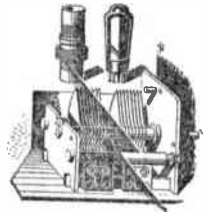
THE PRACTICAL RADIO REFERENCE BOOK

COMPLETE GUIDE IN
QUICK REFERENCE FORM FOR
ALL RADIO TECHNICIANS, STUDENTS
AND AMATEURS

Edited by **ROY C. NORRIS**
Technical Editor, "Electrical and Radio Trading"



ODHAMS PRESS LIMITED
LONG ACRE · LONDON · W.C.2

THE PRACTICAL
RADIO REFERENCE BOOK

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HOW TO USE THIS BOOK

PROPERLY used, this book can be a big time-saver for the practical radio engineer and student alike. It presents a mass of practical and theoretical data in as concise a manner as compatible with intelligibility. Within these covers can quickly be found information which otherwise might be elicited only after thumbing through a whole shelf-full of books on theory, circuit practice, valves, components, sound amplification, instruments, interference suppression, and so forth.

The reader should first familiarize himself with the general 'shape' of the book. It will be seen from the Contents that the volume is divided into numerous sections, each devoted to a department of practice or theory.

A little acquaintance with the volume will enable the reader to turn, in most cases, straight to the section containing the information he requires.

Within each section, data are presented in appropriate sequence—technical or otherwise. This gives each item its logical place, thus aiding reference and at the same time ensuring, in many instances, that the item is explained by what precedes it.

When the reader has no clear conception of the category in which a required fact may be located, he should refer to the detailed index in the end pages. Every effort has been made to ensure that the index is comprehensive but, on occasion, it may be necessary to recollect that some information does not readily lend itself to itemized listing.

While essentially a reference book, the reader will find several features which can be read through. In fact, while full explanation is outside its scope, the volume is more than a plain reference work.

This approach is exemplified in the Valve section. There you will find definitions of terms and brief descriptions of valve types, in addition to the formulæ for understanding and utilizing valve circuits. The diagrams form, in themselves, a pictorial outline of theory as well as a reference guide to the numerous circuit arrangements which are the practical man's concern.

The Component Design section not only contains the necessary data in particularly compact tables and helpful curves, but also explains how the material should be used. It is, in fact, a potted design manual.

The section on Instruments is not concerned with how they work as much as with how their ranges may be modified for particular purposes or with what is conveyed by the patterns on cathode-ray oscillographs. Sound Amplification begins with basic terms and useful reference charts and goes on to such practical matters as the characteristics of microphones and loudspeakers.

The needs of the television installation engineer, as well as of the short-wave enthusiast, have been borne in mind.

A summary of AC theory and of the algebra necessary for its application will be valuable equally to the student and to the older man who needs a refresher. Abacs and charts are given to speed everyday calculations.

It is hoped to revise and extend the book from time to time and suggestions for its improvement from readers will be welcomed.

Thanks are extended to contributors, among them D. H. Smith, B.Sc., Ph.D., E. J. G. Lewis, A.M.Brit.I.R.E., W. B. Hunt, and J. de Gruchy, M.Brit.I.R.E.

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TABLE I

Term	Brief description	Letter symbol
Static electricity	Electricity at rest and existing in excess in charged bodies	
Direct current	Electricity flowing uniformly in a conductor in one direction	DC
Alternating current	Electricity flowing alternately in reverse directions in a periodic manner	AC
Unidirectional current	Electricity flowing in one direction but not at a constant rate of flow	
Electromagnetism	Magnetic effects produced in the neighbourhood of a conductor in which electricity is flowing in any manner	
Charge of electricity	The excess of positive or negative electricity on a body or in space	
Potential difference (abbreviated P.D.)	A difference between the electrical states existing at two points, tending to cause a movement of electricity from one point to another	V
Electric force	A force exerted in the neighbourhood of a charged body on other charged or uncharged bodies	
Electric field	The space in the neighbourhood of a charged body throughout which an electric charge experiences a mechanical force. (An electric force is exerted by a *varying* magnetic field.)	
Line of electric force	A line drawn in an electric field which gives at all points in the field the direction of the electric force at these points	
Displacement	The displacement of electricity in a conductor or a dielectric due to the action of electric forces	
Dielectric	A medium across which a quantity of electricity may be displaced but which is incapable of conducting electricity through it	
Insulating material	Material which offers a relatively high resistance to the passage of an electric current	
Electric flux	A phenomenon produced in the medium in the neighbourhood of a charged body and related to the conception of lines of electric force	
Relative permittivity	Referred to a dielectric. The property of a dielectric in relation to its effect in concentrating electric flux in it when acted upon by an electric force	K
Capacitance	The property of a conductive body by virtue of which a quantity of electricity has to be contained in it to produce a difference of potential between the body and surrounding bodies	C
Capacitor	A component capable of storing electrical energy in the form of electrical stress in insulating material placed between conductive surfaces which are electrically separated by the insulating material	

TABLE I—*continued*

Term	Brief description	Letter symbol
Electromotive force (abbreviated EMF)	Of a source of electricity—that force which tends to cause a movement of electricity in a circuit	E
Electric current	The flow of electricity along any path or round any circuit	I
Resistance	That property of a body by virtue of which it resists the flow of electricity through it	R
Ohm's law	The resistance of the majority of metallic conductors is independent of the potential acting across them and the consequent current flowing in them, provided the conductor is kept at a constant temperature	
Conductance	The reciprocal of resistance	G
Voltage drop	The voltage between any two points on a conductor with current flowing in it. The voltage across a resistor with current flowing in it	
Internal resistance	Of a source. Resistance concealed in a source and existing between physically inaccessible terminals	
Quantity of electricity	The term is self-explanatory, but see Table II	
Electric power	The rate at which energy is converted from electrical to other forms	W
Magnetic field	The space in the neighbourhood of an electric current or a permanent magnet throughout which magnetic forces can be detected	
Line of magnetic force	A line drawn in a magnetic field such that its direction at every point is the direction of magnetic force at that point	
Magnetic flux	A phenomenon produced in the medium in the neighbourhood of electric currents or magnets and associated with lines of magnetic force	Φ
Magnetic flux density	At a point. The amount of magnetic flux per unit area, the area being in a position which gives a maximum value for the flux	
Magnetizing force	The force at a point which produces or is associated with the flux at that point	H
Magnetic circuit	A closed path in a magnetic field	
Magnetomotive force	Around a magnetic circuit. The force which establishes the magnetic forces around a magnetic circuit	F
Permeability	The property of a medium described in relation to its effect of concentrating magnetic flux in it when acted upon by a magnetizing force	μ
Electromagnetic induction	The production of an electromotive force in a circuit by a change of magnetic flux in the circuit	
Mutual induction	The production of an EMF in one circuit by electromagnetic induction caused by varying currents in another circuit	

TABLE I—*continued*

Term	Brief description	Letter symbol
Self-induction	The production of an EMF in a circuit due to the varying currents in that circuit	
Self-inductance (abbreviated inductance)	The property of a circuit by virtue of which self-induction occurs	L
Mutual inductance	The property of a circuit by virtue of which mutual induction occurs	M
Inductor	A component designed to have principally the property of inductance	
Back-electromotive force (abbreviated back-EMF)	An induced electromotive force which opposes the normal flow of current	
Period	The minimum time interval at which similar characteristics of an alternating current or voltage are repeated, the alternations being such as to make this time always the same	
Cycle	The complete series of changes executed by an alternating current or voltage during a period	
Frequency	The number of cycles (of alternation) occurring in a defined time	f
Reactance	A property associated both with capacitance and inductance which causes a back-EMF tending to oppose the flow of an alternating current	X
Impedance	A property associated with a circuit containing both resistance and reactance which limits the value of alternating current flowing in the circuit according to the value of the impedance	Z

TABLE II

Term	Definition (practical units)	Practical unit (unless otherwise stated)	Letter symbol of unit
Unit charge. **Unit quantity of electricity**	That quantity of electricity which passes through a conductor in one second when the mean current is one ampere	Coulomb	C
Potential difference. **Electromotive force**	That electromotive force or potential difference which applied steadily to a conductor the resistance of which is one ohm produces a current of one ampere	Volt	V

TABLE II—*continued*

Term	Definition (practical units)	Practical unit (unless otherwise stated)	Letter symbol of unit
Electric force	Measured in magnitude and direction at any point by the mechanical force per unit charge experienced by a very small body placed at that point	Volt per unit length	E
Relative permittivity	Of a medium. The ratio of the electric flux density produced in the medium to that produced in free space by the same electric force		
Electric flux	The quantity of electricity displaced across a given area in a dielectric. The total flux displaced across a surface enclosing a charge equals the charge		
Electric flux density	The electric flux per unit area normal to the direction of the flux		D
Capacitance	The ratio of a charge on a conductor to its potential when all neighbouring conductors are at zero potential. The ratio of the charge of a capacitor, i.e. the total flux between its electrodes to the potential difference between them	Farad	F
Electric current	Unit current is that which deposits 1·11800 milligramme of silver per second from a solution of silver nitrate	Ampere	A
Resistance	Of a body. Given by the constant difference of potential applied to the ends of the body divided by the current which it produces, no EMF being assumed to act in the body. The *international ohm* is the resistance offered at the temperature of melting ice to an unvarying electrical current by a column of mercury 14·4521 grammes in mass of uniform cross-sectional area and 106·300 centimetres in length	Ohm	Ω
Conductance ..	Unit conductance is the conductance of a body having a resistance of one ohm	mho	
Power	Unit power is the energy expended in one second by an unvarying current of one ampere produced by a voltage of one volt. (For consideration of power and alternating current, see later sections.)	Watt	W

TABLE II—*continued*

Term	Definition (practical units)	Practical unit (unless otherwise stated)	Letter symbol of unit
Energy	Unit of energy, the energy expended in one hour when the power is one watt. One watt-hour = 3,600 joules	Watt-hour	Wh
Magnetizing force	The mechanical force experienced by unit magnetic pole placed at the point where the force is measured. In EM units the force in dynes exercised on unit pole	Oersted (EM unit)	
Magnetomotive force	Along any path. The sum of the magnetic forces around the path. If the path is closed, this is 0·4 π times the ampere-turn	Gilbert (EM unit)	
	The ampere-turns is the multiplication of the turns on a coil and the current in amperes flowing in the coil	Ampere-turn	AT
Amount of magnetic flux	Through any area, measured by the quantity of electricity caused to flow in a circuit bounding the area when the circuit is removed from the area. Unit magnetic flux (EM units) is that flux the removal of which from a circuit of unit resistance causes one electromagnetic unit of electricity to flow	Maxwell (EM unit)	
Magnetic flux density	The amount of magnetic flux per square centimetre over a small area	Gauss (EM unit) (1 gauss = 1 maxwell per square centimetre)	B
Relative permeability	Of a medium. The ratio of the magnetic flux density produced in the medium to that produced in space by the same magnetizing force		
Inductance (self-inductance)	The practical unit of inductance (the henry) is equal to 10^8 flux linkages per ampere	Henry	H
Frequency ..	Measured in cycles per second ..	Cycle/Sec.	c/s
Reactance ..	Of a capacitor: has a numerical value given by the reciprocal of the product of 2 π times the frequency in cycles per second and the capacitance in farads Of an inductor: has a numerical value given by the product of 2 π times the frequency in cycles per second and the inductance in henries	Ohm	Ω

TABLE III

Term	Symbol	Principal relationship with other quantities expressed algebraically
Potential	V	$V = \frac{Q}{C}$
Capacitance	C	$C = \frac{Q}{V}$
Charge	Q	$Q = CV$
Electromotive force, potential difference	E	$E = RI = \frac{I}{G}$
Resistance	R	$R = \frac{E}{I}$
Current	I	$I = \frac{E}{R} = EG$
Conductance	G	$G = \frac{I}{E} = \frac{1}{R}$
Power	W	$W = EI = \frac{E^2}{R} = RI^2$
Magnetic flux density	B	$B = \mu H$
Magnetizing force	H	$H = \frac{B}{\mu}$
Permeability	μ	$\mu = \frac{B}{H}$
Frequency	f	
Angular frequency	ω	$\omega = 2\pi f$
Reactance	X	
Reactance (of a capacitor)	X_C	$X_C = \frac{1}{\omega C}$
Reactance (of an inductor)	X_L	$X_L = \omega L$
Impedance (of a circuit containing resistance and reactance)	Z	$Z = \sqrt{R^2 + X^2}$

TABLE IV: PREFIXES

Prefix	Letter symbol	Interpretation	Example
Mega or meg	M	Millions of	1 megohm = 10^6 ohms
Kilo	k	Thousands of	1 kilocycle per second = 10^3 cycles per second
Deci	d	Tenths of	1 decibel = 10^{-1} bel
Milli	m	Thousandths of	1 milliamp = 10^{-3} amp
Micro	μ	Millionths of	1 microfarad = 10^{-6} farad
Pico or micro-micro	p or $\mu\mu$	Million-millionths of	1 pico-farad 1 micro-microfarad } = 10^{-12} farad

TABLE V: ABBREVIATIONS SOMETIMES USED IN TABLES, TEXT AND DIAGRAMS

A = Ampere
A, or AE = Aerial
A battery = Low-tension battery (American)
AC = Alternating current
AC-DC = All mains
Acc = Accumulator
AF = Audio frequency
AFC = Automatic frequency control
AG = Auxiliary grid
Ah = Ampere-hour
Amps = Amperes
AM = Amplitude modulation
AT = Ampere-turn
AVC = Automatic volume control

B = Magnetic flux density, or Press button
B battery = High-tension battery (American)
B/D, or Brd = Braided wire
BF = Beat frequency
B and S = Brown and Sharpe gauge
Batt = Battery
BT = Bellini-Tosi system of direction finding
BWG = Birmingham wire gauge

C = Capacitance, capacitor, or coulomb
C battery = Grid-bias battery (American)
CB = Circuit-breaker
Cm = Centimetre. Used on Continental capacitors to indicate capacitance. 1 cm = 1·1 μμF
Cp = Counterpoise
cps, or c/s = Cycles per second
CR = Cathode ray
CW = Continuous wave

D = Electric flux density
dB = Decibel
DC = Direct current
DCC = Double cotton-covered wire
Det = Detector
DF = Direction finding
DIR = Double rubber-covered wire
DPC = Double paper-covered wire
DPR = Double-lapped pure rubber-covered wire
DSC = Double silk-covered wire
DX = Distant (reception)

E = Earth, or electro-motive force
EHT = Extra-high tension
EM = Electromagnetic
EMF = Electromotive force
Enam = Enamelled wire
ES, or EX = Extension speaker

f = Frequency
F = Farad, or fuse, or magnetomotive force
FC = Frequency-changer valve
FM = Frequency modulation
ω = Frequency × 2π

G = Generator, or grid, or conductance
GB = Grid bias

H = Henry, or magnetizing force
HC = High-conductivity wire
HD = Hard-drawn copper

TABLE V—*continued*

Het = Heterodyne
HF = High frequency
HMT = Hand micro-telephone
HT = High tension

I = Current
IC = Intercommunication
ICW = Interrupted continuous wave
IF = Intermediate frequency
IFT = Intermediate frequency transformer
Int = Interrupter

J = Jack

K = Permittivity (relative), or Morse key
Kc/s = Kilocycles per second
kVA = Kilovolt amperes
kW = Kilowatt
kWh = Kilowatt-hours

λ = Wavelength
L = Inductance, or inductor
La = Lamp
Lam = Laminated
LF = Low (audio) frequency
LS = Loudspeaker
LT = Low tension
LW = Long wave

M = Meter, or mutual inductance
m = Metre
MA = Mains aerial
mA = Milliamperes
mA/V = Milliamperes per volt
Mc/s = Megacycles per second
MC = Moving coil
MCW = Modulated continuous wave
meg = Megohm
MF = Medium frequency
mFd, or μF = Microfarad
MG = Motor generator
μH = Microhenry
Mic = Microphone
mmFd, or μμF = Micro-microfarad
MO = Master oscillator
mH = Millihenry
μ = Permeability, or amplification factor
mV = Millivolt
MW = Medium wave
N = Neon tube
Ω = Ohm
Osc = Oscillator

P = Padding condenser, or plug
PA = Public address
PB = Pushbutton
PC = Photo-electric cell
Pen = Pentode
pF = Pico-farad (one mmFd)
Φ = Magnetic flux
PL = Lamp signal, or pilot lamp
PM = Permanent magnet
Pot = Potentiometer
PU = Pick-up
PUC = Polyvinyl chloride (plastic) covered cable

QPP = Quiescent push-pull

R = Resistance, or resistor
RC = Remote control
RCC = Resistance-capacitance coupled
Rec = Rectifier, or receiver
Rel = Relay
RF = Radio frequency
RT = Radio-telephony

S, or Sw = Switch
SCC = Single cotton-covered wire
SD = Soft drawn copper wire

TABLE V—*continued*

SG = Screen grid
S/het = Superheterodyne receiver
SIR = Wire with single rubber lapping
Spk = Loudspeaker
SR = Starting relay
SSC = Single silk-covered wire
SW = Short wave
SWC = Single white silk-covered wire
SWG = Standard wire gauge
Sync = Synchronizing

T = Trimming condenser, transformer, transmitter
TCC = Triple cotton-covered wire
Tel = Telephone
TI = Tuning indicator
TPC = Triple paper-covered wire
TR = Transmitter-receiver
Trans = Transformer

TRF = Tuned radio-frequency

USW = Ultra-short wave

V = Potential difference, volt, valve
VA = Volt-ampere
VF = Video frequency
Vib = Vibrator
VIR = Vulcanized india-rubber cable
Vol = Volume control

W = Power, or watt; rectifier
W/C = Wave-change switch
Wh = Watt-hour
WT = Wireless telegraphy

X = Reactance, or crystal
X's = Atmospherics

Z = Impedance

RADIATION OF WAVES

An aerial is a structure capable of radiating waves when it is successively charged, this way and then that, which process results in alternating currents flowing in the aerial.

The relationship between the length of the wave radiated from the aerial and the frequency of the currents flowing in the aerial is that the product of these two quantities is equal to a constant; therefore, the higher the frequency of the currents causing waves to be radiated, the shorter the length of the wave. If the waves are radiated into space, then the product of the frequency of the aerial currents, expressed as cycles per second, and the length of waves in centimetres, is very nearly equal to 3×10^{10} cms per sec., which is the assumed velocity of light. This velocity is approximately 186,000 miles per sec.

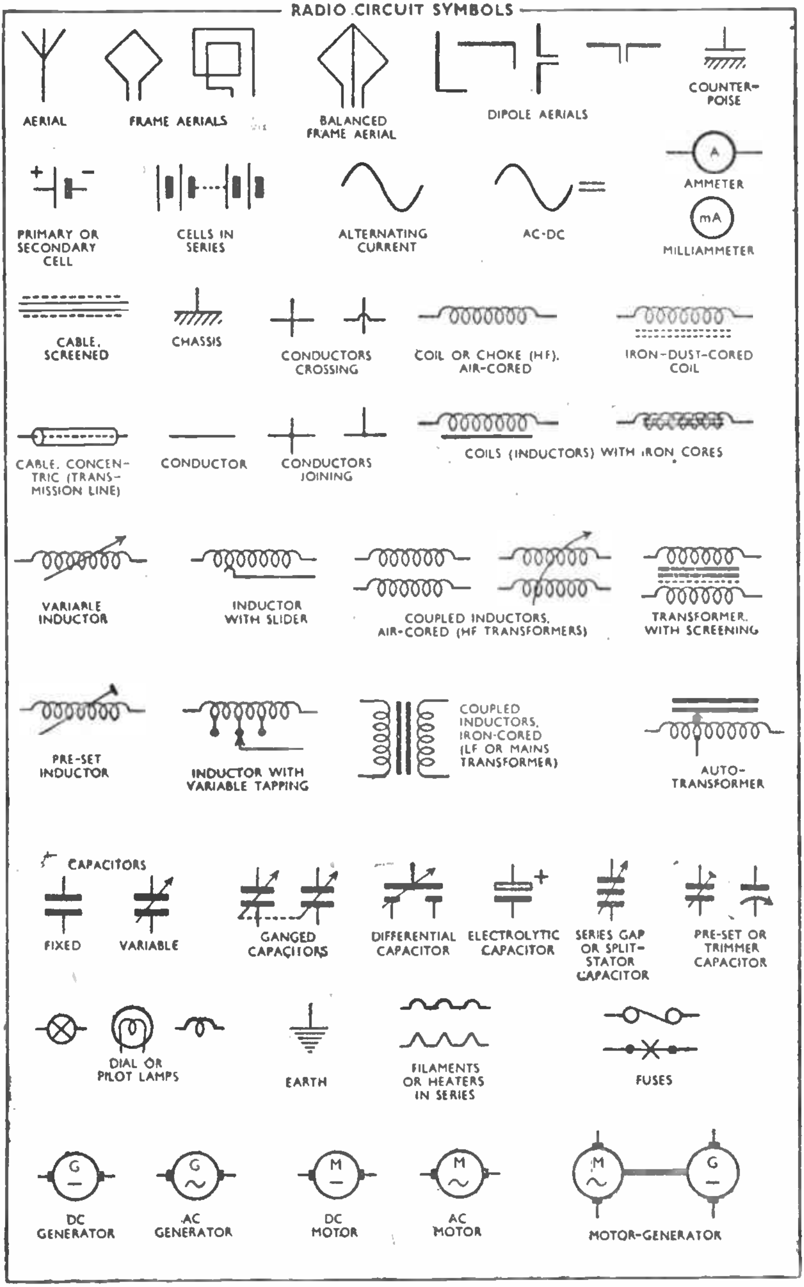
Waves are classified both as to their length and, as it is called, their frequency, meaning basically the frequency of the alternating currents flowing in the sending aerial.

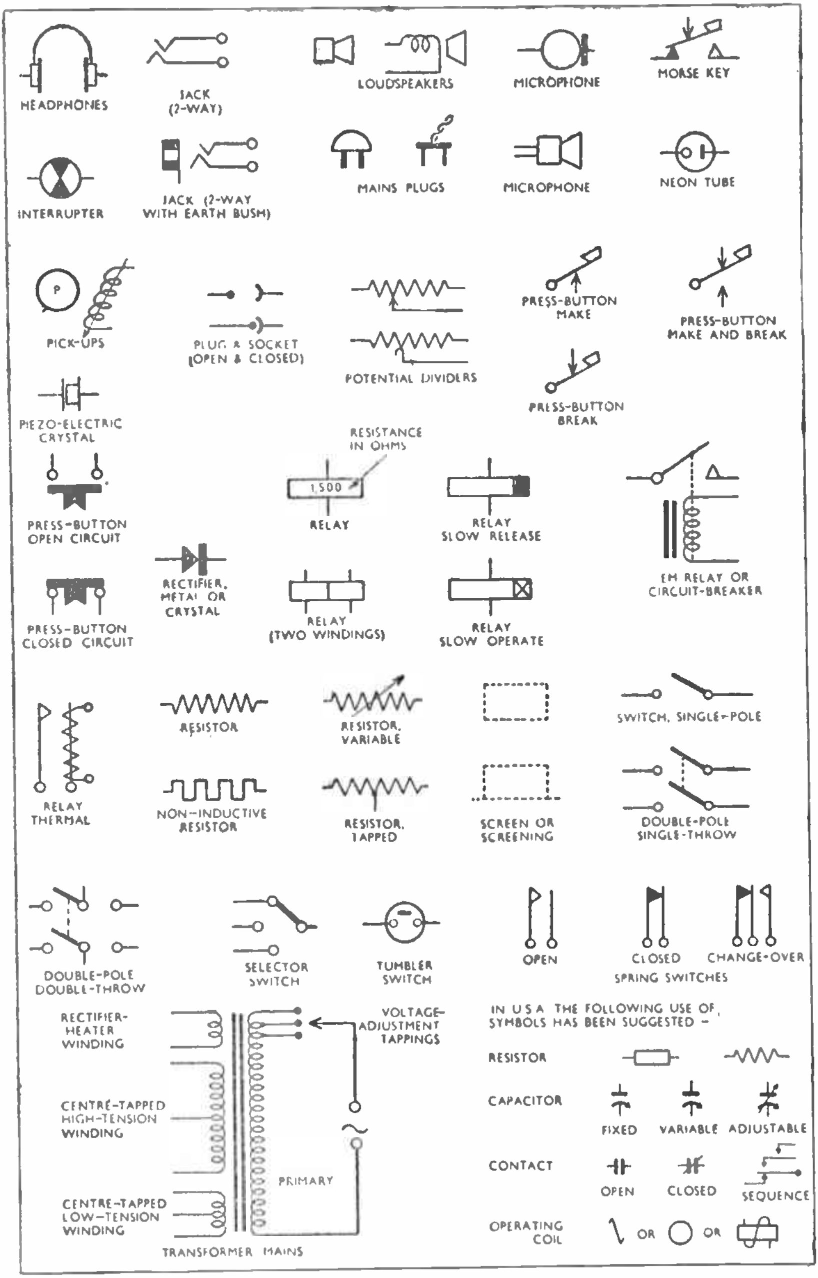
Some qualitative descriptions are attempted, such as short waves, long waves, ultra-short waves, and so forth. (See Fig. 2.)

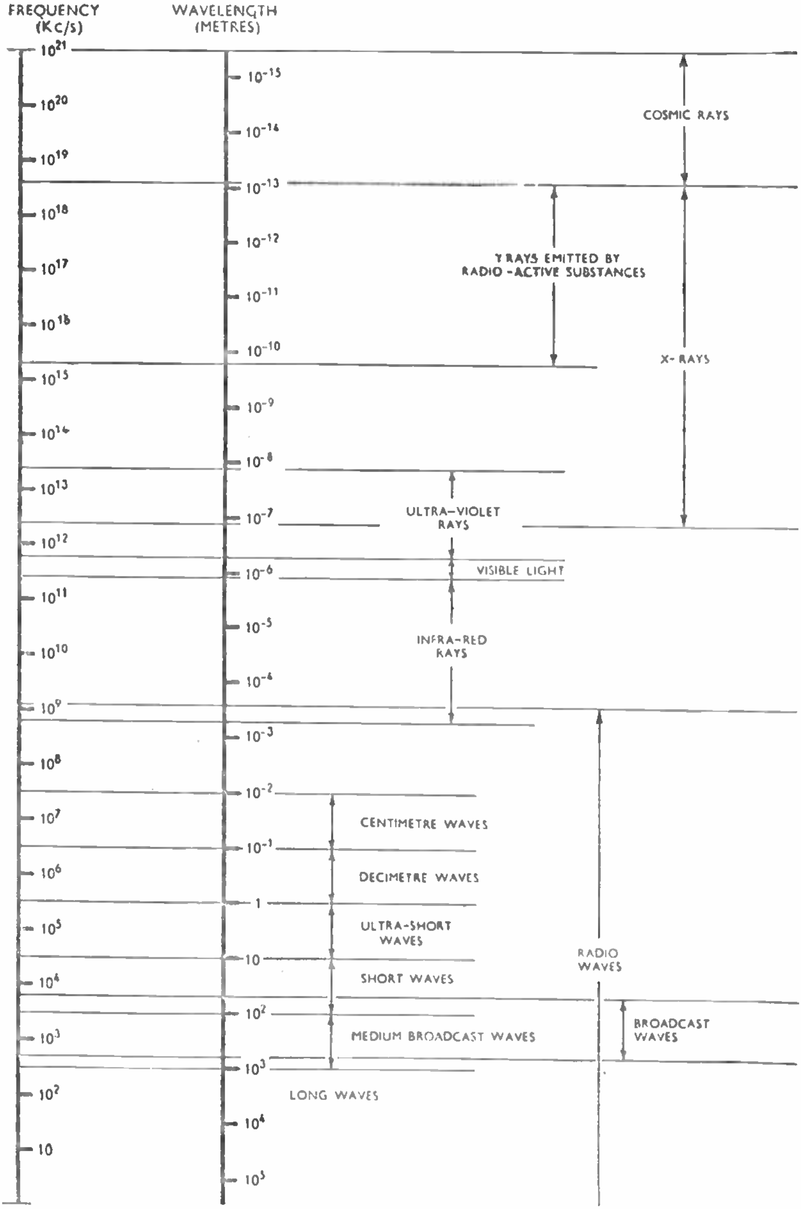
The British Standards Institution publishes information, set out in tabular form on page 26, which attempts to standardize usage.

Note that the product of wavelength in metres and frequency in kilocycles per second is the number 300,000, but also note that this

RADIO CIRCUIT SYMBOLS




HEADPHONES
JACK (2-WAY)
LOUDSPEAKERS
MICROPHONE
MORSE KEY
INTERRUPTER
JACK (2-WAY WITH EARTH BUSH)
MAINS PLUGS
MICROPHONE
NEON TUBE
P
PICK-UPS
PLUG & SOCKET (OPEN & CLOSED)
POTENTIAL DIVIDERS
PRESS-BUTTON MAKE
PRESS-BUTTON MAKE AND BREAK
PRESS-BUTTON BREAK
PIEZO-ELECTRIC CRYSTAL
RESISTANCE IN OHMS
1,500
RELAY
RELAY SLOW RELEASE
EM RELAY OR CIRCUIT-BREAKER
PRESS-BUTTON OPEN CIRCUIT
RECTIFIER, METAL OR CRYSTAL
RELAY (TWO WINDINGS)
RELAY SLOW OPERATE
PRESS-BUTTON CLOSED CIRCUIT
RESISTOR
RESISTOR, VARIABLE
SWITCH, SINGLE-POLE
RELAY THERMAL
NON-INDUCTIVE RESISTOR
RESISTOR, TAPPED
SCREEN OR SCREENING
DOUBLE-POLE SINGLE-THROW
DOUBLE-POLE DOUBLE-THROW
SELECTOR SWITCH
TUMBLER SWITCH
OPEN
CLOSED
CHANGE-OVER
SPRING SWITCHES
RECTIFIER-HEATER WINDING
VOLTAGE-ADJUSTMENT TAPPINGS
CENTRE-TAPPED HIGH-TENSION WINDING
PRIMARY
CENTRE-TAPPED LOW-TENSION WINDING
TRANSFORMER MAINS
IN U.S.A. THE FOLLOWING USE OF SYMBOLS HAS BEEN SUGGESTED –
RESISTOR
CAPACITOR
FIXED
VARIABLE
ADJUSTABLE
CONTACT
OPEN
CLOSED
SEQUENCE
OPERATING COIL
OR
OR



ELECTROMAGNETIC WAVE SPECTRUM

Fig. 2. Depending on frequency and wavelength, ether waves have many different characteristics and uses, and these are clearly explained in this layout and text.

SECTION 3

SERIES AND PARALLEL CONNECTIONS

Resistors in series. The total resistance of any number of resistors connected in series, and having various values of resistance, is the sum of the values of all the resistances. Thus, in Fig. 3,

$$R = R_1 + R_2 + R_3.$$

Resistors in parallel. The total conductance of any number of resistors connected in parallel and having various values of resistance is the sum of the conductances of all the resistors so connected. Thus, in Fig. 4,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

This gives R.

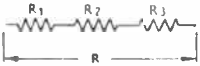


Fig. 3. (Above) Three resistors in series.

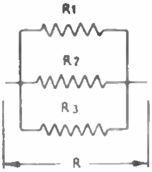


Fig. 4. (Right) Three resistors in parallel.

Resistance networks. The total resistance of some forms of resistance networks can be found by calculating the resistance of groups of resistors forming the network, until the network is resolved into the simplest form containing what are effectively a number of single resistors in series or one resistor. This method cannot be used in all cases (e.g. certain bridges), and the use of Kirchhoff's laws is then convenient.

Numerical examples. The *series connection* of resistors of value 10,000 ohms, 35,000 ohms, and 50,000 ohms is 95,000 ohms. The *parallel connection* of resistors of 10,000 ohms, 50,000 ohms, and 100,000 ohms gives a conductance of

$$\frac{1}{10{,}000} + \frac{1}{50{,}000} + \frac{1}{100{,}000} = 1 \times 10^{-4} + 0{\cdot}2 \times 10^{-4} + 0{\cdot}1 \times 10^{-4} = 1{\cdot}3 \times 10^{-4}$$

mhos, or $\frac{1}{1{\cdot}3} \times 10^{4}$ ohms, or 7,692 ohms, using four significant figures.

The resistance of the network of Fig. 5 is given by first adding the values of the resistors which are in series in each arm and so deriving Fig. 6. It is then possible to add the conductances $\frac{1}{50{,}000}$, $\frac{1}{200{,}000}$ and $\frac{1}{25{,}000}$ to make a resistance of 15,380 (four significant figures), which is added to 200,000 to make 215,400 ohms (four significant figures).

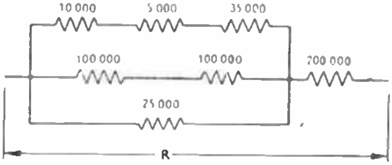


Fig. 5. A network of resistors consisting of both series and parallel arrangements.

Laborious calculation gives 215,384·6 ohms, and if the figure were thus written the implication would be that the resistances themselves could be measured to one part in ten million. This is, of course, quite impracticable, in ordinary everyday work, and even if it were feasible with the finest instruments to measure to this accuracy the resistors would, unless of very special construction and kept in constant conditions, never maintain a value deserving such close measurement.

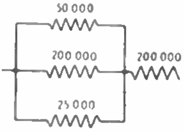


Fig. 6. What is the total resistance ?

Inductors in series. The total inductance of a number of inductors connected in series and having various values (it being assumed that the inductors are not coupled to one another to add or subtract mutual inductance) is the sum of the inductances of all the inductors so connected. In Fig. 7,

$$L = L_1 + L_2 + L_3.$$

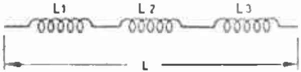


Fig. 7. Three inductors in series.

Inductors in parallel. There is no term relative either to inductance or capacitance to describe the reciprocals of these quantities, and so we must say that the reciprocal of the total inductance of a number of inductors in parallel is the sum of the reciprocals of the several inductances so connected, or, as in Fig. 8,

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}.$$

This gives L.

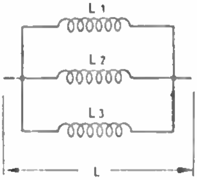


Fig. 8. Three inductors in parallel.

Inductors are treated as resistors; when in series their values are added, when in parallel the reciprocal of the total inductance is given by the sum of the reciprocals of the individual inductors.

Capacitors in parallel. The total capacitance of a number of capacitors in parallel is the sum of the capacitances of all the capacitors, or, as in Fig. 9,

$$C = C_1 + C_2 + C_3.$$

Capacitors in series. The reciprocal of the total capacitance of a number of capacitors in series is the sum of the reciprocals of all the capacitors so connected. Thus, in Fig. 10,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3},$$

which gives C.

No good object is served by giving numerical examples concerning inductors, since the treatment is exactly the same as for resistors, but, so as to make the principles clear, we may consider, without using numerical values, how to calculate the total capacitance of the combination shown in Fig. 11.

First, we should tackle that part of the network containing C_1, C_2 and C_3. The capacitance of C_1 and C_2 in series, which we might call C_a, would be given by $\frac{1}{C_a} = \frac{1}{C_1} + \frac{1}{C_2}$. Having got C_a, we add it to the (parallel) value of C_3. Let C_a and $C_3 = C_b$. Then the total capacitance C of the combination is given by $\frac{1}{C} = \frac{1}{C_b} + \frac{1}{C_4}$. This gives C. If this process were done algebraically, the value of C would be,

$$C = \frac{C_4\ [C_1C_2 + C_3\ (C_1 + C_2)]}{C_1C_2 + (C_3 + C_4)\ (C_1 + C_2)}.$$

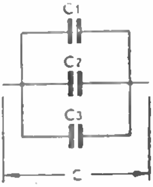


Fig. 9 (Left). Three capacitors in parallel.

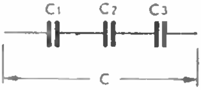


Fig. 10 (Above) Three capacitors in series.

If only the numerical value of the combination is required, it is best to work out each step arithmetically. Note that $\frac{1}{C_1} + \frac{1}{C_2} = \frac{C_1 + C_2}{C_1C_2}$, or that $\frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1R_2}$, showing that the total value of two capacitors in series, of value C_1 and C_2, or two resistors in parallel, of value R_1 and R_2, or two inductors in parallel, of value L_1 and L_2, are, respectively,

$$C = \frac{C_1C_2}{C_1 + C_2};\ R = \frac{R_1\ R_2}{R_1 + R_2};$$

$$L = \frac{L_1L_2}{L_1 + L_2}.$$

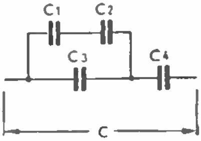


Fig. 11. How is the total capacitance calculated?

SECTION 4

EXPLANATION OF ABACS

THE abacs on the following pages enable various quantities to be ascertained simply by the use of a ruler or straight-edge, preferably of the transparent variety. In most instances, three related quantities are represented by three scales. When any two are known, the third can be ascertained as follows: Lay the straight-edge so that it passes through the appropriate points on the scales representing the known quantities. The third quantity can then be read off on the third scale.

When the scales do not extend to the values required, it is sometimes possible to multiply or divide the quantities and bring them within the ranges. Figs. 12-17 give certain useful abacs.

The abacs can be read with sufficient accuracy for most practical purposes, but where greater precision is necessary, answers should be calculated from the formulæ.

Resistors in parallel, Capacitors in series. The chart of reciprocals (Fig. 12) simplifies the calculation of the effective value of resistors in series, and capacitors in parallel.

The formula giving the total resistance R of a number of resistors in parallel is:

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

The value of $\frac{1}{R}$, and so on, is a reciprocal, and can be read from the chart.

For example, what is the total resistance value when resistors of 20, 15, and 9 ohms are connected in parallel?

The reciprocals are ·05, ·067 and ·11 respectively. Their sum is ·227, and this is the reciprocal of 4·4, which gives R as 4·4 ohms.

Similarly, the formula for capacitors in series is:

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

where C is the total capacitance of three capacitors, C_1, C_2 and C_3, in series. Therefore, if capacitors of ·01 mFd and ·03 mFd are in series, their total capacitance is: Reciprocals 100 and $33{\cdot}\dot{3} = 133{\cdot}\dot{3}$. $133{\cdot}\dot{3}$ is the reciprocal of ·0075, so that $C = {\cdot}0075$ mFd.

Note that, in this case, to find the reciprocal of $133{\cdot}\dot{3}$, the whole number side of the chart (right-hand side) is extended by 'multiplying' by 10 and the reciprocals are 'divided' by 10.

Therefore, 13·33 on the chart is read as 133·3, and ·75 on the chart is read as ·0075.

Abac 1. This chart relates inductance, capacitance and wavelength for parallel- and series-tuned circuits. Place a rule through two known values and read the third on the remaining scale. Range may be extended by multiplying inductance, capacitance and wavelength, but *not* frequency, simultaneously by the same factor.

Examples: (A) What inductance is tuned by ·0005 mFd to 600 m? The answer is, as read on the abac, 200 mH. (B) With this coil tuned by 30 mmFd, what is the wavelength? The answer is 140 m.

Fig. 12. Short cut for calculating resistors in parallel and capacitors in series.

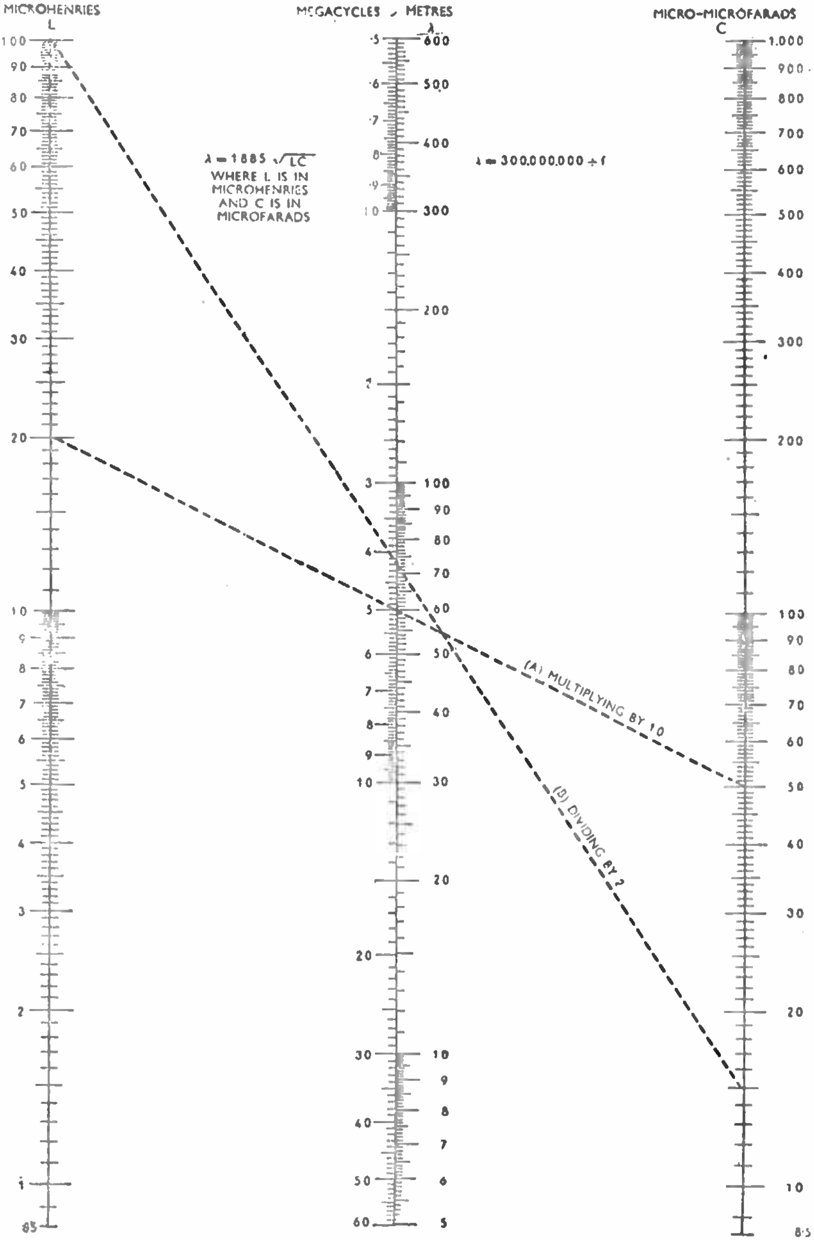


Fig. 13. ABAC I: INDUCTANCE, CAPACITANCE, FREQUENCY, WAVELENGTH

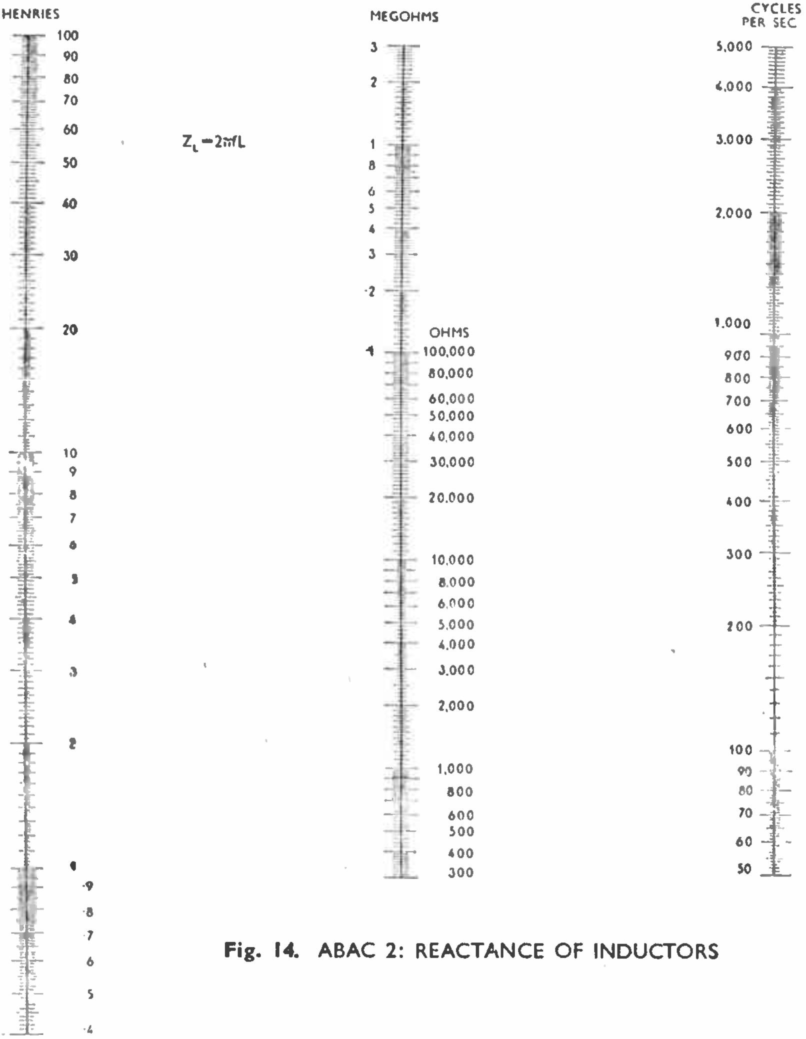


Fig. 14. ABAC 2: REACTANCE OF INDUCTORS

Abac 1 also provides a wavelength-frequency conversion scale. Read one side of the centre scale against the other side. To extend, divide one side and multiply the other side by the same factor.

Example: A frequency of 450 Kc/s (·45 Mc) corresponds to a wavelength of 666 m. (Divide frequency scale, multiply wavelength.)

Abac 2. As drawn, the scales are for low frequencies. For high frequencies, read henries as microhenries, cycles as kilocycles and divide ohms by 1,000. Other extensions are simple, because inductive reactance is proportional to frequency and inductance, e.g., doubling frequency doubles inductive reactance, doubling inductance

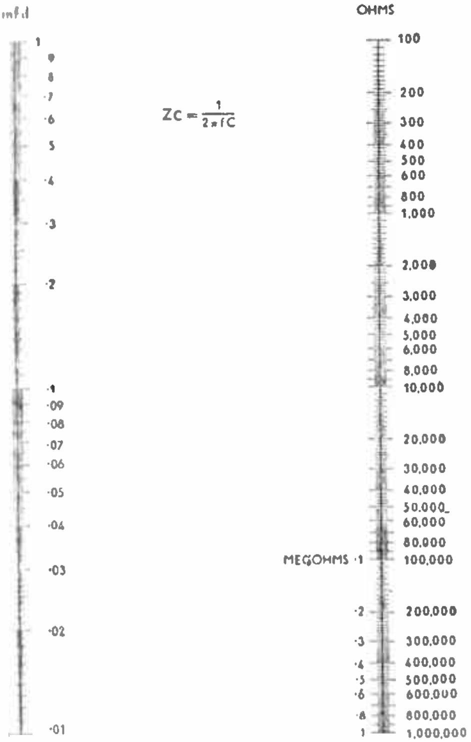


Fig. 15. ABAC 3: REACTANCE OF CAPACITORS

doubles the inductive reactance.

Abac 3. As drawn, the scales are for low frequencies. For high frequencies, read cycles as kilocycles, and divide ohms readings by 1,000; alternatively, read cycles as kilocycles and divide capacitance readings by 1,000. Other extensions are simple, because capacitive reactance is inversely proportional to frequency and to capacitance, e.g., doubling the frequency halves the reactance, doubling the capacitance halves the reactance.

Abac 4. For larger currents, the milliampere scale can be read as amperes, and then either volts must be multiplied by 1,000 or, alternatively, ohms divided by 1,000.

Abac 5. If the volts scale be divided by 1,000 (making it read millivolts), the watts scale must be divided by 1,000 (making it read milliwatts). Similarly, if the amperes scale be divided by 1,000 (making it read milliamps), the watts scale must be divided by 1,000 (making it again read milliwatts). If both volts and amperes scales be divided by 1,000 (making them read millivolts and milliamps) the answer on the watts scale is in microwatts (e.g. 1 volt multiplied by $\frac{10}{1,000} = 10^{-2}$ amps $=$ 10 milliamps, makes 10 milliwatts $=$ 10,000 microwatts, which is the scale reading on the abac for these).

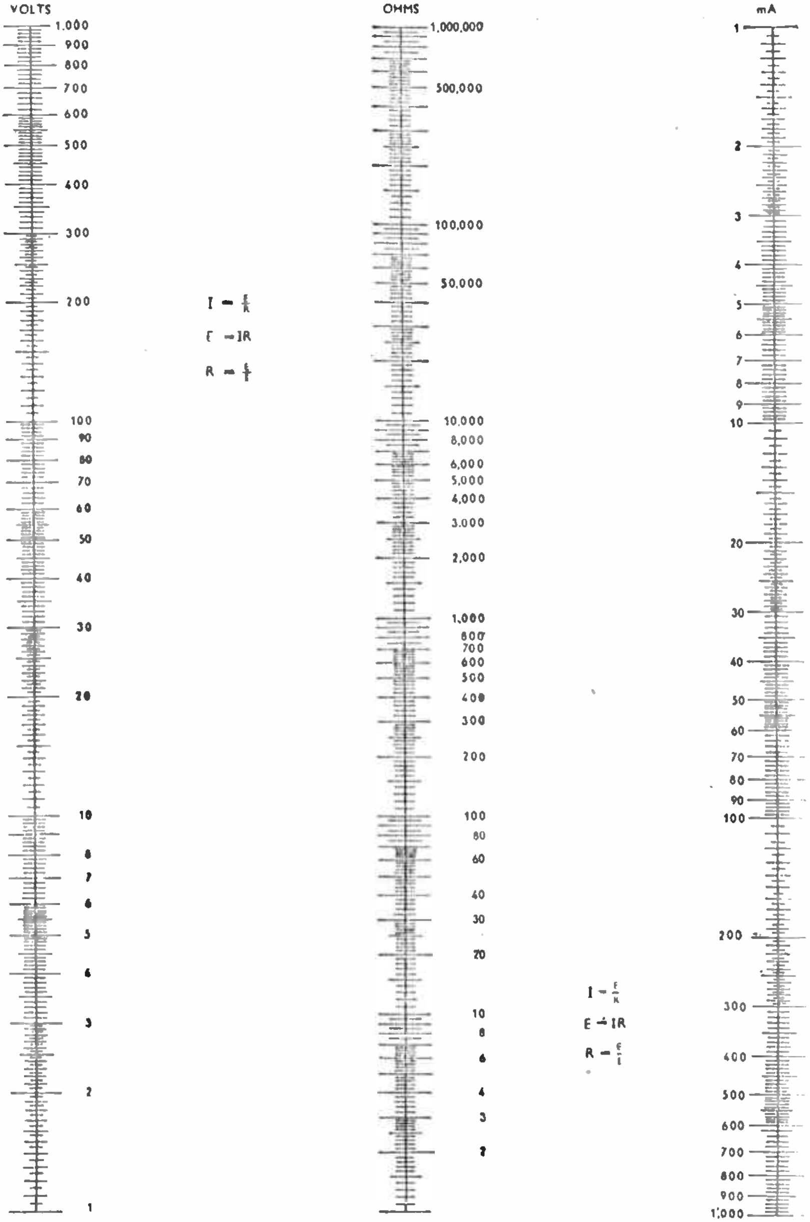


Fig. 16. ABAC 4: OHM'S LAW—VOLTS, OHMS, AMPERES

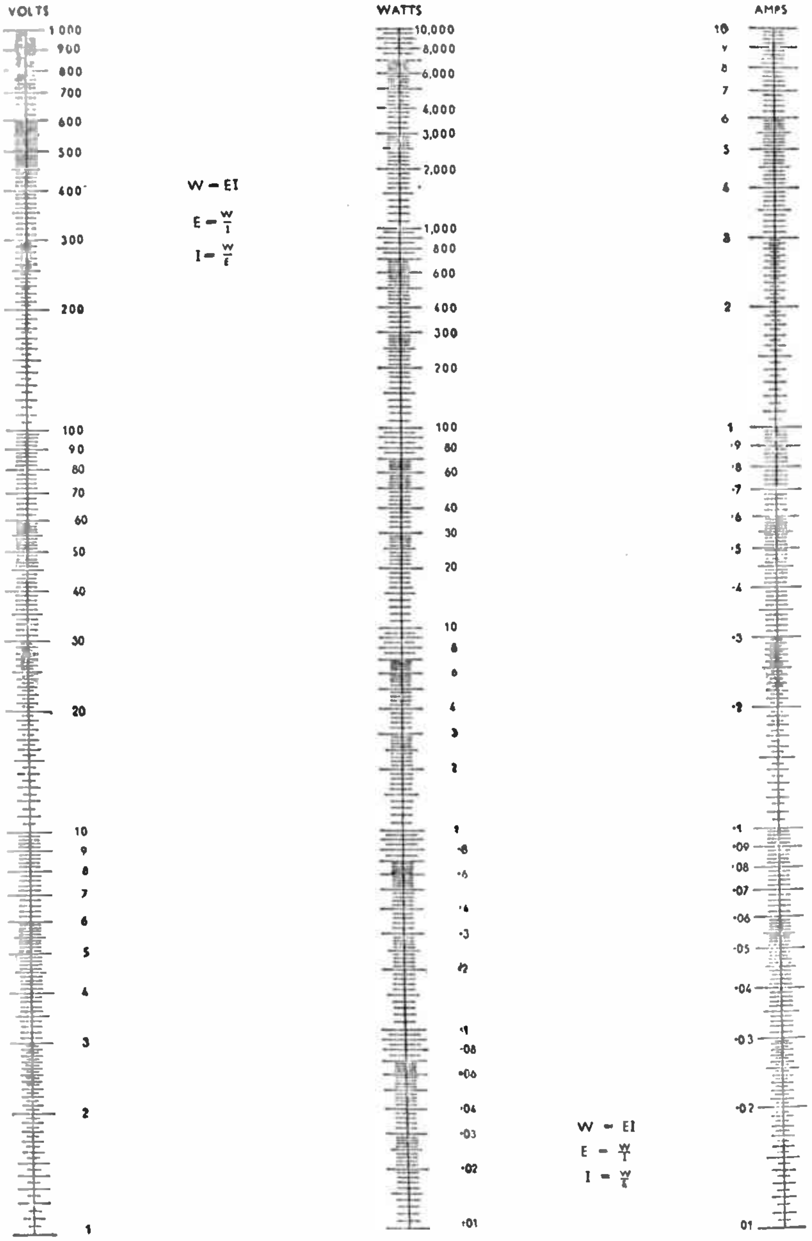


Fig. 17. ABAC 5: POWER—VOLTS, WATTS, AMPERES

1,500 rotations per second, then if $t = \frac{1}{3,000}$th second, the angle swept through by the vector in this time would be $2\pi 1,500 \times \frac{1}{3,000} = \pi$ radians $= 180°$.

If $t = 1{\cdot}5$ sec., the angle swept through would be $2\pi\ 1,500 \times 1{\cdot}5$, or about 14,200 radians.

If we cared to express the angles in degrees, we could say that the angular velocity was $360°f$ and the angle rotated through in t seconds would be, in degrees, $360°ft$, and if f were fifteen times a second and t were $\frac{1}{7}$th second, the angle swept through would be $\frac{360 \times 15}{7}$, about 771°, or about eight right angles and 50°, i.e., twice right round and 50° more.

Cycles per Second

From all this it is clear that, if we go back to radian measure of angles, then the function of the wavy curve to the right of Fig. 18 is given by $y = OP_1 \sin \omega t$, where y is the instantaneous intensity, measured above or below the horizontal line, as delineated by the curve, and t is time plotted uniformly along the horizontal, while $\omega = 2\pi f$, where f is the frequency of rotation of the vector. Since f is the frequency of rotation of the vector, it is, therefore, the number of complete cycles of variation of the sine curve in a second. This means that f is the frequency, expressed in cycles per second, of the alternation.

If the sine curve represents an alternating voltage, the peak value of which is $E_{\max}$ and if E is the intensity of this voltage at any time t, then $E = E_{\max} \sin \omega t$, and expressed in terms of an alternating current I, of peak value $I_{\max}$, $I = I_{\max} \sin \omega t$.

The expression ωt represents an angle. Tables are published giving the sines of angles. From these, and from a study of Fig. 18, it is clear, or can be shown, that $\sin 0° = 0$, $\sin 45° = \frac{1}{\sqrt{2}} = 0{\cdot}707$, $\sin 90° = 1$, $\sin 135° = {\cdot}707$, $\sin 180° = 0$, $\sin 225° = -{\cdot}707$, $\sin 270° = -1$, $\sin 315° = -{\cdot}707$ and $\sin 360° = 0$ again.

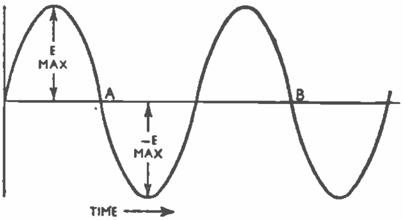


Fig. 19. Sine curve showing variation of a voltage with time.

Also, $\sin 30° = \frac{1}{2} = \sin 150°$ and $\sin 210° = -\frac{1}{2} = \sin 330°$, and these figures indicate the function of the curve, provided we know $\omega = 2\pi f$ and t the time. Note, as in Fig. 19, shown as an alternating voltage obeying a sine law, that $E_{\max}$ has the same magnitude as $-E_{\max}$, because $\sin 90° = 1$ and $\sin 270° = -1$.

Consider now Fig. 20, which represents an ideal alternator. An alternator is a machine for producing an alternating EMF and hence an alternating current in a circuit. A uniform magnetic field, shown by the horizontal lines between N and S, these being the poles of a magnet system, is formed in a cylindrical space between the magnets. The dots, labelled a and c, are supposed to be conductors having their lengths extended at right angles to the surface of the paper.

Induced EMF

Suppose these conductors are secured in an armature, free to rotate about an axis passing through O at right angles to the paper. As this armature rotates, the conductors move so that a comes to b and c to d. Suppose the armature rotates at a uniform angular velocity $2\pi f$. As it rotates, so the conductors cut the magnetic lines and an EMF is voltage must be expressed in terms of a vector addition, not an arithmetical addition, since X_LI and RI are voltages 90° out of phase.

The triangle on the right of Fig. 23 shows the vectors of length proportional to R and length proportional to X_L at right angles to one another producing a resultant proportional to Z in the sketch. From our knowledge of the relationships between the lengths of the sides of a right-angle triangle, we get, $Z_L = \sqrt{R^2 + X_L^2}$.

Using the same principles (Fig. 25), we get $Z_C = \sqrt{R^2 + X_C^2}$, where X_C is the reactance of the capacitor of capacitance C.

Since the back-EMF's X_LI_{max} and X_CI_{max} are 180° out of phase, then for Fig. 26 we get, $Z_S = \sqrt{R^2 + (X_L - X_C)^2}$.

The letter Z denotes what is called an *impedance*, and it is the back-EMF ZI which acts to limit the value of the current.

We may thus write, as a generality for all the circuits shown in Figs. 23, 24 and 25, $I = \frac{E}{Z}$, where I and E are R.M.S. values of current and voltage and $Z = \sqrt{R^2 + X^2}$.

X is $X_L = \omega L$ in Fig. 23, $X_C = \frac{1}{\omega C}$ in Fig. 24, and $X_S = (X_L - X_C)$ in Fig. 25.

Power Factor. The statement has been made that when an alternating current flows in a resistance connected to a source of alternating current having internal resistance, then the same relationships between E, I, and R exist as for DC, provided E and I are expressed in R.M.S. values.

When the circuit connected across an alternating current source contains resistance and reactance, then the power in the circuit is not obtained by a simple multiplication of voltage and current, because voltage and current are not in phase. The multiplication of R.M.S. volts and R.M.S. amps gives the volt-amperes acting, but the power is $EI \cos \varphi$, where φ is the phase angle between volts and amperes. If the circuit is purely reactive, $\varphi = 90^\circ = \frac{\pi}{2}$ radians and $\cos \varphi = 0$, so $EI \cos \varphi = 0$ and no power is developed in a pure reactance.

If the circuit is purely resistive, $\varphi = 0$ $\cos \varphi = 1$, and the power is EI = volt-amps. The power factor, so called, is the ratio of watts to volt-amps, and in the case of sine functions it is equal to $\cos \varphi$.

Vector Algebra. In order to revise what has gone before, Fig. 26 once more underlines the basic principles for deriving a sine curve; the vector OP rotates at a uniform angular velocity and the instantaneous value of PQ is plotted against time to the right of the diagram. Now, consider Fig. 27, in which two sinusoids, derived from the rotating vectors OP_1 and OP_2, both rotating at the same angular velocity, are plotted as shown.

What is the resultant curve?

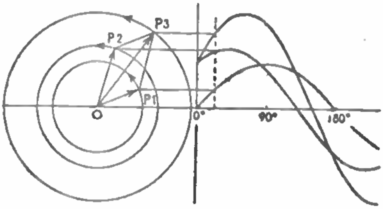


Fig. 27. Result of addition of sine curves shown by vector addition.

This could be found without further recourse to vectors by adding and subtracting the vertical heights of the two sine curves and so getting the third.

But the resultant vector obtained by the vector addition of OP_1 and OP_2 gives OP_3, and the resulting curve, derived from OP_3, is also a sinusoid as shown. It has the same frequency as those derived from

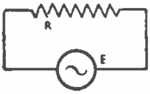


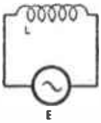
Fig. 28. Alternating voltage applied to resistance.

OP_1 and OP_2, which are also of equal frequency.

Going back over past ground, but giving vector representation of the voltages and currents, we see in Fig. 28 and Fig. 29 this representation where current and voltage are in phase in a pure resistance and where pure arithmetic addition gives the resultant.

Fig. 29. Voltage and current vectors in phase.

In Figs. 30, 31, 32 and 33 it is seen that the quantities involved cannot be added arithmetically because vector quantities, having both magnitude and direction, are involved. Note, comparing Figs. 31 and 33, the 180° relationship between the reactance voltages obtained from inductor and capacitor. Fig. 35, being the vector diagram applicable to Fig. 34, shows the resultant of adding the vector quantities ωLI and RI and the same process in Fig. 37 applicable to Fig. 36.



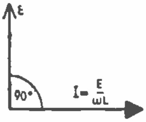
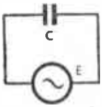


Fig. 30. (Left) Alternating voltage applied to inductance. **Fig. 31.** (Right) Voltage vector leading current vector by 90°.

Consider the three vectors E, jE and $j\ (jE)$ of Fig. 38. It would be legitimate to say that the vector addition of the two vectors E and that labelled $j\ (jE)$ could be an arithmetical one, namely, $E - E$.



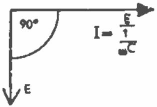


Fig. 32. (Left) Alternating voltage applied to capacitance. **Fig. 33.** (Right) Voltage vector lagging current by 90°.

Thus, if $j \times j = -1$, then j^2 means an operator turning a vector through two right angles in an anti-clockwise direction. If j^2 turns a vector through two right angles in an anti-clockwise direction, then legitimately the operator j turns the vector through one right angle in an anti-clockwise direction. Logically, $j = \sqrt{-1}$.

Using the Operator

Since no number exists which, multiplied by itself, equals -1, the letter j is called an imaginary; it is, in fact, not a quantity, but an operator. It gives the instruction, when written jE, to turn the vector of magnitude E through one right angle in an anti-clockwise direction.

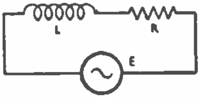


Fig. 34. Alternating voltage applied to combination of resistance and inductance in series.

Fig. 39 illustrates the conclusion that $-j$ as a multiplier means turn through one right angle in a clockwise direction. Thus, $a + jb$ means add together two vectors of length a and b, the vector b is considered to be horizontal and pointing to the right and vector a considered to be vertical and pointing upwards. The magnitude of the resultant must be, from our knowledge of the relationships of a right-angled triangle, $\sqrt{a^2 + b^2}$.

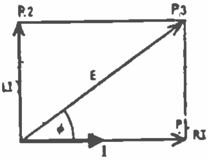


Fig. 35. Voltage and current phase difference is less than 90°.

$a - jb$ is only different from $a + jb$ in that the vector b is vertical but

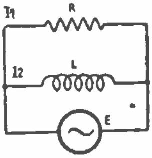


Fig. 36. Alternating voltage applied to resistance and inductance in parallel.

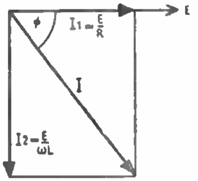


Fig. 37. (Left) Current lags voltage by less than 90°.

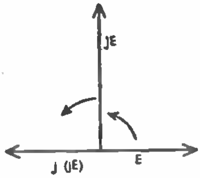


Fig. 38. (Right) Operator *j* turns a vector through 90 degrees in an anti-clockwise direction.

pointing downwards, while the magnitude (not the direction) of the resultant is $\sqrt{a^2 + b^2}$.

All vectors with *j* before them can be added arithmetically, because they all have the same direction.

Thus, $a + jb - jc - jd + je = a + j(b + e - c - d)$, and the resultant is $\sqrt{a^2 + \{(b + e) - (c + d)\}^2}$.

All vectors not having *j* in front can be added arithmetically. $a + b + c - d - e + jf$ has a resultant $\sqrt{\{(a + b + c) - (d + e)\}^2 + f^2}$.

Applying this to previous analyses, currents and voltages can be expressed in terms of *j* and reactances. In Fig. 40, a vector diagram applicable to a voltage acting on an inductor, we can write $I = -j\frac{E}{\omega L}$, or multiplying top and bottom of the ratio $\frac{E}{\omega L}$ by $+j$, as $I = \frac{-j^2E}{+j\omega L} = \frac{-(\sqrt{-1})\ (\sqrt{-1})\,E}{j\omega L} = \frac{E}{j\omega L}$.

Similarly, in Fig. 41, we can derive $I = j\omega CE = \frac{E}{\frac{1}{j\omega C}}$, where $\frac{1}{j\omega C}$ is the capacitive reactance, as was $j\omega L$ previously the inductive reactance.

Fig. 39 (Left) and **Fig. 40** (Right) show phase relations in an inductor.

In Fig. 42, two vectors, which might represent voltages *RI* and *XI*, are shown, using the operator *j*, as *R* and *jX*, and the resultant is $R + jX$, which can be expressed as a magnitude $\sqrt{R^2 + X^2}$, according to previous conclusions.

Other Uses

Another valuable use of the *j* nomenclature is that the value of the angle φ in Fig. 42 can be obtained by writing $\tan \varphi = \frac{jX}{R}$, where tan φ means the tangent of the angle φ, being the vertical side of the right-angle triangle divided by its base. The phase angle of an impedance may always be obtained from the ratio of the *j* terms to terms not multiplied by *j*, or using usual terminology in vector algebra by dividing the imaginary terms by the real terms, real terms being those not multiplied by *j* and associated with resistance.

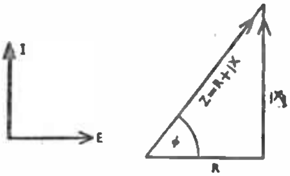


Fig. 41. (Left) Shows voltage and current in a capacitor, and **Fig. 42** (Right) the appropriate impedance triangle.

Impedance of Series Circuit. Using the *j* nomenclature, consider a circuit containing resistance *R*, capacitance *C*, and inductance *L* in series. We can find the resultant impedance by writing, $Z = R + j\omega L + \frac{1}{j\omega C}$,

$$\text{or, } Z = R + j\left(\omega L - \frac{1}{\omega C}\right),$$

$$\text{while } |Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2},$$

where $|Z|$ is the magnitude of the

impedance, while Z is expressed as a vector quantity.

Moreover, $\tan \varphi = \dfrac{\omega L - \dfrac{1}{\omega C}}{R} = \dfrac{\omega L \left(1 - \dfrac{1}{\omega^2 LC}\right)}{R}$.

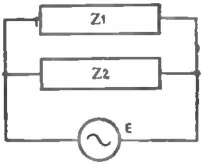


Fig. 43. Alternating voltage applied to impedances in parallel.

Note that when $\omega L = \dfrac{1}{\omega C}$, $Z = |Z| = R$ and $\tan \varphi = 0$, meaning $\varphi = 0$. This is the condition of resonance.

Impedance of Parallel Circuit. In Fig. 43 there are two impedances in parallel. The term *admittance* means the reciprocal of impedance, just as conductance is the reciprocal of resistance. Thus the admittance of Z_1 and Z_2 in Fig. 43 is,

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}, \text{ or}$$

$$Z = \frac{Z_1 Z_2}{Z_1 + Z_2}.$$

Applying this to Fig. 44, and using the j operator, we have,

$$\frac{1}{Z} = \frac{1}{R} + \frac{1}{\dfrac{1}{j\omega C}}$$

$$= \frac{1}{R} + j\omega C$$

$$= \frac{j\omega CR + 1}{R}, \text{ or}$$

$$Z = \frac{R}{1 + j\omega CR}.$$

This is not always a useful form of the expression, because the j term comes in the denominator. We may write, $Z = \dfrac{R\ (1 - j\omega CR)}{(1 + j\omega\ CR)\ (1 - j\omega CR)}$ $= \dfrac{R - j\omega\ CR^2}{1 + \omega^2 C^2 R^2}$, giving a real term, $\dfrac{R}{1 + \omega^2 C^2 R^2}$, and an imaginary term, $= \dfrac{j\omega CR^2}{1 + \omega^2 C^2 R^2}$, and so deriving $\tan \varphi = -\omega CR$, showing a negative angle for φ, because the j vector is pointing downwards. From any of the above equivalences,

$$|Z| = \frac{R}{\sqrt{1 + \omega^2 C^2 R^2}}.$$

Note, if ωC is very small (C very small or frequency very 'low' or both frequency small and C small, so that $\omega^2 C^2 R^2 \ll 1$), then $\tan \varphi =$ very small or $\varphi \approx 0$ and $|Z| = R$, i.e., the circuit 'looks like' a pure resistance. If ωC is very large (frequency very high or C very large or both), φ approaches a right angle and

$$Z = \frac{R}{\omega CR} = \frac{1}{\omega C},$$

and the circuit 'looks like' a pure capacitance.

It is as well to remember that it is often valuable, especially to determine φ, to separate real and imaginary terms so that when a result comes in the form $\dfrac{a + jb}{c + jd}$ we may multiply numerator and denominator by $c - jd$, getting

$$\frac{(a + jb)\ (c - jd)}{c^2 + d^2}$$

$$= \frac{ac - jad + jbc + bd}{c^2 + d^2}$$

$$= \frac{ac + bd}{c^2 + d^2} \text{ and}$$

$$j\,\frac{bc - ad}{c^2 + d^2}.$$

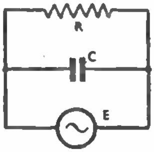


Fig. 44. Alternating voltage applied to resistance and capacitance in parallel.

If $(c - jd)$ comes in the denominator, then multiply the numerator and the denominator by $(c + jd)$.

resonance would be infinite. It is desirable, as the circuit is to be made more selective, that R should be as small as possible. Thus no resistor, of value R, is added and the resistance R in Fig. 45 is shown to represent the resistance of the inductor and capacitor, while R_1 is the internal resistance of the source of alternating voltage energising the resonant circuit.

Effect of Resistance

The resistance R, so far as the external circuit is concerned, is, in practice, almost entirely the resistance of the inductor, the resistance of the capacitor being relatively negligible.

The term $1 - \frac{\omega_0^2}{\omega^2}$ is $\frac{\omega^2 - \omega_0^2}{\omega^2}$.

If we write $\omega = \omega_0 \pm \Delta\omega$, where $\Delta\omega = 2\pi\Delta f$, Δf being a frequency $\ll f_0$, then $\frac{\omega^2-\omega_0^2}{\omega^2} = \frac{(\omega_0 \pm \Delta\omega)^2 - \omega_0^2}{(\omega_0 \pm \Delta\omega)^2} = \frac{\pm 2\Delta\omega\ \omega_0 + \Delta\omega^2}{(\omega_0 \pm \Delta\omega)^2}$. We may neglect $\Delta\omega$ compared with ω_0 in the denominator and we may neglect $\Delta\omega^2$ compared with $2\Delta\omega\omega_0$ and get $1 - \frac{\omega_0^2}{\omega^2} \approx \pm\frac{2\Delta\omega}{\omega_0} = \pm\frac{2\Delta f}{f_0}$.

Thus, $Z_{s0} = \omega_0 L\left\{\frac{1}{Q_0} \pm j\frac{2\Delta\omega}{\omega_0}\right\}$, provided we express $\frac{\omega_0 L}{R_0}$ as Q_0. Thus, Q_0 is the ratio of the reactance to the resistance of the inductor at, or nearly at, resonance.

The voltage across the inductive reactance is $\omega_0 LI = E_L$. The current, $I = \frac{E}{Z_s}$, where E is the voltage acting across the series tuned circuit (see Fig. 45). Therefore,

$$\frac{E_L}{E} = \frac{1}{\frac{1}{Q_0} \pm j\frac{2\Delta\omega}{\omega_0}}$$

$$= \frac{1}{\sqrt{\frac{1}{Q_0^2} + \frac{4\Delta\omega^2}{\omega_0^2}}}.$$

When $f = f_0$, so $\Delta\omega = 0$, then

$$\frac{E_{L0}}{E} = Q_0 = \frac{\omega_0 L}{R}.$$

Since the voltages across capacitor and inductor have very nearly equal values at resonance, so $\frac{E_c}{E_L}$, where E_c is the voltage acting across the capacitor, is virtually,

$$\frac{E_{c0}}{E} = Q_0 = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR}.$$

These expressions are approximate and apply only when the frequency is close to f_0, and when $\frac{\omega_0 L}{R_0} = Q_0$ is at least 5 or more in value. Note that if $\frac{1}{Q_0} = \frac{2\Delta\omega}{\omega_0}$, then $\frac{E_L}{E} = \frac{E_c}{E} = \frac{1}{\sqrt{2}} =$ 0·707 of its maximum value. If ω_0 were $2\pi \times 10^6$ c/s and Q_0 were 100, $2\Delta f = \frac{f_0}{Q_0}$ would give $2\Delta f = \frac{10^6}{10^2}$, or Δf would be 5,000 c/s.

This means that at 5,000 cycles off resonance the ratio of the response to a maximum response would be 0·707 times with a Q value of 100 and a resonance frequency of one million cycles.

A typical resonance curve plotting $\frac{E_L}{E}$ against frequency is shown in Fig. 46, the maximum value of $\frac{E_L}{E}$ being $Q_0 = \frac{\omega_0 L}{R_0}$, and in the case cited being 100, E being considered to remain constant.

Parallel Tuned Circuit. The commoner type of tuned circuit, so far as radio practice is concerned, is the parallel tuned circuit of Fig. 47.

