·47
Silicon bronze	1·5	Aluminium	2·67
Aluminium	1·6	Nickel	12·32
Nickel	4·3	Manganin	42 average
Phosphor bronze	4·4	German silver	21 average
Manganin	27	Iron, annealed	9·07

SULPHURIC ACID TABLE

(Quantities by Volume)

1·350 Sp. Gr. = 1 part acid to 2·3 parts distilled water
1·300 ,, ,, = 1 ,, ,, ,, 2·8 ,, ,, ,,
1·250 ,, ,, = 1 ,, ,, ,, 3·6 ,, ,, ,,
1·200 ,, ,, = 1 ,, ,, ,, 5·0 ,, ,, ,,
1·150 ,, ,, = 1 ,, ,, ,, 7·0 ,, ,, ,,

Note.—Above table assumes undiluted acid to be 1·840 Sp. Gr. Always add acid to water; the reverse procedure is most dangerous.

ACCUMULATOR DISCHARGE TABLE *

Fully charged	.	.	= 1·250 Sp. Gr. at 60° F.
,, ,,	.	.	= 1·240 ,, ,, ,, 70° F.
,, ,,	.	.	= 1·242 ,, ,, ,, 80° F.
Half discharged	.	.	= 1·180 ,, ,, ,, 60° F.
,, ,,	.	.	= 1·170 ,, ,, ,, 70° F.
,, ,,	.	.	= 1·173 ,, ,, ,, 80° F.
Discharged	.	.	= 1·110 ,, ,, ,, 60° F.
,,	.	.	= 1·107 ,, ,, ,, 70° F.
,,	.	.	= 1·105 ,, ,, ,, 80° F.

* Varies slightly with different makers.

ESTIMATION OF TEMPERATURE BY COLOUR

Black red	.	.	=	900° F. =	500° C.
Deep red	.	.	=	1,000° F. =	525° C.
Red	.	.	=	1,400° F. =	775° C.
Brilliant red	.	.	=	1,550° F. =	850° C.
Vivid orange	.	.	=	1,725° F. =	950° C.
Yellow	.	.	=	1,825° F. =	1,000° C.
Whitish yellow	.	.	=	1,975° F. =	1,100° C.
White	.	.	=	2,200° F. =	1,200° C.
Blinding white	.	.	=	2,800° F. =	1,500° C.

ESTIMATION OF SOUND INTENSITY

0 db = Threshold of normal hearing.
10 db = Very quiet but unmistakable sound.
20 db = Kettle boiling at 6 ft. away.
30 db = Sewing machine in adjoining room (door open).
40 db = Moderate radio set in adjoining room.
50 db = Traffic noise on main road with closed windows.
75 db = Very busy suburban main road.
100 db = Road drill other side of road.
125 db = Shattering noise, e.g. unsilenced motor-engine fully revved in small confined space; feeling of discomfort begins to be apparent.
over 125 db At noise-levels 130–140 db, pain rather than hearing is experienced.

Note.—The above indications of sound-intensity are obviously wide approximations; they are the result of measurement in a South-west London suburb, using a microphone. The ear, however, will be greatly influenced by the nature of the sound, e.g. a person singing out of tune may give the impression of being louder than a more pleasing sound of equal intensity; also the human ear is not linear to frequency.

CLIMATIC DATA

Miscellaneous information useful when considering overseas requirements or when erecting large aerial masts.

TEMPERATURES

British Isles	.	= Max. 100° F.	Min.		4° F.
Europe (excluding U.S.S.R.).	.	= ,, 125° F.	,,	−	50° F.
Africa	.	= ,, 136° F.	,,		0° F.
Australia	.	= ,, 127° F.	,,		19° F.
Asia	.	= ,, 125° F.	,,	−	90° F.
North America	.	= ,, 120° F.	,,	−	70° F.
New Zealand	.	= ,, 95° F.	,,		23° F.
South America	.	= ,, 115° F.	,,	−	25° F.
U.S.A.	.	= ,, 134° F.	,,	−	66° F.
U.S.S.R.	.	= ,, 110° F.	,,	−	90° F.

WIND VELOCITY AND PRESSURE

10 m.p.h.	=	·23 lb. per sq. ft. on cylindrical surface						
20 ,,	=	·8 ,,	,,	,,	,,	,,	,,	,,
30 ,,	=	1·7 ,,	,,	,,	,,	,,	,,	,,
50 ,,	=	4·2 ,,	,,	,,	,,	,,	,,	,,
75 ,,	=	8·7 ,,	,,	,,	,,	,,	,,	,,
100 ,,	=	14·5 ,,	,,	,,	,,	,,	,,	,,
125 ,,	=	21·9 ,,	,,	,,	,,	,,	,,	,,
150 ,,	=	30·9 ,,	,,	,,	,,	,,	,,	,,
175 ,,	=	41·4 ,,	,,	,,	,,	,,	,,	,,
200 ,,	=	53·5 ,,	,,	,,	,,	,,	,,	,,
10 ,,	=	·4 lb. per sq. ft. on flat surface						
20 ,,	=	1·3 ,,	,,	,,	,,	,,	,,	,,
30 ,,	=	2·8 ,,	,,	,,	,,	,,	,,	,,
50 ,,	=	9·7 ,,	,,	,,	,,	,,	,,	,,
75 ,,	=	14·5 ,,	,,	,,	,,	,,	,,	,,
100 ,,	=	24·3 ,,	,,	,,	,,	,,	,,	,,
125 ,,	=	36·9 ,,	,,	,,	,,	,,	,,	,,
150 ,,	=	51·9 ,,	,,	,,	,,	,,	,,	,,
175 ,,	=	69·5 ,,	,,	,,	,,	,,	,,	,,
200 ,,	=	89·8 ,,	,,	,,	,,	,,	,,	,,

HUMIDITY

Humidity varies so widely in relatively small areas that brief data is meaningless, but in certain parts of the world humidity is as high as 99 per cent. Its effect on radio receivers may be controlled by spraying with nitrocellulose lacquer. For use in non-built-up areas about 2 per cent. of pentachloralphenol may be added as a fungus deterrent.

READY-WORKED NUMERICAL VALUES

$\pi = 3·1416$	$2\pi = 6·2832$
$\pi^2 = 9·8696$	$\dfrac{1}{2\pi} = ·1592$
$\dfrac{1}{\pi} = ·3183$	$\sqrt{2} = 1·4142$
$\dfrac{1}{\pi^2} = ·1013$	$\sqrt{3} = 1·7321$
$\sqrt{\pi} = 1·7725$	$\dfrac{1}{\sqrt{2}} = ·7071$
$\dfrac{1}{\sqrt{\pi}} = ·5642$	$\dfrac{1}{\sqrt{3}} = ·5773$

Area of circle	$= \pi r^2$
Area of triangle	$= \text{Base} \times \tfrac{1}{2}H$
Area of cylinder	$= 2\pi rH$
Volume of sphere	$= \dfrac{4}{3}\pi r^3$
Volume of cylinder	$= \pi r^2 H$
Volume of cone	$= \dfrac{\pi r^2 H}{3}$

VARIATIONS IN WORLD TIME

Local time is given in considerable detail below owing to its great value when identifying foreign stations. Up-to-date information of this kind and up-to-date frequency changes are given in the *Short-Wave News*, published by The Amalgamated Short-Wave Press Ltd., 57 Maida Vale, W.9.