The first step is to find its impedance. This is most easily done by adding the admittances (*admittance* being the reciprocal of impedance) of the two branches. That containing the capacitor is assumed to have zero resistance and so we want to know its susceptance (*susceptance* being the reciprocal of reactance). Writing Y as the sum of admittance of the inductive branch and the susceptance of the capacitive branch, gives,

$$Y = \frac{1}{j\omega L + R} + j\omega C$$
$$= \frac{1 - \omega^2 LC + j\omega CR}{j\omega L + R}.$$

Writing $\omega^2 LC$ as $\frac{\omega^2}{\omega_0^2}$ and C as $\frac{1}{\omega_0^2 L}$, we can write,

$$Y = \frac{\frac{f}{f_0} + jQ\left(\frac{f}{f_0} - \frac{f_0}{f}\right)}{\omega_0 L\,(Q - j)}.$$

Assuming $Q \gg j \times 1$, the impedance of the parallel tuned circuit is $Zp = \dfrac{\omega_0 LQ}{\frac{f}{f_0} + jQ\left(\frac{f}{f_0} - \frac{f_0}{f}\right)}$ and

$$|Zp| = \frac{\omega_0 LQ}{\sqrt{\left(\frac{f}{f_0}\right)^2 + Q^2\left(\frac{f}{f_0} - \frac{f_0}{f}\right)^2}}.$$

At frequencies very close to resonance, the term $\frac{f}{f_0} - \frac{f_0}{f}$, by putting $f = f_0 \pm \Delta f$, as previously explained, when considering the series tuned circuit, is $\approx \pm \frac{2\Delta f}{f_0}$, so that

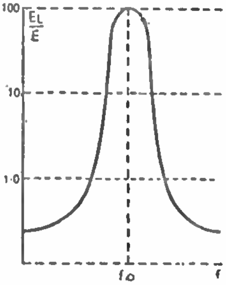


Fig. 46. How voltage across a series tuned circuit varies with applied frequency; f_0 is the resonant frequency of the circuit.

$$Z_{po} = \frac{\omega_0 LQ_0}{1 \pm j\frac{2\Delta f}{f_0}Q_0}$$
$$= \frac{\omega_0 L}{\frac{1}{Q_0} \pm j\frac{2\Delta f}{f_0}}.$$

The denominator of this expression is the same as that which multiplies the inductive reactance in a series tuned circuit.

We see that when $\Delta f = 0$, $Z_{po} = \omega_0 LQ_0$, showing a maximum value of impedance. Thus, provided a resistance R_1, which may well be the internal resistance of the source, exists (as it must, since all sources have some internal resistance), the voltage across the parallel tuned circuit, which we might call E_x (Fig. 47), rises to a maximum at resonance and

$$\frac{E_x}{E} = \frac{Z_{po}}{R_1 + Z_{po}}$$
$$= \frac{1}{\frac{R_1}{Z_{po}} + 1}.$$

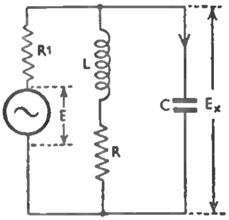


Fig. 47. Parallel tuned circuit, the voltage E_x is maximum at resonance and nearly equals E.

At frequencies far from resonance, $\frac{R_1}{Z_p}$ should be large compared with unity and $\frac{E_x}{E} \approx \frac{Z_p}{R_1}$ and is small.

At resonance, or a frequency very close to resonance, $\frac{R_1}{Z_{po}}$ may be $\ll 1$ and $\frac{E_x}{E} \approx 1$, or $E_x \approx E$. There is, in a parallel tuned circuit, no magnification of voltage, the frequency selective properties depend essentially upon the rising impedance of the circuit, which may rise to values sufficient to cause a sharp increase of voltage, E_x, across the circuit at resonance.

Dynamic Impedance

The impedance at resonance of the parallel tuned circuit is $Z_{po} = \omega_0 LQ_0$, and is sometimes called the dynamic impedance of the circuit. Its phase angle equals 0. A parallel tuned circuit at resonance 'looks like' a high resistance, a series tuned circuit 'looks like' a low resistance.

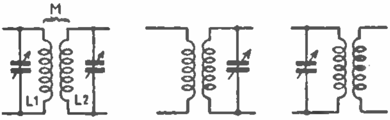
Since, $Q_o = \frac{\omega_o L}{R_o}$, so $Z_{po} = \frac{\omega_o{}^2 L^2}{R_o}$,
and because $L = \frac{1}{\omega_o{}^2 C}$, $Z_{po} = \frac{L}{CR_o}$.

Coupled Circuits. The transfer of energy (between, for instance, stages of a receiver) by means of coupled circuits allows greater flexibility to be obtained in the shape of the resonance curve, while, at the same time, the loading on the preceding valve is of the high impedance associated with the parallel tuned circuit. It also permits the use of variable selectivity. The chief types are :

(1) Mutual inductance coupling (tuned transformer). (Fig. 48.)

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

Either primary, or secondary, or both may be tuned.



(a) (b) (c)

Fig. 48. Three forms of tuned high-frequency transformer.

(2) Common inductance coupling. (Fig. 49.)

$$k = \frac{L_m}{L_1 L_2}.$$

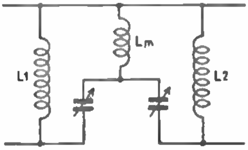


Fig. 49. Band-pass circuit consisting of two tuned circuits with common inductance L_m.

(3) Common capacitance coupling. (Fig. 50.)

$$k = \frac{\sqrt{C_1 C_2}}{C_m}.$$

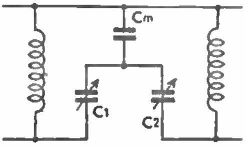


Fig. 50. Band-pass circuit with common capacitance C_m for transference of signal.

(4) 'Top-capacitance' coupling. (Fig. 51.)

$$k = \frac{C_m}{\sqrt{C_1 C_2}}.$$

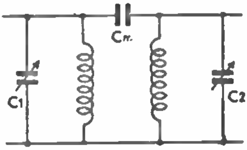


Fig. 51. Band-pass circuit with 'top capacitance' coupling.

Types (1) are most commonly used for coupling between valve stages; for example, in the IF amplifiers of super-heterodyne receivers, while the remaining types are met with more usually in the aerial coupling circuits of the pre-selector stage.

Resonance Curves. The shape of the resonance curve, expressed as the impedance offered to the source of voltage, depends on the closeness of coupling between the circuits. (Fig. 52.)

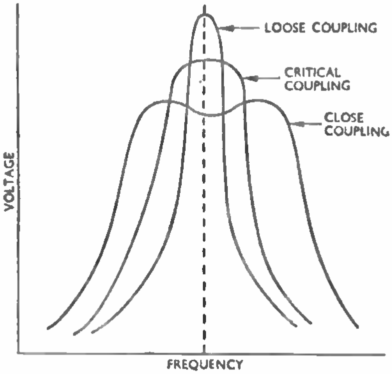


Fig. 52. How the response of coupled tuned circuits varies with degree of coupling.

Loose Coupling. The resonance curve is similar to that of a single parallel tuned circuit.

Critical Coupling. For a certain closeness of coupling, the resonance curve becomes flat-topped.

Close Coupling. For coupling closer than the critical coupling, a double-hump peak appears in the resonance curve.

Cœfficient of Coupling. The cœfficient of coupling is defined as: $k = \frac{M}{\sqrt{L_1 L_2}}$, where M is the mutual inductance between the inductors, and $L_1 L_2$ are in the inductances of the two inductors. (The values of k in the other cases are given above.)

Also, $k = \frac{1}{\sqrt{Q_1 Q_2}}$, where Q_1 and Q_2 are the Q factors of the two circuits.

With identical circuits, $k = \frac{1}{Q}$.

The mutual inductance for critical coupling is, then,

$$M = \sqrt{\frac{L_1 L_2}{Q_1 Q_2}}$$

$$= \frac{\sqrt{R_1 R_2}}{\omega}.$$

With coupling exceeding the critical coupling, the frequency difference between the peaks is,

$$\Delta f = f_0 \sqrt{k^2 - \tfrac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}.$$

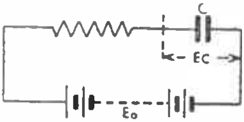


Fig. 53. Capacitor C is charged through the resistor by the battery.

With identical circuits, $\Delta f = f_0 \sqrt{k^2 - \frac{1}{Q^2}}$, where f_0 is the common frequency to which the circuits are tuned.

With the other types of coupling, the resonance curve does not open symmetrically when the coupling is increased beyond the critical value.

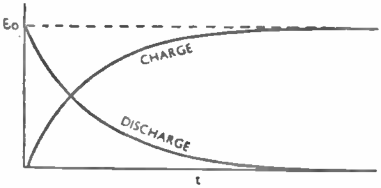


Fig. 54. How voltage across a capacitor varies during charge and discharge.

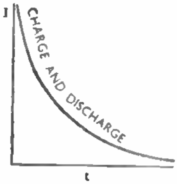


Fig. 55. Current against time for charge and discharge of capacitor.

Time-constant (Figs. 53-55). While circuits associating resistance and capacitance do not come into the category of tuned circuits, they are used for various purposes in receivers which must give selective response and, therefore, merit some mention.

Voltage Rise

When a capacitor is charged through a resistor from a battery or other steady voltage source, the rate at which the voltage across the capacitor rises depends upon the product of the resistance and the capacitance ($R \times C$). The relevant formulæ are:

Let E_0 be the voltage of the source, and let E_c be the voltage across the capacitor t secs. after the circuit is closed. Let Q be the charge on the capacitor at time t, and let Q_0 be the final charge when the capacitor is charged to the voltage E_0.

Then, $E_c = E_0 \left(1 - \varepsilon^{\frac{-t}{RC}}\right)$, where $\varepsilon = 2{\cdot}718$; $Q = Q_0 \left(1 - \varepsilon^{\frac{-t}{RC}}\right)$.

The charging current at time t is,

$$I = \frac{E_0 - E_c}{R}$$

$$= \frac{E_0}{R}\ \varepsilon^{\frac{-t}{RC}}$$

$$= I_0\ \varepsilon^{\frac{-t}{RC}},$$

where $I_0 = \frac{E_0}{R}$ is the initial current.

The product $R \times C$ is called the time-constant of the circuit. It will be a time in seconds if R is in ohms and C in farads.

With the values occurring in practical circuits, R is more usually

SECTION 7

FILTERS AND EQUALIZERS

A FILTER is essentially an electrical network designed to allow the free passage between its input and output terminals of currents having frequencies within one or more frequency bands and to prevent the passage of currents having frequencies outside these frequency bands.

In one sense, a tuned circuit can be considered as a filter and the two basic forms are shown in Fig. 58. The point to be realized, however, is that these circuits do not have selective properties unless associated with other impedances.

The term 'pass' is used to convey the idea of the free passage of currents. The term 'transmit' is used in the same sense. Pass bands of frequencies and transmission bands mean the bands of frequencies which define the frequency of currents freely transmitted through a filter.

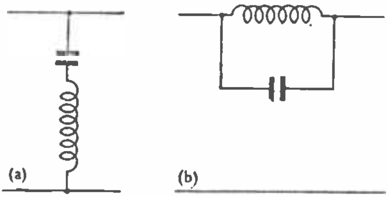


Fig. 58. Basic forms of tuned circuit. (a) Series and (b) parallel.

The term 'stop' may be used to define the condition when the filter acts to prevent or tend to prevent currents of certain frequencies passing between input and output terminals. A more general term, 'attenuation', is used to convey the idea of the prevention of a free passage of currents through a filter.

Filters are classified as (*a*) low pass; (*b*) high pass; (*c*) band pass. These terms describe filters which (1) pass currents of frequencies lower than a so-called *cut-off frequency*, and attenuate currents of frequencies greater than the cut-off frequency; (2) which pass currents of frequency higher than a cut-off frequency and attenuate those of frequencies lower than the cut-off frequency.

In the simpler forms of band-pass filter (3), there are two cut-off frequencies and the filter passes frequencies lying within a band of frequencies bounded by the lower and higher cut-off frequencies, while attenuating currents of frequencies outside the pass band.

A band-stop filter has two cut-off frequencies and the filter attenuates frequencies lying in the band between these frequencies, passing currents of other frequencies.

A filter contains elements which have, ideally, the nature of reactance and no resistance. In an ideal case, in which the filter elements were pure reactances and the terminations of the filter had impedances varying with frequency, exactly matching what is called the filter *image impedance*, there would be no loss at all in the transmission band and attenuation would become finite at frequencies infinitesimally greater or less than the cut-off frequency.

Such conditions cannot be realized in practice, but, using good elements and careful design, the approximation to an ideal performance is reasonably good.

Equalizers

In structures in which elements having the property almost entirely of resistance are associated in the filter proper with elements having chiefly the property of reactance, the action will be such as to give greater attenuation to currents of one frequency than to another. There is no case where resistance is embodied in the filter proper that a sharply defined cut-off frequency exists, and these structures are more properly described as *equalizers*.

This term is used because, in a large number of cases, equalizers are used to compensate for some gradual falling away or increase of response with frequency in some part of a transmission system, which is subsequently equalized.

Referring to Fig. 59, the structures properly described as filters are the high-pass T, π and L sections, the low-pass T, π and L sections, and that labelled 'coupled circuit', because these are structures containing, in themselves, essentially, reactances.

The structures properly described as equalizers are the high-pass $R - C$, the low-pass $R - C$ and $L - R$, and the band-pass single-tuned circuit and the band-stop rejector.

It will be noted that the response curves, which are purely diagrammatic and not to scale, show much sharper rate of change of response with frequency for the filters than for the equalizers.

The load resistances can vary according to requirements. In some of the equalizers shown, the resistance elements of the equalizer are in parallel with the load resistances, and so, to all intents and purposes, the load resistance may be infinite.

Choosing Values

It is extremely important, in the filter structures, to choose the values of the reactances in relation to the terminating or load resistance.

If R be the value of the load resistance, and C and L the values for the capacitors and inductors respectively (where two capacitors or inductors are shown for the filters in Fig. 59 they have equal values), while f is the cut-off frequency (C being in farads, L in henries, f_c in c/s, and R in ohms), we have, for the sections:

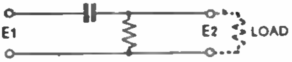
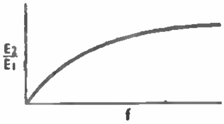
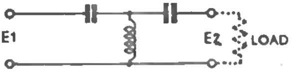
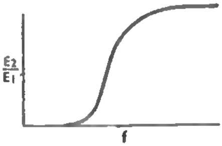
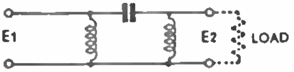
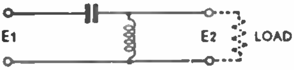
Filter	Section	C (farads)	L (henries)
High pass	T	$\frac{1}{2\pi f_c R}$	$\frac{R}{4\pi f_c}$
	π	$\frac{1}{4\pi f_c R}$	$\frac{R}{2\pi f_c}$
	L	$\frac{1}{2\pi f_c R}$	$\frac{R}{2\pi f_c}$
Low pass	T	$\frac{1}{\pi f_c R}$	$\frac{R}{2\pi f_c}$
	π	$\frac{1}{2\pi f_c R}$	$\frac{R}{\pi f_c}$
	L	$\frac{1}{2\pi f_c R}$	$\frac{R}{2\pi f_c}$

Tone Control. We now turn from filters (typically used in radio in the IF circuit of a super-heterodyne receiver) to a consideration of equalizers, particularly in their application to radio receivers, for altering the 'tone' of the reproduced sounds as it is affected by a greater or lesser gradual relative attenuation of bands of frequencies within the audio spectrum.

In Fig. 60, a capacitor C_1 is connected across the primary of the transformer supplying audio-frequency currents to a loudspeaker. As the frequency of the voltages applied from the valve to the network containing the capacitance and the transformer in parallel increases, so the impedance of the combination gets lower.

Considering the valve as a source of voltage having an internal resistance, clearly the voltage across the transformer drops, owing to the increasing voltage drop in the internal resistance, as the frequency gets higher. The internal resistance of the source varies with the type of valve-source used.

The capacitance value found suitable, if the valve is a pentode, to eliminate what is described as 'shrillness of tone' (in fact, the poor performance of the circuit and

TYPE	STRUCTURE	RESPONSE CURVE
HIGH PASS		
R–C		
T SECTION		
π SECTION		
L SECTION		
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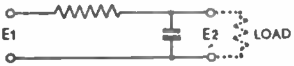
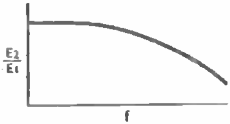
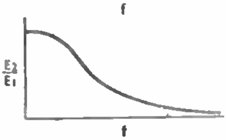
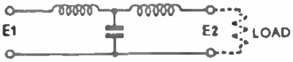
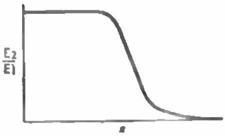
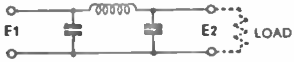
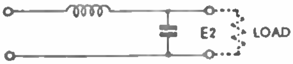
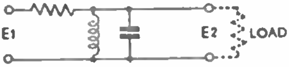
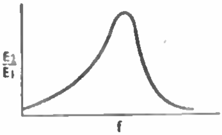
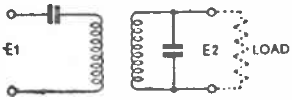
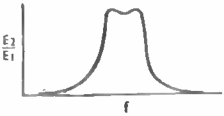
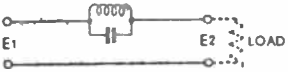
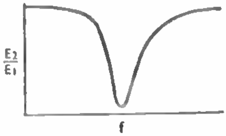
R–C		
L–R		
T SECTION		
π SECTION		
L SECTION		
BAND PASS		
SINGLE TUNED CIRCUIT		
COUPLED CIRCUIT		
BAND STOP (REJECTOR)		

Fig. 59. FILTER CIRCUITS AND THEIR CHARACTERISTICS

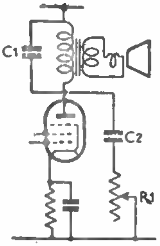


Fig. 60

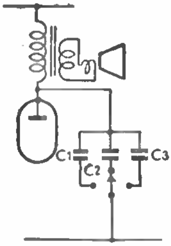


Fig. 61

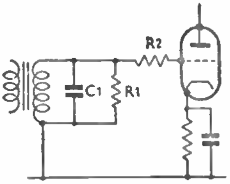


Fig. 62

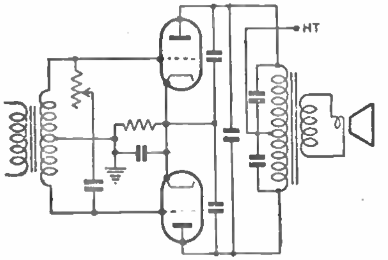


Fig. 63

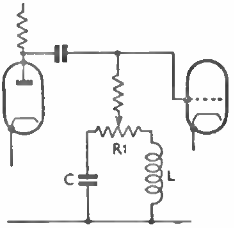


Fig. 64

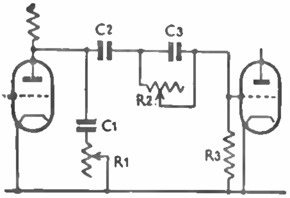


Fig. 65

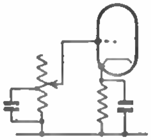


Fig. 66

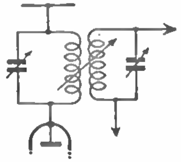


Fig. 67

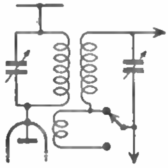


Fig. 68

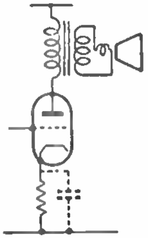


Fig 69

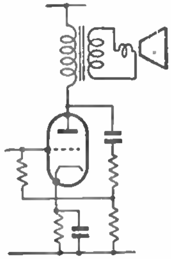


Fig. 70

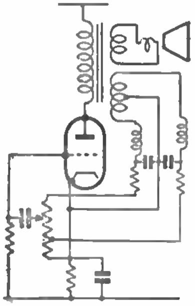


Fig. 71

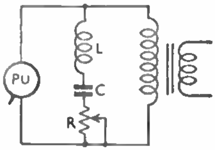


Fig. 72

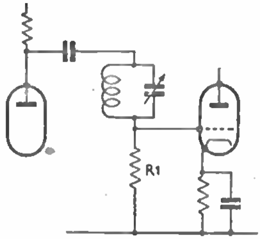


Fig. 73

CIRCUITS THAT CONTROL AUDIO-FREQUENCY RESPONSE

Figs. 60-73. This representative batch of tone-control circuits affords much scope for experiment, and includes methods to prevent shrillness.

SECTION 8

WIRE TABLES

TABLE VIII: BARE COPPER

SWG	Diam. (in.)	Section area (sq. in.)	Ohms per 1,000 yds.	Length per ohm	Weight per 1,000 yds.	Ohms per lb.
				ins.	ozs.	
50	0·001	0·00000079	30,570	1·18	0·145	3,365,000
49	0·0012	0·00000113	21,230	1·7	0·209	1,623,000
48	0·0016	0·00000201	11,941	3·02	0·372	513,500
47	0·002	0·00000314	7,642	4·71	0·581	210,300
46	0·0024	0·00000452	5,307	6·78	0·834	101,440
45	0·0028	0·00000616	3,899	9·24	1·14	54,750
44	0·0032	0·00000804	2,985	10·77	1·49	32,090
43	0·0036	0·0000102	2,359	15·26	1·88	20,040
42	0·004	0·0000126	1,910	18·87	2·32	13,146
41	0·0044	0·0000152	1,578	22·81	2·81	8, 978
40	0·0048	0·0000181	1,326	27·15	3·35	6,340
				yards	lbs.	
38	0·006	0·0000283	849	1·18	0·327	2,597
36	0·0076	0·0000454	529	1·89	0·525	1,008
34	0·0092	0·0000665	361	2·77	0·769	469·8
32	0·0108	0·0000916	262	3·82	1·06	247·4
30	0·0124	0·000121	199	5·03	1·40	142·85
28	0·0148	0·000172	139·5	7·18	1·99	70·14
26	0·018	0·000254	94·3	10·6	2·94	32·06
24	0·022	0·000380	63·2	15·8	4·4	14·366
22	0·028	0·000616	39	25·6	7·12	5·475
20	0·036	0·00102	23·6	42·4	11·8	2·004
18	0·048	0·00181	13·27	75·4	20·9	0·684
16	0·064	0·00322	7·46	134·6	37·2	0·2
14	0·08	0·00503	4·78	208	58·1	0·08216
12	0·104	0·0085	2·83	353	92·8	0·02877
10	0·128	0·013	1·87	535	148·8	0·012537

TABLE IX: FLEXIBLE CORDS

Conductor		Current Rating	Resistance per 1,000 yds. at 60° F. for straight single cores, no allowance being made for twisting
Nominal cross-sectional area	Number and diameter (in.) of wires		
sq. in.		amps	ohms
0·0006	14/0·0076	2	39·7
0·001	23/0·0076	3	24·2
0·0017	40/0·0076	5	13·9
0·003	70/0·0076	10	7·94
0·0048	110/0·0076	15	5·05
0·007	162/0·0076	20	3·43

TABLE X:

COTTON-COVERED AND SILK-COVERED

SINGLE COTTON-COVERED

SWG	Total thickness of covering in mils.	Turns per in.	Turns per sq. in.	Yards per lb.
40	4	112·5	26,600	3,910
38	4	100	10,000	2,550
36	4	86·2	7,430	1,610
34	5	70·5	4,970	1,280
32	5	63·3	4,010	835
30	5	57·5	3,300	634
28	5	50·5	2,550	452
26	5	43·4	1,892	311
24	5	37	1,369	219
22	5/6	29·8	888	134
20	5/6	24·1	581	81·7
18	6/7	18·3	335	46·3
16	7	14·1	198	26·1
14	7/8	11·4	130	16·9
12	7/8	9	81	10·3
10	7/8	7·4	54	6·63

DOUBLE COTTON-COVERED

SWG	Total thickness of covering in mils.	Turns per in.	Turns per sq. in.	Yards per lb.
40	7/9	78	6,080	3,456
38	7/9	71·5	5,110	2,287
36	7/9	64	4,010	1,477
34	8/10	55	3,020	1,024
32	8/10	50·5	2,550	755
30	8/10	47	2,210	587
28	8/10	42	1,790	422
26	8/10	37	1,400	294
24	8/10	32·3	1,043	203
22	9/11	26·3	692	129
20	9/11	21·7	473	79·4
18	9/11	17·3	299	45·4
16	10/12	13·3	177	25·6
14	12/14	10·75	115	16·6
12	12/14	8·5	72	9·09
10	12/14	7·1	50·3	6·58

SINGLE SILK-COVERED

				yds. per oz.
47	1·2	312	97,300	1,375
46	1·2	278	77,300	1,000
45	1·2	250	62,500	752
44	1·2	227	51,530	599
42	1·2	192	36,860	387
40	1·3	164	26,900	276
				per lb.
38	1·3	137	18,770	2,871
36	1·3	112	12,540	1,815
34	1·3	95·2	9,060	1,250
32	1·3	82·6	6,820	912
30	1·3	73	5,330	695
28	1·3	62·1	3,860	488
26	1·3	51·8	2,680	332
24	1·5	42·5	1,810	222
22	2	33·3	1,090	137
20	2	26·3	692	83·3
18	2	20	400	46·8
16	3	15	222	26·4

DOUBLE SILK-COVERED

				yds. per oz.
47	2·2	238	56,600	1,190
46	2·2	217	47,100	871
45	2·2	200	40,000	675
44	2·2	185	34,200	536
42	2·2	161	25,000	358
40	2·5	137	18,800	258
				per lb.
38	2·5	118	13,900	3,760
36	2·5	90·1	8,120	1,750
34	2·5	85·5	7,310	1,220
32	2·5	75·2	5,650	887
30	2·5	67·1	4,500	675
28	2·5	57·8	3,340	478
26	2·5	48·8	2,380	325
24	3	40	1,600	218
22	3	32·2	1,040	134
20	3	25·6	655	82·5
18	3	19·6	384	46·3
16	4	14·7	216	26·1

TABLE XI: ENAMELLED

SWG	Total thickness of covering in mils.	Turns per in.	Turns per sq. in.	Yards per oz.
50	0·2	833	694,000	6,480
49	0·2	714	510,000	4,510
48	0·3	526	277,000	2,500
47	0·3	435	189,000	1,630
46	0·4	357	127,500	1,128
45	0·5	303	91,800	835
44	0·5	270	72,900	642
42	0·6	217	47,100	411
40	0·7	182	33,100	286
				per lb.
38	1·0	143	20,450	2,810
36	1·0	116	13,450	1,840
34	1·0	98	9,600	1,202
32	1·2	83·3	6,940	915
30	1·2	73·5	5,400	694
28	1·6	60·1	3,610	488
26	1·8	50·5	2,550	330
24	2·3	41·1	1,690	221
22	2·5	32·8	1,080	137
20	2·7	25·8	666	83·3
18	2·7	19·7	388	46·9
16	3·5	14·8	219	26·4

TABLE XII: CURRENT RATING

Maximum current in amps at 1,000 amps per sq. in. In practice, the safe current depends on heat dissipation, and in amateur-made transformers—for example, where windings are less compact—the figures below may be doubled.

SWG	Amps	SWG	Amps
12	8·5	28	·172
14	5	30	·12
16	3·2	32	·092
18	1·8	34	·0665
20	1·02	36	·0454
22	·615	38	·0283
24	·38	40	·0181
26	·25		

TABLE XIII: EUREKA RESISTANCE WIRE

SWG	Diameter (in.)	Ohms per yard	Yards per lb.	Current (amps) for temperature rise of 100° C.
8	0·160	0·0335	4·2	29·0
9	0·144	0·0413	5·3	24·0
10	0·128	0·0523	6·7	20·1
11	0·116	0·0637	8·1	18·5
12	0·104	0·0793	10·0	14·8
13	0·092	0·1013	13·0	12·6
14	0·080	0·1339	17·1	10·5
15	0·072	0·1653	21·1	9·3
16	0·064	0·2094	26·7	8·1
17	0·056	0·2733	34·9	7·0
18	0·048	0·3718	47·6	5·75
19	0·040	0·5356	68·4	4·6
20	0·036	0·6613	84·6	4·1
21	0·032	0·8372	106·9	3·6
22	0·028	1·093	139·8	3·1
23	0·024	1·487	190·8	2·7
24	0·022	1·770	226·7	2·4
25	0·020	2·142	274·6	2·18
26	0·018	2·645	337·8	2·0
27	0·0164	3·186	406·5	1·82
28	0·0148	3·914	500·0	1·66
29	0·0136	4·634	592·3	1·54
30	0·0124	5·575	714·2	1·4
31	0·0116	6·370	813·0	1·3
32	0·0108	7·350	943·4	1·2
33	0·010	8·571	1,093·2	1·08

TABLE XIV: KANTHAL RESISTANCE WIRE

SWG	Ohms per ft. at 20 deg. C		Ft. per lb.		Current (amps) for temperature of 200 deg. C. Types A and D
	Type A	Type D	Type A	Type D	
8	·03266	·03172	16·04	15·83	21·5
9	·04032	·03916	19·80	19·54	18·7
10	·05103	·04956	25·07	24·73	16
11	·06214	·06035	30·53	30·11	13·95
12	·07731	·07508	37·97	37·45	12·10
13	·09879	·09594	48·53	47·87	10·17
14	·1306	·1269	64·15	63·29	9·14
15	·1613	·1566	79·23	78·13	7·25
16	·2041	·1983	100·3	98·91	6·20
17	·2666	·2590	131·0	129·2	5·18
18	·3629	·3524	178·2	175·8	4·46
19	·5226	·5075	256·6	253·2	3·29
20	·6452	·6266	316·9	312·6	2·86
21	·8166	·7930	401·2	395·6	2·46

TABLE XIV: KANTHAL RESISTANCE WIRE—*continued*

SWG	Ohms per ft. at 20 deg. C		Ft. per lb.		Current (amps) for temperature of 200 deg. C. Types A and D
	Type A	Type D	Type A	Type D	
22	1·067	1·036	523·9	516·8	2·10
23	1·452	1·410	713·0	703·2	1·67
24	1·728	1·678	848·8	836·8	1·48
25	2·090	2·030	1027	1013	1·30
26	2·581	2·506	1267	1250	1·15
27	3·109	3·019	1526	1506	·995
28	3·817	3·707	1875	1849	·870
29	4·535	4·390	2220	2190	·775
30	5·338	5·281	2671	2634	·685
31	6·214	6·035	3052	3010	·625
32	7·169	6·962	3504	3473	·565
33	8·362	8·121	4108	4050	·510

TABLE XV: COMPARATIVE TABLE OF WIRE GAUGES

No.	British standard gauge SWG	American gauge AWG or BS	No.	British standard gauge SWG	American gauge AWG or BS
	Diam. (in.)	Diam. (in.)		Diam. (in.)	Diam. (in.)
7/0	·500	—	23	·024	·0226
6/0	·464	—	24	·022	·0201
5/0	·432	—	25	·020	·0179
4/0	·400	·4600	26	·018	·0159
3/0	·372	·4096	27	·0164	·0142
2/0	·348	·3648	28	·0148	·0126
0	·324	·3249	29	·0136	·0113
1	·300	·2893	30	·0124	·0100
2	·276	·2576	31	·0116	·0089
3	·252	·2294	32	·0108	·0080
4	·232	·2043	33	·0100	·0071
5	·212	·1819	34	·0092	·0063
6	·192	·1620	35	·0084	·0056
7	·176	·1443	36	·0076	·0050
8	·160	·1285	37	·0068	·0045
9	·144	·1144	38	·0060	·0040
10	·128	·1019	39	·0052	·0035
11	·116	·0907	40	·0048	·0031
12	·104	·0808	41	·0044	—
13	·092	·0720	42	·0040	—
14	·080	·0641	43	·0036	—
15	·072	·0571	44	·0032	—
16	·064	·0508	45	·0028	—
17	·056	·0453	46	·0024	—
18	·048	·0403	47	·0020	—
19	·040	·0359	48	·0016	—
20	·036	·0320	49	·0012	—
21	·032	·0285	50	·0010	—
22	·028	·0253			

TABLE XVIA: FUSE ELEMENTS

IEE Current rating of semi-enclosed fuse	Tinned copper wire		Standard alloy wire (63% tin, 37% lead)	
	Diameter (in.)	SWG	Diameter (in.)	SWG
amps				
1·8	—	—	0·0164	27
3·0	0·006	38	0·024	23
5·0	0·0084	35	0·032	21
8·5	0·0124	30	—	—
10·0	0·0136	29	—	—
15·0	0·020	25	—	—
17	0·022	24	—	—
20	0·024	23	—	—
24	0·028	22	—	—
30	0·032	21	—	—
37	0·040	19	—	—
46	0·048	18	—	—
53	0·048	18	—	—
60	0·056	17	—	—
64	0·056	17	—	—
83	0·072	15	—	—
100	0·080	14	—	—

The ratings given in Table XVIA are the normal maximum current of the circuit, and not the overload at which the fuse will operate. Fusing currents are given in Table XVIB, below.

TABLE XVIB: FUSING CURRENTS

SWG	Approximate fusing currents—amperes				
	Copper (plain)	Standard alloy 63% tin 37% lead	Lead	Tin	Aluminium
12	344		46·5	55	260
14	232		31·5	37	170
16	166		22·5	26·6	120
18	110		14·5	17·3	80
20	70		9·5	11·3	50
21		7·5			
22	50		6·5	7·7	35
23		4·5			
24	35		4·5	5·4	25
26	25		3·5	4·0	18
27		2·7			
28	17		2·5	3·0	14
30	15		1·9	2·3	10
32	12		1·6	1·9	8
34	9		1·2	1·5	7·5
36	7		0·9	1·1	5·0
38	5		0·75	0·8	4
40	3		0·5	0·6	2·5

SECTION 9

COMPONENT DESIGN

Air-cored Coils. The simplest method of calculating the inductance of a coil is the formula given by Terman: $L\,(\mu\text{H}) = N^2dF$, where N is the number of turns, d the diameter of the coil in inches and the term F is a variable, depending upon the ratio of coil diameter to length of winding. F is given in Table XVII for ratios of ·1 to 10, to cover all normal constructions.

TABLE XVII

Factor F in inductance formula $L=N^2dF$, in terms of the length 'l' and diameter 'd' of the winding; l and d in inches.

$\frac{l}{d}$	F	$\frac{l}{d}$	F
·1	·05	1·5	·013
·2	·04	2	·01
·3	·034	2·5	·0085
·4	·029	3	·0072
·5	·026	4	·0056
·6	·023	5	·0047
·7	·021	6	·0039
·8	·019	7	·0033
·9	·018	8	·0029
1	·017	10	·0024

For example, a 50-turn coil of diameter 2 in. and length 1 in., has a ratio $\frac{l}{d}$ of ·5, for which F is obtained from the chart as ·026, and so the inductance becomes: $L = 2{,}500 \times 2 \times {\cdot}026 = 130\ \mu\text{H}$.

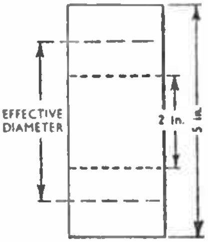


Fig. 74. Effective diameter is used to calculate inductance of a multi-layer coil.

When dealing with a multi-layer coil, d is mean diameter, that is, the inside diameter of the coil plus half the difference of the inside and outside diameters. The inside diameter of the coil shown in Fig. 74 is 2 in., and the outside diameter 5 in., so that the effective value of d to be used in finding the inductance is:

$$2 + \left(\frac{5-2}{2}\right) = 3\tfrac{1}{2}\text{ in.}$$

The charts shown in Figs. 79 and 80 have been compiled from the above information and indicate the number of turns required for a given inductance from ·1 µH to 10 µH with a single layer on different-size formers, but with a constant ratio of $\frac{l}{d}$ of ·5. The gauge of wire to be employed is marked along each graph.

Iron-dust Cores. Where an iron or iron-dust core is employed, the inductance of the coil will be increased by a factor which is the effective permeability of the magnetic circuit. When the iron core forms a complete magnetic circuit around the coil with a negligible air-gap, as for instance in the case of G.E.C. Ironclad, illustrated in Fig. 75, or the NeoSid cup or pot type, the inductance of the coil will be increased by a factor nearly equal to the permeability of the iron core, that is, from 2 to 4 in the radio-frequency bands.

Where, however, the iron core is in the form of a slug inside the coil, the net increase of inductance will be less than the permeability factor, owing to the effective air-gap.

Iron-dust cores having a permeability of 1·3 are made for use at 50 Mc/s and higher permeabilities, up to 15, for use in the IF band at 450-500 Kc/s. The makers' literature should be consulted in choosing a particular core for a given frequency range and purpose.

Advantages of iron-dust core inductances are :

(1) Inductance value can be adjusted.

(2) Lower R loss with the possibility of higher Q for a given coil.

(3) Possibility of achieving constant Q over a band of frequencies.

Low-frequency Chokes. The design of LF chokes is complicated by the fact that, in addition to the ripple component, there is often a direct current flowing through the winding. This necessitates an air-gap in the magnetic circuit.

Since the actual inductance of an iron-cored choke coil is a variable depending upon the DC and upon the ripple voltage applied to it, some simplifying assumptions are made which reduce somewhat the accuracy of the method.

L is taken as equal to $\dfrac{1{\cdot}45\, AN^2}{\sqrt{a} \times 10^7}$,

where

A = cross-sectional area of iron circuit in square inches.

N = number of turns.

a = air-gap in inches. This is assumed to be never less than ·002 in.

In Figs. 81-84, the graphs denote the inductance for a given number of turns on the core shown in the caption. The different curves are for different lengths of air-gap, indicated by the figures at the end of the curve.

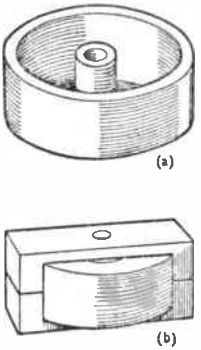


Fig. 75. Forms of iron-dust core for radio-frequency inductors. (a) Totally enclosed pattern, and (b) semi-enclosed.

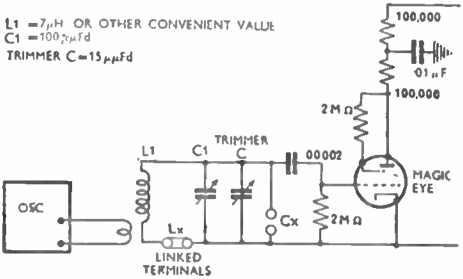


Fig. 76. Circuit for measuring values of inductors and capacitors. Oscillator frequency is set at 6 Mc/s.

The figures along each curve are the limiting values of current, DC plus AC, from the viewpoint of non-saturation. Below each chart is the gauge of wire which may be employed for different numbers of turns, and the resistance.

Measurement of Inductance. For the measurement of small inductances, ·1 – 150 μH, the resonance method is to be preferred on the score of simplicity and accuracy. It is shown in Fig. 76. The oscillator is set to about 6 Mc/s and feeds into the tuned circuit L_1C_1, having two terminals normally connected by a short link.

With the link in position, C_1, the calibrated capacitor, is set to maximum capacitance, and the oscillator tuning is adjusted for maximum reading on the valve voltmeter or magic-eye indicator. The unknown inductance is now connected to the terminals in place of the link and C_1 is adjusted for resonance. L_x, the unknown inductance, is then given by:

$L_x = L_1 \dfrac{C_3}{C_1 - C_3}$, where L_1 is the original inductance, C_1 is the total capacitance, C_3 is the reduction in capacitance to reproduce the resonant condition with L_x in circuit.

For a carefully constructed standard of 7 μH employed with a frequency of 6 Mc/s, the capacitance to inductance ratio for L_x in terms of

C_3 is as shown in the chart (Fig. 85).

For the measurement of larger inductances the impedance bridge of Fig. 78 is to be preferred. In this case, inductances can be read off a resistance scale once the standard inductance is brought into circuit.

Capacitors are grouped according to their dielectric—the insulating material between their plates. These are air, mica and mica substitutes, paper, ceramics and electrolyte.

The capacitance is given by: $C = \frac{A \times SIC}{4{\cdot}45t}$, where A is the area of the opposing plates in square inches, t is the thickness of the dielectric in inches, *SIC* is the permittivity (specific inductive capacitance) of the dielectric, and C is expressed in micro-microfarads.

Table XVIII gives the *SIC* for a number of materials used as dielectrics. It also shows the range of power factors and the breakdown voltage in volts per thousandth of an inch.

Use of Capacitors. In choosing a capacitor for a particular service, consideration must be given to the following points:

(1) The dielectric must be capable of withstanding the peak voltage that will be impressed upon it.

(2) The terminals and plate configuration must be suitable for the peak voltage to be applied, under the worst conditions of atmospheric pollution, or the low pressures of high altitude, that may be encountered.

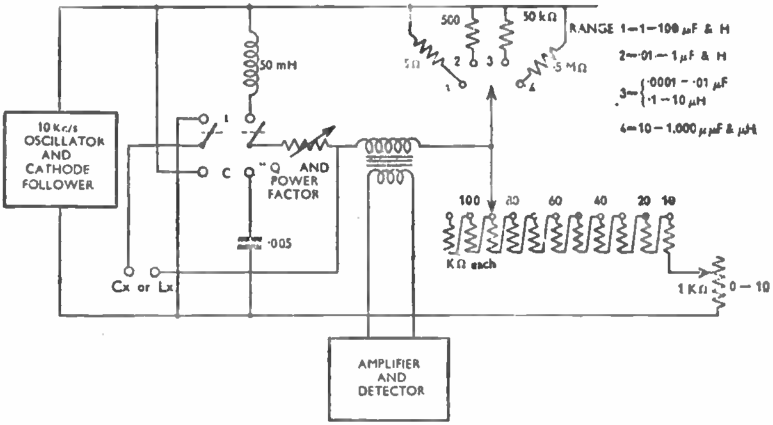
(3) The lugs joining the plates to the terminals must have sufficient cross-section to carry the capacitance current without undue overheating.

(4) The portion of the total current represented by the loss component must not cause a dangerous rise in temperature.

A rise in dielectric temperature in

TABLE XVIII: DIELECTRIC QUALITIES

Material	SIC	Power factor, tan θ	Breakdown strength in volts per thousandth of an inch
Air, normal pressure	1	0	20
Air, five times normal pressure	1	0	80
Air, at altitude of 20,000 ft. ..	1	0	10
Mica	3 — 8	·0001 — ·001	500 — 1,000
Micalex	8	·002	200 — 300
Polystyrene (Distrene, Trolitol, etc.)	2·2 — 2·5	·0002	500
Frequentite, Calit	6	·0003 — ·002	100 — 300
Alsimag, Isolantite	6	·0005 — ·002	100 — 300
Faradex, Condensa	80	—	—
Porcelain	5 — 6	·001 — ·005	50 — 150
Paper	2 — 2·5	·02 — ·05	100 — 500
Glass (Electrical)	4 — 6	·005 — ·01	1,000 — 1,500
Glass (other grades)	3 — 9	·005 — ·05	200 — 500
Ebonite	3 — 5	·005 — ·01	400 — 500
Bakelite (Phenolaldehyde) ..	4 — 7	·02 — ·1	100 — 600
Wood	3 — 5	·002 — ·05	100 — 200



DIRECT-READING IMPEDANCE BRIDGE

Fig. 78. Gives direct readings of impedance of a capacitor or an inductor.

than the standard capacitor employed to be measured. In such a case, it is necessary to connect a resistance in series with the unknown capacitor, set the resistor in series with the standard capacitor to zero and find the value of added resistance that balances the bridge.

As long as the power factor of the standard capacitor is known, the power factor of the unknown capacitor can be calculated, since at the balance point the phase difference in the two reactive arms of the bridge is zero.

For precise results, the readings of the lowest ranges must be reduced by a figure representing the effective capacitance of the terminals and wiring.

For the measurement of very small capacitances, the resonance method is widely employed. The circuit of Fig. 76 may be employed, and the trimmer capacitor calibrated in micro-microfarads.

The trimmer is set to maximum capacitance, and C_1 used to obtain resonance at the detector. The unknown capacitor is then connected at the terminals marked C_x and the trimmer capacitor is set to obtain resonance once more. The difference in its settings is equal to the unknown capacitor connected at C_x.

This method will be found satisfactory for measuring the input capacitance of a valve and its valve holder, also the variation of its capacitance with changes of anode current.

Power Transformers. Because it operates at a constant frequency, and usually with a constant load, the power transformer is a much simpler affair to design than the other transformers employed in radio engineering.

The design tables appended are for 50-cycle input frequency (Table XIX). Transformers based on this data will operate satisfactorily at 60 c/s, but must not be connected to a 25-c/s supply.

The laminations chosen are silicon steel, ·014 in. thick. The sizes are the types most commonly used and the stacks arranged for bobbins that are commercially available.

A flux density of 60,000 lines per sq. in. is provided when the core area A, multiplied by the turns per volt (TPV), equals 7·5.

The required core area is given approximately by $A = \frac{\sqrt{W_P}}{5 \cdot 7}$, where

TABLE XIX: DESIGN DATA FOR

W_s Total secondary load (watts)	Approx. efficiency (per cent)	W_p Primary watts $= \frac{W_s \times 100}{\text{Efficiency}}$	Core area (A) $= \frac{\sqrt{W_p}}{5\cdot7}$	Turns per volt, TPV $= \frac{7\cdot5}{A}$	Primary gauges for 200-250 volt (SWG)	Primary current for 230 volts (amps)	Suitable lamination
50	75	67 watts	1·5	5	26	·3	4A
75	80	94 ,,	1·76	4·5	24	·41	4A
100	85	117 ,,	2·1	4	23	·51	75A
150	90	166 ,,	2·35	3·5	22	·72	75A
200	90	222 ,,	2·7	3	20	1	28A
300	93	323 ,,	3·25	2·5	18	1·4	35A
500	94	530 ,,	4·15	2	16 or 2 × 19	2·4	37A

W_p is the primary power, that is, $\frac{W_s \times 100}{\text{Efficiency per cent}}$, and W_s is the power drawn from the secondaries.

Usual efficiencies that are obtained in small transformer designs are shown in column 2 of Table XIX.

To commence a transformer design, it is first necessary to know W_s, the secondary power. A radio transformer usually carries a centre-tapped HT secondary with two or more LT secondaries. For example :

(1) HT secondary: 350—0—350 volts at 120 mA.

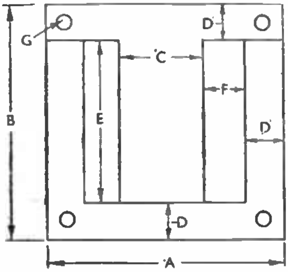
Since only half of the secondary is in use at one time, $W_s = \frac{350 \times 120}{1{,}000} =$ 42 watts.

(2) Rectifier LT = 5 volts, 3 amps = 15 watts.

(3) Normal LT = 6·3 volts, 5 amps = 31·5 watts.

Total secondary power, $W_s = 88\cdot5$.

TABLE XX: DETAILS OF LAMINATIONS

Diagram showing dimensions A, B, C, D, E and F.	Type No.	A	B	C	D	E	F
	4A	3·563	3·188	0·938	0·439	2·313	0·87
	75A	4·000	3·375	1·000	0·500	2·375	1·00
	28A	5·000	4·250	1·219	0·625	3·000	1·26
	35A	6·250	5·250	1·500	0·750	3·750	1·62
	37A	6·750	6·750	1·750	0·875	5·000	1·62
	41A	8·500	7·250	2·500	1·250	4·750	1·75

TYPICAL SMALL POWER TRANSFORMERS

Size of stack (in.)	Window area (sq. in.)	Compensated primary turns			Secondary compensation: to TPV × E_s add	Approx. magnetizing current at 230 volts
		200	230	250		
1·5	2	920	1,060	1,140	6 per cent TPV × E_s	83 mA
2¼	2	850	985	1,060	4 ,, TPV × E_s	86 ,,
2¼	2·375	770	880	960	4 ,, TPV × E_s	103 ,,
2¼	2·375	680	775	845	3 ,, TPV × E_s	150 ,,
2¼	3·8	580	670	725	2 ,, TPV × E_s	170 ,,
1¾	6·1	490	560	610	2 ,, TPV × E_s	240 ,,
2	8·1	395	455	495	1 ,, TPV × E_s (where E_s is the secondary voltage)	350 ,,

From column 2, Table XIX, we see that the efficiency will be of the order of 85 per cent, so that,

$$W_p = \frac{88{\cdot}5 \times 100}{85} = 104 \text{ watts.}$$

The core area A is now fixed by $\frac{\sqrt{104}}{5{\cdot}7} = 1{\cdot}8$ sq. in. and the turns per volt as $\frac{7{\cdot}5}{1{\cdot}8} = 4{\cdot}15$, say 4.

We now choose a suitable lamination size. Table XX lists the widely employed laminations together with suitable bobbins. Values of A for each bobbin are given.

Since the primary power is 104 watts, we can calculate the primary current from $I = \frac{W}{E} = \frac{104}{230}$ for a 230-volt supply, that is, 450 mA.

From the Wire Tables (Section 8), we see that for a conservative rating of 1,000 amps per sq. in. we should employ 23 SWG wire, but that

FOR CHOKE AND TRANSFORMER COILS

STANDARD BOBBINS

Thickness of lamination stack (t) and area of iron path (A), sq. in.

t	A sq. in.	t	A sq. in.	t	A sq. in.
1 in.	·938	1⅛ in.	1·4	2¼ in.	1·88
1 ,,	1	1¼ ,,	1·5	2¼ ,,	2·25
1¼ ,,	1·5	2¼ ,,	2·7	2¾ ,,	3·35
1½ ,,	2·25	2¾ ,,	3·4	2¾ ,,	4·1
1¾ ,,	3·05	2¼ ,,	3·95	—	—
2½ ,,	6·25	3¾ ,,	9·4	5 ,,	12·5

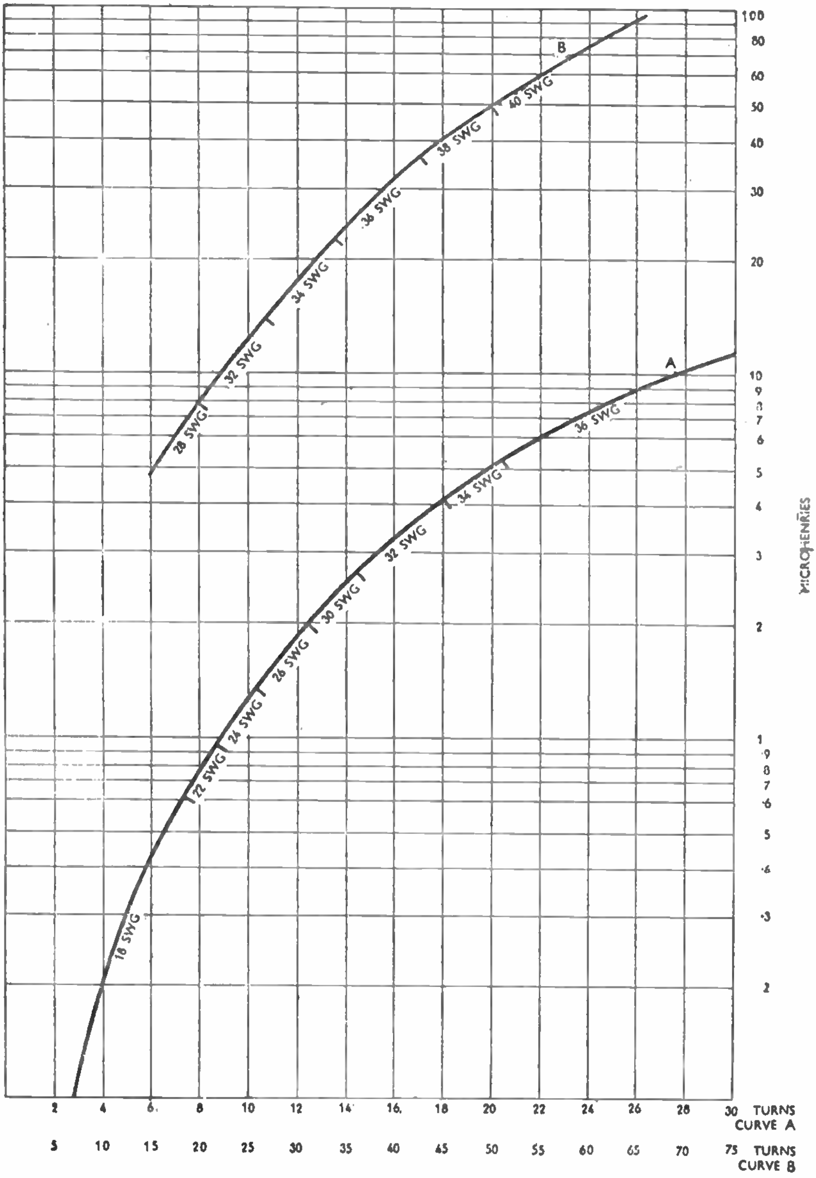


Fig. 79. INDUCTANCE OF AIR-CORED COILS (I)

CURVE A—DIAMETER ¼ IN., LENGTH OF WINDING ¼ IN.

CURVE B—DIAMETER ¾ IN., LENGTH OF WINDING ¾ IN.

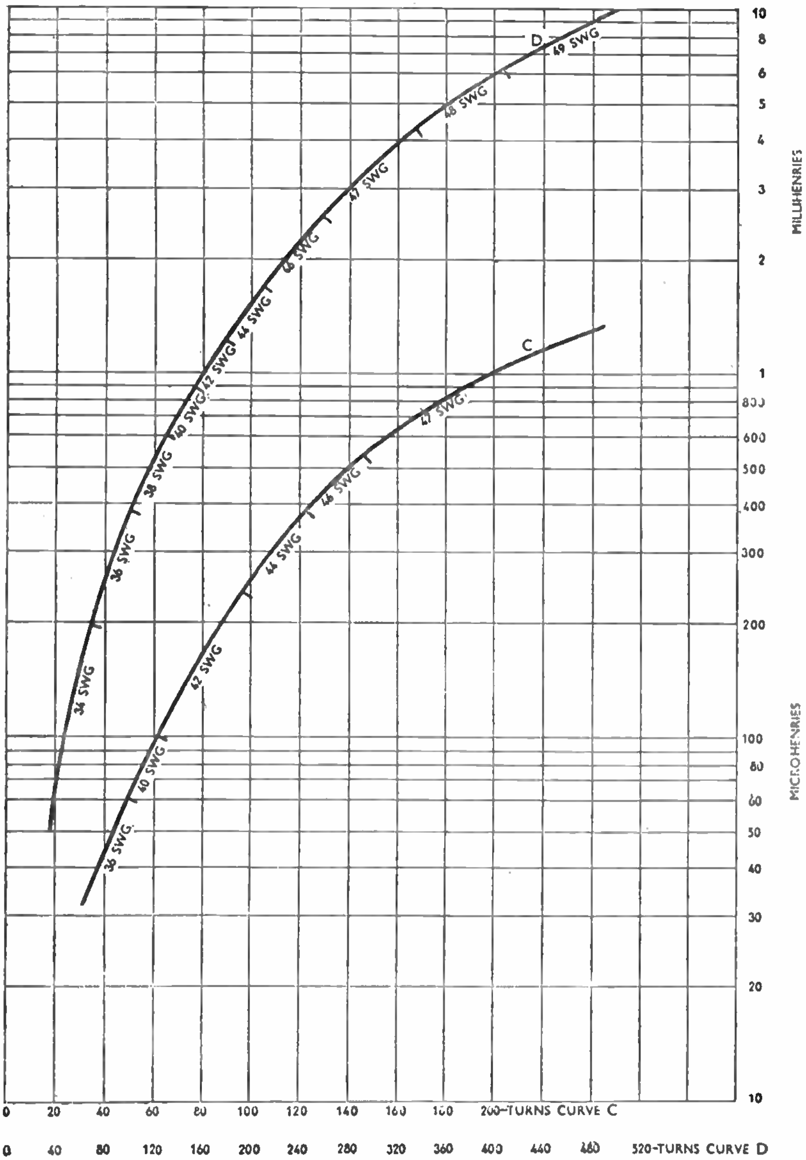


Fig. 80. INDUCTANCE OF AIR-CORED COILS (2)

CURVE C—DIAMETER 1 IN., LENGTH OF WINDING ¼ IN.

CURVE D—DIAMETER 1½ IN., LENGTH OF WINDING ¾ IN.

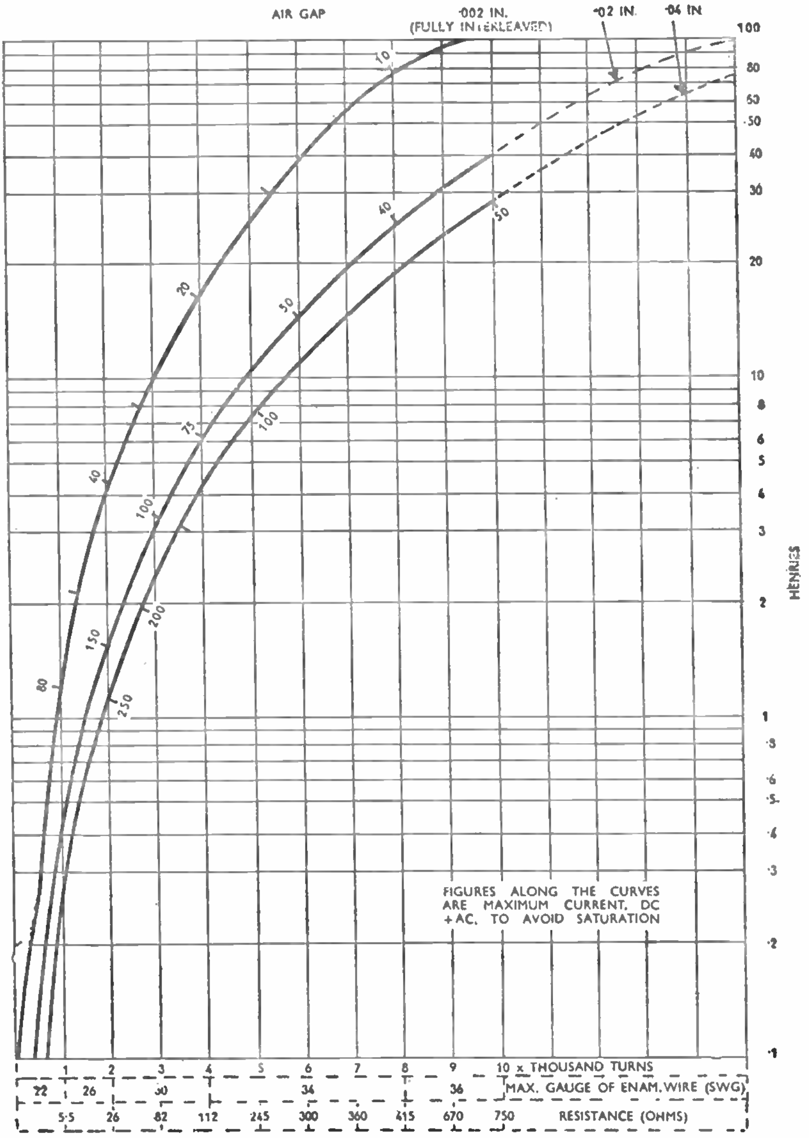


Fig. 81. INDUCTANCE OF IRON-CORED LF CHOKES

No. 15 LAMINATIONS (STALLOY)

CORE ·625 IN. THICK (40 PAIRS)

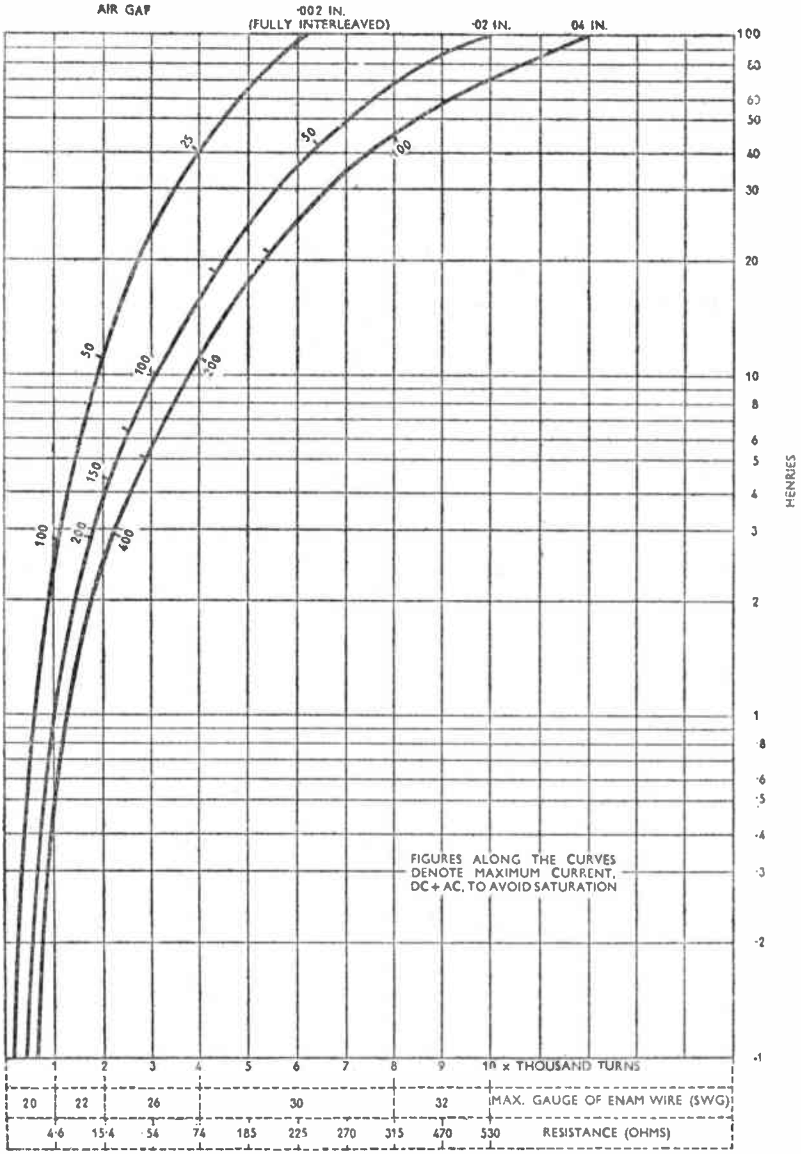


Fig. 82. INDUCTANCE OF IRON-CORED CHOKES

No. 75 LAMINATIONS (STALLOY)

CORE 1 IN. THICK (66 PAIRS ·014 IN.)

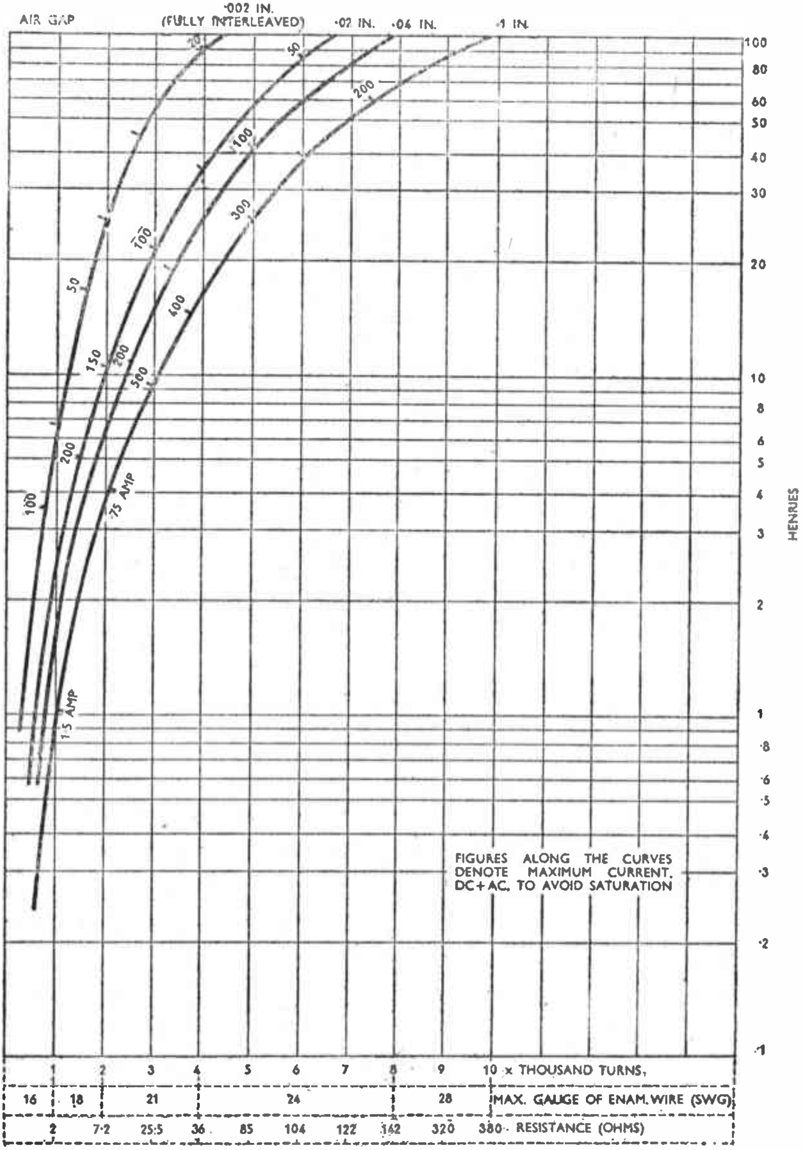


Fig. 83. INDUCTANCE OF IRON-CORED CHOKES

No. 35 LAMINATIONS (STALLOY) 1·5 IN. STACK (98 PAIRS ·014 IN.)

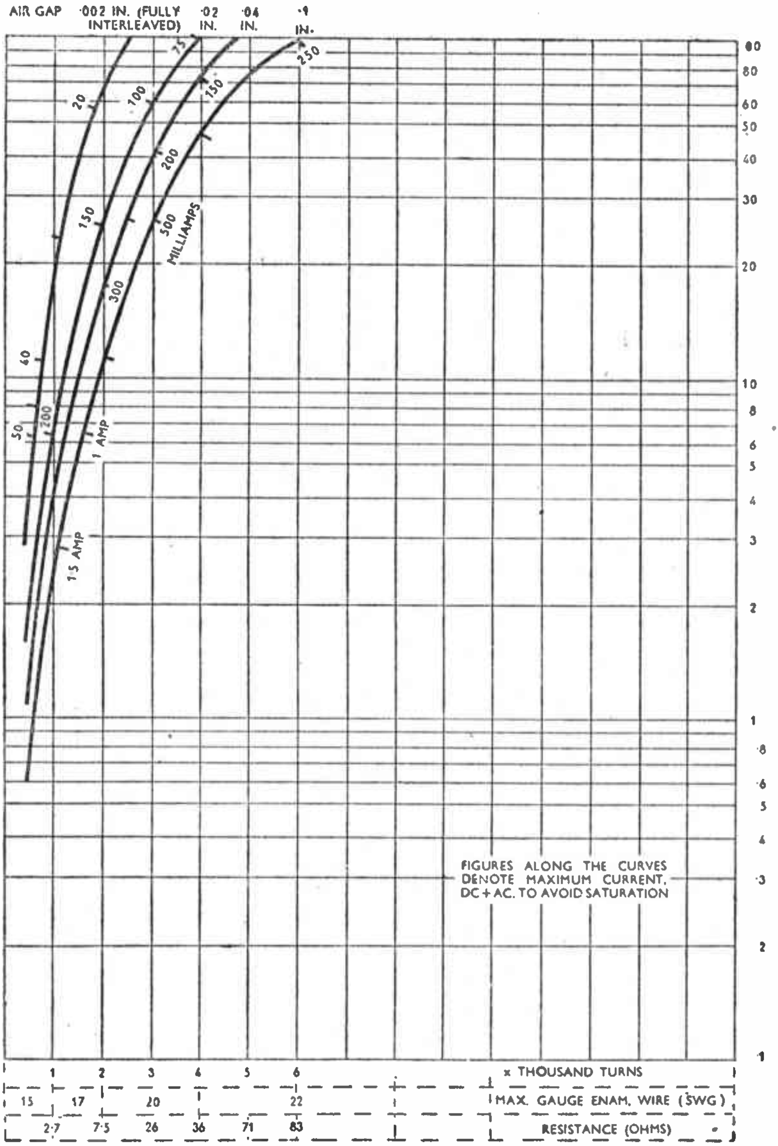
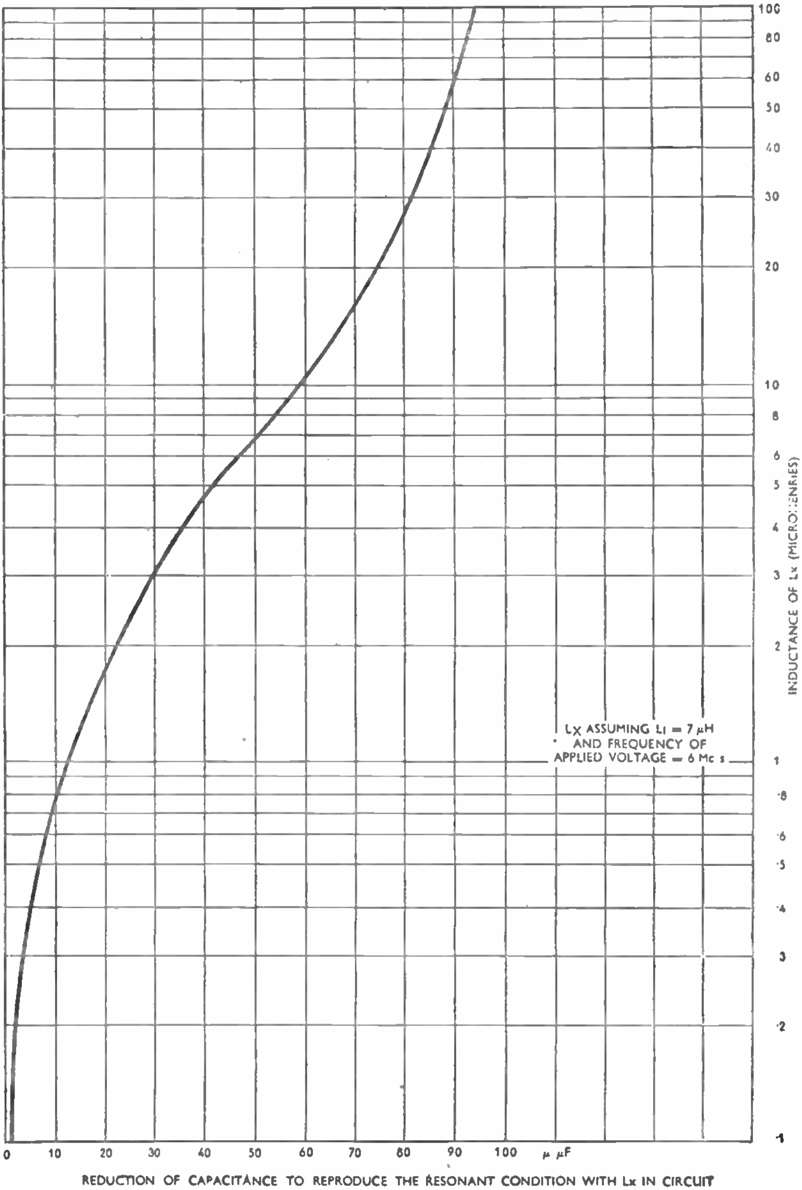


Fig. 84. INDUCTANCE OF IRON-CORED CHOKES

No. 41 LAMINATIONS (STALLOY)

2·5 IN. STACK (166 PAIRS ·014 IN.)



CONVERSION GRAPH FOR INDUCTANCE TESTER

Fig. 85. This chart is for use with the inductance measuring circuit shown in Fig. 76. The inductance of the coil under test is read off against the capacitance change necessary to produce resonance with the 6 Mc/s signal.

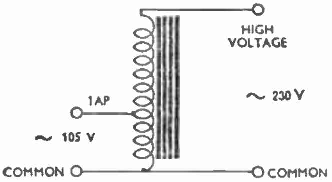


Fig. 86. An auto-transformer has a single tapped winding, as shown in this diagram.

105 volts would appear between the tap and the common terminal.

Since the secondary current flows through the primary turns, it has the effect of reducing the primary current. Therefore, a smaller gauge of wire can be employed for the section between the common terminal and the tap, the reduction being greater as the ratio of input to output voltage approaches unity.

The remaining calculations are as for the double-wound transformer. Find, first, W_s, then W_p, then A and TPV. Calculate I_p from $I_p=\frac{W_p}{E\,\text{(input)}}$, and effective I_p from I_p-I_s, where $I_s=\frac{W_s}{E\,\text{(output)}}$. Now select a suitable gauge of wire for the primary, in terms of the effective current (see Wire Tables, pages 59-64).

For an example, take an auto-transformer for operating a 230-volt receiver, requiring 120 watts from 105-volt AC supply at 50 c/s.

W_s=120 watts; efficiency=85 per cent.

$$W_p=\frac{120\times 100}{85}=140 \text{ watts.}$$

$$I_p=\frac{140}{105}=1{\cdot}33 \text{ amp.}$$

$$I_s=\frac{120}{230}=0{\cdot}53 \text{ amp.}$$

Approximate current from COMMON terminal to TAP=I_p-I_s=0·8 amp, requiring 21 SWG.

Approximate current from TAP to high-voltage terminal=I_s=0·53 amp, requiring 23 SWG.

$$A=\frac{140}{5{\cdot}7}=2{\cdot}0 \text{ sq. in.}$$

TPV=3·5.

Primary turns=380, requiring ·45 sq. in.

Secondary turns=440, requiring ·35 sq. in.

These turns could be accommodated on a 15-size lamination, having a core width of ·625, but this would require a stack of 3·25 in. In this instance, a better design would incorporate a 2-in. stack of No. 4A laminations, and the larger window area would permit the two windings to be carried out in 19 and 21 SWG respectively.

Construction and Testing. When assembling the core, the 'T' laminations should be placed in pairs from each end of the former alternately, and the 'U' pieces likewise.

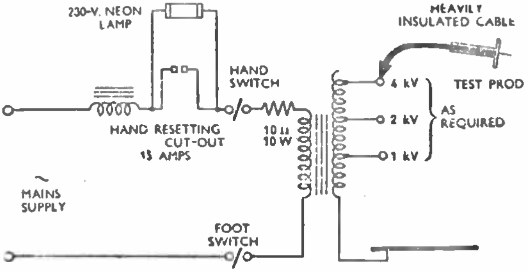


Fig. 87. Circuit for a high-voltage flash tester.

After the transformer has been assembled and bolted up, the magnetizing current should be measured. Approximate figures for this are given in Table XIX, but a variation of at least ± 25 per cent may be encountered, due to variation of stacking, depending upon whether a good magnetic joint has been made, also upon the quality of the iron, which varies from different manufacturers, and sometimes even between one maker's samples.

Assuming that the results of this test are satisfactory, the secondary

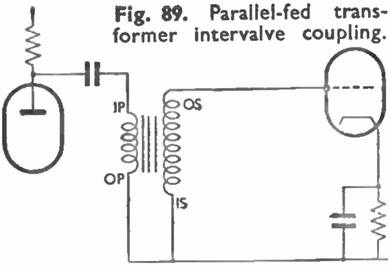


Fig. 89. Parallel-fed transformer intervalve coupling.

large for a Mu-metal core, the use of Radiometal is recommended. Fig. 92 gives the primary inductance for different windings on a core of 60 pairs of 24T Radiometal stampings.