Country	To G.M.T. ADD	From G.M.T. TAKE	Country	To G.M.T. ADD	From G.M.T. TAKE
	Hrs. Mins.	Hrs. Mins.		Hrs. Mins.	Hrs. Mins.
Aden	3 00	—	Kenya	2 30	—
Afghanistan	4 00	—	Korea	9 00	—
Albania	1 00	—	Latvia	2 00	—
Algeria	No change		Liberia	—	44
Argentine	—	4 00	Libya	1 00	—
Australia, N.S.W., Victoria	10 00	—	Lithuania	1 00	—
" Queensland	9 30	—	Madagascar	3 00	—
" Western	8 00	—	Malay States	7 20	—
Bahamas	—	5 00	Malta	1 00	—
Barbados	—	4 00	Manchukuo	8 00	—
Bechuanaland	2 00	—	Mexico	—	6 00
Belgian Congo (Leopoldville)	1 00	—	Mongolia	7 00	—
" " (Stanleyville)	2 00	—	Mozambique	2 00	—
Belgium	No change		Netherlands	20	—
Bermuda	—	4 00	Newfoundland	—	3 30
Bolivia	—	4 33	New Guinea (Dutch)	9 00	—
Borneo, North	8 00	—	" " (British)	10 00	—
" Dutch	7 30	—	New Zealand	11 30	—
Brazil	—	3 00	Nigeria	1 00	—
British Guiana	—	3 45	Norway	1 00	—
British Honduras	—	6 00	Palestine	2 00	—
Bulgaria	2 00	—	Panama	—	5 00
Burma	6 30	—	Paraguay	—	4 00
Canada:			Peru	—	5 00
New Brunswick, Nova Scotia	—	4 00	Poland	1 00	—
Quebec, Ontario	—	5 00	Portugal	No change	
Manitoba	—	6 00	Rhodesia, North	2 00	—
Alberta, Saskatchewan	—	7 00	" South	2 00	—
British Columbia	—	8 00	Rumania	2 00	—
Yukon Territory	—	9 00	Saudi Arabia	3 00	—
Ceylon	5 00	—	Senegal	—	1 00
Chile	—	4 00	Sierra Leone	—	1 00
China, Eastern	8 00	—	Solomon Islands	10 00	—
" Central and Western	7 00	—	Somaliland (Fr. and Brit.)	3 00	—
Colombian Republic	—	5 00	South-West Africa	2 00	—
Costa Rica	—	5 00	Spain	No change	
Cuba	—	5 00	Sudan	2 00	—
Cyprus	2 00	—	Sweden	1 00	—
Czechoslovakia	1 00	—	Switzerland	1 00	—
Denmark	1 00	—	Syria	2 00	—
Ecuador, Guayaguil	—	5 19	Tanganyika	3 00	—
" all other parts	—	5 14	Thailand	7 00	—
Egypt	2 00	—	Transjordan	2 00	—
El Salvador	—	6 00	Trinidad and Tobago	—	4 00
Estonia	2 00	—	Tunisia	1 00	—
Ethiopia	3 00	—	Turkey	2 00	—
Finland	2 00	—	Union of South Africa	2 00	—
France	No change		U.S.S.R., European	3 00	—
French Cameroons	1 00	—	" Ukraine (Kiev)	4 00	—
" Equatorial Africa	1 00	—	" Ural Area (Sverdlovsk)	5 00	—
" Guiana	—	4 00	" Uzbek (Tashkent)	6 00	—
" Indo-China	7 00	—	" Siberian Area (Novosibursk)	7 00	—
Gambia	—	1 00	" Siberian Area (Irkutsk)	8 00	—
Germany	1 00	—	" Asiatic Repb. (Chita, etc.)	9 00	—
Gold Coast	No change		" Asiatic Repb. (Vladivostok)	10 00	—
Greece	2 00	—	U.S.A., Atlantic Coast	—	5 00
Greenland	—	3 00	" Central States	—	6 00
Hawaiian Islands	—	9 30	" Mid-Western States	—	7 00
Honduras	—	6 00	" Pacific Coast	—	8 00
Hungary	1 00	—	Uruguay	—	3 30
India	5 30	—	Venezuela	—	4 30
Iran	3 00	—	Yugoslavia	1 00	—
Iraq	3 00	—			
Italy	1 00	—			
Jamaica	—	5 00			
Japan	9 00	—			
Java	7 30	—			

SYMBOLS

GENERAL SYMBOLS

Admittance	Y, y
Ampere	A
Amplification factor	μ, m
Angular velocity $(2\pi f)$	ω
Anode A.C. resistance (impedance)	R_a
Anode current	I_a
Anode current inductance	L_a
Anode voltage	V_a
Capacity	C
Conductance	C, g
Conductivity	γ
Current (instantaneous)	i
Current (R.M.S.)	I
Dielectric constant	K
E.M.F.	E
E.M.F. (instantaneous)	e
Energy	W
Farad	F
Frequency	f
Grid circuit inductance	L_g
Grid current	I_g
Grid voltage	V_g
Henry	H
Impedance	Z
Inductance	L
Magnetic field	H
Magnetic flux	ϕ
Magnetic flux density	B
Magneto motive force	F
Magnification of tuned circuit	Q
Mutual inductance	M
Number of plates, turns, etc.	N, n
Ohm	Ω
Period	T
Permeability	μ
Phase displacement or angle	ϕ
Power output	P_o
Reactance	X
Reactance, capacitive	X_c
Reactance, inductive	X_L
Reluctivity	v
Resistance	R
Resistance, H.F.	r
Resistivity	ρ
Susceptance	b
Time	t
Velocity	v
Volt	V
Watt	W
Wavelength	λ

VALVE SYMBOLS *

Amplification factor	μ, m
Anode current	I_a
Anode impedance	R_a
Anode voltage	V_a
Capacity, anode cathode	C_{ac}
Capacity, anode output	C_a
Capacity, grid anode	C_{ga}
Capacity, grid cathode	C_{gc}
Capacity, grid input	C_g
Cathode current	I_c
Cathode voltage	V_c
Conversion conductance	g_c
Filament current	I_f
Filament voltage	V_f
Grid current	I_g
Grid input impedance	Z_g
Grid voltage	V_g
Optimum load	R_o
Screen current	I_{sg}
Screen voltage	V_{sg}
Slope	g_m
Transconductance (U.S.A.)	g_m

* A new system of valve symbolisation has been introduced by the B.V.A. and will doubtless pass into general usage in due course; that shown has been in use for many years and, with slight variation, will be found in most text-books.