Having chosen the core and the primary winding to give the necessary primary inductance and step-up ratio, the degree of interleaving of the windings can be decided. Usually, it is sufficient to wind on one-half of the secondary, then the primary winding, and lastly the remainder of the secondary. Care must be given to the interwinding insulation in view of the fact that the voltage between them may exceed the sum of the HT and the GB supplies.

From the foregoing it is seen that the step-up ratio of the normal intervalve transformer is largely controlled by the number of turns needed to obtain the specified primary inductance. For impedance matching, such as connecting a 600-ohm line, or a microphone to the grid circuit of a Class A amplifier, it is necessary to arrange the number of turns so that a correct match is obtained on both sides of the transformer. This is achieved when the ratio of the turns is the square root of the ratio of the impedances connected to the two windings.

Typical ratios are : carbon microphone to grid of Class A amplifier, 25 to 1 ; 600-ohm line to grid of Class A amplifier, 10 to 1.

Low - frequency Power Transformers. With low-frequency power transformers, in addition to the design requirements detailed above, to take into account the losses it is necessary to make an adjustment to the actual turns ratio.

First, the core dimensions are settled by reference to the charts to be found in the low-frequency choke section. The DC flowing controls the core size and gap, the required inductance being obtained as before from chart in Fig. 90. Since a secondary winding has to be wound in part of the space, it is necessary to limit the gauge of wire used for the primary, so that it occupies just less than one half of the total winding space.

Table XXI shows the maximum gauge of wire that may be employed.

Transformers of this type having an output of 5-20 watts, usually have an efficiency of 70 to 80 per cent. This implies that the secondary must be increased above the number of turns required for impedance matching. For the smallest transformers, this increase should be 20 per cent, but for the larger types, handling 20

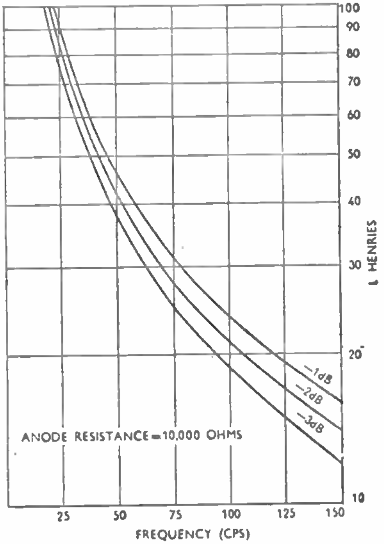


Fig. 90. This chart indicates the inductance necessary in an anode circuit to limit the loss at bass frequencies, as shown, to values indicated by the curves.

watts or more, the increase necessary will be about 12 per cent.

Push-pull Transformers. • Push-pull transformers are fundamentally similar to the single-circuit types just described. The input voltage transformer must provide two equal secondaries, and this precludes the use of the miniature core, unless a step-up ratio as low as 1·5 to 1 can be tolerated. Otherwise, the Radiometal core should be employed; alternatively, a larger Mu-metal assembly.

The push-pull output transformer has the advantage that the DC component in the two primary windings are in opposition magnetically. For production work with unmatched valves, it is usual to assume that the residual DC is 15 per cent of the normal DC component of one of the valves.

TABLE XXI

Gauge of wire (SWG) shown at foot of choke charts	Equivalent gauge SWG of wire for transformer use	Current-carrying capacity. DC-AC
20	22	1 A
22	26	370 mA
24	28	250 mA
26	30	180 mA
28	32	130 mA
30	34	100 mA
32	36	75 mA
34	38	45 mA
36	40	27 mA
38	42	18 mA
40	44	12 mA

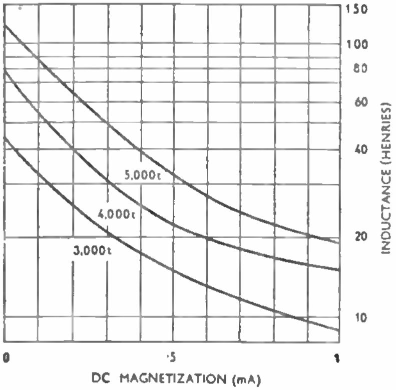
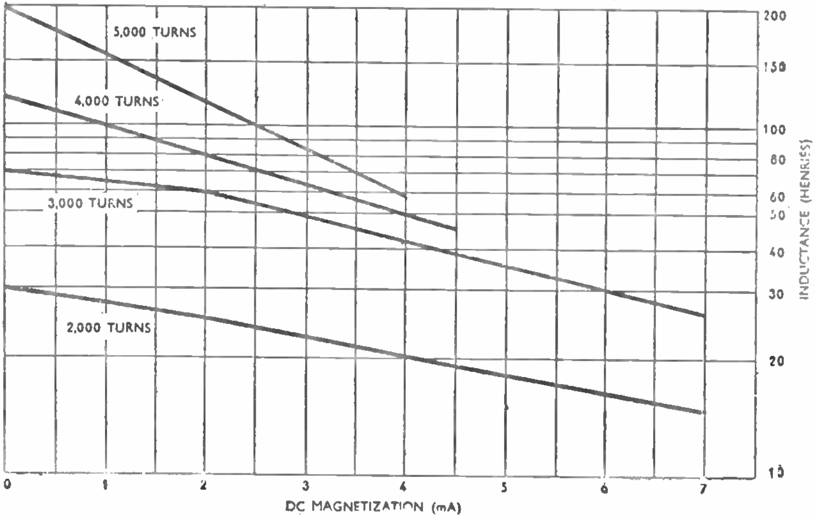


Fig. 91. (Left) How the primary inductance of three coils, all on 12 pairs of 31T Mu-metal stampings, varies with DC magnetization. **Fig. 92.** (Below) How the primary inductance of four coils, on 60 pairs of 24T Radiometal stampings, varies with DC magnetization.



not be exceeded, and at times a series voltage-dropping resistance is necessary. For example, in an RF or IF stage, the DC resistance of the anode load is negligible. If the available HT is 270 volts and the maximum permissible anode voltage is 200 with a current (at normal bias) of 10 mA, the voltage-dropping resistance is $\frac{270 - 200}{\cdot 01} = 7{,}000$ ohms.

In choke- or transformer-coupled LF stages, again the DC resistance of the coupling may be negligible.

With resistance-capacitance coupling, the anode load is a resistor which causes considerable HT drop. The larger the resistance value of the decoupling resistor R_1 (Fig. 97), the lower must be R_2 the anode load, if the HT at the anode is not to be too low.

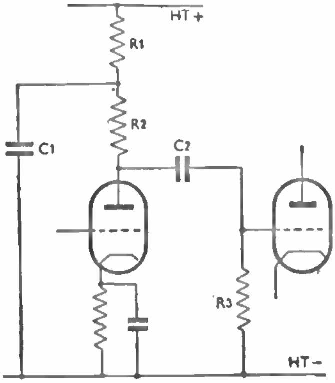


Fig. 97. Resistance-capacitance audio-frequency intervalve coupling. R_1C_1 form anode decoupling circuit.

The maximum permissible anode load resistance may be calculated, and then the smallest possible part of this allocated to the decoupling resistor. Experiment may be necessary.

$R = \frac{E_1 - E_2}{I}$, where R is total anode resistance, E_1 is HT, E_2 is working anode voltage, and I anode current (in amps), at the working anode voltage and corresponding bias.

Anode decoupling will probably be adequate if, at the lowest frequency, the reactance of the capacitor C_1 is one-tenth the resistance of the decoupling resistor. Normally, it is sufficient for C_1 to have a reactance one-fifth of this resistance. Suitable values are given in Table XXII.

TABLE XXII:

DECOUPLING CAPACITANCE

(μF)

Decoupling resistance (ohms)	Reactance at 50 c/s, ·2 of decoupling resistance	Reactance at 50 c/s, ·1 of decoupling resistance
5,000	6	3
10,000	3	1·5
15,000	1	·5

The capacitor must have a working voltage at least as high as that applied, and preferably higher.

Decoupling is not generally necessary unless there are more than two stages. In modern sets with electrolytic capacitors of small reactance providing excellent HT regulation, decoupling may not be needed even for five- and six-stage sets. The smoothing choke and capacitor can be regarded as decoupling all the stages. A voltage-regulated mains unit greatly decreases the effects of common coupling of stages in an amplifier.

The anode load resistance R_2 should be at least twice the AC resistance of the valve. Generally speaking, the higher the load the better, until the point is reached where the anode voltage becomes so low on increases of current due to the signal that amplification is lost.

The grid resistance of the valve R_3 (Fig. 97) must be high, as it is in parallel with R_2. The upper limit,

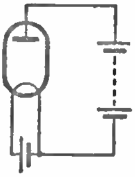


Fig. 98. Diode valve with filament and anode batteries.

so small that the consequent change of current ΔI makes ΔI proportional to ΔE, then we may write, $R_A = \frac{\Delta E_A}{\Delta I_A} = \frac{dE_A}{dI_A}$, showing that R_A is the slope of the curve at any given point on it, and is, therefore, called the *anode slope resistance* of the valve. Anode slope resistance must not be confused with the resistance of the valve considered as a conductor of electricity. The latter resistance, given certain electrode voltages, is the anode voltage divided by the anode current; the slope resistance is the inverse of the slope of the curve plotting anode current (x axis) and anode volts (y axis).

Anode slope conductance is the reciprocal of anode slope resistance.

Other definitions of terms, relevant to the diode as well as more complex forms of valves, are:

Schottky effect, a variation in the electrode current (anode current in the case of a diode) due to the lowering of the work function of the cathode with rise in anode voltage.

Shot effect is random variation in the emission of electrons from the cathode or for other causes. (The result is noise in high-magnification amplifiers.)

Flicker effect is fluctuation of the anode current, being a function of the nature of the cathode material causing variations in total emission. The effect is different from shot effect.

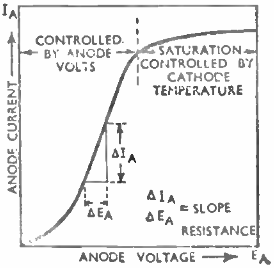


Fig. 99. How anode current of a diode varies with anode voltage.

Secondary emission is the liberation of electrons from an electrode caused by its bombardment by free electrons. Such electrons, released by bombardment, are called *secondary electrons.*

Triode Valve. (Figs. 100 and 101.) The triode valve contains an anode, a cathode, and a third electrode called a grid. The grid (Fig. 101) is placed between cathode and anode. Changes of voltage on the grid cause changes of anode current, the anode voltage remaining constant.

As the grid voltage is made more and more negative, more and more of the electrons emitted from the cathode are repelled and cannot escape to the anode. Therefore, the more negative the grid with respect to the cathode, the less the anode current. Fig. 100 plots the grid-cathode volts against resulting anode current.

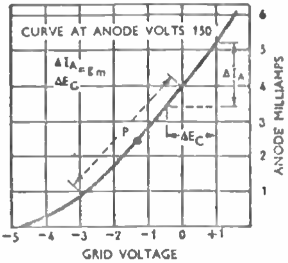


Fig. 100. Anode current/grid voltage curve of a triode valve.

Suppose the grid voltage is changed by an amount ΔE_G (Fig. 100) so small that there is a proportionate increase of anode current ΔI_A (no impedance or resistance in the anode circuit tending to prevent this current rising). Now let the anode voltage be changed by an amount ΔE_A to restore the same anode current as existed before the grid voltage was changed.

The *voltage factor* of a valve is defined as the ratio of the change in

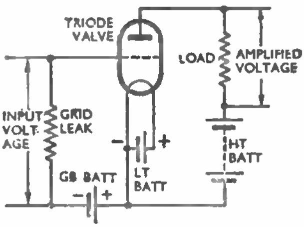


Fig. 101. Basic circuit for the use of a triode as an amplifier.

one electrode voltage to the change in another electrode voltage, to maintain a specified current unchanged, all other electrode voltages remaining constant, so that the *amplification factor* of a triode is the voltage factor of the anode and grid, the anode current remaining unchanged.

Thus one may write μ, the amplification factor, as, $\mu = \frac{\Delta E_A}{\Delta E_G} = \frac{dE_A}{dE_G}$.

The term *transconductance* from one electrode to another is strictly the quotient of the in-phase component of the short-circuit alternating current of the second electrode, divided by the alternating voltage on the first electrode, all other electrode voltages remaining constant.

Mutual conductance, usually symbolized as g_m, is the control-grid to anode transconductance, and we may write that, $g_m = \frac{\Delta I_A}{\Delta E_G}$, namely, the ratio of the small change of anode current given by a small change of grid voltage, the changes being so small that current is proportional to voltage. Thus g_m is expressed in current per potential, or, in practice, milliamps per volt. But $R_A = \frac{\Delta E_A}{\Delta I_A}$, while $g_m = \frac{\Delta I_A}{\Delta E_G}$, so that $g_m R_A = \frac{\Delta E_A}{\Delta E_G} = \mu$, or $g_m = \frac{\mu}{R_A}$.

If an impedance, say, a resistance, is connected in the anode circuit, then a change of grid volts produces a change of anode current, hence a voltage drop in the resistance, hence a change in anode voltage, and the valve acts as a voltage magnifier, but this magnification *m* is the value that, while related to μ, is not, in fact, μ, depending as it does upon the value of the anode resistance, or, with alternating voltages, upon the anode impedance. This is sometimes called a magnification factor, or '*m* value', or *stage gain* of a valve and its associated circuit.

Triode as amplifier. (Figs. 101, 102, 103 and 104.) The basic circuit of a triode used as an amplifier is shown in Fig. 101. The so-called grid-leak resistor has the function of allowing the electrons (which would, if it were insulated, accumulate on the grid, causing it to be more and more negatively charged) to leak back to cathode.

If an alternating voltage be applied between grid and cathode, an alternating anode current flows, producing a magnified alternating voltage across the anode resistor.

The steady grid potential is made more negative than the cathode and the peak signal voltage is usually less than this grid-bias voltage, so that the grid never becomes more positive than the cathode. If the grid is positive with respect to cathode, a

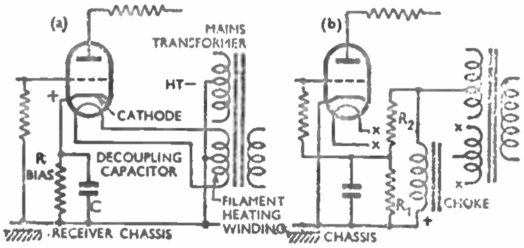


Fig. 102. Indirectly-heated mains-type valves usually have 'automatic' bias, either by (a) cathode resistor or (b) voltage dropper in HT negative of set.

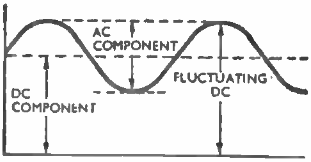


Fig. 103. Fluctuating DC in an anode circuit is equivalent to steady DC plus an AC component.

grid current flows and in so doing represents a resistance which is only finite when the grid is more positive than the cathode. This may cause a distortion of the input voltage and consequent distortion of the amplified voltage.

Grid bias may be supplied by a battery, as in Fig. 101, or by connecting a resistance in the cathode return circuit so that the steady anode current flowing in this resistance raises the cathode to a greater positive potential than the grid. This is equivalent to making the grid more negative than the cathode.

If it be desired to maintain the cathode at a steady positive potential, then the capacitor *C* is used to prevent the alternations of intensity of the anode current producing an alternating potential on the cathode. The reactance of *C* must be $\ll$ than the resistance of *R* at all frequencies amplified by the triode to maintain this condition. If *C* is removed, current feed-back takes place.

In Fig. 103 is shown the superimposition of the variations of anode current due to alternating potentials on the grid of the valve on the steady current flowing when the grid voltage is fixed. Thus the anode current contains an alternating plus a direct component.

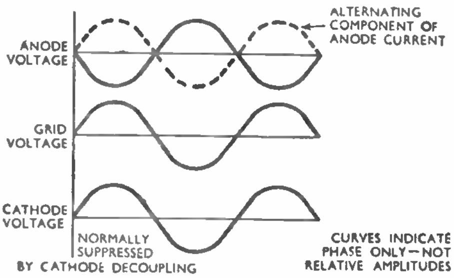


Fig. 104. Voltage and current phase relationships in a triode amplifier.

The phase of the anode voltage and anode current in an amplifying valve having pure resistance in its anode circuit is shown in Fig. 104. The anode voltage is seen to be 180° out of phase with the grid voltage.

If the capacitor *C* in Fig. 102 is omitted, the cathode potential varies in phase with the grid potential, lowering the magnification factor of the system and producing current feed-back. This reduces distortion. The diagram is not to scale.

The phase relationships shown do not exist when the anode load is sensibly reactive.

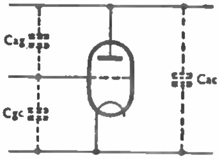


Fig. 105. Capacitances between electrodes in a triode are equivalent to capacitors connected as shown.

Miller effect. (Fig. 105.) The electrodes in a valve have capacitance, which may be expressed as the capacitance between any two electrodes and is called *inter-electrode* capacitance. The effective value of this inter-electrode capacitance is increased because the voltages are amplified on certain electrodes.

In a triode, if C_{gc} is the capacitance between grid and cathode, and C_{ag} the capacitance between grid and anode, then the effective capacitance at the grid cathode electrodes (the input, in fact) is $C_{gc} + (M + 1)\ C_{ag}$, where *M* is the stage gain.

The impedance of the anode load makes an effect upon the input circuit because of the enhanced inter-electrode capacitance in the valve. This is called *Miller effect*, and can be expressed

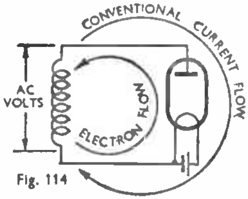


Fig. 114

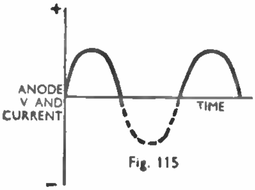


Fig. 115

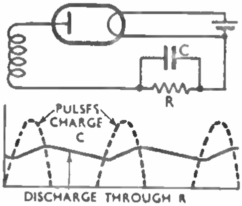


Fig. 116

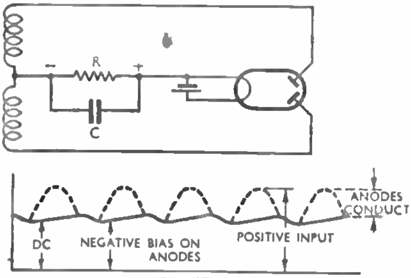


Fig. 117

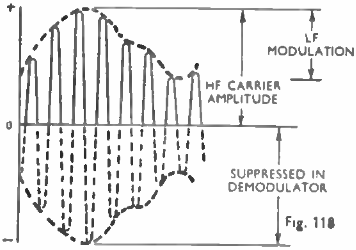


Fig. 118

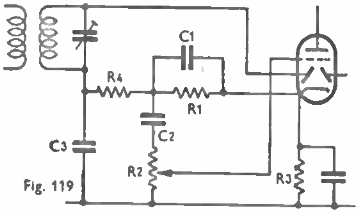


Fig. 119

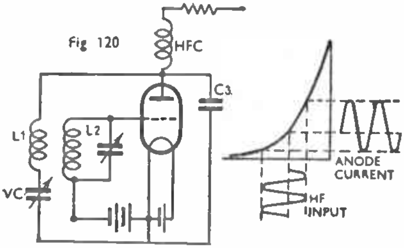


Fig 120

CIRCUITS FOR RECTIFICATION AND DEMODULATION

Figs. 114, 115. Illustrating the principle of rectification. **Fig. 116.** Use of filter. **Fig. 117.** Full-wave rectifier. **Fig. 118.** Principle of demodulation. **Fig. 119.** Using diode for demodulation. **Fig. 120.** Anode-bend 'detection'.

which is vaporized when the valve is operated. Ionization occurs (shown by a bluish-green glow) and a heavy current passes. The valve is used as a rectifier where outputs larger than those given by hard valves are needed. The drop between anode and cathode is only about 15 volts, and varies very little with the current demand.

Ionic Bombardment

In the 'cold cathode' or 'ionic-heated cathode' rectifier or relay valve, the bulb contains a reduced pressure of inert gas. The ions bombard the cathode and heat it; no other heat is applied. The ionic flow may be initiated by use of a starter anode causing a glow discharge.

Fig. 113 shows this valve as a relay operated by a radio transmission. In the quiescent condition, R_1 and R_2 provide the starting anode with a voltage just below the striking value. When a transmission energizes the tuned circuit L_c, the resonant voltage adds to the applied voltage, and the starting anode begins a glow discharge to the cathode. This discharge produces ions which lower the resistance of the valve so that current flows through the main anode and operates the relay. As the supply is AC, operation stops when the transmission ceases.

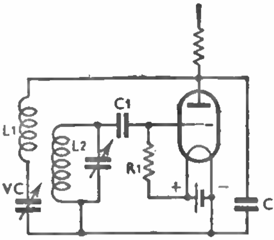


Fig. 121

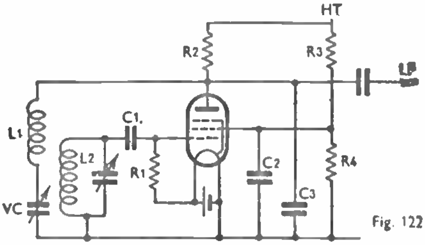


Fig. 122

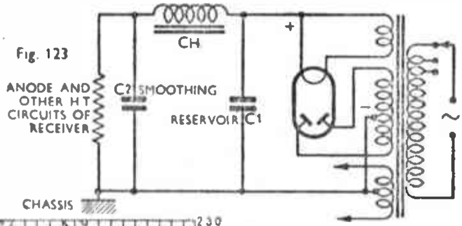


Fig. 123

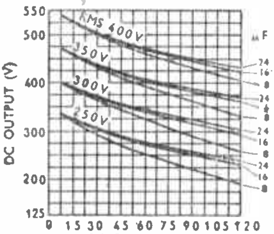


Fig. 124

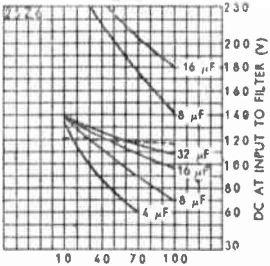


Fig. 125

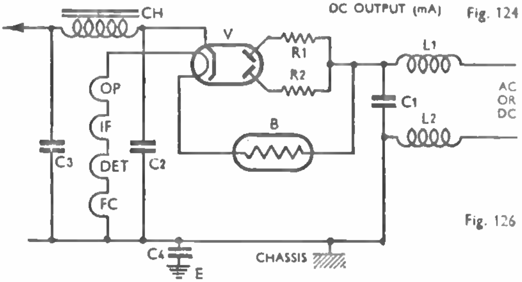


Fig. 126

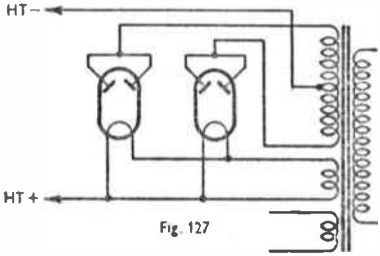


Fig. 127

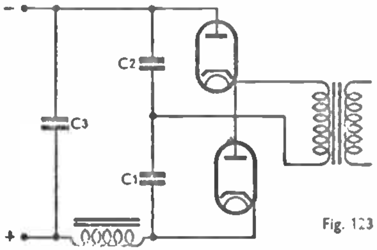


Fig. 123

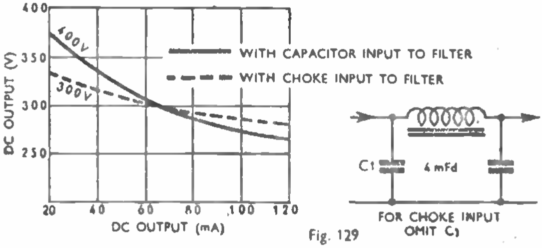


Fig. 129

Fig. 121. Leaky grid detection. **Fig. 122.** Pentode detector. **Figs. 123-129** illustrate various methods of mains rectification using diode and double-diode valves.

TABLE XXVI: CHARACTERISTICS OF TYPICAL RECTIFIERS

Showing regulation and effect of reservoir capacitance

Type of Valve and Heater Rating	Type of Cathode	Normal RMS Input to Anode	Reservoir Capacitance (mFds)	Smoothing Inductance (H)	DC Output			
					mA	Volts	mA	Volts
Full-wave, 4 volts 2 amps	IDH	350–0–350	8	25 upward	120	325	60	390
			16	"	120	365	60	405
			24 (max)	"	120	370	60	410
Full-wave, 4 volts 2·5 amps	DH	350–0–350	16 (max)	"	120	385	60	420
Two-path full-wave, 25 volts ·3 amp	IDH	225	8		120	160	60	220
			16	"	120	200	60	235
			24 (max)		120	205	60	240
Two-path full-wave, 25 volts ·3 amp	IDH	125	8	20 – 30	100	70	40	110
	IDH		32 (max)	20 – 30	100	110	40	125

tance approximately as follows: 8 μF, 50 ohms; 16 μF, 75 ohms; 32 μF, 1,250 ohms.

All the valve heaters are in series, and the detector is placed at the low potential end (chassis) to reduce noise. *B* is a barretter to control the heater current and may be replaced by a tapped adjustment resistor.

Regulation. A rectifier circuit with good regulation is one in which there is little change of output voltage with alteration of load current. Change of output voltage with output current is due to the internal resistance of the valve, transformer, etc., the whole circuit being in the nature of a voltage source with internal impedance (largely resistance if the transformer has little leakage inductance).

The value of this equivalent resistance is approximately $R = R_S + \left(\frac{R_2}{R_1}\right)^2 R_P$, where R_S is resistance of secondary, $\frac{R_2}{R_1}$ is step-up ratio of primary to secondary, and R_P is resistance of primary.

With a DC input as in an AC-DC set on DC, voltage drop across the rectifier is as low as, approximately, 5-25 volts with normal loads.

The apparent increase of voltage in AC circuits at certain reservoir capacitances and loads, is because the input is stated in RMS, and the peak voltage across the valve is greater by $\sqrt{2} = 1{\cdot}41$ times.

Increase of reservoir capacitance means that the valve works into a lower impedance; that is, the charging pulses become larger. This increases the output; but the charging pulses must not exceed the safe saturation emission of the rectifier valve. To limit the charging pulses, a choke input may be employed (Fig. 129).

Peak Inverse Voltage of a rectifier is the highest voltage it can safely stand, in the direction opposite to conduction. This inverse voltage is applied during that part of each cycle when the input voltage is opposite to the voltage across the reservoir capacitor during 'negative' half-cycles of input.

VALVE OSCILLATORS

A valve may be used to set up alternating currents in a parallel tuned circuit, the frequency of the currents being determined by the constants of the tuned circuit and being equal to or nearly equal to the resonance frequency of the tuned circuit.

The alternating currents caused to flow in the tuned circuit are called *oscillating currents*, or *oscillations*, and the valve and associated circuits

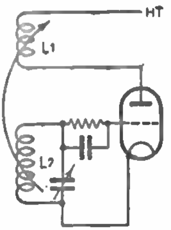


Fig. 131 (a)

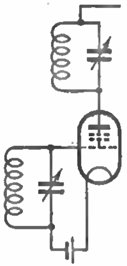


Fig. 131 (b)

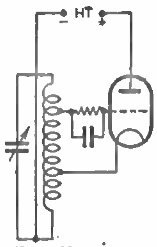


Fig. 132 (a)

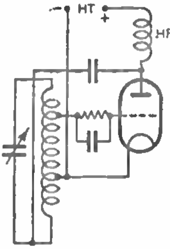


Fig. 132 (b)

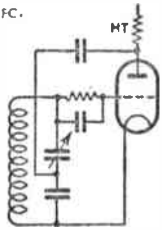


Fig. 132 (c)

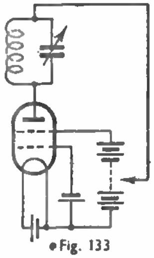


Fig. 133

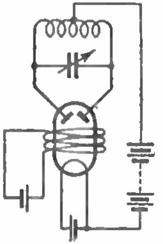


Fig. 134

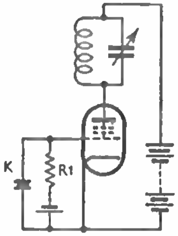


Fig. 135

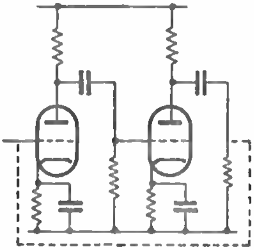


Fig. 136

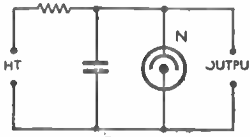


Fig. 137

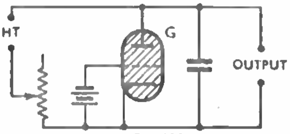


Fig. 138

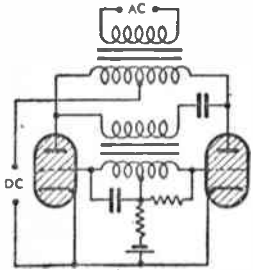


Fig. 139

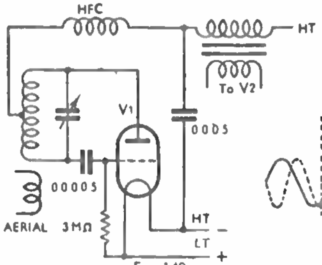


Fig. 140

Fig. 141

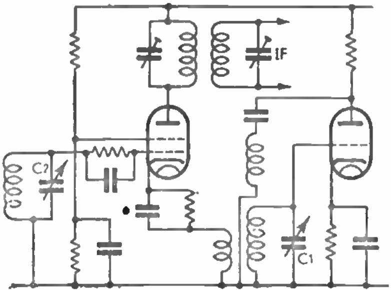


Fig. 142 (a)

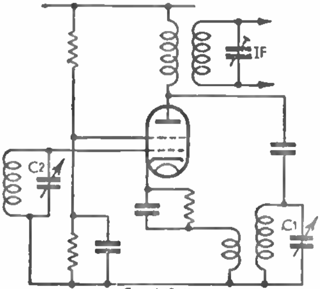


Fig. 142 (b)

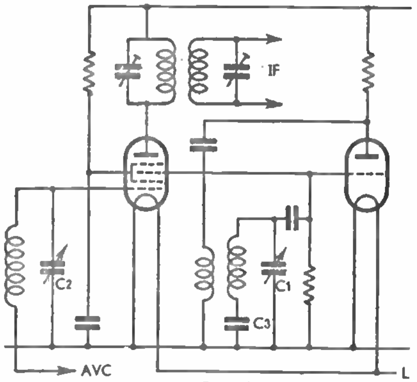


Fig. 143

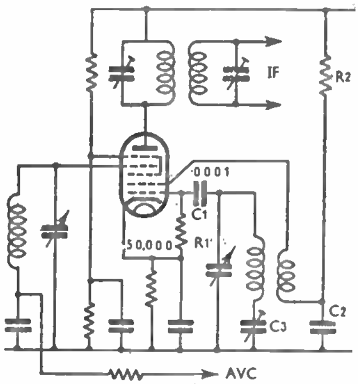


Fig. 144

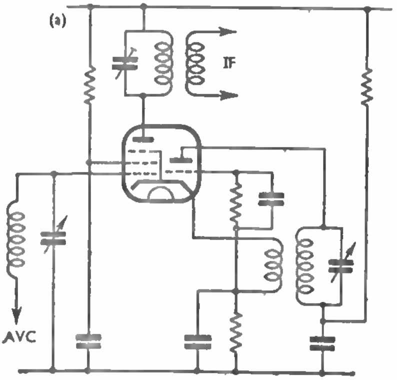


Fig. 145 (a)

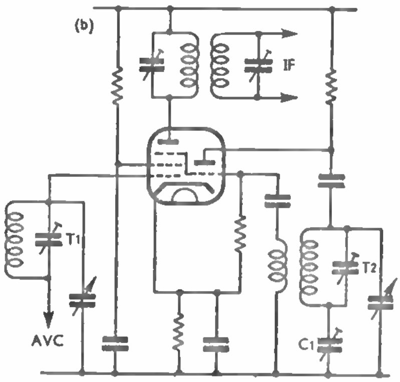


Fig. 145 (b)

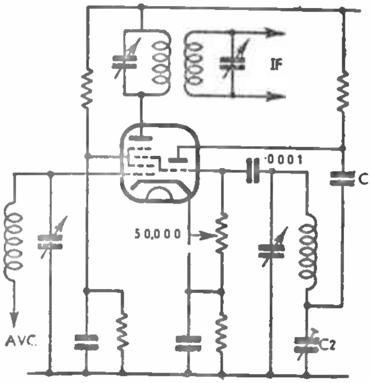


Fig. 146

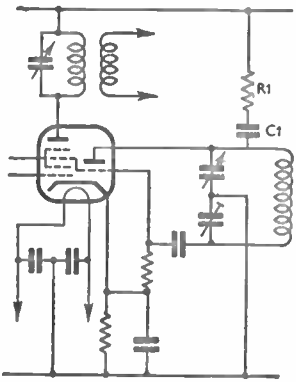


Fig. 147

Figs. 131-147. CIRCUITS WHICH INCORPORATE OSCILLATORS possible for a given harmonic content. Intermediate conditions apply, so there is no hard-and-fast distinction between the two types of amplification.

Fig. 148 shows a single-valve amplifier. Considering the valve as a source having an internal impedance R_A and an EMF μE_g, μ being the amplification factor of the valve, a voltage E being developed across the load resistance, then,

$$\frac{E}{\mu E_g} = \frac{R_L}{R_A + R_L}, \text{ or}$$

$$\text{Voltage gain} = \frac{\mu R_L}{R_A + R_L} = g_m \frac{R_A R_L}{R_A + R_L},$$

where $g_m = \frac{\mu}{R_A}$ is the mutual conductance of the valve.

The power output is, $\frac{\mu^2 E_g^2 R_L}{(R_A + R_L)^2}$, a limit being set to the value of E_g by the increasing harmonic distortion as E_g is increased beyond a given value.

With a certain HT voltage, R_L cannot be increased indefinitely without lowering the anode volts and so reducing g_m (i.e. increasing R_A). The HT voltage cannot be increased beyond certain limits for fear of too large voltages damaging the valve.

Fig. 149 differs only from Fig. 148 in that the anode impedance in Fig. 149 is a tuned circuit. If the grid-cathode voltages (which are the same as the grid-earth voltages if the cathode bias capacitor has negligible reactance at the relevant frequencies) are equal to the resonance frequency of the tuned circuit, the voltage amplification is, $\frac{\mu R_D}{R_A + R_D}$, where R_D is the resistive impedance of the tuned circuit at resonance, i.e. $R_D = \frac{L}{CR_0} = \omega_0 L Q_0 = \frac{\omega_0^2 L^2}{R_0}$, where L and C are the values of the inductor and capacitor respectively which form the parallel tuned circuit, R_0 is the high-frequency resistance of the inductor, while $\omega_0 = 2\pi f_0$, where f_0 is the resonance frequency and $Q_0 = \frac{\omega_0 L}{R_1}$.

If $R_D \gg R_A$ (the inductor having a large value and a large Q value), then the amplification of the circuit of Fig. 149 is approximately μ. If $R_D \ll R_A$, then the amplification is approximately $g_m R_D$, where g_m is the mutual conductance of the valve.

The input capacitance of the valve (a highly important factor in high-frequency amplification) is, $C_C = C_G + (A + 1)\, C_A$, where C_C is the input, C_G the grid to cathode and C_A the grid to anode capacitance, A being the stage gain. The larger is A, the greater is C_C, the percentage increase depending upon the ratio C_A to C_G.

The selectivity of the amplifier, measured as the variation of the grid input volts with the consequent variation of anode volts for small changes of frequency, $\Delta f = \frac{\Delta\omega}{2\pi}$, which small frequencies are added to or subtracted from the resonance frequency, namely, $f_0 = \frac{\omega_0}{2\pi}$, is given by,

$$\frac{1}{1 + \frac{R_A}{\omega_0 L}\left\{\frac{1}{Q_0} + j\frac{2\Delta\omega}{\omega_0}\right\}},$$

showing that for maximum selectivity R_A should be $\gg \omega_0 L$, and $Q_0 = \frac{\omega_0 L}{R_0}$ should be as great as possible.

Transformer coupling is used in the two-valve amplifier of Fig. 150a, and the effective anode impedance $\omega_0 L$ can be increased or decreased as desired by making the turns ratio L_C to L greater or smaller respectively, and so, with a constant R_A, reducing or increasing selectivity.

In Fig. 150b a band-pass filter circuit is used. The characteristics of this filter have already been discussed (see Tuned Circuits).

Multi-valve Amplifiers. Fig. 150a and Fig. 150b are representative of multi-valve high-frequency amplicauses some considerable falling away of response at the higher frequencies.

An auto-transformer connection is shown in Fig. 154; it presents no particular advantages and the general observations made in the foregoing apply, if not exactly, at least in degree.

OUTPUT STAGE

Quite different considerations apply when considering the valve as a means to supply power, with reasonable efficiency, to a load such as a loudspeaker (Fig. 155a).

Provided the grid-cathode voltage does not exceed a value at which tolerable distortion exists in the output, the stages preceding the power (or output) stage exist to give the greatest possible voltage magnification consistent with a low distortion factor. The output stage must be designed for maximum power output and a given value of distortion.

Class A Operation. In so-called Class A valve-operation the anode current flows at all times during the entire electrical cycle; this condition is illustrated in Fig. 155b for a circuit such as that of Fig. 155a, the former figure (of the dynamic characteristic curve of anode current against grid volts) showing that the steady grid bias is symmetrical with respect to the total grid swing.

The dynamic characteristic is one

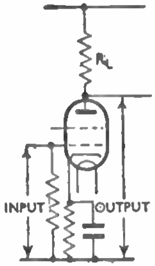


Fig. 148

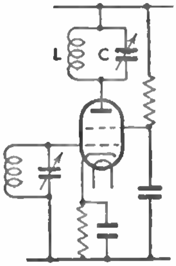


Fig. 149

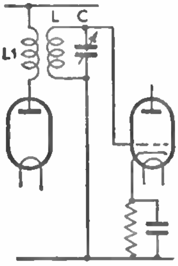


Fig. 150 (a)

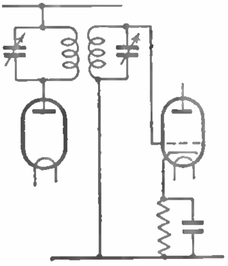


Fig. 150 (b)

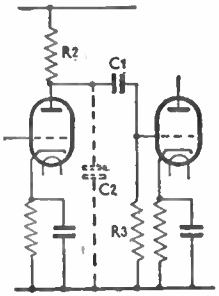


Fig. 151

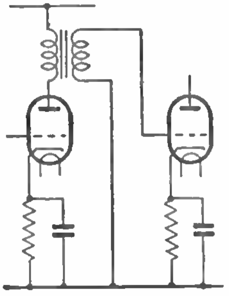


Fig. 152

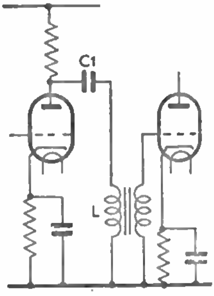


Fig. 153

BASIC VALVE COUPLING CIRCUITS FOR HF AND LF

Fig. 148. Essentials of a valve amplifier stage with automatic bias. **Fig. 149.** Development of Fig. 148 with tuned circuits as anode and grid loads. **Fig. 150.** Two forms of HF intervalve coupling. (a) Single tuned transformer and (b) transformer with both primary and secondary tuned. **Fig. 151.** Resistance-capacitance intervalve coupling; stray capacitance C_2 prevents HF use. **Fig. 152.** Audio-frequency transformer intervalve coupling. **Fig. 153.** Parallel-fed transformer coupling.

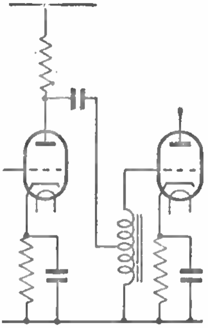


Fig. 154

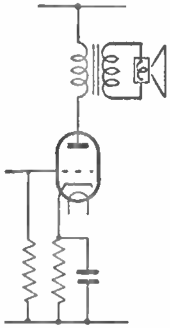


Fig. 155 (a)

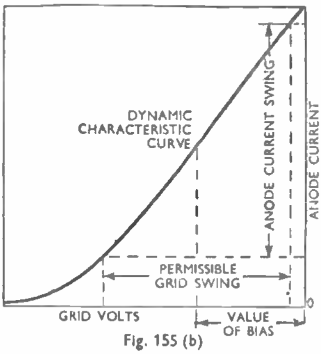


Fig. 155 (b)

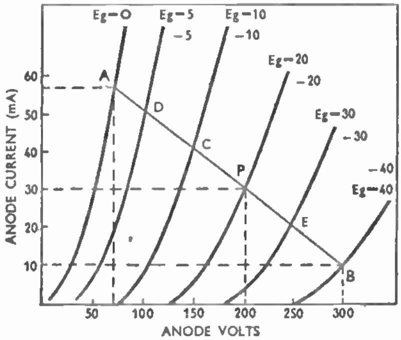


Fig. 156 (a)

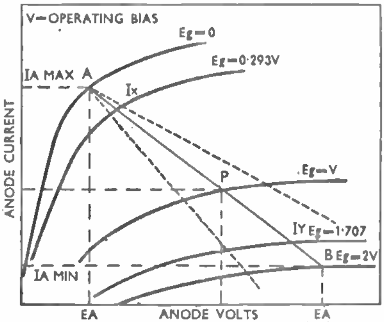


Fig. 156 (b)

COUPLING CIRCUITS AND OUTPUT VALVE LOADING

Fig. 154. Parallel-fed auto-transformer coupling. **Fig. 155.** (a) Output stage delivers power to loudspeaker through a matching transformer. (b) In Class A operation, a valve is biased to the centre of the straight part of its characteristic. **Fig. 156.** To get maximum power with minimum distortion, an optimum value of load is necessary. These are load curves for (a) a triode and (b) a pentode.

representing the relationship between grid volts and anode current where an impedance of a resistive nature but not necessarily a resistor is connected in the anode circuit.

The permissible grid swing is that over which the relationship between grid volts and anode current is linear, or substantially so, so that harmonic distortion is minimized.

A valve, as has been previously shown, may be considered for many practical cases as a source of power containing an EMF μE_g and an internal resistance R_A and, therefore (see Matching), the maximum power is delivered to a load of resistance R_L when $R_L = R_A$.

Since the maximum power output is $\frac{\mu^2 E_g{}^2 R_L}{(R_L + R_A)}$, therefore, when $R_L = R_A$, it is $\frac{\mu^2 E_g{}^2}{4R_A} = \frac{g_m{}^2 R_A E_g}{4}$.

As μ is increased, so the maximum value of E_g, to avoid distortion, is decreased, so that it cannot be said that a valve with a larger value of μ gives a greater power output; each case must be studied in detail and particularly with reference to the amount of distortion which appears under any given set of conditions.

In the foregoing, the case was considered in which R_L was made equal to R_A. It is possible to achieve this condition in a triode but not with a pentode, because R_A, in this latter case, is so large. But even with a

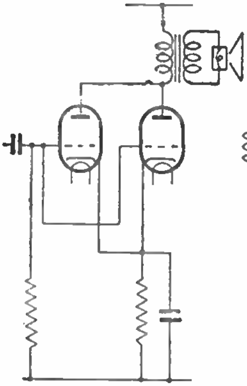


Fig 157

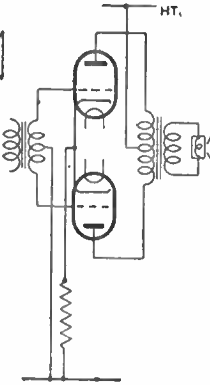


Fig. 158

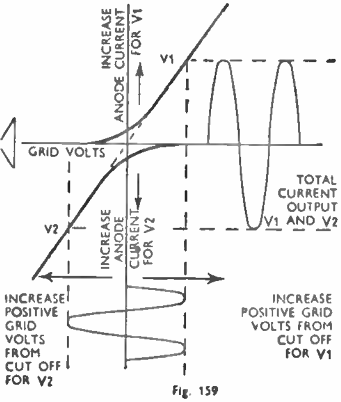


Fig. 159

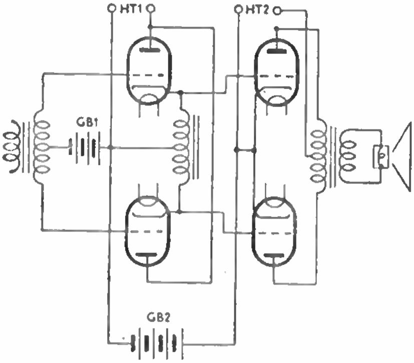


Fig. 160

Fig. 157. Output valves connected in parallel. **Fig. 158.** Transformer-fed push-pull output stage. **Fig. 159.** Graphical representation of push-pull operation. **Fig. 160.** Push-pull stage cathode-coupled to a push-pull output stage. **Fig. 161.** RC coupling to push-pull output using paraphase stages. **Fig. 162.** Two methods of connecting a 'phase splitter' valve when using resistance-capacitance coupling to push-pull valves.

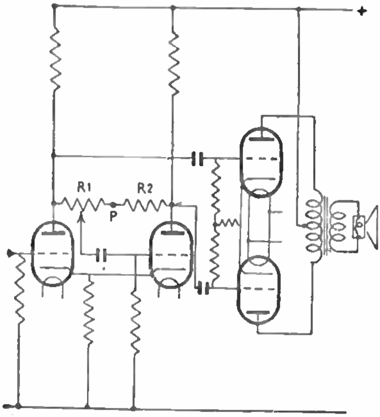


Fig. 161

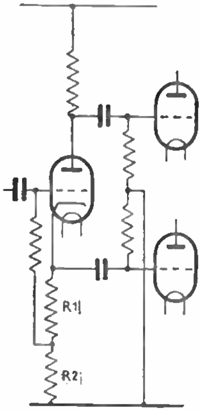


Fig. 162 (a)

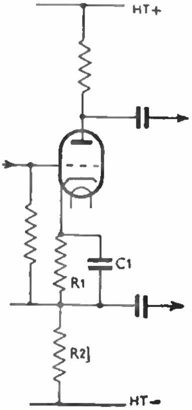


Fig. 162 (b)

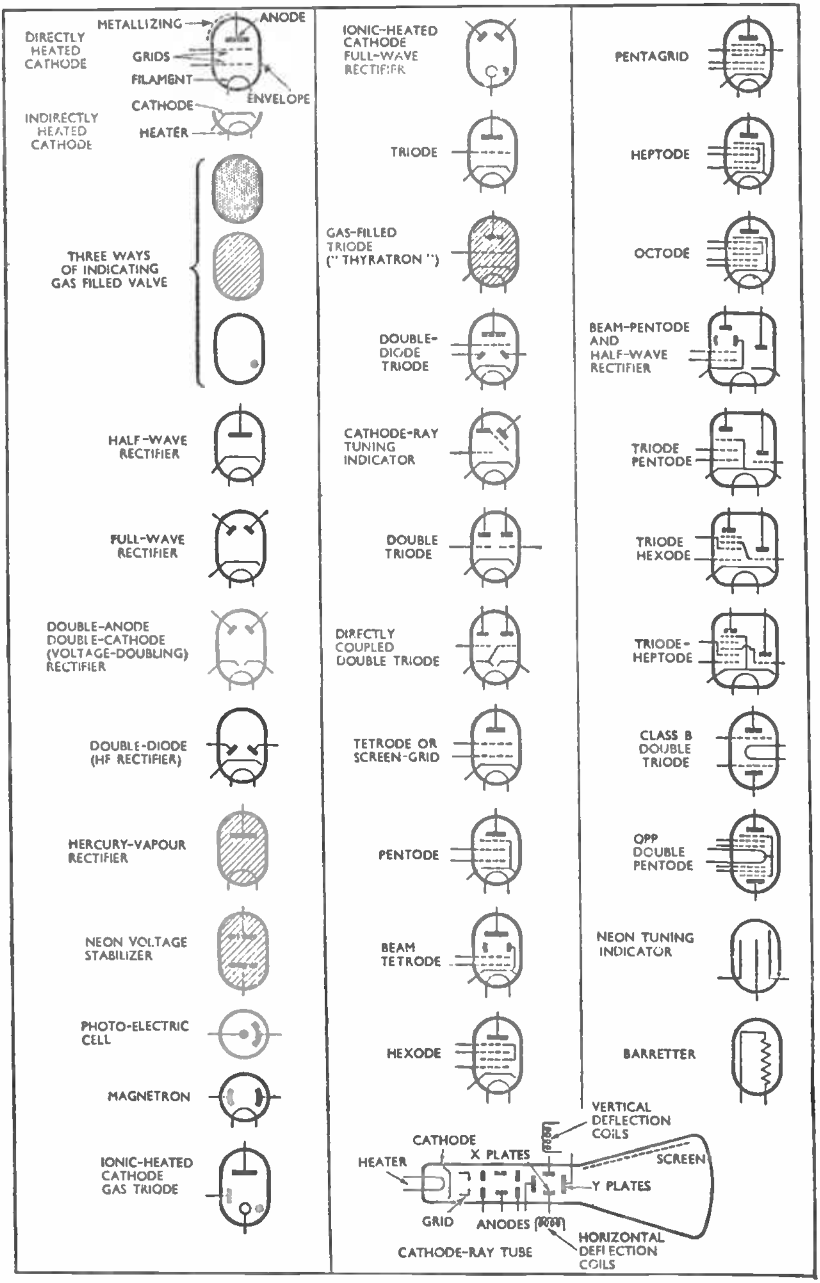

DIRECTLY HEATED CATHODE
METALLIZING
ANODE
GRIDS
FILAMENT
ENVELOPE
INDIRECTLY HEATED CATHODE
CATHODE
HEATER
THREE WAYS OF INDICATING GAS FILLED VALVE
HALF-WAVE RECTIFIER
FULL-WAVE RECTIFIER
DOUBLE-ANODE DOUBLE-CATHODE (VOLTAGE-DOUBLING) RECTIFIER
DOUBLE-DIODE (HF RECTIFIER)
MERCURY-VAPOUR RECTIFIER
NEON VOLTAGE STABILIZER
PHOTO-ELECTRIC CELL
MAGNETRON
IONIC-HEATED CATHODE GAS TRIODE
IONIC-HEATED CATHODE FULL-WAVE RECTIFIER
TRIODE
GAS-FILLED TRIODE (" THYRATRON ")
DOUBLE-DIODE TRIODE
CATHODE-RAY TUNING INDICATOR
DOUBLE TRIODE
DIRECTLY COUPLED DOUBLE TRIODE
TETRODE OR SCREEN-GRID
PENTODE
BEAM TETRODE
HEXODE
PENTAGRID
HEPTODE
OCTODE
BEAM-PENTODE AND HALF-WAVE RECTIFIER
TRIODE PENTODE
TRIODE HEXODE
TRIODE-HEPTODE
CLASS B DOUBLE TRIODE
QPP DOUBLE PENTODE
NEON TUNING INDICATOR
BARRETTER
VERTICAL DEFLECTION COILS
CATHODE
X PLATES
HEATER
SCREEN
Y PLATES
GRID
ANODES
HORIZONTAL DEFLECTION COILS
CATHODE-RAY TUBE

TABLE XXVII: FREQUENCY CHANGERS—*continued*

Make	Type	Description	Base	Fil. Volts	Fil. Amps	Anode Volts	Screen Volts	Oscillator Volts	Conv. Condct. Mhos	Bias Volts
MAZDA—*continued*	TH233	Triode Hexode	0M26	23·0	0·2	250	250	150	640	–3
	TP2620	Triode Pentode	9B5	26·0	0·2	250	250	200	650	–5
MULLARD	DK1	Heptode ..	8S10	1·4	0·05	90	90	45	250	0
	TH2	Triode Hexode	7B10	2·0	0·23	135	60	—	430	–5·0
	FC2	Octode ..	7B8	2·0	0·1	135	70	70	200	0
	FC2A	Octode ..	7B8	2·0	0·13	135	45	45	270	–0·5
	TH4	Triode Hexode	7B37	4·0	1·0	250	70	—	1,000	–1·5
	TH4A	Triode Hexode	7B37	4·0	1·45	250	100	100	750	–2·0
	TH4B	TriodeHeptode	7B37	4·0	1·45	250	100	—	750	–2·5
	FC4	Octode ..	7B36	4·0	0·65	250	90	70	600	–1·5
	ECH3/33	Triode Hexode	8S29/058	6·3	0·2	250	100	—	650	–2·0
	ECH35	Triode Hexode	058	6·3	0·3	250	100	—	650	–2·0
	EK2	Octode ..	8S28	6·3	0·2	250	200	50	550	–2·0
	EK3	Octode ..	8S28	6·3	0·72	250	100	—	650	–2·5
	CCH35	Triode Hexode	058	7·0	0·2	250	100	—	650	–2·0
	FC13	Octode ..	8S28	13·0	0·2	200	90	70	600	–1·5
	FC13C	Octode ..	7B36	13·0	0·2	200	90	70	600	–1·5
	TH13C	Triode Hexode	7B37	13·0	0·31	250	70	180	1,000	–1·5
	TH21C	Triode Hexode	7B37	21·0	0·2	250	70	—	1,000	–1·5
	TH22C	Triode Hexode	7B37	29·0	0·2	250	150	100	—	—
	TH30C	Triode Heptode	7B38	29·0	0·2	250	100	—	750	–2·5
OSRAM ..	X14	Heptode ..	010	1·4	0·05	110	60	—	250	—
	X21	Heptode ..	7B9	2·0	0·1	150	70	—	240	—
	X22	Heptode ..	7B9	2·0	0·15	150	70	150	350	0
	X23	Triode Hexode	7B10	2·0	0·3	150	60	150	250	–1·5
	X24	Triode Hexode	7B10	2·0	0·2	150	60	150	350	–1·5
	MX40	Heptode ..	7B35	4·0	1·0	250	100	250	500	–3·0
	X41	Triode Hexode	7B37	4·0	1·2	250	70	250	640	–1·5
	X42	Heptode ..	7B35	4·0	0·6	250	100	—	490	—
	X73M	Heptode ..	058	6·0	0·16	250	80	250	500	–3·0
	X61M	Triode Hexode	058	6·3	0·3	250	100	—	620	—
	X62	Triode Hexode	058	6·3	1·27	250	120	250	1,750	–1·5
	X63	Heptode ..	054	6·3	0·3	250	100	250	490	–3·0
	X64	Hexode ..	035	6·3	0·3	250	150	—	310	–6·0
	X65	Triode Hexode	058	6·3	0·3	250	100	250	225	–3·0
	X30/32	Heptode ..	7B35	13·0	0·3	250	100	—	800	—
	X31	Triode Hexode	7B37	13·0	0·3	250	80	150	640	–1·5
	X71M	Triode Hexode	058	13·0	0·16	250	100	—	520	—
	X75	Triode Hexode	058	15·0	0·16	250	100	250	225	–3·0
RECORD ..	OC2	Octode ..	7B8	2·0	0·13	135	45	135	270	–1–12
	AC/OC4	Octode ..	7B37	4·0	0·65	250	70	90	700	–1·5–25
	AC/TH4	Triode Hexode	7B37	4·0	1·0	300	80	150	1,000	–1·5–25
	OC/13	Octode ..	7B36	13·0	0·2	200	70	90	600	–1·5–25
	OC/13L	Octode ..	8S28	13·0	0·2	200	70	90	600	–1·5–25
	TH/21DA	Triode Hexode	7B37	21·0	0·2	200	80	150	1,000	–1·5–25
TRIOTRON	O202	Octode ..	7B8	2·0	0·13	135	45	—	250	0–12
	O406	Octode ..	7B36	4·0	0·65	250	70	—	600	–1·5
	TH401	Triode Hexode	7B37	4·0	1·0	300	150	—	750	–2·0
	O1307	Octode	7B36	13·0	0·2	200	70	—	600	–1·5–25
TUNGSRAM	VX2	Hexode ..	7B5	2·0	0·135	135	60	—	300	–1
	V02/S	Octode ..	7B9/8S11	2·0	0·13	135	45	135	270	—
	TH4A/B	TriodeHeptode	7B38	4·0	1·5	275	100	100	750	–2·5
	TX4	Triode Hexode	7B37	4·0	1·0	250	80	150	1,000	–1·5
	V04/S	Octode ..	7B36/8S28	4·0	0·65	250	70	90	600	1·5–25
	V06S	Octode ..	8S28	6·3	0·2	250	50	200	450	–2–25
	VX6S	Hexode ..	8S29	6·3	0·2	250	150	—	350	–3–25
	6E89	Triode Hexode	058	6·3	0·3	250	100	150	650	–2
	6TH8G	Triode Hexode	058	6·3	0·6	250	100	150	1,000	–1·5–25
	ECH11	Triode Hexode	0F5	6·3	0·2	250	100	150	650	–2
	ECH2	TriodeHeptode	8S29	6·3	0·95	250	100	100	750	–2·5
	ECH3/33	Triode Hexode	8S29/058	6·3	0·2	250	100	150	650	–2
	ECH35	Triode Hexode	058	6·3	0·3	250	100	150	650	–2
	EK2	Octode ..	8S28	6·3	0·2	250	50	200	550	–2
	EK3	Octode ..	8S28	6·3	0·65	250	100	100	650	–2·5
	V013/S	Octode ..	7B36/8S28	13·0	0·2	250	70	90	600	1·5–25
	TX21	Triode Hexode	7B37	21·0	0·2	250	80	150	1,000	–1·5
	TH29/30	TriodeHeptode	7B38	29·0	0·2	275	100	100	750	–2·5
	MH1118	Heptode ..	7C4	10·0	0·18	250	100	200	520	–2·5

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Descrip-tion	Base	Fil. Volts	Fil. Amps	
BRIMAR ..	8A1	P	5B19/7B23	4·0	1·0	(1)
	9A1	VP	5B19/7B23	4·0	1·0	(2)
	8D2	P	7B30	13·0	0·2	(3)
	9D2	VP	7B30	13·0	0·2	(4)
	6J7G	P	—	6·3	0·3	(5)
	6K7G	VP	—	6·3	0·3	(6)
COSSOR ..	215SG	S	4B5	2·0	0·15	(7)
	220SG	S	4B5	2·0	0·2	(8)
	220VSG	VS	4B5	2·0	0·2	(9)
	220VS	VS	4B5	2·0	0·2	(10)
	210VPT	VP	4B8/7B4	2·0	0·1	(11)
	210VPA	VP	4B8/7B4	2·0	0·1	(12)
	210SPT	P	4B8/7B4	2·0	0·1	(13)
	220IPT	P	7B28	2·0	0·2	(14)
	MSG/HA	S	5B17	4·0	1·0	(15)
	41MSG	S	5B17	4·0	1·0	(16)
	MSG/LA	S	5B17	4·0	1·0	(17)
	MVSG	VS	5B17	4·0	1·0	(18)
	4TSP	P	7B23	4·0	1·0	(19)
	MS/PEN	P	5B19/7B23	4·0	1·0	(20)
	MS/PEN A	P	7B23	4·0	1·0	(21)
	MVS/PEN	VP	5B19/7B23	4·0	1·0	(22)
	MS/PEN B	P	7B26	4·0	1·0	(23)
	MVS/PEN B	VP	7B26	4·0	1·0	(24)
	OM5	P	047	6·3	0·2	(25)
	OM6	VP	047	6·3	0·2	(26)
	13VPA	VP	7B26	13·0	0·2	(27)
	13SPA	P	7B26	13·0	0·2	(28)
	DVSG	VS	5B17	16·0	0·25	(29)
	DS/PEN	P	5B19	16·0	0·25	(30)
	DVS/PEN	VP	5B19	16·0	0·25	(31)
	202VP	VP	7B23	20·0	0·2	(32)
	202VPB	VP	7B26	20·0	0·2	(33)
	202SPB	P	7B26	20·0	0·2	(34)
	4TPB	P	7B26	4·0	1·0	(35)
	41MPT	P	7B23	4·0	1·0	(36)
	42MPT	P	7B23	4·0	2·0	(37)
	42PTB	P	7B26	4·0	2·0	(38)
	41MTS	Split anode P	7B43	4·0	1·0	(39)
	4TSA	,,	7B44	4·0	1·0	(40)
	42SPT	P	7B23	4·0	2·0	(41)
DARIO ..	PF462	P	7B4	2·0	0·18	(42)
	PF472	VP	7B4	2·0	0·18	(43)
	TB622	S	4B5	2·0	0·18	(44)
	TB552	VS	4B5	2·0	0·15	(45)
	TE424	S	5B17	4·0	1·0	(46)
	TE524	S	5B17	4·0	1·0	(47)
	TE554	VS	5B17	4·0	1·0	(48)
	TE464	P	5B19/7B23	4·0	1·1	(49)
	TF44	P	7B26	4·0	0·65	(50)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND HF PENTODES

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(1)	200	80	–1·5	3·5	0·7	200	4·0
(2)	200	80	–1·5 –30	5·0	1·0	200	4·25
(3)	250	100	–3	2·0	0·5	1,000	1·25
(4)	250	125	–3 –40	10·5	2·6	200	1·65
(5)	250	100	–3	2·0	0·5	1,000	1·25
(6)	250	125	–3 –40	10·5	2·6	200	1·65
(7)	150	80	–1·0	1·25	—	—	1·1
(8)	150	80	–1·0	1·4	—	—	1·6
(9)	150	80	–2·5	2·25	—	—	1·6
(10)	150	80	–2·5	1·0	—	—	1·6
(11)	150	80	–1·5	2·9	7·5	—	1·1
(12)	150	150	–3·0	2·2	—	—	1·1
(13)	150	80	–1·5	1·2	—	—	1·3
(14)	150	80	–1·5	2·5	—	—	1·0
(15)	200	100	–1·5	2·1	—	600	2·0
(16)	200	80	–1·5	0·8	—	1,500	2·5
(17)	200	100	–1·5	5·2	—	250	3·75
(18)	200	100	–1·5	7·8	7·5	V	2·5
(19)	250	250	–3·0	12·0	—	—	8·0
(20)	200	100	–1·5	5·0	—	—	2·8
(21)	200	150	—	9·0	5·0	200	4·0
(22)	200	100	–1·5	4·3	—	V	2·2
(23)	200	100	–1·5	5·0	—	—	2·8
(24)	200	100	–1·5	4·3	—	V	2·2
(25)	250	100	–2·0	3–0	—	—	1·8
(26)	250	100	–2·5	6·0	—	V	2·2
(27)	200	100	–3·0	7·0	—	V	1·8
(28)	200	100	–3·0	2·3	—	—	1·25
(29)	200	100	–1·5	7·5	—	V	2·5
(30)	200	100	–1·5	4·7	—	—	2·3
(31)	200	100	–1·5	5·5	—	V	2·0
(32)	250	100	–1·5	4·3	—	V	2·2
(33)	250	100	–1·5	4·3	—	V	2·2
(34)	250	100	–1·5	4·8	—	—	2·8
(35)	250	250	–3·0	12·0	—	—	8·0
(36)	250	200	–1·5	12·0	—	—	4·8
(37)	250	250	–3·0	34·0	—	—	8·5
(38)	250	250	–3·0	34·0	—	—	8·5
(39)	250	100	—	—	—	—	—
(40)	250	100	—	—	—	—	—
(41)	500	250	–15	27·0	—	—	11·0
(42)	150	150	–0·5	3·0	—	—	1·85
(43)	150	150	–0·5 –16	2·5	—	—	1·7
(44)	150	90	–0·5	2·0	—	—	1·4
(45)	150	75	0–9	1·8	—	—	1·5
(46)	200	100	–1·3	1·5	—	—	0·9
(47)	200	100	–2·0	3·0	—	—	2·0
(48)	200	100	–1·5 –40	3·0	—	V	2·0
(49)	200	100	–2·0	3·0	—	—	2·3
(50)	250	250	–2·4	4·0	—	—	3·4

[*Continued on next page*

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Descrip-tion	Base	Fil. Volts	Fil. Amps	
DARIO—*cont.*	TE474	VP	5B19/7B23	4·0	1·1	(51)
	TE564	VP	5B19/7B23	4·0	1·2	(52)
	TF64	VP	7B26	4·0	0·65	(53)
	TF713	P	7B23	13·0	0·2	(54)
	TF313	VP	7B26	13·0	0·2	(55)
	TB5613	VP	7B26	13·0	0·2	(56)
	TB4620	P	5B19	20·0	0·18	(57)
	TB4720	VP	5B19	20·0	0·18	(58)
EKCO ..	VP41	VP	7B26	4·0	0·65	(59)
	VPU1	VP	7B26	13·0	0·2	(60)
EVER READY	K50M	VP	4B8/7B4	2·0	0·18	(61)
	K50N	VP	7B5	2·0	0·14	(62)
	K40B	S	4B5	2·0	0·18	(63)
	K40N	VS	4B5/7B4	2·0	0·18	(64)
	A40M	VS	5B17/7B23	4·0	1·0	(65)
	A50M	VP	5B19/7B23	4·0	1·0	(66)
	A50N	VP	5B19/7B23	4·0	1·2	(67)
	A50P	VP	7B26	4·0	0·65	(68)
	A50A	P	5B19/7B23	4·0	1·0	(69)
	A50B	P	7B26	4·0	1·65	(70)
	EF9/39	VP	8S24/04	6·3	0·2	(71)
	C50N	VP	7B26	13·0	0·2	(72)
	C50B	P	7B26	13·0	0·2	(73)
FERRANTI ..	VS2	VS	4B5	2·0	0·1	(74)
	VPT2	VP	7B4	2·0	0·15	(75)
	SPT4A	P	7B23	4·0	1·0	(76)
	VPT4	VP	5B19	4·0	1·0	(77)
	VPT4B	VP	7B23	4·0	1·0	(78)
	SPTS	P	7B23	13·0	0·3	(79)
	VPTS	VP	7B23	13·0	0·3	(80)
	VPTA	VP	7B23	13·0	0·2	(81)
	VPTSB	VP	7B23	13·0	0·3	(82)
HIVAC.. ..	XSG 1·5V	S	4D2	1·5	0·08	(83)
	XW 1·5V	P	5D1	1·5	0·08	(84)
	XSG 2·0V	S	4D2	2·0	0·08	(85)
	XVS 2·0V	VS	4D2	2·0	0·08	(86)
	XW 2·0V	P	5D1	2·0	0·08	(87)
	SG215	S	4B5	2·0	0·15	(88)
	SG220	S	4B5	2·0	0·2	(89)
	SG220SW	S	4B10	2·0	0·2	(90)
	VS215	VS	4B5	2·0	0·15	(91)
	HP215	P	4B5/7B4	2·0	0·15	(92)
	VP215	VP	4B5/7B4	2·0	0·15	(93)
	AC/SL	S	5B17	4·0	1·0	(94)
	AC/SH	S	5B17	4·0	1·0	(95)
	AC/VS	VS	5B17	4·0	1·0	(96)
	AC/VH	VS	5B17	4·0	1·0	(97)
	AC/HP	P	5B17/7B23	4·0	1·0	(98)
	AC/VP	VP	5B17/7B23	4·0	1·0	(99)
	VP13	VP	7B23	13·0	0·3	(100)
LISSEN ..	SG215	S	4B5	2·0	0·15	(101)
	SG2V	VS	4B5	2·0	0·15	(102)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND HF PENTODES—*continued*

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(51)	250	100	–1·5 –30	4·5	—	V	2·3
(52)	200	100	–2·0 –22	4·25	—	V	2·5
(53)	250	250	–3·0 –45	11·5	—	V	—
(54)	200	100	–2·0	3·0	—	—	2·1
(55)	200	100	–3·0 –50	8·0	—	V	1·8
(56)	200	100	–2·0 –22	4·5	—	V	2·2
(57)	200	—	–2·0	3·0	—	—	2·2
(58)	200	—	–2·0 –50	4·0	—	V	2·0
(59)	250	250	–3·0 –40	12·0	4·5	180	3·5
(60)	250	250	–3·0 –40	12·0	4·5	180	3·5
(61)	135	135	0–7	3·0	—	V	1·5
(62)	135	60	–1·5	2·0	—	V	1·4
(63)	150	90	0	2·9	—	—	1·5
(64)	150	90	0–7	2·5	—	V	1·4
(65)	200	110	–1·5 –40	6·0	—	V	2·5
(66)	200	100	–2 –50	4·5	—	V	2·3
(67)	200	100	–2·0	4·25	—	V	2·5
(68)	250	250	–3·0	11·5	—	V	2·0
(69)	200	100	–2·0	3·0	—	—	2·3
(70)	250	250	–2·4	4·0	—	—	3·4
(71)	250	100	–2·5	6·0	—	—	2·2
(72)	200	200	–2·0	9·0	—	V	2·2
(73)	200	200	–2·2	2·5	—	—	2·8
(74)	150	70	—	—	—	—	1·0
(75)	150	75	—	—	—	—	1·6
(76)	250	100	–1·5	2·0	1·0	—	3·0
(77)	250	100	–3·28	5·5	3·0	V	—
(78)	250	100	–2·0	6·0	3·0	V	3·6
(79)	250	100	–1·5	2·0	1·0	—	3·0
(80)	250	100	–3·28	5·5	2·0	V	—
(81)	250	100	—	4·2	2·0	V	—
(82)	250	100	–2·0	6·0	3·0	V	3·6
(83)	50	30	0	0·55	0·25	—	0·30
(84)	50	45	0	0·75	0·2	—	0·52
(85)	50	30	0	0·6	0·3	—	0·4
(86)	50	30	0	0·4	0·15	—	0·33
(87)	50	45	0	0·95	0·3	—	0·60
(88)	150	75	–1·5	2·7	0·8	—	1·0
(89)	150	70	–1·5	2·4	0·9	—	1·5
(90)	150	70	–1·5	2·4	0·9	—	1·5
(91)	150	75	0–14	6·0	1·7	V	1·0
(92)	150	70	–1·5	1·5	0·3	—	1·2
(93)	150	70	0·9	3·75	0·75	V	1·25
(94)	200	80	–1	3·8	0·4	250	2·2
(95)	200	80	–1·5	7·4	0·5	200	3·5
(96)	200	80	–1·5 –40	4·4	0·6	V	3·0
(97)	200	80	–1·5 –40	9·3	1·6	V	3·3
(98)	200	100	–2	4·2	1·4	350	3·2
(99)	200	100	–1·5 –30	5·7	2·3	V	3·0
(100)	200	100	–1·5 –30	6·3	2·0	V	3·0
(101)	150	80	—	—	—	—	1·1
(102)	150	80	—	—	—	—	1·2

[*Continued on next page*

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Descrip-tion	Base	Fil. Volts	Fil. Amps	
LISSEN—*cont.*	SG410	S	4B5	4·0	0·1	(103)
	AC/SG	S	5B17	4·0	1·0	(104)
	AC/SGV	VS	5B17	4·0	1·0	(105)
MARCONI ..	Z14	P	07	1·4	0·05	(106)
	S23	S	4B5	2·0	0·1	(107)
	S24	S	4B5	2·0	0·1	(108)
	VS2	VS	4B5	2·0	0·1	(109)
	VS24	VS	4B5	2·0	0·15	(110)
	VS24/K	VS	4B5	2·0	0·15	(111)
	Z21	P	4B8/7B4	2·0	0·1	(112)
	VP21	VP	7B4	2·0	0·1	(113)
	W21	VP	4B8/7B4	2·0	0·1	(114)
	MS4	S	5B17	4·0	1·0	(115)
	MS4B	S	5B17	4·0	1·0	(116)
	MS4B/K	S	5B17	4·0	1·0	(117)
	VMS4	VS	5B17	4·0	1·0	(118)
	VMS4/K	VS	5B17	4·0	1·0	(119)
	VMS4B	VS	5B17	4·0	1·0	(120)
	MSP4	P	5B17/7B23	4·0	1·0	(121)
	MSP41	P	5B17/7B23	4·0	1·0	(122)
	VMP4	VP	5B17/7B23	4·0	1·0	(123)
	VMP4/K	VP	5B17	4·0	1·0	(124)
	VMP4G	VP	7B23	4·0	1·0	(125)
	W42	VP	7B30	4·0	0·6	(126)
	KTZ41	T	7B41	4·0	1·5	(127)
	Z63	P	047	6·3	0·3	(128)
	W63	VP	047	6·3	0·3	(129)
	KTW61	VP	047	6·3	0·3	(130)
	KTW63	VT	047	6·3	0·3	(131)
	KTZ63	T	047	6·3	0·3	(132)
	W30	VP	7B23	13·0	0·3	(133)
	W31	VP	7B23	13·0	0·3	(134)
	DS	S	5B17	16·0	0·25	(135)
	DSB	S	5B17	16·0	0·25	(136)
	VDS	VS	5B17	16·0	0·25	(137)
	VDSB	VS	5B17	16·0	0·25	(138)
	S12	S	4D2	2·0	0·06	(139)
	ZA1	—	Acorn	4·0	0·25	(140)
	Z62	P	047	6·3	0·45	(141)
	ZA2	P	Special	6·3	0·15	(142)
MAZDA ..	SP141	P	0M7	1·4	0·05	(143)
	SG215	S	4B8/7B4	2·0	0·15	(144)
	S215A	S	4B8/7B4	2·0	0·15	(145)
	S215B	S	4B8/7B4	2·0	0·15	(146)
	S215VM	VS	4B8/7B4	2·0	0·15	(147)
	SP210	P	7B4	2·0	0·1	(148)
	SP215	P	7B4	2·0	0·15	(149)
	VP210	VP	7B4	2·0	0·1	(150)
	VP215	VP	7B4	2·0	0·15	(151)
	SP22	P	0M3	2·0	0·1	(152)
	VP22	VP	0M3	2·0	0·1	(153)
	VP23	VP	0M3	2·0	0·05	(154)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND HF PENTODES—*continued*

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(103)	150	80	—	—	—	—	1·25
(104)	200	80	—	—	—	—	3·25
(105)	250	80	—	—	—	—	3·5
(106)	90	90	0	1·2	0·25	—	0·75
(107)	150	70	–1·5	1·3	0·6	—	1·1
(108)	150	70	0	4·5	0·5	—	1·4
(109)	150	70	—	—	—	—	1·25
(110)	150	75	0–9	4·5	0·5	—	1·5
(111)	150	75	0–9	4·4	0·3	—	1·5
(112)	150	150	0	1·7	0·6	—	1·7
(113)	150	60	0	2·8	0·7	—	1·1
(114)	150	150	–1·5	3·0	0·9	—	1·4
(115)	250	70	–1·5	2·4	0·3	550	1·1
(116)	250	80	–2·0	2·5	1·2	440	3·2
(117)	250	80	—	—	—	—	3·2
(118)	250	80	–2	9	2	V	2·4
(119)	250	80	–2	9	2	V	2·6
(120)	250	80	–1	5	1·2	V	2·9
(121)	250	100	–1·75	3·3	1·0	400	4·0
(122)	250	240	–4	8·5	3·2	—	3·2
(123)	250	100	–2	3·0	1·0	V	3·5
(124)	250	100	–2	7·0	3·5	V	2·5
(125)	250	100	–2·0	8·0	5·0	V	2·7
(126)	250	125	–3·0	7·6	1·9	V	1·5
(127)	250	250	–2·5	8·0	2·25	—	7·5
(128)	250	125	–3·0	2·0	0·5	—	1·225
(129)	250	100	–3·0	7·6	1·9	V	1·5
(130)	250	100	–3·0	8·0	2·3	V	2·9
(131)	250	100	–3·0	7·6	1·9	V	1·5
(132)	250	125	–3·0	2·0	0·5	—	1·225
(133)	250	250	—	—	—	V	4·5
(134)	250	100	–1·0	—	—	V	4·0
(135)	200	70	—	—	—	—	1·1
(136)	200	80	—	—	—	—	3·2
(137)	200	80	—	—	—	V	2·4
(138)	200	—	—	—	—	V	2·2
(139)	100	30	0	2·5	0·4	—	0·7
(140)	250	100	–3·0	2·0	0·7	1,500	1·4
(141)	300	150	–2·0	10·0	2·0	—	7·5
(142)	250	100	–3·0	2·0	0·7	—	1·4
(143)	90	90	—	1·8	—	—	0·8
(144)	150	80	–1·5	1·5	0·25	—	1·1
(145)	150	80	—	1·9	0·3	—	1·1
(146)	150	80	–1·5	1·5	0·3	—	1·7
(147)	150	80	0 -8	1·0	0·15	—	1·4
(148)	150	150	–1	1·1	0·33	—	1·2
(149)	150	150	–1·5	1·35	0·47	—	1·3
(150)	120	70	–1·5	1·8	0·63	—	1·03
(151)	150	150	–1·5	1·1	0·385	—	0·82
(152)	150	150	–1·0	1·1	0·38	—	1·2
(153)	150	150	–1·5	1·2	0·32	—	0·02
(154)	150	150	–2·0	1·0	0·35	—	0·8

[*Continued on next page*

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Description	Base	Fil. Volts	Fil. Amps	
MAZDA—*cont.*	AC/SG	S	7B23	4·0	1·0	(155)
	AC/S2	S	5B17	4·0	1·0	(156)
	AC/S1VM	VS	5B17	4·0	1·0	(157)
	AC/SGVM	VS	5B19/7B23	4·0	1·0	(158)
	AC/S2Pen	P	7B23	4·0	1·0	(159)
	AC/SP1	P	7B23	4·0	1·0	(160)
	AC/VP1	VP	7B23	4·0	0·65	(161)
	AC/VP2	VP	7B26	4·0	0·65	(162)
	VP41	VP	0M24	4·0	0·65	(163)
	SP41	P	0M24	4·0	0·95	(164)
	SP42	P	0M24	4·0	0·95	(165)
	SP1320	P	7B23	13·0	0·2	(166)
	VP1320	VP	7B23	13·0	0·2	(167)
	VP1321	VP	7B23	13·0	0·2	(168)
	VP1322	VP	7B26	13·0	0·2	(169)
	VP133	VP	0M24	13·0	0·2	(170)
	SP2220	P	7B23	22·0	0·2	(171)
	DC2/SG	S	7B23	20·0	0·1	(172)
	DC2/SGVM	VS	7B23	20·0	0·1	(173)
MULLARD ..	DF1	P	8S6	1·4	0·05	(174)
	DF51	P	4D3	1·5	0·067	(175)
	DAS1	T	4D2	2·0	0·06	(176)
	SP2	P	7B4	2·0	0·18	(177)
	PM12	T	4B5	2·0	0·15	(178)
	PM12A	T	4B5	2·0	0·18	(179)
	PM12M	VT	4B5	2·0	0·18	(180)
	VP2	VP	7B4	2·0	0·18	(181)
	VP2B	VP	7B5	2·0	0·14	(182)
	AP4	P	ACORN	4·0	0·2	(183)
	S4V	S	5B17	4·0	1·0	(184)
	S4VA	T	5B17	4·0	1·0	(185)
	S4VB	T	5B17	4·0	1·0	(186)
	MM4V	VT	5B17	4·0	1·0	(187)
	VM4V	VS	5B17	4·0	1·0	(188)
	TSP4	P	7B26	4·0	1·3	(189)
	SP4	P	5B19/7B23	4·0	1·0	(190)
	SP4B	P	7B26	4·0	0·65	(191)
	VP4	VP	5B19/7B23	4·0	1·0	(192)
	VP4A	VP	5B19/7B23	4·0	1·2	(193)
	VP4B	VP	7B26	4·0	0·65	(194)
	4672	P	ACORN	6·3	0·15	(195)
	EF5	VP	8S24	6·3	0·2	(196)
	EF6/36	P	8S24/047	6·3	0·2	(197)
	EF8/38	P	8S25/051	6·3	0·2	(198)
	EF9/39	P	8S24/047	6·3	0·2	(199)
	SP13	P	8S24	13·0	0·2	(200)
	SP13C	P	7B26	13·0	0·2	(201)
	VP13A	VP	8S24	13·0	0·2	(202)
	VP13C	VP	7B26	13·0	0·2	(203)
OSRAM ..	Z14	P	07	1·4	0·05	(204)
	S23	S	4B5	2·0	0·1	(205)
	S24	S	4B5	2·0	0·15	(206)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND HF PENTODES—*continued*

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(155)	200	80	–1·5	8·5	—	—	2·4
(156)	200	80	–1·5	7·0	—	—	4·4
(157)	200	100	–1·5	5·7	—	—	1·1
(158)	200	80	–2	5·8	—	—	2·0
(159)	250	150	–4·25	5·25	1·75	—	5·5
(160)	250	250	–3·0	4·9	4·1	300	2·65
(161)	250	250	–4	8·8	2·2	—	2·0
(162)	250	250	–4	8·8	2·2	—	2·0
(163)	250	250	–4	8·6	2·3	—	2·0
(164)	250	250	–2·1	11·1	2·8	150	8·4
(165)	200	200	–1·25	27·0	6·75	37	9·0
(166)	250	250	–2·0	3·5	0·3	—	1·9
(167)	250	250	–1·5	4·7	1·25	—	2·0
(168)	250	250	–4	8·8	2·2	—	2·0
(169)	250	250	–4	8·8	2·2	—	2·0
(170)	200	200	–0·7	7·2	2·0	—	2·35
(171)	250	250	–3·0	4·9	4·1	—	2·65
(172)	200	100	–1·5	11·0	—	—	2·4
(173)	200	100	–4	8·0	—	—	1·6
(174)	90	90	0	1·2	—	—	0·75
(175)	45	13·5	0	0·125	—	—	0·17
(176)	120	60·0	–2·7	1·5	—	—	0·58
(177)	135	135·0	0	3·0	1·0	—	1·8
(178)	150	75	—	4·25	—	—	1·1
(179)	135	75	0	2·0	—	—	1·5
(180)	150	90	0–7	2·5	—	—	1·4
(181)	135	135	0–7	3·0	1·25	—	1·5
(182)	135	60	–1·5	2·0	—	—	1·4
(183)	250	100	–3·0	2·0	0·7	—	1·4
(184)	200	75	–1·0	1·5	—	600	1·1
(185)	200	110	–1·5	2·75	—	460	2·0
(186)	200	110	–1·5	4·6	—	—	2·5
(187)	200	110	–1·5 –40	6·0	—	V	2·5
(188)	200	100	–1·5 –40	8·5	—	200	1·2
(189)	250	250	–3·0	10·5	2·0	250	4·7
(190)	200	100	–2·0	3·0	—	—	2·3
(191)	250	250	–2·4	4·0	1·5	500	3·4
(192)	200	100	–2 –50	4·5	—	V	2·3
(193)	200	100	–2·0	4·25	1·8	V	2·5
(194)	250	250	–3·0	11·5	4·25	V	2·0
(195)	250	100	–3·0	2·0	—	—	1·4
(196)	250	100	–3 –50	8·0	—	V	1·7
(197)	250	100	–2·0	3·0	—	—	1·8
(198)	250	250	–2·5	8·0	—	—	1·8
(199)	250	100	–2·5	6·0	—	—	2·2
(200)	200	100	–2·0	3·3	—	400	2·2
(201)	200	200	–2·2	2·5	0·9	600	2·8
(202)	200	100	–2·0	4·0	1·4	V	2·2
(203)	200	200	–2·0	9·0	3·6	V	2·2
(204)	90	90	—	—	—	—	0·75
(205)	150	70	–1·5	1·3	0·6	—	1·1
(206)	150	70	0	4·5	0·5	—	1·4

[*Continued on next page*

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Description	Base	Fil. Volts	Fil. Amps	
OSRAM—*cont.*	VS2	VS	4B5	2·0	0·15	(207)
	VS24	VS	4B5	2·0	0·15	(208)
	VS24K	VS	4B5	2·0	0·15	(209)
	Z21	P	4B8/7B4	2·0	0·1	(210)
	Z22	P	7B4	2·0	0·1	(211)
	VP21	VP	7B4	2·0	0·1	(212)
	W21	VP	4B8/7B4	2·0	0·1	(213)
	MS4	S	5B17	4·0	1·0	(214)
	MS4B	S	7B23	4·0	1·0	(215)
	VMS4	VS	5B17	4·0	1·0	(216)
	VMS4B	VS	5B19/7B23	4·0	1·0	(217)
	VMS4/B	VS	5B19/7B23	4·0	1·0	(218)
	MSP4	P	5B17/7B23	4·0	1·0	(219)
	MSP41	P	5B17/7B23	4·0	1·0	(220)
	VMP4	VP	5B19/7B23	4·0	1·0	(221)
	VMP4G	VP	7B23	4·0	1·0	(222)
	W42	VP	7B30	4·0	0·6	(223)
	KTZ41	T	7B41	4·0	1·5	(224)
	KTZ73	P	030	6·0	0·16	(225)
	KTW73M	T	030	6·0	0·17	(226)
	KTW74M	T	030	13·0	0·16	(227)
	Z62	P	047	6·3	0·45	(228)
	Z63	P	050	6·3	0·3	(229)
	W63	VP	050	6·3	0·3	(230)
	KTW61	VP	047/050	6·3	0·3	(231)
	KTW63	VP	050	6·3	0·3	(232)
	KTZ63	T	050	6·3	0·3	(233)
	W30	VP	7B23	13·0	0·3	(234)
	W31	VP	7B23	13·0	0·3	(235)
	DS	S	5B17	16·0	0·25	(236)
	DSB	S	7B23	16·0	0·25	(237)
	VDS	VS	5B17	16·0	0·25	(238)
	VDSB	VS	5B17	16·0	0·25	(239)
	S12	T	4D2	2·0	0·06	(240)
	ZA2	P	Acorn	6·3	0·15	(241)
RECORD ..	S2	S	4B5	2·0	0·12	(242)
	VS2	VS	4B5	2·0	0·12	(243)
	HFP2	P	4B5	2·0	0·12	(244)
	VHP2	VP	4B5	2·0	0·12	(245)
	AC/S	S	7B23	4·0	1·0	(246)
	AC/VS	VS	5B17	4·0	1·2	(247)
	AC/HFP	P	5B19/7B23	4·0	1·0	(248)
	AC/HPB	P	7B26	4·0	0·65	(249)
	AC/VHFP	VP	5B19/7B23	4·0	1·0	(250)
	AC/VHPB	VP	7B26	4·0	0·65	(251)
	HFP/13	P	7B26	13·0	0·2	(252)
	HFP/13L	P	8S24	13·0	0·2	(253)
	HPB/13	P	7B26	13·0	0·2	(254)
	VHFP/13	VP	7B26	13·0	0·2	(255)
	VHFP/13L	VP	8S24	13·0	0·2	(256)
	VHP/13	VP	7B26	13·0	0·2	(257)
	VHP/13L	VP	8S24	13·0	0·2	(258)
	VHPB/13	VP	7B26	13·0	0·2	(259)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(207)	150	75	0–15	5·0	2·0	—	1·25
(208)	150	75	0–9	4·5	0·5	—	1·5
(209)	150	75	0–9	4·4	0·3	—	1·5
(210)	150	150	-0·5	1·7	0·6	—	1·7
(211)	150	150	—	—	—	—	1·4
(212)	150	60	0	2·8	0·7	—	1·1
(213)	150	150	0	3·6	1·2	—	1·4
(214)	250	70	–1·5	2·4	0·3	550	1·1
(215)	250	80	–2·0	3·4	1·2	250	3·2
(216)	250	80	–2 –30	7·5	2·0	V	2·4
(217)	250	80	–1 –15	5·0	1·2	V	2·9
(218)	250	80	—	—	—	V	2·0
(219)	250	100	–1·75	3·3	1·0	400	4·0
(220)	240	240	-4·0	9·0	3·2	—	3·2
(221)	250	100	—	—	—	V	3·5
(222)	250	100	–2·0	8·0	5·0	V	2·8
(223)	250	125	–3·0	7·6	1·9	V	1·5
(224)	250	250	–1·5	18·0	5·25	65	12·0
(225)	250	100	–3·0	2·0	0·25	1,000	1·5
(226)	250	100	–3·0	6·5	1·3	V	1·7
(227)	250	100	—	—	—	V	1·5
(228)	300	150	–2·0	10·0	2·3	160	7·5
(229)	250	125	–3·0	2·0	0·5	1,200	1·225
(230)	250	100	–3 –40	7·6	1·9	V	1·5
(231)	250	100	-3·0	8·0	2·3	V	2·9
(232)	250	125	–3·0	7·6	1·5	V	1·5
(233)	250	125	–3·0	2·0	0·5	1,200	1·23
(234)	250	250	—	—	—	V	4·5
(235)	250	100	–2·5	8·1	5·0	V	2·78
(236)	200	70	—	—	—	—	1·1
(237)	200	80	—	—	—	—	3·2
(238)	200	80	—	—	—	—	2·4
(239)	200	—	—	—	—	—	2·2
(240)	100	30	0	2·5	0·4	—	0·7
(241)	250	100	—	—	—	—	1·4
(242)	150	75	–0·9	1·5	0·3	—	1·4
(243)	150	75	–0·5	1·0	0·1	—	1·5
(244)	150	150	–1·5	1·9	0·7	—	1·9
(245)	150	150	-0·9 –17	2·5	0·6	—	1·7
(246)	200	100	–2·0	3·0	0·8	500	3·0
(247)	200	100	–1·5 –40	3·0	0·8	V	3·0
(248)	200	100	–2·0	3·5	0·6	600	3·5
(249)	250	250	–2·0	2·9	0·8	500	4·0
(250)	200	100	–2·0 –35	5·0	1·3	V	3·5
(251)	250	250	–1·0 –50	10·0	2·5	V	4·0
(252)	200	100	–2·0	3·0	1·5	450	2·4
(253)	200	100	–2·0	3·0	1·5	450	2·4
(254)	200	200	–1·5	3·5	1·5	300	3·5
(255)	200	100	–1·0 –10	8·0	2·9	V	3·5
(256)	200	100	–1·0 –10	8·0	2·9	V	3·5
(257)	200	100	–3·0 –55	8·0	2·6	V	2·8
(258)	200	100	–3·0 –55	8·0	2·6	V	2·8
(259)	200	200	–1·0 –50	10·0	3·5	V	3·5

[*Continued on next page*

TABLE XXVIII: SCREEN-GRIDS

Make	Type	Description	Base	Fil. Volts	Fil. Amps.	
TRIOTRON ..	S217	VP	7B4	2·0	0·2	(260)
	S218	P	7B4	2·0	0·2	(261)
	S215	S	4B5	2·0	0·18	(262)
	S213	VS	4B5	2·0	0·15	(263)
	S434N	VP	5B19/7B23	4·0	1·1	(264)
	S420	VP	7B26	4·0	0·65	(265)
	S440	P	7B26	4·0	0·65	(266)
	S435N	P	5B19/7B23	4·0	1·1	(267)
	S415N	VS	5B17	4·0	1·0	(268)
	S410N	S	5B17	4·0	1·0	(269)
	S430N	S	5B17	4·0	1·0	(270)
	S1324	P	7B26	13·0	0·2	(271)
	S1328	P	8S24	13·0	0·2	(272)
	S1323	VP	7B26	13·0	0·2	(273)
	S2034N	VP	5B19	20·0	0·18	(274)
	S2035N	P	5B19	20·0	0·18	(275)
TUNGSRAM ..	SE211	VS	4B5	2·0	0·12	(276)
	SE211C	VS	4B5	2·0	0·12	(277)
	HP210	P	4B8/7B4	2·0	0·12	(278)
	HP210C	P	7B4	2·0	0·12	(279)
	HP210NC	P	4B8/7B4	2·0	0·12	(280)
	SP2B	HF PEN	7B3	2·0	0·05	(281)
	SP2D	P	7B3	2·0	0·1	(282)
	SS210	T	4B5	2·0	0·12	(283)
	VP2B	VP	7B3	2·0	0·05	(284)
	VP2D	VP	7B3	2·0	0·1	(285)
	HP211C	VP	7B4	2·0	0·12	(286)
	AS4125	VS	5B17	4·0	1·2	(287)
	AS4120	T	5B17	4·0	1·0	(288)
	HP4101	P	5B19/7B23	4·0	1·0	(289)
	HP4115	P	7B23	4·0	1·0	(290)
	SP4B	P	7B26	4·0	0·65	(291)
	HP4106	VP	5B19/7B23	4·0	1·0	(292)
	VP4B	VP	7B26	4·0	0·65	(293)
	EF12	P	0F3	6·3	0·2	(294)
	SP6S	P	8S24	6·3	0·2	(295)
	VP6S	VP	8S24	6·3	0·2	(296)
	EF11	VP	0F3	6·3	0·2	(297)
	EF6	P	8S24	6·3	0·2	(298)
	EF5	VP	8S24	6·3	0·2	(299)
	EF9/39	VP	8S24/047	6·3	0·2	(300)
	SP13	P	7B26	13·0	0·2	(301)
	SP13B	P	7B26	13·0	0·2	(302)
	HP13	VP	7B26	13·0	0·2	(303)
	VP13	VP	7B26	13·0	0·2	(304)
	VP13B	VP	7B26	13·0	0·2	(305)
	EF8	HF HEX	8S25	6·3	0·2	(306)
	HP2118	VP	5B19	20	0·18	(307)
	HP2018	P	5B19	20	0·18	(308)
	HP1118	VP	7C3	10	0·18	(309)
	HP1018	P	7C3	10	0·18	(310)
	SS2018	S	5B17	20	0·18	(311)
	S2018	S	5B17	20	0·18	(312)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND HF PENTODES—*continued*

	Anode Volts	Screen Volts	Bias Volts	Anode Current (mA)	Screen Current (mA)	Bias Res. Ohms	Slope mA/V
(260)	150	150	–0·5 –16	2·5	—	—	1·7
(261)	150	150	–0·5	3·0	—	—	1·85
(262)	150	90	–0·5	2·0	—	—	1·4
(263)	150	75	0–9	4·0	—	—	1·5
(264)	200	100	–1·5 –30	4·5	—	V	3·5
(265)	250	250	–3·0	11·5	—	V	—
(266)	250	250	–2·4	4·0	—	—	3·4
(267)	200	100	–2·0	3·0	—	—	3·5
(268)	200	100	–1·5 –40	3·0	—	V	—
(269)	200	60	–1·3	1·5	—	—	1·0
(270)	200	100	–2·0	3·0	—	—	2·0
(271)	200	100	–2·0	3·0	—	—	2·4
(272)	200	100	–2·0	3·0	—	—	2·4
(273)	200	100	–3 –55	8·0	—	V	1·8
(274)	200	100	–2 –35	5·0	—	V	3·5
(275)	200	100	–2·0	3·0	—	—	3·5
(276)	150	75	–9 –5	1·0	0·1	—	1·3
(277)	150	75	–5	1·0	0·1	—	1·5
(278)	150	150	–1·5	1·9	0·7	—	1·9
(279)	150	150	–1·5	1·9	0·7	—	1·9
(280)	150	150	–1·5	1·9	0·7	—	1·9
(281)	135	135	–0·5	2·6	1·0	—	1·0
(282)	150	150	–1·0	1·45	0·35	—	1·7
(283)	150	75	–0·9	1·5	0·3	—	1·4
(284)	135	135	0–15	2·5	0·8	—	0·65
(285)	150	150	–1·5 –12	1·3	0·6	—	2·0
(286)	150	150	–0 –17	2·6	0·6	—	1·7
(287)	200	100	–1·5 –40	3·0	0·8	V	3·0
(288)	200	100	–2·0	3·0	0·8	500	3·0
(289)	250	100	–3·0	3·5	1·8	600	3·5
(290)	200	100	–2·0	4·5	1·5	150	3·2
(291)	250	250	–3·0	3·2	1·5	500	4·0
(292)	250	100	–1·5–35	5·0	1·3	V	3·5
(293)	250	250	–1 –50	10·0	2·5	V	4·0
(294)	300	100	–2·0	6·0	1·0	500	3·0
(295)	250	100	–2·0	3·0	1·0	500	2·0
(296)	250	100	–3 –50	8·0	2·5	V	1·7
(297)	300	125	–2·0	6·0	2·0	250	2·2
(298)	300	125	–2·0	3·0	1·1	—	2·0
(299)	250	125	–3·0 –50	8·0	2·6	V	1·7
(300)	300	300	–2·5 –55	6·0	1·7	V	2·2
(301)	200	100	–2	3·0	1·5	450	2.4
(302)	200	200	–1·5	3·5	1·5	—	3·5
(303)	200	100	0–10	8·0	2·9	V	3·5
(304)	200	100	–3 –55	8·0	2·6	V	2·8
(305)	250	200	–1 –50	10·0	2·0	V	3·5
(306)	250	250	–2·5	8·0	0·25	—	1·8
(307)	200	100	–2·0	5·0	1·1	—	3·5
(308)	200	100	–2·0	4·0	1·2	—	3·5
(309)	250	100	–3·0	8·2	2·0	—	1·6
(310)	250	100	–3·0	2·0	0·5	—	1·22
(311)	200	100	–3·0	3·0	1·0	—	3·0
(312)	200	60	–3·0	4·0	1·2	—	1·2

TABLE XXIX: DIODES

Make	Type	Description	Base	Filament		Max. Diode Volts	Max. Diode Current
				Volts	Amps		
BRIMAR ..	10D1	DD	5B12	13·0	0·2	—	—
	6H6G	DD	—	6·3	0·3	—	—
COSSOR ..	220DD	DD	5B12	2·0	0·2	—	—
	DDL4	DD	5B12	4·0	0·75	—	—
	DD4	DD	5B12	4·0	0·75	—	—
	OM3	DD	O38	6·3	0·2	—	—
DARIO ..	TB24	DD	5B12	4·0	0·65	—	—
	TB213	DD	5B12	13·0	0·2	—	—
EVER READY	A20B	DD	5B12	4·0	0·65	200	0·8
	EB34	DD	O38	6·3	0·2	200	0·8
	C20C	DD	5B12	13·0	0·2	200	0·8
FERRANTI	ZD	DD	5B12	7·0	0·2	—	—
HIVAC ..	*Ac/DD	DD	5B12	4·0	1·0	—	—
MARCONI	D41	DD	5B12	4·0	0·3	—	—
	D42	D	4B18	4·0	0·6	75	15·0
	D63	DD	O38	6·3	0·3	100	2·0
MAZDA ..	DD207	DD	4B3	2·0	0·075	—	—
	DD41	DD	OM18	4·0	0·5	—	—
	V914	DD	5B12	4·0	0·3	—	1·0
	*DD620	DD	5B12	6·0	0·2	—	1·0
	DD101	DD	OM18	10·0	0·2	—	—

[*Continued on opposite page*

TABLE XXX: DIODE

Make	Type	Description	Base	Fil. Volts	Fil. Amps	Anode Volts	
BRIMAR ..	11A2	DDT	7B19	4·0	1·0	200	(1)
	11D3	DDT	7B19	13·0	0·2	250	(2)
	11D5	DDT	7B19	13·0	0·15	250	(3)
	6Q7G	DDT	—	6·3	0·3	250	(4)
	6R7G	DDT	—	6·3	0·3	250	(5)
COSSOR ..	210DDT	DDT	5B2	2·0	0·1	150	(6)
	2102	DDT	6UX2	2·0	0·12	150	(7)
	DDT	DDT	7B19	4·0	1·0	200	(8)
	DD/Pen	DDP	7B34	4·0	1·0	250	(9)
	420TDD	DDP	7B22	4·0	2·0	250	(10)
	13DHA	DDT	7B19	13·0	0·2	250	(11)
	DDT16	DDT	7B19	16·0	0·25	200	(12)
	202DDT	DDT	7B19	20·0	0·2	200	(13)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TABLE XXIX: DIODES—*continued*

Make	Type	Description	Base	Filament		Max. Diode Volts	Max. Diode Current
				Volts	Amps		
MULLARD	2D2	DD	5B12	2·0	0·9	125	0·5
	2D4A	DD	5S2	4·0	0·65	200	0·8
	2D4B	DD	7B16	4·0	0·35	200	0·8
	EB4/34	DD	8S18/038	6·3	0·2	200	0·8
	EAB1	DDD	8S19	6·3	0·2	200	0·8
	2D13	DD	5B12	13·0	0·2	200	0·8
	2D13A	DD	5S1	13·0	0·2	200	0·8
	2D13C	DD	5B12	13·0	0·2	200	0·8
OSRAM	D41	DD	5B12	4·0	0·3	—	—
	*D42/43	D	4B18/4B19	4·0	0·6	75	15·0
	D63	DD	O38	6·3	0·3	100	2·0 each
RECORD	Ac/DD4A	DD	5B12	4·0	0·65	200	0·8
	DDA/13	DD	5B12	13·0	0·2	200	0·8
	DDA/13L	DD	8S16	13·0	0·2	200	0·8
TRIOTRON	D400	DD	4B12	4·0	0·65	200	0·8
	D1300	DD	8S16	13·0	0·2	200	0·8
TUNGSRAM	DD4	DD	5B12	4·0	0·65	200	0·8
	DD4D	DD	7B16	4·5	0·4	100	4·0
	*D418	D	4B15	4·0	0·18	200	1·5
	*DD6DS	DD	8S16	6·3	0·2	200	0·8
	EB4	DD	8S18	6·3	0·2	200	0·8
	EAB1	DDD	8S19	6·3	0·2	200	0·8
	DD13/13S	DD	5B12/8S16	13·0	0·2	200	0·8
	DD18	DD	5B11	8·0	0·18	100	1·5

COMBINATIONS

	Screen Volts	Amp. Factor	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Output (mW)
(1)	—	50	2·8	−2·0	—	3·0	—
(2)	—	100	1·1	−2·0	5,000	0·4	—
(3)	—	40	1·5	−3·0	750	3·8	—
(4)	—	70	1·2	−3	4,000	1·1	—
(5)	—	16	1·9	−9	1,000	9·5	—
(6)	—	27·5	1·1	0	—	2·3	—
(7)	—	30	1·3	0	—	2·5	—
(8)	—	41	2·4	−3·0	—	3·4	—
(9)	200	—	2·7	−2·5	—	5·0	—
(10)	250	—	7·0	−5·5	—	34·0	—
(11)	—	125	1·5	−1·5	—	1·0	—
(12)	—	40	2·5	−3·0	—	5·0	—
(13)	—	41	2·4	−3·0	—	3·5	—

[*Continued on next page*

TABLE XXX: DIODE

Make	Type	Descrip-tion	Base	Fil. Volts	Fil. Amps	Anode Volts	
DARIO ..	BBC12	DDT	5B2	2·0	0·1	130	(14)
	TBC14	DDT	7B19	4·0	0·65	250	(15)
	TE444	D Tetrode	7B50	4·0	1·1	200	(16)
	TBL14	DDP	7B32	4·0	2·25	250	(17)
	TBL44	DDP	7B33	4·0	2·25	250	(18)
	TBC113	DDT	7B19	13·0	0·2	200	(19)
EKCO ..	DT41	DDT	7B19	4·0	0·65	200	(20)
EVER READY	K23A	DDT	5B2	2·0	0·1	150	(21)
	K23B	DDT	5B2	2·0	0·12	135	(22)
	A23A	DDT	7B19	4·0	0·65	250	(23)
	A27D	DDP	7B33	4·0	2·25	250	(24)
	EBC3/EBC33	DDT	8S21/041	6·3	0·2	275	(25)
	EBL1/31	DDP	8S27/053	6·3	1·5	250	(26)
	C23B	DDT	7B19	13·0	0·2	200	(27)
FERRANTI	H2D	DDT	SB2	2·0	0·1	150	(28)
	H4D	DDT	7B19	4·0	1·0	250	(29)
	PT4D	DDP	7B32	4·0	2·0	250	(30)
	HSD	DDT	7B19	13·0	0·3	200	(31)
	HAD	DDT	7B19	13·0	0·2	200	(32)
	PTSD	DDP	7B32	13·0	0·3	250	(33)
HIVAC ..	DDT215	DDT	5B2	2·0	0·15	150	(34)
	AC/DDT	DDT	7B19	4·0	1·0	200	(35)
	AC/2DD	DDTetrode	7B32	4·0	2·0	250	(36)
	DDT213	DDT	7B19	13·0	0·3	200	(37)
MARCONI	HD14	DD	04	1·4	0·05	90	(38)
	HD21	DDT	5B2	2·0	0·2	150	(39)
	HD22	DDT	5B2	2·0	0·2	150	(40)
	HD23	DDT	5B2	2·0	0·15	150	(41)
	HD24	DDT	5B2	2·0	0·1	150	(42)
	WD40	VPDD	9B6	4·0	1·0	250	(43)
	MHD4	DDT	7B19	4·0	1·0	200	(44)
	DH42	DDT	7B19	4·0	0·6	250	(45)
	DL63	DDT	041	6·3	0·3	250	(46)
	DN41	DDP	7B32	4·0	2·3	250	(47)
	DH63	DDT	041	6·3	0·3	250	(48)
	WD30	VPDD	9B6	13·0	0·3	250	(49)
	DH30	DDT	7B19	13·0	0·3	200	(50)
	DHD	DDT	7B24	16·0	0·25	200	(51)
MAZDA ..	H141D	DT	OM6	1·4	0·05	90	(52)
	HL21/DD	DDT	5B2	2·0	0·15	150	(53)
	L21/DD	DDT	5B2	2·0	0·1	150	(54)
	L22/DD	DDT	OM2	2·0	0·1	150	(55)
	HL23/DD	DDT	OM2	2·0	0·05	150	(56)
	AC/HLDD	DDT	7B19	4·0	1·0	250	(57)
	AC/HLDDD	Triple DT	9B3	4·0	1·0	250	(58)
	AC2/PENDD	DDP	7B32	4·0	2·0	250	(59)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

COMBINATIONS—*continued*

	Screen Volts	Amp. Factor	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Output (mW)
(14)	—	16	1·5	-4·5	—	2·5	—
(15)	—	27	2·0	-7·0	—	4·0	—
(16)	33	1,000	3·0	-2·3	—	0·35	—
(17)	250	—	9·5	—	—	36·0	—
(18)	250	—	9·5	—	—	36·0	—
(19)	—	27	2·0	-5·0	—	4·0	—
(20)	—	29	3·0	-3·5	470	7·5	—
(21)	—	16·5	1·4	-1·5	—	2·5	—
(22)	—	30	1·2	-1·5	—	1·95	—
(23)	—	27	2·0	-7·0	—	4·0	—
(24)	250	—	10·0	-6·0	—	36·0	4,300
(25)	—	30	2·0	-6·25	—	5·0	—
(26)	250	—	9·5	-6·0	—	36·0	4,300
(27)	—	27	2·0	-5·0	—	4·0	—
(28)	—	—	—	—	—	—	—
(29)	—	39	2·7	-3·0	—	4·5	—
(30)	250	—	7·5	-6·0	140	7·5	3,600
(31)	—	39	2·7	-3·0	—	4·5	—
(32)	—	39	2·7	-3·0	—	3·3	—
(33)	250	—	7·5	-6·0	140	7·5	3,600
(34)	—	20	1·6	-3·0	—	3·0	—
(35)	—	35	2·3	-4·0	800	5·0	—
(36)	250	—	8·0	-9·5	160	32·0	3,000
(37)	—	35	2·3	-4·0	800	5·0	—
(38)	—	65	0·275	0	—	0·14	—
(39)	—	27	1·5	-1·5	—	—	—
(40)	—	27	1·5	-1·5	—	—	—
(41)	—	40	1·4	-1·5	—	2·0	—
(42)	—	40	1·4	-1·7	—	1·7	—
(43)	100	—	3·5	—	—	—	—
(44)	—	40	2·2	—	750	3·2	—
(45)	—	70	1·2	-3·0	2,000	1·5	—
(46)	—	37	1·65	-3	—	5·0	—
(47)	250	—	10·0	-4·4	90	32·0	4,400
(48)	—	70	1·2	-3·0	2,000	1·1	—
(49)	100	—	2·6	—	—	—	—
(50)	—	80	4·5	-2·0	1,000	2·7	—
(51)	—	40	2·2	—	—	—	—
(52)	—	65	0·48	—	—	0·065	—
(53)	—	32	1·5	-2·0	—	2·0	—
(54)	—	18·5	1·85	-5·0	—	2·8	—
(55)	—	18·5	1·85	-5·0	—	2·3	—
(56)	—	25	1·2	-1·5	—	0·6	—
(57)	—	36	2·6	-3·0	700	4·3	—
(58)	—	35	2·7	-3·0	700	4·3	—
(59)	250	—	8·0	-5·3	140	32·0	3,500

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TABLE XXX: DIODE

Make	Type	Description	Base	Fil. Volts	Fil. Amps	Anode Volts	
MAZDA—*continued*	AC5/PENDD	DDP Tet	7B22	4·0	2·0	250	(60)
	PEN 45/DD	DDP Tet	OM25	4·0	2·0	250	(61)
	HL41/DD	DDT	OM21	4·0	0·65	250	(62)
	HL42/DD	DDT	OM21	4·0	0·65	250	(63)
	HLDD1320	DDT	7B19	13·0	0·2	250	(64)
	HL133/DD	DDT	OM21	13·0	0·2	250	(65)
	PENDD1360	DDP	7B32	13·0	0·6	250	(66)
	DC2HLDD	DDT	7B19	25·0	0·1	200	(67)
	PENDD4020	DDP	7B32	40·0	0·2	250	(68)
	PEN453/DD	DD Tet	OM25	45·0	0·2	200	(69)
MULLARD	DAC1	DT	8S3	1·4	0·05	90	(70)
	TDD2	DDT	5B2	2·0	0·1	150	(71)
	TDD2A	DDT	5B2	2·0	0·12	135	(72)
	SD4	D Tetrode	7B50	4·0	1·0	250	(73)
	TDD4	DDT	7B19	4·0	0·65	250	(74)
	PEN4DD	DDP	7B33	4·0	2·25	250	(75)
	EBC3/33	DDT	8S21/041	6·3	0·2	275	(76)
	EBF2	DDP	8S27	6·3	0·2	250	(77)
	EBL1/31	DDP	8S27/053	6·3	1·5	250	(78)
	TDD13C	DDT	7B19	13·0	0·2	200	(79)
	PEN40DD	DDP	7B33	44·0	0·2	200	(80)
	CBL1/31	DDP	8S27/053	44·0	0·2	200	(81)
OSRAM ..	HD14	DT	04	1·4	0·05	90	(82)
	HD21	DDT	5B2	2·0	0·2	150	(83)
	HD22	DDT	5B2	2·0	0·2	150	(84)
	HD23	DDT	5B2	2·0	0·15	150	(85)
	HD24	DDT	5B2	2·0	0·1	150	(86)
	WD40	VPDD	9B6	4·0	1·0	100	(87)
	MHD4	DDT	7B19	4·0	1·0	250	(88)
	DH42	DDT	7B19	4·0	0·6	250	(89)
	DH41	DDP	7B32	4·0	2·3	250	(90)
	DN41	DDP	7B32	4·0	2·3	250	(91)
	DH73M	DDT	O41	6·0	0·17	250	(92)
	DL74M	DDT	O41	13·0	0·16	250	(93)
	DH63	DDT	O41	6·3	0·3	250	(94)
	DL63	DDT	O41	6·3	0·3	250	(95)
	WD30	VPDD	9B6	13·0	0·3	250	(96)
	DH30	DDT	7B19	13·0	0·3	200	(97)
	DHD	DDT	7B19	16·0	0·25	200	(98)
RECORD	DDTR2	DDT	5B2	2·0	0·1	135	(99)
	AC/DDTR	DDT	7B19	4·0	0·65	250	(100)
	DDTR/13	DDT	7B19	13·0	0·2	200	(101)
	DDTR/13L	DDT	8S21	13·0	0·2	200	(102)
TRIOTRON	DT215	DDT	5B2	2·0	0·1	135	(103)
	DT436	DDT	7B19	4·0	0·65	250	(104)
	DP495/6	DDP	7B33/7B32	4·0	2·25	250	(105)
	DT1336	DDT	7B19	13·0	0·2	200	(106)
	DP4480	DDP	7B33	44·0	0·2	200	(107)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

COMBINATIONS—*continued*

	Screen Volts	Amp. Factor	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Output (mW)
(60)	250	—	9·0	–8·5	175	40·0	5,800
(61)	250	—	9·0	–8·5	175	40·0	5,800
(62)	—	30	2·5	–7·4	1,400	2·2	—
(63)	—	23	2·9	–1·25	450	2·8	—
(64)	—	30	2·0	–3·0	700	4·3	—
(65)	—	32	2·5	–2·2	1,750	1·25	—
(66)	250	—	8·0	–5·3	140	32·0	—
(67)	—	30	2·0	–3·0	700	3·75	—
(68)	250	—	7·0	–7·75	150	43	3,900
(69)	200	—	12·0	–10·0	130	64·0	3,750
(70)	—	65·0	0·275	0	—	0·14	—
(71)	—	16·5	1·4	–5·5	—	2·5	—
(72)	—	30·0	1·2	–1·5	—	1·95	—
(73)	100	—	3·0	—	—	—	—
(74)	—	27·0	2·0	–7·0	1,500	4·0	—
(75)	250	—	9·5	–6·0	150	36·0	4,300
(76)	—	30·0	2·0	–6·25	—	5·0	—
(77)	100	—	1·8	–2·0	—	5·0	—
(78)	250	—	9·5	–6·0	—	36·0	4,300
(79)	—	27·0	2·0	–5·0	1,250	4·0	—
(80)	200	—	8·0	–8·5	—	45·0	4,000
(81)	200	—	8·0	–8·5	—	45·0	4,000
(82)	—	65	0·275	—	—	—	—
(83)	—	27	1·5	–1·5	—	—	—
(84)	—	27	1·5	–1·5	—	—	—
(85)	—	40	1·4	–1·5	—	1·7	—
(86)	—	40	1·4	–1·7	—	1·7	—
(87)	—	—	2·6	—	—	—	—
(88)	—	40	2·2	–4·0	1,000	4·0 each	—
(89)	—	70	1·2	–3·0	1,500	—	—
(90)	250	—	10·0	–3·5	90	32·0	3,500
(91)	250	—	10·0	–5·0	120	32·0	—
(92)	—	44	2·0	—	—	—	—
(93)	—	36	1·6	—	—	—	—
(94)	—	70	1·2	–3·0	2,000	1·1 each	—
(95)	—	36	1·6	–3·0	1,500	4·2 each	—
(96)	100	—	2·6	—	—	—	—
(97)	—	80	4·5	–2·0	1,000	2·7	—
(98)	—	40	2·2	—	—	—	—
(99)	—	30	1·4	–3·0	—	1·0	—
(100)	—	40	3·6	–5·0	1,000	4·0	—
(101)	—	40	3·6	–5·0	1,000	4·0	—
(102)	—	40	3·6	–5·0	1,000	4·0	—
(103)	—	16	1·0	–4·5	—	2·5	—
(104)	—	27	2·0	–7·0	—	4·0	—
(105)	250	—	—	–6·0	—	36·0	—
(106)	—	27	2·0	–5·0	—	4·0	—
(107)	200	280	8·0	–8·5	—	45·0	—

[*Continued on next page*

TABLE XXX: DIODE

Make	Type	Description	Base	Fil. Volts	Fil. Amps	Anode Volts	
TUNGSRAM	DDT2	DDT	5B16	2·0	0·1	135	(108)
	DDT2B	DDT	5B16	2·0	0·1	135	(109)
	DDT4/S	DDT	7B19/8S21	4·0	0·65	250	(110)
	DDPP4B/M	DDP	7B32/7B33	4·0	2·0	250	(111)
	EBF11	DDP (HF)	0F4	6·3	0·2	300	(112)
	DDT6S	DDT	8S21	6·3	0·2	250	(113)
	EBC3/33	DDT	8S21/041	6·3	0·2	300	(114)
	EBF2	DDP (HF)	8S27	6·3	0·2	300	(115)
	EBL1/31	DDP	8S27/053	6·3	1·4	250	(116)
	DDT13/S	DDT	7B19/8S21	13·0	0·2	250	(117)
	DDPP39/M/S	DDP	7B32/7B33/8S27	39·0	0·2	200	(118)
	DDPP6B	DDP	7B32	6·3	1·4	250	(119)

TABLE XXXI: GENERAL-

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
BRIMAR ..	4215A	—	1·0	0·25	45	(1)
	HLA2	5B15	4·0	1·0	200	(2)
	4D1	7B18	13·0	0·2	200	(3)
	6C5G	—	6·3	0·3	250	(4)
	6J5G	—	6·3	0·3	250	(5)
COSSOR ..	210RC	4B4	2·0	0·1	150	(6)
	210HL	4B4	2·0	0·1	150	(7)
	210HF	4B4	2·0	0·1	150	(8)
	210DET	4B4	2·0	0·1	150	(9)
	210LF	4B4	2·0	0·1	150	(10)
	41MRC	5B15	4·0	1·0	200	(11)
	41MH	5B15	4·0	1·0	200	(12)
	41MHF	5B15	4·0	1·0	200	(13)
	41MHL	5B15	4·0	1·0	200	(14)
	41MLF	5B15	4·0	1·0	180	(15)
	DHL	5B15	16·0	0·25	200	(16)
	41MTL	5B15	4·0	1·0	250	(17)
	41MTB	5B15	4·0	1·0	250	(18)
	41MTA	5B15	4·0	1·0	200	(19)
DARIO ..	TB282	4B4	2·0	0·1	150	(20)
	TB172	4B4	2·0	0·1	150	(21)
	TB102	4B4	2·0	0·1	150	(22)
	TB122	4B4	2·0	0·2	135	(23)
	TE994	5B15	4·0	1·0	200	(24)
	TE384	5B15	4·0	1·0	200	(25)
	TE244	5B15	4·0	1·0	200	(26)
	TE094	5B15	4·0	1·0	200	(27)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

COMBINATIONS—*continued*

	Screen Volts	Amp. Factor	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Output (mW)
(108)	—	30	1·4	–1·5	—	1·0	—
(109)	—	16	1·0	–4·5	—	2·5	—
(110)	—	40	3·6	–5·0	—	4·0	—
(111)	250	—	10·0	—	150	36·0	3,600
(112)	125	—	1·8	—	—	—	—
(113)	—	30	2·5	–5·5	1,000	5·0	—
(114)	—	—	2·0	–6·25	—	5·0	—
(115)	300	—	1·8	–2·0	—	2·0	—
(116)	250	—	10·0	–6·0	150	36·0	3,600
(117)	—	40·0	3·6	–5·0	1,000	4·0	—
(118)	200	—	8·5	—	170	45·0	3,200
(119)	250	—	10·0	–6·0	—	2·0	—

PURPOSE TRIODES

	Amp. Factor	Impedance (Ohms)	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)
(1)	6	25,000	0·4	–3·0	0·8	—
(2)	50	9,000	5·5	–2·0	8·0	400
(3)	40	10,000	4·0	–3·0	5·0	800
(4)	20	10,000	2·0	–8	8·0	1,000
(5)	20	7,700	2·6	–8	9· 0	900
(6)	40	50,000	0·8	–1·5	0·45	—
(7)	24	22,000	1·1	–1·5	2·0	—
(8)	24	15,000	1·5	–1·5	2·25	—
(9)	15	13,000	1·15	–1·5	4·5	—
(10)	14	10,000	1·4	–3·0	4·5	—
(11)	50	19,500	2·6	–1·0	2·5	—
(12)	72	18,000	4·0	–1·5	1·5	—
(13)	41	14,500	2·8	–2·0	2·5	—
(14)	52	11,500	4·5	–3·0	4·0	—
(15)	15	7,900	1·9	–4·5	7·5	—
(16)	58	13,000	4·5	–1·5	3·8	—
(17)	44	15,000	3·0	–3·0	4·0	—
(18)	104	40,000	2·6	–1·0	3·4	—
(19)	—	—	—	—	—	—
(20)	28	22,000	1·3	–2·0	2·0	—
(21)	17	12,000	1·4	–3·0	4·5	—
(22)	10	8,000	1·25	–6·0	5·0	—
(23)	12	6,000	2·0	–6·0	5·0	—
(24)	100	25,000	4·0	–1·6	1·0	—
(25)	38	25,000	1·5	–2·5	1·5	—
(26)	24	10,000	2·4	–3·5	6·0	—
(27)	9	7,000	1·3	–16·0	12·0	—

[*Continued on next page*

TABLE XXXI: GENERAL-

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
DARIO—*cont.*	TC113	7B18	13·0	0·2	200	(28)
	TB9920	5B15	20·0	0·18	200	(29)
EVER READY	K30K	4B4	2·0	0·1	135	(30)
	K30D	4B4	2·0	0·1	150	(31)
	K30E	4B4	2·0	0·1	135	(32)
	A30B	5B15	4·0	0·65	200	(33)
	A30D	5B15	4·0	0·65	250	(34)
	C30B	7B18	13·0	0·2	200	(35)
FERRANTI ..	D4	5B15	4·0	1·0	200	(36)
	DA	7B18	13·0	0·2	200	(37)
	DS	5B15	13·0	0·3	200	(38)
HIVAC.. ..	XH1·5V	4D1	1·5	0·08	50	(39)
	XD1·5V	4D1	1·5	0·08	50	(40)
	XH2·0V	4D1	2·0	0·08	50	(41)
	XD2·0V	4D1	2·0	0·08	50	(42)
	H210	4B4	2·0	0·1	150	(43)
	D210	4B4	2·0	0·1	150	(44)
	D210SW	4B11	2·0	0·1	150	(45)
	L210	4B4	2·0	0·1	150	(46)
	AC/HL	5B15	4·0	1·0	200	(47)
	HL13	7B18	13·0	0·3	200	(48)
LISSEN ..	H2	4B4	2·0	0·1	150	(49)
	HL2	4B4	2·0	0·1	150	(50)
	L2	4B4	2·0	0·1	150	(51)
	AC/HL	5B15	4·0	1·0	200	(52)
MARCONI ..	H2	4B4	2·0	0·1	150	(53)
	HL21	4B4	2·0	0·1	150	(54)
	HL2	4B4	2·0	0·1	150	(55)
	HL2/K	4B4	2·0	0·1	150	(56)
	HL210	4B4	2·0	0·1	150	(57)
	L21	4B4	2·0	0·1	150	(58)
	L210	4B4	2·0	0·1	150	(59)
	H42	7B18	4·0	0·6	250	(60)
	MH41	5B15	4·0	1·0	200	(61)
	MH4	5B15	4·0	1·0	200	(62)
	MHL4	5B15	4·0	1·0	250	(63)
	H63	039	6·3	0·3	250	(64)
	L63	034	6·3	0·3	250	(65)
	H30	7B18	13·0	0·3	250	(66)
	L30	7B17	13·0	0·3	200	(67)
	DH	5B15	16·0	0·25	200	(68)
	ET1	4B1	1·0	0·1	4–10	(69)
	H11	4DS1	1·0	0·1	100	(70)
	L11	4D51	1·0	0·1	100	(71)
	H12	4D1	2·0	0·06	100	(72)
	L12	4D1	2·0	0·06	100	(73)
	A537	4DS	4·0	0·4	150	(74)
	A577	5B14	4·0	1·0	250	(75)
	MH40	5B15	4·0	1·0	200	(76)
	HA1	Acorn	4·0	0·25	180	(77)
	HA2	Acorn	6·3	0·15	180	(78)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

PURPOSE TRIODES—*continued*

	Amp. Factor	Impedance (Ohms)	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)
(28)	—	—	3·3	–3·7	5·0	—
(29)	100	—	3·0	—	—	—
(30)	30	21,500	1·4	–1·5	2·2	—
(31)	18	12,000	1·5	–4·5	4·0	—
(32)	18	12,000	1·5	–4·5	2·0	—
(33)	72	20,600	3·5	–2·0	2·2	—
(34)	40	11,500	3·5	–4·5	6·5	—
(35)	40	12,000	3·3	–3·7	5·0	—
(36)	40	12,500	3·3	–3·0	4·0	650
(37)	40	12,500	3·3	–3·0	3·7	650
(38)	40	12,500	3·3	–3·0	4·0	650
(39)	25	50,000	0·5	0	0·45	—
(40)	20	50,000	0·4	0	0·45	—
(41)	28	50,000	0·56	0	0·45	—
(42)	21	38,000	0·56	0	0·65	—
(43)	25	22,000	1·15	–3	1·1	—
(44)	16	12,000	1·35	–4·5	2·4	—
(45)	16	12,000	1·35	–4·5	2·4	—
(46)	12	7,500	1·6	–6·0	4·2	—
(47)	35	10,000	3·5	–2·75	6·0	460
(48)	35	10,000	3·5	–2·75	6·0	460
(49)	50	45,000	1·1	—	—	—
(50)	35	22,000	1·6	—	—	—
(51)	20	10,000	2·0	—	—	—
(52)	40	10,000	4·0	—	—	—
(53)	35	35,000	1·1	–1·5	1·5	—
(54)	27	18,000	1·5	–1·5	2·0	—
(55)	27	18,000	1·5	–1·5	2·0	—
(56)	27	18,000	1·5	–1·5	2·0	—
(57)	24	20,000	1·2	–3	1·2	—
(58)	16	8,900	1·8	–6·0	2·2	—
(59)	11	12,000	0·9	–7·5	2·5	—
(60)	100	66,000	1·5	–2	1·0	—
(61)	80	13,000	6·0	–2·0	—	400
(62)	40	11,100	3·6	–3·0	—	700
(63)	20	8,000	2·5	–9	5·5	850
(64)	100	66,000	1·5	–2·0	1·0	2,000
(65)	20	7,700	2·6	–9	7·5	—
(66)	80	13,300	6·0	–2·5	3·0	—
(67)	12	2,860	4·2	–10	20	—
(68)	40	10,800	3·7	—	—	—
(69)	—	—	0·08	—	—	—
(70)	15	30,000	0·5	0	—	—
(71)	4·4	7,700	0·57	0	—	—
(72)	26	108,000	0·24	0	—	—
(73)	4·8	6,000	0·8	—	2·5	—
(74)	15·5	10,000	1·55	—	—	—
(75)	6	3,000	2·0	—	—	—
(76)	45	18,000	2·5	—	—	—
(77)	25	12,500	2·0	–5·0	4·5	—
(78)	25	12,500	2·0	–5·0	4·5	—

[*Continued on next page*

TABLE XXXI: GENERAL-

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
MAZDA ..	H2	4B4	2·0	0·1	150	(79)
	HL2	4B4	2·0	0·1	150	(80)
	L2	4B4	2·0	0·1	150	(81)
	AC/HL	5B15	4·0	1·0	200	(82)
	AC2/HL	5B15	4·0	1·0	200	(83)
	HL41	0M19	4·0	0·65	250	(84)
	P41	0M19	4·0	0·95	250	(85)
	AC/P4	5B13	4·0	1·0	700	(86)
	HL1320	7B18	13·0	0·2	250	(87)
	HL133	0M20	13·0	0·2	250	(88)
	DC3HL	5B15	25·0	0·1	200	(89)
MULLARD ..	DC51	4D1	1·5	0·067	45	(90)
	DA1	4D1	2·0	0·05	40	(91)
	PM1A	4B4	2·0	0·1	150	(92)
	PM1HF	4B4	2·0	0·1	150	(93)
	PM1HL	4B4	2·0	0·1	135	(94)
	PM2HL	4B4	2·0	0·1	135	(95)
	PM1LF	4B4	2·0	0·1	150	(96)
	PM2DX	4B4	2·0	0·1	135	(97)
	PM2DL	4B4	2·0	0·1	135	(98)
	AT4	Acorn	4·0	0·25	200	(99)
	994V	5B15	4·0	0·65	200	(100)
	904V	5B15	4·0	0·65	200	(101)
	484V	5B15	4·0	1·0	200	(102)
	354V	5B15	4·0	0·65	250	(103)
	244V	5B15	4·0	0·65	200	(104)
	154V	5B15	4·0	0·65	200	(105)
	4761	Acorn	6·3	0·15	180	(106)
	HL13	8S20	13·0	0·2	200	(107)
	HL13C	7B18	13·0	0·2	200	(108)
OSRAM ..	H2	4B4	2·0	0·1	150	(109)
	HL2	4B4	2·0	0·1	150	(110)
	HL2/K	4B4	2·0	0·1	150	(111)
	HL210	4B4	2·0	0·1	150	(112)
	H210	4B4	2·0	0·1	150	(113)
	L21	4B4	2·0	0·1	150	(114)
	H42	5B15	4·0	0·6	250	(115)
	MH41	5B15	4·0	1·0	250	(116)
	MH4	5B15	4·0	0·1	250	(117)
	MHL4	5B15	4·0	1·0	250	(118)
	H63	039	6·3	0·3	250	(119)
	L63	039	6·3	0·3	250	(120)
	H30	5B15	13·0	0·3	250	(121)
	DH	5B15	16·0	0·25	200	(122)
	H12	4D1	2·0	0·06	100	(123)
	A577	5B14	4·0	1·0	250	(124)
	MH40	5B15	4·0	1·0	200	(125)
	HA1	Acorn	4·0	0·25	180	(126)
	HA2	Acorn	6·3	0·15	180	(127)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

PURPOSE TRIODES—*continued*

	Amp. Factor	Impedance (Ohms)	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)
(79)	50	45,000	1·1	0	2·5	—
(80)	32	21,000	1·5	–1·5	2·7	—
(81)	19	10,000	1·9	–3·0	5·3	—
(82)	35	11,700	3·0	–3·5	5·0	700
(83)	75	11,500	6·5	–1·75	4·5	390
(84)	36	10,300	3·5	–3·1	2·2	1,400
(85)	17	—	8·0	–10	30·0	—
(86)	20	2,800	7·0	–35	5·0	—
(87)	30	10,000	3·0	–4·5	7·5	600
(88)	36	10,600	3·4	–1·95	1·3	1,500
(89)	35	11,700	3·0	–3·5	5·0	700
(90)	25	66,000	0·38	0	0·34	—
(91)	32	80,000	0·4	0·25	0·25	—
(92)	50	41,600	1·2	–1·0	1·0	—
(93)	18	22,500	0·8	–3 –4·5	1·5	—
(94)	28	23,400	1·2	–1·5	2·3	—
(95)	30	21,500	1·4	–1·5	2·2	—
(96)	11	12,000	0·9	–7·5	4·0	—
(97)	18	18,000	1·0	–4·5	2·0	—
(98)	18	12,000	1·5	–4·5	2·0	—
(99)	25	12,500	2·0	–6·0	4·5	—
(100)	135	35,000	3·6	–1·5	1·35	1,000
(101)	72	20,600	3·5	–2·0	2·2	900
(102)	48	21,800	2·2	–3·0	2·8	1,000
(103)	40	11,500	3·5	–4·5	6·5	700
(104)	25	9,000	2·8	–5·5	5·5	1,000
(105)	15	7,500	2·0	–7·5	9·0	800
(106)	25	12,500	2·0	–5·0	4·5	—
(107)	40	12,000	3·3	–3·7	5·0	740
(108)	40	12,000	3·3	–3·7	5·0	740
(109)	35	35,000	1·0	–1·5	1·5	—
(110)	27	18,000	1·5	–1·5	2·0	—
(111)	27	18,000	1·5	–1·5	2·0	—
(112)	24	20,000	1·2	—	—	—
(113)	35	50,000	0·7	—	—	—
(114)	16	8,900	1·8	–6·0	2·2	—
(115)	100	66,000	1·7	–2·0	1·0	2,000
(116)	80	13,300	6·0	–2·5	3·6	700
(117)	40	11,000	3·6	–4·0	5·0	750
(118)	20	8,000	2·5	–8·0	8·0	1,000
(119)	100	66,000	1·5	–2·0	1·0	2,000
(120)	20	7,700	2·6	—	—	—
(121)	80	13,300	6·0	—	—	—
(122)	40	10,800	3·7	—	—	—
(123)	26	21,600	1·2	—	—	—
(124)	6·0	3,000	2·0	—	—	—
(125)	45	18,750	2·4	—	—	—
(126)	20	11,700	1·7	–6·5	4·5	—
(127)	25	12,500	2·0	—	—	—

[*Continued on next page*

TABLE XXXI: GENERAL-

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
RECORD ..	H2	4B4	2·0	0·1	200	(128)
	L2	4B4	2·0	0·12	150	(129)
	DL2	4B4	2·0	0·1	150	(130)
	AC/NHL	5B15	4·0	0·65	250	(131)
	NHL/13	7B18	13·0	0·2	200	(132)
	NHL/13L	8S20	13·0	0·2	200	(133)
TRIOTRON ..	HD2	4B4	2·0	0·08	200	(134)
	TD2	4B4	2·0	0·1	150	(135)
	A214	4B4	2·0	0·1	150	(136)
	W213	4B4	2·0	0·1	150	(137)
	A440N	5B15	4·0	1·0	200	(138)
	A2040N	5B15	20·0	0·18	200	(139)
TUNGSRAM ..	HR2	4B4	2·0	0·06	135	(140)
	HR210	4B4	2·0	0·1	200	(141)
	HL2	4B4	2·0	0·13	135	(142)
	LD210	4B4	2·0	0·1	150	(143)
	LL2	4B4	2·0	0·2	135	(144)
	HL4+	5B15	4·0	0·65	250	(145)
	HL4g	7B18	4·0	0·65	250	(146)
	LL4C	5B13	4·0	1·2	350	(147)
	HL13	7B18	13·0	0·2	200	(148)

TABLE XXXII: POWER

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
BRIMAR ..	PA1	5B15	4·0	1·1	200	(1)
COSSOR ..	215P	4B4	2·0	0·15	150	(2)
	220P	4B4	2·0	0·2	150	(3)
	220PA	4B4	2·0	0·2	150	(4)
	230XP	4B4	2·0	0·3	150	(5)
	2P	4B4	2·0	2·0	250	(6)
	2XP	4B4	2·0	2·0	300	(7)
	41MP	5B15	4·0	1·0	200	(8)
	41MXP	SB15	4·0	1·0	200	(9)
	4XP	4B4	4·0	1·0	250	(10)
	DP	7B18	16·0	0·25	200	(11)
	402P	7B18	40·0	0·2	200	(12)
DARIO ..	TB052	4B4	2·0	0·15	150	(13)
	TB062	4B4	2·0	0·33	150	(14)
	TB032	4B4	2·0	0·2	150	(15)
	TF104	4B4	4·0	2·0	550	(16)
	TF364	4B4	4·0	2·0	400	(17)
	TD044	4B4	4·0	0·65	250	(18)
	TD4	4B4	4·0	1·0	300	(19)
EVER READY ..	K30G	4B4	2·0	0·2	135	(20)
	S30C	4B4	4·0	1·0	300	(21)
	S30D	4B4	2·0	2·0	300	(22)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

	Amp. Factor	Impedance (Ohms)	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)
(128)	30	23,000	1·3	–3·0	1·0	—
(129)	17	15,000	1·2	–5·0	3·2	—
(130)	18	14,000	1·3	–4·5	3·0	—
(131)	33	11,000	3·5	–4·5	5·0	1,000
(132)	30	12,000	3·5	–4·0	6·0	1,000
(133)	30	12,000	3·5	–4·0	6·0	1,000
(134)	15	15,000	1·0	–5·0	5·0	—
(135)	10	8,000	1·25	–6·0	5·0	—
(136)	17	12,000	1·4	–4·5	4·0	—
(137)	28	22,000	1·3	–2·5	1·0	—
(138)	100	25,000	4·0	–1·6	1·0	—
(139)	100	25,000	4·0	–1·5	0·2	—
(140)	25	40,000	0·6	–1·5	1·2	—
(141)	30	23,000	1·3	–3·0	1·0	—
(142)	30	21,000	1·5	–1·5	2·2	—
(143)	18	14,000	1·3	–4·5	3·0	—
(144)	30	11,500	2·6	–2·5	3·0	—
(145)	33	11,000	3·5	–4·5	5·0	1,000
(146)	33	11,000	3·5	–4·5	5·0	1,000
(147)	10	—	3·5	—	—	—
(148)	30	12,000	3·5	–5·5	6·0	1,000

OUTPUT TRIODES

	Impedance	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)	Output (mW)	Optimum Load (Ohms)
(1)	1,050	12·0	–9·0	50·0	260	1,250	4,000
(2)	4,000	2·25	–7·5	10·0	—	150	9,000
(3)	4,000	2·25	–7·5	11·0	—	190	9,000
(4)	4,000	4·0	–4·5	10·0	—	180	9,000
(5)	1,500	3·0	–18·0	22·0	—	450	3,500
(6)	1,150	7·0	–22·0	40·0	—	—	3,000
(7)	900	7·0	–36·0	50·0	—	—	4,000
(8)	2,500	7·5	–7·5	24·0	320	1,250	3,000
(9)	1,500	7·5	–12·5	40·0	300	2,000	2,000
(10)	900	7·0	–28·5	48·0	600	3,000	3,000
(11)	2,800	6·0	–7·5	25·0	300	—	3,500
(12)	1,330	7·5	–9·5	30·0	320	—	2,500
(13)	4,200	1·2	–18·0	7·0	—	150	11,000
(14)	3,000	2·0	–10·5	13·0	—	1,550	6,000
(15)	2,000	1·5	–30·0	12·0	—	500	6,000
(16)	2,500	4·0	–36·0	45·0	—	—	—
(17)	3,000	3·8	–92·0	63·0	—	—	—
(18)	1,300	2·7	–40·0	40·0		—	—
(19)	1,200	5·0	–38·0	48·0	—	—	—
(20)	6,000	2·0	–6·0	5·0	—	150	7,000
(21)	1,200	5·0	–38·0	50·0	600	3,500	2,300
(22)	1,200	5·0	–38·0	50·0	600	3,500	2,300

[*Continued on next page*

TABLE XXXII: POWER

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
FERRANTI	L2	4B4	2·0	0·1	150	(23)
	LP4	4B4	4·0	1·0	250	(24)
HIVAC ..	XL1·5V	4D1	1·5	0·08	50	(25)
	XLO1·5V	4D1	1·5	0·08	50	(26)
	XP1·5V	4D1	1·5	0·08	50	(27)
	XL2·0V	4D1	2·0	0·08	50	(28)
	XLO2·0V	4D1	2·0	0·08	50	(29)
	XP2·0V	4D1	2·0	0·08	50	(30)
	P215	4B4	2·0	0·15	150	(31)
	P220	4B4	2·0	0·2	150	(32)
	PP220	4B4	2·0	0·2	150	(33)
	PX230	4B4	2·0	0·3	150	(34)
	PX230SW	4B11	2·0	0·3	150	(35)
	AC/L	5B15	4·0	1·0	200	(36)
	PX41	4B4	4·0	1·0	250	(37)
	PX5	4B4	4·0	2·0	400	(38)
LISSEN ..	LP2	4B4	2·0	0·2	150	(39)
	P220	4B4	2·0	0·2	150	(40)
	PX240	4B4	2·0	0·4	200	(41)
MARCONI ..	LP2	4B4	2·0	0·2	150	(42)
	P215	4B4	2·0	0·15	150	(43)
	P2	4B4	2·0	0·2	150	(44)
	ML4	5B15	4·0	1·0	200	(45)
	PX4	4B4	4·0	1·0	300	(46)
	PX25	4B4	4·0	2·0	400	(47)
	PX25A	4B4	4·0	2·0	400	(48)
	DA30	4B4	4·0	2·0	500	(49)
	DA60	4L1	6·0	4·0	500	(50)
	DA100	4L1	6·0	2·7	1,000	(51)
	DA250	4M1	10·0	2·0	2,500	(52)
	DA41	4UX1	7·5	2·5	1,000	(53)
	DL	5B15	16·0	0·25	200	(54)
MAZDA ..	P220	4B4	2·0	0·2	150	(55)
	P220A	4B4	2·0	0·2	150	(56)
	PA20	4B4	2·0	2·0	300	(57)
	AC/P	5B15	4·0	1·0	200	(58)
	AC/P1	5B15	4·0	1·0	200	(59)
	PP5/400	4B4	4·0	2·0	400	(60)
	PP3/250	4B4	4·0	1·0	300	(61)
Per pair in push-pull }	PA40	4B4	4·0	2·0	400	(62)
	PP3521	7B17	35·0	0·2	250	(63)
	DC2/P	5B15	35·0	0·1	200	(64)
MULLARD	DD51	4D1	1·5	0·67	45	(65)
	DA2	4D1	2·0	0·05	40	(66)
	DA3	4D1	2·0	0·05	40	(67)
	PM2A	4B4	2·0	0·2	135	(68)
	PM2	4B4	2·0	0·2	150	(69)
	PM252	4B4	2·0	0·2	150	(70)
	PM202	4B4	2·0	0·2	150	(71)
	164V	5B15	4·0	0·65	200	(72)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

OUTPUT TRIODES—*continued*

	Impedance	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)	Output (mW)	Optimum Load (Ohms)
(23)	6,800	1·6	—	5·6	—	—	—
(24)	980	5·5	–35·0	48·0	730	2,800	2,500
(25)	20,000	0·6	–1·0	0·7	—	—	—
(26)	20,000	0·65	–1·0	0·9	—	—	—
(27)	7,250	0·72	–4·5	1·75	—	—	—
(28)	12,500	0·84	–1·0	1·0	—	—	—
(29)	12,500	0·92	–1·1	1·1	—	—	—
(30)	6,000	1·0	–3·0	2·0	—	—	—
(31)	3,600	2·2	–12	8·0	—	150	10,000
(32)	4,700	3·0	–7·5	6·0	—	175	9,000
(33)	2,300	3·0	–12·0	12·5	—	250	5,000
(34)	1,850	3·5	–15·0	17·5	—	450	4,000
(35)	1,850	3·5	–15·0	17·5	—	450	4,000
(36)	2,350	4·25	–13·5	17·0	760	675	6,300
(37)	830	6·0	–40·0	48·0	830	2,500	3,500
(38)	1,480	6·5	–34·0	62·5	530	5,750	3,000
(39)	3,500	3·5	—	—	—	200	—
(40)	4,000	1·75	—	—	—	100	—
(41)	1,500	3·0	—	—	—	800	—
(42)	3,900	3·85	–6·0	7·0	—	—	9,700
(43)	5,000	1·4	–12·0	8·5	—	—	12,000
(44)	2,150	3·5	–12·0	14·0	—	200	6,000
(45)	2,860	4·2	–8·0	25	400	—	6,000
(46)	830	6·0	–50·0	50·0	1,000	4,500	3,500
(47)	1,265	7·5	–30·0	6·25	530	5,500	4,000
(48)	580	6·9	–103·0	62·5	1,630	8,400	4,500
(49)	910	3·85	–134·0	60·0	—	—	—
(50)	835	3·0	–135·0	120·0	1,100	—	2,800
(51)	1,410	3·9	–150·0	100·0	—	—	—
(52)	2,300	7·0	–130·0	80·0	—	—	—
(53)	17,500	3·6	0	—	—	—	—
(54)	2,660	4·5	—	—	—	—	—
(55)	3,700	3·4	–7·0	5·5	—	180	10,000
(56)	1,850	3·5	–14·0	15·0	—	350	4,100
(57)	1,000	6·5	–29·0	42·0	690	2,650	2,750
(58)	2,650	3·75	–13·5	17·0	750	650	6.000
(59)	1,450	3·7	–28·0	24·0	1,200	1,000	5,000
(60)	1,500	6·0	–32·0	62·5	510	5,900	2,700
(61)	1,000	6·5	–30·0	42·0	715	2,650	2,750
(62)	425	4·5	–85·0	210·0	400	33,500	3,700
(63)	600	10·0	–25·0	70·0	360	2,300	2,000
(64)	2,650	3·75	–13·5	17·0	800	650	6,000
(65)	10,000	0·5	–3·0	1·7	—	—	—
(66)	13,600	0·5	–2·15	1·25	—	—	—
(67)	7,600	0·62	–2·8	1·8	—	—	—
(68)	6,000	2·0	–6·0	5·0	—	150	7,000
(69)	4,400	1·7	–12·0	6·6	—	—	9,000
(70)	2,000	3·5	–12·0	14·0	—	—	3,700
(71)	2,000	3·5	–12·0	14·0	—	—	3,700
(72)	3,640	4·5	–8·5	13·0	—	—	—

[*Continued on next page*

TABLE XXXII: POWER

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
MULLARD— *continued*	104V	5B15	4·0	1·0	250	(73)
	TT4	5B15	4·0	1·0	250	(74)
	TT4A	5B15	4·0	1·0	250	(75)
	AC104	4B4	4·0	1·0	200	(76)
	AC064	4B4	4·0	1·0	200	(77)
	AC044	4B4	4·0	1·0	300	(78)
	AC042	4B4	2·0	2·0	300	(79)
	D024	4B4	4·0	1·85	400	(80)
	D026	4B4	4·0	2·0	400	(81)
	D030	4B4	4·0	1·85	500	(82)
	D010	4B4	6·0	0·85	400	(83)
	D025	4B4	6·0	1·1	400	(84)
	D020	4B4	7·5	1·1	425	(85)
	EC31	034	6·3	0·65	250	(86)
OSRAM ..	L12	4D1	2·0	0·06	100	(87)
	LP2	4B4	2·0	0·2	150	(88)
	P215	4B4	2·0	0·15	150	(89)
	P2	4B4	2·0	0·2	150	(90)
	ML4	5B15	4·0	1·0	250	(91)
	PX4	4B4	4·0	1·0	300	(92)
	PX25	4B4	4·0	2·0	400	(93)
	PX25A	4B4	4·0	2·0	400	(94)
	DA30	4B4	4·0	2·0	500	(95)
	DET 5	4B4	4·0	2·0	600	(96)
	DA60	4L1	6·0	4·0	500	(97)
	DA100	4L1	6·0	2·7	1,000	(98)
Double	DET19	7UX10	6·3	0·8	300	(99)
	DA41	4UX3	7·5	2·5	1,000	(100)
	DET12	4B4	7·5	3·2	1,250	(101)
	DET14	4UX3	7·5	3·0	1,500	(102)
	DA250	4M1	10·0	2·0	2,500	(103)
	DL	5B15	16·0	0·25	200	(104)
TRIOTRON	ZD2	4B4	2·0	0·15	150	(105)
	UD2	4B4	2·0	0·33	150	(106)
	E235	4B4	2·0	0·2	150	(107)
	E430N	5B15	4·0	1·0	200	(108)
	K480	4B4	4·0	2·0	550	(109)
	K435/10	4B4	4·0	0·65	250	(110)
	T1325	7B49	13·0	0·2	200	(111)
TUNGSRAM	LP220	4B4	2·0	0·2	150	(112)
	P215	4B4	2·0	0·15	150	(113)
	SP220	4B4	2·0	0·2	150	(114)
	LL4	5B15	4·0	1·2	350	(115)
	P12/250	4B4	4·0	1·0	250	(116)
	P15/250	4B4	4·0	1·0	250	(117)
	015/400	4B4	4·0	1·0	400	(118)
	P26/500	4B4	4·0	2·0	500	(119)
	P27/500	4B4	4·0	2·0	500	(120)
	P25/500	4B4	6·0	1·1	500	(121)
	P60/500	4L1	6·0	4·0	600	(122)
	P25/450	4B4/4UX3	7·5	1·25	450	(123)
	PX2100	4B4	7·5	1·25	425	(124)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

OUTPUT TRIODES—*continued*

	Impedance	Slope (mA/V)	Bias Volts	Anode Current (mA)	Bias Res. (Ohms)	Output (mW)	Optimum Load (Ohms)
(73)	3,300	3·2	−16·0	20·0	—	500	10,000
(74)	3,300	3·2	−16·0	20·0	—	500	10,000
(75)	4,400	4·1	−9·0	20·0	—	400	5,000
(76)	2,850	3·5	−14·0	11·0	1,500	400	6,000
(77)	2,000	3·0	−21·0	20·0	1,000	620	5,000
(78)	1,200	5·0	−38·0	50·0	—	3,500	2,300
(79)	1,200	5·0	−38·0	50·0	—	3,500	2,300
(80)	1,070	7·5	−40·0	63·0	—	7,100	3,200
(81)	950	3·8	−92·0	63·0	1,500	7,500	3,000
(82)	890	3·5	−140·0	60·0	—	—	—
(83)	2,850	0·85	−130·0	25·0	5,500	2,500	6,000
(84)	800	3·75	−112·0	63·0	1,780	7,000	4,000
(85)	2,000	2·5	−66·0	40·0	1,650	5,000	5,000
(86)	3,300	3·2	−16·0	20·0	—	500	10,000
(87)	6,000	0·8	−4·5	1·9	—	1·2	—
(88)	4,170	3·6	−6·0	5·6	—	100	—
(89)	5,000	1·4	—	—	—	—	—
(90)	2,150	3·5	−12·0	14·0	—	200	—
(91)	2,860	4·2	−16·0	14·0	1,000	—	7,000
(92)	830	6·0	−42·0	50·0	900	3,500	4,000
(93)	1,265	7·5	−31·0	62·5	530	5,500	3,200
(94)	580	6·9	−103·0	62·5	1,630	8,400	4,500
(95)	580	6·9	−134·0	60·0	—	11,000	6,000
(96)	1,265	7·0	—	—	—	35,000	—
(97)	835	3·0	−135·0	120·0	1,100	—	2,800
(98)	1,410	3·9	−150·0	100·0	—	30,000	6,800
(99)	3,340	2·1	—	—	—	16,000	—
(100)	17,500	3·6	—	—	—	—	—
(101)	—	—	—	—	—	70,000	—
(102)	—	—	—	—	—	80,000	—
(103)	2,290	7·0	−130·0	80·0	—	800,000	12,000
(104)	2,660	4·5	—	—	—	—	—
(105)	4,200	1·2	−18·0	7·0	—	—	—
(106)	2,000	2·0	−15·0	12·0	—	—	—
(107)	3,000	3·0	−7·5	13·0	—	—	—
(108)	7,000	1·3	−16·0	12·0	—	—	—
(109)	2,500	4·0	−36·0	45·0	—	—	—
(110)	1,300	2·7	−40·0	40·0	—	—	—
(111)	—	3·3	−3·7	5·0	—	—	—
(112)	3,500	3·5	−6·0	5·0	—	200	7,500
(113)	3,300	1·5	−12·0	8·0	—	260	7,000
(114)	2,200	3·0	−18·0	14·0	—	360	6,700
(115)	—	3·5	—	24·0	—	—	—
(116)	850	6·0	−33·0	48·0	700	2,800	2,400
(117)	660	6·0	−44·0	60·0	750	3,500	2,500
(118)	1,800	5·0	−38·0	30·0	1,000	3,700	7,000
(119)	670	4·7	−100·0	62·5	1,600	6,500	5,000
(120)	1,100	8·0	−32·0	62·5	500	5,000	4,000
(121)	1,000	3·0	−112·0	62·5	1,950	4,000	7,000
(122)	1,000	3·5	−125·0	116·0	1,080	15,000	3,000
(123)	2,000	2·0	−82·0	55·0	1,500	5,100	5,000
(124)	5,000	1·6	−39·0	18·0	2,000	1,600	10,200