MATHEMATICAL SYMBOLS

Is equal to	$=$
Is not equal to	$\neq$
Is approx. equal to	$\doteqdot$
Is the same as	$\equiv$
The difference between	$\sim$
Varies as ; is proportional to	$\propto$
Greater than	$>$
Not greater than	$\not>$
Less than	$<$
Not less than	$\not<$
The sum of	Σ
General symbol of an angle	θ
A small difference	δ
Angle	$\wedge$
An unknown quantity	x
Angular velocity ; $2\pi f$	ω

C.G.S. MECHANICAL SYMBOLS

Length	(cm.)	l
Mass	(gm.)	m
Time	(sec.)	t
Surface	(sq. cm.)	A
Volume	(cu. cm.)	V
Velocity	(cm. per sec.)	v
Acceleration	(cm. per sec.)	a
Force	(dyne)	F
Work	(erg)	W
Energy	(erg)	W
Power	(erg per sec.)	P
Pressure	(dynes per sq. cm.)	p
Angle	(radian)	ϕ
Angular velocity	(radians per sec.)	ω

DIRECTORY OF RADIO AND ELECTRICAL INSTITUTIONS AND ASSOCIATIONS

BRITISH INSTITUTION OF RADIO ENGINEERS
General Secretary : G. D. CLIFFORD, F.C.C.S., 9 Bedford Square, London, W.1. (Museum 1901-2.)

INSTITUTION OF ELECTRICAL ENGINEERS
Secretary : W. K. BRASHER, Savoy Place, Victoria Embankment, London, W.C.2. (Temple Bar 7676.)

THE TELEVISION SOCIETY
Joint Secretary : G. PARR, 68 Compton Road, London, N.21. (Laburnum 4123.)

INCORPORATED RADIO SOCIETY OF GREAT BRITAIN
Secretary : J. CLARRICOATS, New Ruskin House, Little Russell Street, London, W.C.1. (Holborn 7373.)

INSTITUTION OF RADIO ENGINEERS, AUSTRALIA
Secretary : N. S. GILMOUR, Box 3120, G.P.O., Sydney, Australia.

INSTITUTE OF RADIO ENGINEERS (INC.)
330 West 42nd Street, New York.

RADIO TRADES' EXAMINATION BOARD
Secretary : G. D. CLIFFORD, F.C.C.S., 9 Bedford Square, London, W.1. (Museum 1901-2.)

CITY AND GUILDS OF LONDON INSTITUTE
Dept. of Technology, 31 Brechin Place, South Kensington, S.W.7. (Freemantle 1121.)

RADIO INDUSTRY COUNCIL
Secretary : R. P. BROWNE, O.B.E., B.Sc., 59 Russell Square, London, W.C.1. (Museum 6901-5.)

BRITISH RADIO EQUIPMENT MANUFACTURERS' ASSOCIATION
Secretary : S. E. ALLCHURCH, O.B.E., 59 Russell Square, London, W.C.1. (Museum 6901-5.)

BRITISH RADIO VALVE MANUFACTURERS' ASSOCIATION
Secretary : W. R. WEST, Piccadilly House, 16 Jermyn Street, London, S.W.1. (Regent 5168.)

RADIO COMMUNICATION AND ELECTRONIC ENGINEERING ASSOCIATION
Secretary : L. R. BATTEN, O.B.E., B.Sc., LL.B., 59 Russell Square, London, W.C.1. (Museum 6901-5.)

RADIO COMPONENT MANUFACTURERS' FEDERATION
Secretary : W. T. ASH, 22 Surrey Street, Strand, London, W.C.2. (Temple Bar 6740.)

RADIO AND TELEVISION RETAILERS' ASSOCIATION
Secretary : H. A. CURTIS, A.C.I.S., 18 Woburn Square, London, W.C.1. (Museum 3987.)

SCOTTISH RADIO RETAILERS' ASSOCIATION
Secretary : R. BURNETT, C.A., 4 Forres Street, Edinburgh 3.

NORTHERN IRELAND RADIO RETAILERS' ASSOCIATION
General Secretary : A. J. WALMSLEY, 20 Victoria Street, Belfast. (Belfast 26631 and 21109.)

WIRELESS DEALERS' ASSOCIATION
Secretary : J. J. McCANN, 29-30 Dame Street, Dublin. (Dublin 71693.)

INSTITUTE OF PUBLIC ADDRESS ENGINEERS
Secretary : H. A. CURTIS, A.C.I.S., 18 Woburn Square, London, W.C.1. (Museum 3987.)

BRITISH STANDARDS INSTITUTION
Director : P. GOOD, 28 Victoria Street, London, S.W.1. (Abbey 3333.)

BRITISH "WIRELESS FOR THE BLIND" FUND
226 Great Portland Street, London, W.1. (Euston 5251.)

VALVE BASE CONNECTIONS

Every care has been taken in compiling the information given below; it will be realised that the author is dependent, in many cases, upon information received from various sources; errors may therefore exist and no liability can be accepted.

A solid arc drawn through the edge of a base pin indicates an internal shield connection; a similar arc drawn dotted illustrates a metallising connection.

FOR CORRESPONDING VALVE BASE DIAGRAMS, SEE PAGES 80–85.

BRIMAR

S.G. and H.F. Pens.
BATTERY

1A4E	UX7
1LN5E	L5
1N5EG	O14
15E	UX29
32E	UX7
34E	UX7

S.G. and H.F. Pens.
MAINS

6B8SG	O28
6C6	UX53
6D6	UX53
6F7B	UX105
6J7G	O17
6K7EG	O16
6K7G	O16
6U7G	O16
7A7	L4
7A7E	L4
7B7E	L4
7C7E	L4
7H7	L4
8A1	B61
8A1	B113
8D2	B120
9A1	B61
9A1	B113
9D2	B120
12J7GT	O16
12K7GT	O16
24A	UX29
24E	UX29
36	UX29
36E	UX29
39/44	UX29
39/44E	UX29
77	UX53
77E	UX53
78	UX53
78E	UX53

Frequency Changers
BATTERY

1A6	UX56
1A7EG	O32
1A7GT	O32
1C6	UX56
1LA6E	L9

Frequency Changers
MAINS

6A7	UX101
6A7E	UX101
6A8EG	O33
6A8G	O33
6F7	UX105
6F7B	UX105
6F7E	UX105
6K8G	O36
6L7G	O31
6P8G	O35
7A8E	L11
7B8	L10
12K8GT	O36
15A2	B132
15D1	B132
15D2	B132
20A1	B127
20D2	B128

Triodes and Diode Triodes
BATTERY

1H5G	O12
1LH4	L2
27	UX26
30	UX5
45	UX5
2102	UX51

Diodes, Triodes and Diode Triodes
MAINS

4D1	B105
6A3	UX5
6B4G	O8
6B6G	O13
6C5G	O9
6F5G	O11
6H6G	O7
6J5G	O9
6K5G	O10
6Q7G	O13
6R7G	O13
7B6	L3
7C6	L3
10D1	B51
11A2	B106
11D3	B106
11D5	B106
12Q7GT	O13
37	UX26
71A	UX5
75	UX52
76	UX26
85	UX52
HLA2	B54
PA1	B54