TABLE XXXIII: OUTPUT PENTODES

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
BRIMAR ..	6F6G	—	6·3	0·7	250	(1)
	6V6G	—	6·3	0·45	250	(2)
	25A6G	—	25·0	0·3	180	(3)
	PENB1	5B4	2·0	0·2	150	(4)
	7A2	5B18/7B31	4·0	1·2	250	(5)
	7A3	7B31	4·0	2·0	250	(6)
	PENA1	5B4	4·0	1·0	250	(7)
	7D5	7B31	13·0	0·315	250	(8)
	7D8	7B31	13·0	0·65	250	(9)
	7D3	7B31	40·0	0·2	180	(10)
	7D6	7B31	40·0	0·2	250	(11)
COSSOR ..	210PT	4B6/5B4	2·0	0·2	150	(12)
	220HPT	4B6/5B4	2·0	0·2	150	(13)
(Tetrode)	220 0T	5B3	2·0	0·2	150	(14)
	230PT	4B6/5B4	2·0	0·3	150	(15)
	PT41	5B4	4·0	1·0	250	(16)
	PT41B	5B4	4·0	1·0	400	(17)
	MP Pen	5B18/7B27	4·0	1·0	250	(18)
	42MP Pen	7B27	4·0	2·0	250	(19)
	41MPT	7B23	4·0	1·0	250	(20)
	42MPT	7B23	4·0	2·0	250	(21)
	41MTS	7B43	4·0	1·0	250	(22)
	PT10	7B27	4·0	2·0	250	(23)
(Tetrode)	42 0T	7B20	4·0	2·0	250	(24)
	DP/Pen	7B27	16·0	0·25	250	(25)
(Tetrode)	402 0T	7B21	40·0	0·2	250	(26)
	40PPA	7B27	40·0	0·2	150	(27)
	402 Pen	7B29	40·0	0·2	250	(28)
	402 Pen/A	7B29	40·0	0·2	150	(29)
DARIO ..	TC432	4B6/5B4	2·0	0·2	150	(30)
	TC434	5B4	4·0	0·25	300	(31)
	TE534	7B27	4·0	1·1	250	(32)
	TE434	5B4	4·0	1·1	250	(33)
	TE634	5B18/7B27	4·0	1·35	250	(34)
	TL44	7B27	4·0	1·75	250	(35)
	TL54	7B27	4·0	2·0	250	(36)
	TL413	7B27	33·0	0·2	200	(37)
	TB4320	8S22	24·0	0·2	200	(38)
	TBL226	5B4	24·0	0·18	200	(39)
EKCO ..	OP41	7B27	4·0	1·8	300	(40)
	0P42	7B27	4·0	1·8	250	(41)
EVER READY	K70B	5B4	2·0	0·15	135	(42)
	K70D	5B4	2·0	0·3	135	(43)
	A70B	7B27	4·0	1·35	250	(44)
	A70D	7B27	4·0	1·95	250	(45)
	A70E	7B27	4·0	2·1	250	(46)
	EL32	030	6·3	0·2	250	(47)
	EL3/33	8S23/048	6·3	0·9	250	(48)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND TETRODES

	Screen Volts	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode and Screen Current (mA)	Output (mW)	Optimum Load (Ohms)
(1)	250	2·35	–16·5	410	40·5	3,000	7,000
(2)	250	4·10	–12·5	240	49·5	4,250	5,000
(3)	135	2·5	–20	440	45	2,750	5,000
(4)	150	2·5	–4·5	—	9·6	—	18,000
(5)	250	3·2	–17·5	330	38·5	3,500	8,000
(6)	250	10·0	–6	150	38·0	3,750	8,500
(7)	250	3·6	–16·5	450	38·5	2,700	8,000
(8)	250	2·35	–16·5	410	40·5	3,000	7,000
(9)	250	10·0	–6	150	38·0	3,750	8,500
(10)	135	2·5	–20	440	45·0	2,750	5,000
(11)	250	10·0	–6	150	38·0	3,750	8,500
(12)	150	2·5	–7·5	—	—	—	8,000
(13)	150	2·5	–3·0	—	—	—	20,000
(14)	150	2·5	–4·5	—	—	—	20,000
(15)	150	2·0	–15·0	—	23·0	—	10,000
(16)	200	3·0	–12·5	350	36·0	—	8,000
(17)	300	2·25	–33·0	—	—	—	8,000
(18)	250	3·5	–16·0	450	36·0	—	10,000
(19)	250	7·0	–5·5	140	38·0	—	8,000
(20)	200	4·8	—	—	—	—	—
(21)	250	7·0	—	—	—	—	—
(22)	100	1·6	—	—	—	—	—
(23)	250	9·0	–7·5	—	—	—	5,000
(24)	250	7·0	–5·5	130	—	—	6,500
(25)	250	3·5	–10·0	300	—	—	10,000
(26)	250	7·0	–6·6	—	—	—	5,500
(27)	150	4·0	–25·0	600	42·0	—	4,000
(28)	250	7·0	–6·7	140	—	—	5,500
(29)	150	8·0	–9·0	—	—	—	2,500
(30)	150	2·4	–4·5	—	—	—	—
(31)	200	1·7	–25·0	—	—	—	—
(32)	250	2·5	–15·0	—	—	—	—
(33)	250	2·8	–14·0	—	—	—	—
(34)	250	2·7	–22·0	—	—	—	—
(35)	250	9·5	—	—	—	—	—
(36)	275	8·5	—	—	—	—	—
(37)	200	8·0	–8·5	—	—	—	—
(38)	100	3·1	–19·0	—	—	—	—
(39)	—	8·0	–19·0	—	—	—	—
(40)	250	9·0	–13·0	200	66·0	8,000	4,000
(41)	250	11·0	–6·0	145	36·5	3,800	8,000
(42)	135	2·2	–4·5	—	—	340	19,000
(43)	135	3·0	–2·4	—	—	300	24,000
(44)	250	2·8	–22·0	—	—	3,800	6,000
(45)	250	9·5	–5·8	—	—	3,800	8,000
(46)	275	8·5	–14·0	—	—	8,800	3,500
(47)	250	2·8	–18·0	—	—	3,600	8,000
(48)	250	9·0	–6·0	—	—	4,500	7,000

[*Continued on next page*

TABLE XXXIII: OUTPUT PENTODES

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
FERRANTI	PT4	7B27	4·0	2·0	250	(49)
	PTA	7B27	13·0	0·3	250	(50)
	PTSA	—	26·0	0·3	250	(51)
	PTZ	—	40·0	0·2	250	(52)
HIVAC . .	XY1·5V	5D2	1·5	0·16	45	(53)
	XY2·0V	5D2	2·0	0·16	50	(54)
(Tetrode)	Y220	4B12	2·0	0·2	150	(55)
,,	Z220	4B12	2·0	0·2	150	(56)
,,	AC/Y	5B18/7B27	4·0	1·0	250	(57)
,,	AC/YY	7B27	4·0	2·0	250	(58)
,,	AC/Z	7B27	4·0	2·0	250	(59)
,,	AC/Q	7B27	4·0	1·35	375	(60)
,,	FY	4B12	4·0	1·0	250	(61)
,,	AC/QA	7B27	6·3	0·9	375	(62)
,,	Y13	7B27	13·0	0·3	250	(63)
,,	Z26	7B27	26·0	0·3	250	(64)
LISSEN . .	PT225	4B6/5B4	2·0	0·2	150	(65)
	PT240	4B6/5B4	2·0	0·4	200	(66)
	PT2A	4B6/5B4	2·0	0·2	250	(67)
	PT425	4B6/5B4	4·0	0·25	200	(68)
	PT611	4B6	6·0	0·1	150	(69)
	AC/PT	5B4/7B27	4·0	1·0	250	(70)
MARCONI . .	N14	08	1·4	0·1	90	(71)
(Tetrode)	KT2	5B4	2·0	0·2	150	(72)
,,	PT2	5B4	2·0	0·2	150	(73)
,,	KT21	4B4	2·0	0·3	150	(74)
,,	KT24	4B4	2·0	0·2	150	(75)
,,	MKT4	7B27	4·0	1·0	250	(76)
,,	MPT4	7B27	4·0	1·0	250	(77)
,,	MPT4K	7B27	4·0	1·0	250	(78)
,,	KT41	7B27	4·0	2·0	250	(79)
,,	N40	7B27	4·0	1·0	250	(80)
,,	N41	7B27	4·0	2·0	250	(81)
,,	KT42	7B27	4·0	1·0	250	(82)
,,	N42	7B27	4·0	1·0	250	(83)
	N43	7B29	4·0	2·0	250	(84)
	PT4	5B4	4·0	1·0	250	(85)
	PT25	5B4	4·0	2·0	400	(86)
	PT25H	5B4	4·0	2·0	400	(87)
	PT16	5B4	4·0	1·0	300	(88)
,,	KT61	048	6·3	0·95	250	(89)
,,	KT63	048	6·3	0·7	250	(90)
,,	KT66	048	6·3	1·27	400	(91)
	N30	7B27	13·0	0·3	250	(92)
	KT30	7B27	13·0	0·3	250	(93)
	DPT	7B27/5B4	16·0	0·25	200	(94)
,,	KT31	7B46	13·0 26·0	0·6 0·3	200	(95)
	N31	7B46	13·0 26·0	0·6 0·3	200	(96)
,,	KT32	048	26·0	0·3	135	(97)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND TETRODES—*continued*

	Screen Volts	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode and Screen Current (mA)	Output (mW)	Optimum Load (Ohms)
(49)	250	7·0	—	—	—	—	—
(50)	250	—	—	—	37·5	—	—
(51)	250	—	−8·9	—	37·5	—	—
(52)	250	—	—	—	47·0	—	—
(53)	45	1·0	−1·5	—	2·1	—	—
(54)	50	1·4	−2·0	—	2·15	—	—
(55)	150	2·5	−4·5	—	11·8	500	11,500
(56)	150	2·5	−6·0	—	20·1	1,000	7,500
(57)	250	3·5	−10·0	300	36·3	3,000	6,500
(58)	250	7·5	−10·0	140	78·0	5,000	3,000
(59)	250	8·0	−5·5	160	36·3	3,000	6,500
(60)	250	6·0	−22	370	59·5	11,500	4,000
(61)	250	5·0	−10	250	38·0	3,000	6,000
(62)	250	6·0	−22	370	59·5	11,500	4,000
(63)	250	4·0	−22	550	39·5	3,000	4,000
(64)	250	8·0	−11	250	44·0	3,000	4,000
(65)	150	1·6	—	—	—	300	—
(66)	150	2·3	—	—	—	1,000	—
(67)	150	2·5	—	—	—	1,100	—
(68)	150	2·3	—	—	—	1,000	—
(69)	150	1·4	—	—	—	300	—
(70)	250	4·0	—	—	—	2,500	—
(71)	90	1·55	−7·5	—	9·0	250	8,000
(72)	150	2·5	−4·5	—	9·2	500	17,000
(73)	150	2·5	−4·5	—	9·2	500	17,000
(74)	150	5·3	−2·5	—	12·3	750	10,000
(75)	150	3·2	−2·8	—	12·1	640	10,000
(76)	225	3·0	−13·5	360	37·0	3,200	7,000
(77)	200	3·0	−10·5	250	37·5	—	8,000
(78)	200	3·0	−10·5	250	37·0	—	8,000
(79)	250	10·5	−4·4	90	48·5	4,300	6,000
(80)	225	2·9	—	—	—	—	—
(81)	250	10·5	−4·4	90	48·5	4,300	6,000
(82)	250	2·5	−16·5	420	39·5	3,000	7,000
(83)	250	2·5	−16·5	420	39·5	3,000	7,000
(84)	250	10·0	−4·5	—	50·0	—	5,400
(85)	250	2·85	−10·0	400	38·0	2,500	7,500
(86)	200	4·0	—	—	—	—	—
(87)	400	6·5	−16·0	250	75·0	10,000	5,000
(88)	300	4·8	−15	270	63·0	—	5,000
(89)	250	10·5	−4·4	90	47·5	4,300	6,000
(90)	250	2·5	−16·5	420	39·5	3,000	7,000
(91)	300	6·3	−15	170	92·0	7,250	2,200
(92)	250	3·9	−14·0	375	37·0	2,600	7,500
(93)	250	3·9	−14·0	375	37·0	2,600	7,500
(94)	200	3·0	—	—	—	—	—
(95)	200	10·0	−4·5	95	54·0	3,000	6,500
(96)	180	10·0	−4·5	95	—	3,000	6,500
(97)	135	9·0	−7·6	95	80·0	3,500	1,300

[*Continued on next page*

TABLE XXXIII: OUTPUT PENTODES

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
MARCONI—*continued*	KT33C	048	26·0 13·0	0·3 0·6	200	(98)
	KT35	048	26·0 13·0	0·3 0·6	200	(99)
	KT44	7B23	4·0	2·0	400	(100)
MAZDA ..	PEN141	0M4	1·4	0·1	90	(101)
	PEN231	5B4	2·0	0·3	150	(102)
	PEN220	5B4	2·0	0·2	150	(103)
	PEN220A	5B4	2·0	0·2	150	(104)
	PEN24	0M4	2·0	0·3	150	(105)
	PEN25	0M4	2·0	0·15	150	(106)
	AC/PEN	7B27	4·0	1·0	250	(107)
	AC2/PEN	7B27	4·0	1·75	250	(108)
	AC4/PEN	7B20	4·0	1·75	250	(109)
	AC5/PEN	7B20	4·0	1·75	250	(110)
	AC6/PEN	7B47	4·0	1·75	330	(111)
	PEN44	0M22	4·0	2·1	275	(112)
	PEN45	0M22	4·0	1·75	250	(113)
	PEN46	0M23	4·0	1·75	330	(114)
	PEN1340	7B27	13·0	0·4	250	(115)
	PEN3520	7B27	35·0	0·2	250	(116)
	DC2/PEN	7B27	35·0	0·1	250	(117)
	PEN3820	7B20	38·0	0·2	200	(118)
	PEN383	0M22	38·0	0·2	200	(119)
MULLARD	DL1	8S8	1·4	0·05	90	(120)
	DL2	8S8	1·4	0·1	90	(121)
	DL51	4D3	1·5	0·134	45	(122)
	PM22	4B6/5B4	2·0	0·2	150	(123)
	PM22A	4B6/5B4	2·0	0·15	135	(124)
	PM22C	5B4	2·0	0·3	150	(125)
	PM22D	5B4	2·0	0·3	135	(126)
	PEN4VA	5B18/7B27	4·0	1·35	250	(127)
	PEN4VB	7B27	4·0	1·95	250	(128)
	PENA4	7B27	4·0	1·95	250	(129)
	PENB4	7B27	4·0	2·1	250	(130)
	PEN428	7B27	4·0	2·1	375	(131)
	PM24	4B6/5B4	4·0	0·15	150	(132)
	PM24A	5B4	4·0	0·275	300	(133)
	PM24M	5B4	4·0	1·1	250	(134)
	PM24B	5B4	4·0	1·0	400	(135)
	PM24C	5B4	4·0	1·0	400	(136)
	PM24E	5B4	4·0	2·0	500	(137)
	EL2/32	8S22/050	6·3	0·2	250	(138)
	EL3/33	8S23/048	6·3	0·9	250	(139)
	EL35	048	6·3	1·35	250	(140)
	EL6/36	8S23/048	6·3	1·3	250	(141)
	PEN13C	7B27	13·0	0·5	250	(142)
	PEN26	8S22	24·0	0·2	200	(143)
	PEN36C/CL33	7B27/048	33·0	0·2	200	(144)
	CL4	8S22	33·0	0·2	200	(145)
	CL6	8S22	35·0	0·2	200	(146)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND TETRODES—*continued*

	Screen Volts	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode and Screen Current (mA)	Output (mW)	Optimum Load (Ohms)
(98)	200	10·0	–13·2	188	70·0	5,000	3,000
(99)	200	10·0	–11·5	200	58·5	4,300	4,000
(100)	300	6·3	—	—	—	—	—
(101)	90	1·75	–8·1	—	5·0	210	10,000
(102)	150	5·3	–2·2	—	5·5	290	19,000
(103)	150	2·5	–4·5	—	6·0	350	17,000
(104)	150	2·5	–9·0	—	22·2	1,000	7,500
(105)	150	5·7	–3·3	—	6·0	440	16,000
(106)	150	4·5	–3·6	—	6·0	400	14,000
(107)	250	2·5	–15·5	250	32·0	3,300	7,500
(108)	250	8·0	–5·3	140	38·0	3,500	6,700
(109)	250	11·0	–8·75	114	77·0	6,900	3,300
(110)	250	9·0	–8·5	175	47·5	5,800	4,500
(111)	220	8·5	–6·9	90	77·0	—	—
(112)	275	11·0	–11·1	135	82·0	9,250	2,650
(113)	250	9·0	–8·5	175	47·5	4,850	5,200
(114)	220	8·5	–6·9	90	77·0	—	—
(115)	250	6·5	–8·6	175	49·0	4,000	5,500
(116)	250	7·0	–8·0	165	48·0	3,000	4,400
(117)	200	2·5	–10·0	300	30·0	2,300	10,000
(118)	200	12·0	–8·7	145	60·0	2,650	2,800
(119)	200	12·0	–8·7	145	60·0	2,650	2,800
(120)	90	1·25	–3·0	—	—	170	22,500
(121)	90	1·55	–7·5	—	—	240	8,000
(122)	45	1·5	–1·5	—	—	—	—
(123)	150	1·3	–10·0	—	19·0	600	8,000
(124)	135	2·2	–4·5	—	7·0	340	19,000
(125)	150	3·0	–20·0	—	27·0	1,450	8,000
(126)	135	3·0	–2·4	—	5·8	300	24,000
(127)	250	2·8	–22·0	500	39·0	3,800	6,000
(128)	250	9·5	–5·8	145	41·0	3,800	6,000
(129)	250	9·5	–5·8	145	41·0	3,800	8,000
(130)	275	8·5	–14·0	175	79·0	8,800	3,500
(131)	275	8·0	–20·5	165	71·0	8,000	6,500
(132)	150	1·75	–11·0	650	25·0	—	8,000
(133)	200	2·0	–22·5	1,000	23·5	—	10,000
(134)	250	3·0	–17·0	500	35·6	2,800	7,000
(135)	300	2·1	–40·0	1,100	37·0	—	8,000
(136)	200	3·0	–28·0	850	34·5	—	12,000
(137)	200	4·0	–35·0	750	59·0	—	7,000
(138)	250	2·8	–18·0	—	—	3,600	8,000
(139)	250	9·0	–6·0	—	—	4,500	7,000
(140)	250	5·0	–15·5	—	—	—	—
(141)	250	15·0	–7·0	—	—	8,000	3,500
(142)	250	6·0	–11·9	250	39·0	3,200	6,400
(143)	100	3·1	–19·0	420	45·0	3,000	5,000
(144)	200	8·0	–8·5	—	—	4,000	4,500
(145)	200	8·0	–8·5	—	—	4,000	4,500
(146)	100	8·0	–9·5	—	—	4,000	4,500

[*Continued on next page*

TABLE XXXIII: OUTPUT PENTODES

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
OSRAM ..	N14	08	1·4	0·1	90	(147)
	N15	012	1·4/2·8	0·05/0·1	90	(148)
(Tetrode)	KT2	5B4	2·0	0·2	150	(149)
”	KT21	5B4	2·0	0·3	150	(150)
”	KT24	5B4	2·0	0·2	150	(151)
	PT7	7B27	2·0	0·3	240	(152)
	ZA1	Acorn	4·0	0·25	250	(153)
”	MKT4	5B18/7B27	4·0	1·0	250	(154)
	MPT4	7B27	4·0	1·0	250	(155)
”	KT41	7B27	4·0	2·0	250	(156)
	N41	7B27	4·0	2·0	250	(157)
”	KT42	7B27	4·0	1·0	250	(158)
	N42	7B27	4·0	1·0	250	(159)
	N43	7B29	4·0	2·0	250	(160)
	PT4	5B4	4·0	1·0	250	(161)
	PT5	5B4	4·0	1·0	1,250	(162)
	DET8	7B27	4·0	2·0	400	(163)
	PT10/14	7B23	4·0	1·25	500	(164)
	PT25	5B4	4·0	2·0	400	(165)
	PT25H	5B4	4·0	2·0	400	(166)
	KT73	048	6·0	0·4	175	(167)
	KT8	5B17	6·3	1·27	600	(168)
”	KT61	048	6·3	0·95	250	(169)
”	KT63	048	6·3	0·7	250	(170)
”	KT66	048	6·3	1·27	400	(171)
	N30	7B27	13·0	0·3	250	(172)
	N30G	7B27	13·0	0·3	250	(173)
	KT30	7B27	13·0	0·3	250	(174)
”	KT72	048	16·0	0·17	175	(175)
”	KT74	048	15·0	0·16	175	(176)
	DPT	7B27/5B4	16·0	0·25	200	(177)
”	KT31	7B46	26·0	0·3	200	(178)
	N31	7B46	26·0	0·3	200	(179)
”	KT32	048	26·0	0·3	135	(180)
”	KT35	046	26·0	0·3	200	(181)
	KT33C	046	26·0	0·6	200	(182)
RECORD ..	PT2	4B6/5B4	2·0	0·22	150	(183)
	PT2C	5B4	2·0	0·26	150	(184)
	AC/PT	5B18/7B27	4·0	1·2	350	(185)
	AC/PTA	5B18/7B27	4·0	1·2	250	(186)
	AC/PT4VB	7B27	4·0	2·0	250	(187)
	PT/24M	5B4	4·0	1·1	250	(188)
	PT/24DA	7B27	24·0	0·2	200	(189)
	PT/24DAL	8S23	24·0	0·2	200	(190)
	PT/35DA	7B27	35·0	0·2	200	(191)
TRIOTRON	P225	4B6/5B4	2·0	0·2	150	(192)
	P469	7B27	4·0	2·0	250	(193)
	P441N	7B27	4·0	1·35	250	(194)
	P440N	5B18/7B27	4·0	1·1	250	(195)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

	Screen Volts	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode and Screen Current (mA)	Output (mW)	Optimum Load (Ohms)
(147)	90	1·55	—	—	—	—	—
(148)	90	2·0	—	—	—	—	—
(149)	150	2·5	–4·5	—	9·5	—	17,000
(150)	150	5·3	–2·5	—	6·5	—	19,000
(151)	150	3·2	–3·2	—	12·0	800	10,000
(152)	150	—	—	—	—	1,500	—
(153)	100	1·4	—	—	—	—	—
(154)	225	3·0	–11·0	300	37·0	—	8,000
(155)	225	3·0	—	—	—	—	—
(156)	250	10·5	–4·4	90	50·0	—	5,400
(157)	250	10·0	—	—	—	—	—
(158)	250	2·5	–16·5	420	39·5	—	7,000
(159)	250	2·5	—	—	—	—	—
(160)	250	10·0	–4·5	—	40·0	—	5,400
(161)	250	2·85	–16·0	400	40·0	2,500	7,500
(162)	300	4·0	—	—	—	80,000	—
(163)	200	4·0	—	—	—	—	—
(164)	250	—	—	—	—	20,000	—
(165)	200	4·0	—	—	—	—	—
(166)	400	6·5	–16·0	240	75·0	10,000	4,000
(167)	175	2·5	–12·5	300	39·0	2,000	6,000
(168)	300	—	—	—	—	38,000	—
(169)	250	10·5	–4·1	90	47·5	4,300	6,000
(170)	250	2·5	–16·5	420	39·5	3,000	7,000
(171)	300	6·3	–30·0	—	—	50,000	2,800
(172)	250	3·9	—	—	—	—	—
(173)	250	3·9	—	—	—	—	—
(174)	250	3·9	–14·0	375	37·0	3,000	7,500
(175)	175	2·5	–12·5	300	36·0	2,000	6,000
(176)	175	2·5	—	—	—	—	—
(177)	200	3·0	—	—	—	—	—
(178)	200	10·0	–4·4	90	50·0	2,500	5,500
(179)	200	10·0	—	—	—	—	—
(180)	135	9·0	–7·6	95	80·0	3,500	1,300
(181)	200	10·0	—	—	—	—	—
(182)	200	10·0	–13·2	188	70·0	5,000	3,000
(183)	150	3·0	–6·0	—	8·0	600	14,000
(184)	150	2·0	–12·0	—	20·0	1,000	6,000
(185)	250	3·5	–18·0	400	40·0	3,000	7,000
(186)	250	3·5	–16·5	400	41·0	3,000	7,000
(187)	250	10·0	–6·0	150	40·0	3,600	7,000
(188)	250	4·0	–15·0	400	42·0	3,100	7,500
(189)	100	8·0	–19·0	400	45·0	3,000	5,000
(190)	100	8·0	–19·0	400	45·0	3,000	5,000
(191)	200	8·5	–8·0	170	50·0	3,200	4,400
(192)	150	2·0	–4·5	—	10·0	500	15,000
(193)	275	8·5	–14·0	—	—	—	—
(194)	250	4·0	–22·0	500	37·0	3,800	7,000
(195)	250	3·5	–15·0	650	28·0	2,000	7,500

[*Continued on next page*

TABLE XXXIII: OUTPUT PENTODES

Make	Type	Base	Fil. Volts	Fil. Amps	Anode Volts	
TRIOTRON —*continued*	P496	7B27	4·0	1·5	250	(196)
	P425	5B4	4·0	0·25	300	(197)
	P435	5B4	4·0	1·1	250	(198)
	P3580	7B27	33·0	0·2	200	(199)
	P2060	8S23	24·0	0·2	200	(200)
	P2460	5B4	24·0	0·18	200	(201)
	P2020N	5B4	20·0	0·18	200	(202)
TUNGSRAM	PP2/S	5B5/8S8	2·0	0·14	135	(203)
	PP222	4B6/5B4	2·0	0·22	150	(204)
	PP225	5B4	2·0	0·26	135	(205)
	PP4/S	5B4/8S8	4·0	1·1	250	(206)
	APP4A/S	7B31/8S22	4·0	1·2	250	(207)
	APP4B/S	7B27/8S23	4·0	1·95	250	(208)
	APP4C	7B24	4·0	2·0	250	(209)
	APP4E	7B27	4·0	2·1	375	(210)
	APP4G	7B30	4·0	2·0	250	(211)
	PP6AS	8S23	6·3	0·2	250	(212)
	PP6BS	8S23	6·3	1·2	250	(213)
	PP6B	6UX9	6·3	1·2	250	(214)
	PP6C	7B27	6·3	1·2	250	(215)
	PP6E	7B27	6·3	1·2	375	(216)
	EL2	8S22	6·3	0·2	250	(217)
	EL3/33	8S23/048	6·3	1·0	250	(218)
	EL5	8S23	6·3	1·35	250	(219)
	EL6/36	8S23/048	6·3	1·4	250	(220)
	6M6G	048	6·3	1·0	250	(221)
Double P	ELL1	8S26	6·3	0·45	250	(222)
	PP13A	7B27	13·0	0·3	250	(223)
	PP24	7B29	24·0	0·2	200	(224)
	CL6/PP37	8S22/7B29	35·0	0·2	200	(225)
	PP34	7B29	35·0	0·2	200	(226)
	PP35	7B27	35·0	0·2	200	(227)
	PP36	7B24	35·0	0·2	200	(228)
	CL33	048	35·0	0·2	200	(229)

TABLE XXXIV: DOUBLE

Make	Type	Circuit	Base	Fil. Volts	Fil. Amps	
COSSOR ..	220B	Class B	7B2	2·0	0·2	(1)
	240B	Class B	7B2	2·0	0·4	(2)
	2103	QPP	7UX5	2·0	0·26	(3)
	240QP	QPP	7B6	2·0	0·4	(4)
DARIO ..	TB402	Class B	7B2	2·0	0·2	(5)
	BLL32	QPP	9B1	2·0	0·45	(6)
EVER READY	K33A	Class B	7B2	2·0	0·2	(7)
	K33B	Class B	7B2	2·0	0·2	(8)
	K77A	QPP	9B1	2·0	0·45	(9)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

AND TETRODES—*continued*

	Screen Volts	Slope (mA/V)	Bias Volts	Bias Res. (Ohms)	Anode and Screen Current (mA)	Output (mW)	Optimum Load (Ohms)
(196)	250	9·5	–6·0	—	—	—	—
(197)	200	1·7	–25·0	—	—	—	—
(198)	250	3·5	–14·0	—	—	—	—
(199)	200	8·0	–23·0	—	—	—	—
(200)	100	3·1	–19·0	—	—	—	—
(201)	200	8·0	–19·0	—	—	—	—
(202)	200	2·5	–18·0	1,000	19·0	1,350	9,000
(203)	135	2·1	–5·0	—	8·0	440	19,000
(204)	150	3·0	–6·0	—	9·0	600	14,000
(205)	135	2·0	–12·0	—	18·0	1,000	6,000
(206)	250	4·0	–15·0	400	42·0	2,800	7,500
(207)	250	3·5	–16·5	400	40·5	3,000	7,000
(208)	250	10·0	–6·0	140	40·0	3,600	7,000
(209)	250	10·0	–6·0	140	40·0	4,000	7,000
(210)	275	8·5	–13·5	175	80·0	8,000	3,500
(211)	250	10·0	–6·0	150	40·0	4,000	7,000
(212)	250	2·8	–18·0	500	37·0	2,250	8,000
(213)	250	10·0	–5·5	140	40·0	3,600	7,000
(214)	250	10·0	–5·5	140	40·0	3,600	7,000
(215)	250	10·0	–5·5	140	40·0	3,600	7,000
(216)	275	8·5	–17·0	200	80·0	8,800	3,500
(217)	250	2·8	–18·0	480	37·0	3,600	8,000
(218)	275	10·0	–7·0	175	40·5	3,600	7,000
(219)	275	8·5	–14·0	175	79·0	8,800	3,500
(220)	250	15·0	–7·0	85	80·5	8,200	3,500
(221)	250	10·0	–7·0	175	40·5	3,600	7,000
(222)	275	1·3	–21·5	600	44·6	5,400	16,000
(223)	250	2·5	–16·5	410	40·5	3,000	7,000
(224)	100	8·0	–19·0	400	45·0	3,000	5,000
(225)	100	8·5	–9·5	140	50·0	4,000	22,000
(226)	200	8·5	–8·0	170	50·0	3,200	4,400
(227)	200	8·5	–8·0	170	50·0	3,200	4,400
(228)	200	8·5	–8·0	170	50·0	3,200	5,000
(229)	200	8·5	–8·0	170	50·0	3,200	4,400

OUTPUT VALVES

	Anode Volts	Screen Volts	Quiescent Current (mA)	Peak Current (mA)	Bias Volts	Output (mW)	Optimum Load (Ohms)
(1)	120	—	2·5	—	0	—	12,000
(2)	120	—	4·0	—	0	—	8,000
(3)	150	150	4·0	—	–10·5	—	35,000
(4)	120	120	3·5	—	–9·0	—	24,000
(5)	150	—	—	—	0	—	—
(6)	135	135	—	—	–10·5	—	—
(7)	120	—	3·0	—	0	1,250	14,000
(8)	120	—	3·0	—	–4·5	1,450	14,000
(9)	150	150	4·0	—	–13·5	2,000	16,000

[*Continued on next page*

TABLE XXXIV: DOUBLE

Make	Type	Circuit	Base	Fil. Volts	Fil. Amps	
FERRANTI	HP2	Class B	7B2	2·0	0·4	(10)
HIVAC ..	B230	Class B	7B2	2·0	0·3	(11)
	DB240	Driver Class B	7B12	2·0	0·4	(12)
	QP240	QPP	7B6	2·0	0·4	(13)
LISSEN ..	BB240	Class B	7B2	2·0	0·4	(14)
MARCONI ..	QP21	QPP	7B6	2·0	0·4	(15)
	B21	Class B	7B2	2·0	0·2	(16)
	B30	Class B	7B2	13·0	0·3	(17)
MAZDA ..	QP230	QPP	7B6	2·0	0·3	(18)
	QP240	QPP	9B1	2·0	0·4	(19)
	QP25	QPP	0M9	2·0	0·2	(20)
	PD220	Class B	7B2	2·0	0·2	(21)
	PD220A	Class B	7B2	2·0	0·2	(22)
MULLARD	PM2B	Class B	7B2	2·0	0·2	(23)
	PM2BA	Class B	7B2	2·0	0·2	(24)
	QP22A	QPP	9B1	2·0	0·45	(25)
	QP22B	QPP	7B6	2·0	0·3	(26)
	ECC31	Double Triode	042	6·3	0·95	(27)
OSRAM ..	QP21	QPP	7B6	2·0	0·4	(28)
	B21	Class B	7B2	2·0	0·2	(29)
	B30	Class B	7B2	13·0	0·3	(30)
RECORD ..	BB2A	Class B	7B6	2·0	0·25	(31)
	BB2B	Class B	7B6	2·0	0·25	(32)
TRIOTRON	E220B	Class B	7B2	2·0	0·2	(33)
TUNGSRAM	CB215/S	Class B	7B2/8S5	2·0	0·22	(34)
	CB220	Class B	7B2	2·0	0·25	(35)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TABLE XXXV: METAL RECTIFIERS—WESTECTORS

Make	Type	Class	Max. safe input voltage	Max. current output (mA)
WESTING-HOUSE	W.4 ..	Half-wave ..	24 volts peak carrier	0·25
	W.6 ..	Half-wave ..	36 „ peak carrier	0·28
	WX.6 ..	Half-wave ..	36 „ peak carrier	0·12
	WM.142	Full-wave centre-tapped	24 „ each side of C.T.	0·5
	WM.162	Full-wave centre-tapped	36 volts each side of C.T.	0·5

(WM.142 and WM.162 are the new code numbers of the earlier WM.24 and WM.26 respectively.)

OUTPUT VALVES—*continued*

	Anode Volts	Screen Volts	Quiescent Current (mA)	Peak Current (mA)	Bias Volts	Output (mW)	Optimum Load (Ohms)
(10)	150	—	3·0	—	—	—	—
(11)	150	—	2·5	32·0	0	1,250	14,500
(12)	120	—	3·0	3·0	–4·5	—	—
	150	—	2·5	32·0	0	1,250	14,500
(13)	150	150	8·0	32·0	–18	1,400	14,500
(14)	150	—	—	—	—	2,400	—
(15)	150	150	3·5	—	–9	1,200	30,000
(16)	150	—	2·2	—	–6	1,500	12,000
(17)	180	—	—	—	0	5,000	7,000
(18)	110	110	5·3	—	–8·6	700	17,000
(19)	150	150	4·0	—	–11·5	—	15,000
(20)	120	120	5·5	—	–9·75	1·2	15,500
(21)	150	—	0·8	45·0	–1·15	—	—
(22)	150	—	2·5	50·0	–6·0	—	—
(23)	120	—	3·0	20·0	0	1,250	14,000
(24)	120	—	3·0	20·0	–4·5	1,450	14,000
(25)	135	135	—	—	–12·0	1,400	16,000
(26)	135	135	—	—	–11·7	1,330	14,700
(27)	250	—	—	—	–4·6	—	—
(28)	150	150	3·5	—	–9·0	1,200	24,000
(29)	150	—	2·2	—	–6·0	1,500	12,000
(30)	180	—	—	—	0	5,000	7,000
(31)	150	—	2·5	—	–3·0	2,000	10,000
(32)	135	—	—	—	0	1,700	10,000
(33)	150	—	—	—	—	—	—
(34)	135	—	3·0	21·0	0	1,700	10,000
(35)	150	—	3·0	26·7	–3·35	2,000	10,000

TABLE XXXV: METAL RECTIFIERS—LT TYPES

Make	Type	Output		Nominal AC input (Volts)	Replaces
		Volts	Amps		
WESTINGHOUSE	LT.41	12	1	22	LT.5, LT.9, A.3
	LT.42	6	1	11	LT.1, LT.2, LT.4, LT.7, LT.8
	LT.44	12	2	22	LT.10, A.4
	LT.45	6	4	11	LT.11, A.6

TABLE XXXV: METAL RECTIFIERS

Make	Type	Maximum smoothed DC output		Max. current output (mA)	Maximum AC input Half-wave		
		Volts	mA		Volts	mA	
WESTINGHOUSE	HT.14	130	20	30	135	30	(1)
	HT.15	200	30	40	250	80	(2)
	HT.16	300	60	60	400	90	(3)
	HT.17	200	100	150	250	150	(4)
(For Class B)	HT.17	150	25	—	150	40	(5)
(2 in series)	HT.17	500	120	150	—	—	(6)
Used voltage doubler only	HT.41	250	60	100	300	90	(7)
	HT.42	450	100	100	540	150	(8)
	H.1	3·6	10	10	3·5	20	(9)
	H.10	36	10	10	35	20	(10)
	H.50	180	10	10	175	20	(11)
	H.75	270	10	10	260	20	(12)
	H.100	360	10	10	350	20	(13)
	H.120	432	10	10	420	20	(14)
	H.176	650	10	10	620	20	(15)
	J.10	80	2	2	74—80	4	(16)
	J.50	400	2	2	370—400	4	(17)
	J.100	800	2	2	740—800	4	(18)
	J.125	1,000	2	2	920—1,000	4	(19)
	J.176	1,400	2	2	1,300—1,400	4	(20)
2 units in series	H.120	870	10	10	—	—	(21)
2 ,, ,, ,,	H.176	1,300	10	10	—	—	(22)
10 ,, ,, ,,	H.176	6,500	10	10	—	—	(23)
2 ,, ,, ,,	J.10	170	2	2	—	—	(24)
2 ,, ,, ,,	J.50	850	2	2	—	—	(25)
2 ,, ,, ,,	J.100	1,700	2	2	—	—	(26)
4 ,, ,, ,,	J.125	4,000	2	2	—	—	(27)
2 ,, ,, ,,	J.176	3,000	2	2	—	—	(28)
10 ,, ,, ,,	J.176	15,000	2	2	—	—	(29)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TABLE XXXVI: HT RECTIFYING VALVES

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
BRIMAR ..	25Z4G	—	25	0·3	250	75
	5Z4G	—	5·0	2·0	350 + 350	125
	R1	4B17	4·0	1·0	250 + 250	60
	R2	4B17	4·0	2·5	350 + 350	120
	R3	4B17	4·0	2·5	500 + 500	120
	1D5	5B10	40·0	0·2	250	75
	(Mercury)	4B2	2·0	1·2	6,000	3
COSSOR ..	44SU	4B1	4·0	0·4	200	20
	412SU	4B1	4·0	1·0	250	70

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—HIGH-TENSION TYPES

	Maximum AC input		Capacitors		Remarks
	Full-wave		Capacity of each (V.D.) mFd	Working voltage (V.D.)	
	Volts	mA			
(1)	80	60	6	200	Replaced by HT.41
(2)	140	120	4	200	Replaced by HT.41
(3)	240	200	4	400	Replaced by HT.42
(4)	150	300	8	250	Replaced by HT.41
(5)	—	—	8	350	Replaced by HT.41
(6)	300	550	6	500	Replaced by HT.41
(7)	150	180	8	250	—
(8)	270	300	8	400	—
(9)	—	—	100	12	—
(10)	—	—	10	50	—
(11)	—	—	2	250	—
(12)	—	—	2	400	—
(13)	—	—	1	500	—
(14)	—	—	0·85	600	—
(15)	—	—	·5	1,100	—
(16)	—	—	10	250	—
(17)	—	—	2	650	—
(18)	—	—	1	1,250	—
(19)	—	—	1	1,500	—
(20)	—	—	·5	2,000	—
(21)	480	30	0·5	700	—
(22)	720	30	0·25	1,000	—
(23)	3,600	30	0·35	5,000	—
(24)	74—80	6	10	250	—
(25)	370—400	6	2	650	—
(26)	740—800	6	1	1,250	—
(27)	1,600—1,700	6	0·5	3,000	—
(28)	1,300—1,400	6	0·5	2,000	—
(29)	6,500—7,000	6	0·1	12,000	—

TABLE XXXVI: HT RECTIFYING VALVES—*continued*

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
COSSOR— *continued*	506BU	4B3	4·0	1·0	250 + 250	60
	408BU	4B3	4·0	1·0	250 + 250	30
	412BU	4B3	4·0	1·0	250 + 250	70
	442BU	4B3	4·0	2·5	350 + 350	120
	460BU	4B3	4·0	2·5	500 + 500	120
	431U	4B17	4·0	2·5	350 + 350	120
	441U	4B17	4·0	2·5	500 + 500	120
	4/100BU	4B3	4·0	2·5	500 + 500	200
	451U	4B17	4·0	3·5	500 + 500	250

[*Continued on next page*

TABLE XXXVI: HT RECTIFYING VALVES—*continued*

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
COSSOR—*continued*	405BU	4B3	4·0	0·5	1,500 + 1,500	20
	SU2150A	4B16	2·0	1·5	5,000	10
	SU2150	4B16	2·0	1·15	8,000	2
	612BU	4B3	6·0	0·4	250 + 250	50
	825BU	4B3	7·5	2·0	500 + 500	120
	40SUA	5B10	40·0	0·2	250	75
	225DU	7B1	2+2	·5+·5	750 + 750	20
DARIO ..	TW1	SB10	20·0	0·2	250	80
	TW2	7B15	30·0	0·2	250	120
	TBY233	7B15	33·0	0·18	250	120
	SW1	4B3	4·0	1·0	400	60
	FW1	4B3	4·0	1·0	300 + 300	75
	FW2	4B3	4·0	2·0	350 + 350	120
	TZ34	4B17	4·0	2·0	350 + 350	120
	FW3	4B3	4·0	2·0	500 + 500	120
	IFW1	4B17	4·0	2·5	500 + 500	120
EKCO ..	R41	4B3	4·0	2·0	350 + 350	120
EVER READY	S11A	4B3	4·0	1·0	250 + 250	60
	A11B	4B17	4·0	2·4	350 + 350	120
	S11D	4B3	4·0	2·0	350 + 350	120
	A11D	4B17	4·0	2·0	350 + 350	120
	A11C	4B17	4·0	2·4	500 + 500	120
	AZ1/31	8S1	4·0	1·1	300 + 300	100
	CY31	O35	20·0	0·2	250	75
	C10B	5B10	20·0	0·2	250	75
FERRANTI	R4	4B3	4·0	2·5	350 + 350	120
	R4A	4B3	4·0	2·5	500 + 500	120
(Mercury)	IR4	—	4·0	1·0	5,000	3
(Mercury)	GR4	4B3	4·0	3·0	350 + 350	350
	RS	5B10	13·0	0·3	250	75
	RA	5B12	13·0	0·3	250 + 250	50
	RZ	5B10	20·0	0·2	250	75
HIVAC ..	UU60/250	4B3	4·0	1·25	300 + 300	75
	UU120/350	4B3	4·0	2·5	350 + 350	120
	UU120/500	4B3	4·0	2·5	500 + 500	120
	U26	7B42	13or26	·6 or ·3	250	120
	MR1	4B1	4·0	3·0	1,000	250
LISSEN ..	UU41	4B3	4·0	1·0	300 + 300	80
	U650	4B1	5·6	0·5	300	40
MARCONI	MU12	4B17	4·0	2·5	350 + 350	120
	MU14	4B17	4·0	2·5	500 + 500	120
	U5	4B3	5·0	1·6	400 + 400	45
	U8	4B3	7·5	2·4	500 + 500	120
	U9	4B3	4·0	1·0	250 + 250	75
	U10	4B3	4·0	1·0	250 + 250	75
	U12	4B3	4·0	2·5	350 + 350	120
	U14	4B3	4·0	2·5	500 + 500	120
	U16	4B2	2·0	1·0	5,000	5
	U17	4B2	4·0	1·0	2,500	30
	U18	4B3	4·0	3·75	500 + 500	250
	U20	4B3	4·0	3·75	850 + 850	125
	U30	7B42	26·0 13·0	0·3 0·6	250	120
	U31	O35	26·0	0·3	250	120

TABLE XXXVI: HT RECTIFYING VALVES—*continued*

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
MARCONI —*continued*	U50	O2	5·0	2·0	350 + 350	125
	U52	O2	5·0	3·0	500 + 500	250
(Mercury)	GU1	4B1	4·0	3·0	1,000	250
(Mercury)	GU5	4B2	4·0	3·0	1,500	250
(Mercury)	GU50	4B2	4·0	3·0	1,500	250
	A831	4B3	1·8	2·8	30 + 30	1·3 amp
MAZDA ..	UU4	4B17	4·0	2·2	350 + 350	120
	UU5	4B17	4·0	2·3	500 + 500	120
	UU120/500	4B17	4·0	2·5	500 + 500	120
	UU6	OM17	4·0	1·4	350 + 350	120
	UU7	OM17	4·0	2·3	350 + 350	180
	UU8	OM17	4·0	2·8	350 + 350	250
	U4020	5B10	40·0	0·2	250	120
	U403	OM15	40·0	0·2	250	120
	UD41	7B48	4·0	1·15	550	35
	U21	4B16	2·0	1·85	4,500	5
	U22	OM16	2·0	2·0	4,500	5
(Mercury)	MU2	4B2	2·0	3·1	12,500	5
MULLARD	DW2	4B3	4·0	1·0	250 + 250	60
	DW3	4B3	4·0	2·0	350 + 350	120
	DW4/350	4B3	4·0	2·0	350 + 350	120
	DW4	4B3	4·0	2·0	500 + 500	120
	DW4/500	4B3	4·0	2·0	500 + 500	120
	IW2	4B17	4·0	1·2	250 + 250	60
	IW3	4B17	4·0	2·4	350 + 350	120
	IW4/350	4B17	4·0	2·0	350 + 350	120
	IW4	4B17	4·0	2·4	500 + 500	120
	IW4/500	4B17	4·0	2·4	500 + 500	120
	FW4/500	4B3	4·0	3·0	500 + 500	250
	CY1/31	8S15/035	20·0	0·2	250	75
	UR1	8S15	20·0	0·2	250	75
	UR1C	5B10	20·0	0·2	250	75
	CY/2/32	8S17/038	30·0	0·2	250 + 250	120
	UR3	8S17	30·0	0·2	250 + 250	120
	UR3C	7B15	30·0	0·2	250 + 250	120
	UY31	O35	50·0	0·1	250	125
	HVR1	4B2	2·0	0·3	6,000	5
	HVR2	4B2	4·0	0·65	6,000	3
OSRAM ..	MU12/14	4B17	4·0	2·5	500 + 500	120
	MU14	4B13	4·0	2·5	500 + 500	120
	U5	4B3	5·0	1·6	400 + 400	45
	U8	4B3	7·5	2·5	500 + 500	120
	U10	4B13	4·0	1·0	250 + 250	60
	U12/14	4B13	4·0	2·5	500 + 500	120
	U14	4B13	4·0	2·5	500 + 500	120
	U16	4B2	2·0	1·0	5,000	5
	U17	4B2	4·0	1·0	2,500	30
	U18/20	4B3	4·0	3·75	500 + 500 850 + 850	250 125
	U23	4B2	4·0	3·3	1,750	250
	U30	7B42	25·0 26·0 13·0	0·3 0·3 0·6	180 220 250	120 75 120
	U31	O35	26·0	0·3	250	120

TABLE XXXVI: HT RECTIFYING VALVES—*continued*

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
OSRAM—*continued*	U50	O2	5·0	2·0	400 + 400	110
	U52	O2	5·0	3·0	500 + 500	250
	U71	O35	30·0	0·17	250	100
	U74	O35	30·0	0·16	250	75
(Mercury)	GU1	4B1	4·0	3·0	1,000	250
(Mercury)	GU5	4B2	4·0	3·0	1,500	250
	GU50	4B2	4·0	3·0	1,500	250
PHILIPS ..	373	4B1	4·0	1·0	220	40
(Miniwatt)	505	4B1	4·0	1·0	400	60
	506	4B3	4·0	1·0	300 + 300	75
	506K	4B17	4·0	1·2	250 + 250	60
	1560	4B3	5·0	2·0	300 + 300	125
	1561	4B3	4·0	2·0	500 + 500	120
	1801	4B3	4·0	0·6	250 + 250	30
	1802	4B3	4·0	0·5	250	30
	1803	4B1	4·0	—	500	30
	1805	4B3	4·0	1·0	250 + 250	60
	1807	4B3	4·0	2·0	350 + 350	120
	1815	4B3	4·0	2·3	500 + 500	180
	1817	4B3	4·0	4·0	350 + 350	300
	1821	4B3	4·0	1·0	250 + 250	60
	1831	4B3	4·0	1·0	700 + 700	60
	1832	4B1	4·0	1·2	700	120
	1861	4B17	4·0	2·4	500 + 500	120
	1867	4B17	4·0	2·4	350 + 350	120
	1876	8S12	4·0	0·3	850	5
	1877	4B16	4·0	0·65	6,000	5
	1881	4B17	4·0	1·0	250 + 250	60
	1881A	4B17	4·0	2·4	250 + 250	60
	AZ1/31	8S1/02	4·0	1·1	300 + 300	100
	EZ2	8S16	6·3	0·4	350 + 350	60
	CY1/31/C	8S15/035/ 5B10	20·0	0·2	250	75
	CY2	5B10	30·0	0·2	250 + 250	120
RECORD ..	1FW4A	4B17	4·0	2·0	400 + 400	120
	FW350	4B13	4·0	1·0	300 + 300	80
	FW3	4B17	4·0	2·0	350 + 350	120
	FW5	4B13	4·0	2·0	500 + 500	120
	FW6	4B13	4·0	2·0	600 + 600	180
	UFW/30	5B10	30·0	0·2	275	120
	UFW/30L	8S17	30·0	0·2	275	120
	HW/20	5B10	20·0	0·2	250	80
	HW/20L	8S15	20·0	0·2	250	80
	HW/30	5B10	30·0	0·2	275	120
TRIOTRON	G429	4B1	4·0	0·3	250	30
	G470	4B13	4·0	1·0	300 × 300	70
	G4120	4B13	4·0	2·0	500 × 500	120
	G4120N	4B17	4·0	2·0	500 × 500	120
	G2080	5B10	20·0	0·2	250	80
	G3060	8S17	30·0	0·2	125 × 125	120
	G3120	7B15	30·0	0·2	250	120
TUNGSRAM	PV4	4B3	4·0	2·0	350 + 350	120
	PV4200	4B3	4·0	2·0	500 + 500	120
	PV4201	4B3	4·0	2·0	600 + 600	180

TABLE XXXVI: HT RECTIFYING VALVES—*continued*

Make	Type	Base	Filament		Anode Volts Max. (RMS)	Output (mA)
			Volts	Amps		
TUNGSRAM *—continued*	AP4V	4B17	4·0	2·0	350 + 350	120
	RV120/350/S	4B3/8S1	4·0	2·4	350 + 350	120
	RV120/500/S	4B3/8S1	4·0	2·4	500 + 500	120
	RV200/600	4B3	4·0	2·8	600 + 600	200
	PV75/1000	4B3	2·2	4·0	1,000+1,000	75
	PV100/2000	4B3	4·0	2·2	2,000+2,000	100
	PVA6S	8S16	6·3	0·25	350 + 350	60
	PVB6S	8S16	6·3	0·65	350 + 350	100
	PVC6S	8S16	6·3	0·9	350 + 350	175
	EZ2	8S16	6·3	0·4	350 + 350	60
	EZ3	8S16	6·3	0·65	400 + 400	100
	EZ4	8S16	6·3	0·9	400 + 400	175
	V20/S	5B10/8S15	20·0	0·2	250	80
	PV25	7B15	25·0	0·3	275 and 275	120
	V 30	5B10	30·0	0·2	275	120
	PV29/S	7815/8S17	30·0	0·2	125 and 125	60
	PV30	7B15	30·0	0·2	275	120
	PV30S	8S17	30·0	0·2	275	120
	V2118	5B10	20·0	0·18	250	80
	PV3018	7C1	30·0	0·18	250	100

TABLE XXXVII: BARRETTERS

Make	Type	Base	Current (amps)	Voltage range
ATLAS ..	150A/4	4B20	0·2	100—200
	150A/C	8S27	0·2	100—200
	150B/UX4	4-pin US	0·3	100—200
	130B	6-pin US	0·3	85—170
	110B	6-pin US	0·3	75—145
	150C	4B20	0·18	100—200
DARIO ..	T1	ES cap	0·2	100—200
MARCONI ..	171	ES cap	0·16	100—200
	202	ES cap	0·2	120—200
	251	ES cap	0·25	100—180
	301	ES cap	0·3	138—221
	302	ES cap	0·3	112—195
	303	ES cap	0·3	86—129
	304	ES cap	0·3	95—165
OSRAM ..	301	ES cap	0·3	138—221
	302	ES cap	0·3	112—195
	303	ES cap	0·3	86—129
	304	ES cap	0·3	95—165
	251	4B20	0·25	100—180
	202	4B20	0·2	120—200
PHILIPS .. (Miniwatt)	C1/C	8S33/4B20	0·2	90—230
	C2	8S33	0·2	60—120
	C3	8S33	0·2	100—200
	C9	8S33	0·2	35—100
	C13	8S33	Special low-voltage resistance lamp.	

TABLE XXXVII: BARRETTERS—*continued*

Make	Type	Base	Current (amps)	Voltage range
PHILIPS—*continued*	1941	4B20/ES	0·3	100—240
	1933	4B20	0·1	50—160
	1934	4B20	0·25	85—195
	1927	4B20	0·18	60—120
	1928	4B20	0·18	100—210
	1920	4B20	0·25	40—70
	1904	4B20/and bayonet cap	0·1	40—70
TUNGSRAM	BR201	4B20	0·2	100—200
	BR201/S	8S33	0·2	100—200

TABLE XXXVIII: GAS-FILLED RELAYS

Make	Type	Base	Filament		Anode Volts	Anode Current
			Volts	Amps		
BRIMAR ..	4039A	5B13	4·0	1·0	500	100 mA
COSSOR ..	GDT4B	5B13	4·0	1·75	350	100 ,,
	GDT4	5B13	4·0	1·5	500	20 ,,
MARCONI	GT1	5B15	4·0	1·3	1,000	1·0 amp
	GT1A	5B15	4·0	1·3	300	0·6 ,,
	GT1B	5B15	4·0	1·35	120	2·0 mA
	GT1C	5B15	4·0	1·3	500	1·0 amp
MAZDA ..	T11	5B13	4·0	1·2	700	300 m/A
	T21	5B13	4·0	1·2	200	300 ,,
	T31	5B13	4·0	1·5	400	500 ,,
	T41	OM19	4·0	1·5	400	500 ,,
OSRAM ..	GT1	5B15	4·0	1·3	1,000	0·3 amp
	GT1A	5B15	4·0	1·3	300	0·2 amp
	GT1B	5B15	4·0	1·35	120	2·0 mA
	GT1C	5B15	4·0	1·3	500	0·3 amp

PILOT AND DIAL LAMPS

British Dial Lamps. Radio panel or dial lamps are made by E.L.M.A. firms in the following standard shapes and sizes. All have clear finish, miniature screw cap and an objective life of 1,000 hours, except those marked * in Table XXXIX, which have an objective life of 10 hours.

TABLE XXXIX

Rating		Bulb	Dimensions	
Volts	Amps		Diameter (mm)	Overall length (mm)
6	0·04	Round	11	—
6	0·06	Round	11	—
6	0·5	Round	15	—
*6·2	0·3	Round	15	—
6·3	0·64	Round	15	—
6·5	0·3	Round	11	—
10	0·2	Round	18	—
4	0·3	Tubular	10	30
*6·2	0·3	Tubular	10	30
*6·3	0·15	Tubular	10	30
6·5	0·3	Tubular	10	30

Standard Flashlamps given in Table XL with round bulbs, clear finish and miniature Edison Screw (MES) caps are:

TABLE XL

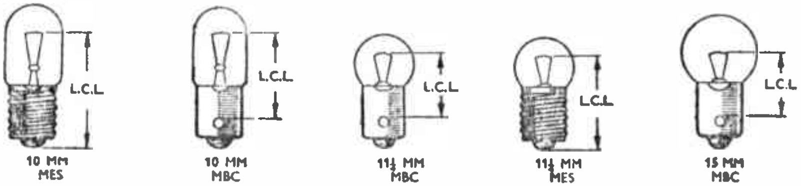
Rating		Diameter mm	Rating		Diameter (mm)
Volts	Amps		Volts	Amps	
2	0·3	11	3·5	0·3	11
2	0·6	15	4	0·3	11
2·5	0·2	11	4·5	0·3	15
2·5	0·3	11	6·2	0·3	15
3·5	0·15	11	6·5	0·3	11

Recommended lamps and uses are shown in Table XLI.

TABLE XLI

Description	Type of receiver for which suitable
2 volts 0·6 amp, 15 mm flat ..	2-volt battery
3·5 volts 0·15 amp, 15 mm flat ..	Fuse
2·5 volts 0·3 amp, 12 mm round ..	2-volt battery
3·5 volts 0·15 amp, 12 mm round..	2-volt battery
3·5 volts 0·3 amp, 12 mm round ..	AC, 2 in series across 4-volt transformer
6·2 volts 0·3 amp, 15 mm round ..	AC, 4-volt transformer. AC-DC with 0·2-amp valves
6·5 volts 0·16 amp, 12 mm round..	AC-DC with 0·16-amp valves
6·5 volts 0·3 amp, 12 mm round ..	AC-DC with 0·3-amp valves. AC with 6·3-volt transformer
8 volts 1·6 watt, MES Indicator ..	AC

American Pilot Lamps. Current ratings of American Pilot Lamps are indicated on their bases by code numbers which are given in the first column of Table XLII. Caps are standard Miniature Edison Screw (MES) and Miniature Bayonet Cap (MBC). Types 40, 44, and 46 are sometimes marked 6·3 volts; when marked 6-8 volts they are usually of 7·5-volt rating and are produced for use in certain AC-DC sets where they are temporarily overrun while the valves are warming up. MOL means maximum overall length; other features are shown in Fig. 163.



AMERICAN PILOT LAMPS

Fig. 163. Types and dimensions of the common pilot lamps in use in the U.S.A.

TABLE XLII

Code No.	Volts	Amps	CP	Bulb (mm)	Base	Bead Colour	LCL (in.)	MOL (in.)
40	6-8	0·15	0·5	10	MES	Brown	$\frac{29}{32}$	$1\frac{1}{8}$
41	2·5	0·5	0·5	10	MES	White	$\frac{29}{32}$	$1\frac{1}{8}$
42	3·2	0·5	0·75	10	MES	Green	$\frac{29}{32}$	$1\frac{1}{8}$
43	2·5	0·5	0·5	10	MBC	White	$\frac{23}{32}$	$1\frac{1}{8}$
44	6-8	0·25	0·8	10	MBC	Blue	$\frac{23}{32}$	$1\frac{1}{8}$
45	3·2	0·5	0·75	10	MBC	Green	$\frac{23}{32}$	$1\frac{1}{8}$
46	6-8	0·25	0·8	10	MES	Blue	$\frac{29}{32}$	$1\frac{1}{8}$
47	6-8	0·15	0·5	10	MBC	Brown	$\frac{23}{32}$	$1\frac{1}{8}$
48	2·0	0·06	0·03	10	MES	Pink	$\frac{29}{32}$	$1\frac{1}{8}$
49	2·0	0·06	0·03	10	MBC	Pink	$\frac{23}{32}$	$1\frac{1}{8}$
49-A	2·1	0·12	0·07	10	MBC	White	$\frac{23}{32}$	$1\frac{1}{8}$
50	6-8	0·2	1·0	11½	MES	White	$\frac{23}{32}$	$\frac{15}{16}$
51	6-8	0·2	1·0	11½	MBC	White	$\frac{1}{2}$	$\frac{15}{16}$
55	6-8	0·4	1·5	15	MBC	White	$\frac{1}{4}$	$1\frac{1}{16}$
292	2·9	0·17	0·3	10	MES	White	$\frac{29}{32}$	$1\frac{1}{8}$
292-A	2·9	0·17	0·3	10	MBC	White	$\frac{23}{32}$	$1\frac{1}{8}$
631	6-8	0·1	—	10	MES	Black	$\frac{29}{32}$	$1\frac{1}{8}$
713	3·8	0·3	—	11½	MES	Green	$\frac{23}{32}$	$\frac{15}{16}$
714	2·5	0·3	—	11½	MES	Blue	$\frac{23}{32}$	$\frac{15}{16}$

American Equivalents. Certain valves in the Marconi and Osram International ranges are equivalent to standard American types. These are given below, the American type being shown first in each case: 1A7 = X14; 1N5 = Z14; 1H5 = HD14; 1C5 = N14; 5X4 = U52; 573 and 5Z4 = U50; 6AG6 = KT61; 6A8 = X63; 6F5 = H63; 6F6 = KT63; 6H6 = D63; 6J5 = L63; 6J7 = 263 and KTZ63; 6U7 and 6K7 = KTW63 and W63; 6K8 = X65; 6L6 = KT66; 6L7 = X64; 6N7 = B63; 6Q7 = DH63; 6R7 = DL63; and 25L6 = KT32.

TABLE XLIII: TUNING INDICATORS

Make	Name	Base	Type	Operation Characteristics
BRIMAR ..	6G5/6U5	—	Cathode Ray	Fil. 6·3 volts, 0·3 amps; max. anode 250 volts
COSSOR ..	3180	NE1	Neon	145—160 volts
	3184	NE2	Neon	145—160 volts
	41ME	8S31	Cathode Ray	Fil. 4·0 volts, 0·3 amps; max. anode 250 volts
DARIO ..	TM14	8S31	Cathode Ray	Fil. 4·0 volts, 0·3 amps; max. anode 250 volts
EVER READY ..	A39A	8S31	—	Fil. 4 volts, 0·3 amps; max. anode 250 volts
MARCONI ..	Y61/62 Y63/64	O59	Cathode Ray	Fil. 6·3 volts, 0·3 amps; max. anode 250 volts
MAZDA ..	AC/ME	7B40	Cathode Ray	Fil. 4·0 volts, 0·5 amps; max. anode 250 volts
	ME41	OM27	„	Fil. 4·0 volts, 0·5 amps; max. anode 250 volts
	ME91	OM27	„	Fil. 9·0 volts, 0·2 amps; max. anode 200 volts
	ME920	7B40	„	Fil. 9·0 volts, 0·2 amps; max. anode 250 volts
MULLARD	TV4	8S31	Cathode Ray	Fil. 4·0 volts, 0·3 amps; max. anode 250 volts
	TV4A	8S31	„	Fil. 4·0 volts, 0·3 amps; max. anode 250 volts
	*TV6	8S31	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EM1	8S31	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EM3	8S31	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EM4	8S32	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EFM1	8S30	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
OSRAM ..	Y61/62/63/64	O59 O59	Cathode Ray	Fil. 6·3 volts, 0·3 amps; max. anode 250 volts
	Y73	O59	„	Fil. 6·0 volts, 0·16 amps; max. anode 180 volts
TUNGSRAM	ME4S	8S31	Cathode Ray	Fil. 4·0 volts, 0·3 amps; max. anode 250 volts
	VME4	7B40	„	Fil. 4·0 volts, 0·5 amps; max. anode 250 volts
	ME6S	8S31	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EM1	8S31	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EM4	8S32	„	Fil. 6·3 volts, 0·2 amps; max. anode 250 volts
	EFM1	8S30	„	Fil. 6·3 volts, 0·2 amps; max. anode 300 volts

TABLE XLIV: VALVE EQUIVA-

Brimar	Cossor	Ever-Ready	Ferranti	Hivac	
—	210DG	—	—	—	(1)
—	—	K50N	—	—	(2)
—	—	—	—	—	(3)
—	210PG 210SPG	K80A K80B	VHT2 VHT2A	—	(4)
—	—	—	—	—	(5)
—	210VPT	K50M	—	VP215	(6)
—	210SPT	—	—	HP215	(7)
—	—	—	—	—	(8)
—	—	—	—	—	(9)
—	—	—	—	—	(10)
—	—	—	—	—	(11)
5B1	215SG 220SG	K40B	—	SG215 SG220 SG210	(12)
—	220VS 220VSG	K40N	VS2	VS215 VS210	(13)
HLB1	210HL	K30C	—	—	(14)
—	—	—	—	—	(15)
—	210HF 210RC	K30A	—	H210	(16)
—	—	—	—	—	(17)
—	—	K23B	—	DDT220	(18)
—	—	—	—	—	(19)
—	—	K23A	H2D	DDT215	(20)
—	—	—	—	—	(21)
—	210LF 210DET	K30B K30D	—	D210	(22)
—	—	K30E	L2	L210	(23)
—	—	—	—	—	(24)
PB1	220P 220PA	K30G	—	P220	(25)
—	215P	—	—	P215	(26)
—	230XP	—	—	PP220 PX230	(27)
PenB1	220HPT 220OT	K70B	PT2	Y220	(28)
—	—	—	—	—	(29)
—	220PT 230PT	—	—	Z220	(30)
—	—	—	—	—	(31)
—	240B 220B	K33A	HP2	B230	(32)
—		—	—	—	(33)
—	—	—	—	—	(34)
—	—	K33B	—	—	(35)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

LENTS—2-VOLT RANGE

	Marconi Osram	Mazda	Mullard	Philips	Tungsram
(1)	DG2	—	PM1DG	—	DG210/0
(2)	—	—	VP2B	—	VX2
(3)	—	—	—	KH1	VX2s
(4)	X21 X22	—	FC2 FC2A	—	VO2
(5)	—	—	—	KK2	VO2s
(6)	VP21 W21 KTW21	VP215 VP210	VP2	—	HP211c
(7)	Z21 KTZ21	SP215 SP210	SP2 —	—	HP210nc
(8)	—	—	—	KF3	VP2Bs
(9)	W22	—	—	—	VP2D
(10)	—	—	—	KF4	SP2Bs
(11)	Z22	—	—	—	SP2D
(12)	S21 S22 S23 S24	SG215 S215 S215A S215B	PM12 PM12A	—	SS210
(13)	VS24 VS24K	S215VM	PM12M PM12V	—	SE211c
(14)	HL2 HL2K	HL2	PM1HL PM2HL PM2DX	B228	HL2
(15)	—	—	—	KC4	HL2s
(16)	H2 H210 HL210 DEH210	H2 HL210	PM1A PM1HF	—	HR210
(17)	—	—	—	KC1	HR2s
(18)	HD22 HD23	HL21DD	TDD2A	—	DDT2
(19)	HD21	—	—	—	DDT2A
(20)	—	L21DD	TDD2	—	DDT2B
(21)	—	—	—	KBC1	DDT2Bs
(22)	L210 DEL210	—	PM1LF	B217	LD210
(23)	L21	L2	PM2DL	—	LL2
(24)	—	—	—	KC3	LL2s
(25)	LP2	P220	PM2A	—	LP220
(26)	P215 DEP215	P215	PM2	—	P215
(27)	P2 P2B	P220A	PM202 PM252	—	SP220
(28)	PT2 KT2	Pen220	PM22 PM22A	C243N	PP2
(29)	—	—	—	KL1	PP215s
(30)	—	Pen220A	PM22C	—	PP225
(31)	—	—	—	KL2	PP225s
(32)	—	PD220	PM2B	B240	CB215
(33)					
(34)	—	—	—	KDD1	CB215s
(35)	B21	PD220A	PM2BA	—	CB220

TABLE XLIV: VALVE EQUIVA-

Brimar	Cossor	Ekco	Ever-Ready	Ferranti	Hivac	
20A1	—	—	A36B A36C	—	—	(1)
—	41STH	—	A36A	—	—	(2)
—	—	—	A80A	—	—	(3)
—	—	—	—	—	—	(4)
15A2	41MPG	—	—	VHT4	—	(5)
—	—	—	—	—	—	(6)
9A1	—	—	A50M	VPT4A	AC/VP	(7)
—	—	—	—	—	—	(8)
—	MVS/Pen	—	A50N	VPT4B	—	(9)
8A1	MS/PenA 41MPT MS/Pen	—	A50A	SPT4A	AC/HP	(10)
—	MVS/PenB	—	—	—	—	(11)
—	—	—	—	—	—	(12)
—	—	—	—	—	—	(13)
—	—	VP41	A50P	—	—	(14)
—	MS/PenB	—	—	—	—	(15)
—	—	—	—	—	—	(16)
—	—	—	A50B	—	—	(17)
—	MVSG	—	A40M	—	AC/VS	(18)
—	MSGHA MSGLA 41MSG	—	—	—	AC/SH AC/SL	(19)
HLA1 HLA2	41MH 41MHF 41MHL 41MLF 41MRC	T41	A30B A30D	D4	AC/HL	(20)
—	—	—	—	—	—	(21)
—	—	—	—	—	—	(22)
—	—	—	—	—	—	(23)
—	DD4	—	A20B	—	AC/DD	(24)
—	—	2D41	—	—	—	(25)
—	—	—	—	—	—	(26)
11A2	DDT	DT41	A23A	H4D	AC/DDT	(27)
—	—	—	—	—	—	(28)
PA1	41MP 41MXP	—	—	—	AC/L	(29)
—	—	—	—	—	—	(30)
—	—	—	—	—	—	(31)
7A2	MP/Pen	—	A70B	—	AC/Y	(32)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

LENTS—4-VOLT (AC) RANGE

	Marconi Osram	Mazda	Mullard	Philips	Tungsram
(1)	—	AC/TH1	TH4A TH4B	—	TH4A TH4B
(2)	X41	—	TH4	—	TX4
(3)	—	—	FC4	—	VO4
(4)	—	—	—	AK2	VO4s
(5)	MX40 X42	—	—	—	MH4105/71
(6)	—	—	—	AK1	MH4105/73
(7)	—	—	—	E447	HP4106c
(8)	VMP4 VMP4G	—	—	—	HP4105
(9)	—	—	VP4A	AF2	HP4115c
(10)	MSP4	AC/SP1 AC/S2Pen	SP4	E446	HP4101c
(11)	W42	—	—	—	VP4
(12)	—	—	—	AF3	VP4s
(13)	—	—	—	AH1	VX4s
(14)	—	AC/VP2	VP4B	—	VP4B
(15)	—	—	—	—	SP4
(16)	—	—	—	AF7	SP4s
(17)	—	—	SP4B	—	SP4B
(18)	VMS4 VMS4B	ACS1VM ACSGVM	VM4V MM4V	E445 E455	AS4125
(19)	MS4 MS4B	ACSG ACS2	S4V S4VA S4VB	E452T E442 E442S	AS4120
(20)	MH4 MH41 MHL4	AC/HL AC2/HL	154V 164V 244V 354V 484V 904V 994V	E424N E438 E499	HL4+
(21)	H42	—	—	—	HL4g
(22)	—	—	—	AC2	HL4gs
(23)	—	—	2D4	AB1	DD465
(24)	D41	V914 AC/DD	2D4A	—	DD4
(25)	—	—	2D4B	—	DD4D
(26)	—	—	—	AB2	DD4s
(27)	MHD4 DH42	ACHLDD	TDD4	—	DDT4
(28)	—	—	—	ABC1	DDT4s
(29)	ML4	AC/P AC/P1	104V TT4 054V	E409	LL4
(30)	—	AC/P4	—	—	LL4C
(31)	—	—	—	AL2	APP4As
(32)	MKT4 N42 MPT4 KT42	AC/Pen	Pen4V Pen4VA	—	APP4A

[*Continued on next page*

TABLE XLIV: VALVE EQUIVA-

Brimar	Cossor	Ekco	Ever-Ready	Ferranti	Hivac	
7A3	42OT 42MP/Pen	OP42	A70C A70D	PT4	AC/Z	(33)
—	—	—	—	—	—	(34)
—	42OTDD	—	—	PT4D	AC/ZDD	(35)
—	—	DO42	A27D	—	—	(36)
—	—	OP41	A70E	—	AC/YY	(37)
—	—	—	—	—	—	(38)
PenA1	425PT PT41 415PT 410PT	—	—	—	FY	(39)
—	—	—	—	—	—	(40)
—	4XP	—	S30C	LP4 P4	PX41	(41)
—	—	—	—	—	—	(42)
1A7 R1 R2	431U	—	A11B A11D	—	UU60/250 UU120/350	(43)
—	—	—	—	—	—	(44)
—	442BU 506BU	—	S11A S11D	R4	—	(45)
—	—	—	—	—	—	(46)
R3	—	R41	—	R4A	—	(47)
—	—	—	—	—	—	(48)
—	4/100BU	—	—	—	—	(49)
—	—	—	—	—	—	(50)
—	—	—	—	—	—	(51)

TABLE XLIV: VALVE EQUIVA-

Cossor	Ekco	Ever-Ready	Ferranti	Marconi Osram	
202STH	—	C36A	—	—	(1)
—	—	C36B C36C	—	—	(2)
—	—	—	—	—	(3)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

LENTS—4-VOLT (AC) RANGE—*continued*

	Marconi Osram	Mazda	Mullard	Philips	Tungsram
(33)	KT41 N41	AC2/Pen AC5/Pen	Pen4VB PenA4	—	APP4B
(34)	—	—	—	AL3 AL4	APPB4s
(35)	DN41	AC2/PenDD AC5/PenDD	—	—	DDPP4B
(36)	—	—	Pen4DD	—	DDPP4M
(37)	—	—	PenB4 Pen428	—	APP4E*
(38)	N43	—	—	—	APP4G*
(39)	PT4	Pen425	PM24M PM24 PM24A	E443H E443N	PP4
(40)	—	—	—	AL1	PP4s
(41)	PX4	PP3/250	AC044 AC064	E406N	P12/250
(42)	—	—	—	AD1	P15/250s
(43)	MU12	UU4 UU60/250 UU120/350	1W2 1W3 1W4/350	1881 1867 1881A	APV4
(44)	—	—	AZ3	—	IRV120/350s
(45)	U10 U12	UU120/350	DW2 DW3 DW4/350	506 1805 1807 1821	RV120/350
(46)	—	—	AZ1	AZ1	RV120/350s
(47)	U14	UU120/500	DW4 DW4/500	1561	RV120/500
(48)	—	—	AZ2	AZ2	RV120/500s
(49)	U18	—	FW4/500	1560 1815 1831	RV200/600
(50)	—	AC/ME	—	—	VME4
(51)	—	—	TV4 TV4A	—	ME4s