G.P. and Output Pentodes and Tetrodes with and without Diodes
BATTERY

1A5G	O23†
1C5G	O23†
1LA4E	L8
1Q5G	O21†
3Q5G	O21
2101	UX27
PenA1	B59

† Ignore filament centre tap

G.P. and Output Pentodes and Tetrodes with and without Diodes
MAINS

6AG6G	O26
6B7	UX100
6B7E	UX100
6B8EG	O28
6B8G	O28
6B8SG	O28
6F6EG	O25
6F6G	O26
6K6G	O26
6L6G	O22
6V6G	O22
7A2	B64
7A2	B117
7A3	B117
7B5E	L7
7C5	L6
7D3	B117
7D5	B117
7D6	B117
7D8	B117
12A6	O22
12A7	UX104
12C8GT	O28
18	UX54
25A6G	O26
25L6G	O22
41	UX54
41E	UX54
42	UX54
42E	UX55
43	UX54
43E	UX55
47	UX27
47E	UX27
2151	UX54
PenA1	B62

Class B and Q.P.P.
BATTERY

19	UX59
2103	UX106

Double Triodes
MAINS

6B5	UX57
6N6G	O39
6N7G	O37
79	UX58

Tuning Indicators

6U5/6G5	UX60

Rectifiers

1D5	B50
5R4GY	O2
5U4G	O2
5V4G	O5
5X4G	O3
5Y3G	O2
5Y4G	O3
5Z3	UX3
5Z4G	O5
6X5	O6
6ZY5G	O6
7Y4	L1
7Z4	L1
12Z3	UX2
25RE	UX50
25Y5	UX50
25Z5	UX50
25Z6G	O7
35RE	UX50
80	UX4
84	UX25
OZ4	O4
R1	B8
R2	B8
R3	B8

COSSOR

S.G. and H.F. Pens.
BATTERY

1A4E	UX7
1N5G	O15
1N5VG	O15

S.G. and H.F. Pens.

BATTERY

15	UX29
32E	UX7
34E	UX7
210SPT	B13
210SPT	B110
210VPA	B110
210VPT	B13
210VPT	B110
215SG	B10
220IPT	B112
220SG	B10
220VS	B10
220VSG	B10

S.G. and H.F. Pens.

MAINS

4TPB	B114
4TSA	B140
4TSP	B113
6J7G	O16
6K7G	O16
13SPA	B114
13VPA	B114
24E	UX29
36E	UX29
39/44E	UX29
41MSG	B57
41MPT	B113
41MTS	B139
42MPT	B113
42PTB	B114
42SPT	B113
77E	UX53
78E	UX53
202SPB	B114
202VP	B113
202VPB	B114
DS/PEN	B61
DVSG	B57
DVS/PEN	B61
MSG/HA	B57
MSG/LA	B57
MS/PEN	B61
MS/PEN	B113
MS/PEN/B	B114
MVSG	B57
MVS/PEN	B61
MVS/PEN/B	B114
MVS/PEN	B113
OM5	O16
OM6	O16

Frequency Changers

BATTERY

1A6E	UX56
1A7G	O32
1A7VG	O32
1C6E	UX56
210DG	B59
210PG	B131
210PGA	B131
210SPG	B131
220TH	B130

Frequency Changers

MAINS

4THA	B127
6A7E	UX101
6A8EG	O33
6F7B	UX105
6K8G	O36
13PGA	B132
41MDG	B60
41MPG	B132
41STH	B127
202MPG	B132
202STH	B127
302THA	B127
OM8	O33
OM10	O35

Diodes, Triodes and Diode Triodes

BATTERY

1H5G	O12
30	UX5
210DDT	B56
210DET	B9
210HF	B9
210HL	B9
210LF	B9
210RC	B9
220DD	B51
2102	UX51

Diodes, Triodes and Diode Triodes

MAINS

6H6G	O7
6K5G	O10
6R7G	O13
6Q7G	O13
13DHA	B106
27	UX26
37	UX26
41MH	B54
41MHF	B54
41MHL	B54
41MLF	B54
41MTA	B54
41MTB	B54
41MTL	B54
75	UX52
76	UX26
85	UX52
202DDT	B106
DD4	B51
DDL4	B51
DDT	B106
DDT16	B106
DHL	B54
GDT4	B66
GDT4B	B66
OM3	O7
OM4	O13

Output Triodes

BATTERY

215P	B9
220P	B9
220PA	B9
230XP	B9

Output Triodes

MAINS

2P	B9
2XP	B9
4XP	B9
6A3	UX5
6B4G	OS
6J5G	O9
41MP	B54
41MXP	B54
45	UX5
402P	B103
DP	B54

G.P. and Output Pentodes and Tetrodes with and without Diodes

BATTERY

1C5G	O23†
220HPT	B14
220HPT	B62
220OT	B58
220PT	B14
220PT	B62
230PT	B14
230PT	B62
2101	UX27

† Ignore filament centre tap

G.P. and Output Pentodes and Tetrodes with and without Diodes

MAINS

6B7E	UX100
6B8EG	O28
6F6EG	O26
6K6G	O26
18E	UX55
25A6G	O26
38E	UX28
40PPA	B117
41E	UX55
42E	UX55
42MP/PEN	B117
420T	B107
420TDD	B109
43E	UX55
47E	UX27
4020T	B108
402PEN	B119
402PEN/A	B119
807	UX30
2151	UX54
DD/PEN	B121
DP/PEN	B117
MP/PEN	B64
MP/PEN	B117
OM9	O27
PT10	B117
PT41	B62
PT41B	B62

Double Valves

BATTERY

19	UX59
220B	B137
240B	B137
240QP	B138
2103	UX106

Double Valves

MAINS

6N7G	O37
79	UX58

Tuning Indicators and Miscellaneous

4TP	B136
41ME	SC50
S130	B20

Rectifiers

4/100BU	B7
5X4G	O3
5Y4G	O3
5Z3	UX3
6ZY5G	O6
25RE	UX50
25Z5	UX50
35RE	UX50
40SUA	B50
43IU	B8
44IU	B8
45IU	B8
80	UX3
84	UX25
225DU	B103
405BU	B7
442BU	B7
460BU	B7
506BU	B7
OM1	O1
SU2150	B3
SU2150A	B3

MAZDA

S.G. and H.F. Pens.

BATTERY

SP22	MO13
SP141	MO11
SP210	B110
VP22	MO13
VP23	MO13
VP210	B110

S.G. and H.F. Pens.

MAINS

10F9	NBS20
AC/S2PEN	B113
AC/SP1	B113
AC/SP3	B114
AC/VP1	B113
AC/VP2	B114
SP41	MO12
SP42	MO12
VP41	MO12
VP133	MO12
VP1321	B113
VP1322	B114

Frequency Changers
Battery

FC141	MO18
TP22	B200
TP23	B126
TP25	MO19
TP26	MO19

Frequency Changers
Mains

10C1	NBS30
AC/TH1	B129
AC/TP	B201
TH41	MO20
TH233	MO20
TH2320	B129
TH2321	B129
TP2620	B201

Diodes, Triodes and Diode Triodes
Battery

DD207	B7
H141D	MO8
HL2	B9
HL21/DD	B56
HL22	MO5
HL23	MO5
HL23/DD	MO9
L2	B9
L21/DD	B56
L22/DD	MO9
P20	B9
P220A	B9

Diodes, Triodes and Diode Triodes
Mains

6D1	Misc. 1
6L18	NBS10
10LD11	NBS15
AC2HL	B54
ACHL	B54
AC/HLDD	B106
AC/P	B54
AC/P1	B54
AC/P4	B53
DD41	MO4
DD101	MO4
DD620	B51
HL41	MO7
HL41DD	MO10
HL42DD	MO10
HL133	MO6
HL133DD	MO10
HL1320	B105
HLDD/1320	B106
P41	MO7
PP3/250	B9
PA20	B9
PA40	B9
PP5/400	B9
PP3521	B104
T11	B53
T21	B53