LENTS—UNIVERSAL (AC-DC) RANGE

	Mazda	Mullard	Philips	Tungsram
(1)	—	TH21C	—	TX21
(2)	TH2320 TH2620	TH22C TH30C	—	TH29 TH30
(3)	—	—	CH1	VX13s

[*Continued on next page*

TABLE XLIV: VALVE EQUIVALENTS—

Cossor	Ekco	Ever-Ready	Ferranti	Marconi Osram	
13PGA	—	C80B	VHTA	—	(4)
—	—	—	—	—	(5)
—	—	—	VPTA	—	(6)
13VPA	—	—	—	—	(7)
—	—	—	—	—	(8)
—	VPU1	C50N	—	—	(9)
—	—	—	—	—	(10)
13SPA	—	—	—	—	(11)
—	—	—	—	—	(12)
—	—	C50B	—	—	(13)
—	—	C30B	DA	—	(14)
—	—	—	—	—	(15)
—	—	C20C	—	—	(16)
—	—	—	—	—	(17)
—	—	—	ZD	—	(18)
13DHA 202DDT	DTU1	C23B	HAD	—	(19)
—	—	—	—	—	(20)
—	—	—	—	—	(21)
—	—	—	PTA	N30 N30G KT30	(22)
—	—	—	—	—	(23)
402Pen 402OT	—	—	—	—	(24)
—	—	—	—	—	(25)
—	—	C70D	PTZ	—	(26)
—	—	—	—	—	(27)
—	—	—	—	—	(28)
—	—	—	—	—	(29)
—	—	C10B	RZ	—	(30)
—	—	—	—	—	(31)
—	—	—	—	U30	(32)
—	—	—	—	—	(33)
40SUA	—	—	—	—	(34)
—	—	—	—	—	(35)
—	—	—	—	—	(36)
—	—	C39A	—	—	(37)
—	—	—	—	—	(38)
—	—	—	—	—	(39)
—	—	—	—	—	(40)
—	—	—	—	—	(41)
—	—	—	—	—	(42)
—	—	—	—	—	(43)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

UNIVERSAL (AC-DC) RANGE—*continued*

	Mazda	Mullard	Philips	Tungsram
(4)	—	FC13C	—	VO13
(5)	—	FC13	CK1	VO13s
(6)	—	—	—	VP13
(7)	—	—	—	VP13K
(8)	—	—	CF3	VP13s
(9)	VP1322	VP13C	—	VP13B
(10)	—	VP13A	CF2	HP13s
(11)	—	SP13A	—	SP13
(12)	—	SP13	CF1 CF7	SP13s
(13)	—	SP13C	—	SP13B
(14)	HL1320	HL13C	—	HL13
(15)	—	HL13	CC2	HL13s
(16)	—	2D13C	—	DD13
(17)	—	2D13A	CB2	DD13s
(18)	DD620	—	—	DD6
(19)	HLDD1320	TDD13C	—	DDT13
(20)	—	TDD13	CBC1	DDT13s
(21)	—	—	CL1	PP13s
(22)	—	—	—	PP13A
(23)	—	Pen26	CL2	PP24s
(24)	—	—	—	PP34
(25)	—	—	CL4	PP34s
(26)	Pen3520	Pen36C	—	PP35
(27)	—	CL6	CL6	CL6
(28)	PenDD4020	—	—	DDPP39
(29)	—	Pen40DD	—	DDPP39M
(30)	—	UR1C	CY1C	V20
(31)	—	UR1	CY1	V20s
(32)	—	—	—	PV25
(33)	—	UR2	CY2	PV29s
(34)	U4020	—	—	V30
(35)	—	UR3C	—	PV30
(36)	—	UR3	CY3	PV30s
(37)	—	TV6	—	ME6s
(38)	—	VP20 MM20 VM20	B2047 B2045	HP2118
(39)	—	SP20	B2046	HP2018
(40)	—	SG20A	B2052T	SS2018
(41)	—	SG20	—	S2018
(42)	—	H20 HL20	B2038	R2018
(43)	—	Pen20	B2043	PP2018

TABLE XLV: CATHODE-

Type No.	Description	Base	Screen		Heater		
			Diam.	Colour	V	A	
BAIRD							
12MW1	Elec.-Magnetic . .	—	12 in.	W	2·2	2·5	(1)
15MW2	„	—	15 in.	W	2·2	2·5	(2)
MARCONI (EMISCOPE)							
3/1	Magnetic . .	—	5 in.	—	4·0	1·3	(3)
3/2	„ . .	—	7 in.	—	4·0	1·3	(4)
3/3	„ . .	—	9 in.	—	4·0	1·3	(5)
6/5	Electrostatically Focused Hexode	—	9 in.	—	4·0	1·3	(6)
6/6	„ . .	—	12 in.	—	4·0	1·3	(7)
4/1	„ . .	—	3½ in.	G	—	—	(8)
MAZDA							
CRM71	Double Magnetic . .	—	180 mm	W	2·0	1·4	(9)
CRM91	„ . .	—	228 mm	W	2·0	1·4	(10)
CRM121	„ . .	—	316 mm	W	2·0	1·4	(11)
MULLARD							
MS11/1	Projection-Magnetic	—	—	—	4·0	1·0	(12)
MW18/2	Magnetic . .	R	7 in.	W	2·0	1·2	(13)
MW22/1	„ . .	Q	9 in.	W	4·0	1·0	(14)
MW22/3	„ . .	R	9 in.	W	2·0	1·2	(15)
MW22/5	„ . .	Q	9 in.	W	6·3	0·65	(16)
MW31/3	„ . .	Q	12 in.	W	6·3	0·65	(17)
MW31/6	„ . .	Q	12 in.	W	6·3	0·6	(18)
MW39/3	„ . .	Q	15 in.	W	6·3	0·65	(19)

TABLE XLVI: CATHODE-RAY

Type No.	Description	Base	Screen		Heater		Anode Volts				No. of Anodes	
			Diam. (in.)	Colour	V	A	1st	2nd	Final Max.	Final Normal		
COSSOR							(V = Final anode volts)					
32	Standard Gas Focused	B	5¼	B	0·65	1·25	—	—	1,500	1,000	1	(1)
37	Non-Origin Distortion, Gas Focused	A	4¼	B & GD	0·6	1·25	—	—	1,500	1,000	1	(2)
36	„	B	5¼	B & GD	0·6	1·2	—	—	1,500	500	1	(3)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

RAY TUBES—MAGNETIC

	Anode Volts				No. of Anodes	Cathode Current (μA)	Overall Dimensions	
	1st	2nd	Final Max.	Final Normal			Diameter	Length
(1)	—	—	5,300	—	—	—	—	—
(2)	—	—	7,000	—	—	—	—	—
(3)	—	—	2,500	—	—	—	—	13 in.
(4)	—	—	2,500	—	—	—	—	16·5 in.
(5)	—	—	3,500	—	—	—	—	20⅛ in.
(6)	850	5,000	—	—	—	—	—	24 in.
(7)	850	5,000	—	—	—	—	—	28·5 in.
(8)	—	—	—	800	—	—	—	—
(9)	—	—	4,000	—	—	—	—	—
(10)	—	—	6,000	—	—	—	—	—
(11)	—	—	6,000	—	—	—	—	—
(12)	500	25,000	—	—	—	—	114 mm	341–354 mm
(13)	4,000	—	—	—	1	–43	185 mm	364–372 mm
(14)	250	5,000	—	—	2	0–100	226 mm	360 mm
(15)	4,000	—	—	—	1	0–55	217–223 mm	352–360 mm
(16)	125–250	5,000	—	—	2	0–100	225–231 mm	368–376 mm
(17)	125–250	5,000	—	—	2	0–100	310 mm	460 mm
(18)	125–250	5,000	—	—	2	0–100	302–308 mm	455–465 mm
(19)	125–250	6,000	—	—	2	0–1,000	395 mm	580 mm

TUBES—ELECTROSTATIC

	Cathode Current (μA)	Negative Grid Volts			Sensitivity		Capacitances (μμF)				Overall Dimensions	
		Normal	Cut-off	Min.	Y Axis (mm/V)	X Axis (mm/V)	Grid (To o	X Plate ther elec	Y Plate trodes)	Y or X to Opposites	Diameter (mm)	Length (mm)
(1)	70–150	$\frac{1}{10}$V	—	—	430/V	430/V	8	6	6	3·0	135	409
(2)	50–150	$\frac{1}{10}$V	—	—	300/V	275/V	9	5	5	1·5	114	345
(3)	50–150	$\frac{1}{10}$V	—	—	375/V	340/V	9	5	5	3·0	135	409

[*Continued on next page*

TABLE XLVI: CATHODE-RAY

Type No.	Description	Base	Screen		Heater		Anode Volts				No. of Anodes	
			Diam. (in.)	Colour	V	A	1st	2nd	Final Max.	Final Normal		
COSSOR—*continued*												
09	Double Beam, Non-Trapezium, High Vacuum	D	4½	G	4·0	1·0	—	¼V	2,000	1,200	3	(4)
39	,,	E	6½	B	4·0	1·1	—	V/5–V/6	5,000	3,000	3	(5)
59	,,	F	9	BG	4·0	1·0	—	V/5–V/6	5,000	3,000	3	(6)
26	Single Beam ,,	D	4½	G	4·0	1·0	—	¼V	2,000	1,200	3	(7)
21	,,	E	8	W	4·0	1·1	—	V/6	6,000	5,000	3	(8)
79	,,	F	9	B & GD	4·0	1·0	—	V/5–V/6	5,000	3,500	3	(9)
41	,,	F	11	W	4·0	1·0	—	V/6	5,000	3,000	3	(10)
22	,, (High volt)	G	6½	B	4·0	1·0	— 1,000 V	V/5 V/5–V/6	10,000	5,000	3	(11)
23	,, (Monitor)	H	2¾	G	4·0	1·1	—	V/6	2,000	800	3	(12)
18	Magnetic ..	C	13½	W	4·0	1·1	—	—	6,000	5,000	1	(13)
66	.. .. ..	C	15	W	4·0	1·1	—	—	6,000	5,000	1	(14)
MULLARD												
E40/G3	Double Electrostatic Oscillograph	N	3	G	4·0	1·0	140–220	500–800	—	—	2	(15)
A40/G3	,,	O	3	G	4·0	1·0	140–220	500 800	—	—	2	(16)
A40/N3	,,	O	3	GD	4·0	1·0	140–220	500–800	—	—	2	(17)
A41/G4	,,	P	4	G	4·0	1·0	400	1,000	—	—	2	(18)
A41/B4	,,	P	4	B	4·0	1·0	400	1,000	—	—	2	(19)
A41/N4	,,	P	4	GD	4·0	1·0	400	1,000	—	—	2	(20)
E42/G6	,,	M	6	G	4·0	1·0	200–400	1,000–2,000	—	—	2	(21)
E42/B6	,,	M	6	B	4·0	1·0	200–400	1,000–2,000	—	—	2	(22)
E46/G10	,,	—	—	G	4·0	1·0	250	1,400	5,000	—	—	(23)
E46/B10	,,			B	4·0	1·0	250	1,400	5,000	—	—	(24)
E41/G4	Double Electrostatic Oscillograph	P	4	G	4·0	1·0	400	1,000	—	—	2	(25)
E41/B4	,,	P	4	B	4·0	1·0	400	1,000	—	—	2	(26)
ECR30	Electrostatic Oscillograph	S	3	G	4·0	1·0	120–150	1,000	—	—	2	(27)
ECR35	,,	T	3·5	G	4·0	1·0	180–270	1,200	—	—	2	(28)
ECR60	,,	T	6	G	4·0	1·0	250–450	2,000	—	—	2	(29)
E46/10	Electrostatic	—	—	—	4·0	1·0	250	1,400	—	—	—	(30)
E46/12	,,	—	—	—	4·0	1·0	250	1,400	—	—	—	(31)
STANDARD												
4050AB	Gas filled	I	—	B	0·75	0·7–1·1	—	—	1,500	500	—	(32)
4050AD	,, ...	I	—	BD	0·75	0·7–1·1	—	—	1,500	500	—	(33)
4050AG	,, ...	I	—	G	0·75	0·7–1·1	—	—	1,500	500	—	(34)
4050BB	,, ...	I	—	B	0·75	0·7–1·1	—	—	1,500	500	—	(35)
4050BD	,, ...	I	—	BD	0·75	0·7–1·1	—	—	1,500	500	—	(36)
4050BG	,, ...	I	—	G	0·75	0·7–1·1	—	—	1,500	500	—	(37)
4063AB	Vacuum	J	5½	B	2·0	1·8–2	150	·27V	5,000	—	—	(38)
4063YB	,, ...	K	5¼	B	2·0	1·8–2	150	·27V	5,000	—	—	(39)
VLS492 AG	,, ...	L	1½	G	2·0	1·8	60–300	—	250–1,000	—	—	(40)

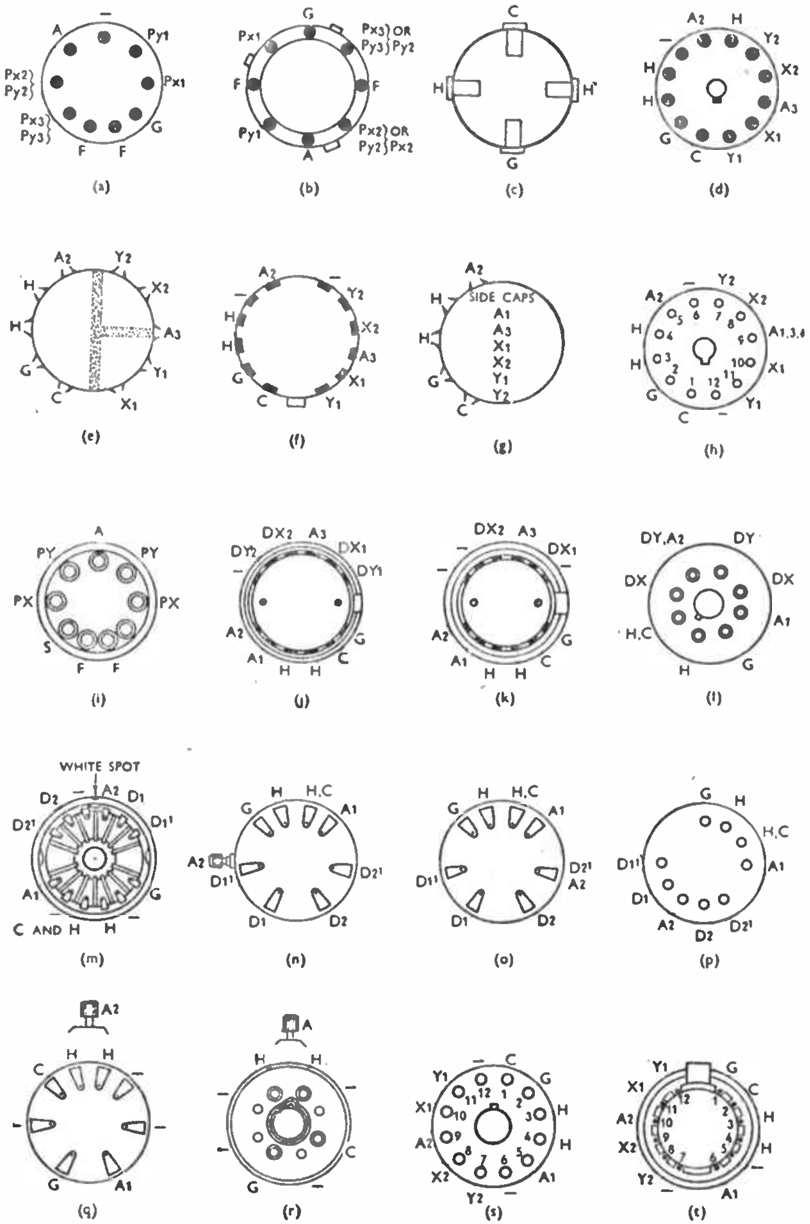
(Screen Colour: B, Blue; G, Green; W, White; D, Long Delay).

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TUBES—ELECTROSTATIC—*continued*

	Cathode Current (μA)	Negative Grid Volts			Sensitivity		Capacitances (μμF)				Overall Dimensions	
		Normal	Cut-off	Min.	Y Axis (mm/V)	X Axis (mm/V)	Grid (To other electrodes)	X Plate	Y Plate	Y or X to Opposites	Diameter (mm)	Length (mm)
(4)	0–500	V/80	V/40	0	400/V	400/V	8·5	14	14	1·0	114	375
(5)	0–400	V/360	V/180	0	650/V	700/V	7	11	12	1·0	160	455
(6)	0–350	V/360	V/180	0	650/V	750/V	7	11	12	1·0	228	525
(7)	0–50	V/80	V/40	0	390/V	350/V	9	14	11	1·0	114	375
(8)	0–350	V/360	V/180	0	966/V	735/V	8	16	13	5·0	205	507
(9)	0–350	V/360	V/180	0	600/V	600/V	7	11	12	1·0	228	525
(10)	0–350	V/360	V/180	0	600/V	600/V	11	17	15	1·0	295	580
(11)	0–250	V/360	V/180	0	980/V	780/V	6	14	10	3·0	135	490
(12)	0–150	6·5	V/70	0	170/V	170/V	20	15	15	1·0	70	200
(13)	—	—	—	—	—	—	—	—	—	—	350	605
(14)	—	—	—	—	—	—	—	—	—	—	382	675
(15)	—	0·30	—	—	—	—	—	—	—	—	75	150–165
(16)	—	0–30	—	—	—	—	—	—	—	—	75	150–165
(17)	—	0–30	—	—	—	—	—	—	—	—	75	150–165
(18)	—	0–40	—	—	—	—	—	—	—	—	103	326–349
(19)	—	0–40	—	—	—	—	—	—	—	—	103	326–349
(20)	—	0–40	—	—	—	—	—	—	—	—	103	326–349
(21)	—	0–35	—	—	—	—	—	—	—	—	167	425–450
(22)	—	0–35	—	—	—	—	—	—	—	—	167	425–450
(23)	—	0–60	—	—	—	—	—	—	—	—	258	570–595
(24)	—	0–60	—	—	—	—	—	—	—	—	258	570–595
(25)	—	0–40	—	—	—	—	—	—	—	—	103	326–349
(26)	—	0–40	—	—	—	—	—	—	—	—	103	326–349
(27)	—	–1–15	—	—	—	—	—	—	—	—	70	200
(28)	—	–1–50	—	—	—	—	—	—	—	—	90	340
(29)	—	–1–100	—	—	—	—	—	—	—	—	160	431
(30)	—	—	—	—	—	—	—	—	—	—	258	570–595
(31)	—	—	—	—	—	—	—	—	—	—	310	630–660
											(in.)	(in.)
(32)	—	—	—	—	370/V	370/V	—	—	—	7·0	4½	13½
(33)	—	—	—	—	370/V	370/V	—	—	—	7·0	4¼	13¼
(34)	—	—	—	—	370/V	370/V	—	—	—	7·0	4½	13½
(35)	—	—	—	—	580/V	580/V	—	—	—	7·0	7	18½
(36)	—	—	—	—	580/V	580/V	—	—	—	7·0	7	18½
(37)	—	—	—	—	580/V	580/V	—	—	—	7·0	7	18½
(38)	—	0–5	–30	—	600/V	700/V	18	16	10	—	6¼	21
(39)	—	0–5	–30	—	600/V	700/V	18	16	3·5	—	6¼	21
(40)	—	0–5	—	—	110/V	120/V	8·5	6·6	6·0	—	1½	6½

CATHODE RAY TUBE BASES



(a) (b) (c) (d)

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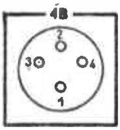
BRITISH FOUR-PIN

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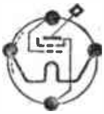
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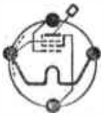
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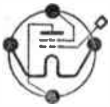
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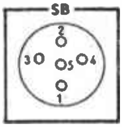


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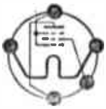
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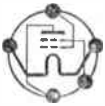
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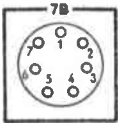
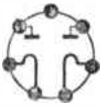
BRITISH SEVEN-PIN

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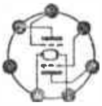
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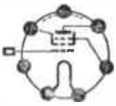
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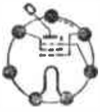
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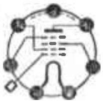
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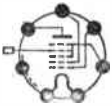
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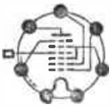
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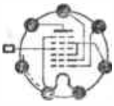
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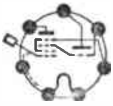
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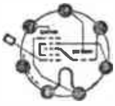
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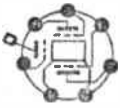
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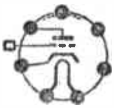
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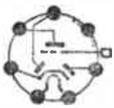
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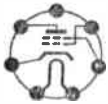
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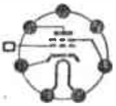
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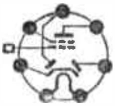
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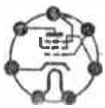
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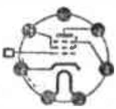
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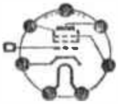
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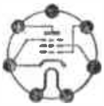
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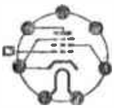
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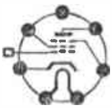
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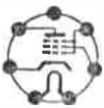
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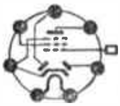
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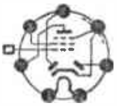
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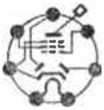
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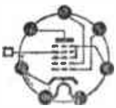
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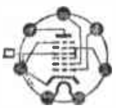
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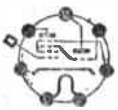
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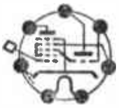
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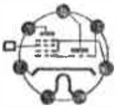
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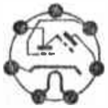
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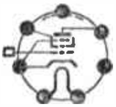
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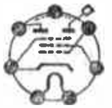
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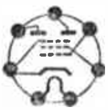
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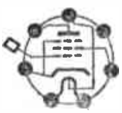
7B45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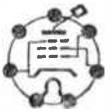
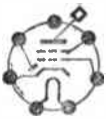

7B47

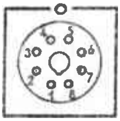

7B48


7B49


7B50

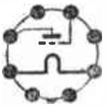
BLANKS HAVE BEEN LEFT AT THE END OF SOME GROUPS SO THAT THE READER MAY INSERT DETAILS OF FUTURE TYPES

OCTALS




O1


O2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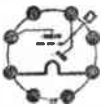
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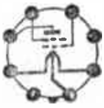
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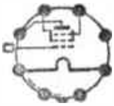
OCTALS (contd.)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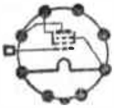
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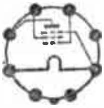
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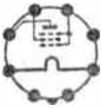
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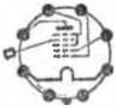
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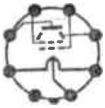
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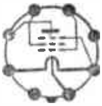
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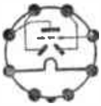
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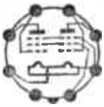
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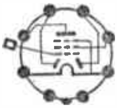
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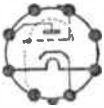
O16

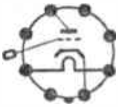

O34


O35


O36


O37


O38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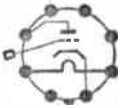
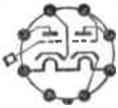

O40


O41


O42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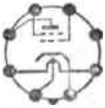
O44


O45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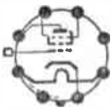
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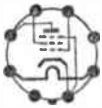
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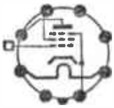
O49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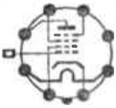
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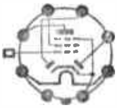
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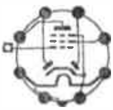
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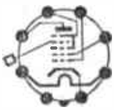
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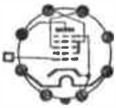
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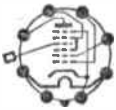
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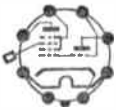
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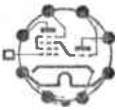
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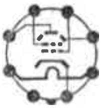
O59

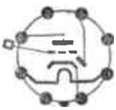

O60


O61


O62


O63


O64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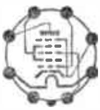
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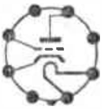
O67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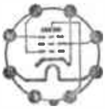
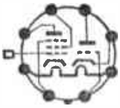
O69


O70

OCTALS (contd.)


O71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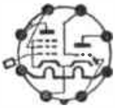

O73


O74

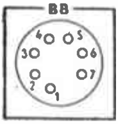

O75

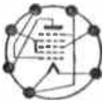

O76

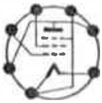

O77

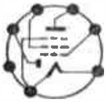

O78

AMERICAN MINIATURE BUTTON BASES


BB


BB1


BB2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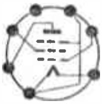
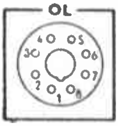
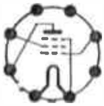

BB4

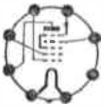
LOCTALS


OL


OL1


OL2


OL3


OL4


OL8

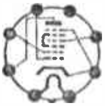

OL9


OL10


OL11


OL12


OL13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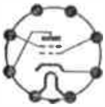
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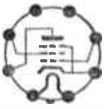
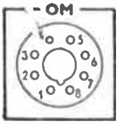

OL16

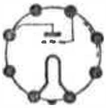

OL17


OL18


OL19

MAZDA OCTALS


OM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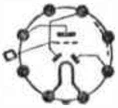
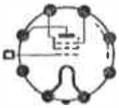
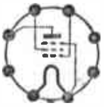

OM2


OM3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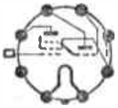
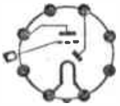

OM5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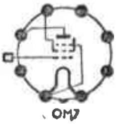
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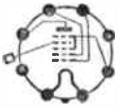
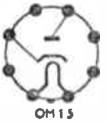

OM8


OM9


OM15

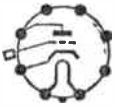

OM16

MAZDA OCTALS (contd.)


OM17


OM18


OM19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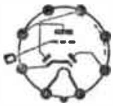
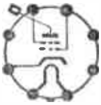
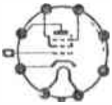

OM21


OM22


OM23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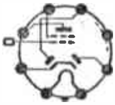
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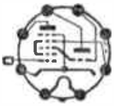
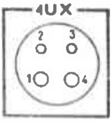
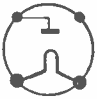

OM26


OM27

AMERICAN UX

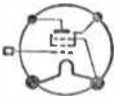
4UX



4UX1


4UX2


4UX3


4UX4


4UX5


4UX6

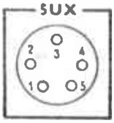

4UX7

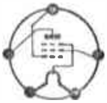

4UX8


4UX9


4UX10


4UX11

5UX
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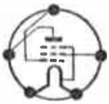
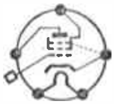

5UX2

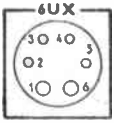

5UX4

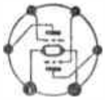

5UX5


5UX6


5UX7


5UX8

6UX
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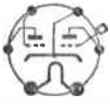
6UX2

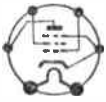

6UX3


6UX5


6UX6


6UX7


6UX8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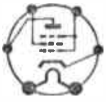
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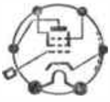
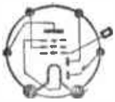

6UX11


6UX12

AMERICAN UX (contd.)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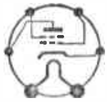
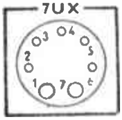
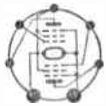
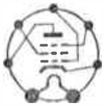

6UX14

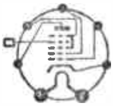

6UX15




7UX1


7UX4

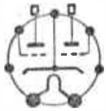

7UX5


7UX6


7UX7


7UX8


7UX9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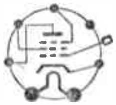
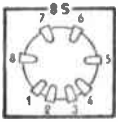
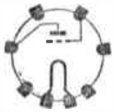

7UX11

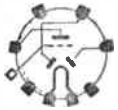
SIDE CONTACT

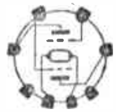



8S1


8S2


8S3


8S4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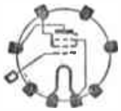
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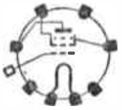
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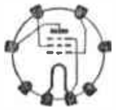
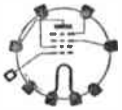

8S8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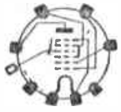
8S10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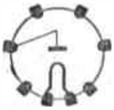
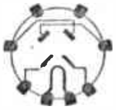

8S12


8S15


8S16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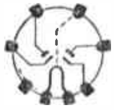
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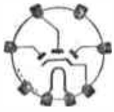
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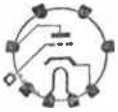
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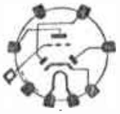
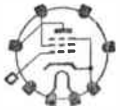
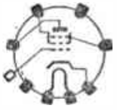

8S21


8S22


8S23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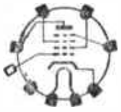
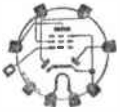
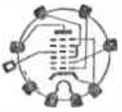

8S25


8S26


8S27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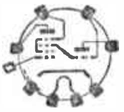
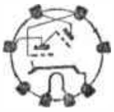

8S29


8S30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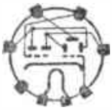
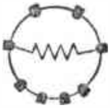
SIDE CONTACT (contd.)

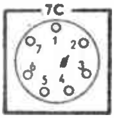


8S32

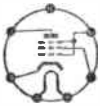


8S33

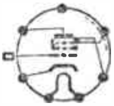
CONTINENTAL



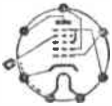
7C1



7C2

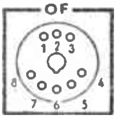


7C3



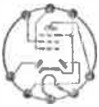
7C4

FOOTLESS

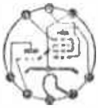


OF1

OF2

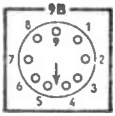


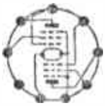
OF3



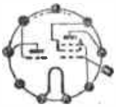
OF4

BRITISH NINE-PIN





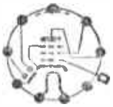
9B1



9B2

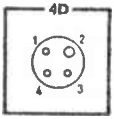
9B3

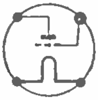
9B5



9B6

BRITISH SPECIALS

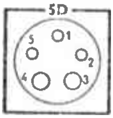


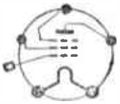


4D1

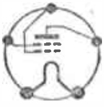
4D2

4D3

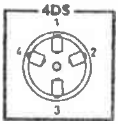


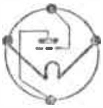


5D1

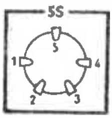


5D2



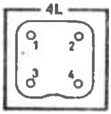


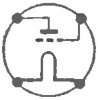
4DS1



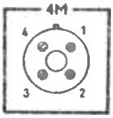
5S1

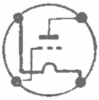
5S2



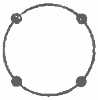


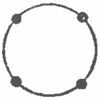
4L1

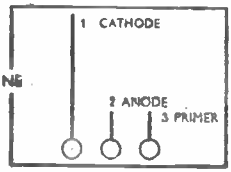


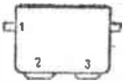


4M1

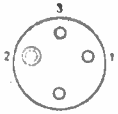








NE1



NE2

TYPES

	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Screen Current (mA)	Slope mA/V (*=Conv. Condt. μA/V)	Impedance (Ohms)	Amp. Factor	Output (Watts)	Optimum Load (Ohms)
(1)	—	—	1·5	—	0·666	30,000	20	—	—
(2)	—	—	—	—	—	—	—	75mA	—
(3)	—	—	1·5	—	0·666	30,000	20	—	—
(4)	–3–15	—	2·3	0·8	0·75	1 meg.	750	—	—
(5)	–4·5	—	4·0	0·8	0·85	300,000	255	0·115	25,000
(6)	–3–22·5	—	1·3	2·4	*300	500,000	—	—	—
(7)	0–3	—	1·2	0·6	*250	600,000	—	—	—
(8)	0	—	2·3	—	*250	—	—	—	—
(9)	–3·0	—	1·7	0·6	0·65	1·5 meg.	—	—	—
(10)	–3·0	—	0·8	—	0·575	35,000	20	—	—
(11)	–7·5	—	7·5	1·6	1·55	115,000	180	0·24	8,000
(12)	–3–14	—	1·5	2·0	*325	750,000	—	—	—
(13)	–3·0	—	1·5	2·0	*325	750,000	—	—	—
(14)	–3·0	—	2·3	0·8	0·75	1 meg.	—	—	—
(15)	–3·0	—	1·3	2·4	0·3	500,000	—	—	—
(16)	–3·0	—	1·7	0·6	0·65	1·5 meg.	—	—	—
(17)	–7·5	—	7·5	2·2	1·425	260,000	—	0·575	24,000
(18)	–4·5	432	8·0	2·4	1·7	200,000	—	0·31	16,000
(19)	–4·5	432	8·0	2·4	1·7	200,000	—	0·31	16,000
(20)	–1·5	—	2·2	0·7	0·65	1 meg.	—	—	—
(21)	–1·5	—	2·2	0·7	0·65	1 meg.	—	—	—
(22)	–13·5	—	3·1	—	0·9	10,300	9·3	—	—
(23)	0	—	0·14	—	0·275	240,000	65	—	—
(24)	–3·0	—	0·8	—	0·575	35,000	20	—	—
(25)	0	—	5·0	—	—	—	—	2·1	10,000
(26)	–4·5	—	4·0	0·8	0·85	300,000	255	0·115	25,000
(27)	0–3·0	—	1·2	0·6	*250	600,000	—	—	—
(28)	0	—	0·14	—	0·275	240,000	65	—	—
(29)	0	—	1·6	0·35	0·8	1·1 meg.	880	—	—
(30)	0–4·0	—	1·2	0·3	0·75	1·5 meg.	1160	—	—
(31)	0	—	1·6	—	0·65	1 meg.	—	—	—
(32)	–4·5	—	9·5	1·6	2·1	—	—	0·27	8,000
(33)	—	—	1·7	3·0	—	—	—	—	—
(34)	–7·0	—	7·2	1·5	—	—	—	—	—
(35)	—	—	3·0	7·0	—	—	—	—	—
(36)	—	—	3·7	1·25	—	—	—	—	—
(37)	—	—	—	—	—	—	—	45mA	—
(38)	–45·0	750	60·0	—	5·25	800	4·2	3·5	2,000
(39)	–16·5	410	34·0	6·5	2·65	30,000	190	3·0	7,000
(40)	–2·0	5,000	0·8	—	1·1	90,000	100	—	—
(41)	–3–40	300	3·5	2·2	*520	360,000	—	—	—
(42)	–3·0	—	10·0	2·3	1·2	600,000	—	—	—
(43)		—	—	—	—	—	—	—	—
(44)	—	—	—	—	—	—	—	—	—
(45)	–4·5	—	9·5	1·6	2·1	—	—	0·27	8,000
(46)	—	—	—	—	—	—	—	250mA	—
(47)	—	—	—	—	—	—	—	250mA	—
(48)	—	—	—	—	—	—	—	200mA	—
(49)	—	—	—	—	—	—	—	200mA	—
(50)	—	—	—	—	—	—	—	125mA	—

[*Continued on next page*

TABLE XLVII: AMERICAN

Type	Description	Base	Fil. or Heater (Volts)	Fil. or Heater Current (Amps)	Anode Volts	Screen Volts	
5Y4	Rectifier	01	5·0	2·0	RMS 350	—	(51)
5Z3	Rectifier	4UX2	5·0	3·0	RMS 500	—	(52)
5Z4	Rectifier	036	5·0	2·0	RMS 350	—	(53)
6A3	Power Triode ..	4UX3	6·3	1·0	250	—	(54)
6A4	LF Pentode.. ..	5UX1	6·3	0·3	180	180	(55)
6A6	Double Triode ..	042	6·3	0·8	300	—	(56)
6AG6	LF Pentode.. ..	049	6·3	1·2	250	250	(57)
6A7	Frequency Changer	7UX6	6·3	0·3	250	100	(58)
6A8	Frequency Changer	054	6·3	0·3	250	100	(59)
6AB5	Tuning Indicator ..	6UX12	6·3	0·15	180	Target 180	(60)
6AD6	Tuning Indicator ..	061	6·3	0·15	—	Target 150	(61)
6AE6	Twin Anode Control	063	6·3	0·15	250	—	(62)
6AF6	Tuning Indicator ..	061	6·3	0·15	—	Target 135	(63)
6B4	Power Triode ..	03	6·3	1·0	250	—	(64)
6B5	Double Triode ..	6UX8	6·3	0·8	300	—	(65)
6B6	DD Triode	041	6·3	0·3	250	—	(66)
6B7	DD HF Pentode ..	7UX5	6·3	0·3	250	125	(67)
6B8	DD HF Pentode ..	053	6·3	0·3	250	125	(68)
6B8S	DD HF Pentode ..	053	6·3	0·3	250	100	(69)
6C5	Triode	034	6·3	0·3	250	—	(70)
6C6	HF Pentode ..	6UX11	6·3	0·3	250	100	(71)
6C7	DD Triode	—	6·3	0·3	250	—	(72)
6D6	HF Pentode ..	6UX11	6·3	0·3	250	100	(73)
6D8	Pentagrid	054	6·3	0·15	250	100	(74)
6E5	Tuning Indicator ..	6UX12	6·3	0·3	250	—	(75)
6E6	Double Triode ..	7UX9	6·3	0·6	250	—	(76)
6E7	HF Pentode ..	7UX11	6·3	0·3	250	100	(77)
6E8	Triode Hexode ..	058	6·3	0·3	250	100	(78)
6F5	Triode	039	6·3	0·3	250	—	(79)
6F6	LF Pentode.. ..	049	6·3	0·7	250	250	(80)
6F7	Triode Pentode ..	7UX8	6·3	0·3	250	100	(81)
6G5	Tuning Indicator ..	6UX12	6·3	0·3	250	—	(82)
6G6	LF Pentode.. ..	048	6·3	0·15	180	180	(83)
6H4	Diode	064	6·3	0·15	100	—	(84)
6H6	Double Diode ..	037	6·3	0·3	—	—	(85)
6J5	Triode	034	6·3	0·3	250	—	(86)
6J7	HF Pentode ..	050	6·3	0·3	250	125	(87)
6K5	Triode	040	6·3	0·3	250	—	(88)
6K6	LF Pentode.. ..	048	6·3	0·4	250	250	(89)
6K7	HF Pentode ..	047	6·3	0·3	250	125	(90)
6K8	Triode Hexode ..	057	6·3	0·3	250	100	(91)
6L5	Triode	034	6·3	0·15	250	—	(92)
6L6	LF Pentode.. ..	060	6·3	0·9	250	250	(93)
6L7	Frequency Changer	055	6·3	0·3	250	150	(94)
6M6	LF Pentode.. ..	048	6·3	1·2	250	250	(95)
6N5	Tuning Indicator ..	6UX12	6·3	0·15	180	—	(96)
6N6	Double Triode ..	044	6·3	0·8	300	—	(97)

Note.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TYPES—*continued*

	Bias Volts	Bias Res. (Ohms)	Anode Cur- rent (mA)	Screen Cur- rent (mA)	Slope mA/V (*=Conv. Condt. µA/V)	Imped- ance (Ohms)	Amp. Factor	Out- put (Watts)	Opti- mum Load (Ohms)
(51)	—	—	—	—	—	—	—	125mA	—
(52)	—	—	—	—	—	—	—	250mA	—
(53)	—	—	—	—	—	—	—	125mA	—
(54)	–4·5	—	60·0	—	5·25	800	4·2	3·2	2,500
(55)	–12·0	465	22·0	3·9	2·2	45,500	—	1·4	8,000
(56)	0	0	—	—	—	—	35	10·0	—
(57)	–6·0	150	32·0	6·0	10·0	60,000	600	3·75	8,500
(58)	–3–40	300	3·5	2·2	*550	360,000	—	—	—
(59)	–3–40	300	3·5	2·2	*550	360,000	—	—	—
(60)	—	—	—	—	—	—	—	—	—
(61)	—	—	—	—	—	—	—	—	—
(62)	—	—	6·5	—	—	—	—	—	—
(63)	—	—	—	—	—	—	—	—	—
(64)	–45·0	—	60·0	—	5·25	800	4·2	3·2	2,500
(65)	—	—	43·0	—	2·25	24,000	54	5·0	7,000
(66)	–2·0	5,000	0·4	—	1·1	90,000	100	—	—
(67)	–3·0	250	7·5	2·1	1·1	650,000	700	—	—
(68)	–3·0	—	9·0	2·3	1·1	600,000	800	—	—
(69)	–3–30	—	6·5	1·4	1·0	800,000	800	—	—
(70)	–8·0	1,000	8·0	—	2·0	10,000	20	—	—
(71)	–3·0	600	2·0	0·5	1·25	1·5 meg.	1,900	—	—
(72)	–9·0	—	5·5	—	1·25	16,000	20	—	—
(73)	–3–40	300	8·2	2·0	1·6	800,000	1,280	—	—
(74)	–3·0	—	3·5	2·6	*550	400,000	—	—	—
(75)	—	—	—	—	—	—	—	—	—
(76)	–27·5	—	36·0	—	3·4	7,000	6·0	1·6	14,000
(77)	–3·0	—	7·5	1·75	1·5	770,000	20	—	—
(78)	—	—	3·3	—	*650	—	—	—	—
(79)	–2·0	2,000	0·9	—	1·5	66,000	100	—	—
(80)	–16·5	410	34·0	6·5	3·25	80,000	190	3·5	7,000
(81)	–3–35	500	6·5	1·5	1·1	850,000	900	—	—
(82)	0–22	—	—	—	—	—	—	—	—
(83)	–9·0	—	15·0	2·5	2·3	—	—	—	—
(84)	—	—	4·0	—	—	—	—	—	—
(85)	—	—	—	—	—	—	—	—	—
(86)	–8·0	—	9·0	—	2·6	7,700	20	—	—
(87)	–3·0	600	2·0	0·5	1·25	1·5 meg.	1,900	—	—
(88)	–3·0	3,000	1·1	—	1·4	50,000	70	—	—
(89)	–18·0	—	32·0	—	2·2	68,000	—	3·4	7,600
(90)	–3·0	200	10·5	2·6	1·65	600,000	1,000	—	—
(91)	–3–30	300	2·5	4·5	*350	1 meg.	—	—	—
(92)	–9·0	—	8·0	—	1·9	9,000	17	—	—
(93)	–14·0	170	72·0	5·0	6·0	22,500	135	6·5	2,500
(94)	–3·0	260	3·3	8·3	*350	1 meg.	—	—	—
(95)	—	140	36·0	4·0	10·0	—	—	4·4	7,000
(96)	—	—	—	—	—	—	—	—	—
(97)	0	—	43·0	8·0	8·0	24,000	54	5·0	7,000

[*Continued on next page*

TABLE XLVII: AMERICAN

Type	Description	Base	Fil. or Heater (Volts)	Fil. or Heater Current (Amps)	Anode Volts	Screen Volts	
6N7	Double Triode	042	6·3	0·8	300	—	(98)
6P8	Triode Hexode	058	6·3	0·8	250	80	(99)
6Q6	Diode Triode	065	6·3	0·15	250	—	(100)
6Q7	DD Triode	041	6·3	0·3	250	—	(101)
6R7	DD Triode	041	6·3	0·3	250	—	(102)
6S7	HF Pentode	047	6·3	0·15	300	100	(103)
6T7	DD Triode	041	6·3	0·15	250	—	(104)
6U5	Tuning Indicator	6UX12	6·3	0·3	250	—	(105)
6U7	HF Pentode	047	6·3	0·3	250	100	(106)
6V6	LF Pentode	060	6·3	0·45	250	250	(107)
6W7	HF Pentode	047	6·3	0·15	300	100	(108)
6X5	Rectifier	037	6·3	0·6	RMS 350	—	(109)
6Y5	Rectifier	—	6·3	0·8	RMS 350	—	(110)
6Z4	Rectifier	—	6·3	0·5	RMS 350	—	(111)
6ZY5	Rectifier	037	6·3	0·3	RMS 350	—	(112)
7A6	Double Diode	0L9	6·3	0·15	150	—	(113)
7A7	HF Pentode	—	6·3	0·3	250	100	(114)
7A8	Frequency Changer	0L17	6·3	0·15	250	100	(115)
7B5	LF Pentode	0L12	6·3	0·4	250	250	(116)
7B6	DD Triode	0L11	6·3	0·3	250	—	(117)
7B7	HF Pentode	0L12	6·3	0·15	250	100	(118)
7B8	Frequency Changer	0L13	6·3	0·3	250	100	(119)
7C5	LF Pentode	0L16	6·3	0·45	250	250	(120)
7C6	DD Triode	0L11	6·3	0·15	250	—	(121)
7C7	HF Pentode	0L12	6·3	0·3	250	100	(122)
7Y4	Rectifier	0L10	6·3	0·5	RMS 350	—	(123)
10	Power Triode	4UX3	7·5	1·25	450	—	(124)
12	Triode	4UX3	1·1	0·25	135	—	(125)
12A6	Beam Power Output	048	12·6	0·15	250	250	(126)
12A7	Diode Pentode	7UX7	12·6	0·3	135	135	(127)
12A8	Pentagrid	054	12·6	0·15	300	100	(128)
12B6	Diode Triode	065	12·6	0·15	250	—	(129)
12B7	HF Pentode	0L12	12·6	0·15	250	—	(130)
12C8	DD HF Pentode	053	12·6	0·15	300	125	(131)
12E5	Triode	034	12·6	0·15	250	—	(132)
12F5	Triode	039	12·6	0·15	250	—	(133)
12G7	DD Triode	041	12·6	0·15	250	—	(134)
12J5	Triode	034	12·6	0·15	250	—	(135)
12J7	HF Pentode	047	12·6	0·15	250	100	(136)
12K7	HF Pentode	047	12·6	0·15	300	125	(137)
12K8	Triode Hexode	057	12·6	0·15	250	100	(138)
12Q7	DD Triode	041	12·6	0·15	250	—	(139)
12SA7	Pentagrid	066	12·6	0·15	300	100	(140)
12SC7	Double Triode	067	12·6	0·15	250	—	(141)
12SF5	Triode	068	12·6	0·15	250	—	(142)
12SG7	HF Pentode	069	12·6	0·15	250	150	(143)
12SJ7	HF Pentode	070	12·6	0·15	250	100	(144)
12SK7	HF Pentode	070	12·6	0·15	250	100	(145)
12SQ7	DD Triode	071	12·6	0·15	250	—	(146)
12SR7	DD Triode	071	12·6	0·15	250	—	(147)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TYPES—*continued*

	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Screen Current (mA)	Slope mA/V (*—Conv. Condt. µA/V)	Impedance (Ohms)	Amp. Factor	Output (Watts)	Optimum Load (Ohms)
(98)	0	—	—	—	—	—	35	10·0	—
(99)	−1·5–30	300	2·2	3·0	*650	750,000	—	—	—
(100)	−3·0	—	1·2	—	1·05	—	—	—	—
(101)	−2·0	4,000	1·1	—	1·2	58,000	70	—	—
(102)	−9·0	1,000	9·5	—	1·9	8,500	16	—	—
(103)	−3·0	—	8·5	2·0	1·75	1 meg.	—	—	—
(104)	−3·0	—	1·2	—	1·05	62,000	65	—	—
(105)	0–22	—	—	—	—	—	—	—	—
(106)	−3–40	300	8·2	2·0	1·6	800,000	1,280	—	—
(107)	−12·5	240	45·0	4·5	4·1	52,000	218	4·25	5,000
(108)	−3·0	—	2·0	0·5	1·225	1·5 meg.	—	—	—
(109)	—	—	—	—	—	—	—	75mA	—
(110)	—	—	—	—	—	—	—	50mA	—
(111)	—	—	—	—	—	—	—	60mA	—
(112)	—	—	—	—	—	—	—	35mA	—
(113)	—	—	8·0 (each anode)		—	—	—	—	—
(114)	−3–35	300	8·6	2·0	2·0	800,000	1,600	—	—
(115)	−3–35	300	3·0	2·8	*600	700,000	—	—	—
(116)	−18·0	500	32·0	5·5	2·2	68,000	150	3·4	7,600
(117)	−2·0	2,000	1·0	—	1·1	91,000	100	—	—
(118)	−3·0	300	8·5	2·0	1·7	700,000	1,200	—	—
(119)	−3·0	300	3·5	2·7	*550	360,000	—	—	—
(120)	−12·5	240	45·0	4·5	4·1	52,000	218	4·25	5,000
(121)	−1·0	—	1·3	—	1·0	100,000	100	—	—
(122)	−3·0	1,200	2·0	0·5	1·2	1·5 meg.	1,850	—	—
(123)	—	—	—	—	—	—	—	60mA	—
(124)	−32·0	—	18·0	—	1·6	5,000	—	1·6	10,000
(125)	−10·5	—	3·0	—	0·44	15,000	6·6	—	—
(126)	−12·5	—	30·0	3·5	3·0	50,000	—	—	—
(127)	−13·5	1,250	9·0	2·5	0·975	102,000	100	0·55	13,500
(128)	−3·0	—	3·5	2·7	*550	360,000	—	—	—
(129)	−2·0	—	0·9	—	1·1	91,000	—	—	—
(130)	−3·0	—	9·2	—	2·0	800,000	—	—	—
(131)	−3·0	—	10·0	2·3	1·325	600,000	—	—	—
(132)	−13·5	—	5·0	—	1·45	9,500	—	—	—
(133)	−2·0	—	0·9	—	1·5	66,000	—	—	—
(134)	−3·0	—	—	—	1·2	58,000	—	—	—
(135)	−8·0	—	9·0	—	2·6	7,700	—	—	—
(136)	−3·0	2·0	0·5	—	1·225	2 meg.	—	—	—
(137)	−3·0	—	10·5	2·6	1·65	600,000	—	—	—
(138)	−3·0	—	2·5	6·0	0·35	600,000	—	—	—
(139)	−3·0	—	1·1	—	1·2	58,000	—	—	—
(140)	—	—	3·5	8·5	*450	1 meg.	—	—	—
(141)	−2·0	—	2·0	—	1·325 each	53,000	—	—	—
(142)	−2·0	—	0·9	—	1·5	66,000	—	—	—
(143)	−2·5	—	9·2	3·4	4·0	1 meg.	—	—	—
(144)	−3·0	—	3·0	0·8	1·65	1·5 meg.	—	—	—
(145)	−3·0	—	9·2	3·4	1·65	1·5 meg.	—	—	—
(146)	−2·0	—	0·8	—	1·1	91,000	—	—	—
(147)	−9·0	—	9·5	—	1·9	8,500	—	—	—

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TABLE XLVII: AMERICAN

Type	Description	Base	Fil. or Heater (Volts)	Fil. or Heater Current (Amps)	Anode Volts	Screen Volts	
12Z3	Rectifier	4UX10	12·6	0·3	RMS 250	—	(148)
14A4	Triode	OL19	12·6	0·15	250	—	(149)
14A5	Beam Power Output	OL16	12·6	0·15	250	250	(150)
14A7/12B7	HF Pentode	OL12	12·6	0·15	250	100	(151)
14B8	Pentagrid	OL13	12·6	0·15	250	100	(152)
14C7	HF Pentode	OL12	12·6	0·15	250	100	(153)
14F7	Double Triode	OL18	12·6	0·15	250	—	(154)
15	HF Pentode	5UX8	2·0	0·22	135	67·5	(155)
18	LF Pentode	6UX10	14·0	0·3	250	250	(156)
19	Class B	6UX1	2·0	0·26	135	—	(157)
20	Power Triode	4UX3	3·3	0·132	135	—	(158)
22	Screen Grid	4UX6	3·3	0·132	135	67·5	(159)
24	Screen Grid	5UX8	2·5	1·75	250	90	(160)
24A	Screened Tetrode	5UX8	2·5	1·75	250	90	(161)
25A6	LF Pentode	049	25·0	0·3	180	135	(162)
25A7	Diode Pentode	062	25·0	0·3	100	100	(163)
25B5	Double Triode	6UX15	25·0	0·3	180	100	(164)
25B8	Triode Pentode	072	25·0	0·15	100	100	(165)
25D8	Diode-Triode-Pentode	073	25·0	0·15	—	—	(166)
25L6	LF Pentode	060	25·0	0·3	110	110	(167)
25N6	Double Triode	—	25·0	0·3	180	110	(168)
25R	Rectifier	6UX5	25·0	0·3	RMS 250	—	(169)
25X6	Rectifier	—	25·0	0·15	RMS 125	—	(170)
25Y4	Rectifier	035	25·0	0·15	RMS 125	—	(171)
25Y5/25Z5	Rectifier	6UX5	25·0	0·3	RMS 250	—	(172)
25Z6	Rectifier	037	25·0	0·3	RMS 250	—	(173)
26	Triode	4UX3	1·5	1·05	180	—	(174)
27	Triode	5UX6	2·5	1·75	250	—	(175)
30	Triode	4UX3	2·0	0·06	180	—	(176)
31	Triode	4UX3	2·0	0·13	180	—	(177)
32	HF Tetrode	4UX5	2·0	0·06	180	67·5	(178)
33	LF Pentode	5UX1	2·0	0·26	135	135	(179)
34	HF Pentode	4UX5	2·0	0·06	180	67·5	(180)
35	HF Tetrode	5UX9	2·5	1·75	250	90	(181)
35A5	Beam Power Output	OL16	32·0	0·15	110	110	(182)
35L6	Beam Power Output	048	35·0	0·15	110	110	(183)
35R	Rectifier	6UX5	35·0	0·3	RMS 250	—	(184)
35Z3	Rectifier	OL8	35·0	0·15	RMS 170	—	(185)
35Z4	Rectifier	015	35·0	0·15	RMS 125	—	(186)
35Z5	Rectifier	075	35·0	0·15	RMS 125	—	(187)
36	Screened Tetrode	5UX8	6·3	0·3	250	90	(188)
37	Triode	5UX6	6·3	0·3	250	—	(189)
38	LF Pentode	5UX7	6·3	0·3	250	250	(190)
39/44	HF Pentode	5UX8	6·3	0·3	250	90	(191)
40	Triode	4UX3	5·0	0·25	180	—	(192)
40Z5	Rectifier	075	45·0	0·15	RMS 125	—	(193)
41	LF Pentode	6UX10	6·3	0·4	250	250	(194)
42	LF Pentode	6UX10	6·3	0·7	250	250	(195)
43	LF Pentode	6UX10	25·0	0·3	180	135	(196)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

	Bias Volts	Bias Res. (Ohms)	Anode Current (mA)	Screen Current (mA)	Slope mA/V (*=Conv. Condt. µA/V)	Impedance (Ohms)	Amp. Factor	Output (Watts)	Optimum Load (Ohms)
(148)	—	—	—	—	—	—	—	60mA	—
(149)	–8·0	—	—	—	2·6	7,700	—	—	—
(150)	–12·5	—	30·0	3·5	3·0	50,000	—	—	—
(151)	–3·0	—	9·2	2·6	2·0	800,000	—	—	—
(152)	–3·0	—	3·5	2·7	*550	360,000	—	—	—
(153)	–3·0	—	2·2	0·7	1·575	1 meg.	—	—	—
(154)	–2·0	—	2·3	—	1·6	44,000	—	—	—
(155)	–1·5	—	1·85	0·3	0·75	800,000	600	—	—
(156)	–16·5	410	34·0	6·5	2·35	80,000	190	3·5	7,000
(157)	0	—	—	—	—	—	—	2·1	—
(158)	–22·5	—	6·5	—	0·525	6,300	3·3	0·11	6,500
(159)	–1·5	—	3·7	1·3	0·5	325,000	—	—	—
(160)	–3·0	500	4·0	1·7	1·0	400,000	400	—	—
(161)	–3·0	500	4·0	1·7	1·05	600,000	630	—	—
(162)	–20·0	440	38·0	7·5	2·5	40,000	100	2·75	5,500
(163)	–15·0	—	20·5	4·0	1·8	50,000	—	0·77	4,500
(164)	0	—	46·0	5·8	2·3	15,200	35	3·8	3,800
(165)	–3·0	—	7·6	2·0	*2,000	75,000	—	—	—
(166)	—	—	—	—	{ 1·9 { 1·1	200,000 91,000	Pentode } Triode }	—	—
(167)	–7·5	140	49·0	4·0	8·2	10,000	82	2·2	2,000
(168)	0	—	45·0	7·0	11·4	11,400	25	2·0	2,000
(169)	—	—	—	—	—	—	—	80mA	—
(170)	—	—	—	—	—	—	—	60mA	—
(171)	—	—	—	—	—	—	—	75mA	—
(172)	—	—	—	—	—	—	—	85mA	—
(173)	—	—	—	—	—	—	—	85mA	—
(174)	–14·5	—	6·2	—	1·15	7,300	8·3	—	—
(175)	–21·0	—	5·2	—	0·97	9,250	9·0	—	—
(176)	–13·5	—	3·1	—	0·9	10,300	9·3	—	—
(177)	–30·0	—	12·3	—	1·05	3,600	3·8	0·375	5,700
(178)	–3·0	—	1·7	0·4	0·65	1·2 meg.	780	—	—
(179)	–12·0	—	—	—	2·0	—	—	1·0	6,000
(180)	–3–22·5	—	2·8	1·0	0·62	1·2 meg.	620	—	—
(181)	–3·0	—	6·5	2·5	1·05	400,000	—	—	—
(182)	–7·5	—	41·0	7·0	5·8	14,000	—	—	—
(183)	–7·5	—	41·0	7·0	5·8	13,800	—	—	—
(184)	—	—	—	—	—	—	—	120mA	—
(185)	—	—	—	—	—	—	—	100mA	—
(186)	—	—	—	—	—	—	—	100mA	—
(187)	—	—	—	—	—	—	—	100mA	—
(188)	–3·0	850	3·2	1·0	1·08	550,000	595	—	—
(189)	–18·0	—	7·5	—	1·1	8,400	9·2	—	—
(190)	–25·0	970	22·0	3·8	1·2	100,000	1·2	2·5	10,000
(191)	–3·0	400	5·8	1·4	1·05	1 meg.	1,050	—	—
(192)	–3·0	—	0·2	—	0·2	150,000	30	—	—
(193)	—	—	—	—	—	—	—	100mA	—
(194)	–18·0	480	32·0	5·5	2·2	68,000	150	3·4	7,600
(195)	–16·5	410	34·0	6·5	2·35	80,000	190	3·5	7,000
(196)	–20·0	440	38·0	7·5	2·5	40,000	100	2·75	5,000

[*Continued on next page*

TABLE XLVII: AMERICAN

Type	Description	Base	Fil. or Heater (Volts)	Fil. or Heater Current (Amps)	Anode Volts	Screen Volts	
45	LF Triode	4UX3	2·5	1·5	250	—	(197)
45Z5	Rectifier	075	45·0	0·15	RMS 125	—	(198)
46	Dual Grid LF ..	5UX4	2·5	1·75	250	—	(199)
47	LF Pentode.. ..	5UX1	2·5	1·75	250	250	(200)
48	LF Tetrode ..	6UX14	30·0	0·4	125	100	(201)
49	Dual Grid LF ..	5UX4	2·0	0·12	135	—	(202)
50	Power Triode ..	4UX3	7·5	1·25	450	—	(203)
50C6	Beam Power Output	048	50·0	0·15	200	135	(204)
50L6	Beam Power Output	048	50·0	0·15	110	110	(205)
50Y6	Rectifier	038	50·0	0·15	RMS 117	—	(206)
50Z7	Rectifier	074	50·0	0·15	RMS 117	—	(207)
51	HF Tetrode ..	5UX9	2·5	1·75	250	90	(208)
53	Class B	7UX9	2·5	2·0	300	—	(209)
55	DD Triode	6UX6	2·5	1·0	250	—	(210)
56	Triode	5UX6	2·5	1·0	250	—	(211)
57	HF Pentode ..	6UX11	2·5	1·0	250	100	(212)
58	HF Pentode ..	6UX11	2·5	1·0	250	100	(213)
59	Triple Grid Output	7UX4	2·5	2·0	250	250	(214)
70A7	Rectifier and Beam Power Output	062	70·0	0·15	RMS 117 110	— —	(215) (216)
70L7	Rectifier and Beam Power Output	076	70·0	0·15	RMS 117 110	— 110	(217) (218)
71A	Power Triode ..	4UX3	5·0	0·25	180	—	(219)
75	DD Triode	6UX6	6·3	0·3	250	—	(220)
76	Triode	5UX6	6·3	0·3	250	—	(221)
77	HF Pentode ..	6UX11	6·3	0·3	250	100	(222)
78	HF Pentode ..	6UX11	6·3	0·3	250	125	(223)
79	Class B	6UX7	6·3	0·6	250	—	(224)
80	Rectifier	4UX11	5·0	2·0	RMS 350	—	(225)
80A	Rectifier	4UX10	7·5	1·25	RMS 700	—	(226)
81	Rectifier	4UX10	7·5	1·25	RMS 700	—	(227)
82	Rectifier (mercury)..	4UX7	2·5	3·0	RMS 450	—	(228)
83	Rectifier (mercury)	4UX7	5·0	3·0	RMS 450	—	(229)
83V	Rectifier	4UX8	5·0	2·0	RMS 400	—	(230)
84	Rectifier	5UX5	6·3	0·5	RMS 350	—	(231)
85	DD Triode	6UX6	6·3	0·3	250	—	(232)
89	Triple Grid Output	6UX11	6·3	0·4	250	—	(233)
V99	Triode	4UX9	3·0–3·3	0·06–0·063	90	—	(234)
X99	Triode	4UX3	3·0–3·3	0·06–0·063	90	—	(235)
112A	Triode	4UX3	5·0	0·25	180	—	(236)
117Z6	Rectifier	077	117·0	0·15	RMS 117	—	(237)
183	Triode	4UX3	5·0	1·25	250	—	(238)
484	Triode	—	3·0	1·3	180	—	(239)
950	LF Pentode.. ..	5UX2	2·0	0·12	135	135	(240)
2101	LF Pentode.. ..	5UX1	2·0	0·12	135	135	(241)
2102	DD Triode	6UX2	2·0	0·12	135	—	(242)
2103	Double LF Pentode	7UX1	2·0	0·26	135	135	(243)
2151	LF Pentode.. ..	6UX10	14·0	0·3	250	250	(244)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

TYPES—*continued*

	Bias Volts	Bias Res. (Ohms)	Anode Cur-rent (mA)	Screen Cur-rent (mA)	Slope mA/V (*=Conv. Condt. µA/V)	Imped-ance (Ohms)	Amp. Factor	Out-put (Watts)	Opti-mum Load (Ohms)
(197)	–50·0	—	34·0	—	2·17	1,600	3·5	1·6	3,900
(198)	—	—	—	—	—	—	—	100mA	—
(199)	–33·0	—	22·0	—	2·35	2,380	5·6	1·25	6,400
(200)	–16·5	450	31·0	6·0	2·5	60,000	150	2·7	7,000
(201)	–20·0	310	56·0	9·5	3·9	—	—	2·5	1,500
(202)	–20·0	—	6·0	—	1·125	4,175	4·7	0·17	11,000
(203)	–84·0	1,530	55·0	—	2·1	1,800	3·8	4·6	4,350
(204)	–14·0	—	16·0	2·2	7·1	18,300	—	—	—
(205)	–7·5	—	49·0	4·0	8·2	10,000	—	—	—
(206)	—	—	—	—	—	—	—	75mA	—
(207)	—	—	—	—	—	—	—	65mA	—
(208)	–3·0	—	6·5	2·5	1·05	400,000	—	—	—
(209)	0	0	—	—	—	—	35	10·0	—
(210)	–20·0	2,500	8·0	—	1·1	7,500	8·3	0·35	20,000
(211)	–13·5	2,500	5·0	—	1·45	9,500	13·8	—	—
(212)	–3·0	600	2·0	0·5	1·22	1 meg.	—	—	—
(213)	–3–40	300	8·2	2·0	1·6	800,000	1,280	—	—
(214)	–18·0	410	35·0	9·0	2·5	40,000	—	3·0	6,000
(215)	—	—	—	—	—	—	—	60mA	—
(216)	–7·5	—	40·0	—	5·8	—	—	—	—
(217)	—	—	—	—	—	—	—	70mA	—
(218)	–7·5	—	43·0	6·0	7·5	15,000	—	—	—
(219)	–40·5	—	20·0	—	1·7	1,750	3	0·79	4,800
(220)	–2·0	5,000	0·4	—	1·1	90,000	100	—	—
(221)	–13·5	2,500	5·0	—	1·45	9,500	13·8	—	—
(222)	–3·0	1,000	2·3	0·5	1·25	1·5 meg.	1,500	—	—
(223)	–3–40	200	10·5	2·6	1·65	600,000	1,000	—	—
(224)	0	—	—	—	—	—	—	8·0	14,000
(225)	—	—	—	—	—	—	—	125mA	—
(226)	—	—	—	—	—	—	—	85mA	—
(227)	—	—	—	—	—	—	—	85mA	—
(228)	—	—	—	—	—	—	—	115mA	—
(229)	—	—	—	—	—	—	—	225mA	—
(230)	—	—	—	—	—	—	—	200mA	—
(231)	—	—	—	—	—	—	—	50mA	—
(232)	–20·0	2,500	8·0	—	1·1	7,500	8·3	0·35	20,000
(233)	–31·0	970	32·0	—	1·8	2,600	4·7	0·9	5,500
(234)	–4·5	—	—	—	—	—	—	—	—
(235)	–4·5	—	—	—	—	—	—	—	—
(236)	–13·5	—	—	—	—	—	—	0·285	10,650
(237)	—	—	—	—	—	—	—	60mA	—
(238)	–60·0	—	25·0	—	1·8	1,800	3·2	2·0	4,500
(239)	–9·0	—	6·0	—	1·35	9,300	12·5	—	—
(240)	–16·5	—	7·0	2·0	0·95	105,300	100	0·45	13,500
(241)	–4·5	—	8·0	2·6	1·7	200,000	340	0·45	16,000
(242)	–1·5	—	2·1	—	1·3	23,000	30	—	—
(243)	–7·5	—	4·0	1·2	1·6	—	350	0·6	—
(244)	–31·0	—	47·0	11·6	2·4	50,000	120	6·0	—

AMERICAN BARRETTERS OR BALLAST TUBES

American sets fitted with barretters or ballast tubes for voltage regulation do not need a line cord resistor unless used on mains of a higher voltage than those for which they were designed.

Octal-based barretters are listed under a standard code consisting of prefix letters, a number, and suffix letters such as K55B. The central number denotes the volts dropped by the tube when it is correctly run. The letter prefixes denote the current rating and the type of pilot lamp to be used with the barretter: K, 6·3 volts, 0·15 amp and type 40 pilot lamps. L, 6·3 volts, 0·25 amp and type 46 pilot lamps. M, 6-8 volts, 0·2 amp and type 50 or 51 pilot lamps. B, when in front of either of the above, denotes a ballast tube, and can be ignored.

The suffixes indicate the base wiring diagrams: A, Plain resistance. B, 1 tap for 1 pilot lamp. C, 1 tap for 2 pilot lamps. D, 2 taps for 1 pilot lamp. F, 1 tap for 1 pilot lamp (tap isolated from body). G, 1 tap for 2 pilot lamps (tap isolated from body). H, 2 taps for 1 pilot lamp (tap isolated from body). Final letters G or MG, in addition to the above, indicate glass or metal-glass envelopes. G also denoted at one time that an octal base was fitted.

UX-based barretters, introduced before the above types, are also coded, but this was not adhered to strictly. It consists of a number indicating the resistance of the tube, followed by a letter, or combination of letters, denoting the basing arrangement. The suffixes usually used are: R, Plain resistor. R4, 1 tap for 1 0·15-amp lamp. R8, 1 tap for 2 0·15-amp lamps. R44, 2 taps for 1 0·15-amp lamp. L4, 1 tap for 1 0·25-amp lamp. L8, 1 tap for 2 0·25-amp lamps. L44, 2 taps for 1 0·25-amp lamp.

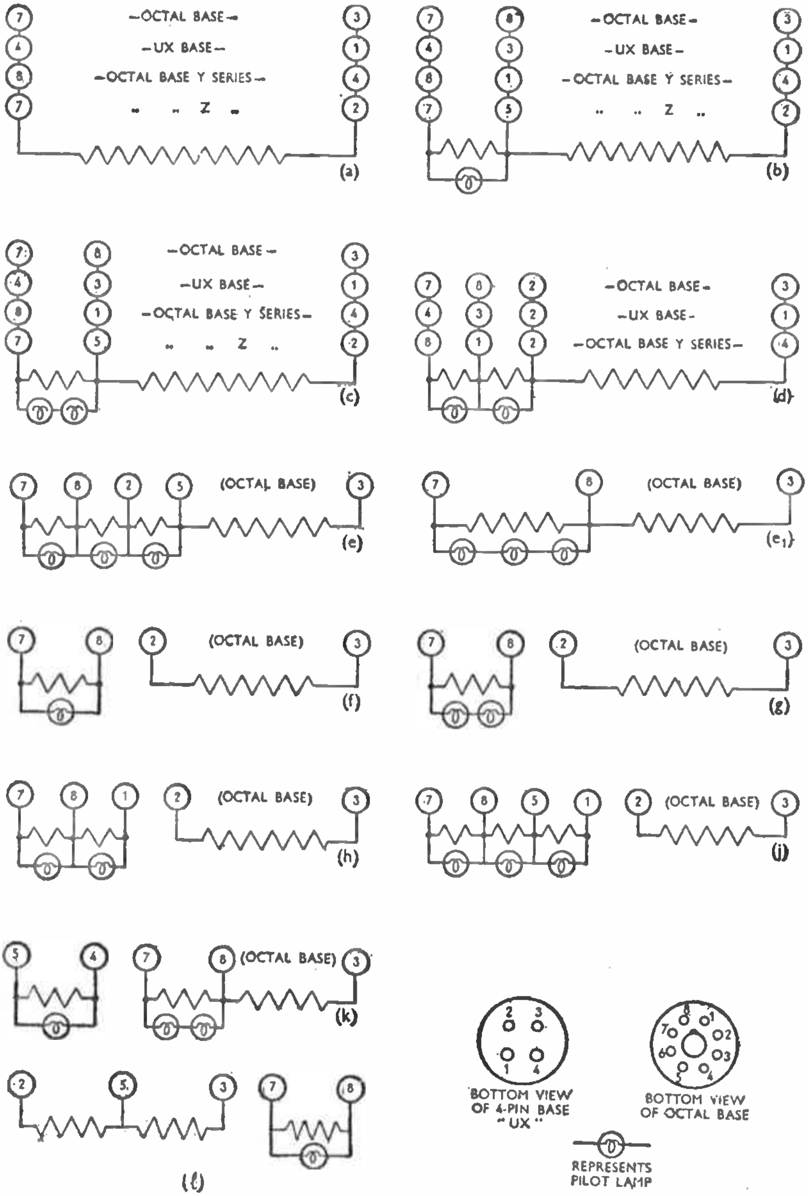
Tubes generally in use are listed in Table XLVIII, together with recommended alternatives. The code letters in the base column refer to the Standard American RMA ballast tube connection diagram, which is also reproduced. (See Fig. 164.)

TABLE XLVIII: AMERICAN BALLAST TUBES

Type	Volts Dropped at 117·5 V	No. of Pilot Lamps	Rating of Lamps (Amps)	Base Code	Base Type	Equivalents	Equivalent with Base Changed
42A	42·3	0	—	A	Octal	K42A, 42AG, K42AG, K43A	140R
42A1	42·3	0	—	AY	Octal	KY42A	140R
42A2	42·3	1	0·15	BY	Octal	KY42B	140R4
42B2	42·3	2	0·15	CY	Octal	KY42C	140R8
K42A	42·3	0	—	A	Octal	42A	140R
K42B	42·3	1	0·15	B	Octal	K42BG, K43B, 135K1	140R4
K42C	42·3	2	0·15	C	Octal	K42CG, BK42C, 95K2, K40C, 5516, 5530	140R8
K42D	42·3	2	0·15	D	Octal	K42DG, BK42D, K40D, 8326	140R44
KX42B	42·3	1	0·15	BX	4-pin	140R4	K42B
KX42C.	42·3	2	0·15	CX	4-pin	140R8	K42C
KY42D	42·3	2	0·15	DY	Octal	2LR212	—
L42B	42·3	1	0·25	B	Octal	BL42B, L42BG, 5547	104L4
L42BX	42·3	1	0·25	BX	4-pin	140L4, LX42B	L42B
L42C	42·3	2	0·25	C	Octal	BL42C, L42CG, L40C, 69·2037, 5548, 16035	140L8
L42D	42·3	2	0·25	D	Octal	BL42D, L42DG, 5549	104L44
L42DX	42·3	2	0·25	DX	4-pin	140L44	L42D

TABLE XLVIII: AMERICAN BALLAST TUBES—*continued*

Type	Volts Dropped at 117·5 V	No. of Pilot Lamps	Rating of Lamps (Amps)	Base Code	Base Type	Equivalents	Equivalent with Base Changed
L42F	42·3	1	0·25	F	Octal	—	—
L42S1	42·3	1	0·25	S1	Octal	L40S1	—
L42S2	42·3	2	0·24	S2	Octal	L40S2	—
M42C	42·3	2	0·2	C	Octal	K42C or L42C and alter pilot lamps	—
49A	48·6	0	—	A	Octal	K49A, 49KA, K50A	165R
49A1	48·6	0	—	AY	Octal	KY49A	165R
49A2	48·6	1	0·15	BY	Octal	KY49B	165R4
49B2	48·6	2	0·15	CY	Octal	KY49C	165R8
K49A	48·6	0	—	A	Octal	49A	165R
K49B	48·6	1	0·15	B	Octal	BK49B, 49KB, K43B2, W43357, 115·41, 5533, 8593, 5623	165R4
K49C	48·6	2	0·15	C	Octal	49KC, BK49C, K50C, K49CB, A16040, 81966-2, 5534	165R8
K49D	48·6	2	0·15	D	Octal	49KD, BK49D, BK49D-10, 5633, 5518, 69116, 115·28, 3334, 3334A	165R44
KX49A	48·6	0	—	AX	4-pin	165R, 340	49A
KX49C	48·6	2	0·15	CX	4-pin	165R8, 50A2	K49C
KZ49B	48·6	1	0·15	B2	Octal	50B2MG	165R4
KZ49C	48·6	2	0·15	CZ	Octal	50A2MG	165R8
L49B	48·6	1	0.25	B	Octal	49LB, BL49B, 2UR224, 69·2033, 5511, 5550	165L4
L49C	48·6	2	0·25	C	Octal	49LC, L49-5·5C, BL49C, 2995, 5552, 16036	165L8
L49D	48·6	2	0·25	D	Octal	49LD, BL49D, 3CR-241, 5567	165L44
L49F	48·6	1	0·25	F	Octal	—	—
M49B	48·6	1	0·2	B	Octal	BM49B, 38710	—
M49C	48·6	2	0·2	C	Octal	BM49C	—
M49H	48·6	2	0·2	H	Octal	M49HG	—
55A	54·9	0	—	A	Octal	K55A	185R
55A1	54·9	0	—	AY	Octal	KY55A	185R
55A2	54·9	1	0·15	BY	Octal	KY55B	185R4
55B2	54·9	2	0·15	CY	Octal	KY55C	185R8
K55A	54·9	0	—	A	Octal	55A	185R
K55B	54·9	1	0·15	B	Octal	55KB, K55BG, K54B, BK55B, 3613, 5519, 7-TU-9, 5535, 16039	185R4
K55C	54·9	2	0·15	C	Octal	BK55C, 5536	185R8
K55D	54·9	2	0·15	D	Octal	BK55D, 115·22	185R44
K55H	54·9	2	0·15	H	Octal	K52H	—
L55B	54·9	1	0·25	B	Octal	2V4215, 2903, 5555, 8598, 2VR215	185L4
L55C	54·9	2	0·25	C	Octal	55LC, L55-5·5C, 2904	185L8
L55D	54·9	2	0·25	D	Octal	55LD	185L44
L55F	54·9	1	0·25	F	Octal	BL55F	—
M55F	54·9	1	0·2	F	Octal	—	—
M55H	54·9	2	0·2	H	Octal	M55HG, M52H	—
C9266	54·9	—	—	L	Octal	—	—
100R8	29·7	2	0·15	CX	4-pin	KX30C	K80C
120R8	36·0	2	0·15	CX	4-pin	KX36C	K36C
140L4	42·3	1	0·25	BX	4-pin	L42BX, LX42B	L42B
140L8	42·3	2	0·25	CX	4-pin	L42CX, LX42C	L42C
140L44	42·3	2	0·25	DX	4-pin	L42DX, LX42D	L42D
140R	42·3	0	—	AX	4-pin	—	42A
140R4	42·3	1	0·15	BX	4-pin	40B2, KX42B	K42B
140R8	42·3	2	0·15	CX	4-pin	40A2, KX42C	K42C
165L4	48·6	1	0·25	BX	4-pin	L49BX, LX49B	L49B
165L8	48·6	2	0·25	CX	4-pin	LX49C	L49C
165R	48·6	0	—	AX	4-pin	—	49A
165R4	48·6	1	0·15	BX	4-pin	50B2, KX49B	K49B
165R8	48·6	2	0·15	CX	4-pin	50A2, KX49C	K49C
185L4	54·9	1	0·25	BX	4-pin	LX55B	L55B
185L8	54·9	2	0·25	CX	4-pin	—	L55C
185R	54·9	0	—	AX	4-pin	50X3, KX55A	K55A
185R4	54·9	1	0·15	BX	4-pin	KX55B	K55B
185R8	54·9	2	0·15	CX	4-pin	50X3T, KX55C	K55C
200R	60·0	0	—	AX	4-pin	—	—
290L4	—	1	0·25	BX	4-pin	Special Type	—
300R4	79·5	1	0·15	BX	4-pin	KX80B	K80B



BASES OF U.S.A. BALLAST 'TUBES'

Fig. 164. These are the diagrams issued by the American R.M.A. and in which are shown the base connections of the common plug-in resistor or ballast 'tubes'.