T31	B53
T41	MO7
V312	B55
V914	B51

Output Tetrodes and Pentodes with and without Diodes
Battery

Pen24	MO17
Pen25	MO17
Pen141	MO17
Pen220	B62
Pen231	B62

Output Tetrodes and Pentodes with and without Diodes
Mains

6P25	O22
10P13	NBS40
10P14	O22
AC/Pen	B117
AC2/Pen	B117
AC2/PenDD	B122
AC4/Pen	B107
AC5/Pen	B107
AC5/PenDD	B109
AC6/Pen	B142
Pen44	MO14
Pen45	MO14
Pen45DD	MO16
Pen46	MO15
Pen383	MO14
Pen453DD	MO16
Pen3520	B117
PenDD4020	B122
PenDD4021	B109

Double Valves
Battery

PD220	B137
PD220A	B137
QP25	MO21
QP230	B138
QP240	B202

Tuning Indicators

ME41	MO50
ME91	MO50
ME920	B175

Rectifiers

MU2	B2
U21	B3
U22	MO2
U201	O1
U403	MO1
U404	NBS1
U4020	B50
UU4	B8
UU5	B8
UU6	MO3
UU7	MO3
UU8	MO3

FERRANTI
Battery Types

H2D	B56
HP2	B137
L2	B9
VHT2	B130
VHT2A	B130
VPT2	B110
VS2	B10

S.G. and H.F. Pens.
Mains

6J7G	O17
6K7G	O16
SPT4A	B113
SPTS	B113
VPT4	B61
VPT4B	B113
VPTA	B113
VPTS	B113

Frequency Changers
Mains

6A8G	O33
6K8G	O36
VHT4	B129
VHTA	B129
VHTS	B129

Diodes, Triodes and Diode Triodes
Mains

6Q7G	O13
D4	B54
DA	B105
H4D	B106
HAD	B106
HSD	B106
LP4	B9
ZD	B51

Output Pentodes and Tetrodes with and without Diodes
Mains

6B8G	O28
6F6G	O26
6V6G	O22
PTA	B117
PT4	B117
PT4D	B109
PTSD	B122
PTZ	B119

Rectifiers

5Y3G	O2
R4	B7
R4A	B7
RA	B51
RS	B50
RZ	B50

MULLARD
S.G. and H.F. Pens.
Battery

1A4	UX7
1N5G	O14
15	UX29
32	UX7
34	UX7
DF1	SC13
DF33	O15
KF35	O14
PM12	B10
PM12A	B10
PM12M	B10
SP2	B110
VP2	B110
VP2B	B125

S.G. and H.F. Pens.
Mains

2A6	UX52
2B7	UX100
6C6	UX53
6D6	UX53
6F7	UX105
6J7G	O16
6K7G	O16
6S7G	O16
6U7G	O16
24A	UX29
35	UX30
36	UX29
39/44	UX29
58	UX53
77	UX53
78	UX53
EF5	SC14
EF6	SC14
EF8	SC20
EF9	SC14
EF36	O16
EF38	O30
EF39	O16
MM4V	B57
S4VA	B57
S4VB	B57
SP4	B61
SP4	B113
SP4B	B114
SP13	SC14
SP13C	B114
VP4	B61
VP4	B113
VP4A	B61
VP4A	B113
VP4B	B114
VP13A	SC14
VP13C	B114

Frequency Changers
Battery

1A6	UX56
1A7G	O32
1C6	UX56
1C7G	O32
DK1	SC21
DK32	O32
FC2	B135
FC2A	B135
KK32	O32
TH2	B126

Frequency Changers
MAINS

2A7	UX101
6A7	UX101
6A8G	O33
6D8G	O33
6L7G	O31
ECH2	SC24
ECH3	SC24
ECH33	O35
EK2	SC22
EK3	SC22
FC4	B133
FC13	SC22
FC13C	B133
TH4	B129
TH4B	B129
TH21C	B128
TH22C	B128
TH30C	B129

Diodes, Triodes and Diode Triodes
BATTERY

1H4G	O8
1H5G	O12
2D2	B51
30	UX5
2102	UX51
DAC1	SC9
DAC32	O12
KBC32	O13*
PM1A	B9
PM1HF	B9
PM1HL	B9
PM2DL	B9
PM2DX	B9
PM2HL	B9
TDD2	B56
TDD2A	B56

* Ignore cathode

Diodes, Triodes and Diode Triodes
MAINS

2D4A	B51
2D4B	B101
2D13	SC27
2D13A	SC27‡
2D13C	B51
6C5G	O9
6F5G	O11
6H6G	O7
6J5G	O9
6K5G	O10
6L5G	O9
6Q7G	O13
6R7G	O13
27	UX26
56	UX26
75	UX52
76	UX26
85	UX52
164V	B54
244V	B54
354V	B54
904V	B54
EA50	Misc.1
EAB1	SC6
EB4	SC5
EBC3	SC11
EBC33	O13
HL13	SC8
HL13C	B105
TDD4	B106
TDD13C	B106

‡ Ignore second anode and top cap

Output Triodes
BATTERY

PM2	B9
PM2A	B9
PM202	B9
PM252	B9

Output Triodes
MAINS

2A3	UX5
6A3	UX5
45	UX5
71A	UX5
104V	B54
ACO42	B9
ACO44	B9
DO24	B9
DO25	B9
DO26	B9
DO30	B9
TT4	B54
TT4A	B54

Pentodes and Diode Pentodes
BATTERY

1C5G	O23†
1F4	UX27
1F5G	O23†
1F7G	O28*
33	UX27
2101	UX27
DL1	SC15
DL2	SC15
DL33	O23
KL35	O23
PM22	B14
PM22	B62
PM22A	B14
PM22A	B62
PM22D	B62

† Ignore filament centre tap
* Ignore cathode

Tetrodes and Pentodes with and without Diodes
MAINS

2A5	UX54
6A4	UX27
6B7	UX100
6B8G	.028
6L6G	O22
6F6G	O26
6V6G	O22
12A5	UX107
12A7	UX104
18	UX54
25A6G	O26
25L6G	O22
41	UX54
42	UX54
43	UX54
47	UX27
89	UX53
2151	UX54
CBL1	SC18
CBL31	O28
CL4	SC16
CL6	SC16
CL33	O26
EBL1	SC18
EBL31	O28
EL2	SC16
EL3	SC17
EL6	SC17
EL32	O27
EL33	O26
EL36	O26
Pen4DD	B123
Pen4VA	B64
Pen4VA	B117
Pen4VB	B117
Pen26	SC16
Pen36C	B117
Pen40DD	B123
Pen428	B117
PenA4	B117
PenB4	B117
PM24	B14
PM24	B62
PM24A	B62
PM24B	B62
PM24E	B62
PM24M	B62