SECTION 12

INTERMEDIATE FREQUENCIES

This list covers models going back to the first commercial superhets and has been submitted, where possible, to the makers for checking. Frequencies thus: 465, 473, are alternatives, but 123-127 indicates the circuits should be staggered over the band indicated. Sometimes the frequencies for each circuit in a 'staggered' set are shown thus : 127-123-123-127.

ACE	Kc/s
RG3	470
RG5	427
RG6	427
S6	125
SH6	125
RG7	427
RG8	470
RG9	427
AW35	470
AW53	427
AW53B	427
AW73	427
AC85	470
AW94	427
AW115	470
AW563	427
AC939	450
A50	465

AERODYNE	
Aerogram	125
Aeromagic	125
Cardinal	125
Falcon	125
Silver Wing	125
Swallow	125
42	125
47	125
50	125
53	125
54	465
56	125
58	125
63	465
73	125
100	117·5
105	465
110	117·5
115	465
135	465
290	465
291	465
295	465
300	117·5
301 AC	460
302 AC/DC	460
305	117·5

ALBA	Kc/s
AC superhet	473
5V Bat. SH, 1934	473
Clipper	470
35	470
40 Universal	370
57 AC and Universal	117·5
67	473
68 AC and Universal	117·5
78	473
79 AC and Universal	117·6
90	465
98	365
230	117·5
315	117·5
320	460
330	117·5
335	460
340	470
450	117·5
455	460
461 AC	460
462 AC/DC	460
510	470
540	117·5
550 AC and Universal	117·5
605	465
610	470
615	117·5
620	117·5
625	117·5
635	460
640	117·5
650	117·5
660 AC and Universal	117·5
670	117·5
698	365
710	470
725	117·5
730	470
740	117·5
745	470
755	470
770 AC and Universal	117·5
790	465
798	365
805	465
810	470
815	117·5
820	117·5
825	117·5
830	470
835	460
845	470
850	117·5
855	470
870 AC and Universal	117·5
880 AC and Universal	117·5
890 AC and Universal	117·5
905	465
910	117·5
920	117·5
930	460
970	117·5
990 and Universal	117·5

ALLWAVE	
Standard Superhet, 1935	465
Standard Superhet RG	465
Tallboy RG, 1935	465
Ambassador 6778	465

AMPLION	
Radiolux Superhet	110
Radiolux Superhet RG	110

ARMSTRONG	
5V 7 stage	110
5V 8 stage	110
RF/PP	465
RF/PR	465
2B/PR	118
2B/T	118
3NBP/8	457
3NBP/8 Late model	470
3NBP/10	427
3WT/PB	427

ARMSTRONG—*cont.*

AW3/PB	427
AW/38	465
4B/PR	118
4B/T	118
AW/36	465
AW/59	470
AW93PP	427
RF94PP	427
AW125PP	470
SS10	465
3NWT	450
3NBP/T	427
U3NBP/T	427

ATLAS

758	117·5
A13	126
A17	126
A24	126

BEETHOVEN

Baby Grand	450·5
Little Prodigy AC	450·5
Little Prodigy, Bat.	450·5
Twin Speaker, All-electric Superhet	118
AC40	450·5
AC42	450·5
B43	450·5
AC77	118
B88	118
PBA201	450·5
AD303	450·5
AD404	450·5
RG717	118
AC720	450·5
B730	450·5
AC740	450·5
PBB750	450·5
AD770	450·5
PBA780	450·5
RG827	118
PBA820	450·5
B848	450·5
AC852	450·5
909	450·5
909AC	450·5
RG938	450·5

BELMONT

520	465
525	465
530AC-DC Midget	456
541	456
544	465
545	465
555	465
566	465
570P	465
600	465
625	465
650	465
700	465
720	465
721	465
746	465
755	465
760P	465
770	465
780	465
781	465
800	465
820	465
821	465
845	465
856	465
860P	465
900	465
1100	465
1150	465

BENSON

AWP Midget Portable	470

BLUE SPOT

Aristocrat	465
A67	465
A68	465
A69	465
AC5	110

BRUNSWICK

BCA/01	456
BCA/1	456
BCW/01	456
BGA/01	456
BGA/1	456
BGA/1E	456
BGA/2	456
BGA/3	465
BGCA/01	456
BGCA/1	456
BGCA/3	465
BGU/01	456
BPU/1	465
BTA/01	456
BTA/1	456
BTA/1E	456
BTA/2	456
BTA/3	465
BTB/1	456
BTU/01	456
39CGM	465
39EH	120
39TGM	465
40	465
40U	465
42	380
42D	380
43D	380
45	380
47	380
47U	380
50	465
51	465
54	465
56	465

BTS

Trophy 5	465

BURGOYNE

AW47	473
AWS	473
AWS/G	473
BSH	117·5
DTG	473
Dragon	437
Dragon AC Recordagraph	473
Dragonette	473
Superhet 5, B5	117·5

BURNDEPT

Ethodyne 209	473
Universal Trans.	130
Universal Superhet	473
201	130
203	473
209	473
210	473
211	473
218	130
225	130
226	130
229	130
231	130
233	450
257	130
259	473
266	473
267	473
276	473
281	473
285	473
290	473
292	450
298	473
299	473
303	473
309	450
312	473

BURNDEPT—*cont.*

313	473
314	473
315	473
316	473
317	473
318	473
319	473
323	465

BURRELL

4Y Superhet	110

BUSH

DAC1	123
SAC1	123
SUG1	123
SB1	123
TG1	123
SB3	123
SAC4	123
SB4	123
BP5	123
SAC5	123
SAC6	123
SAC7	123
DAC21	123
DUG21	123
SAC21	123
SB21	123
SAC25	123
SAC31	123
SAC35	123
SUG31	123
RG33	465
SSW33	465
SUG33	465
RG37	465
SSW37	465
SUG37	465
RG41	465
SW41	465
BA43	465
DAC43	465
DUG43	465
RG43	465
SUG43	465
SUG43G	465
SW43	465
SB44	123
SW45	465
PB50	465
BA51	465
DAC51	465
DUG51	465
PB51	465
RG52	465
RG52G	465
SUG52	465
BA53	465
DAC53	465
PB53	465
RG53	465
PB55	465
SUG55	465
PB60	465
BA61	465
PB61	465
SUG61	465
DUG62	465
BA63	465
DAC63	465
PB63	465
RG63	465
RG63 Auto	465
RG64	465
RG64G	465
SUG64	465
PB65	465
SUG65	465
BP70	465
BA71	465
DAC71	465
DAC73	465
DUG73	465
PB73	465
SUG73	465
RG64 Auto.	465
AC81	465
PB83	465
DAC81	465
BA81	465

CAC

Austin Superhet AC	110
Austin Bat. 5	110

CAMEO

AC Cameo	430
All Wave	430
Atom	430
Bookcase RG	430
Cameo	430
Cameogram	430
Emergency	430
Super·Midget 4	430
ABX	430
ARP	430
AWP	430
P	430
RP	430
RP9	430
TW	430

CIVILIAN WAR-TIME RECEIVERS

Battery model	460
AC model	460

CLIMAX

AC5	115
AC-DC5	115
S4AC	121
S5	115
534	111

COLUMBIA

356	128-125-125-125
357	125
358	125
380	125
621	125
631	128-125-125-125
640 and 640A	125·2
1006	125

COSSOR

31	465
32	465
33	465
34	465
35	465
37	465
AD41	465
46	465
47	465
53	465
55	465
56	465
57	465
61	SW 1363 465
62, 62B	465
63	465
64, 64B	465
66, 66A	465
67	465
67A	465
70	465
71, 71B	465
72	465
73	465
74	465
77, 77B	465
81	465
82	465
85	465
338 and 348 SW only	1563
364	128
365	128
366	128
366A	128
374	128
375	465
375U	465
376B	128
385	465

COSSOR—*cont.*

394		465
395		465
396		465
397		465
398		465
438	(SW 1363)	465
438U	(SW 1363)	465
439		465
456AC		465
455B		465
464AC		465
483	(SW 1363)	465
484	(SW 1363)	465
484U	(SW 1363)	465
485		465
535		128
538		465
583		465
584		465
584U		465
598		465
634		128 or 134
635		128 or 134
736		128
737		128
836		128
837		465
3733 SW only		1563
3764		465
3774		465
3783 SW only		1563
3864		465
3884		465
3952		465
3974		465
3974A		465
6864		465
6874		465

CROSLEY

Roamio	455
A358	455
5C2	181·5
538BT	450
638T	450
848C	450
848CU	450
848R	450
848RU	450
848T	450
848TU	450
1058AR	450
1058T	450

DECCA

Twin S/het R/GAC6	183
AW3	380
AW3P	380
AW4 341	465
AW6	465
AW6V	465
Decca-Brunswick 6V RG (Med W only)	183
AW7	465
AW8	465
AW9	465
AW10	465
AWD47	380
AWG16	465
ML	465
MLB	465
ML4	380
ML5 and 42	380
ML6	465
ML6U	465
MLD/3	380
MLD/5	380
PC/AW	465
PC/ML	465
PG/AC	465
PG/AW	465
PG/ML	465
PG/U	450 465
PT/AC5	456
PT/AW	465
PT/BS	465
PT/M	125 465
PT/ML	465
PT/ML/B	465
PT/ML/U	450 465
PT/U	465
PAW5	465
UAW78	465
Double Decca MB5	380
Portrola	130
Portrola AC/DC 1939	465
44	465
55	465
56	465
Prestomatic	465
66	465
77	465
88	465
88U	465
99	456
110	456
120	456
180	130
190	130
350	130
400	130
405	130
500	130
510	130
520	456
530	456
540	456
550	130
919	130
1010	130
1111	130
1616	130
4040	130
4141	130
4242	130
4343	130

DRUMMER

M45	117·5

EKCO

C25	110
RG25	110
SH25	110
AC64	110
DC64	110
AD65	110
B67	126·5
BV67	126·5
AW69	126·5
BAW69	126·5
C69	126·5
CU69	126·5
UAW69	126·5
AW70	126·5
UAW70	126·5
BAW71	126·5
AC74	110
B74	110
DC74	110
AD75	480
AC76	130
AD76	130
AC77	126·5
AD77	126·5
CT77	126·5
CTU77	126·5
BAW78	460
BV78	460
C78	460
UAW78	460
RG84	110
AC85	110
B86	130
AC86	130
AD86	130
B86	110
RG86	130
AW87	460
CTA87	460
AW88	126·5
C88	126·5
UAW88	126·5
ADT95	110
BT95	110

EKCO—*cont.*

ACT96	130
AC97	126·5
RG97	126·5
AW98	126·5
BAW98	126·5
ARG107	126·5
AW108	460
RG109	126·5
AW119	126·5
UAW119	126·5
P150	465
PB179	465, 480
PBU179	465, 480
PB189	126·5
PBU189	126·5
PB199	480
PB279	465, 480
PB289	126·5
C389	126·5
ARG399	480
RG489	126·5
C501	126·5
TRG502	126·5
PB505	477
PBU505	477
PB506	477
PBU506	477
PB507, 508	477
(If red serial No. 465)	
C509	465
CU509	465
PB510	126·5
C511	126·5
PB515	126·5
RG516	126·5
EX401	126·5
EXU401	126·5
EX402	480
A21	477
B25	477

EVER READY

5001	127
5002	127
5003	127
5004	127
5005	127
5006	127
5007	127
5008	127
5011	465
5014	465
5019	127
5025	465
5029	455
5030	455
5031	455
5032	455
5033	455
5034	455
5036	455
5038	455
5040	455
5101	452
5103	452
5104	452
5105	473
5117	452
5118	452
5122	473
5132	473
5203	452
5214	452
5215	452
5216	452
5218	452
5219	452
5221	455
5247	452
5263	452
5347	452
5380	452
5381	452

EMERSON

301	455
330	455
331	455
332	455
336	455
351	455
453	455
376	455
400	455
414	455
415	455
419	455
421	455
422	455
425	455
439	455
441	455
461	455
463	455

FERGUSON

Fergusonic	470
Fergusonic AC-DC Batt.	470
101, 101U, 101UX	470
Fergusonic Mains Minor	470
103B	470
104	470
104 AC6	470
106	470
350	465
365	465
366	465
378	465
378U	465
454	470
501	465
502	465
502C	465
502 RG	465
503	465
503C	465
503CT	465
503RG	465
503RGT	465
503T	465
601	465
602	465
602C	465
602RG	465
603	465
603C	465
603CT	465
603RG	465
603RGT	465
603T	465
701	465
702	465
704	465
705	465
715	465
771	465
772	465
773	465
774	465
775	465
777	465
801	465
802	465
804	465
805	465
815	465
881	465
882	465
884	465
885	465
901	470
901U	470
902	470
902U	470
903B	470
904	470
904U	470
905	470
906	470
907 Fergusonic AC-DC	470
908	470
909	470

FERRANTI

1933/4 Gloria	125

FERRANTI—*cont.*

1933/4 Lancastria	125
1933/4 Arcadia ..	125
1933/4 Battery S/het	125
1934/5 Arcadia AC S/het	125
1934/5 Gloria ..	125
1934/5 Gloria Arcadia ..	125
1934/5 Lancastria	125
„ Lancastria Portable ..	125
„ Lancastria Reflex ..	125
„ Universal ..	125
1936/7 Magna AC	125
1935/6 Gloria Autogram	125
1935/6 Nova AC ..	125
1935/6 Nova AC-DC	125
1935/6 Lancastria AC	125
1935/6 Lancastria AC-DC ..	125
1935/6 Arcadia Cons and R/G	125
1935/6 Arcadia AC	125
1935/6 Nova Batt.	125
1936 All Wave S/het	125
1936/7 Nova 2-wave AC	125
1936/7 Nova All-wave	125
1936/7 Nova All-wave Batt. ..	125
1936/7 Nova All-wave AC-DC ..	125
1936/7 Magna All-wave AC ..	125
1936/7 Magna AC-DC	125
1936/7 Arcadia All-wave AC ..	125
1936/7 Arcadia Console	125
1936/7 Arcadia R/G	125
A1	135
48B	125
49B	125
139	450
141	450
239	450
241 and 341 ..	450
512AM	450
513	450
513AM	450
514	450
514PB	450
515PB	450
539	450
617PB	450
837	450
1037	450
1037U	125
1137	450
1137B	125
1137U	125
1237B	125
1737	125
1737 Gram ..	125
2037	125
2337	450
145	450

GAROD

930	456
931 Consoles ..	456
930D	456
931D	456
930KC	456
931KC Gram ..	456
1240	456
1240E Gram ..	456
1240LC	456
1650	456
1650H Console ..	456
1650LC Gram ..	456

GEC

3358	110
3440	107
3441	107
3442	107
3443	107
3444	107
3445	107
3446	125
3448	107
3449	107
3460	125
3466	125
3480	125
3484	125
3488	125
3540	125
3541	125
3542	125
3544	125
3545	107
3548	125
3550	125
3551	125
3558	125
3558R	125
3566	125
3640	125
3645	125
3646	125
3650	125
3651	125
3658	125
3659	125
3740	125
3745	125
3746	125
3748	125
3750	445
3754	125
3758	445
3760	445
3762	445
3766	445
3780	445
3781	445
3782	445
3788	445
3789	445
3846	456
3850	456
3855	456
3856	456
3857	456
3860	456
3862	456
3865	456
3866	445
3867	456
3868	456
3880	445
3882	445
3888	445
3889	445
3890	456
3892	456
3910	456
3918	456
3940	456
3942	445
3946	456
3950	456
3955	456
3956	456
3957	445
3960	456
3964	456
3965	456
3966	445
3967	456
3968	456
3969	456
3970	456
3972	445
3978	445
3977	445
3979	445
4010	445
4018	445
4040	456
4045	456
4046	456

GEC—*cont.*

4050	456
4051	456
4054	456
4055	456
4056	456
4058	456
4059	456
4060	456
4065	456
4066	456
4070	456
4135	456
4141	456
4157	445
4166	445
4172	445
4173	445
4177	445
4177U	445
4178	445
4178R	445
4179R	445
4227	430
4237	445
4247	445
4242	445
4262	445
4267	445
4337	445
4342	445
4347	445
4362	445
4367	445
4641	456
4650	456
4652	456
4655	456

GILBERT

Kumfe 2	122·5
A50	110
A63	122·5
C64	122·5
Gordon Elf	430
Cameo AC, DC5	430

HMV

146	456
147	456
166	465
340	456
341	456
381	123-127-125-125
404	128-123-128-125·5
425	123-127-125-125
438	128-123-128-125·5
440	128-123-128-125·5
441	125
442	123-127-123-127
443	123-127-123-127
444	125
445	123-127-125-125
446	123-127-125-125
456	465
457	465
458	465
459	125
462	125
463	127-123-123-127
464	126·5-121·5-121·5-126·5
467	120-114-117-117
469	465
470	128-125-125-125
479	465
480	460
481	460
482	465
485	460
485A	460
486	465
487	465
488RG	460
489	465
490	465
491	465
492	465
493	465
494	465
495	465
496	460
497	460
498	460
499	465
505	128-123-128-125·5
512	128 123-128-125·5
523	128-125 125-125
524 and 524A	120-114-117-117
531	125·2
532	125·2
532C	125·2
540	128·123·128·125·5
540A	125
541	125
542	128-123-128-125·5
545RG	123-127-125-125
546	123-127-125-125
570	123-127-123-127
580	122-112-117-117-117-117
581RG	460
582	460
622RG	123-127-125-125
632	123-127-125-125
642	465
645	123-127-125-125
650	465
651	465
653	465
654	465
655	465
656	465
657	465
658	465
659	465
660	465
661	465
663	465
664	465
665	465
666	465
668	465
670	465
671	465
682	465
800 Auto RG	125
801 Auto RG	460
1100	465
1101	465
1102	465
1103	465
1104	465
1105	465
1106	465
1107	465
1111	485
1112	485
1113	465
1200	465
1300	465
1301	465
1350	465
1351	465
1351A	465
1354	485
1355	485
1400	465
1403	465
1404	465
1406	465
1500	465
1501	465
1504	465
1600	465
1601	465
1750	465
5211	485
5212	485
5311	485
5312	485

HALCYON

Briton	130·5
Briton Radiogram	130·5
Nine-Stage AC	110
Royal County	130·5
Seven-Stage Universal	110

HALCYON—*cont.*

Royal Gram and Auto	130·5
A57	130·5
A581	130·5
A5820	130·5
AC5	110
AC6	110
AC7	110
AC7G	110
B691	130·5
GA33	130·5
GR37	130·5
MS6	465
RGA581	130·5
RGCA581	130·5
RGCU6801	130·5
RGU6801	130·5
U57	130·5
U537	130·5
U571	130·5
U573	130·5
U5820	130·5
U6801	130·5
701	110
4501	110
4501G	110
4501GA	110
4701	110
4701G	110
4701GA	110
6701	110

HARTLEY-TURNER

MA	130
MA7	130
MA12	130
MA25	130
RF41	465
RGMA12	130
RGNA25	130

HAYNES

All Superhet Models	110

HIGGS

A48R (and G)	465
A49R	450
AW49C	450
AW49R	450
AW57R (and G)	465
AW58R (and G)	465
AW59C	450
AW59R	450
AW69B	450
AW69G	450
AW69PB	450
AW69PG	450
AW99C	450
AW99G	450
BW49PR	450
BW49R	450
UW57R (and G)	465
UW58R (and G)	465
UW59C	450
UW59R	450
UW69B	450
UW69G	450
UW69PB	450
UW69PG	450

INVICTA

Multi Mains	110
SF	119
SHB	127
UP2	467
A29	465
B29P	465
A40RG	465
A40	465
A40C	465
B39	465
B40	465
U40	465
AC/45	127
AC/45D	127
AC/45RG	127
45U	127
45U/RG	127
A46PB	465
AC47	127
47B	127
47U	127
47U/RG	127
AC48/RG	127
A49	465
A49C	465
A49PB	465
A49RG	465
AR49	465
B29P	465
B39	465
B49	465
U49	465
AW56	465
AW57	465
AW57/RG	465
300	465
310	465
310/RG	465
330	465
360	465
390	465
400	465
430	465
431	465
440	465
450	465
460	465
461	465
500	465
502	465
503	465
510	465
520	465
570	465
580	465
635	110
635 (D)	110
635/RG	110
650/NJ	465
800	469
820	465

KOLSTER-BRANDES

285	114
286	114
339	130
345	130
346	130
365	130
365A	130
378KB	130
381	130
383	130
398	130
405	130
405A	130
422	130
425	130
426	130
427	130
427A	130
428	130
428A	130
444	130
444A	130
540	130
550	130
560	464
580	130
590	464
592	464
610	130
630	464
632	464
640	464
642	464
650	464
652	464
660	464
666	130
666A	130
666B	130
666C	130
670	464
720	130
730	464

KOLSTER-BRANDES —*cont.*

735	464
740	464
740P	464
750	464
760	464
770	464
800	464
808	464
817	464
820	464
830 and OA1	464
831	464
835 and OA1	464
840	464
850	472
860	464
865	464
870	464
875	464
880	464
885 and OA1	464
888 A, B, C	130
890	472
935	130

LISSEN

All Purpose	452
Arundel	452
Balmoral	452
Caernarvon	473
Carisbrooke	452
Conway	452
Dover	455
Edinburgh	473
Glamis	452
Kenilworth	452
Lancaster	452
Marquis	455
Richmond	452
Salisbury	452
Skyscraper 7 (Fixed)	126
Winchester	452
York	452
8060	126
8108	127
8109	127
8110	127
8111	127
8114	465
8116	127
8117	127
8121	127
8125	127
8128	127
8129	127
8169	127
8214	465
8301	455
8302	455
8304	455
8317	455
8318	455
8319	455
8321	455
8322	455
8329	455
8401	452
8402	473
8414, 8415	452
8417	452
8418	452
8421	473
8422	473
8424	455
8432	473
8458	452
8468	452
8480	452
8481	452
8482	452
8485	452
8503	452
8514	452
8515	452
8518	452
8521	455
8529	452
8533	452
8539	452
8547	452
8563	452
8647	452

MAJESTIC

4V Midget Superhet	465
15/15B	175
20	175
21	175
22	175
23	175
25	175
44	465
49	465
52	175
60	175
61A	175
120	175
150	175
151	175
153	175
154	175
155	175
156	175
163	175
194	465
261A	125
261B	125
264	125
265	125

MARCONIPHONE

209	123-127-125-125
219	123-127-125-125
222	465
223	456
224	456
234	456
236	456
239	123-127-125-125
249	123-127-125-125
255	125
256	128-125-125-125
257	456
258	128-125-125-125
262	128-123-128-125·5
264	125
269	125
272	128-123-128-125·5
273	125
274	128-123-128-125·5
276	120-114-117-117
278DC	128-123-128-125·5
279	127-123-123-127
280DC	128-123-128-125·5
286	128-123-128-125·5
Q286	125
287	125
288	128-123-128-125·5
289	123-127
290	120-114-117-117
291	120-114-117-117
292	122-112-117-117-117-117
296	123-127
297	125
298	123-127
336	125-125-122-128
345	460
346	460
347	460
363	460
365	460
366	460
367	460
382	465
392	465
395	465
534	465
535	128·8-122·8-126·5-122·5
536	128·8-122·8-126·5-122·5
537	465
538	465
539	465
549	465
556	465
557	465
559	465

MARCONIPHONE —*cont.*

561	465
562	126·5-121·5-121·5-126·5
563	465
564	465
566	465
567	465
571	465
572	465
573	465
575	465
576	465
851	465
852	465
853	465
855	465
857	465
857T	465
858	465
859	465
861	465
864	465
865	465
866	465
868	465
869	465
870	465
871	465
872	465
873	465
874	465
878	465
879	465
880	465
881	465
882	465
883	465
884	465
885	465
888	465
890	465
891	465
892	465
893, 893A	465
895	465
911	465
918	485
919	485
920	485
921	485
922	465
950	465

McCARTHY

BPS6	127
BS4	127
BS4/AW	465
BS6/AW	465
PP6/AW	125
PP8/AW	465
PP9/AW	473
PP9/AW De Luxe	473
RF6/AW	465
RF6/AW/AC-DC	465
RF7/AW	465
RF7/AW/AC-DC	465
RGS6	465
S5/AW/AC-DC	465
S5/AW/AC	465
S6/AW	465
S6/AW/AC-DC	465
S8/AW	465
S6/AW/AC-DC De Luxe	110

McMICHAEL

AC Mains Superhet	428·5
Superhet Trans	110
Twin Spker S/H (Early Models 406/410)	428
135	128·5
135U	128·5
137	465
137U	465
138	465
235	128·5
235	128·5
361	128·5
362	465
363	128·5
364	128·5
365	128·5
366	128·5
368	128·5
369	128·5
371	128·5
371U	128·5
372	128·5
373	128·5
374	128·5
375	465
378	128·5
380	460
380U	460
381	465
382	465
385	460-465
386	460
386RC	460
386RG	460
386U	460
388	465
389	465
390	465
391	465
393	465
394	465
396	465
396RC	465
396RG	465
398	465
399	465
401	128·5
401U	128·5
435	128·5
535	128·5
802	465
803	465
808	465
903	465

McMURDO-SILVER

Masterpiece VI	465
Masterpiece Chippendale	465
Masterpiece Olympic	465
Masterpiece Sheraton	465
15-17 Chassis	465
15-17 Georgic	465
15-17 Homeric	465
15-17 Olympic	465

MILNES

Diamond (SW 3·1 Mcs.)	465
Emerald (SW 3·1 Mcs.)	465
Mercury	450
Onyx	450
Pearl (SW 3·1 Mc/s)	465
Ruby (SW 3·1 Mc/s)	465
Saturn	450
Venus	450
466 (SW 3·1 Mc/s)	465
466 B (SW 3·1 Mc/s)	465
589 (SW 3·1 Mc/s)	465

MULLARD

MAS2	128
MAS3	128
MBS3	128
MUS3	128
MAS4	128
MBS4	128
MUS4	128
MAS5	128
MUS5	128
MAS6	128
MBS6	128
MUS6	128
MAS7	128
MBS7	470
MAS8	128
MAS12	128
MUS12	128
MAS15	470
MUS15	470

MULLARD—*cont.*

MAS17	470
MUS17	470
MAS18	128
MUS18	128
MAS20	128
MUS20	128
MBS23	128
MAS24	470
MUS24	470
MU35	115
MAS82	470
MUS82	470
MAS90	128
MUS90	128
MAS94	128
MAS97	128
MUS97	128
MAS103	470
MAS104	128
MAS137	128
MUS137	128
MAS139	470
MXS139	470

MURPHY

A4	117-120
D4	117-120
B5	117
A8	120
A24	117
A24C	117
A24RG	117
B24	117
D24	117
D24C	117
D24RG	117
B25	117-119
A26	117-119
A26C	117-119
A26RG	117-119
D26	117-119
D26C	117-119
D26RG	117-119
B27	119
A28	119
A28C	119
A28RG	119
D28	119
D28C	119
D28RG	119
A30	119
A30C	119
A30RG	119
D30	119
D30C	119
D30RG	119
AD32	119
B33	119
A34	119
A34RG	119
D34	119
D34RG	119
A36	119
D36	119
A38C	119
D38C	119
A40	119
A40C	119
A40RG	119
A46	465
A46C	465
A46RG	465
D46	465
D46C	465
D46RG	465
B47	465
B47A	465
B47C	465
A48	465
A48RG	465
D48	465
D48A	465
D48RG	465
A50	465
A50C	465
D50	465
D50C	465
A52 (SW 1st 3·1 Mc/s, 2nd 465 Kc/s)	465
B69	465
A70	465
A70C	465
A70RG	465
D70	465
D70C	465
D70RG	465
B71	465
B71A	465
A72	465
A72RG	465
D72	465
D72A	465
A74	465
A74C	465
A76	465
A78C	465
A78RG	465
B81	465
B81	465
A90	465
A90RG	465
D90	465
D90RG	465
B91	465
A92	465
B89	465
B93	465
B95	465
B97	465
AD94	465
SAD94S	465
SAD94L	465
A96	465
A98	465

ORR

Multimains	110
SF	119
SHB	127
AC/45	127
45/U	127
AC/47	127
47/U	127
AW/56	465
AW/57	465
635	110
635D	110

PETO SCOTT

Trophy 5	465
Trophy 6	465
Trophy 8	465
S51	465
H51	465

PHILCO

Empire 5	451
Empire 7	451
Empire 20	470
4 Star BG	125
5 Star BG	125
5 Star CG	125
A1	470
A1RG	470
B1	465-468
BEF1 and BEF2	465
U1	465
A2	465
B2, B29	451
U2	465
A3	451
A4	451
BP4	465
C4	125
C4T, C4S	125
A5	451
C5	470
A7	451
A9	451
A9RG	451
16	460
16B	460
34B	460
A52BG	451
A53BG	451
U53BG	451
54	460
56	125

PHILCO—*cont.*

70	260
70A	260
71	125
98/1	460
98/2	451
99	451
116N	460
116Q	460
116RX	470
116S	460
116X	460
200X	175
237	125
238	125
247E	125
248	125
248E	125
255	451
256	125
260	125
261	125
263	125
264	125
265	125
269BG	451
269CG	451
269RG	451
271	125
280	460-451
282	451
281A	125
281F	125
281G	125
282	451
290	451
295	451
322	470
A421	451
U427	451
P429	470
U429BG	475
444	451
450	451
471CG	451
471RG	451
D521	475
D521B	475
D521W	475
S521	475
S521B	475
S521W	475
X521	475
X521B	475
X521W	475
A527	451
C527	451
P527	451
U527	451
D531	475
D531B	475
D531RG	475
D531W	475
A537BG	451
A537CG	451
A537RG	451
B537	451
C537BG	451
U537BG	451
V537	451
V537BG	451
W537	451
P538BG	470
A539BG	475
A539PB5	475
A539RG	475
580	451
581	451
582BG	451
582CG	451
582RG	451
583BG	451
583CG	451
583RG	451
584BG	451
584CG	451
584RG	451
620	125
A637BG	451
A637CG	451
A637RG	451
A638ARG	470
A638BG	451
C638	470
C638BG	470
CA638	470
U638BG	470
U647BG	451
U647CG	451
680	460
D732	475
D732BG	475
D732CG	475
A847BG	470
A938CG	470
1237	125
1260	125
1263	125
1280	460-451
1280X	460-451
1281	125
1281A	125
1281F	125
1281G	125
1281Q	125
1282X	451
1582ARG	451
1583ARG	451
1584ARG	451
U1647	451
U1647RG	451
A1847RG	470
A2258	470
A2258ARG	470
2620	460
2620A	460
2620E	460

PHILCO CAR RADIO

806 + 806T	260
801T	260
803T	125
M522T	475
M522S	475
Transitone 10 + 10T	260
Transitone 5	460
Transitone 11 + 11T	260
C4T	125
C4S	125
K728T	125
K728S	125
L728T	125
L728S	125
K628T	125
K628S	125
L628T	125
L628S	125
K628TC	125
K627TS	125
6	260
9	260
12	260

PHILIPS

V5A	128
V7A	128
V7U	128
206H, 206A	470
212B	128
218B	128
219B	128
225B	470
228B	470
229B	470
241	115
243	115
245	115
246	115
247	128
248	128
249	128
250	128
258	470
259	470
260	470
261	470
262	470
263	470
264	470
265, 265B	470
268	470

PHILIPS—*cont.*

269	470
361A	475
361U	475
362A	475
362U	475
470A	128
470U	128
480A	128
480L	128
520A	115
522A	115
539A	115
555A	128
555U	128
575A	115
580A	115
584A	115
585HU	115
587HU	115
588A	115
588U	115
597A	128
597U	128
599A	128
617L, 617A	128
650A	470
650U	470
660A	470
660U	470
680A	128
691A	128
691U	128
698A	128
698U	128
699A	128
699U	128
701AX	128
702A	128
702U	128
711A	128
714B	128
716B	128
727A	128
727U	128
735A	128
735L	128
745A	128
745U	128
747A	128
747AX	128
748A	128
748U	128
753A	470
753U	470
771A	475
771U	475
785AX	128
787AX	128
790A	128
790U	128
791A	128
791U	128
792A	128
792U	128
794A	128
794U	128
795A	128
795U	128
797A	128
797U	128
805A	470
805X	470
855X	470

PILOT

Armchair Console	456
Little Maestro	451
Major	451
Twin Miracle	451
B34	451
C35	451
RG35	451
T35	451
PT36	451
PTC36	451
B43	451
53	451
C53	451
RG53	451
C63	451
T63	451
U106	456
CU225	456
RGAU225	456
RGU225	456
RU225	456
U225	456
C335	451
RG335	451
T335	451
B344	456
CB344	456
C350	451
T350	451
U353	456
CU355	456
RU355	456
U355	456
CU357	456
LM357	456
RGAU357	456
RGU357	456
U357	456
CU385	456
LM385	456
RGAU385	456
RGU385	456
U385	456
T404	451
T405	451
EX405	451
T455	451
RGAU475	456
RGU475	456
U475	456
530	451
BT530	451
BTC30	451
BT532	451
BTC32	451
C533	451
RG530	451
T533	451
CU535	456
LM535	456
RGAU535	456
RGU535	456
U535	456
BL550	456
RG583	456
RGA583	456
C633	456
T633	456
CU650	456
RGAU650	456
RGU650	456
U650	466
CU690	456
RGAU690	456
RGU690	456
U690	456

PORTADYNE

Jubilee Superhet	112
Jubilee 5v Battery Superhet	112
A36	112
A37	112
A38	456
A39	450
A52	112
A53	456
A58	450
A59	112
A64	456
A72	112
AC55	112
B36	112
B37	112
B42	112
B48	112
B49	450
B72	112
J/AC	112
J/AC-DC	112
J/RG	112
MS5	450
PA6	112
PB6	112

REGENTONE—*cont.*

Transportable 6	465
World Wide 5	456
5V S/Het with round cans	110
—Otherwise	123
AC/47	110-123
AC/56	110-123
AC/56U	110-123
AC/57	110-123
AC/57U	110-123
AW/S	465
RG66	110-123
RG66U	110-123
USP59	465
R55	465
R55A	465
AW44	465
AW66	465
U33	465
U33X	465

REMCO

All Models	465

RGD

166	465
166U	465
196	465
196U	465
296	465
296U	465
356	465
356U	465
516AC	460
522	460
535	460
623AC	460
623DC	460
625AC	460
625DC	460
628AC	460
628DC	460
630AC	460
630DC	460
643DC	460
645AC	460
645DC	460
658	460
660	460
700AC	110
700DC	110
701AC	110
701DC	110
702AC	110
702DC	110
703AC	110
704AC	110
704C	110
704DC	110
704RG	110
705	460
718AC	460
718AC-DC	465
722	465
723AC	465
723AC-DC	465
727	465
739AC	465
739AC-DC	465
A739AC	465
A739AC-DC	465
743	465
748	465
878	460
880	460
901AC	110
901DC	110
925	465
930	465
948	465
955	465
1015	465
1129	465
1135	465
1153	465
1155	465
1175	465
1201	110
1202	110
1203	460
1204	110
1220	460
1221	465
1295	465
3611	465
5311	465
5511	465
7511	465
1046G	465
1046	465

RI

4V Batt. Superhet	118
Superhet RG	118
Airflo	118
Duotone	118
Moderne	118
Ritz	118
Ritz AC S/Het	118
Ritz Micrion Batt 5	118
Ritz Twin Speaker	118

ROBERTS

Up to 1939 :	
M5A	430
P6	126
M4D	430
From 1939 onwards :	
M5A	465
P6	126
M4D	465
1946	
P5A	465
P4D	465

ROGERS MAJESTIC

11/6	456
11/8	456
11/8X	456
11/9	456
11/9DX	456
11/11	456
11/11X	456
12/6	456
12/7	456
12/9	456
13/8	456
13/8C	456
13/10	456
13/15	456
14/8C	456
14/8R	456
14/8T	456

SELMER

Truvoice 5	450
139	450
140	450
1239	450

SPARTAN

401	465
501	465
510	465
511	465
519	465
520	465
521	465
530	465
531	465
540	465
541	465
548RG	345
548T	345
559	465
610	465
611	465
619	465
620	465
621	465
629	465
630	465
631	465
639	465
640	465
641	465
648AG	345
648C	345

SPARTAN—*cont.*

648RG	345
649	465
650	465
651	465
719	345
748AG	345
748C	345
748T	345
1268AG	456

SPENCER

All Models	430

STANDARD

S40	130
S60	130

SUNBEAM

22	456

SUNRAY

55	110
99	465

TELSEN

6V Superhet	117·5
3435/BH	117·5
3435/BV	117·5
3435/MH	117·5
3435/MV	117·5

TEMPOREX

R3	465
R3G	465
R3U	465
R3UG	465

TRUPHONIC

AT5	127
AW5	127
AW5A	127
AW5B	127
AW5C	127
AW5T	127
AW6	456
B4	127
BB4	127
BW5	127
BW5B	127
CA6	127
CU6	127
MA5	465
MA5RG	465
MA5T	465
MU5	465
MU5RG	465
MU5T	465
MA6	465
MA7	465
MA8	465
MA8RG	465
MU5	465
MU5RG	465
MU5T	465
NA5	127
NAC5	127
NAW5	127
NU5	127
NUWS	127
PA5	465
PAT5	127
PU5	465
PUT5	127
RGAW5C	127
RGA6	127
RGUW5	127
RGU5C	127
RGU6	127
UT5	127
UW5	127
UW5B	127
UW5C	127
NW5T	127
U6	127
UW6	127

ULTRA

1934 Panther AC	456
Tiger M AC-DC	456
M22	470
22AC	456
22 Batt	456
22DC	456
M23	470
25AC	456
25DC	456
26AC and AC-DC	456
44	456
47	456
48	456
49	456
50	456
P60	510
P61	510
P62	510
P63	460
P70	510
88	456
95	456
96	456
97	456
99	456
101	456
102	456
103	456
105	470
106	470
115	456
116	456
121	456
122	456
123	456
125	456
133	456
134	456
140	456
150	456
201	470
202	470
203	470
204	470
205	470
206	470
207	470
208	470
209	470
210	470
301	470
302	470
303	470
304	470
305	470
306	470
307	470
308	470
309	470
310	470
315	470
316	470
320	470
330	470
400	456
500	470
401	470
402	470
405	470

VARLEY

AC Superhet 4	110
AP46	110
AP48	110
Square Peak Mains Superhet	110

VIDOR

220	473
221	473
227	130
237	130
258	130
275	473

VIDOR—*cont.*

277	473
280	473
284	473
288	450
291	473
300	473
301	473
302	473
308	450
322	465
323	465
351	456

WAR-TIME CIVILIAN RECEIVER

(See Civilian War-time Receivers, page 213).

WR

4VA/wave Superhet	128
5VA/wave Superhet	128
394B	128
395	128

ZENITH

5S29	252·5

ZETAVOX

ST/AC	125

USA Receivers Imported by Board of Trade

ADMIRAL

67M5	455
76P5	455
77P5	455
78P6	455
79P6	455
P6XP6	455
4202B6	455
4203B6	455
4204B6	455
4220 D5	455

ANDREA

35H5	455

EMERSON

301	455
310	455
311	455
318	455
320	455
330	455
331	455
332	455
336	455
343	455
349	455
350	455
351	455
353	455
363	455
376	455
389	455
400	455
402	455
413	455
414	455
415	455
418	455
419	455
421	455
422	455
424	262
425	455
426	455
427	262
428	262
433	455
439	455
440	455
441	455
461	455
463	455
465	455
465A	455
467	455

FADA

115	455
148	455
200	455
203	455
205	455
209	455
215	456
220	455
252	455
PD41	456
PL23	456
PL41	456
169W	456
215T	456

GE

HJ612	455
J54W	455
L513	455
L541	455
L543	455
L570	455
L571	455
L572	455
L574	455
L600	455
L604	455
L613	455
L621	455
L643	455
L651	455
LB673	455
LB700	455
LB702	455

MOTOROLA

51X16	455
51X19	455
61X17	455
61L11	455

PHILCO

PT3	455
PY87	455
PT88	455
PT95	455
321T	455
42-327T	455
42-842T	455

RCA

1X	455
6X2	455
14X	455
34X	455
35X	455
36X	455
45X12	455
15X	455
55X	455
16X2	455
16X3	455
16X11	455
16X13	455
26X1	455
26X3	455
26X4	455
26BP	455
26X21	455

STROMBERG-CARLSON

500H	455

WESTINGHOUSE

12X4	455
13X8	455
WR13X8	455
WR62K1	455
WR62K2	455

ZENITH

5G603M	455
6G601	455

SECTION 13

COLOUR CODES

BRITISH

Resistors. Small moulded and wire-wound resistors usually have their ohmic values indicated by the same three-colour code as the American (Table L).

In past years, tolerance was seldom indicated. Where it was, gold denoted 5 per cent tolerance, and silver 20 per cent. Most unmarked resistors had a tolerance of 10 per cent.

Recently, preference has been given to a four-band coding, identical with the American code, including tolerance indication. With these band-marked resistors, therefore, a fourth band of gold indicates 5 per cent tolerance, and silver indicates 10 per cent, while the standard no-colour, or unmarked, resistor has a tolerance of 20 per cent.

Moulded Mica Capacitors. The latest proposal is that the American code (Table L) should be adopted, giving the capacitance in micro-microfarads.

Colour coding for small capacitors has not been widely employed in Britain. A five-dot system was at one time recommended, the first three dots indicating the value in micro-microfarads, in the same way as for resistors. Fourth and fifth dots indicated tolerance and voltage as shown in Table XLIX.

Where there were only three dots, or bands, the capacitance was indicated; two dots showed tolerance and voltage; one dot showed tolerance.

In another system, tolerances are indicated as follows: White, 1 per cent ; orange, 2 per cent; green, 3 per cent; red, 10 per cent; brown, 15 per cent; blue, 20 per cent; yellow, 25 per cent. (No colour shows standard tolerance of $-0+100$.) Test voltages are shown by: 1,000 V, no colour; 2,200 V, green; 5,000 V, brown.

TABLE XLIX

Colour	Tolerance per cent	Voltage Rating
Brown	1	100
Red ..	2	200
Orange	3	300
Yellow	4	400
Green	5	500
Blue ..	6	600
Violet ..	7	700
Grey ..	8	800
White ..	10	1,000

In a third system, tolerances are indicated as follows: Green, 1 per cent; violet, 2 per cent; yellow, 3 per cent; white, 5 per cent; red, 10 per cent. Up to and including 1,000 V DC test, there is no voltage marking; a light blue star indicates 1,500 V DC test.

Electrolytic Capacitors. These are not coded for voltage or capacitance.

An agreement was made some years ago, regarding the following wiring code, but was never universally adopted, while, during the war, the wire supply position made any coding impracticable. Single capacitor with two leads: positive, red; negative, black. Multiple capacitor, case insulated; lead connected to capacitor of highest voltage and/or capacitance, red; lower voltage and/or capacitances in descending order, yellow, green, blue; negative, black; other negative leads, brown; any special connections, white.

AMERICAN

Capacitors. When the ratings of a moulded mica capacitor are not stamped on the case, a colour code may be employed to indicate the values (Table L).

The colours are applied as dots on the trade-mark side of the case. The dots are read from left to right. An arrow or the trade name is provided to indicate which way up the component must be held, to read the dots in the right sequence.

The first three dots indicate the capacitance in micro-microfarads:

(1) The colour of the first dot (*A* in the diagrams) gives the first figure.

(2) The colour of the second dot (*B*) indicates the second figure.

(3) The colour of the third dot (*C*) indicates the number of noughts following the first two figures.

Example: If the sequence of colours is red, green, black, the capacitance is 25 mmFd, or ·000,000,000,025 F. Usually, capacitances are stated in microfarads, hence the value is ·000025 mFd.

If the colours were green, black, red, the value would be 5,000 mmFd, or ·005 mFd.

Note: To convert mmFd to mFd, move decimal point six places to left.

Where only three dots are given, the capacitor is rated at a working voltage of 500 DC, and the capacitance tolerance is plus or minus 20 per cent.

(4) A fourth dot (*D*) indicates the *DC* working voltage rating, and this is shown in Table LI.

(5) A fifth dot (*E*) indicates the percentage tolerance in the accuracy of the capacitance rating.

Six-dot Code. When there are three significant figures in the capacitance value, six dots are necessary if voltage and tolerance are also indicated. In this case, the first three dots give the three significant figures, and the lower right-hand dot the number of noughts. Remaining two dots show working voltage and tolerance.

TABLE L

Colour	First or second figure	Noughts after second figure
Black	0	None
Brown	1	0
Red ..	2	00
Orange	3	000
Yellow	4	0,000
Green	5	00,000
Blue ..	6	000,000
Violet..	7	0,000,000
Grey ..	8	00,000,000
White..	9	000,000,000

TABLE LI

Colour	DC voltage rating	Tolerance per cent
Brown ..	100	± 1
Red ..	200	± 2
Orange	300	± 3
Yellow	400	± 4
Green ..	500	± 5
Blue ..	600	± 6
Violet ..	700	± 7
Grey ..	800	± 8
White ..	900	± 9
Gold ..	1,000	—
Silver ..	—	±10

Resistors. Carbon-type moulded resistors and small wire-wound types are given a protective paint covering which is coloured in dots, or bands, to provide indication of the resistance value (Table L) and, in some cases, the tolerance in accuracy of rating.

(1) The first figure of the value is indicated by the colour of the body of the resistor (*A* in Fig. 165).

(2) The second figure is indicated by the colour of one end (*B*).

(3) The number of noughts following these two figures is indicated by a dot or band (*C*).

(4) When given, the tolerance is indicated by the colouring of the other end of the resistor (*D*).

The colour code for the value is the same as for capacitors.

The code for tolerance is: Gold, ± 5 per cent; silver, ± 10 per cent; no colour, ± 20 per cent.

As gold and silver are not used for values, there is no question as to the sequence in which colours are read.

Examples: A resistor has a red body, green end and black dot. The value is 25 ohms with a tolerance of ± 20 per cent.

A resistor is coloured yellow with violet and gold ends, and a green dot. Value is 4,700,000 ohms accurate, within ± 5 per cent.

Note: If a dot or end colour is missing, it is same as the body.

Coding by Bands. An alternative coding employs three- or four-coloured bands and dispenses with the body colour and dot. The sequence from left to right is :

(1) First figure.
(2) Second figure.
(3) Number of noughts.
(4) Tolerance.

Flexible Resistors. Flexible wire-wound fabric-covered resistors are also coded. The body colour gives the first figure, the thicker thread the second figure, and the thinner thread the number of noughts. If either of the threads is missing, it is taken as being the body colour.

Line Cord Resistors. American line cords have three wires, two directly from the line plug and one from the resistor. The two line wires are red and blue or red and black.

The colour of the third wire indicates the resistance value as shown in Table LII.

Power Transformer. The standard code to identify leads is:

Primary: If the primary winding is not tapped, both primary leads are black. If the primary winding is tapped, the leads are as follows: Common, black; tap, black/yellow; finish, black/red.

Rectifier HT winding: Outside leads, red; centre tap, red/yellow.

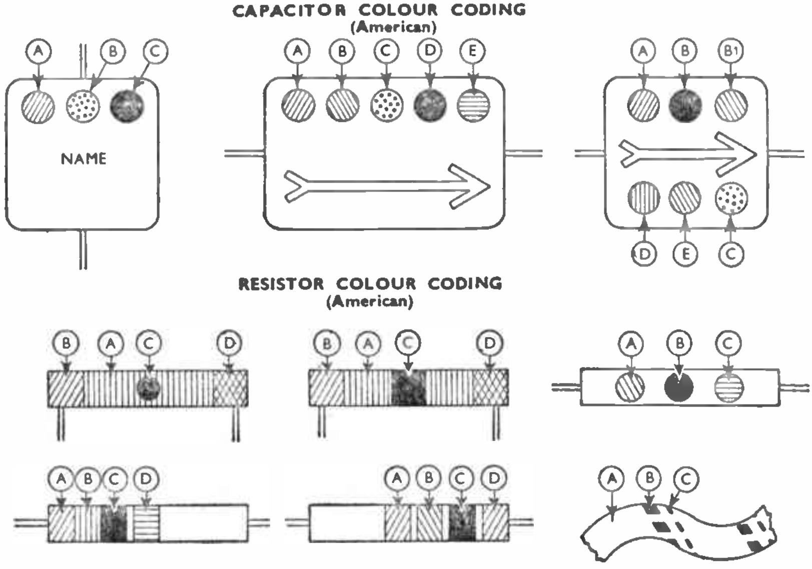
Rectifier LT winding: Outside leads, yellow; centre tap, yellow/blue.

Heater winding 1: Outside leads, green; centre tap, green/yellow.

Heater winding 2: Outside leads, brown; centre tap, brown/yellow.

Heater winding 3: Outside leads, slate; centre tap, slate/yellow.

It should be appreciated that as



AMERICAN COLOUR CODINGS

Fig. 165. Showing the different ways that capacitors and resistors may be marked with the standard American value codes.

TABLE LV

Ohms ± 20%	Ohms ± 10%	Ohms ± 5%	Ohms ± 20%	Ohms ± 10%	Ohms ± 5%	Ohms ± 20%	Ohms ± 10%	Ohms ± 5%
10	10	10	1,000	1,000	1,000	100,000	100,000	100,000
		11			1,100			11,000
	12	12		1,200	1,200		120,000	120,000
		13			1,300			130,000
15	15	15	1,500	1,500	1,500	150,000	150,000	150,000
		16			1,600			160,000
	18	18		1,800	1,800		180,000	180,000
		20			2,000			200,000
22	22	22	2,200	2,200	2,200	220,000	220,000	220,000
		24			2,400			240,000
	27	27		2,700	2,700		270,000	270,000
		30			3,000			300,000
33	33	33	3,300	3,300	3,300	330,000	330,000	330,000
		36			3,600			360,000
	39	39		3,900	3,900		390,000	390,000
		43			4,300			430,000
47	47	47	4,700	4,700	4,700	470,000	470,000	470,000
		51			5,100			510,000
	56	56		5,600	5,600		560,000	560,000
		62			6,200			620,000
68	68	68	6,800	6,800	6,800	680,000	680,000	680,000
		75			7,500			750,000
	82	82		8,200	8,200		820,000	820,000
		91			9,100			910,000
100	100	100	10,000	10,000	10,000	1·0 meg	1·0 meg	1·0 meg
		110			11,000			1·1 meg
	120	120		12,000	12,000		1·2 meg	1·2 meg
		130			13,000			1·3 meg
150	150	150	15,000	15,000	15,000	1·5 meg	1·5 meg	1·5 meg
		160			16,000			1·6 meg
	180	180		18,000	18,000		1·8 meg	1·8 meg
		200			20,000			2·0 meg
220	220	220	22,000	22,000	22,000	2·2 meg	2·2 meg	2·2 meg
		240			24,000			2·4 meg
	270	270		27,000	27,000		2·7 meg	2·7 meg
		300			30,000			3·0 meg
330	330	330	33,000	33,000	33,000	3·3 meg	3·3 meg	3·3 meg
		360			36,000			3·6 meg
	390	390		39,000	39,000		3·9 meg	3·9 meg
		430			43,000			4·3 meg
470	470	470	47,000	47,000	47,000	4·7 meg	4·7 meg	4·7 meg
		510			51,000			5·1 meg
	560	560		56,000	36,000		5·6 meg	5·6 meg
		620			62,000			6·2 meg
680	680	680	68,000	68,000	68,000	6·8 meg	6·8 meg	6·8 meg
		750			75,000			7·5 meg
	820	820		82,000	82,000		8·2 meg	8·2 meg
		910			91,000			9·1 meg
						10·0 meg	10·0 meg	10·0 meg

sistors have standardized three-tolerance ranges of ± 20 per cent, ± 10 per cent and ± 5 per cent.

Examples: A '100-ohm' resistor in the ± 20 per cent range may have a value between 80 and 120 ohms. In the ± 5 per cent range, the value will be accurate between 95 and 105 ohms.

The standardization given in Table LV reduces the total of resistors necessary to cover 10 ohms-10 meg from well over 800 to 255.

SECTION 14

INTERFERENCE SUPPRESSION

THE principle of the suppression of interference at the source is illustrated in Fig. 167. *S* is the source, usually an interrupted contact such as a switch or a commutator. An high-frequency potential appears across the impedance of the gap; unless suppressed, it drives HF currents back through the machine into the mains. The interference may thus be conducted to radio sets, or electromagnetic waves may be radiated and picked up by receiver aerials.

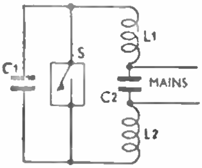


Fig. 167. Principle of mains filter.

Suppression is applied by connecting a capacitor C_1 across the source. C_1 must be of sufficient size to present a low impedance in comparison to the impedance of the gap and of the machine and mains. Average impedance of mains is about 150 ohms. Various examples of the application of suppression at source are given in Figs. 168-174.

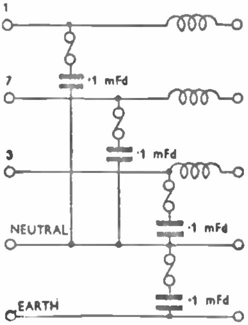


Fig. 169. Filter components for a four-wire mains system.

Where C_1 alone is not adequate, reduction of the HF voltage applied to the mains can be obtained by the filter structure L_1, C_2, L_2. The HF potential is across the capacitor C_1, but little appears across C_2 since it is of low impedance, while the chokes L_1, L_2, are of high impedance.

Exact values of capacitance and inductance are best determined by trial, but will be within the ranges set out in Tables LVI and LVII.

SUPPRESSION CAPACITORS

Suppression Capacitors are classified in three types:

Type X, employed across AC or DC mains up to 250 volts working.

Type Y, employed from any main to earth or frame where voltage to earth does not exceed 500 volts working, or employed across 500 volts DC mains.

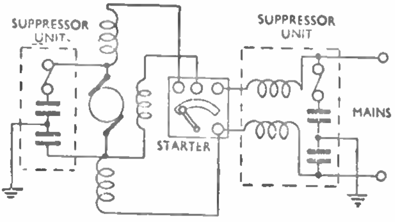


Fig. 168. Suppression applied to motor and starter.

Type XX, employed across mains up to 500 volts AC.

Other requirements of capacitors are set out in BSS613.

Post Office Recommendation

With unearthed appliances, the G.P.O. recommends that the capacitor connected between main and frame should not exceed ·005 mFd, or any person touching the frame may receive a shock from the charging current.

Suitable standard inductance values as given by Belling & Lee, Ltd., are shown in Table LVII.

TABLE LVI

Designation of Capacitor	Voltage Tests		Insulation—Resistance Tests	
	Between Terminals of Capacitor (Volts)	Between Terminals and Metal Casing (Volts)	Between Terminals of Capacitor (Megohms)	Between Terminals and Metal Casing (Megohms)
X0·005 to X0·1 X0·5 X1 X2	1,500 (DC)	1,500 (AC)	1,000 600 300 150	100
Y0·005 to Y0·1 Y0·5 Y1 Y2	2,250 (DC) or 1,500 (AC)	1,500 (AC)	1,000 600 300 150	100
XX0·005 to XX0·1 XX0·5 XX1 XX2	3,000 (DC) or 2,000 (AC)	2,000 (AC)	1,000 600 300 150	100

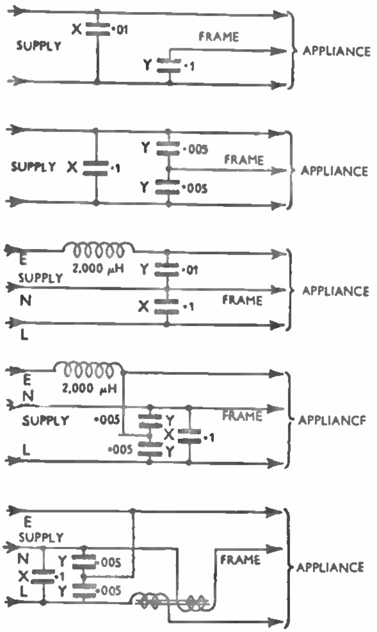


Fig. 170. Suppression filter circuits for mains leads to portable appliances.

TABLE LVII

Circuit Current (amps)	Inductance (microhenries)
·5	10,000
1	5,000
5	2,000
15	1,000
30	500
60	250
100-300	100

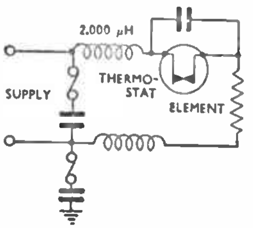


Fig. 171. Suppressor for a thermostat as fitted to a refrigerator or cooker. It consists of two 2,000-microhenry chokes in series with the appliance and a parallel capacitor of ·005 mFd or more.

Limits of Interference. According to BSS800, 1939, a signal-to-noise ratio of 100-1 is desirable.

Between 200-1,500 Kc/s, interference level at the machine terminals, or from terminals to frame, should not exceed 500 microvolts, whether the frame is earthed or not.

Over the same frequency range, the field intensity at 10 yards or less should not exceed 100 mV per M.

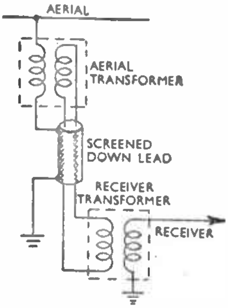


Fig. 177. Screened anti-static lead-in system for aerial connection to receiver.

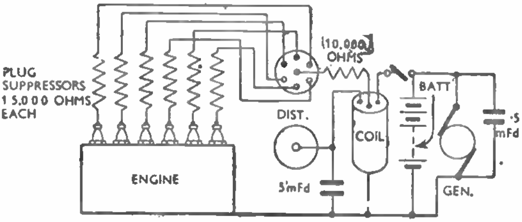


Fig. 172. Comprehensive suppression applied to an automobile.

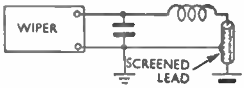
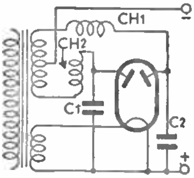


Fig. 173. Windscreen-wiper suppression.

Fig. 174. HF filter capacitors and inductors added to a full-wave rectifier circuit.



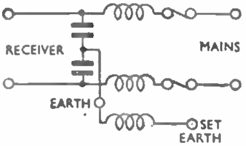


Fig. 175. HF filter in mains lead to a receiver.

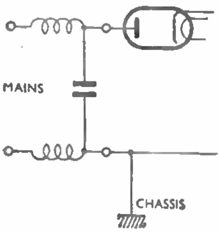


Fig. 176. Mains filter for AC-DC receiver.

Suppression at Receiver. Where adequate suppression at source is not possible, the following steps may be taken at the receiver to prevent the entry of interference: (*a*) By conduction over the mains; (*b*) by direct pick-up in the receiver; (*c*) by pick-up on the aerial.

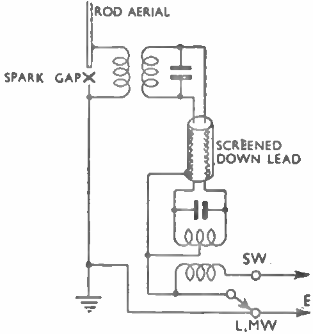


Fig. 178. Anti-static lead-in system used with Belling Lee 'Skyrod' aerial.

For (*a*) there are set-lead filters (Fig. 175). Screening of the receiver cabinet is necessitated by (*b*), and (*c*) is secured by the use of a screened aerial system. In the latter, the open signal collector is erected outside the interference field, and the lead-in is fully screened.

To prevent undue signal loss in the screened cable, the impedance is reduced by transformer.

Reference to Figs. 176-178 will make clear the methods adopted.

SECTION 15

SOUND RELATED TO ITS AMPLIFICATION BY ELECTRICAL APPARATUS

Absorption Co-efficient. This is the fraction of sound energy absorbed by a surface. Theoretically, the absorption of an open window is taken as unity. (*See* Table LVIII.)

Audio Freqnency is a frequency occurring at a rate between approximately 20 and 20,000 cycles per second. Air waves of these frequencies are heard as sound. Frequencies of the musical scale, and of instruments, are shown in Figs. 179 and 180 and Tables LIX and LX.

Intelligence can be communicated within a limited frequency range. It has been internationally agreed that minimum bands desirable are: for commercial telephony, 300-3,400 cycles; for music over wires, 50-6,400 cycles; for radio, 30-8,000 cycles.

Bar. Unit of sound pressure, equal to one dyne per sq. cm, and one-millionth of the bar in meteorology.

Bel. Logarithmic unit for comparison of powers. Where P_1 and P_2 are two powers, and N is the number of bels expressing their ratio : $N = \log_{10} \frac{P_1}{P_2}$.

Decibel is a tenth of a bel, and is the unit commonly used to express ratios of power, voltage or current. If N is the number of decibels, $N = 10 \log_{10} \frac{P_1}{P_2}$.

Where two powers are dissipated in equal resistances, the ratio of voltage to voltage, or current to current, may be expressed in decibels (or bels). For a given resistance, the power is proportional to the square of the voltage or current, and since, in logarithms, to square a quantity the logarithm is multiplied by two, then,

$$N \text{ bels} = 2 \log_{10} \frac{V_1}{V_2}, \text{ or } 2 \log_{10} \frac{I_1}{I_2};$$

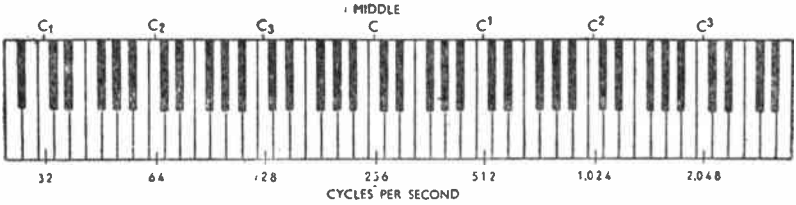
$$N \text{ decibels} = 20 \log_{10} \frac{V_1}{V_2}, \text{or } 20 \log_{10} \frac{I_1}{I_2};$$

where V is voltage and I is current.

Advantage of the decibel is that it provides a unit of ratio which corresponds in some degree to the average person's perception of change in loudness.

To produce an apparent doubling of loudness, the actual intensity must be increased about ten times. A difference in loudness of one decibel is about the smallest change that can be discerned by the ear.

A second advantage is, that when the decibel gain or loss of the



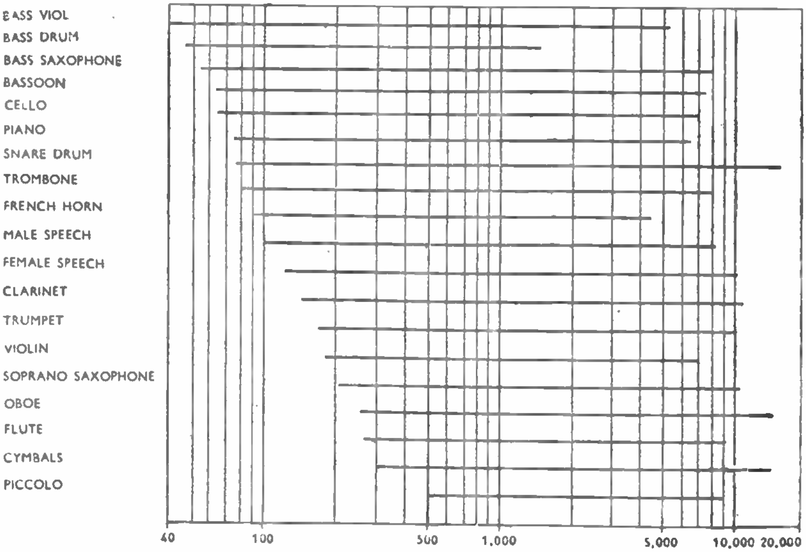
FREQUENCIES OF PIANO NOTES

Fig. 179. Showing a piano keyboard and frequency limits of octaves of C.

TABLE LVIII:

ABSORPTION COEFFICIENTS OF COMMON MATERIALS

Material	Absorption Coefficient for Frequency						
	64	128	256	512	1,024	2,048	4,096
Brick wall	·021	·024	·025	·03	·042	·049	·07
Plaster on brick	—	·013	—	·025	—	—	·045
Lime on wood lath with finishing coat	·036	·012	·013	·018	·045	·028	·055
Cork (coarse, 1 in.) ..	—	·14	·25	·4	·25	·34	·21
Hair felt (1 in.)	·09	·1	·2	·52	·7	·66	·44
Rock wool (1 in.) ..	—	·35	·49	·63	·80	·83	—
Carpet	—	·09	·08	·21	·26	·27	·37
Wood flooring	—	·05	·03	·06	·09	·1	·22
Cushions, canvas and plush	·86	·99	1·1	1·8	1·7	1·4	·91
Curtains, heavy	—	·1	—	·5	—	—	·9
Fibreboard (·5 in.) ..	—	·05	—	·54	—	—	·6



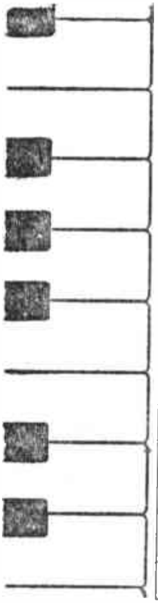
FREQUENCY RANGES COVERED BY INSTRUMENTS AND VOICES

Fig. 180. These ranges include harmonics; the range of fundamental frequencies is much less and can be discovered from the musical notation.

component parts of a system is known, the overall gain or loss can be found by simple addition and subtraction of the individual decibel ratings. To say an amplifier has a gain of so many decibels is correct, but the information is more complete if the input power is stated. An

TABLE LIX:

MUSICAL INTERVALS



Equal Temperament Frequency Ratios	True Diatonic Frequency Ratios
C^2 $2\,(\times fc^1)$	2
B 1·888	1·875
A♯ 1·782	—
A 1·682	1·667
G♯ 1·587	—
G 1·489	1·500
F♯ 1·414	—
F 1·335	1·333
E 1·260	1·250
D♯ 1·189	—
D 1·122	1·125
C♯ 1·059	—
C^1 1	1

arbitrary zero level may be used and, in sound engineering, this is frequently accepted as 6 mW, or ·006 watt. Zero level in telecommunications technology is defined as 1 mW.

Examples: If an amplifier gives an output of 50 watts with an input of ·1 watt, the decibel gain is calculated as follows:

The power ratio is $\frac{50}{\cdot 1} = 500.$

The log of 500 is 2·699, or about 2·7; therefore, the gain is 2·7 bels, or 27 decibels. (See Fig. 181.)

The output power from, for instance, a transformer will be less than the input power. This loss of power is called the *insertion loss* of the transformer.

If there is an input of 20 watts and an output of 17, then

$$\frac{17}{20} = \cdot 85, \ \log_{10} \cdot 85 = \bar{1}\cdot 9294.$$

As one part of the log is negative and the other positive, the actual log is $-1 + \cdot 9294 = \cdot 0706$. The loss is ·706 dB.

Suppose an amplifier is stated to have a gain of 40 dB, the reference level being 6 mW, the output will be 10^4 the power of the input, i.e. 60 watts.

If the gain of an amplifier is given as 64 dB, we know that 60 dB is 10^6 and 4 dB is 2·512. The power gain, therefore, is $2\cdot 512 \times 10^6 = 2{,}512{,}000$.

Gains and losses are readily ascertainable from the accompanying conversion chart (Fig. 181).

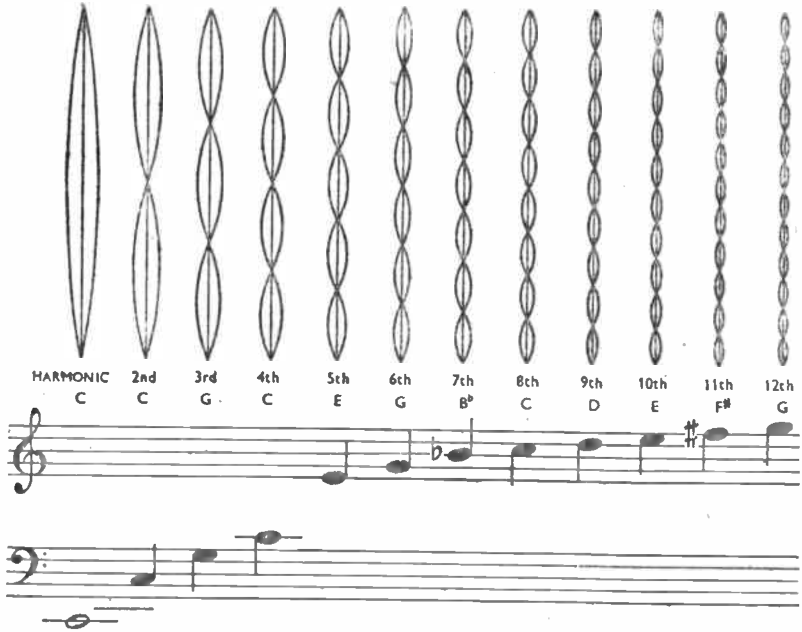
Distortion is the change of wave form which occurs between two points in a transmission system.

TABLE LX:

PEAK POWER OF INSTRUMENTS

(*As stated by C. W. Horn*)

Instrument	Peak Power (watts)
Heavy orchestra ..	70
Large bass drum ..	25
Pipe organ ..	13
Cymbals	10
Trombone	6
Piano	·4
Trumpet	·3
Bass viol	·16
Clarinet	·05
Triangle	·05



HARMONICS WITH CORRESPONDING VIBRATIONS

Fig. 182. Fundamental vibration of a cord and its harmonics. If the length of the cord is such that the fundamental is C, the harmonics have the notation shown.

audibility, and the lowest pressure which gives a sensation of feeling is the *threshold of feeling*. Both vary with the frequency (Fig. 183).

Loudness is the psychological effect of a sound, and *intensity* is measured in physical units.

Appreciation of pitch varies slightly with loudness.

Interference between sound waves may result in 'beats' and in zones of silence.

Logatom. An isolated syllable.

Neper. A unit of comparison giving the natural logarithm of the ratio of two currents independently of the resistance of the circuit.

$N = \log_e \frac{I_1}{I_2}$, where N is the number of nepers and I is current.

This unit is used in some continental countries, but the decibel is commonly employed in Great Britain and America.

The decineper is $\frac{1}{10}$th of a neper.

Phon. British standard unit for the measurement of sound intensity. The sound under measurement and a standard tone are heard alternately, and the standard tone adjusted until judged by a normal hearer to be of equal loudness. The intensity level of the standard tone with reference to an R.M.S. sound pressure of ·0002 dyne per sq. cm (10^{-16} watts per sq. cm) stated in decibels, is the equivalent loudness of the original sound in phons.

The standard tone is a plane sinusoidal 1,000-cycle wave from a position directly in front of the hearer. The reference level, with exactness, is an R.M.S. pressure of

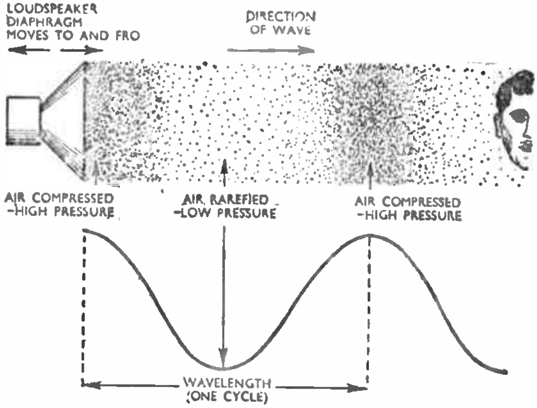


Fig. 185. Sound is caused by a pressure wave and can be represented, as shown in this diagram, by a sine wave.

particles and pressure in a plane wave are:

$$u = U\cos\frac{2\pi}{\lambda}(ct - x),$$

$$a = \frac{\lambda U}{2\pi c}\sin\frac{2\pi}{\lambda}(ct - x),$$

$$p = C_{po}\,U\cos\frac{2\pi}{\lambda}(ct - x),$$

where u is the instantaneous velocity of a particle; U the maximum velocity; ct, velocity of the sound wave; x, a co-ordinate taken in the direction of propagation; λ, the wavelength; a, the displacement of the particles; p, the pressure; and p_o the density of air.