Double Valves
BATTERY

19	UX59
2103	UX106
PM2B	B137
PM2BA	B137
QP22A	B202
QP22B	B138

Double Valves
MAINS

6A6	UX102
6B5	UX57
6N6G	O39
6N7G	O37
79	UX58

Tuning Indicators

6E5	UX60
6U5/6G5	UX60
EFM1	SC51
EM1	SC50
EM3	SC50
EM4	SC52
TV4	SC50
TV4A	SC50
TV6	SC50

Rectifiers and Doublers

1/V	UX2
5U4G	O2
5V4G	O5
5X4G	O3
5Y3G	O2
5Y4G	O3
5Z3	UX3
5Z4G	O5
6X5G	O6
12A7	UX104
25Y5	UX50
25Z5	UX50
25Z6G	O7
80	UX4
83	UX3
84	UX25
AZ1	SC2
AZ2	SC2
AZ3	SC4
AZ31	O2
AZ32	O2
CY1	SC1
CY2	SC3
CY31	O1
CY32	O7
DW2	B7
DW3	B7
DW4/350	B7
DW4/500	B7
EZ2	SC4
FW4/500	B7
HVR2	B3
IW2	BS
IW3	B8
IW4	B8
IW4/350	B8
IW4/500	B8
UR1	SC1
UR1C	B50
UR3	SC3
UR3C	B100

MARCONI
OSRAM

S.G. and H.F. Pens.
BATTERY

S21	B10
S22	B10
S23	B10
S24	B10
V52	B10
VP21	B110
VS24	B10
W21	B13
Z14	O14
Z21	B13

S.G. and H.F. Pens.
MAINS

KTW61	O16
KTW61M	O16
KTW63	O27
KTW73M	O27
KTZ41	B116
KTZ63	O27
KTZ73M	O27
MS4	B57

MARCONI
OSRAM—*continued*

S.G. and H.F. Pens.
MAINS

MS4B	B57
MSP4	B57
MSP4	B113
MSP41	B57
MSP41	B113
VMP4	B57
VMP4	B113
VMP4G	B113
VMS4	B57
VMS4B	B57
W42	B120
Z62	O16

Frequency Changers
BATTERY

X14	O32
X21	B134
X22	B134
X23	B126
X24	B126

Frequency Changers
MAINS

MX40	B132
X30/32	B132
X31	B127
X41	B127
X42	B132
X61M	O35
X62	O35
X63	O33
X63M	O33
X65	O35
X71M	O35
X73M	O33
X75	O35

Triodes and Diode Triodes
BATTERY

H2	B9
HD14	O12
HD22	B56
HD23	B56
HD24	B56
HL2	B9
HL21	B9
L21	B9
L210	B9
LP2	B9
P2	B9
P215	B9

Diodes, Triodes and Diode Triodes
MAINS

D 41	B51		
D42	B5		
D43	B6		
D63	O7		
DA30	B9		
DA41	UX5		
DH30	B106		
DH42	B106		
DH63	O13		
DH73	O13		
DL63	O13		
H63	O11		
L63	O9		
MH4	B54		
MH40	B54		
MH41	B54		
MHD4	B106		
MHL4	B54		
ML4	B54		
PX4	B9		
PX25	B9		
PX25A	B9		

Output Pentodes and Tetrodes
BATTERY

KT2	B62
KT21	B62
KT24	B62
N14	O23†
PT2	B62

† Ignore filament centre tap

Output Pentodes and Tetrodes with and without Diodes
MAINS

KT32	O22
KT33	O22
KT33C	O20
KT35	O20
KT41	B107
KT42	B107
KT61	O22
KT63	O22
KT66	O22
KT72	O22
KT73	O22
MKT4	B64
MKT4	B107
MPT4	B64
N30	B117
N30G	B117
N41	B117
N42	B117

Double Valves
BATTERY AND MAINS

B21	B137
BL62	O38
DET19	UX103
QP21	B138

Tuning Indicators

Y61	O50
Y62	O50
Y63	O50
Y64	O50
Y73	O50

Rectifiers

GU5	B2
GU50	B2
MU12/14	B8
U10	B7
U12/14	B7
U16	B2
U17	B2
U18/20	B7
U30	B102
U31	O1
U50	O2
U52	O2
U70	O6
U71	O1
U134	O7

EVER READY
All Types
BATTERY

K23A	B56
K23B	B56
K30A	B9
K30C	B9
K30D	B9
K30E	B9
K30G	B9
K30K	B9
K30M	B110
K33A	B137
K33B	B137
K40B	B10
K40N	B10
K50N	B125
K70B	B62
K70D	B62
K77A	B202
K80A	B134
K80B	B135

H.F. Pentodes and Frequency Changers
MAINS

A36A	B127
A36C	B129
A50A	B113
A50B	B114
A50M	B113
A50N	B61
A50N	B113
A50P	B114
A80A	B133
C36A	B127
C36C	B129
C50B	B114
C50N	B114
C80B	B133
ECH3	SC24
EF9	SC14
EF39	O16

Diodes, Triodes and Diode Triodes
MAINS

A20B	B51
A23A	B106
A30B	B54
A30D	B54
C20C	B51
C23B	B106
C30B	B105
EB34	O7
EBC3	SC11
EBC33	O13
S30C	B9
S30D	B9

Output Pentodes and Diode Pentodes
MAINS

A27D	B123
A70B	B117
A70D	B117
A70E	B117
C70D	B117
EBL1	SC18
EBL31	O28
EL3	SC17
EL32	O27
EL33	O26

Rectifiers

A11C	B8
A11D	B8
AZ1	SC2
AZ31	O2
C10B	B50
CY31	O1
S11A	B7
S11D	B7

BRITISH 4 PIN

B1 B2 B3 B4 B5 B6

B7 B8 B9 B10 B11 B12

B13 B14 B20

BRITISH 5 PIN

B50 B51 B52 B53 B54 B55

B56 B57 B58 B59 B60 B61

B62 B63 B64 B65 MISC 1 B66

Note.—All connections are as viewed from underside of valve base.

80

B100   B101   B102   B103   B104   B105

B106   B107   B108   B109   B110   B111

B112   B113   B114   B115   B116   B117

B118   B119   B120   B121   B122   B123

B124   B125   B126   B127   B128   B129

B130   B131   B132   B133   B134   B135

B136   B137   B138   B139   B140

B142   B175   B200   B201   B202

Note.—All connections are as viewed from underside of valve base.

81

Note.—All connections are as viewed from underside of valve base.

AMERICAN UX 4 PIN

UX 1 UX 2 UX 3 UX 4 UX 5 UX 6

UX 7

AMERICAN UX 5 PIN

UX 25 UX 26 UX 27 UX 28 UX 29 UX 30

AMERICAN UX 6 PIN

UX 50 UX 51 UX 52 UX 53 UX 54 UX 55

UX 56 UX 57 UX 58 UX 59 UX 60

AMERICAN UX 7 PIN

UX 100 UX 101 UX 102 UX 103 UX 104 UX 105

UX 106 UX 107

Note.—All connections are as viewed from underside of valve base.

83

MAZDA OCTAL

MO 1, MO 2, MO 3, MO 4, MO 5, MO 6

MO 7, MO 8, MO 9, MO 10, MO 11, MO 12

MO 13, MO 14, MO 15, MO 16, MO 17, MO 18

MO 19, MO 20, MO 21, MO 50

LOCTAL

L 1, L 2, L 3, L 4, L 5, L 6

L 7, L 8, L 9, L 10, L 11

NEW BRITISH STANDARD

NBS 1, NBS 10, NBS 15, NBS 20, NBS 30, NBS 40

Note.—All connections are as viewed from underside of valve base.

84

SIDE CONTACT

Note.—All connections are as viewed from underside of valve base.

VALVE EQUIVALENTS GUIDE

The following suggested equivalents are given in good faith, and it is realised that some possible equivalents may be missing and that errors may exist, since sources of information may on occasion be inaccurate. Certain valves listed may not be obtainable, but the information will nevertheless be of value to those who possess such types. Valves enclosed by a bracket are mutually interchangeable.

Equivalents of Continental valves are not included; for such information and for equivalents of British, U.S.A., German and Italian war-time service valves, it is suggested that reference be made to the *Radio Tube Vade-Mecum*, by P. H. Brans, published at 28 Rue du Prince Leopold, Anvers, Belgium. This book has all data in English, and may be purchased in this country.

| Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
2-V BATTERY (BRITISH AND U.X. BASES)						
Screened Grids and H.F. Pentodes						
32E	32E	—	—	—	—	32
5B1	215SG	K40B	—	S23	S215A	PM12
—	220SG	—	—	S22	S215B	PM12A
—	—	—	—	S24	SG215	—
—	—	—	—	S21	—	—
—	220VS	K40N	VS2	VS2	S215VM	PM12M
—	220VSG	—	—	VS24	—	—
—	210SPT	—	—	Z21	SP210	SP2
—	210VPA	K50M	VPT2	VP21	VP210	VP2
—	210VPT	—	—	W21	VP215	—
1A4E	1A4E	—	—	—	—	1A4
34E	34E	—	—	—	—	34
15E	15	—	—	—	—	15
Frequency Changers						
—	210PG	K80A	VHT2A	X21	—	FC2
—	210SPG	—	—	X22	—	FC2A
—	210PGA	K80B	VH2	—	—	FC2A
—	—	—	—	X24	—	TH2
1A6	1A6E	—	—	—	—	1A6
1C6	1C6E	—	—	—	—	1C6
Diodes and Triodes						
—	220DD	—	—	—	DD207	2D2
—	210DDT	K23B	H2D	HD22	HL21DD	TDD2A
—	—	K23A	—	HD24	L2DD	TDD2
—	—	—	—	HD23	L21DD	—
2102	2102	—	—	—	—	2102
Triodes						
—	210RC	K30A	—	H2	H2	PM1A
HLB1	210HL	K30K	—	HL2	HL2	PM2HL
—	210HF	K30C	—	HL210	HL210	PM1HF
	210LF	K30D	L2	L210	L2	PM1LF
(1)	210DET	K30B	—	L21	L210	PM2DL
	—	K30E	—	L2/B	—	PM2DX
—	215P	—	—	P215	P215	PM2
PB1	220PA	K30G	L2	LP2	P220	PM2A
—	230XP	—	—	P2	P220A	PM202
30	30	—	—	—	—	30

(1) Certain valves in this group have special anti-microphonic properties. These are not necessarily shared by all the equivalents shown.

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
Output Pentodes and Tetrodes						
PenB1	220HPT	K70B	—	PT2	Pen220	PM22A}
—	220OT	—	—	KT2	—	
—	220PT	—	—	—	Pen220A	PM22}
—	—	—	—	—	—	PM22C}
—	—	K70D	—	KT21	Pen231	PM22D}
—	—	—	—	KT24	—	
2101	2101	—	—	—	—	2101
Class B Output						
—	220B	K33A	—	—	PD220	PM2B
—	240B	K33B	HP2	—	PD220A	PM2BA
19	19	—	—	—	—	19
Q.P.P.						
—	240QP	—	QPT2	QP21	QP23	QP22B
—	—	K77A	—	—	QP240	QP22A
2103	2103	—	—	—	—	2103
1·4-V BATTERY (OCTAL BASES)						
H.F. Pentodes						
1N5G	1N5G	1N5G	—	Z14	—	1N5G
—	—	.	—	—	SP141	DF33
Frequency Changers						
—	—	—	—	—	FC141	DK32
1A7EG	1A7G	1A7G	—	X14	—	1A7G
Diode Triode						
—	—	—	—	—	H141D	DAC32
1H5G	1H5G	1H5G	—	HD14	—	1H5G
Output Pentodes						
—	—	—	—	—	Pen141	DL35
1C5G	1C5G	1C5G	—	N14	—	1C5G
4-V A.C. MAINS (BRITISH BASES)						
Screened Grids						
SGA1	MSG/HA	—	—	MS4	AC/S2	S4VA}
—	41MSG	—	—	—	—	S4V
—	MSG/LA	—	—	MS4B	AC/SG	S4VB
—	MVSG	A40M	—	VMS4	AC/S1VM	MM4V}
—	—	—	—	VMS4B	AC/SGVM	VM4V}
H.F. Pentodes						
8A1	MS/Pen	A50A	SPT4	MSP4	AC/S2Pen	VP4}
—	MS/PenA	—	SPT4A	—	—	
—	—	—	—	—	AC/SP3	TSP4
9A1	MVS/Pen	A50M	VPT4	VMP4	AC/VP1	VP4}
—	—	A50N	VPT4A	VMP4G	—	VP4A}
—	—	—	VPT4B	—	—	
—	MVS/PenB	A50P	—	W42	AC/VP2	VP4B
—	MS/PenB	A50B	—	—	—	SP4B
Frequency Changers						
20A1	41STH	A36A	—	X41	AC/TH1	TH4
—	—	A36B	—	—	—	—
15A2	41MPG	A80A	VHT4	X42	—	FC4}
—	—	—	—	MX40	—	
—	4THA	A36C	—	—	—	TH4B

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
				Diodes and Diode Triodes		
—	DD4	A20B	—	D41	AC/DD	2D4A
—	—	—	—	—	V914	—
11A2	DDT	A23A	H4D	MHD4	AC/HLDD	TDD4
—	—	—	—	DH42	—	—
				Triodes		
HLA1	41MH	A30B	—	MH41	AC2/HL	904V
HLA2	41MHF	A30D	D4	MH4	—	354V
—	41MHL	—	—	—	—	244V
—	41MLF	—	—	MHL4	—	164V
—	41MP	—	—	ML4	AC/P	104V
—	—	—	—	—	—	TT4
PA1	41MXP	—	—	—	AC/P1	O54V
—	—	—	—	DA30*	PA40*	DO26*
—	—	—	—	PX25A*	V503*	DO30*
—	4XP*	S30C*	LP4*	PX4*	PP3/250*	ACO44*
—	—	—	—	PX25*	PP5/400*	DO24*
—	2P†	—	—	—	PA20†	ACO42†
—	2XP†	—	—	—	—	—
				Output Pentodes and Tetrodes		
7A2	MP/Pen	A70B	—	MPT4	AC/Pen	Pen4V
—	—	—	—	MKT4	—	Pen4VA
—	—	—	—	KT42	—	—
7A3	42MP/Pen	A70D	PT4	KT41	AC2/Pen	Pen4VB
—	42OT	A70C	—	N41	—	PenA4
—	42OTDD	—	PT4D	DN41	AC2/PenDD	—
—	—	A27D	—	—	—	Pen4DD
PenA1	PT41	—	—	PT4	—	PM24
—	PT41B	—	—	—	—	PM24B
—	—	—	—	PT25	—	PM24E
—	—	—	—	PT25H	—	—