For a spherical wave, where A is the strength of a source at the centre of the sphere and r the radius:

$$u = \frac{A}{2\lambda r}\cos\frac{2\pi}{\lambda}(ct - r) + \frac{A}{4\lambda r^2}\sin\frac{2\pi}{\lambda}(ct - r),$$

$$a = \frac{A}{4\pi r^2}\sin\frac{2\pi}{\lambda}(ct - r) - \frac{\lambda A}{8\pi^2 r^2 c}\cos\frac{2\pi}{\lambda}(ct - r),$$

$$p = \frac{c p_o A}{2\lambda r}\cos\frac{2\pi}{\lambda}(ct - r).$$

A sound wave is a form of energy. The transfer of energy through a sq. cm of surface is called the energy flux density (J). The kinetic or potential energy in any small region of the path of the wave is called the energy density (E):

$$J = \frac{p^2}{p_o c};\ E = \frac{p^2}{p_o c^2}.$$

Wavelength of a sound wave λ is: $\lambda = \frac{V}{f}$, where V is the velocity and f the frequency.

Sound Intensity. Rate of flow of sound energy per unit area in the normal direction of propagation. The unit is an erg per second per sq. cm.

Sound Pressure. The alternating component of the total pressure in a sound field. It is stated in dynes per sq. cm.

Speed of Sound varies with the medium and the temperature. For most purposes, the velocity in air can be taken as 1,140 ft. per second, or approximately one mile in 5 seconds. Where θ is the air temperature in degrees centigrade, the velocity in metres per second is given by: $330{\cdot}6\sqrt{1 + {\cdot}0037\theta - 1{\cdot}256\theta^2\,10^{-7}}$.

Velocity in air is independent of pressure, but is proportional to the

TABLE LXI

Material	Metres per second	Material	Metres per second
Brick	3,600	Woods:	1,250
Cork	500	Ash (across grain)	4,700
Ebonite	1,500		
Glass	5,000		
Marble	3,800	Ash (parallel to grain)	5,250
Nitrogen	340		
Oxygen	315		
Slate	4,500	Fir	4,150
Steel	5,000	Mahogany	3,380
Water	1,433	Oak	3,320
		Pine	4,780

resonant diaphragms may give a poor frequency characteristic, but as the diaphragms are more stretched, so sensitivity reduces but fidelity increases.

Table LXII compares the sensitivities, direct and with transformer gain, of different types of microphone and broadly specifies the typical performance of typical designs.

TABLE LXII: MICROPHONE CHARACTERISTICS

Type	Sensitivity (1,000-2,000 c/s)		Impedance
	Without Transformer Gain	With Transformer Gain	
General description and performance	Decibels below 1 volt/bar		Ohms
Carbon, Post Office type. Poor frequency characteristic. Suitable commercial uses. Background hiss.	– 30	– 10	200 - 400
Carbon. Better fidelity than Post Office type. Used in simple P.A. systems. Prone to background hiss.	– 50	– 30	200 - 400
Capacitive. High fidelity. Disadvantage of high impedance overcome by amplifier in housing. May require electrostatic shielding.	– 90	– 90	500,000 to 1,000,000
Crystal. High fidelity. May require electrostatic shielding.	– 60 – 100	– 60 – 100	50,000
Moving Iron. Sound power. Sometimes used in aeroplanes. Poor frequency characteristic, but good intelligibility, high sensitivity at maximum.	– 10	– 10	100 - 600
Moving Coil. A ubiquitous type for fidelity and high-fidelity work. Subject wind flutter. May require magnetic shielding.	– 60 – 80	– 30 – 50	25
Ribbon. Much used in broadcasting and cinema work. Liable wind flutter. May require magnetic shielding.	– 70 – 80	– 40 – 50	0·5 to 1

TABLE LXIII:
TYPICAL MOVING-COIL LOUDSPEAKER CHARACTERISTICS

Type	Power-handling capacity (watts)	Efficiency (per cent)	Angle of distribution (deg.)	Average frequency range (c/s)
Baffle and Cabinet:				
Small permanent magnet . .	1½ to 2	5 - 10	90	120 - 8,000
Large permanent magnet . .	5	5 - 10	90	80 - 8,000
Very large energized (auditorium type)	15	5 - 10	90	80 - 8,000
Directional Baffle	5	10 - 20	60 - 100	150 - 8,000
Projector:				
45 in. air column	7	10 - 35	35 - 60	200 - 7,000
72 in. to 96 in. air column . .	8	10 - 35	35 - 60	200 - 8,000

TABLE LXIV:
ELECTRICAL POWER OUTPUT REQUIRED FOR CERTAIN COVERAGES

Power Output (watts)	Coverages			
	Indoors		Outdoors	
	Cu. ft.	No. of people	Sound dispersal (radius in ft.)	Distance along speaker axis (ft.)
1	2,000 (Small domestic rooms)	—	—	—
2	5,000 (Large domestic rooms)	—	—	—
5	50,000 (Halls)	500	—	—
10	130,000 (Halls)	1,000	300	450
15	300,000	2,000	400	650
30 to 40	1,000,000	5,000	600	1,000
90	—	—	1,500 (Audience between 75,000 and 100,000 people)	2,500

efficiency of their loudspeakers upon request.

Upon the efficiency of any particular loudspeaker will depend the watts output from an amplifier necessary to provide the required acoustical wattage to cover a certain area or cubic volume. Fig. 187 gives a curve of acoustic watts against cubic volume, but this is only approximate for average conditions. Furnishings, material of walls,

TABLE LXV:

USEFUL METER RANGES AND THEIR APPLICATIONS

Measurement	Range	Application
Current (DC)	0 – 100 μA	Grid current; diodes.
	0 – 2·5 mA	Resistance-capacitance-coupling anode circuits.
	0 – 10 mA	HF, osc., IF, LF, valves and battery output valve anode feeds.
	0 – 50 mA	Majority of power valves in domestic receivers; total HT feed through field windings of medium-sized receivers.
	0 – 500 mA	PA power valves; total HT feeds in large domestic receivers; heater current of valves on DC up to ·5 amp.
Current (AC)	0 – 500 mA	Heater current of AC valves up to ·5 amp.
	0 – 1 amp	Heater current of AC valves up to 1 amp; mains transformer primary current of equipment taking up to 250 watts on 250-volt mains.
Volts (DC)	0 – 2·5 volts	Grid bias of general-purpose valves; single dry cells; accummulator cells if not on charge.
	0 – 10 volts	Grid bias of small power valves; grid-bias batteries; valve heaters up to 10 volts on DC supplies.
	0 – 50 volts	Grid bias of large power valves; heaters of most AC/DC type valves on DC; sections of HT batteries; screen-grid and detector anode voltages in battery sets.
	0 – 250 volts	HT batteries; anode and screen circuit voltages of battery receivers and most 4-5-valve mains receivers; check up of DC mains voltages.
	0 – 1,000 volts	HT circuits of large domestic receivers and PA equipment.
Volts (AC)	0 – 10 volts	Heater circuit of AC receivers; LT secondaries of mains transformers; as an output meter across loudspeaker speech coils.
	0 – 50 volts	Heater voltages of AC/DC valves on AC; low-voltage turntable motors fed through a dropping resistance; voltage applied to tuning motors (generally about 20 volts).
	0 – 250 volts	AC mains voltage check; AC volts on anodes of rectifying valves up to 250 volts-0-250 volts; as an output meter with blocking capacitor between anode and chassis of output valves.
	0 – 1,000 volts	AC mains voltage on 'high' mains which may go up to 265 volts; AC volts on rectifier anodes up to 1,000 volts-0-1,000 volts.

[*Continued on page* 252

TABLE LXV: USEFUL METER RANGES AND THEIR APPLICATIONS—*continued*

Measurement	Range	Application
Resistance	0 – 100 ohms	Tuning coils; wavechange switch contact efficiency; speech coils; primary and LT secondaries of mains transformers; LF chokes; motor windings; low impedance pick-ups; valve heaters and filaments; resistances up to 100 ohms.
	0 – 1,000 ohms	Some of the above when over 100 ohms; field windings; intervalve transformer windings; mains transformer secondaries; line cords, voltage droppers and other forms of resistances up to 1,000 ohms.
	0 – 100,000 ohms	Resistances up to 100,000 ohms; high impedance pick-ups; continuity checks (lower ranges often take heavy current from internal dry cells, and should be used only sparingly for measurements).
	0 – 10 megohms	Resistances up to 10 meg; indication of low insulation if a fairly high battery voltage is used.

its maximum resistance, ensuring that the minimum current flows through the meter.

Assume that a meter has a 0–10-mA range and it is desired to increase this to 0–50 mA. First adjust the variable resistor until the meter reads exactly 10 mA without the shunt. Then connect the shunt and alter its resistance until the meter reads exactly 2 mA. This means that the 10 mA flowing through the circuit now registers only as 2 mA on the meter scale, and that the full-scale deflection of the meter will be five times its original value, i.e., 50 mA.

The maximum value of the variable resistor should be such that, with the applied voltage, the current flowing is less than that taken by the meter for full-scale deflection. For example, a 10-mA meter with a 3-volt dry cell would require a resistor of resistance at least 300 ohms, because, from Ohm's Law, $R = \frac{E}{I} = \frac{3}{\cdot 01} =$ 300 ohms.

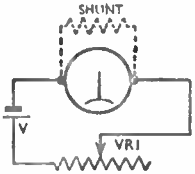


Fig. 190. Circuit for making a shunt by trial and error.

A suitable practical value for the resistor would be 500 ohms, but too high a value should not be used, otherwise difficulty will be found in getting a fine control at low readings.

Shunting Shunts. If a meter already incorporates shunts but it is required to provide a lower range, it is quite in order to add an external shunt if it is not desired to open up the meter and interfere with its internal shunts and switching arrangements. The extra shunt may be made by the trial-and-error method described above, or the total resistance of meter and its shunts measured by well-known methods.

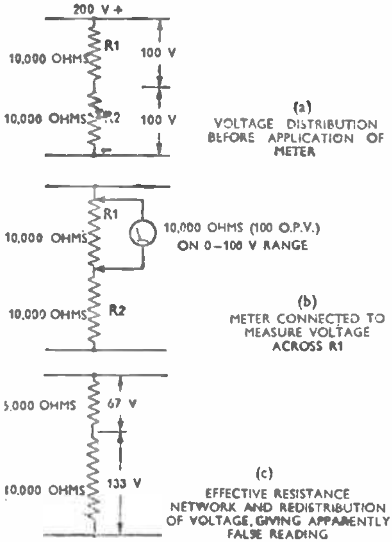


Fig. 195. Indicating in detail the effect of meter resistance on voltage readings.

where R_1 = multiplier resistance in ohms, R_2 = ohms-per-volt sensitivity figure of the meter, range = original range of meter in volts, n = multiplication ratio.

Example: A meter having a sensitivity of 200 ohms-per-volt and a range of 0-150 volts is required to measure 0-750 volts; what is the value of the multiplier resistance required?

The multiplication ratio is 150 : 750, or 1 : 5, and from the above formula we have, $R_1 = 200 \times 150 \times (5 - 1) = 30{,}000 \times (4) = 120{,}000$ ohms.

Effect of Voltmeter on Circuits being Tested. When a voltmeter is applied to a resistance network in order to measure the voltage across any part of that network, the resistance of the voltmeter and the current required to operate it (which is drawn from the circuit under test) give rise to a rearrangement of the potentials across the various portions of the resistance network. Fig. 195a shows a simple network of two resistances of equal value across a supply of 200 volts; this can represent an HT potential divider for the screening grids of the valves in a radio receiver.

Figs. 195b and 195c show how the voltage across the two resistances is altered by the application of a voltmeter to R_1. It will be appreciated from this simple example how important it is to have a meter with as high a sensitivity as possible, i.e., with a high value of ohms-per-volt; 1,000 ohms-per-volt is a general figure, but many good-class voltmeters have sensitivity figures exceeding 20,000 ohms-per-volt.

AC Measurements. To measure AC, moving-coil meters may be

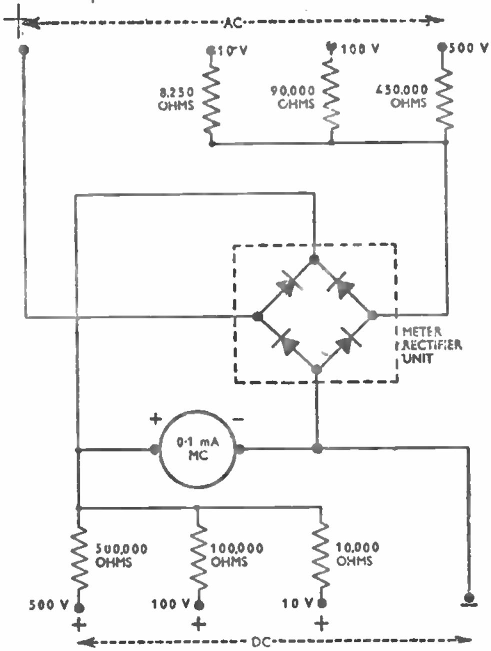
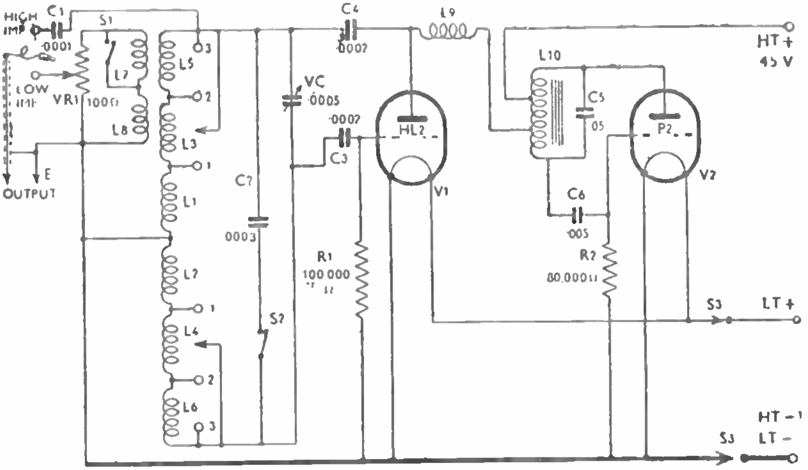
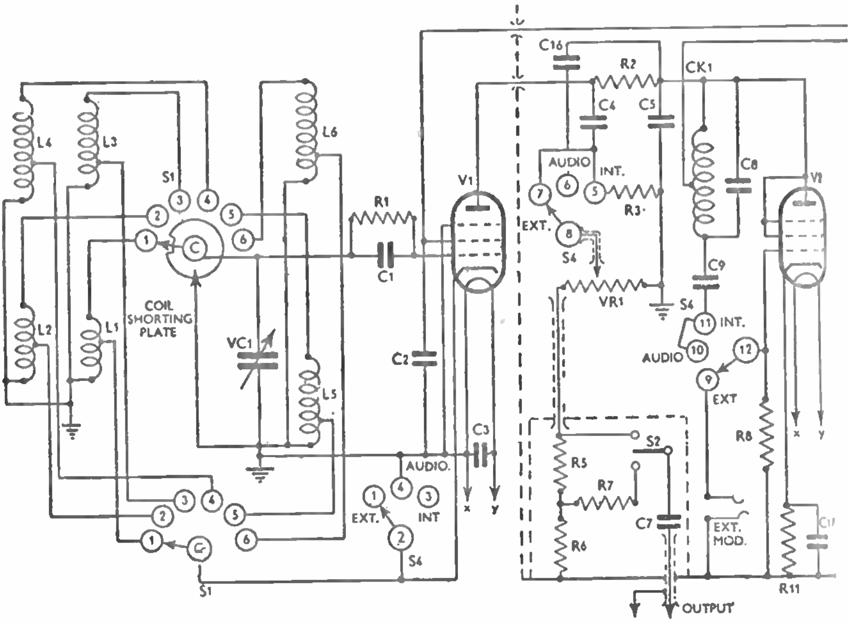


Fig. 196. Circuit for a triple-range AC-DC voltmeter. Note the lower values of AC multipliers to compensate for voltage drop across rectifier unit.



CIRCUIT FOR A BATTERY-DRIVEN SERVICE OSCILLATOR

Fig. 202. *V*₁ with its associated tuning circuit generates high-frequency oscillations which are modulated at audio-frequency by oscillations generated by *V*₂ stage. Radio-frequency output can be calibrated against known frequencies.



MAINS-DRIVEN OSCILLATOR

Fig. 203. Illustrated above is the circuit of an alternating-current mains operated all-wave oscillator for realignment of domestic radio sets. (It is published with acknowledgements to E.M.I. Service, Ltd.) It will be seen that again *V*₁ stage is the

tuned circuit shall not cause variations in the calibration due to supply voltage variations, changes of valves, and so forth.

If an oscillating circuit, the frequency of oscillation of which is to be measured, has an anode-feed meter measuring the HT current to the oscillation valve, then when an external tuned circuit, coupled to the oscillating circuit, is brought into resonance, the feed meter will show a change of reading indicating the resonant condition.

If, therefore, a wavemeter be coupled to the oscillator, it absorbs power at resonance and this is indicated by the anode-feed meter. In this case, the wavemeter is called an *absorption wavemeter.*

The method is not very accurate; if accurate measurements are required, it is essential that the wavemeter be very loosely coupled to the source of oscillation (the frequency of which is to be measured) and that the wavemeter itself be equipped with some indicator showing the increase of voltage across the wavemeter circuit when resonance takes place. This indicator must not affect the calibration of the wavemeter; a valve voltmeter circuit having a very large input impedance is, therefore, suitable.

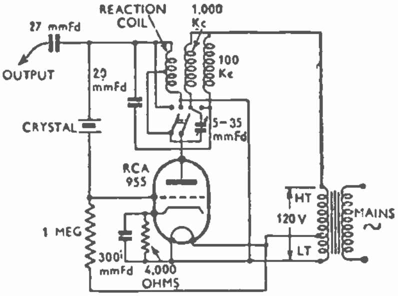


Fig. 204. Simple single-valve, mains-operated oscillator with crystal control and modulated at mains frequency.

Crystal Calibrators. Fig. 204 gives the circuit of a simple crystal calibrator which may be used for calibrating oscillators and receivers by means of harmonics from a crystal-controlled oscillator valve. The crystals employed in these calibrators have a dual frequency and will oscillate on 100 Kc/s along the length, and at 1,000 Kc/s through the thickness. The 100-Kc/s frequency range and harmonics is the more accurate, and the 1,000-Kc/s output is convenient for identifying the 100-Kc/s points.

Precautions should be taken to ensure that ambient temperature variations are the less as the demands for consistency of performance of the crystals are the greater.

AUDIO-FREQUENCY OSCILLATORS

An audio-frequency oscillator suitable for testing audio-amplifiers and so forth should be capable of giving any frequency between about 20 and 20,000 c/s at a constant output and good wave form.

The very large ratio of maximum to minimum frequency makes it difficult to design oscillators embodying tuned circuits, tuned to the audio-frequency required, and set into oscillation by valve circuits. Certain resistance-capacitance networks can be designed to fulfil the requirements, but here again the very wide range of frequencies introduces difficulties.

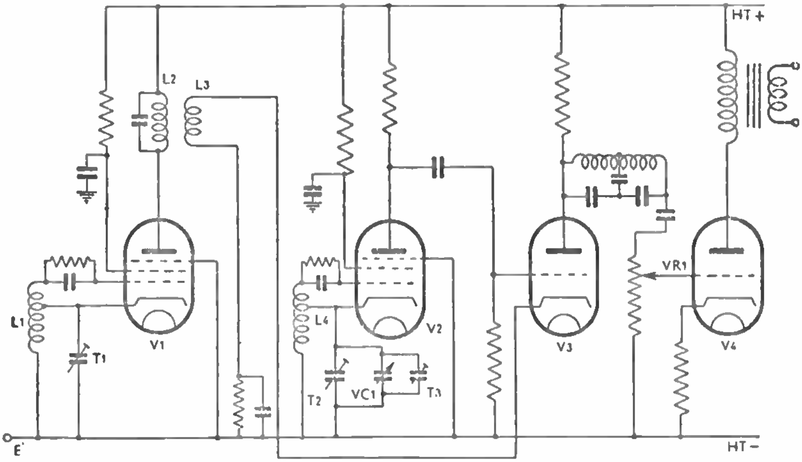
The most practical solution to the problems introduced by the wide range of frequencies required is to produce audio-frequencies the values of which are given as the difference between two much higher frequencies.

In the *beat-frequency oscillator,* two oscillating circuits are provided, one having a fixed, the other a variable frequency, so that the difference frequency varies over wide ranges by small alterations of the variable frequency.

If the fixed frequency be 300 Kc/s, then, to cover a range of difference (audio) frequencies from 0 to 30,000 c/s, the frequency of one oscillator need only be changed by 10 per cent.

Fig. 205 shows the circuit of a typical BFO.

V_1 is the fixed oscillator, with its tuning inductor L_1 and trimmer capacitor T_1. The output from the oscillator is coupled by a transformer L_2 and L_3 to V_3, the detector valve, the secondary, L_3, being in the cathode circuit of that valve.



ANOTHER AUDIO-FREQUENCY OSCILLATOR CIRCUIT

Fig. 205. V_1 and V_2 are two high-frequency oscillators. Their outputs are combined, forming in V_3 an audio-frequency beat signal which is amplified by V_4.

The variable oscillator is V_2, with its tuning inductor L_2 and primary trimmer T_2. T_1 and T_2 are used initially to set up the two oscillators to the same frequency (zero beat). Across T_2 is the main control of the instrument, VC_1, with a subsidiary trimmer T_3 for resetting calibration when required.

The output of V_2 is resistance-capacitance coupled to the grid of V_3, which acts to produce the required difference frequency, since it is also energized from both oscillators. The output from V_3 is passed through a filter network and blocking capacitor to the attenuator VR_1, which feeds the grid of the amplifier output valve V_4. The filter network is designed to suppress all radio frequencies greater than the difference frequency which is produced by the two oscillators. The output from the instrument is taken via a coupling transformer from the output valve V_4.

All circuits are very carefully screened from each other, especially the V_1 and V_2 circuits, and it will be seen that electron coupling to the anodes of V_1 and V_2 is employed, the screening grids being the actual oscillator anodes. This arrangement minimizes interaction between circuits, particularly when the difference frequency is small and the oscillators, therefore, tend to 'cog'.

Another much-used circuit is that of Fig. 206. V_1 is the fixed oscillator and V_2 the variable oscillator. VC_1 is the variable capacitor altering the frequency of one oscillator. The output of V_1 is resistance-capacitance coupled to the coupling coils L_5 and L_6, a portion of the anode signal being fed to the tuning coil L_1, whose reaction coil is L_2. From L_6 the signal is fed to the grid of the detector valve V_3.

The variable oscillator V_2 circuit is similar to that of V_1, L_3 being the tuning coil and L_4 the grid reaction coil. The output of V_2 is resistance-capacitance coupled to the grid circuit of V_3, via a centre-tapped resistance network. The output from V_8 is resistance-capacitance coupled to a filter circuit for suppressing radio frequencies, so that the intermediate frequency of AF is passed to the attenuator VR_1 and, in this particular circuit, passed straight out to the test leads without further amplification.

Other Sources of AF. Where good turntable equipment is available, with, preferably, a hysteresis motor operating from controlled mains, special gramophone records may be employed as a source of AF.

For fault-finding and simple tests, a constant-freauency audio output, produced from a simple audio-frequency oscillator such as the modulator circuit of a signal generator, suffices.

Calibration. If the equipment is available, a BFO may be calibrated by means of Lissajous figures on an oscillograph, using a known single frequency input to one set of plates, and feeding the output from the BFO across the second pair of plates. Quite a number of calibration points can be obtained using a 50-cycle or 100-cycle input.

Having got up to 1,000 cycles in this way, a simple LF oscillator-valve circuit may be connected up and tuned to 1,000 cycles by the aid of the BFO. The oscillator can then

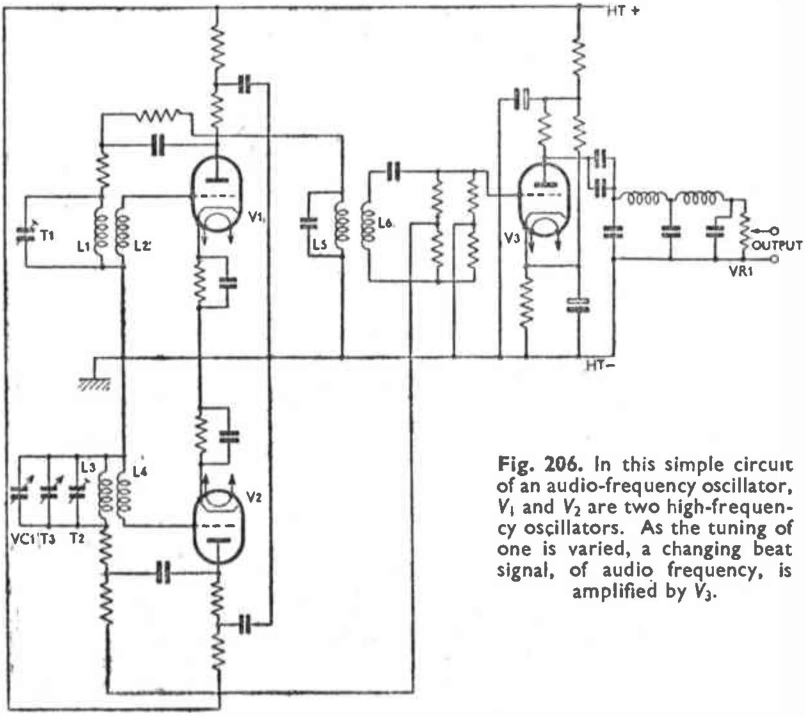


Fig. 206. In this simple circuit of an audio-frequency oscillator, V_1 and V_2 are two high-frequency oscillators. As the tuning of one is varied, a changing beat signal, of audio frequency, is amplified by V_3.

TABLE LXVI: CONTROLS AND FUNCTIONS

Control Designations	Operational Function
Brilliance, Intensity, Brightness	Adjusts brightness of spot and image.
Focus	Controls definition or clarity of the trace by altering the size of the spot and, therefore, the thickness of trace.
Range, Capacitor, Frequency Coarse	Governs approximate frequency range of internal time base.
Frequency, Frequency Fine, Velocity	Fine control of time base frequency.
Sync., Syn., Hold ..	Stops movement of trace across the screen so that one or more cycles may be examined stationary.
'Int-50∼-Ext' Switch ..	Selects sync. signal to time base circuits from either applied signal, mains supply, or external frequency source.
Ampl. A, Ampl. Y, Vert Ampl. Switch	Applies input either direct or through an amplifier to vertically deflecting (*Y*) plates.
Ampl.B., Ampl. X, Horiz.-Ampl. Switch	Applies input either direct or through an amplifier to horizontally deflecting (*X*) plates.
Gain, Height, Vert. Gain	Controls amplitude of trace in a vertical direction. (Top to bottom of screen.)
Gain, Width, Base, Horiz.-Gain	Controls amplitude of trace in a horizontal direction. (Across screen.)
Y Shift, Vert. Shift, Beam Centring	Generally a pre-set control for centring spot in screen area in a vertical direction to counteract stray magnetic fields, etc.
X Shift, Horizontal Shift, Beam Centring	As above but in a horizontal direction.

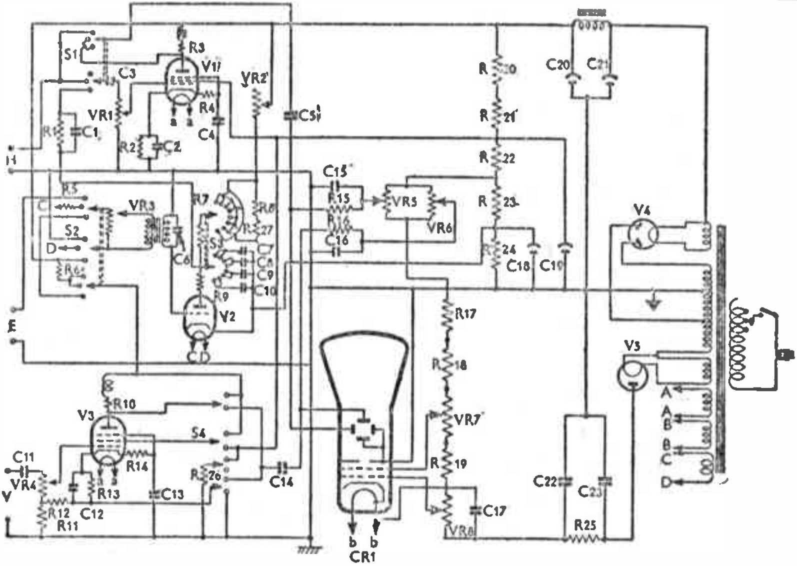


Fig. 208. Circuit diagram of a typical commercial oscillograph.

OF A TYPICAL COMMERCIAL OSCILLOGRAPH

Fig. 208 Circuit Component	Technical Function
VR_8	Controls bias on grid of cathode-ray tube.
VR_7	Affects difference of potential between first and second anodes for electrostatic focusing of beam.
S_3 (Two-bank)	Selects applicable time base capacitor for approximate frequency. Gives two ranges for each capacitor by means of R_8, R_{27}.
VR_2	Alters frequency by V_2 anode voltage adjustment.
VR_3	Applies part of 'work' or input to time base to keep its frequency in step, or synchronized, with frequency of input.
S_2 (Three-bank)	Switches VR_3 to 'work' input. Ext. Sync. terminals (to which could be connected a standard source of frequency) or to secondary winding CD for 50~ synchronizing signal.
S_4 (Four-bank)	Cuts out amplification of V_3 in upper (OFF) position and connects signals across R_{11} to vertical plates via C_{14}.
S_1 (Two-bank)	Connects horizontal plates via C_5 either direct to input terminals or to output of V_1. In third position feeds VR_3 with time base signals.
VR_4	Controls input to grid of V_3.
VR_1	Controls input to grid of V_1.
VR_6	Applies a standing 'bias' voltage across vertical plates.
VR_5	Applies a standing 'bias' voltage across horizontal plates.

TABLE LXVII:

COMPONENT VALUES OF TYPICAL COMMERCIAL OSCILLOGRAPH

R	Purpose	Ohms
1	Decoupler between V_2 and V_1	1·5 meg
2	Cathode bias V_1	750
3	Anode load V_1	·1 meg
4	Cathode decoupler V_1	·23 meg
5	Current limiter for 50~ input	2,000
6	Voltage dropper for V_3 anode (compensates for VR_3)	1,000
7	Anode load V_2	·25 meg
8 27	Voltage dropper to change frequency of time base to give two ranges for C_7, C_8, etc.	·75 meg 1 meg
9	Anode suppressor V_2	100
10	Anode load V_3	·1 meg
11	Load resistance for direct input to vertical plates	1 meg
12	Residual grid-cathode resistance for V_3	15,000
13	Cathode bias V_3	750
14	Cathode decoupler V_3	·23 meg
15	Decoupler for beam centring (horizontal plates) circuit	·5 meg
16	Decoupler for beam centring (vertical plates) circuit	·5 meg
17 18 19	Potential divider network for cathode-ray tube, second anode and grid biasing	·5 meg ·5 meg ·23 meg

[*Continued on page* 266

TABLE LXVII: COMPONENT VALUES OF TYPICAL COMMERCIAL OSCILLOGRAPH—*continued*

R	Purpose	Ohms
20	Potential divider network for V_1, V_2 V_3, voltage supplies	40,000
21		40,000
22		35,000
23		15,000
24		1,000
25	Smoother for cathode-ray tube HT	·23 meg
26	Compensating load for V_3 screen	·1 meg
27	See R_8	—
VR_1	V_1 gain control	1 meg
VR_2	Fine control of time base frequency	2 meg
VR_3	Sync. control to time base	1,000
VR_4	V_3 gain control	2 meg
VR_5	Horizontal beam centring	·375 meg
VR_6	Vertical beam centring	·375 meg
VR_7	Focus control	·375 meg
VR_8	Brilliance control	·1 meg

VALVES

V	Purpose	Type
1	Amplifier for horizontal plates	6J7G, Z63
2	Time base oscillator	884, GT1B
3	Amplifier for vertical plates	6J7G, Z63
4	HT rectifier for V_1, V_2, V_3	5Y3G, U50
5	HT rectifier for cathode-ray tube	879, U17
CR_1	Cathode-ray tube. 1,500 volts max anode 1, 475 volts max anode 2	3 in. hard vacuum

C	Purpose	mFd
1	HF by-pass for R_1	23 mmFd
2	V_1 cathode decoupler	·0035
3	V_1 grid blocking capacitor	·1
4	V_1 suppressor decoupler	·1
5	Horizontal plates feed from V_1	·23
6	By-pass for oscillator transformer	·005
7	Time base capacitors	·15
8		·023
9		·005
10		·00075
11	Blocking capacitor for vertical input	·1
12	V_3 cathode decoupler	·0035
13	V_3 suppressor decoupler	01
14	Vertical plates feed from V_3	·23
15	Horizontal centring decoupler	·23
16	Vertical centring decoupler	·23
17	Cathode-ray tube cathode decoupler	·23
18	V_2 cathode decoupler	20
19	V_1, V_3, screens decoupler	8
20	HT smoothing	4
21		
22	EHT smoothing	·25
23		

Examination of speech and musical instrument's wave-forms.

Detection of parasitic oscillation.

Examination of effect of tone-control circuits.

Monitoring.

Observation of atmospherics.

With Frequency-Modulator:

Aligning band-pass circuits.

Adjusting AFC circuits.

Sensitivity and selectivity tests.

Band-width measurements.

Adjusting wave-trap circuits.

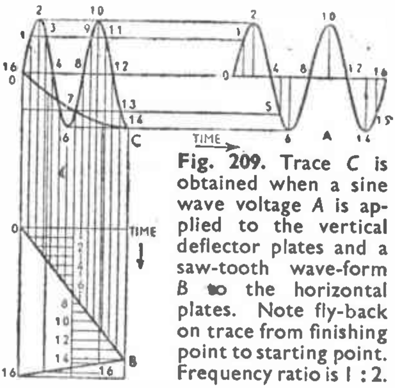


Fig. 209. Trace *C* is obtained when a sine wave voltage *A* is applied to the vertical deflector plates and a saw-tooth wave-form *B* to the horizontal plates. Note fly-back on trace from finishing point to starting point. Frequency ratio is 1 : 2.

LISSAJOUS FIGURES

Figs. 210-213 show the graphical construction of four fundamental Lissajous figures. From these it will be seen that, if the frequency of one of the voltages is known, the frequency of the other voltage can be determined by knowledge of the resultant of combination.

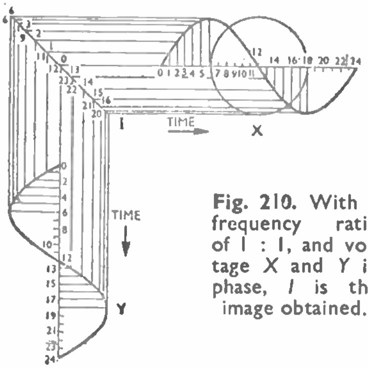


Fig. 210. With a frequency ratio of 1 : 1, and voltage *X* and *Y* in phase, *I* is the image obtained.

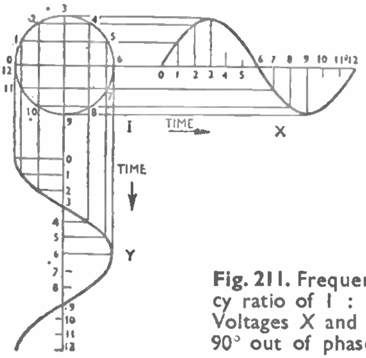


Fig. 211. Frequency ratio of 1 : 1. Voltages *X* and *Y* 90° out of phase.

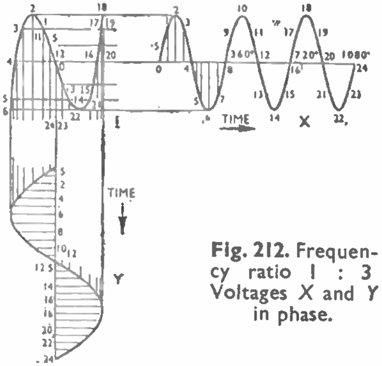
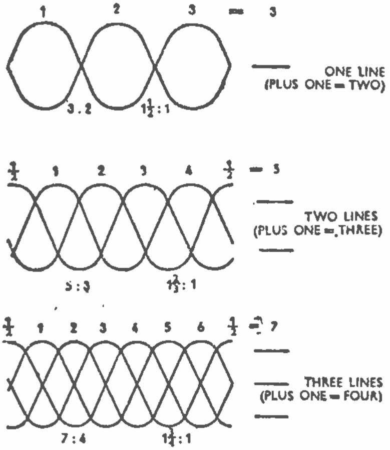


Fig. 212. Frequency ratio 1 : 3 Voltages *X* and *Y* in phase.

Fig. 214a-e are for 1 : 1 frequency ratio, while below (f-j) will be seen the effect of making the frequency ratio 2 : 1 for the different phase relationships.

As the frequency ratio increases above about 10 : 1, the figures become more complex. They are then difficult to diagnose, and it is of assistance to separate the left-to-right movement of the spot from the right-to-left movement. This can be accomplished by vertically displacing the latter movement so that the figure appears as a slowly rotating



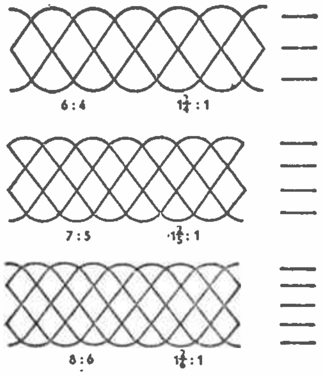


Fig. 218. Frequency ratio determination by peaks and lines of intersection.

'one + number of horizontal lines of intersection'.

Fig. 217 gives three examples of this method. Note that where two half peaks occur at each end (or there may be, say, a quarter peak one end and three-quarters of a peak the other end), these are added together and counted as one peak.

It is important when examining 'flat' patterns (i.e., those not obtained with a phase-splitting circuit), that the front trace does not coincide with the back trace and so cause confusion and the incorrect calculation of the frequency ratio. For example, in the Fig. 217a pattern, the front trace is shown in a thick line, and the back trace as a fine line to emphasize this point. If the traces do remain stationary and coincident, the unknown frequency should be altered very slightly to cause the figure to commence turning.

ATTENUATORS AND GAIN CONTROL SYSTEMS

The term attenuator is often used to describe a device producing the attenuation of power, or voltage, or current between its input and output terminals. (Note that an attenuator composed of reactances does not give a reduction of power.)

A more restricted use of the term describes an adjustable resistance network arranged so that the input and output resistance is constant at all settings of the attenuator and so that the ratio of output to input power is known from a calibration or labelling of the adjustment. The term attenuator will be used in this restricted sense here.

The term volume control is, in fact, a misnomer, unless it is taken to describe a device to maintain the mean volume of the reproduced sounds constant by increasing the loudness of the weaker and decreasing the loudness of the stronger. The term gain control is more descriptive when it means a device changing the gain of an amplifier between input and output terminals.

A potential divider (potentiometer means a device for measuring potential, not altering it), is shown in Fig. 219, and is arranged to alter the power supplied to the loudspeaker as the slider is moved along the resistor. The load presented to the input is not constant, if the slider

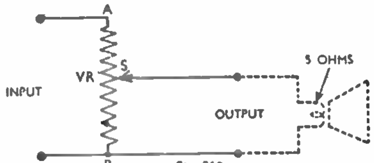


Fig. 219

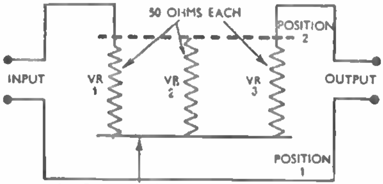


Fig. 220

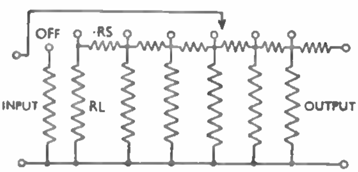


Fig. 221

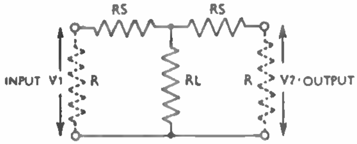


Fig. 222

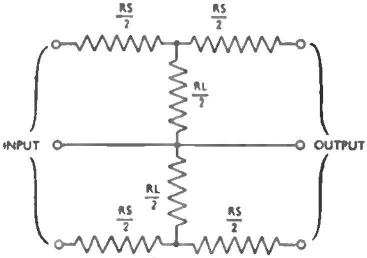


Fig. 223

Fig. 219. Attenuator or volume control applied to a loudspeaker. **Fig. 220.** Three ganged potential dividers for attenuation with little effect on impedance matching. **Fig. 221.** Resistance network for attenuation with constant impedance. **Fig. 222.** Simple Tee attenuator. **Fig. 223.** Attenuator of two Tee units back to back.

is at *A*, it is of the total resistance of the potential divider in parallel with the loudspeaker; if at *B*, of the potential divider only.

The variation of load if the input is from a valve may cause distortion; if the total resistance of the potential divider is much less than the loudspeaker impedance, the load tends to remain constant but the arrangement is inefficient, the greater part of the input power being dissipated in the potential divider.

Fig. 220 shows three ganged potential dividers for attenuation with little effect on impedance matching.

The attenuator of Fig. 221 consists of a network with series and shunt arms, so arranged that as the slider contacts the different studs a different attenuation is produced, the input resistance remaining constant. This is achieved by choosing different resistance values for the different resistors.

'T' Attenuator. By correctly apportioning the values of R_S and R_L, the input resistance of the T network of Fig. 222 can be made constant and equal to R, the terminating resistance, and the total attenuation of the network varied by varying the resistance values of the three arms, the two series arms R_S always having equal values.

If α be the ratio < 1 of the input to the output voltage, then,

$$R_S = R\,\frac{1-\alpha}{1+\alpha};$$

$$R_L = R\,\frac{2\alpha}{1-\alpha^2}.$$

'H' Attenuators. In circuits having systems balanced to earth, such as in push-pull circuits, two 'T' types inverted are used, as in Fig. 223. These are generally termed 'H' type attenuators. To obtain the same results with 'H' as in 'T' networks, the values of the resistances are half those in the 'T' type.

The table given in Fig. 181, p. 239,

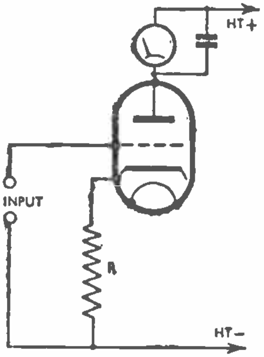


Fig. 225. Mains-driven version of Fig. 224. *R* not only biases the valve, but extends the input volts range.

voltage range can be applied to the grid before the upper limit of the milliammeter scale or valve curve is reached.

Increasing Range. To increase the range still further, a potential-divider network may be connected across the input, but this, of course, will create a greater load upon the circuit being tested, but it can still be made very high, as shown in Fig. 226.

This is an American circuit, and an interesting feature is that by biasing the valve up to the middle of its curve, a centre-zeroed milliammeter (calibrated in volts, of course) gives a positive or a negative reading, so that a correct reading is obtained no matter which way round the test leads are applied to the circuit under test.

The variable bias resistor (pre-set) is adjusted with the particular valve to give the necessary anode current to bring the meter needle to its centre position. A positive-grid potential will increase the reading, so the right half of the scale is calibrated as positive volts 0–5, 50, etc., according to the ranges provided.

A negative grid potential will decrease the meter reading, and the left half of the scale is calibrated with negative volts.

How to Zero the Meter

The meter is set to zero by shorting the input to the instrument and adjusting the variable resistance in the HT potential divider, thereby altering the anode current by adjusting the anode volts.

In other types, the valve is biased nearly back to the lower bend of its curve. This leaves a very small anode current flowing, and the meter needle may be set on zero by means of the usual mechanical adjustment so that the needle reads zero with the input shorted. The application of a positive voltage to the grid will then increase the anode current, and the whole meter scale is available for calibration in a forward direction. The test leads must be reversed to obtain the negative voltage readings.

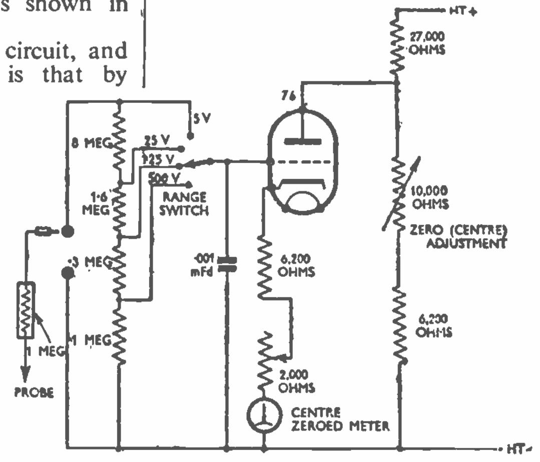


Fig. 226. Direct-current valve voltmeter. The meter is centre-zeroed and is not of the centre zero type. It does not register a change of current direction, only an increase or decrease in value.

Anode-bend AC Valve Voltmeters. The last-mentioned type of valve voltmeter could be biased to give an indication of AC volts because, being biased back to the lower bend, rectification will occur, the negative half cycles having little effect upon the anode current. The anode current is then a measure of the effective value of the positive half-cycles.

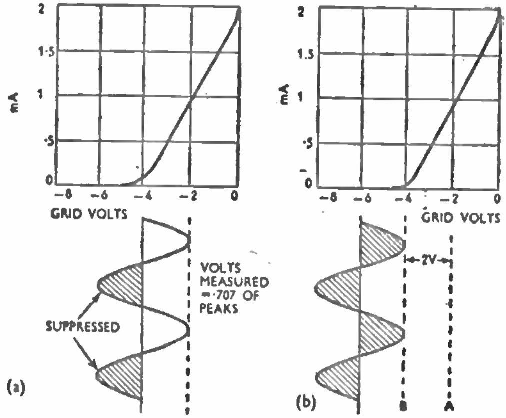


Fig. 227. Left (a) Anode-bend valve voltmeter indicates, by the change in anode current, the effective value of the applied AC volts. (b) Peak valve voltmeter indicates (by a voltmeter across the bias supply) the volts necessary to shift the peaks from position *A* to position *B*.

If the valve is biased back still further so that only the peaks of each cycle just give rise to a change of anode current, the reading will indicate peak volts. Fig. 227a shows how the valve curve is used for effective volts measurement, while Fig. 227b shows peak measurement.

Peak Valve Voltmeter. Fig. 228 is the circuit of a peak-valve voltmeter and is of the type often termed 'slide back', because of its operation, which is as follows. The valve is first biased to its cut-off point (zero anode current) by VR_1 with VR_2 at zero and the input shorted. The application of an AC voltage to the input will then cause the anode current to rise to a certain figure. VR_2 is then adjusted (thereby providing more negative bias) until the anode milliammeter just reads zero again. The reading of the bias voltmeter is then that of the peak value of the AC input.

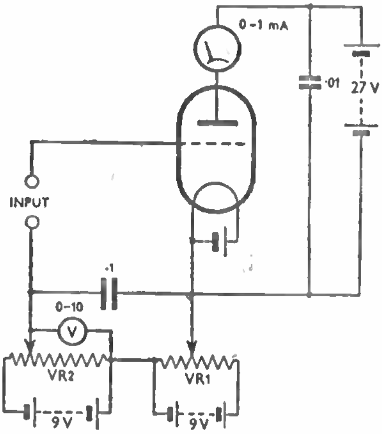
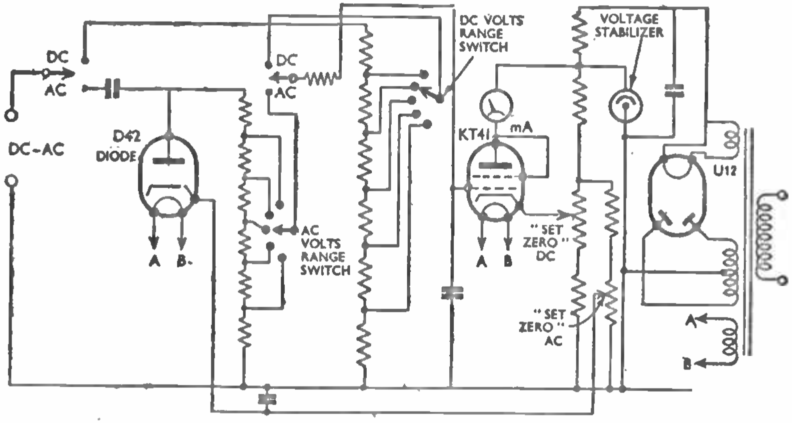


Fig. 228. Peak valve voltmeter of the slide-back type. The bias voltmeter *V* should be accurate but need not be exceptionally sensitive; 500 or 1,000 ohms-per-volt being suitable.

'Magic Eye' as an Indicator. As the milliammeter is used only to give an indication of zero anode current, it may be dispensed with and a 'Magic Eye' tuning indicator used so that at zero or minimum anode current the shadow segment closes. The applied AC voltage being measured will then cause the segment to open and the bias control is adjusted until the shadow closes again.

Diode Rectifier Valve Voltmeter. To obviate the need of the adjustment of controls every time a measurement is to be made, a separate diode rectifier may be used, as shown in Fig. 229. The diode load comprises a resistance network which forms a range-potential divider for the DC amplifier-triode valve, which is biased by an adjustable cathode resistance for setting to zero on DC. A second variable resistance is to give the diode a slight bias and it is used for setting to zero on AC.



MAINS-DRIVEN VALVE VOLTMETER FOR AC AND DC READINGS
Fig. 229. Showing a direct-voltage valve voltmeter with the addition of a diode and separate range resistance network for reading alternating voltages.

The capacitor in the input circuit exists to block off any DC that may be present, such as in the anode circuit of a valve stage.

In some commercial instruments, the diode is incorporated in the triode valve, a double-diode-triode being used with the diodes strapped.

In Fig. 229 a tetrode is connected as a triode.

General Notes. As both test leads may be at a high DC potential (e.g., across an anode coil), the case of a valve voltmeter must not be connected to the 'earth' side of the voltmeter circuit and must be earthed on its own.

Meters and HT-supply circuits must be thoroughly decoupled by high-quality capacitors.

Voltage stabilizers are advisable across the HT supply, to keep the voltage constant over the mains-voltage range of each particular tapping on the mains transformer.

It should be appreciated that for many applications, with an input signal to a circuit under test that can be properly attenuated, a valve voltmeter need not be accurately calibrated, or may even not be calibrated at all. Taking a single stage gain measurement as an example, if when the valve voltmeter is connected to the input to the stage a certain measurement is obtained, say one division on the meter scale, and then when connection is made to the output of the stage a higher reading is obtained, the attenuator on the signal generator providing the signal source has only to be adjusted to give a lower output that will bring the meter needle back to the one division mark. The attenuator ratio between its first and second readings will then be a measure of the stage gain.

AC Voltage Values. Fig. 230 shows the relationship between peak, effective (RMS) and average values. The relationship is only as shown for pure sine waves.

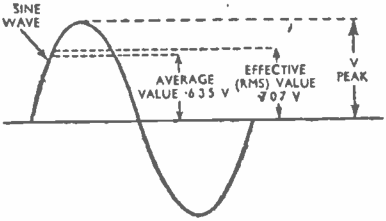


Fig. 230. Relationship between peak, RMS, and average values of alternating current.

A peak valve voltmeter may be calibrated (or its calibrations converted) for RMS values by multiplying the peak values by ·707.

'Bucking' Meter Current. In some types of valve voltmeters where a standing or residual current flows through the anode meter, this current is 'bucked out' by applying a reverse voltage across the meter. By means of a variable resistor, the 'bucking' current is made exactly to cancel out the standing current, and so bring the meter needle to zero. Thus the whole length of the scale is available for voltage calibration. Fig. 231 shows two methods of applying this feature.

A way of obviating 'bucking' circuits is sometimes employed in valve voltmeters of the type shown in Fig. 229, and is accomplished by using a meter, the needle of which when at rest is at the right-hand end of the scale. When current is switched on, the needle moves to the left, which becomes a zero reading at a maximum anode-current reading. This point is calibrated as zero volts.

The input is arranged so that negative potentials are applied to the grid which reduce the anode current and bring the meter needle toward the right. The scale voltage calibrations increase, of course, from left to right.

This method not only does away with 'bucking' circuits, but also safeguards the meter against overloads, because the higher the voltage applied to the grid of the valve, the lower is the current flowing through the meter.

Tools and Leads. It is not inappropriate to conclude this section with a word on the importance, in workshop and laboratory, of having a proper set of tools and connecting leads. Too often people spend many pounds on oscillographs, oscillators and other instruments and baulk at the few extra pounds needed for the 'bits and pieces' that go with them.

For example, proper trimming tools permit trimmer adjustments to be done rapidly, without damage to the components, and ensure freedom from spurious magnetic or capacitive effects.

With the oscillograph in particular, it is necessary to employ correctly screened and terminated leads if spurious effects are to be avoided. As long as there is possibility of these, the results of tests are difficult to interpret or misleading, and to obviate them, by makeshift methods, is a long and wearisome job.

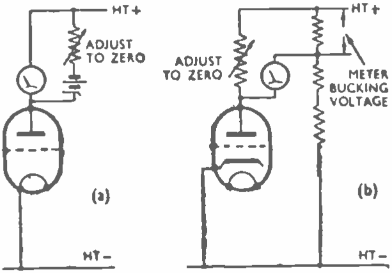


Fig. 231. (a) Battery and (b) mains versions of meter current bucking circuits.

Work is much quicker using leads properly fitted with clips, plugs and so forth, and chances of accident much reduced owing to the tidier terminations and neat insulation, which the wave passes through and fails to return. The angle becomes smaller, as frequency rises. When reflection does occur, there is a region between the ground wave area and the region where the reflected wave returns to earth, over which there is no reception (skip distance). Therefore, the greater the distance, the lower is the permissible frequency. The best frequency will depend upon the season and upon the time of day. (See Figs. 232 and 233.)

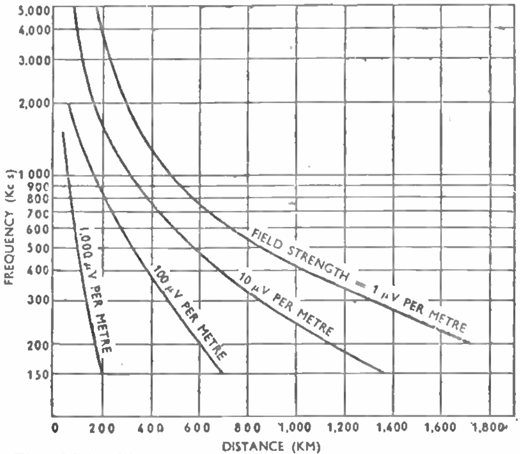


Fig. 234. How fall of ground wave field strength with distance varies with transmission frequency.

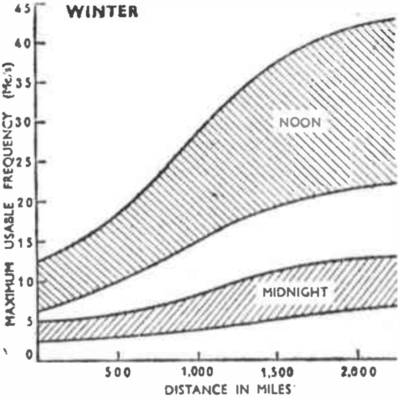


Fig. 232. Showing usable frequency band for short-wave distance communication at noon and midnight in winter.

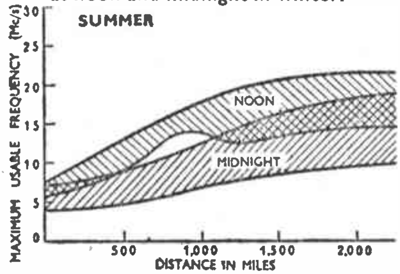


Fig. 233. In summer, the frequencies usable are more limited than in winter.

With very short waves, in the decimetre region, propagation is possible only over optical distances.

Propagation Data and Formulæ. The field strength in an electromagnetic wave is defined as the potential difference between two points in the wave front, one metre apart, and is usually measured in millivolts or microvolts per metre. This means that the EMF induced in a receiving aerial by the wave is obtained by multiplying the field strength by the effective height of the aerial in metres.

Ground-wave Propagation. The field strength F due to the ground wave from a vertical quarter-wave aerial is given by:

$$F = \frac{11{,}400 \quad \sqrt{WA}}{d} \quad \text{mV/metres,}$$

where W is power radiated (kilowatts), d is distance in kilometres, and A is an attenuation factor depending on the nature of the soil.

$$A = \frac{2 + 0{\cdot}3\,\rho}{2 + \rho + 0{\cdot}6\,\rho^2}, \text{ where}$$

$$\rho = \frac{9{\cdot}38 + 0{\cdot}621 \times 10^{-21} f^2 d}{\rho \times 10^{-9}},$$

ρ is the specific conductivity of the

soil (mhos per cm cube), and f is the frequency in Kc/s per sec.

ρ varies from about 10^{-4} to 10^{-6} mhos per cm cube between soils of good and bad conductivity; its value for sea water is about 4×10^{-2}.

Fig. 234 shows the field strength in the ground wave, per kilowatt of power radiated, for soil of conductivity $\rho = 10^{-4}$ mhos per cm cube.

Long-distance Propagation. The curves (Figs. 232 and 233) show the maximum usable frequency for various distances, at different times and at different seasons of the year, where the propagation is by reflection from the ionized layers.

AERIALS

Half-wave Dipole. The fundamental type of aerial is the half-wave dipole. It is resonant to the transmitter frequency when its length is about 95 per cent of the half wavelength (excluding the length of insulator at the middle), and the input impedance is then 70-80 ohms. The current is greatest at the centre, falling to zero at the ends, the distribution of current strength along the dipole following almost exactly a sine curve.

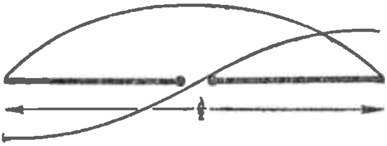


Fig. 235. Voltage and current distribution in a half-wave dipole.

The voltage is lowest at the centre and has its greatest value at the ends (the curve in Fig. 235 represents the voltage at any point above the voltage where the feed is connected).

It is convenient for use at all wavelengths below a few metres, where its length becomes manageable, and it may be used vertically or horizontally. The intensity of radiation from it varies in the vertical plane in the first case and in both vertical and horizontal planes in the second case, in a manner which depends on its height above the ground and on the electrical characteristics of the soil.

In Fig. 236, the vertical (*a*) and horizontal (*b*) directivity curves for a vertical half-wave dipole in free space are shown.

Assuming a length equal to 95 per cent of the half wavelength, the length can be calculated from the formula, $L = \frac{468}{f}$ ft., where f is frequency in Mc/s.

Simple Reflectors. The directivity in the horizontal and vertical planes of a vertical half-wave dipole can be much improved by using a reflector, both for transmission and reception. The simplest type of reflector is a

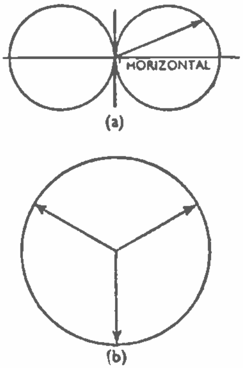


Fig. 236. Directivity curves of vertical dipole in free space. (a) Vertical directivity curve; length of the arrow indicates the intensity of radiation in that direction. (b) Horizontal directivity curve; the dipole radiates equally well in all horizontal directions.

second dipole, in the form of a plain rod, mounted parallel to the 'active' dipole, and separated from it by one-quarter wavelength.

In the case of transmission, a current is induced in the reflector by the current in the excited dipole, and the reflector radiates. The effect of the spacing is that, on the line joining the dipoles, the two radiated waves are in phase on the side towards the excited dipole, and the total field strength is increased. On the side toward the reflector, the two radiated waves are in opposite phase, and annul each other. The polar diagrams for both vertical and horizontal directivity are shown in Figs. 237a and 237b respectively.

This system is used considerably in television reception. The line joining the two dipoles must point toward the transmitting station, the 'active' dipole being nearer to it. Then the wave passing the system sets up a current in the reflector, which re-radiates, and produces a current in the active dipole in phase with that set up by the direct wave. The result is equivalent to an increase in signal strength.

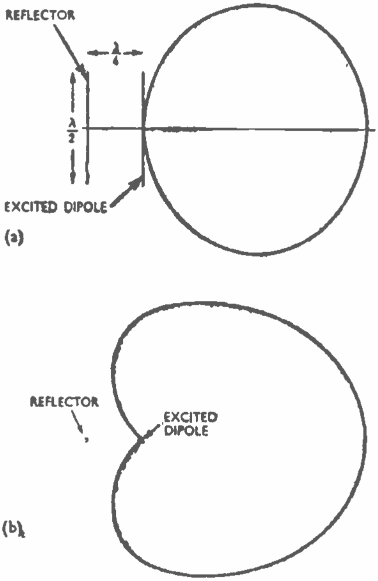


Fig. 237. (a) Vertical directivity curve of dipole with reflector. (b) Horizontal directivity curve of dipole with reflector.

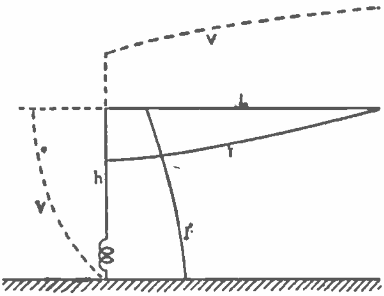


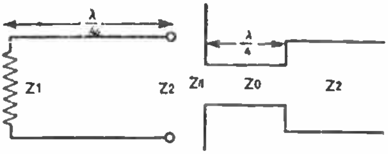
Fig. 238. Theoretic diagram showing *L* aerial with added curves representing current and voltage distribution.

Such dipoles are usually made with copper tube, of about ½ in. diameter, cadmium plated to prevent corrosion. They should be mounted as high above the earth's surface as possible.

The Marconi Aerial. At lower frequencies where the dipole is too cumbersome, the simplest type of aerial is the Marconi or λ/4 aerial. This consists of a vertical wire (or a tower or mast in the case of transmitting aerials) one-quarter wavelength long, whose lower end is earthed, the feed being between two points close to the earthed end.

The radiated field is that which would be obtained from the aerial and an 'image' in the surface of the earth. The radiated field is greatest over a perfectly conducting earth and, to increase the conductivity in the neighbourhood of the aerial, a network of copper wires is usually buried below the aerial, radiating out from it.

The distributions of current and voltage are similar to those in the upper half of a half-wave dipole, but in any actual case they will be influenced by the nature of the soil in the neighbourhood of the foot of the aerial. Marconi aerials of this or



Figs. 240-241. Maximum power is delivered to an aerial by using matching devices.

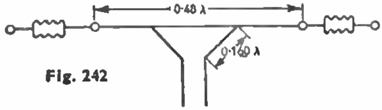


Fig. 242

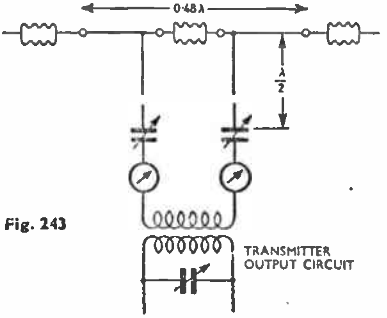


Fig. 243

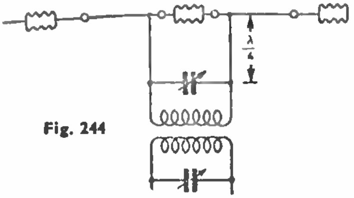


Fig. 244

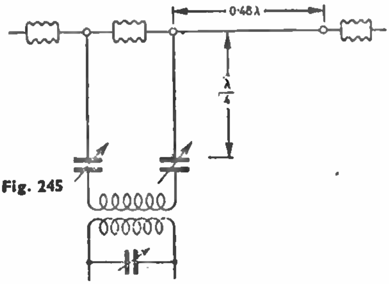


Fig. 245

Figs. 242-245. Feeder circuits for coupling transmitter, or receiver, to aerial.

used with signal generators for aligning receivers.

Matching Devices for Transmission Lines. In order that a transmission line may deliver maximum power to the aerial which it is feeding, the load on the line must be equal to its characteristic impedance. Thus if a half-wave dipole, whose input resistance is 75 ohms, is fed by a 600-ohm twin transmission line, some matching device is needed between the line and the dipole which will make the effective load on the former 600 ohms. Some matching devices which are used are:

(1) Quarter-wave transformer.

If a length of feeder one-quarter wavelength long is loaded by an impedance Z_1 (Fig. 240), then the transferred impedance across the other end is $Z_2 = \frac{Z_0^2}{Z_1}$, where Z_0 is the characteristic impedance. To match a dipole to a feeder line of characteristic impedance Z_2 (Fig. 241), a quarter wavelength of feeder of characteristic impedance Z_0, calculated from this formula, is interposed.

(2) Delta match.

The feeder may be fanned out. Dimensions are given for a 600-ohm feeder (Fig. 242).

(3) Current-fed (centre-fed) half-wave dipole with half-wavelength tuned feeder (Fig. 243).

The capacitors are adjusted for maximum current.

(4) Current-fed (centre-fed) half-wave dipole with quarter-wavelength tuned feeder (Fig. 244).

The arrangements in Figs. 242, 243 and 244 are used where it is possible to place the aerial close to the transmitter.

(5) End-fed (voltage-fed) half-wave dipole, with quarter-wavelength tuned feeder (Zeppelin aerial) (Fig. 245).

In this arrangement, only one wire of the feeder is actually transferring energy. The presence of the second keeps radiation from the feeder low.

SECTION

PROPERTIES OF

Material	Dielectric Constant	Power Factor	Frequency (Mc/sec)	Dielectric Strength (kV/mm)	
Amber	2·8	0·002	1	—	(1)
Bakelite (mouldings)	5–11	0·02–0·06	3	—	(2)
Bakelite laminated (paper base)	5	0·04	—	10	(3)
Bakelite laminated (fabric base)	6	0·03	—	10	(4)
Beetle, Calan	6·5	0·004	10	40	(5)
Calit	6·5	0·0004	—	—	(6)
Cellulose acetate	4–4·8	0·06–0·08	3	—	(7)
Conda N	40–50	0·00055	—	—	(8)
Conda S	80–100	0·00041	—	—	(9)
Cotton, varnished	3	High	—	—	(10)
Diakon, Perspex	2·8	0·02	1	20	(11)
Ebonite, pure	3·0	0·009	1	150	(12)
Ebonite, mineral loaded ..	4·5	0·03	1	85	(13)
Ebonite, silica loaded	3·5	0·007	1	80	(14)
Empire cloth	4–6	—	—	—	(15)
Frequentite	6	0·0008	10	50	(16)
Frequelex	6	0·0006	3	—	(17)
Faradex	80	0·0003	3	—	(18)
Glass	3–4·5	High	—	—	(19)
Guttapercha	8	—	—	—	(20)
Isolantite	6	0·0018	3	—	(21)
Kerafar	80	0·001	1	—	(22)
Keramot	3·6	0·010	1	—	(23)
Marble	8	High	—	—	(24)
Mica	7	0·0002	10	50	(25)
Micanite	7	Poor	—	—	(26)
Mycalex	6·5	0·011	1	14	(27)
Paper, dry	1·5–2·5	—	—	—	(28)
Paper, impregnated	2·5–4·0	—	—	—	(29)
Paraffin wax	2·2	0·0001	1	20	(30)
Paxolin	2	0·05	—	—	(31)
Permalex	80	0·0013	—	—	(32)
Permitel	5	0·01	—	—	(33)
Phenol fibre	6	Poor	—	—	(34)
Porcelain	5·5	0·008	1	—	(35)
Polystyrene	2·5	0·0003	1	30	(36)
Polyethylene	2·2	0·0006	3	—	(37)
Polyisobutylene	2·5	0·0005	3	—	(38)
Pyrex	4·5	0·00017	3	—	(39)
Quartz, fused	3·8	0·0002	1	20	(40)
Rubber, pure	2·2–2·4	—	—	—	(41)
Rubber, vulcanized	3·0–3·5	—	—	—	(42)
Shellac	3·0–3·5	—	—	—	(43)
Silvonite	3	0·009	—	—	(44)
Slate	6	High	—	—	(45)
Steatite	6·1	0·002	—	—	(46)
Tempas	16	0·0005	3	—	(47)
Transformer oil	2·2	0·0001	3	—	(48)
Trolitul	2·2	0·0004	3	—	(49)
Tufnol	5	0·03	—	—	(50)
Ultra-calan	7·1	0·0001	—	—	(51)
Vinyl chloride	4·5–6·5	0·04–0·1	3	—	(52)

NOTE.—*The figures in parentheses are for quick reference and to facilitate reading across the pages.*

18

INSULATING MATERIALS

	Volume Resistivity (Ohm/cm)	Surface Resistivity (Ohm/cm sq.)	Water Absorption (per cent)	Nature and Chief Constituent
(1)	10^{17}	10^{14}	—	Natural resin
(2)	10^{5}	—	0·1–1·2	Phenol formaldehyde (synthetic resin)
(3)	10^{11}	10^{12}	—	—
(4)	10^{12}	10^{12}	—	—
(5)	—	—	—	Finely divided mica
(6)	—	—	—	—
(7)	$4{\cdot}5 \times 10^{10}$	—	—	—
(8)	—	—	—	—
(9)	—	—	—	—
(10)	4×10^{8}	—	—	—
(11)	10^{16}	10^{14}	0·4	Methyl methacrylate
(12)	10^{16}	10^{9}–10^{15}	—	Rubber and sulphur
(13)	10^{14}	—	—	—
(14)	—	—	—	—
(15)	—	4×10^{8}	—	—
(16)	10^{15}–10^{17}	—	—	Magnesium silicate
(17)	10^{20}	—	—	—
(18)	—	—	—	Ceramic (rutile)
(19)	10^{7}–10^{9}	10^{13}	—	—
(20)	4×10^{8}	—	—	—
(21)	10^{17}	—	—	—
(22)	—	—	—	Ceramic (rutile)
(23)	—	10^{13}	—	—
(24)	10^{6}–10^{8}	—	—	—
(25)	10^{17}	10^{11}	—	—
(26)	3×10^{9}	—	—	Mica
(27)	10^{13}	4×10^{0}	0–0·2	Mica
(28)	10^{5}	—	—	—
(29)	10^{8}	—	—	—
(30)	10^{17}	10^{16}	—	—
(31)	10^{12}	—	—	—
(32)	—	—	—	—
(33)	—	—	—	Chlorinated diphenyl
(34)	—	—	0·3–9·0	Phenol formaldehyde
(35)	10^{14}	—	—	—
(36)	10^{20}	10^{14}	Nil	Plastic
(37)	10^{17}	3×10^{16}	Nil	Plastic
(38)	10^{16}	2×10^{15}	Nil	Plastic
(39)	10^{14}	—	—	—
(40)	10^{17}	10^{13}	—	—
(41)	10^{16}	—	—	—
(42)	5×10^{9}	—	—	—
(43)	5×10^{9}	—	—	—
(44)	10^{16}	—	—	—
(45)	$2{\cdot}5 \times 10^{6}$	—	—	—
(46)	10^{14}–10^{15}	—	—	—
(47)	—	—	—	—
(48)	—	—	—	—
(49)	—	—	—	—
(50)	10^{12}	—	—	—
(51)	—	—	—	—
(52)	3×10^{12}	2×10^{11}	0·2	Plastic

SECTION 19

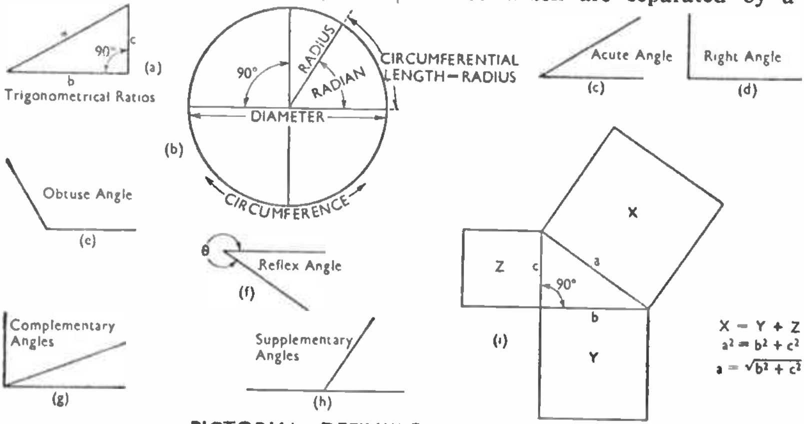
TRIGONOMETRIC RATIOS

THE circle is divided into 360 degrees and each degree is divided as follows:

1 degree = 60 minutes,
1 minute = 60 seconds.

If two diameters divide a circle into four equal parts, the four angles at the intersection are $\frac{360^\circ}{4} = 90^\circ$, and are known as right angles.

The circumference of a circle divided by its diameter is a fixed ratio known as π ('pi'). π is an indeterminable non-recurring decimal but, to five places of decimals, the value is 3·14159.



PICTORIAL DEFINITIONS OF ANGLES

Fig. 246. Self-explanatory diagrams showing geometrical terms in frequent use.

The area of a circle is $\frac{\pi d^2}{4}$, or πr^2, where r is the radius and d the diameter ($r = \frac{1}{2}d$).

Any angle, θ ('theta'), in a right-angle triangle may be measured in terms of the ratio of one side to another. (See Fig. 246a.)

Ratio $\frac{c}{a}$ is the *sine* of the angle;
„ $\frac{b}{a}$ is the *cosine* of the angle;
„ $\frac{c}{b}$ is the *tangent* of the angle.

Their reciprocals are:
$\frac{a}{c}$ is the *cosecant* of the angle;
$\frac{a}{b}$ is the *secant* of the angle;
$\frac{b}{c}$ is the *cotangent* of the angle.

Angles may be measured in radians. A radian is an angle formed between lines drawn from the centre of a circle to points on its circumference which are separated by a circumferential length equal to the radius of the circle. (See Fig. 246b.)

Since circumference = 2π × radius, there are 2π radians in a circle, or

$$360^\circ = 2\pi \text{ radians;}$$
$$180^\circ = \pi \text{ radians;}$$
$$90^\circ = \frac{\pi}{2} \text{ radians;}$$

and one radian = 57·3° (approx.).

(c), (d), (e), (f), (g), and (h) in the diagram above give pictorial definitions of terms used in geometry as well as illustrating the fact that the sum of the squares of the lengths of the two shorter sides of a right-angle triangle is equal to the square of the length of the longest side.

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T.1046.S. *Printed in Great Britain by McCorquodale & Co., Ltd., Newton-le-Willows.*