A.C./D.C. MAINS (BRITISH BASES)

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
				Screened Grids and H.F. Pentodes		
—	—	—	SPTS	—	SP1320	—
—	—	—	VPTA	—	VP1320	—
—	—	—	—	—	VP1321	—
9D2	13VPA	C50N	—	—	VP1322	VP13C
				Frequency Changers		
—	302THA	C36N	—	—	—	TH30C
—	—	—	—	—	TH2321	TH22C
—	—	—	—	X31	—	TH13C
—	202STH	C36A	—	—	—	TH21C
15D1	13PGA	C80B	—	—	—	FC13C
				Diodes and Triodes		
10D1	—	C20C	ZD	—	DD620	2D13C
11D3	13DHA	C23B	HAD	—	HLDD1320	TDD13C
				Triodes		
4D1	—	C30B	DA	—	HL1320	HL13C
7D3	40PPA	—	—	—	—	—
				Output Pentodes		
7D8	—	—	—	—	Pen1340	Pen13C
—	402Pen	—	PTZ	—	—	—
—	402OT	—	—	—	—	—
7D6	—	C70D	—	—	Pen3520	Pen36C
—	—	—	—	—	Pen3820	—

* Directly heated. Bias resistors in use should be checked for suitability.
† 2-volt filaments. Same remarks as * apply.

Brimar	Ferranti	Cossor	Marconi Osram	Mullard	U.S.A.*
INTERNATIONAL MAINS VALVES (U.X. AND OCTAL BASES)					
Screened Grids †					
36	—	36E	—	36	36
36E	—	—	—	—	—
24A	—	24E	—	24A	24A
24E	—	—	—	—	—
H.F. Pentodes and Double Diode H.F. Pentodes †					
78	—	78E	—	78	78
78E	—	—	—	—	—
6U7G	—	—	KTW63	6K7G	6U7
39/44	—	39/44E	—	39/44	39/44
39/44E	—	—	—	—	—
6K7G	6K7G	6K7G	—	6K7G	6K7
6K7EG	—	—	—	—	—
77	—	77E	—	77	77
77E	—	—	—	—	—
6B8G	—	6B8EG	—	6B8G	6B8
6B8EG	—	—	—	—	—
6B7	—	6B7E	—·	6B7	6B7
6B7E	—	—	—	—	—
6J7G	—	—	Z63	—	6J7
Frequency Changers					
6A7E	—	6A7E	—	6A7	6A7
6A8G	6A8G	6A8EG	X63	6A8G	6A8
6A8EG	—	—	—	—	—
6L7G	—	—	X64	—	6L7
—	—	—	X65	—	6K8
Diodes, Diode Triodes and Diode L.F. Pentodes					
6H6G	—	6H6G	D63	6H6G	6H6
6R7G	—	6R7G	DL63	6R7G	6R7
75	—	75	—	75	75
85	—	85	—	85	85
6Q7G	6Q7G	6Q7G	DH63	6Q7G	6Q7
6B8G	—	6B8EG	—	6B8G	6B8
6B8EG	—	—	—	—	—
6B7	—	6B7E	—	6B7	6B7
6B7E	—	—	—	—	—
Triodes					
6K5G	—	6K5G	—	6K5G	6K5
6J5G	—	—	L63	6J5G	6J5
6F5G	—	—	H63	—	6F5
6B4G	—	6B4G	—	—	6B4
6A3	—	6A3	—	6A3	6A3
76	—	76	—	76	76
27	—	27	—	27	27
37	—	37	—	37	37
45	—	45	—	45	45
Output Pentodes and Tetrodes †					
6L6G	—	—	KT66	EL35	6L6
6F6G	6F6G	6F6EG	KT63	6F6G	6F6
6F6EG	—	—	—	—	—
41E	—	41E	—	41	41
42	—	42E	—	42	42
42E	—	—	—	—	—
18	—	18E	—	18	18
43E	—	43E	—	43	43
47	—	47E	—	47	47
47E	—	—	—	—	—
—	—	—	KT32	25L6G	25L6

* In this column only the significant characters are given; the suffix characters denote type of envelope.

† Valves with an E suffix are not necessarily equivalents when used as oscillators.

Brimar	Ferranti	Cossor	Marconi Osram	Mullard	U.S.A.*

Class B Output

Brimar	Ferranti	Cossor	Marconi Osram	Mullard	U.S.A.*
6N7G	—	6N7G	—	6N7G	6N7
79	—	79	—	79	79

MISCELLANEOUS

Cossor	Marconi Osram	Ferranti	Marconi Osram	Cossor	Mullard
DVSG	VDS	VHTS	X30	OM4	EBC33
DHL	DH	VPTS	W31	OM5	EF36
DDT16	DHD	DS	H30	OM6	EF39
DP/Pen	DPT	HSD	DH30	OM9	EL32
		PTA	KT30	OM10	ECH33

RECTIFIERS
A.C. (British Bases)

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
—	506BU	S11A	—	U10	UU2	DW2
R2	43IU	A11B	—	—	UU4	IW3
—	—	A11D	—	—	—	IW4/350
—	442BU	S11D	R4	U12	UU120/350	DW3
—	—	—	—	—	—	DW4/35
R3	44IU	A11C	—	MU12	UU5	—
—	—	—	—	MU14	—	—
—	460BU	—	R4A	U14	UU120/500	DW4
—	—	—	—	—	—	DW4/500
—	408BU	—	—	—	UU30/250	RG1/250
—	—	—	—	GU1	—	RG1/240
—	—	—	—	GU50	—	
—	4/100BU	—	—	U18	—	
—	415U	—	—	—	—	FW4/500

A.C./D.C. British Bases

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
1D5	40SUA	—	—	—	U4020	—
—	—	C10B	RZ	—	—	UR1C

U.X. AND OCTAL BASES

Brimar	Cossor	Ever Ready	Ferranti	Marconi Osram	Mazda	Mullard
—	—	—	—	U52	—	5U4G
5X4G	5X4G	—	—	—	—	5X4G
—	—	—	—	U50	—	5Y3G
5Y4G	5Y4G	—	—	—	—	5Y4G
5Z3	5Z3	—	—	—	—	5Z3
6ZY5G	6ZY5G	—	—	—	—	—
25RE	25RE	—	—	—	—	—
35RE	35RE	—	—	—	—	—
25Z5	25Z5	—	—	—	—	25Z5
—	80	—	—	—	—	80
84	84	—	—	—	—	84

*In this column only the significant characters are given; the suffix characters denote type of envelope.